Integrated land and water management

Challenges and new opportunities

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STOCKHOLM Vatten

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Although it is widely known that water is essential to life, the critical character of water issues were not prominent in either the 1987 Brundtland Commission report or in the preparations for the UN Conference on Environment and Development in Rio 1992. The Stockholm Water Symposia are organized against an awareness that water may in fact be **the** environmental problem of the next few decades.

The Stockholm Water Symposia are a series of future-oriented water policy symposia, arranged to address key environmental issues on the threshold to the 21st century. The approach taken is integrative: across disciplines, professions and societal sectors. The selected niche - water quality management - is addressed in a logical and sequential manner, starting with key measures needed to minimize harmful fluxes from land to water, later analyzing different sets of barriers that stand in the way for implementing those measures.

The first **1991 Symposium** identified two main global problems relating to water: water scarcity as a major constraint to socio-economic development, on the one hand, and large-scale water quality deterioration, which was selected as **the niche** of the coming sequence of Stockholm Water Symposia.

The **1992 Symposium** analyzed the water pollution problems in different world regions. It identified a number of key measures in seeking effective solutions to the world-wide water pollution dilemmas. The symposium concluded that there is plenty of knowledge on what needs to be done to minimize harmful fluxes from land to water. There are however a **multitude of barriers** impeding the implementation of these measures - barriers that may in fact be almost as large as the water pollution threat itself.

The **1993 Symposium** addressed a first subset of these barriers and how they might best be overcome: those due to lack of credible economic rationale for minimizing harmful pollutant fluxes; due to incomplete mechanisms for financing; and due to gaps in the communication between scientists and decision makers. The symposium concluded that the world - full of vested interests producing pollutants that will end up in water - indeed **lacks a strong water quality protection constituency.** There is a widespread water illiteracy among both decision makers and the general public. In politicians' perceptions, more focus is put on solving small visible problems than on the large invisible ones which are deteriorating our life support systems.

The **1994 Symposium** addressed **challenges and new opportunities in a set of different areas:** in educational renewal (politicians, the general public and the new generation); in greening of industry; in coping with hazardous waste; in achieving increased agricultural yields with reduced water pollution; in finding new ways to financing through public/ private partnership; and in taking an integrated approach to land and water.

This volume contains the proceedings of the Symposium 1994. The **first part** contains the Conclusions of the symposium followed by the contributions of the Key Speaker and the Invited Plenary Speakers. The **second part** is composed in the Reports to the six workshops, together with a Synthesis of the Posters. The authors are fully responsible for the views presented in their papers.

Malin Falkenmark
Professor, Chair of the Scientific Programme Committee

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- satisfies our users' water-service needs
- contributes effectively to making Stockholm a city in ecological equilibrium.

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- continuous, reliable distribution
- reduced environmentally harmful chemicals in wastewater
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is an international environmental award given annually in recognition of outstanding contributions in the field of water conservation. Awarded by the non-profit Stockholm Water Foundation, the US$ 150,000 prize honours the person, company or institution that, over the last four years, has made the greatest contribution to improving water quality, water protection and water resource management. The award is financed by interest on a fund supported by Swedish and international companies and administered by the Stockholm Water Foundation. The Stockholm Water Prize Laureate is chosen by a nominating committee under the auspicies of the Royal Swedish Academy of Sciences. The Stockholm Water Prize is presented by H M King Carl XVI Gustaf at a ceremony in the City Hall in connection with the Stockholm Water Symposium.

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CONCLUSIONS FROM THE FOURTH STOCKHOLM WATER SYMPOSIUM

Malin Falkenmark, Professor, Chair of the Scientific Programme Committee

Background

Earlier Stockholm Water Symposia have indicated that the escalating water quality deterioration is one of the major environmental problems on the threshold to the 21st century. The 1994 Symposium addressed challenges and new opportunities in minimizing the flux of harmful substances from land to water. Although large, today's waste treatment efforts are too slow to keep pace with the escalating output of pollutants from growing human populations, expanding industry, and intensifying agriculture. This widening gap has created a strong sense of urgency.

Highlights

Attitudes to water

The water passing through a country constitutes its very life support. It therefore represents a natural capital, to be preserved in order not to erode the future of the country. Better informed and less irresponsible ways of water quality management in a country are fundamental for long-term health, socio-economic sustainability, and - indeed - national creditworthiness.

Reductionist and other overly simplified views on water can be misleading and create communication barriers and barriers to progress. For example, that charging the full price of provided water is a panacea to water problems, or the economist view of water as an economic good have evident validity limitations, i. e. water in its biological functions, such as the water filling the human body, or the rain that the atmosphere provides in life support to a region. The same holds for providing water at any cost to grow food in arid areas under the label of "food security". Reductionist visions have evidently to be complemented by a more generally accepted and comprehensive mental image of water. A wider understanding is needed in society of the implications of the integrity of the water cycle, circulating a unique solvant, chemically active and biologically crucial.

Attitudes towards water have to be more informed. As a first step in changing attitudes and lifestyles, a broad public awareness has to be generated. Children have to be engaged and stimulated to actively motivate their environmental concern: they have fantasy, they are flexible, and they represent the platform for societal changes.

Complexity demands systems approach

The complexity of many water-related issues demands a systems approach. Education has a strategic role in developing an improved capacity among environmental professionals to address and communicate on particularly complex issues. New more efficient ways of learning have to be developed.

Water quality protection has to involve, as an integral component, land use management, taking an integrated landscape-ecological approach to land and water use planning. The lessons learned from a set of successful integration cases include a fruitful mix of bottom-up and top-down approaches, combining local action with higher level guidance and incentives; the usefulness of computer-based animation; the need for regional integration also of institutional arrangements; and education and training to secure a common language between the multifactoral managers who will lead the process.

Minimizing harmful fluxes from land to water

The world needs to take a realistic approach to technology, i. e. see its role in wealth creation. The concept of environmental impact of water-related projects has to be broadened to include environmental preconditions for human activities in general. Equally necessary is to ensure that the environmental impacts are real and not hypothetical, as has been noted in ex-post evaluation of some major water projects. Industry cannot in the long run be in disharmony with nature. Its greening industry however calls for economic realism to arrive at cost-effective anti-pollution measures, and priority setting based on longer-term, stable environmental objectives.

Food security to a rapidly growing world population will demand intensified agriculture. This growth cannot be implemented by an uncritical increase of agrochemicals like under the Green Revolution. Thus, to avoid water pollution escalation, special efforts are needed to reduce the use of chemical fertilizers and pesticides, and to develop biofertilizer systems and less water-demanding crops. Diet preferences may involve strong driving forces on agriculture: a reduction of the meat diet in central Europe would for example contribute in reducing the nutrient leakage to passing rivers.

Toxic waste, already forming a hidden layer in many industrial regions, continues to escalate, calling for a reactive as well as a proactive approach. The barrier to remediation of old sites is financing rather than knowhow. Waste avoidance by minimization in all the different phases of a product represents an even larger challenge, paying attention also to the ultimate fate of contaminants in a global perspective.

The world has broad experience of a failing public management of community water supply and sanitation. Total privatization, privatization of certain tasks and various forms of private sector participation, may be seen as an important and promising alternative mode of operation. This approach can bring in a higher level of professional, technical and mangerial skills and the needed capital to properly expand and improve service. Since community water supply and sanitation are natural monopolies, it is vital that proper attention be paid to the need for transparency and clarity of purpose. To meet the needs of a particular community, all the possible alternatives for public/private partnerships should be evaluated.

Workshops

Challenges and opportunities in minimizing harmful fluxes from land to water were addressed in six thematic workshops, focusing on educational renewal, workshop 1, minimizing different pollutant sources, workshops 2, 3 and 4, alternatives to public sector management, workshop 5, and land/water integration and its implications, workshop 6.

WORKSHOP NR 1

CHALLENGES AND NEW OPPORTUNITIES OF EDUCATIONAL RENEWAL

The workshop - attended by some fifty persons representing a broad spectrum of cultural, social as well as environmental situations - was centered around a few core issues:
- awareness of the time perspective: on the one hand to look back, on the other to look to the future. It is most important to foresee the inevitable population growth in the coming decades, as well as a significant technological development, but also crises of all kinds;
- how to meet the challenge - as a first step in changing attitudes and lifestyles - to actively motivate environmental concern;
- how to promote communication on particularly complex issues.

A set of important **methodological aspects** were highlighted. It is necessary to recognize the need for comprehensive views on water quality management. The reflective principle (to prevent) is preferable rather than to take measures afterwords. A fundamental challenge is the fact that science is fragmentized but the real world is not. A systems approach is necessary, in which the components and the processes are analyzed, and the different parts of the system integrated into its entity. In taking such a systems approach, global water cycle management may be a useful tool; and the river catchment form an effective framework. There is however a need for more adequate definitions, and a more powerful language.

Particular attention was paid to the **pedagogics** needed to secure educational renewal. First, courses should have a major objective and promote critical thinking. Second, it is useful to learn from Nature. Water should be looked upon not only as a fundamental resource but also as a risk factor. Finally, schools often show an interest for cross-cultural exchange. Furthermore community involvement should be considered.

A number of **additional reflections** were made. A more qualified handling of water information (hydroinformatics) is a new interesting aspect of water resources management with a great potential. Special attention has to be given to resolve health problems which are very much related to water use. Finally, for improving quality of life, water projects must be also financially attractive.

Conclusions and recommendations

Stockholm Water Symposia should continue to elaborate on the strategic role of education;
- An International School-Youth Symposium could be convened in connection with the Symposium 1995. The Life-Link in Sigtuna has offered to host such an activity;
- The opening session could have a multimedia approach - in order to set a proper "mood" for the symposium and provide a reminder of our common dependence on water;

- Women should be more involved in the planning process of educational programmes. Being close to the water use, they have in many ways a direct influence on sustainable development;
- Similarly, it is essential to engage and stimulate the children - they have fantasy, they are flexible, and they represent the platform for societal changes.

WORKSHOP NR 2

GREENING OF INDUSTRY

The workshop centered around **Education, Communication, Legislation and Policies**, some successful examples of greening were also presented from both the developed and the developing world.

Education and Communication

On the educational and communication side there appears to be an almost world wide need to assist small and medium sized enterprises. They need information on legislation, the effect of emissions on the environment and on the possibilities and opportunities to limit emissions. There is an important task for international organizations to promote education, technology transfer and necessary funding.

Cooperation between consumers and producers for instance as a result of technology procurement can lead to a demand pull and thereby "the market" accelerates the introduction of greener products.

Many successes today in the greening process have been achieved on a voluntary basis. Financial assistance by international financial institutes is necessary to encourage promising initiatives and make better use of successes.

Legislation and Policies

Environmental reporting and environmental assessment are valuable tools. Industry could make a greater effort to utilize environmental reporting to improve the dialogue with the society as well as its awareness. The greening progress could thus be followed in a more uniform and legible way.

Standardization of environmental management system is currently under development. But there is a requirement from the industry side for a pragmatic and non-bureaucratic approach with due regard to the small and medium sized enterprises.

Due to the fact that world wide there are significant differences between the economic, social and cultural and environmental situation in the various countries a tailor made approach towards greening of the industry is to be recommended. Although clean production is the preferred path, end of pipe solutions should not be ruled out.

Transplanting legislation from one country to another should be done with great care and take into account differences between countries.

Reducing subsidies on artificially low utility prices will lead to a greener industry e. g. by reducing energy and water consumption and waste production. Subsidies deplete natural resources and make a country less credit-worthy.

Policies and legislation should set the broad framework on product requirements and emission limits and give industry room for a flexible, cost-effective implementation of estimated measures.

More emphasis should be placed on the implementation of policies rather than on developing new ones. Industry needs longer terms and stable environmental objectives.

Law enforcement is necessary to ensure implementation of legislation and thereby creating a level playing field for industry. Lack of resources at the regulatory authorities is a problem. Promising techniques are being developed to improve effectiveness and efficiency of compliance monitoring by authorities and compliance reporting by companies.

WORKSHOP NR 3

HAZARDOUS WASTE MANAGEMENT

The workshop covered several aspects of problems related to the management of hazardous waste:

- identification and rating of contaminated soils;
- identification of abandoned army bases in Estonia and Lithuania, for which the remediation phase was judged to last for at least ten years;

- the control of hazardous waste, i.e. identification, registration of producers, and licensing of operators;
- classification of hazardous waste;
- remediation of contaminated soils and sediments;
- methods for solidification and stabilization, as well as the utilization of separated and treated waste;
- proposals for changed technology;
- ideas on decision theory.

Problems and limiting factors for the optimal management of hazardous waste were analyzed. The most important factors were considered to be the following:
- economical constraints;
- lack of public awareness;
- producers' unwillingness to pay their costs;
- shortage of management expertise;
- unclear legal responsibility regarding contaminated soil;
- waste classification not related to disposal classes;
- lack of trained manpower.

It was agreed that the problems concerning hazardous waste do not differ very much from one country to another. It was strongly stressed that public awareness must be increased everywhere. A major problem concerning hazardous waste was considered to be management of future waste, whilst the remediation of old sites may be looked upon as a manageable task that will be finalized within decades, but of course at considerable costs.

The major way of addressing hazardous waste is prevention rather than remediation. There are however difficulties in controlling high and advanced technologies. The correct way of approaching the issue of hazardous waste was judged to be the principle of minimization and planning for the whole product cycle. This means that it was seen as important that the fate of the products must be followed from their creation to their final disposal, the so called cradle-to-grave concept. Priorities should not only be decided from a site specific perspective; also the global aspect must be taken into account. The ultimate fate of the contaminants is in other words a vital issue for consideration.

Particular problems may occur if legislation and norms are transferred between countries without taking into consideration differences in culture, living standards and economy. The workshop finally recommended adherence to the polluter pays principle.

WORKSHOP NR 4

AGRICULTURAL CONFLICTS

Large and rapidly growing human populations in dry and semi-dry regions will ask for considerable increases in food production by upgrading of agriculture. With water as the most important limiting factor for such growth, the world is facing enormous problems in management of scarce resources. The resources necessary for food production have shown a marked deterioration during the last two decades. Despite optimistic believes in only positive effects of the Green Revolution, with its increased inputs of energy, chemical fertilizers, pesticides, water and improved seeds, such modern agriculture has had also adverse effects, not only on the physical environment, but also on human health. There is now an emerging awareness and understanding of the many corrections to be made in agricultural policy and practice, and also the many pitfalls to be avoided in future actions to be initiated.

Our present food production is estimated to be adequate for 7 billion people, fed by vegetarian diet and under the condition of ideal distribution of food and no grain fed to livestock. About 16 % of the world's total cropland is now under irrigation, contributing about 1/3 of the total crop production. The irrigated areas yield on an average about 2 1/2 times as much per unit area as non-irrigated land. With the limited amount of new areas for cropland available, water must be considered to represent the major limiting factor for a strongly increased agricultural production in years to come. The central role of water as a basis for life may give us the right to claim that socio-economic development, in countries with dry and hot climates, will be impossible without a sufficient supply of water for plants, animals and humans. We reckon that most of the large group of people presently without adequate food supply, live in drylands.

Much of the ongoing discussions on future appropriate agricultural practices - the concepts of green revolution contra organic farming - is based on the fact that a variety of unexpected problems has their origin in use of chemicals and the resulting water pollution. Increased use of chemical fertilizers and pesticides has been generally practised in developing countries, and most of its use is applied to irrigated areas. Through leaching effects and soil erosion, a large amount of harmful compounds are brought in contact with surface- and groundwater. The awareness of this problem, and of potential and serious health effects, is growing, at least in developed countries. Many of these problems were addressed in the workshop, proving the importance of initiating both political and professional actions, for a better understanding of the many interrelated problems involved, and necessary changes to be made in agricultural practises.

Activities to be initiated - very high priority and subject to immediate concern

1. More emphasis should be put on the needs for institution building at all levels in developing countries, with special view to a more integrated water and land use planning in river basins. Social and environmental impact assessments, with all their implications of interdisciplinary coordination should be stressed. Such assessments should be followed up by eventual monitoring of objectives achieved. Involvement of local water users in both planning, implementation and operation is highly needed.

2. Economical incentives in water management should be given a growing importance. The use of pricing mechanisms as tools for obtaining substantial reductions in water consumption is considered most necessary. Pricing is reckoned to be useful also for the reduction in consumption of chemical fertilizers and pesticides. There are needs for reconsidering the subsidizing policies now in practice, to promote development of less water demanding crops and more extensive use of biofertilizer systems and organic farming. However, water pricing is a complex technical, political and socio-economic process. Its introduction has to be handled sensitively in developing countries, to ensure that very poor people do not suffer unduly.

3. With the aim of reducing evaporation and water wastage, the appropriateness and efficiency of various technical irrigation methods needs to be developed and evaluated, for a variety of different local conditions.

4. Prevention of the use of limited groundwater resources for extensive agricultural irrigation, calls for an overall and long term resource management planning, to be initiated immediately. In most of the developing countries a formal legal basis for protection/use of groundwater is lacking and should be developed.

5. There is an urgent need for continuing education of professionals and users of water at all levels, to give them an understanding of necessary integrated and concerted professionals and social goals and actions to be organized in the years to come.

WORKSHOP NR 5

FINANCING OPTIONS - PRIVATIZATION

The world has a broad experience of a failing public management of community water supply and sanitation, even an almost total breakdown of public sector systems in many third and second world countries. As a consequence, private sector participation for financing and management of water supply and waste water projects in its many different forms, from simple service contracts over concession type arrangements to outright private sale of assets, is growing steadily, not only in the traditionally private sector friendly countries of Western Europe and North

America, but also in many developing countries. What role does it have to play? The workshop brought together an interesting cross section of views regarding the desirability and purpose of getting the private sector involved in the municipal water and waste water business.

The discussion led to a strong support for the need to look for alternative management forms ranging from full privatization to various degrees of private/public sector involvement. Total privatization, privatization of certain tasks, and various forms of private sector participation, may be seen as important and promising alternative modes of operation of community water supplies and waste water treatment systems. This approach can bring in a higher level of professional, technical and mangerial skills and the needed capital to properly expand and improve service, especially in those countries where the public sector is unable to provide water and sanitation services efficiently.

However, since community water supply and sanitation are natural monopolies, it is vital that proper attention will be paid to assure public control of standards of quality, levels of service and fair pricing which takes into consideration the basic needs of the economically deprived sectors. Putting any part of this service into private hands requires regulation, control and supervision from public authorities. The important choice is therefore the degree and form of privat **and** public sector involvement under different circumstances. The degree of regulation increases with the level of involvement of the private sector. The more of the responsibility is given to the private sector, the more prepared and skilled must public entities be to make sure that the private sector discharges its functions as contracted.

Full privatization is not the only option, and all the different possible alternatives for public/private partnerships should be carefully evaluated in each case so as to meet the needs of the particular community. Different situations call for different solutions. Publicly run companies can be successful (and Stockholm was mentioned as an example), but they can also fail. Similarly, privately run water works may be more or less successful. In many cases, turning over the management of water and waste water treatment systems to a private operator may even be the only way to liberate utilities from the straightjacket of political interference and the many disincentives which often come with running a water and sanitation enterprise in the public domain. The case of Buenos Aires was mentioned as an instructive example. Whether one specific composition of public/private involvement is good or bad depends largely on local circumstances and management cultures.

Relying on the private sector is a convenient and proven way to effect capacity building and efficiency gains in utility management and operations, as well as bringing in financial resources which public budgets cannot and should not supply. The institutional character of private corporations make them good for some purposes, but not for all purposes. The private profit motive can play a role to improve performance, but the non-profit nature of public companies may also be considered an advantage. Issues of irreversibility (whether a move towards privatization can be reversed or not and at what costs), availability of information to citizens and other aspects of democracy should also be considered.

Whether moves in the direction of more public or more private involvement is a step forward or not is in some cases a matter of ideology, i.e. ideas about means-ends relationships. What one can do from a scientific point of view is to recommend a many-sided and multidimensional informtion basis before decisions are taken. It is essential that the public agent clearly understands the pros and cons of private sector participation, and is fully aware of the options available. Private sector participation should be acquired in a transparent manner, preferably employing a competitive process. Political pressure to rush through the process may prove unwise.

There are many models of public/private partnership or interaction that can be considered. Parameters in these models include determination of tariffs, ownership of fixed assets, control of operation and management systems, and the handling of control programs. Efficiency cannot be reduced to a matter of monetary cost per unit of water supplied. In addition, quality of water and more generally environmental performance has to be clearly evaluated. When privatization is considered, the objectives should be clearly formulated. Requirements of tender documents should be clearly specified and independent expert advice secured. Not only private but also public sources of expert advice should be used, for instance in the case of Eastern European countries that regard privatization as an option.

There was, finally, a loud and clear call for the private sector and the public sector to unite forces to work towards providing safe water supply and sanitation services to the people on this planet.

INTEGRATED APPROACH TO LAND AND WATER MANAGEMENT

Neither land nor water has very distinct functions when seen in isolation. Due to their intimate linkages, both get much of their value in combination with the other. Land as a system is passed by water, many types of land use depend on access to water and, at the same time, affect the flow and quality of the water that passes through the land. Land/water interaction also causes problems like erosion, water-logging etc. An integrated landscape-ecological and catchment area approach to land and water use planning is advocated in various chapters of Agenda 21, and Ch 10 in particular. A prime example of integration of land and water management is wetlands. Their use for recreation, for biodiversity protection, for wastewater treatment, or as potentially valuable agricultural land, depends very much on local socio-economic conditions.

An integrated approach to land and water will require integration also of institutional arrangements in the land and water fields. It will also require education and training in order to secure a common language between the multi-factoral managers who will lead the process. The analysis, including the time and space scales chosen, depends on the type of problem, as exemplified by the Landcare movement in Australia, and cases of catchment management planning in Singapore and UK. Issues to be considered in such integrated analysis include:

- agroecological zoning based on climatic and soil conditions, to be complemented with water resources data, and compared with socioeconomic conditions to arrive at water resource management domains;
- degree of drought proneness, since recurrent droughts should be seen as "normal" to be properly planned for rather than exceptional events;
- flood risk and the damage that it would involve to settlements and human property;
- accessibility of water - groundwater as well as surface water - as a long-term source for water supply;
- the possible functions of structural and nonstructural measures such as waste treatment plants, controlled waste management practices, reafforestation, etc;
- the capacity of water bodies and river systems to restore themselves (resilience);
- a striving to cultivate the political will necessary to move land and water management issues.

Guidelines should be developed for integrated use of the land/water system with proper attention on the one hand to reconcile conflicting interests, for instance water allocation between rural, urban, industry, leisure etc, and on the other for regional upstream/downstream water sharing. Methodologies needed include comparison of monetary values of land and water resources but also their non-monetary values. A manual of practices is needed as basis for development of national land and water management strategies in order to secure life support for future populations. The planning has to be an iterative process, involving periodical revision of the relevant data bases, and improving its accuracy.

The discrepancy between a "top-down" and a "bottom-up" approach to the integrated planning and management of land and water resources is only apparent. In reality, there should rather be a mixture, where the first has a function at national level, the latter at village or catchment level. The various groups of stakeholders can meet halfway to arrive at an optimization of land and water use through a negotiation process. In issue-driven approaches, involving conflicts, threats etc, groups of affected stakeholders should activate themselves in communicating, motivating, participating, empowering, negotiating etc, and should be given the mandate to negotiate with controlling authorities in an interactive transparent manner. Useful tools in securing a broad local participation may be computerbased animation.

STOCKHOLM AND TWENTYTWO YEARS LATER

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Two months back I headed the Egyptian delegation to the UN Commission on Sustainable Development in New York . Fresh water and changing patterns of Consumption and Production and lifestyles were high on the agenda of the Commission . Within the overall context of the documents discussed and the views expressed during that meeting ,I would like to share with you a few thoughts on some aspects of these two major issues . But allow me before addressing them to make a brief introduction to the whole topic of environment and development.

There is nothing static about either "environment" or its relationship to development . The environment - which we now see as our home - provides the resources and ecological process which make all life possible .

And development is the means by which we utilize the environment to produce goods and services . Our understanding of these processes is in a constant state of evolution.

Early human beings lived by hunting and gathering . They transformed many areas of the Earth and wiped out several animal species . Then , about 1,000 years ago, people in various parts of the world started to cultivate food plants and keep animals . They began to set up agricultural communities , exchanging uncertainties and hardships of hunting and wandering for the routines of settlement.

During those early times ,people learned that their actions could damage the natural resources by which they lived . Tree cutting , overgrazing and soil erosion undermined agricultural productivity around the Mediterranean , in Southern and central China , in India and in central America . Historical records give evidence of early attempts at conservation : religious taboos protecting some species of animals , some forest groves and plants ; the use of organic fertilizer and other practices to maintain soil fertility and prevent erosion; the creation of wildlife or natural reserves.

The Industrial Revolution of the later 18th and early 19th centuries and the 20th century scientific and technological revolutions dramatically increased humanity's need for natural resources and its pressure on the environment. Overwhelmingly , the impact has been negative .

Today - as we stand before a new millennium - we face an ecological crisis that has assumed planetary dimensions. The problems are so great that they threaten to derail economic development.

The technological advances in the first half of this century raised fundamental questions about the future. Could the globe continue to support its rapidly growing population ? And how appropriate was the technology itself ? These questions were first debated in scientific circles , but soon caught the attention of the public.

By the late 1950s public concern was rising : people had died in smog episodes in Belgium , the United States , and the United Kingdom ; lives had been shattered by mercury pollution in Minamata and Niigata Japan ; acidification was killing lakes in Scandinavia and North America ; birds were dying from the side effects of pollution and oil spills had polluted the sea. The concern gathered momentum in the 1960s and culminated in the convening of the United Nations Conference on the Human Environment held here in Stockholm in 1972.

The Stockholm Conference was the turning point in the history of environmental awareness and action . Its action Plan , the establishment of the United Nations Environment Programme (UNEP), and the enthusiasm of non-governmental organizations (NGOs) , both at and after the Conference , gave further impetus to the environmental movement and gave it effective expression in the international community.

Thus environmentalism - once the domain of prescient and often privileged few , primarily concerned with wildlife conservation - has broadened , both in its public support and in its scope . The movement has taken on board all aspects of the natural environment : land , water minerals , all living organisms and life processes , the atmosphere and climate , the polar icecaps and remote ocean deeps, even outer space . What is more , the movement no longer concentrates on the natural environment alone but also addresses the interrelation between environment and human well being and between environment and such aspects of international economic cooperation as debt , commodity prices, structural adjustments and subsidies.

Also over the past 20 years , our knowledge of the environment has grown significantly. Ecology and environmental sciences have matured . In some cases , we have been able to turn the theories of 20 years ago into fact , in others to dismiss them entirely or to uncover new areas of concern.

A subtle change of emphasis has taken place during the past 20 years , from worrying about changes in the state of the physical environment to concern over the causes and impact of such changes. Our perceptions and our understanding have evolved .

Twenty years ago , preserving wild plants and animals was seen as worthwhile in itself . Today , there is widespread recognition that the future of agriculture and of the pharmaceutical and other industries hinges on the conservation of wild species . In the same way , we have come to regard forests ,soil , fish , clean air fresh water as resources to be nurtured. Conservation is no longer seen as vaguely desirable , but as crucial to our survival.

We have also come to realize that everything in the environment is related to everything else. Stratospheric ozone depletion,climate warming , acid rain and nitrogen shortage in the soil used to be seen as separate problems , soluble on their own. We now know they are closely linked through the global cycles of carbon , oxygen , nitrogen and sulphur.

Harsh experience has shown that environmental neglect in one quarter can have harmful consequences elsewhere. The useful life of some dams , for example , has been halved by siltation caused by unchecked deforestation in watersheds far away.

Environmental neglect can have repercussions way beyond national borders. Oil spillage is a problem far all nations which share a common sea ; acid rain causes problems where it originates and even more serious problems in countries with the misfortune to lie downwind.

The Stockholm Conference accepted the idea that the solution lays in an environment-based development which enhanced rather than damaged the planet . Then , it was a revolutionary concept ; today it is common currency among decision makers . Strategies , action plans, programmes and guidelines have resulted . All this vast knowledge over thetwenty years since the Stockholm Conference was pooled by the United Nations Conference on Environment and Development-the Earth Summit- held in Rio de Janeiro in 1992.

With this brief introduction to the evolution of the relationship between environment and development , let me now turn to the two main issues before the Symposium :

First : changes of Lifestyles : and in this area I wish to concentrate on changing consumption and production patterns.

At the United Nations Conference on Environment and Development the issue of changing patterns of production and consumption , particularly in developed countries ,in order to reduce environmental stress was put firmly on the agenda for multilateral negotiations . Among the many concerns expressed then about the impact of significant changes in the consumption and production patterns in developed countries are:

1- The levels of consumption per capita are so high as to reduce the access of people in developing countries to basic goods and services by reducing global savings needed for fixed capital formation;

2- The resource intensity of this consumption is such as to deplete natural resources needed by developing countries for their own economic development in the future.

3- Contemporary patterns of production and consumption generate a volume of environmentally harmful by-products that swamp the absorptive capacity of the globally shared environmental resources and that therefore threaten to impose costs on developing countries that developed countries avoided in the early stages of their own economic growth and industrialization.

The first concern has to be seen in its broad context. Actions taken to reduce levels of consumption per se would reduce global demand and thereby worsen the export prospects of developing countries. However ,if consumption was reduced by a tax that financed a transfer of resources to developing countries the results would presumably be positive to these countries . Similarly if consumption in developed countries was reduced by a tax that caused the public sector borrowing requirement to fall, long-term interest rates might be reduced and this could favour investment in developing countries .Macroeconomic policies are governed not only by sustainability concerns , but also by a variety of other objectives like inflation management, employment, and trade competitiveness.

The second concern dominated international discussions in the early 1970s when the "limits to growth" hypothesis focused attention on the scarcity of natural resources as an input to production , an argument that carried considerable force after the oil price shocks of the 1970s . In this area , the behaviour of market prices , measures of reserve adequacy and projected trends of material intensity of production provide considerable guidance.The consensus among students of natural resource economics is that the emergence of serious scarcity of tradable raw materials is unlikely over the next few decades . Indeed , there has been considerable concern expressed by developing country exporters of agricultural raw materials and metals and minerals about the prolonged period of slow growth in world demand for these products and that associated low (and often falling) prices that they command in international markets.

The third area of concern , namely , environmentally damaging by-products of contemporary consumption and production patterns , has many aspects , among which are :

a) Emissions of greenhouse gases,including the impact of the transport sector;

b) Release to the environment of toxic materials such as heavy metals, hazardous chemicals and harmful gases, including stratospheric ozone-depleting gases.

c) Generation of solid waste resulting in disposal problems. The magnitude and growth expected in these areas , given current patterns of consumption and production , threaten such environmental resources as clean air, clean water fertile soil, many ecosystems and biodiversity .

In many developing countries some of these same concerns are present , and are becoming increasingly perceived as important problems , especially where urban agglomerations are large and growing rapidly . In nearly all developing countries however , the most serious environmental degradation relates to unsustainable land and water use patterns , which are among the direct consequences of the efforts of people living in poverty to improve their lot and , often , merely to survive . Deforestation , desertification and the loss of biodiversity owing to habitat destruction and the poaching of endangered species are the result. It is generally recognized , moreover that without the kind of economic policies that simultaneously reduce poverty and encourage the movement of people away from marginal land and fragile ecosystems , there is little prospect for improvement on the environmental front.

From this sketch of issues related to consumption and production patterns , it is obvious that many of the solutions will be found by directly influencing methods of production through , inter alia (a) development and dissemination of more eco-efficient technologies ; (b) a mix of regulations by command and control and the use of economic instruments to encourage more eco-friendly and sustainable production in industry , agriculture, forestry and fishing.

If environmental policy is to be cost-effective , it is important to develop a framework for understanding the links between consumption of certain products and their adverse impact on the environment , on the one hand , and the consequences both for the environment and for the rest of the economy of the changes that policy is meant to bring about.

The economic agents whose behaviour as consumers could be the target of policy measures include households, business and industry and Governments . The immediate objective of measures to change consumer behaviour could , for example include : reducing the material and energy intensity of final consumption; reducing the waste of water , the content of environmentally harmful substances and the bulk of solid waste produced as well as reducing the direct threats to biodiversity.

Effective measures to achieve most of these goals incorporate the principle of internalizing to economic agents the full external costs that their behaviours impose on others when environmental resources are treated as free goods . The basic principles that should be respected by policy makers in seeking to internalize such costs include the polluter pays principle and the full-cost resource pricing principle . At the end of the debate on the subject of changing consumption and production patterns the UN Commission on Sustainable Development recommended a number of activities which this forum may wish to consider supporting or acting on some of them . These include:

One : Pursuing measures and steps to change consumption and production patterns , by appropriate instruments particularly economic instruments , public awareness campaigns , adequate guidance in the field of advertising , education , information and advice for the purpose of energy conservation and the use of renewable sources of energy ; greater use of public transport; waste minimization, recycling and reuse; reducing the quantity of packaging ; encouraging consumption of products produced by more environmentally sound processes; reducing environmentally harmful substances in products; and reducing waste of water.

One issue that is now apparent in this respect is that despite the growing interest in the use of economic instruments for changing consumption patterns and lifestyles especially in developed countries , there is not as yet sufficient quantitative evidence to evaluate adequately the effectiveness of their use in practice . This is an area which deserves consideration and concrete action.

Another crucial area for further work is a better understanding of the interrelationship among consumption patterns, production structures and techniques , economic growth, employment, population dynamics and environmental stress. What is urgently needed here is to intensify and expand efforts to collect relevant data at the national and subnational levels ; and to undertake projections and perspective studies so as to better appreciate the consequences of present policy stances and the possible impact of changing those policies.

The second recommendation of the UN Commission is the need to undertake national and regional studies of environmental ,social and economic trends and damage from present patterns of consumption and production to assess their sustainability and their repercussions.

The third is on measures for using pricing policy to internalize the costs of risk and damage to the environment depending on the varying circumstances of developed and developing countries and countries with economies in transition.

The Second issue before this Symposium is : Land and Water: Ninety-seven percent of the world's water is contained in saline oceans; of what remains ,69 percent is in the form of snow and ice . Freshwater for human use , found in lakes swamps , and rivers , makes up only 0.008 percent of the Earth's water.

Freshwater is distributed unevenly over the Earth's surface . The world's natural store of freshwater isconcentrated in the high Latitudes - the glaciers of Greenland and Antarctica and the lakes of North America and Russia. Water supplies also vary widely by latitude ,being concentrated in tropical humid ozone . Brazil , for example accounts for over 13 percent of the world's total renewable supply of freshwater most of it in rivers. Not only is freshwater unevenly distributed ,but in many areas quantities of it also peak seasonally . For instance more than 65 percent of Australia's runoff occurs in January February , and March.

To modify such seasonal and geographical variations humans have built thousands of large dams (36, 000 or more over 15 meters in height) . By the late 1980s , these impounded more than 5,000 cubic kilometers of fresh water and the total is expected to rise to as much as 7,500 cubic kilometers by the year 2000 if current plans for dam building are carried out. Whether they will be built is open to question , for in recent years ,controversy has been growing about the potential impact of large dams on human populations and natural ecosystems.

Irrigation , the largest consumer of freshwater ,not least because of evaporation and evapotranspiration ,will likely be expanded to meet the demand for food as the human population grows. Between 1900 and the year 2000 agricultural water consumption will have grown sixfold .

The data of the latest World Resources Report 1994-1995 published by the WRI in co-operation with UNEP and UNDP shows that the world population, which in 1990 totalled 5.3 billion people,is expected to increase by approximately 1 billion by the year 2000 with about 93 % of the increase taking place in developing countries,particularly in Africa and Asia. Twenty countries with a total population of 131 million people were already in a condition of scarcity in 1990. Another eight with a total population of 203 million were under stress. Water scarcity is defined here as a per capita availability of freshwater resources of 1,000 cubic meters or less . Water-stress as a per capita availability of between 1,000 and 17,00 cubic meters . By the year 2010, 26 countries ,with a total population of 407 million will be under stress. By the year 2025 ,a full 35 % of the world population will be living under conditions of scarcity or stress, compared with about 6 % in 1990. In 1987, the World Commission on Environment and Development concluded that some 80 countries , with 40 % of the world population were already suffering from serious water shortages.

The availability of freshwater is further affected as a result of serious deterioration of its quality. Most of the sources of pollution that have severely affected the industrialized countries are also present in the developing world and there are few parts of the world that are still exempt from problems of degraded water quality and pollution of surface water and groundwater sources. The waste-assimilative capacity of freshwater bodies adjacent to towns in many developing countries has often been outstripped . There is also increasing concern about the entry of fertilizers and pesticides into surface and ground waters.

The rapid growth of urban centres brings with it increased demands for domestic , municipal and industrial uses. Increased levels of population also generate a demand for more food production , with its implications for intensified cropping and increased competition and conflicts among various land and water uses. Land scarcities are already very acute in some countries and regions , namely South Asia and Near East/North Africa .

It is further expected that problems related to food production will be exacerbated by a degradation of existing irrigation systems to the point that they have to go out of use. Degradation of soils is estimated to affect some 1.2 billion hectares of land worldwide, of which 450 million are in Asia , 320 million are in Africa , 227 million are on the American continent and 158 million are in Europe.

Deforestation and overgrazing are each estimated to account for about one third of the total area affected while the bulk of the remaining affected area has been caused by mismanagement of arable land.

Constraints vis-a-vis the availability of water for agriculture will be even more severe than land constraints. Irrigated agriculture will increasingly have to compete with higher-value uses and , at the same time , it will be expected to produce much more with less water. An estimated 80 % of the additional food supplies required to feed the world in the next 30 years will depend on irrigation.

Over-extraction of groundwater , while most acute in the Near East , is a growing problem in other areas , including large areas of South Asia , where food is heavily dependent on irrigation . Over pumping in these areas is causing water levels to fall beyond the reach of shallow tubewells , with the risk that irrigation may eventually become too expensive or physically impractical.

Floods continue to exact an increasing toll in life and damages ,particularly in the many developing countries that lack forecasting and warning systems. At the other extreme droughts plague parts of Africa , Asia and Latin America killing many people and disrupting development.

While in the past there was a tendency to regard water problems as being local or regional in nature , there is a growing recognition that their increasingly widespread occurrence is quickly adding up to a crisis of global magnitude. Water scarcity relative to demand is no longer a problem in arid or semi-arid areas alone but is now common occurrence in both developed and developing countries.

For a large part of the world , the issue of sustainable land and water resources development is intimately related to the issue of poverty . To the very poor, who may barely eke out a living in rural or peri-urban areas, concerns about degradation of the environment will take a back seat to concerns of day-to-day survival . The modern sector and mass poverty coexist in the vast majority of developing countries. Both bring with them obstacles to the sustainable development of land and water resources. For the poor, the temptation exists to mortgage the future by engaging in development projects that may bring short-term economic benefits but are not sustainable in the long run .

While in some cases damage done to the environment might be reversible , it may only be remedied at exceedingly high social and economic costs , or not at all . Without a concerted effort to deal with economic growth , poverty and a more equitable distribution of income developing countries will not be able to cope with issues related to the long-term sustainability of land and water development.

Many of the important water basins of the world are shared by more than one country . Common basins make up 60 % of the total area of Africa and South America. The importance that nations attach to their water resources is reflected in the existence of over 2,000 treaties relating to common basins. But, in many areas treaties are either nonexistent or inadequate. Besides direct bilateral agreements to manage resources , a body of international law has grown up based on the principle that no state can harm other states in its use and management of the common resource. But there is still no mechanism for solving competing claims . The most common conflict occurs between upstream users who claim sovereign rights to water that originates and flows through their territory (including the right to use, store, divert, or pollute) and downstream users who demand that the watercourse be maintained in its natural state.

The potential for conflict over shared water resources is most obvious in the Nile Basin,south west Asia, and the Middle East . But there are precedents for a peaceful and even equitable resolution of potential conflicts over water resources . India and Pakistan have managed to share development of the Indus River .India and Bangladesh have agreed to maintain minimal flows on the Ganges . The United States and Mexico have drawn up terms for the Colorado and Rio Grande rivers .Argentina and Brazil have agreed on the management of the Parana River to maintain Argentina's development potential . The potential conflicts over freshwater are real . But feasible solutions are also real . What is needed is a mechanism to work on conflict resolution in cases of freshwater.This forum would do well to the world community if it addresses this issue and makes some concrete recommendations for action.

Another aspect of the sustainable management of water is the problems arising from the fact that irrigation projects are some of the most heavily subsidized economic activities in the world . In some cases, subsidies to irrigation covered 90 % of the total operating and maintenance costs.The question of user fees for irrigation is closely associated with the appropriateness of scale and design in terms of affordability and capacity for operation and maintenance . Urgent attention needs to be given to the implementation of pricing policies that take fully into account the user's ability to pay.

These future - oriented water policy symposia convened here in Stockholm assume a tremendous importance as we stand at the gates of the 21st century . I wish there were similar symposia on other environmental components and development activities. We need to design a better future. We have the power to do so . To use science and technology not only to safeguard but also to enhance the quality of our lives and to respect that of generations yet to be borne. We know too what the major challenges are . We have created all the problems we face today. We can solve them. Governments and Intergovernmental bodies cannot do that on their own . With people and their representatives, with business and industry , and with the scientific community they can.

THE FUTURE of EARTH'S WATER:

WHAT MUST BE SUSTAINABLE?

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Since their inception in 1991, the Stockholm Water Symposia have struggled mightily to identify and mitigate four major problems about key environmental issues relating to the future of Earth's water:

- adequate quantities to maintain public health;
- protection of water quality;
- financial constraints in policy making;
- miscommunication between scientists and policy makers.

This fourth symposium takes its point of departure from expressions of alarm at the lack of current efforts to address "the creeping water crisis." Water scarcity and quality deterioration are commonly regarded as resulting from three factors, namely, an escalation of population growth, mismanaged land/water resources, and excessive fertilization of crops to increase agricultural yields. When a selection of "key environmental issues" is made, these three causal factors are quick to surface.

Many remain entrenched in the belief that environmental pollutants from agriculture and industrialization now threaten public health and safety as never before. The entire planet has allegedly become endangered by 'unsustainable' patterns of consumption and 'profligate' lifestyles of too many people. There is widespread belief that finite resources, escalating environmental degradation, an epidemic of cancer, and rising expectations of an exploding population are bound together in mortal conflict. The only resolution to such an impasse seems to be either some catastrophic end to an affluent society as we know it, or a spineless compromise in which no one wins and everyone loses.

Within this cultural climate of opinion, widespread water illiteracy has been identified as a partial explanation for why policy makers seem inclined to focus more readily on "small, visible problems" rather than "large, invisible erosions of a life-support system." The fundamental role of water appears to be unrecognized, in particular its integrating functions as provider of

- the lifeblood of Earth's biosphere
- a medium of biomass production
- a cyclic continuity in cascading environmental disturbances.

Clearly an integrated approach to management of land and water resources calls for an acceptance of the challenge presented by water illiteracy among decision makers and the general public alike. But it is not at all clear that efforts to counteract water illiteracy should entail a pedagogical concentration upon the "environmental sins" allegedly perpetrated by industry and agriculture in developed nations, especially when they stand accused of perpetuating a North-South polarization.

To a non-member of the community of water professionals, there is both wisdom and prudence in suggesting that water illiteracy is only a partial explanation for what appears to be a set of mistaken priorities in dealing with key environmental issues threatening public health and safety. The issue that begs for explanation is the underlying heated dispute about what constitutes "environmental quality" and -- in the case at hand -- why an integrated management of land and water resources depends upon far greater literacy in public understanding of *actual* versus *perceived* threats to Earth's water as an indicator of environmental quality.

Centuries ago, Socrates articulated a time-honored admonition: "The unexamined life is not worth living." The question about key environmental issues prompts me to paraphrase his maxim: "An unexamined problem is not worth solving." How easily we lose sight of the fact that the most important thinking we do is not invested in trying to discover *solutions* to questions and problems. Rather our most thoughtful reflection ought to be invested in the care and circumspection with which we formulate the problems about our common humanity. Why? Because it is our horizon of vision and threshold of perception dictating the way we choose to formulate a problem that predetermines what we are going to allow to count as a solution to it.

FORMULATING THE WATER PROBLEM

It is tempting to follow a path of least resistance and allow our problematic arc to become foreshortened by a concentration on demonizing a roster of villains among developed nations. But if we choose such a path, genuine solutions to problems about the future of Earth's water will forever elude us.

From my reading and research I am persuaded that a more fruitful line of inquiry invites us to probe more deeply into two paradoxical questions.

> First, if industrial and agricultural pollutants are presumed to pose the greatest threat to the health and safety of the world's inhabitants, why is it the case that both the quantity and quality of water supplies in developed nations are far superior to water supplies in developing nations?
>
> Second, if the ultimate goal of integrated water management is the protection of human health in present and future generations, why has "health" become redefined as the assured outcome of environmental auditing to achieve zero pollution from industrial wastes and agricultural chemicals?

There are several reasons for characterizing these questions as "paradoxical." Contrary to conventional wisdom, a number of scientists have begun to claim that "health" can no longer be interpreted as referring to the basic well-being of individual human beings. In an unusual recent issue of *The Lancet,* a lead editorial expresses unambiguous support of an article authored by Dr. Maurice King, a faculty member of the Department of Public Health Medicine at the University of Leeds. Dr. King focuses attention on the 1988 World Health Organization report. He deplores its official neglect of what he calls "the health of the planet itself, and the contribution to planetary ill health made by the industrial one-fifth of the world, which makes greater demands on the global ecosystem than do the remaining four-fifths." He calls upon the WHO to devise policies more consistent with its name. Heretofore it has been exclusively concerned with the health of the *people* of the world. A World Health Organization must now recognize that their health depends upon "the health of the planet as a whole." He proposes a new strategy: "HSE 2100 -- Health in a sustainable ecosystem for the year 2100."

For Professor King, a new era of *measured and managed sustainability* will require major changes in the structural relations between North and South. "Most difficult for those in the industrial North, with its unsustainable economy, a sustainable lifestyle means consumption control. . . ." It also requires "the deliberate quest of poverty." To protect the interest of future generations, world communities must decide which consumption pattern ought to be foregone and by whom. Among many "desustaining" or "sustainability reducing" measures, oral rehydration procedures "should not be introduced on a public health scale, since they increase the man-years of human misery, ultimately from starvation." Just as ethical principles forbid us to do evil in order to achieve a good outcome, do they not also forbid us to do good when a foreseeable outcome is evil? This dilemma leads King to ask whether one should not deliberately "set levels of mortality control" as a prophylactic against the consequences of *unsustainability*.

King's elevation of Global Sustainability to an ethical mandate for planetary survival, and his extension of "health" to include the entire Earth, reflects an emerging conflict in values. This clash is made all the more obvious when an influential segment of the public is persuaded that industrial applications of modern science and technology have imposed upon humanity an intolerable burden of uncertainties and risk. This burden not only appears to overwhelm our coping capacity, but it also seems insidiously to strip us of traditional moral moorings. Environmental pollutants have become the metaphor of moral corruption. They are singled out as not simply dangerous and harmful but morally wrong. Professor Peter Sandman has stated unequivocally: "Our society has reached near-consensus that pollution is morally wrong – not just harmful or dangerous . . . but wrong."

Moral claims such as these raise crucial ethical questions about the relentless search of human beings for health and safety, as well as an endless quest for certitudes and salvation. What is *'health'*? What criteria should measure *safety*? How safe is *safe enough'"*? How clean is *'clean enough'*? Ordinary citizens are ill-equipped to answer these conversation stoppers. An escalation of sophisticated rhetoric and esoteric conflicts about the 'quality of our environment' has steadily eclipsed an ordinary exercise of common sense. Widespread belief that 'government will protect us' has taken over, while its fateful consequences for the preservation of human liberties are conveniently ignored.

There is little dispute about the fact that, since national governing bodies in the 1970s required pollution controls in industry and commerce, substantial progress has been made:

- huge quantities of water polluted with human sewage have been treated and rendered harmless by massive treatment plants;
- potential degradation of rivers and lakes has been dramatically reversed;
- industrial discharges of organics and metals have been reduced by as much as 90%

However, considerable dispute has erupted about the magnitude of remaining *relative risks* in water quality. as well as alternative market incentives for pursuing additional levels of *"purity."*

A healthy skepticism has questioned the philosophy underlying priorities set forth in a United States Environmental Protection Agency document titled, *"Reducing Risk: Setting Priorities and Strategies for Environmental Protection."* Its authors declare it "inappropriate" to distinguish human health risks from ecological risks. The document claims that

> ". . . in the real world, there is little distinction between the two. Over the long term, ecological degradation either directly or indirectly degrades human health and the economy."

There is real world support for this rather sweeping assertion in the fact that the leading cause of death in the world -- especially in developing nations -- happens to be infant diarrhea and cholera caused by biological contaminants in water. However, in developed nations which require water utilities to disinfect and prefilter drinking water, health experts expect that these measures will prevent more than 85,000 cases of water-borne diseases such as hepatitis and giardia.

These real world examples demonstrate a fundamental *ethical priority*. Laws and regulations should be required to concentrate on water quality improvements where there is a clearly demonstrable health improvement potential. Human health protection does not require that -- wherever water occurs on this planet -- it must be potable. Neither does it need to be fishable and swimmable when in fact the costs of chasing trivial risks will result in ignoring genuine dangers to human well-being. Those who claim that clean water demands zero pollution throughout Planet Earth cannot escape bearing the burden of proof justifying such massive expenditures of public funds.

Ernest Rosenberg has articulated the key insight undergirding the future of Earth's Water:

> "The move toward controlling less and less pollution at greater and greater expense -- until you are spending everything to control nothing -- is one of the big water quality problems that we are facing in the future."

Rather than claim that 'clean water' can and should be made technically purer to the point of 'zero pollution,' regulators should be compelled to answer a fundamental **ethical question:**

How fair is clean enough and safe enough?

Is it ethically just to pursue merely possible threats at the cost of ignoring immediate life-threatening dangers? With protection of human health as a moral compass, a minimal ethical requirement is a total-spectrum analysis of a scientifically verifiable array of actual threats to human health which time, money, and human effort can mitigate or eliminate. The expenditure of public funds to foreclose the mere possibility of exposure to merely hypothetical threats -- not to mention phantom risks -- is devoid of ethical justification.

In today's cultural climate of opinion and politically correct intolerance, it may appear that human health and ecological protection belong on the same footing. As always, however, appearances are deceptive. A house built on sand cannot stand against the inevitable tide of scientific scrutiny. The concepts of 'clean' and 'safe' and 'fair' confront thoughtful people with three ethically salient questions:

- What popular assumptions about **environmental quality** have led people to conclude that **man- made toxics** are the dominant threats to present and long-term levels of public health and safety?
- What historical and scientific evidence exists to support or to refute these assumptions?
- How can common sense be used to resolve value conflicts about a preferred environmental quality -- in particular the quality of water resources?

ENVIRONMENTAL QUALITY: WHOSE TO CHOOSE?

We are all environmentalists. However, we differ from one another on how we define a "preferred environmental quality." We also differ profoundly on how we rank priorities and implement methods for achieving "environmental protection" both regionally and globally.

No social movement is monolithic, much less univocal in its public expression. Richard Neuhaus in his book, **In Defense of People,** was one of the first to point out that people perceive and respond to their concerns about environmental quality at four distinct levels.

First there are those who consider it a housekeeping movement -- one of urging industries and municipalities to adopt cleaner habits of waste management. Environmental concern at this level, Neuhaus insists, is making an important contribution.

At a second level, however, are those in adversary cultures who adopt the movement as a means of protest. More often than not, they fritter away their energies in search of some "true self" through getting back to Nature as a way to liberate themselves from the decadence of cities, from bondage to manufactured gadgets, and from any ongoing involvement in the sorry state of the world. In their view, the revolution has already happened within your consciousness if you believe that it has.

A third sector of the movement is comprised of both Old and New Preservationists who "put up the money and provide the political clout." Their overwhelming desire is simply to commune with an untouched wilderness where they expect "not to be disturbed as they live out their declining years" in what they consider to be a declining world.

In sharp contrast to Romantics or Escapists of any stripe are the Relentless Realists, the hard-nosed defenders against what they envision as an impending environmental catastrophe. They bring technical sophistication, political experience, and academic respectability to the movement. They are the executors of a "new Environmental Ethic" replacing an old discredited "Ethic of Utility" which pursued "the greatest good for the greatest number." Some are resolved to eliminate over-population by withholding food and resources from starving people in developing nations, since this would run the risk of sinking the only lifeboat which would assure "us" of survival in a sustainable world. Other Relentless Realists claim to stand on higher moral ground where they devise political agendas for turning off economic growth and ridding ourselves of alienating technologies in favor of "appropriate technologies" designed to integrate man once more into proper harmony with the fragile state of Nature's Balance.

How has it happened that affluent citizens in industrialized nations have been transformed into fear-ridden critics protesting against technological hazards, environmental pollution, personal contamination, and focusing blame on so-called unmanageable offsprings of an industrial society? Have innovations in science and engineering actually made the world unsafe without any redeeming benefits?

The question posed by Mary Douglas and Aaron Wildavsky in their book, **Risk and Culture**, asks what people today find fearsome. Their answer is both bewildering and ironic:

> "Nothing much really, except the food they eat, the water they drink, the air they breathe, the land they live on, and the energy they use."

These authors maintain that it is a pernicious mistake to assume that risks exist "out there" in a physical world as the principal attributes of technology or industrial systems. To be sure scientific evidence demonstrates that the external world is a virtual sea of toxic substances and elements with the potential for harming humans and other valued organisms. But "toxicity" must be scientifically distinguished from "hazard." A hazard exists only when and to the degree that harmful exposure occurs to the human body or other valued living systems. Such exposure must be a genuine, not merely a hypothetical, possibility. That possibility can exist only when there is a management failure to devise and maintain controlling actions or safeguards. Human beings structure hazards. Hazards are human artifacts.

Then why is it that advanced nations during the past quarter century have selected out *environmental risks* as the primary focus for moral concern? People pay attention to certain risks, and ignore others, for a purpose – namely to reinforce and conform to a specific way of life already selected on other grounds. People not only disagree about risks they are disposed to take or avoid, but also which risks are "actual" versus merely "perceived." Their disagreement signals divergent agendas for preserving or changing preferred forms of social organization. In short, it is cultural bias that dictates risk selection.

This insight invites us to examine more closely why risks to the preservation of some pristine natural environment have been selected and defined by avowed opponents of industrialization who repeatedly characterize it as the enemy of human safety and health. It is instructive that environmentalism's Relentless Realists contrast the modern biosphere with its condition 12,000 years ago. Any subsequent change is stigmatized as a violation and contamination of a supposedly pristine condition in which Nature's fragile, precarious balance existed prior to man's technological encroachments. Changes wrought by the Industrial Revolution are particularly abhorrent. Planet Earth must be returned, they claim, to its original condition regardless of cost.

Advocates of this policy regard human liberty and the anarchic pursuit of individual self-interest as a suitable characterization of the exercise of economic liberty in a market economy. Presumably we cannot continue to pursue our constitutional liberties without an irreversible destruction of our natural environment. Political coercion is entirely justified in the name of preserving our only habitable planet. Political control over wetlands, forests, lakes and waterways, deserts, cities and an ever-widening range of land and water uses is proclaimed to be a necessity, regardless of an "anachronistic claim" to private property rights. The World according to Relentless Realists is perilous indeed. It is a World in which Catastrophe will be our destiny unless freedom is sacrificed. Coercive control by a powerful few must prevail if the unenlightened many are to be "saved."

A profound transformation in public selection of environmental risks to be avoided begs for a deeper explanation. In his recent book, **Century's End: A Cultural History of the Fin de Siècle from the 990s through the 1990s**, Hillel Schwartz has amassed evidence of a phenomenon recurring since the end of the first millennium. As a society approaches the end of a century, from its ranks emerge all manner of prophecies of doom and destruction at our own hands. In the 1990s this phenomenon is the more poignant because America is approaching the end of the second millennium. The belief has become widespread that the end of the world as we know it is at hand, and large discontinuities must displace old ideas, affluent life-styles, and unrealistic expectations for the majority of people on earth.

Social engineers have skillfully discredited the traditional role of professionals in scientific engineering who are summarily dismissed as the failed architects of an industrial system raping the earth. Critics claim that markets cannot be given custody of industrial offspring -- land-use abuses, air and water pollutants, hazardous wastes. The only custodian with sufficient coercive power seems to be the regulatory bureaucracy. The crusader's rallying cry has become *sustainability.*

Four preconceptions undergird the altar of *sustainability*, which its acolytes call *a new and exciting doctrine.* Consistent with a belief that Nature exists in a fragile, precarious balance, Earth's carrying capacity is claimed to have a finite, quantifiable limit. This dictates the belief that growth has its fixed and finite limits in population, resource usage, and absorptive accumulation. The power of modern technology is allegedly capable not only of destroying the life-sustaining biosphere by global warming, greenhouse gases, ozone depletion and the like, but also of depleting water and energy resources that are conceptualized as finite, fixed and approaching exhaustion.

Mankind, among all living forms on earth, is accused of introducing cancer-causing agents, especially since World War II, with the growth of the petrochemical and nuclear industries. The second report of the Club of Rome, **Mankind at the Turning Point**, was introduced by the epigraph: "The World has cancer, and the cancer is man." As an ethical statement, this belief has pernicious consequences. Among them is the widespread belief that there is 'no safe dose' of exposure to any carcinogen; to achieve zero exposure requires zero pollution.

Clearly there is a virulent pessimism and hatred of humankind embedded in seeing the world through the lens of the Catastrophist and its acolytes, the Relentless Realists. To reduce the dominant threats to human health and safety to man-made toxins -- in the belief that nature devoid of human intrusion and alleged technological encroachments would exist in a pure, pristine, benevolent condition -- flies in the face of historical and scientific evidence.

A WORLD in OPPOSITION: THE BURDEN OF PROOF

If we wish to avail ourselves of a powerful antidote to historical amnesia, Otto Bettmann's book, **The Good Old Days: They Were Terrible!** is an appropriate prescription. Bettmann's old tintypes and lithographs tell a vastly different story about the dangers confronting humankind when life was lived "close to nature" without benefit of modern technologies. Widespread disease, infant mortality, and a life expectancy of less than 50 years were the ordinary destiny of the human species in North America only a century ago. Without automobiles, millions of horses would be producing billions of pounds of emissions calculated at 25 pounds per horse per day. Human and animal excrement befouled the air rendering it unbreathable in summer heat. Water was besotted with human and animal wastes even in rural areas. Without refrigeration, food had to be preserved with salt (not even on the GRAS list today) or by drying it in the sun where maggots and insects competed for survival. Women's lives from dawn to dusk were dogged by drudgery. As is the case today, the introduction of new technologies in the past -- such as the steam locomotive and even the baby carriage -- were greeted with pious outcries protesting against these ominous threats to human wellbeing.

In direct opposition to the World of the Catastrophist is the World of the Cornucopian. We are all familiar with the symbolic Horn of Plenty. Cornucopians insist that we re-examine history with its recurring alarms about an impending resource crisis. In every case, some form of technological substitutability has emerged to resolve the supposed crisis. In his book, **The Lever of Riches: Technological Creativity and Economic Progress,** Joel Mokyr has amassed convincing evidence since Graeco-Roman times that the role of technology in producing economic progress is analogous to the plodding horse drawing the wagon with its cargo of improvements in the living conditions and environmental quality-of-life enjoyed by human beings. Thomas Hobbes has said it best: life lived in a "state of nature" is "solitary, poor, nasty, brutish, and short."

George Gilder's insightful study, **Wealth and Poverty**, among many others, helps to remind us that "Richer is safer, Wealthier is healthier, Poorer is riskier." Contrary to popular belief, Wealth is not some 'motherlode' out there that needs only to be uncovered and then distributed to otherwise indigent and meritorious people. Wealth is <u>created.</u> Wealth is <u>generated</u> by hard, tedious work and an endless series of risk-taking decisions. The greatest pollutant on Planet Earth happens to be <u>poverty.</u> If we were morally serious about "protecting the environment," we would do our utmost to enable all peoples of the world to emerge from poverty by dint of their industriousness and pursuit of opportunities for innovation. Technology is the Lever of Wealth Creation.

As Eric Hoffer has observed, however, "Mass movements can rise without belief in God, but never without belief in a devil." In today's cultural climate of opinion and "politically correct" ideas, the devil is <u>technology</u>, together with the industrial infrastructure that has been its companion. **Blaming Technology: The Irrational Search for Scapegoats** by Samuel Florman uncovers its many expressions.

Critics of the myth of "benevolent Nature" remind us that history is replete with stark lessons about the harm inflicted on humans and their life-sustaining biosphere by a natural environment with its heedless malevolence. Winds from the Great Hurricane of 1900 caused a storm surge in Galveston, Texas that claimed 6,000 lives. A volcanic eruption at Mont Pelee, Martinique, in 1902 caused 30,000 immediate deaths. These events surely qualify as "hazard spectaculars" against which human beings have tried to defend themselves. Engineers have devised systems of flood control, as well as early-warning systems for hurricanes and volcanic eruptions. These tragic reminds of the destructive power of Nature heighten a sense of man's precarious achievements in technological control over natural forces. It is specious to argue that, since humans cannot prevent or control the forces of nature, man ought to concentrate time, effort, and public money on eliminating technological risks. To the contrary, technologies throughout history have been remarkably successful in protecting human life from exposure to nature's harmful effects.

H. L. Mencken has made an incisive observation about the consequences of irrational scapegoating: "The whole aim of practical politics is to keep the populace alarmed -- and hence clamorous to be led to safety -- by menacing it with an endless series of hobgoblins, all of them imaginary."

COMMON SENSE: WHAT DIFFERENCE DOES ETHICS MAKE?

The misguided idea that we must abandon an "old and discredited ethic" -- defined by the goal of pursuing the greatest good for the greatest number -- in favor of a "new Environmental Ethic -- supposing that fragile and benign Nature should be the source of our norms for ethics -- suffers from a terminal internal illness: it dies the death of a thousand qualifications.

In the 1990s, scientific evidence and the historical record attest to the validity of a world-view dominated by Cornucopian principles. Instead of pursuing a myopic goal of "environmental protection," with its untenable assumptions and unachievable objectives, I propose that we begin to pursue a serious goal placed within the framework of Human Ecology. If our focus were upon human ecology rather than hypothetical, mentally constructed ecosystems, our priority concerns would concentrate on the only kinds of living entities on this planet who can protect a variable environment at a level worthy of all human beings. It is in developing nations where poverty reigns that massive environmental destruction occurs. Starvation and desertification are rampant. People are driven to cut down forests, to carve out a radius in which they can grow food, because they have remained predominantly agrarian. People in wealthy nations have gotten off the land and devised technologies that provide livelihoods for more people than ever before in history. It is our myopia as citizens in an affluent society that has reduced our horizon to mere "environmental protection." We must expand our problematic arc so that we can focus upon **human ecology** as a necessary condition for achieving "environmental protection."

If we are to work constructively toward commonsense solutions that will assure an integrated management of the quality and quantity of water resources necessary to protect human health, three changes are urgently needed. First, the time has come to abandon statutory inconsistencies generated by a zero-risk philosophy. We are chasing a receding zero because sophisticated assay methods are driving zero into infinity. Second, it is time to reinstate the Law of Diffusion as an antidote to the quest for zero pollution. Thirdly, basic scientific research in response to market forces and needs must supplant tax-supported/politicized science coupled with aggressive enforcement by lawyers of a specious legal compliance with a disappearing zero.

Regulatory scientists have failed to apply the same standards of research to naturally-occurring toxins as they have applied to industrial by-products. When they assume that an exposure to even a single molecule is dangerous, and then hypothesize about a minute non-zero dose, they have succumbed to intellectual bankruptcy in a real world governed by the Law of Diffusion. This law of physics -- which governs the movement and intermingling in nature of all molecules of liquids, gases, and solids -- requires the conclusion that nothing is completely uncontaminated by anything else. It is popularly known as "the gefilte fish effect." In other words, there is a little bit of something in everything.

As matters currently stand, the long and perilous sword of "safety" exercises a tyranny of fear and pessimism about the quality of our lives. "Better safe than sorry" is heard as often as "Better to err on the side of caution." In his insightful book, **Science Under Siege,** Michael Fumento offers a penetrating translation of such bromides: "I am unable to make a convincing argument. I just want you to do what I say anyway."

The Health of Nations by Leonard Sagan makes it unambiguously clear that health is directly correlated with the wealth of nations. Richer is safer. Wealthier is healthier. Poorer is riskier. Poverty will not "save the planet," much less provide a preferred environmental quality.

How fair is safe enough and clean enough must become the operative ethical question. For those who have taken the trouble to follow the matter, tax-supported scientific research has taken a quantum leap in expanding the role of governments by allocating funds for their preferred research projects in universities and favored private organizations. Government control has dramatically usurped the previous role of private enterprise and industry which provided funds for research driven by response to market forces. Since World War II, government funding has gradually yet decisively determined the direction of basic scientific research deemed to be "in the public interest." Coupled with the power of enforcement wielded by regulatory agencies, "regulatory science" has been trained to serve a Master significantly different from the traditional Master of "basic science." The **politicization of science** bears out the truth of the ancient dictum, "No man can serve two masters."

There is little if any indication that federal funding for regulatory agencies and their oppressive enforcement policies will disappear and diminish the overwhelming burden on taxpayers. There is every indication that an underemployed legal profession has been eminently resourceful in crafting laws and regulations that will require its services in lucrative litigation procedures.

A flagrant misallocation of funds poured into enforcement programs has had a dramatic effect on the incentive for scientific innovation and research that would increase both the quantity and quality of water for human needs throughout the globe. A striking case in point is the slow and hard fought funding for research and commercialization of Super Critical Water Oxidation conducted at the University of Texas at Austin. This innovative process could magnify manyfold the availability of potable water in Third and Fourth World nations. It is a triumph of basic science over regulatory science.

Eternal vigilance is the price of our sacred liberties. In the Court of Justice, judges are bound to apply the law. But the Court is not required to measure out the law like a pharmacist. The law is not some bloodless prescription. It is meant to be an expression of what is moral and just. It remains to be seen whether Oliver Wendell Holmes' dictum will bear fruit among ordinary citizens of the world:

"Man's mind, once stretched by a new idea,
never regains its original dimensions."

LINKAGES BETWEEN WATER QUALITY PROTECTION, EDUCATIONAL RENEWAL, AND CREDITWORTHINESS.

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Introduction

If we are not talking about money, we are not talking about anything at all. This is the underlying theme of this paper. Money links us all together in the same way as water. Both are necessary for the wellbeing and smooth functioning of all the socio-economic activities in our artificial economy. The artificial economy being everything we engineer and do business with and the money and water which circulates within it. However in order of priority, water is the more important, because without it there would be no life and no natural economy from which to make money. The natural economy being ecology and the environment. Water is therefore the source of money and both should be treated as equals ie. equal respect, equal treatment and equal vocabulary. Of these three, "vocabulary", is probably the most important. When one is dealing with money, the words and terms used by the banking and financial community command our immediate attention, especially ones like capital, bankruptcy and creditworthiness. Water is capital, in fact it is "critical capital" ie. it is vital and nonsubstitutable. Without water the natural economy will become bankrupt causing financial bankruptcy. With little water the natural economy will be relatively small and not very attractive for investment, ie. not very creditworthy, causing those who have to eak a living from it to be equally financially uncreditworthy. Being uncreditworthy is probably one of the most miserable circumstances to find oneself in, and it erodes all attempts to improve one's quality-of-life, both spiritually and materially. This is very important because the improvement of quality-of-life is what we all strive to maintain and improve, and is the primary objective of the international development community. I believe that this logic between water, money, quality-of-life and creditworthiness is understood by us all to a greater or lesser extent, but we do not wish to acknowledge it because it damages our ego. The fact is we are not supreme, and we must acknowledge that water must be treated as a partner. A partner for life in every sense. So if we do not have the courage to educate ourselves and our children to understand this reality and become aware of the linkages which bind us all together, then water, and the natural economy it supports, will have the final word and we will pay the ultimate price. The bottom line then is as follows. Whether we wish to maintain our species on this planet or not makes absolutely no difference to the natural economy, it will continue to thrive with us or without us. So the question is, how much are we willing to pay to stay in the game, and where should we invest to obtain the best value for our money? The best value being quality-of-life growth with sustained creditworthiness.

Water and Investment Risk

To address this question one must return to the water, money, quality-of-life, creditworthiness logic and to Principle No.1 of the International Conference on Water and the Environment, Dublin, 1992, which states, "Freshwater is a finite and vulnerable resource, essential to sustain life, development and the environment". The environment also includes the seas because they are the eventual recipients of the fresh water which the artificial economy appropriates, manipulates and evacuates to water courses, and creditworthiness of seas is equally important for business. The key words in Principle No.1 are "finite" and "vulnerable", and they mean that water quantity is always at "risk". When this word enters the logic, the logic becomes very dynamic. We do not like the word risk when it applies to critical capital, it implies the probability of declining quality-of-life and questionable creditworthiness, and that makes the adrenalin run, especially in the financial community.
Water quantity risk weakens investment potential, and this risk is to be found at any time in any place.

Importance of Water Quality

Freshwater quantity can be affected in two ways, either through variations in the behaviour of the water cycle ie. droughts, floods or precipitation at the wrong moment, or through a reduction in its quality caused by pollutants from the artificial economy. To date we have attempted to address both quantity and quality management through the single approach of increasing supply by developing new water resources to fulfill new demand and to overcome the constraints of deteriorating quality through high quality water substitution. However as we reach the quantitative limits of economically mobilizable and environmentally acceptable freshwater resource development projects, the water resource development approach is becoming less successful as a combined water quantity and water quality management tool. The two aspects of water quantity management must now be regarded as separate options, and two separate businesses, ie. the business of water resource development and the business of water quality management, with the added complication of investment options. The process of identifying the investment requirements for the business of water resource development are obviously wellknown, however the investment requirements for the business of water quality management do not have the same historical advantage. The immediate challenge for the 21st. Century is therefore to enhance the capability of national governments to make cost-effective judgements about (i) water resource development policy, (ii) water quality management strategy and (iii) investment options.

Linkages

Due to the historical neglect of water quality management and the need to be able to master it before water supply stress begins to debilitate quality-of-life, options for business investment, and the natural economy, there is an urgent need for the public and private sector decision makers and stakeholders to be made aware of the interdependent relationship between these three government responsibilities, and to concentrate on building both the institutional and community capacity to understand and face this challenge. To begin with there must be a clear awareness of the linkages between water quality protection, educational renewal, and the creditworthiness of the artificial and natural economies. Then a way must be found to operationalize these linkages to obtain the maximum economic benefit that the natural environment can afford, without testing it to destruction.
The essential linkages in quality-of-life development are water, money, culture, and ecology. They all interact in a constant state of flux, transmitting and receiving information between them about quantity, quality and behaviour, indicating possible development options and scenarios. The interaction is extremely complex and intricate. So much so that it is impossible for the human mind to know and understand all what is happening at any particular time. Before water stress this was not a major issue because there was always enough water to absorb our "mistakes". Unfortunately the scale of the artificial economy has now grown to such an extent that due to an inadequate supply of freshwater the regeneration capacity of the natural economy is being threatened. The result is an increasingly vulnerable investment market. The time has come therefore to examine the linkages.

The Aquatic Equation

In all linkages "water is a common denominator". This means that it can transmit information and, being finite and unsubstitutable, help determine parameters. These are very useful properties, because the future balancing of the allocation and distribution of freshwater between and within the natural and artificial economies will not happen spontaneously, it will have to be planned. The planning objective would be to "balance the aquatic equation". To balance the aquatic equation the development planning process demands information, that is, information about all the uses of water throughout the natural and artificial economies. This is a highly complex and time consuming activity and hardly practical, and above all it is extremely expensive. This is a very serious constraint which must be overcome as soon as possible. Apart from the historical failure to recognize the importance of water quantity and quality in development, the data which has been collected is quite often for scientific purposes and not cost effective for management. This is because the objective of data collection programs is increased knowledge, rather than data for managing which are usually just good enough estimations. Educational renewal should therefore include the recognition of a need for analysis that examines the cost of data collection relative to the minimum amount of data required to make management judgements, in other words an analysis of the value of data. This is a field of discussion which is of great relevance to the scientific community because donors spend millions of dollars annually on scientific research whose results make little or no direct contribution to development programs. This is not to say that scientific research should decline but rather a new equilibrium should be sort between science versus management on the basis of cost effectiveness. There is for example a new field of scientific study based on the property of water to transmit information, which has as its goal the reduction of the total cost to both society and the ecosystem of industrial and agricultural operations, in so far as these operations interact with the aquatic environment. This is "hydro-informatics".

The Hydro-economy

Whenever water is manipulated it mirrors that manipulation in some way. It will move, change volume, flow and pressure, change chemical composition, or temperature, carry sediment, pollutants and biomass. These parameters can assist in both the design and monitoring of water manipulation. This is especially useful for policing environmental law and human behaviour with regard to water quality protection and conservation. When viewing development from the hydro-information perspective, one can conclude that water is "vital", and life on this planet is essentially an aquaculture living in an hydro-economy. Furthermore as development is synonymous with the manipulation of fresh water resources, one can consider development investment as hydro-economic development investment, which leads one to the notion of sustainable hydro-economic development. This would imply that development investment risk depends on the quality of hydro-information, and water becomes a key sustainable development indicator for investors to monitor. This fits in very nicely with a statement from the Dublin Water and Environment Conference which could be interpreted as follows, "Water resources (information) management is a prerequisite for sustainable development".

Water Quality Ethic

Monitoring fresh water at or in the vicinity of the centers of production of the artificial economy is however only effective if the degree of water supply stress is still comfortable, ie if accidents and errors can be absorbed fairly easily and are of insufficient port to generate political, social and commercial conflict. Many regions on this planet have lost this luxury and they are either suffering intense stress or are approaching this situation. Their finite water supply is being squeezed every day to generate more productivity per cubic meter than before. Quantitative climatic risk has been mitigated by control structures, such as dams, leaving qualitative risk management to be the number one preoccupation. In most of these stressed regions water quality awareness education is on the front line, but is this enough? Through this education one becomes aware not only of one's vulnerability, but also of one's power over socio-economic and environmental management institutions. To pay or not to pay the pollution fee, to invest or not in anti-polluting processes, to manage the land-fill better, to pass new laws or change the tax structure, all can be contested in a court of law or in the political arena for whatever reason, while potential economic benefits are foregone, accidents and natural disasters occur, resulting in a reduction in perceived creditworthiness. This may deprive future generations, perhaps forever, of the same opportunities for quality-of-life development as their parents enjoyed. To mitigate this risk it is suggested that part of the educational renewal process should be dedicated to the search for a water ethic with the goal of protecting water quality. The message would be, "One does not pollute fresh water". The objective of this ethic would be to satisfy a broad range of human needs ranging from survival and biological exigency to an enlightened existence in harmony with one's inner character, others, and nature. In practical terms, ie money, this means (i) reduced costs of treatment for drinking water, (ii) less litigation, conflict management, and environmental restoration, (iii) enhanced creditworthiness, (iv) enhanced aesthetic values, and (v) conservation of natural absorptive capacity to cope with accidents and natural disasters.

Information Management

As previously mentioned the linkages which interact to balance the aquatic equation are extremely complex and impossible for the human mind to understand. As a consequence solutions must be found by a continuous process of consensus building. Community participation in the formulation of the development of fresh water is therefore a prerequisite. Small groups of people can normally manage this quite well, but communities, and population centers sharing river basins need assistance with the task of harmonizing intersectoral interests. To this end the use of "user-friendly" decision-aiding information systems, is desirable. An information system for water resource management decision-aiding needs high quality data. At present there is ample high quality data and information about the artificial economy, but very little about water quantity, water quality and the natural economy. To address this situation the World Bank, the World Meteorological Organisation and UNESCO are promoting the Hydrological Cycle Observing System (HYCOS) concept. This concept now in the process of development will blend "real time" hydrological data with environmental and land use data, water resource management information, and socio-economic data, which through the medium of hydroinformatics will eventually contribute to the creation of an Interactive Community Information System (ICIS). The prime objective of the ICIS is stakeholder and public education to enable them to participate in the business of water resources management by sending strong and reliable signals to commercial institutions and government, indicating that they have an unequivocal respect for water and are willing to pay for sustainable hydrocapital conservation measures, as long as they are cost effective. This will enhance the judgemental capability of governments in the business of (i) formulating water resources development policy, (ii) water quality management strategy, and (iii) investment options.

Conclusion

To understand the linkages between water quality protection, educational renewal, and creditworthiness one must consider water as the source of money and quality-of-life. To accomplish this it is recommended that water resource management be considered as "the business of managing the critical capital for development", with the objective of "quality-of-life growth with sustained creditworthiness". The linkages are extremely complex and full participation of an educated public will be needed in the decision making process to guide commercial institutions and the government in their quest to fullfil the aforementioned development objective. This water resource management approach will be extremely information intensive, so it is recommended that "user friendly" information technology systems should be employed, such as the HYCOS/ICIS concept. Information must be cost effective and to that end hydro-informatics could make an important contribution. So as water supply stress increases, and management of water quality becomes the critical issue, the investment option to obtain the best value for money, that is quality-of-life growth with sustained creditworthiness, will be an educational renewal process which clearly illustrates the financial advantages of hydro-economic development through global water cycle management and ethically based water quality conservation practices.

Disclaimer: The ideas, vocabulary and opinions expressed in this paper are those of the author and should in no way be attributed to the World Bank.

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GREENING OF INDUSTRY

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General Introduction

Achieving sustainable development will be a major challenge for society at large. In this development greening of the industry will form one of the main elements. If we wish to arrive at the desired improved environmental performance of industrial activities the utilization of resources, the industrial processes and products will have to be taken into account simultaneously and on an integral basis.
Fundamentally, sustainable industrial development calls for creating an equilibrium situation in the mineral cycle as well as in the biocycle of our planet. Global availability in technical and economic sense of chemical elements should be a keyfactor in developing the industrial green strategy to reach this equilibrium. On the energy side the strategy should aim to create a balance between renewable and non-renewable energysources. In the same context an equilibrium situation in the biocycle would call for a balanced use of the biological (e.g., wood, cattle) and the physical environmental resources like air, water and soil.
For a sustainable industrial strategy realizing this equilibrium is almost a mandatory objective, in the long term industry cannot afford to be in disharmony with the environment.

Within the above framework industry will have to develop fundemental changes in the methods of production and consumption. This will have both technically and economically significant impacts on the way industry operates. It will be necessary to set a realistic time horizon for the process of change in line with economic sustainability of society and industry.
In this process of change we will also need to remove a number of potential psychological barriers in order to initiate the process, to mention some:

- short term needs dominate long term;
- lacking insight leads to misestimates;
- environment as a threat leads to short term orientation;
- cultural differences hamper cooperation and partnerships.

Apart from these potential barriers, in the development of the strategy we need to remind ourselves that economically and environmentally countries are out of phase (developed/developing). Moreover we need to realise that in dealing with environmental problems local issues may well develop into global issues and vice versa.

For industry it is important that conditions under which it can operate are harmonized globally in order not to distort competition between industries. There fore ideally environmental and economic regulations should be introduced uniformely and simultaneously.
There is an energing trend that international agreements are being concluded on environmental issues.

The Montreal and Copenhagen treaties on the use of chlorofluorohydro-carbons are well-known examples. And rather than just policy it calls for action and implementation.
Policy partnerships like the chemical industry's Responsible Care program which calls for a continuous improvement of the chemical industry's performance in the areas of health, safety and environment is another instrument which can be used to improve the environment.
Voluntary approaches on environmental issues by industry or industry sectors can serve as an effective and efficient instrument to achieve environmental progress. Unilateral declarations by one party to the type of voluntary agreements concluded between industry and government in the Netherlands offer a wide range of possiblities for policiy partnerships.
Joint-implementation programmes could in some cases offer a costeffective approach to environmental issues. Forestation is one of the practical examples in this field. Technologytransfer can catalyse the greening of the industry if industrial intellectual property rights are recognized it forms another important element in the process.

Greening of the industry is also a process of interaction between society, authorities and industry. The role of the consumer and his willingness to accept change are of paramount importance to succes. Governments can promote the supply of facilities which help consumers to adopt more sustainable consumption patterns. Sustainable consumption could develop into a direction where the durability of products is increased, more emphasis is placed on reuse and potential recycling and where more efficient use of products is made (rental versus ownership).

This development will have to start at the product design stage. By employing integrated chain management including life cyle analysis it can be assured that production patterns are sustainable.
Integrated Chain Management offers a strategic approach in the intelligent use of matter and energy and an objective tool for comparing the environmental impact of different products from craddle to grave. In addition to the environmental qualities of a product also other factors like product functionality, safety of production and economics will have to be taken into account in productselection, also here an integral approach is required.

It is quite likely that product renewal will have to be accompanied by the development of new sustainable technologies. In order to realise a stepchange advance in the development of technology a new approach in technology development is also required. "Backcasting" is a technique which can assist in this process, it starts from future, (long term) technology requirements and from those it defines relevant short term objectives.

Process-emissions usually constitute only part of the environmental load of a product throughout its life cycle. Nevertheless current industrial activities demand a reduction of processemissions as well.

Dutch Environmental Approach

In the Netherlands an integrated approach of process emissions to air and water and of waste has been developed by the government. It offers industry and society the possibility to arrive at solutions that represent an optimum balance between environmental and economic factors.

In 1989 the Dutch government published the National Environmental Policy Plan (in short NEPP). The NEPP is a national strategy for the environment which aims to achieve sustainable development in the Netherlands within one generation. The plan establishes key environmental quality objectives for the country and sets out a programme for long term actions to ensure realization of the objectives.
The plan recognises that in addition to conventional control measures a mixture of new clean technologies and structural changes in production and consumption patterns will be required.

In the NEPP an integral set of reduction targets is formulated for all environmental aspects. These targets were formulated on the basis of an elaborate inventory of the country's emissions made since 1985. Hence, a quantitative basis for the plan existed.

The plan was accepted by Dutch Parliament in 1990 and is now being implemented. For the implementation a management approach to environmental problems is achieved by
- adressing all environmental aspects;
- involving all sectors of society;
- setting quantitative targets and a timescale;
- defining responsibilities for actions;
- recognizing dependence on international cooperation and action.

This approach has been selected because the traditional environmental protection measures were not sufficient to achieve significant improvements. The traditional measures were based on regulation of substances or processes which pose a risk to human health or the environment. The integral approach enables the focus of measures on sources of pollution (e.g., industry, transport) rather than on their multiple environmental impact. Furthermore the integral approach prevents transfer of environmental problems from one compartment to another.

For the implementation of the plan the government choose to work through voluntary approaches with target groups as for instance agriculture, transportation and industry.
As a result of a deliberate government policy, which started around 1987, an approach, often resulting in voluntary agreements, has been initiated on a wide range of issues. For the chemical industry a.o. agreements on reduction of volatile organic compounds, environmental care systems, energy conservation and the integral environmental plan on the basis of the NEPP have been concluded.

The voluntary agreement approach is being applied for specific environmental issues, industrywide or for a specific sector or for dealing with all environmental aspects for an entire industry sector.
Shifting the emphasis from the command-control approach via legislation and permits to partnership with industry to achieve environmental improvements requires a change in attitude by industry and authorities. Industry will have to move from a defensive, passive role towards an offensive, active position. Cocurrently authorities will develop from a negative position based on distrust to a positive one based on confidence. Obviously this process will take time, it is a process in which the partners will be learning by doing.

For industry it requires a change in response pattern. Traditionally industry has responded mostly reactive or receptive on environmental challenges. As a result end-of-pipe measures or process changes were implemented. Industry had resolved its problems by installing technical means.
However, the challenge for industry will be to show a constructive, pro-active approach. This will require strategic vision from industry whereby productchanges are introduced and ultimately the customer will be involved in product development.

Realities of life, like economics, will determine the rate of change and the timescale but there is no doubt about the direction. The technical steps can be implemented whilst industry develops its productstrategy.

The voluntary agreement "Integrated Environmental Plan" (IEP) recently concluded between Dutch authorities and Dutch Chemical Industry offers the technical as well as the strategic elements described above.
Up to now 85% of the membercompanies of the Association of the Dutch Chemical Industry have signed a Declaration of Intent. They represent well over 90% of the chemical industry's emission and roughly 30% of the national industrial emissions. The remaining membercompanies who have not signed the agreement for various reasons are voluntary participating as if they had signed. Companies are now preparing their Site Environmental Plan on basis of the Declaration of Intent

In the Declaration of Intent parties accept the government's environmental policy as basis for the agreement. Both industry and authorities see the agreement as a management tool to implement this policy. Since voluntary agreements are a relative new instrument, the legal status of a Declaration of Intent is still somethat uncertain, particularly in legal permit application procedures. In the plan (IEP) long term environmental objectives are defined, industry has requested that new objectives are only introduced after prior consultations and with full consent.
Realization of the plan will require a heavy investment programme by industry and therefore industry has insisted that no unilateral, national fiscal measures (e.g. "ecotaxes") are introduced which would effect the industry's investment potential. Another important element for the chemical industry has been international harmonization of environmental legislation.

An environmental regime whereby Holland is in the topleague is acceptable but with an export dominated industry (75% export) significant deviations would be counterproductive towards a sustainable industrial development on a worldscale.
In the current economic climate too ambitious targets would likely surpass the financial viability of a number of industries. In those cases, phasing of investments, possibly resulting in some delay in realization forms a pragmatic solution whilst maintaining the original targets. Prioritysetting will therefore form another important element in the realization process.

The integral plan covers all themes of the NEP and sets environmental targets for the entire chemical industry -not for the individual companies- for the next 20 years. Some of the targets for these themes are indicated in tables 1-3.

Companies will develop a Site Environmental Plan which will contain the basic site information, emission data and specify the reduction targets to be achieved during the next 4 years with an indication for the following 4-years period. Technical and economical viability will be taken into account. The plan is to be discussed and agreed upon with the permit issuing authorities and will be used as basis for future permit application. Through coupling of the plan and the permit the implementation of environmental measures will be realized. Subsequent to approval the Site Environmental Plan is open to public. The company is further committed to publish an annual program report.
Non-participating companies will have their permits reviewed and if necessary adjusted by the authorities in the same timeframe. Sofar non-government organizations are not officially participating in the voluntary agreement process. However, they still have their traditional role in the permit application procedure.

Industry envisages a number of potential advantages in undertaking the voluntary agreement with the government. First of all because there will be certainty about the long term environmental targets to be achieved thus moving away from "end-of-pipe" solutions to process or product integrated measures. The agreement will enable industry to attune the programme for environmental investments and normal investments and hence allow a cost-effective approach. The integrated approach of all environmental segments, air/water/waste, will also allow industry to practive an integrated approach in planning the necessary investments.
A consultative committee has been set up betwen government and industry to form a platform to facilitate implementation of the agreement. The agreement ensures that the entire industry sector will be treated along the same lines, thus creating level playing field for all participants and avoiding unfair competition.

The agreement also calls for horizontal and vertical integration and coordination between government and authorities and calls for a consistent policy througout the country.

Chemical industry expects that investments for environmental improvement will increase from the current level of 15-20% to 20-25% of total investments to realize the objectives of the agreement.

Good cooperation between industry and government is an essential condition to achieve this ambitious environmental policy. Realizing these goals will enable a greener chemical industry to hand over an improved environment to the next generations, a great step forward towards sustainable development.

TABLE 1

DISPERSION
REDUCTION TARGETS CHEMICAL INDUSTRY
AIR EMISSIONS

COMPONENT	REDUCTION PERCENTAGE		
	1995	2000	2010
Ethene	-	50	90
Benzene	-	75	97,5
Dichloromethane	-	80	90
Zinc	50	50	80
Cadmium	70	70	80

TABLE 2

DISPERSION
REDUCTION TARGETS CHEMICAL INDUSTRY
WATEREMISSIONS

COMPONENT	REDUCTION PERCENTAGE		
	1995	2000	2010
Benzene	60	75	90
Dichloromethane	-	50	50
Zinc	65	65	80
Cadmium	90	90	90

TABLE 3

EUTROPHICATION
REDUCTION TARGETS CHEMICAL INDUSTRY
WATER EMISSIONS

COMPONENT	REDUCTION PERCENTAGE		
	1995	2000	2010
Nitrate	50	70	75
Phosphate	50	75	90

INTEGRATING LAND AND WATER - VIEWS OF A 'CENTRAL EUROPEAN', WITH NITROGEN AS AN EXAMPLE

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M.Zeßner-Spitzenberg, T.Kaas, P.H.Brunner and H.Fleckseder, all from the same Institute, performed the "Regional Balancing" for Upper Austria, with G.Bauer and P.H.Brunner setting up the systems analysis with the processes selected.

The Problem encountered.

In numerous reports it is at present estimated that the loads in nutrients - among them nitrogen - in river catchments in the developed world are increased (to strongly increased) over that ones existing at a point in time when the prosperity in goods was not as pronounced as it is today. When comparing the situation in the Danube Basin, there are indications that the ratios in load of *nitrogen* in front of the Danube Delta increased between 1960 and 1990 ~ 1000% and the ones for *phosphorus* ~ 300% (MEE, 1992). Wether these ratios can actually be looked upon as valid, remains open in regard to a non-existing integrated sampling in the 1960s. On the other hand, the change in population - looked upon at first sight as the main *driving force* for such changes - in the Danube catchment increased by < 20%. Assuming constant life habits over time, thus the population increase alone cannot account for the increase in e.g. the nitrogen load. The conclusion is that the increase must have to deal with a change in lifestyle over time, in land-water interactions along the drainage network, but also with different "uses" of human excreta over time.

Thus, the questions remain: Can we find a plausible method indicative with sufficient evidence what activities are causing the loss of nitrogen to the water environment? Who are the actual players and who the ones who seem it to be, but in fact are only secondary players? What are the various causes for this increase? And in relation to the title: Are the decisive decisions actually taking place distributed on the land surface, as we assume this to be the case with nonpoint-source pollution, or are they taken elsewhere?

Regional Mass Flux Budgeting.

The problem encountered is one of mass flux, i.e. the reason to be puzzled is that the mass fluxes observed or monitored have increased over time. In dealing with mass fluxes, the application of the mass balance principle has to come into our mind. Everyone with a higher education had to learn this principle, but e.g. common economics is only balancing in monetary terms and as yet not structured towards mass flux budgeting.

Alas, there is hope in sight. It can be called *Regional Mass Flux Budgeting*, and it is becoming an established tool. It is still a young undertaking, originating among academia of various origins, with chemists and chemical engineers as the leading ones. These sciences have always had to deal with the mass balance principle. In certain states - e.g. Austria, Denmark, Germany, Switzerland - the introduction of mass flux budgeting for - private and public - accounting and thus decision making is beginning to be discussed.

In *Regional Mass Flux Budgeting*, systems boundaries have to be established first: They are a region (or a drainage basin) in horizontal extension, in the vertical either including the planetary boundary layer or the atmosphere up to the troposphere, and into the underground such that the 1st groundwater floor is within the system. Within these boundaries, Processes describe the *Activities* relevant for the mass cycles internal to the system. In any Process, *either transport, transformation or storage are taking place*. The term Process does here not relate to an individual enterprise, but to all activities of the same type within the system boundaries. The time period for which *Regional Mass Flux Budgets are established can vary*; in nutrition, a balance for a year is meaningful and will thus be chosen for nitrogen. Balances can only be established for specified compounds or total elements. The principles and methods of this approach are further demonstrated in BACCINI&BRUNNER, 1991.

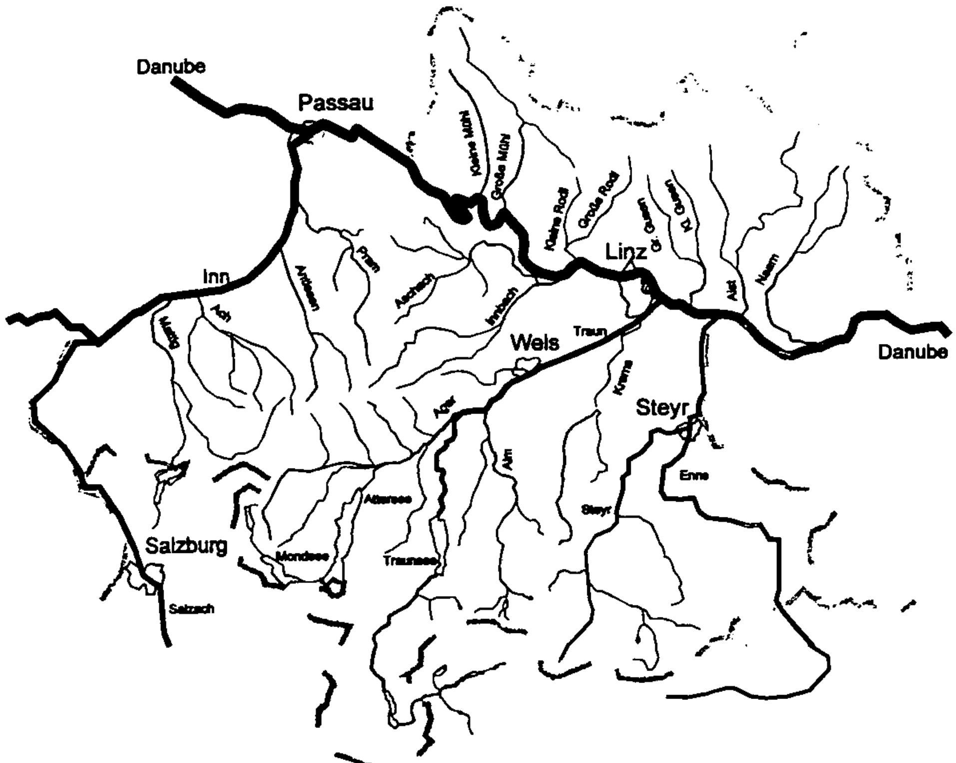
Being as this, balancing can contribute in showing who is responsible for what, but balancing has to be supplemented by other tools in order to take the effects into account. With nitrogen as an example, a flux of ammonium-nitrogen of the same size as nitrate-nitrogen would have in the same receiving river a completely different impact, although the contribution to the eutrophication of a receiving lake or sea, provided that nitrogen is limiting, would be quite similar!

Application of "Regional Mass Flux Budgeting of Nitrogen for Upper Austria".

The Bundesland Upper Austria.

Upper Austria is *one* of the *nine Länder* of Austria. As a preliminary N-balance had been established for Austria (FLECKSEDER, 1992), interest arose to have one for that *Land*, the driving forces being that only 62% of the population was in 1991 linked to centralised sewerage and biological wastewater treatment, the wastewaters of the remaining share being disposed of (trucking to sewage treatment plants; application on land) as well as leaking into the underground. In order to give some guidance to revised provincial ordinances both for sewage sludge disposal as well as wastewater treatment, it was the idea that we should indicate where the problems are. The preliminary N-balance for Austria had been established without officials from agriculture participating with this work. Thus, when this balance was discussed with colleagues from this side, its numeric validity was questioned. For the balance for Upper Austria, we proposed agriculture to be participating from the beginning, preferably by designating high-ranking delegates. This, by chance, was possible, thus the data obtained are scrutinised also from this side and agriculture will no longer claim that the balance established is wilfully unfair to its side and extremely fair to incineration processes and to waste management.

Upper Austria (see Fig. 1) is 11,980 km^2 in size, Linz - the biggest industrial centre in Austria - being its capital, and in 1991 (the reference year selected) it had ~ 1.3 Mio. inhabitants. The only nitrogen fertiliser factory existing in Austria is located at Linz. Large rivers bordering are the Enns, the Inn and the Salzach, and the large river entering and leaving is the Danube. There are rivers within Upper Austria reaching the Danube, e.g. the Traun. Dissolved oxygen conditions both in the lakes and rivers in Upper Austria are generally good, thus denitrification in surface waters has - at first sight! - not been selected as a process of importance to be numerically taken into account.



Area: 11,980 km^2

Agricultural Soils: 5,765 km^2

Forest Soils: 4,872 km^2

Other Soils: 1,243 km^2

Population:

1981: 1,276,800
1991: 1,340,000
1992: 1,352,500

Fig.1: Some Characteristcs of Upper Austria

A Systems Analysis for Regional Flux Mass Balancing of Nitrogen in Upper Austria.

The work on the topic was performed in 1992 (ZESSNER-SPITZENBERG, KAAS, FLECKSEDER, BRUNNER, 1992). Within the boundary of Upper Austria, the upper vertical limit was set with the planetary boundary layer, and the lower boundary limit with the 1st groundwater floor within the system. The processes of 1st order selected were Planetary Boundary Layer (PBL), Households (incl. the buying of goods and their end disposal), Incineration (incl. heating, industrial process heat and traffic) , Industry and Trade (incl. chem. industry, trade, other industry and processing of food and forest products), Waste Management (Wastewater treatment and solid wastes management), Forests incl. Soils, Agriculture incl. Soils (incl. agric. soil, agric. vegetation, farm and feed stock), Other Soils, Subsoil, Groundwater and Surface Water.

The first task was to establish the matrix of fluxes of goods (containing nitrogen) between these Processes, to transform the fluxes of goods into fluxes of total nitrogen, and to balance these fluxes between the various processes. The dominant processes of 1st order selected were subdivided into processes of 2nd order as indicated, e.g. Agriculture incl. Soils into Agricultural Soils, Agricultural Vegetation, Farm and Feed Stock. It was also possible from the beginning to predict that local groundwater problems can be investigated with this tool only if the systems boundary is much smaller, i.e. the horizontal extension describes the individual groundwater catchment area.

All work was based on existing data, with the view that the procedure should be improved in a smaller region (Krems Valley; ~ 500 km^2, ~ 50.000 inhabitants) in order to see how data can be obtained at such a level and what links there are to the processes selected. For all fluxes of nitrogen, lower and upper bounds were established. The reference year was 1991, but if no other data were available, values from neighbouring years were chosen. There were data with quite good accuracy, e.g. the ones from the urea plant and subsequent processing, and other data, where the fluxes were obtainable only after a certain amount of transformations (goods from statistics with nitrogen contents from statistics transformed into yearly nitrogen fluxes). Balancing thus is impacted by the inaccuracy of the data sets; how to overcome that by statistical methods was a task assigned to the follow-up project, budgeting of the Krems Valley Region. Values indicating change in storage of a process thus are showing either real storage taking place or they are indicative of data inaccuracy.

Overall Results regarding *Imports* and *Exports* across the systems boundaries.

Overall results are shown in Fig. 2, and as with preparing this publication, they are as yet preliminary and will be confirmed by the experience gained within the Krems Valley. They are expressed in kt of N per year. Ongoing work on the Krems Valley budget shows that most of the results obtained are valid. There are three main *imports* into the system: *Atmospheric nitrogen (incl. depositable compounds)*, *nitrogen compounds in surface water* and *nitrogen in fertilizers, fodder and food*, as well as three main *exports* from the system corresponding to *atmospheric nitrogen*, *nitrogen compounds in surface water* and *nitrogen compounds in marketable goods*. Assuming that Upper Austria is neither net importer nor net exporter of atmospheric nitrogen, as shown lateron as a possible assumption, the important outcome - corresponding to previous as well as other work - is that nitrogen *imported* to Upper Austria *leaves it by the water route*, i.e. our flowing waters are the ex-

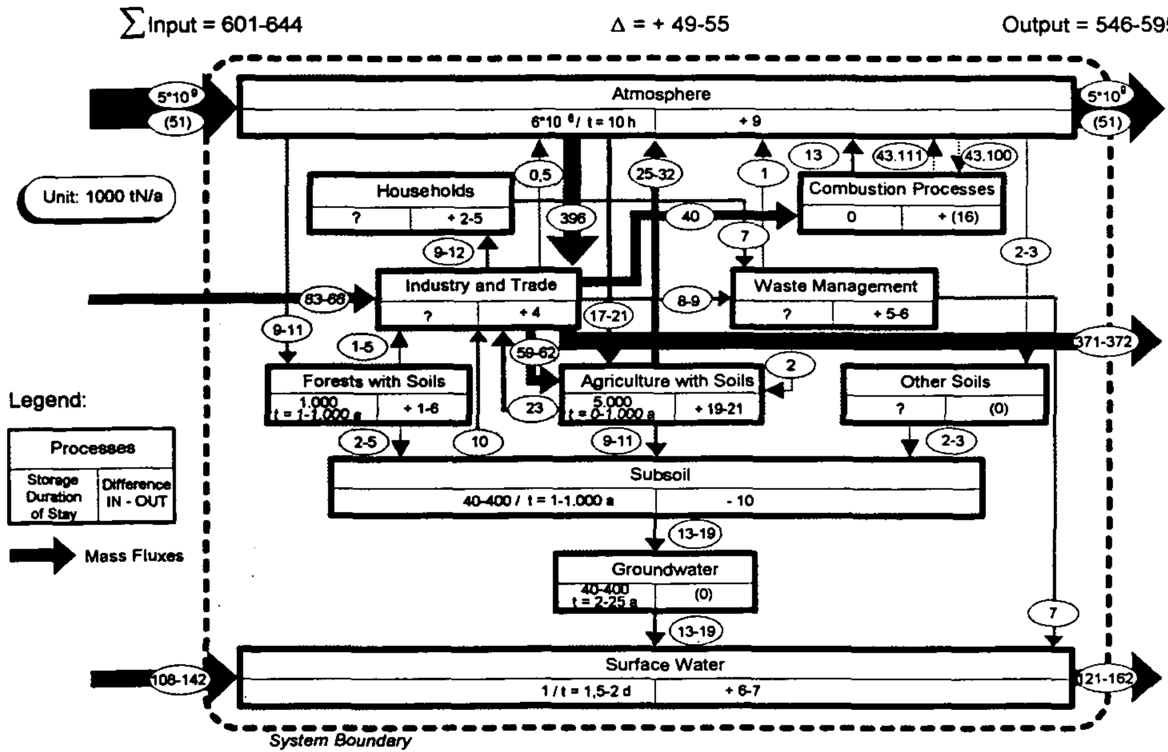


Fig.2: The Overall Nitrogen Balance of Upper Austria

port tracks of nitrogen, see BUNDI, 1993, FLECKSEDER, 1992, ISERMANN, 1992, 1993, and VAN DER VOET et al., 1994. This statement is also valid for regions not impacted at all by an excessive use of nitrogen.

Overall results regarding the internal processes and fluxes of importance.

A flux *entering a process* will be called *input*, and the one *leaving it, output*. Comparing the fluxes from Waste Management, i.e. *point source discharges* with only a 'partial' removal of nitrogen in wastewater treatment, with the ones via Subsoil and Groundwater, i.e. *nonpoint-source discharges*, one can realise that also in this 'Land' the bigger weight of input to Surface Waters is not on the point-source, but on the nonpoint-source-side. Up to after the year 2,000, an expansion of wastewater treatment plants bigger than 5,000 p.e. to include denitrification will allow for a reduction of the point source discharge.

Industry and Trade. When subtracting the export of nitrogen from Upper Austria from that amount 'abstracted' from the atmosphere by the urea plant, there is an overall non-elemental *input* into this process of ~ 97÷105 kt/a, including ~10 kt/a in coal abstracted from Subsoil, and out of that 59÷62 kt/a are the overall input to Agriculture incl. Soils. In Industry and Trade, their should be only a very minor increase in storage, and this is relative to the input also the case.

Waste Management. In contrast to this, the increase in storage in this process is, relative to the total input, much bigger. This is due to the fact that with our present disposal methods, we are creating also some nitrogen build-up in disposal sites, but also to the fact that our present-day knowledge about the quantification of both input and output to this process is not very precise at all. From the input of 15 ÷ 16 kt/a, 7 kt/a are assignable in Upper Austria to Households (5 kt/a going to Wastewater Treatment and 2 kt/a to Waste Management). The 2 kt/a passing on to Agriculture incl. Soils account for sewage sludge as well as for compost.

Incineration. Despite the fact that 40 kt/a are the input in the form of non-elemental N, 13 kt/a is the present estimate as NO_X-N emitted to Planetary Boundary Layer. A much bigger flux of elemental nitrogen is cycled between this process and the PBL.

Households. They are receiving 9÷12 kt/a and are discharging 7 kt/a to Waste Management. The difference of 2÷5 kt/a has again to account both for actual storage in materials as well as data inconsistencies.

Agriculture incl. Soils. In regard to the processes having relation to soils, this is the most important one. The *inputs* are: 'wanted' in fertilisers and fodder 59÷62 kt/a, from Waste Management 2 kt/a and in deposition as NO_X-N as well as NH_X-N from the atmosphere and including also biological fixation is 17÷21 kt/a, yielding a total input of 78÷85 kt/a. The *outputs* are: 25÷32 kt/a in the form of NH_3-N passing on to PBL, 23 kt/a (incl. slaughterhouse waste recycled as fodder) to Processing of Agricultural Products, and 9÷11 kt/a via Subsoil and Groundwater to Surface Water. Denitrification of nitrogen applied in fertilisers is included with an estimate of ~ 8 kt/a. The interesting comparison between Agriculture incl. Soils and Incineration is that the loss to the atmosphere is so much more influenced by agricultural activities, and that a total of 17÷21 kt/a are actually in the form of NH_X-N. This is primarily due to the fact that agriculture in Upper Austria is a net exporter of meat and dairy products to other parts of Austria (and outside of Austria). As the losses in conversion from primary protein to animal protein are so much bigger than they are for the production of primary protein alone, even under best agricultural practice, is - as we are assuming at present - the reason for this context. The increase in stock in Agriculture incl Soils is for sure existing, but the difference between input and output has also to be explained by inconclusive data. This balance, as part of the pathway of nitrogen for human nutrition, will be discussed in greater detail in a passage to come.

Forests incl. Soils. Fertilising forests is in Austria forbidden by law. Our forests are nevertheless receiving both NO_X-N as well as NH_X-N by deposition. Output from this process to Subsoil was estimated with 2÷5 kt/a, and in the wood harvested - the big variation being due to inconsistent data about the nitrogen content of wood in literature - 1÷5 kt/a to Industry and Trade, yielding a difference of 1÷6 kt/a. Part of this may go to an increase in stock.

Other Soils, i.e. in general uncultivated land situated in mountains as well as some land in human settlements etc.. These are estimated to receive a deposition of 2÷3 kt/a which is assumed to pass on to Subsoil and from there consequently via Groundwater to Surface Water.

Underground. The withdrawal of nitrogen in coal had to be set, otherwise it was assumed that no increase in stock - based on the time scale selected - is taking place, and thus the inputs are passed on to Groundwater and from there to Surface Water. The balance for this last process will be dealt with in greater detail at a passage to come.

From this overall view, one could conclude that the ***comparatively biggest player in regard to nitrogen in the environment***, and thus also to Surface Water, is the **overall field of** Agriculture and that we should now, since we are implementing denitrification in wastewater treatment, also force agriculture to undertake its share to curb nitrogen emissions.

Such a view is to a certain extent possible, as not all measures indicating *best agricultural practice* are for sure implemented in Upper Austria (as well as in other parts of Austria). However, in comparison to other Western European regions, as well as in Central and Eastern European regions before the geopolitical change (and maybe also in the future under better than present-day economic constraints), the amount of nitrogen in market fertiliser applied in Austria is not very high in areaspecific terms, and the same is true for fodder. Thus the question arises in what context nitrogen has to be put in the *balance of nutritional products* for Upper Austria.

The *Balance of Nitrogen in nutritional products* for Upper Austria.

This balance is assembled in Fig. 3. In order to better understand it, the matrix of inputs and outputs of the process Agriculture incl. Soils is presented in some detail, see Table 1. It should be noted that nitrogen in primary agricultural production in Upper Austria was estimated at 82 ÷ 93 kt/a and input from Farm to Agricultural Soil with 93 ÷ 99 kt/a, but these are fluxes internal to Agriculture incl. Soils and too difficult to explain in short for the purposes of this paper.

One realises from Fig. 3 that from a 'wanted' as well as 'unwanted' input to Agriculture of 75 ÷ 82 kt/a, 34 ÷ 43 kt/a are losses to the *Environment*, and based on the remarks about an 'unlikelihood' of a change in stock of the PBL, thus not to the *Atmosphere*, but in

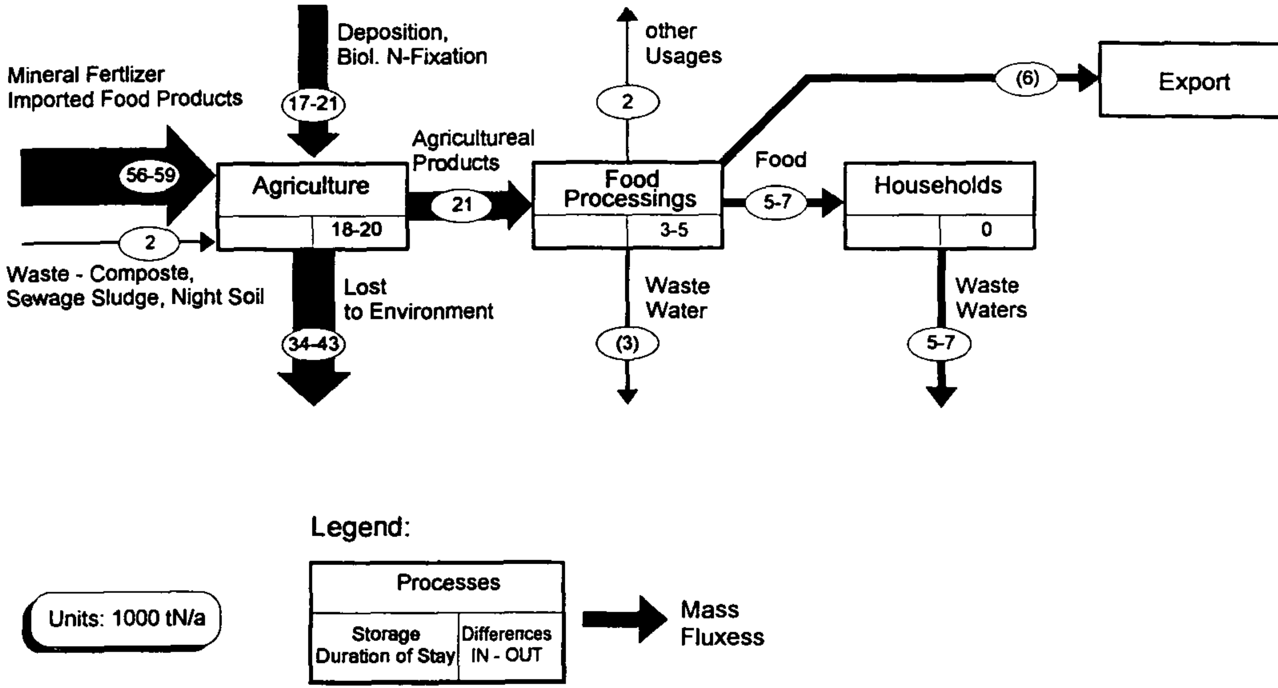


Fig.3: The Balance of Nitrogen in Nutritional Products in Upper Austria

the end to the *Water Route*, i.e. Surface Water, 21 kt/a go to further processing (fodder and food), and 18 ÷ 20 kt/a are a difference which accounts for the increase in stock as well as inconclusive data. The balance around Processing of Agricultural Products shows that from the input of 21 kt/a, 11 to 13 kt/a are the estimate for marketable products being *exported from Upper Austria* as well as *reaching* Households in Upper Austria, whereas 3 ÷ 5 kt/a are attributable to inconclusive data (an actual increase in stock is not conceivable), and 2 kt/a are for other uses.

Table 1: Nitrogen-Balance of Agriculture incl. Soils in Upper Austria

Input	kt/a	%
Market fertilisers	34	45 ÷ 41
Imports of fodder (also from within Austria!)	22 ÷ 25	29 ÷ 31
Deposition (NO_X-N, NH_X-N)	10 ÷ 14	14 ÷ 17
Biological fixation of N	7	10 ÷ 9
Compost	1	1
Sludges (sewage treatment, nightsoil)	1	1
Sum	75 ÷ 82	100
Output	**kt/a**	**%**
Products	21*	28 ÷ 26
In primary products	8	11 ÷ 10
In transformed products (meat, dairy products, eggs)	13*	17 ÷ 16
Losses	34 ÷ 43	45 ÷ 52
NH_3-N	17 ÷ 24	12 ÷ 13
Leaching	9 ÷ 11	12 ÷ 13
Denitrification	8	11 ÷ 10
Sum	55 ÷ 64	73 ÷ 78
Difference	**20 ÷ 18**	**27 ÷ 22**
Stock in Agric. Soils	~ 5,000 kt	

* without slaughterhouse waste, ~ 2 kt/a, which is recycled as fodder

The fact remains that from a total - 'wanted' and 'unwanted' - input of 75 ÷ 82 kt/a, only 11 ÷ 13 kt/a are reaching humans, i.e. the present overall efficiency along the nutritional food chain for the *Agricultural System of Upper Austria* from the total input of nitrogen to agricultural production to the consumption of marketable products by humans is only around 15%, and even these 15% are in the end also waste to the environment and have subsequently to be processed in wastewater treatment and waste management. REMMERT (1992) showed that in the FRG the nitrogen efficiency in 'animal production' varied in the period 1950 and 1990 between 13 and 19%. If the efficiency in nitrogen transformation is based on the total output from the agricultural sector in the stricter sense (21 kt/a) versus the total input, it reaches 27%.

It is estimated that the N-flux in the harvest from Agricultural Vegetation to Farm in Upper Austria was in 1991 between 82 and 93 kt/a, and of that, 10 to 11 kt/a were put back to

Agricultural Soils. The output to further processing is, as shown in Table 2, 21 kt/a, and most of that is in the form of animal protein. As most of the evaporation of NH_3 is linked with the production of animal protein and as a sensible part of the nitrogen leached and denitrified is also caused by the transformation of primary protein to animal protein due to the larger areas under cultivation in comparison to a human nutrition more based on primary protein, one has to conclude that the present-day nutritional habits are playing an important role.

<u>The balance for the Planetary Boundary Layer, here shortened as Atmosphere.</u>

This balance is shown in Fig. 4, and please be aware that only the balance for NO_X as well as NH_X is presented, and the amounts denitrified to elemental N (from soil, in wastewater treatment), 8 kt/a, is not shown due to the fact that elemental nitrogen is so dominant in the atmosphere. Assuming that the *import* to Upper Austria equals the *export*, there is a yearly difference which has to be attributed to inconclusive data, but maybe also to the fact that the previous assumption is not justified, Upper Austria being the biggest meat producer among the 'Länder' of Austria. One realises that in regard to inputs, Agriculture incl. Soils dominates over Traffic and Traffic over Industry, and that the output (deposition) is also biggest with Agriculture incl. Soils, is also big with Forests incl. Soils and smaller with Other Soils.

<u>The balance explaining the input to Surface Water,</u> (see Fig. 5).

The rivers flowing into Upper Austria do bring in substantial amounts of nitrogen, and the size of Upper Austria relative to the catchment and activities upstream along the drainage System (Baden-Württemberg; Bavaria, some other parts of Austria) are such that based both in regard to monitoring, incl. the variations from year to year, as well as in regard to the conciseness of the input data from Upper Austria to Surface Water do allow only for a rough balance. As already shown previously, Agriculture incl. Soils dominates in the nonpoint-source inputs, and Waste Treatment is having its minor part, which will further diminish in the coming years due to the efforts in Wastewater Treatment. One of the assumptions set at the beginning of the work was that no denitrification is accounted for in receiving waters. The yearly difference shown can be explained in part by the fact that this assumption will not be completely true, in part also to data inconsistencies

Discussion of the N-Balance of Upper Austria.

Having shown the accuracy and precision obtainable at present with this approach, the weight of the individual players shown may vary somewhat, but in the end, will stay within the proportions indicated. Within Upper Austria, there are ***two main players***, Agriculture and Incineration, the other ones - like Waste Management - being minor ones. If we are taking P.Harremoës' plea at the 1993 Stockholm Conference that one should make it prestigious to sit on a compost toilet or an adequate disposal pit with all earnest, human excreta could be also recycled as we did in the past and as is being done with animal manure.

Thus, there are only **two decisive activities dominating the flux of nitrogen to the environment**, and these are **to nourish** and to **burn**, and ***<u>to nourish</u>*** has, at least in Upper Austria, a markedly bigger impact than ***<u>to burn</u>***.

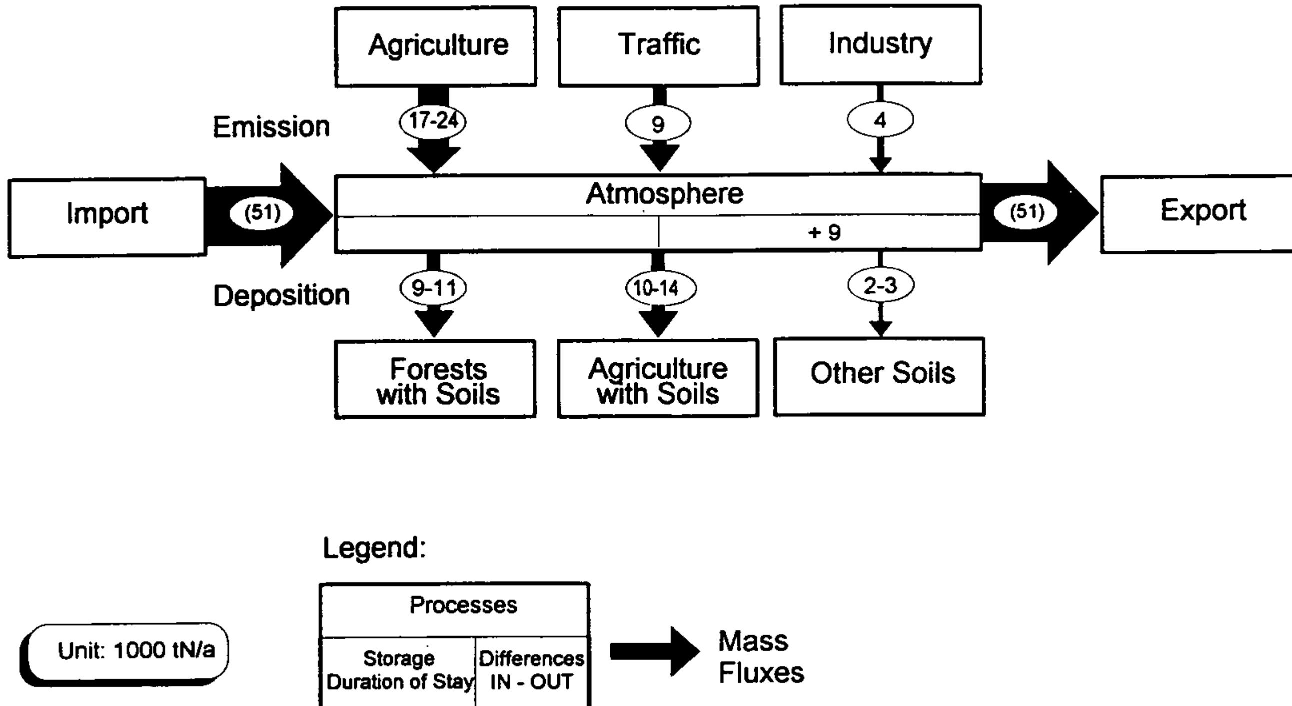


Fig.4: The Balance of (NH_X - + NO_X -)- N of the Atmosphere in Upper Austria

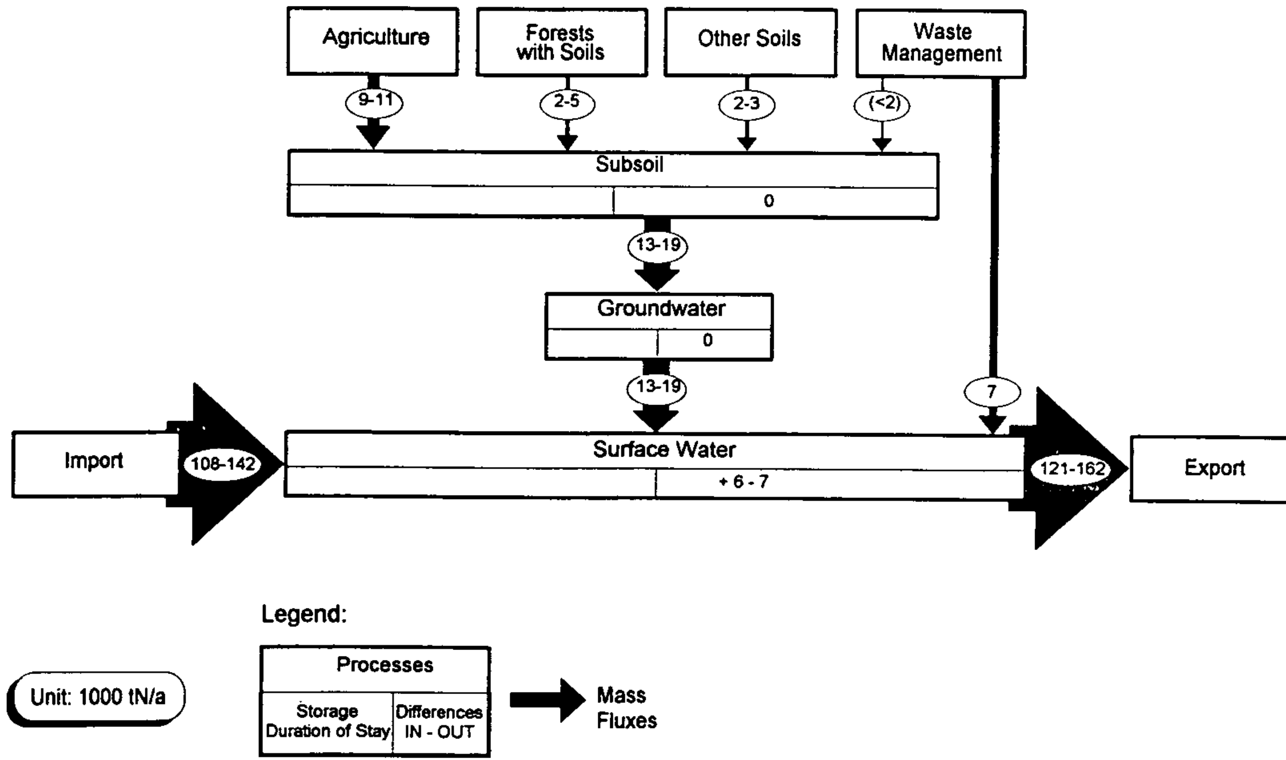


Fig. 5: The Balance Explaining the Inputs of Nitrogen into Surface Waters in Upper Austria

The second additional point of importance, at least to me, is that despite the fact that Agriculture is such a big player, **it is only a player of secondary importance**, and this is for me also true for Incineration.

The **primary players** are for me the **individual decision makers**, i.e. ***in practice you and me with our lifestyles***, in this case the average personal lifestyle at around 1991 in Upper Austria and Central Europe. If we can influence these lifestyles, a lowering of the *exports*, where balances for land catchments show that the one via the *water route* will dominate the one via the *atmospheric route* by far, should be possible, and the lifestyles and their change in time do relate to the **two decisive activities, *to nourish* and *to burn***.

In discussing the activity ***to nourish***, let me mention that the consumption of meat in Austria evolved along the following route as shown in Table 2.

Table 2: Headspecific consumption of meat over time in Austria (various sources).

	1930s	1940/44	1961	1985	1991
kg/pe.a	~ 45	~ 20	~ 65	~ 95	~ 90

The sources do not show wether this is actual meat on the plate or only meat as overall part of the animal. Animal protein in eggs and dairy products have to be added, and fish is for the average Austrian not a form of protein he eats in big quantities. In addition, the calories required for a balanced human nutrition were existing in these years or there was even over consumption. Experts for human nutrition from the medical profession - and not those who are extremists regarding vegetarianism - are indicating that 0.85 g of protein per kg of body weight are what we should consume, but on average, the value is 30% bigger (BILLEN-GIRMSCHEID&SCHMITZ, 1986; HOLTMEIER, 1986). The indication thus is by **eating less, without a change in protein composition and the technology how this protein is being produced, savings should be possible.**

In addition, the **advice by the experts on nutrition mentioned is that 1/3 of the protein should be of animal origin, the remainder of primary origin.** Let me define the ***average Central European*** - child to elderly people, male as well as female - as having 60 kg of weight and let us select 18% to be the share of protein in meat (wet weight). From these assumptions one can conclude that an ***average Central European*** should consume a maximum of ~ 35 kg of meat per year on the plate, and doing that he should skip eggs or dairy products completely! Thus, by reducing the quantity of meat or other animal protein consumed, the flux of nitrogen to the environment will decrease, based on Fig. 3, as this is valid for a point in time when the average meat consumption was ~ 90 kg/pe.a.

Agriculture as a sector in society will suffer as long as we are believing that there prices have to be low indefinitely in time towards the future. Contrary to GATT and the founding principles of the EC, in order to advance in environmental protection, the price of products containing animal protein has to be high. ISERMANN (1994), one of the recent observers to bridge the gap between agricultural activities and their impact on the environment and despite the fact that being employed with BASF it has not always been easy for him to express his views, estimates that a doubling of the price of products containing animal protein will for sure lower their consumption. In repeating P.Harremoës plea, transformed to the situation of nitrogen and animal protein, *in order to make it prestigious to eat more primary and less animal protein, we will have to increase the price of products of animal origin.*

There is no doubt that agricultural techniques are improvable which will allow a lowering of the export via the two main routes from Agriculture incl. Soils to the *Environment*, namely *leaching to* Groundwater and *evaporation to the* Planetary Boundary Layer. Development of new techniques and in certain places a re-conversion to previous practice, among that also *organic agriculture*, is under way. However, ISERMANN (1990; 1992) estimated the impact of these measures to be limited, and the same result was obtained by VAN DER VOET et al. (1994) in her study. VAN DER VOET et al. as well as ISERMANN plea for a mix of measures, including an increase in price of products containing animal protein, the application of *best available techniques in agricultural practice*, but also levees on fodder and fertilisers as long as their prices are low.

It is also clearly conceivable that the situation encountered cannot be solved by an individual state or in a single River Basin, be it as big as the River Danube Basin is, but only globally. The statement **'think globally, act locally' is second to none valid in this field,** but in actual life not acknowledged at all. The quickest way in overcoming the elevated contribution from this side could be convincing people to act accordingly, but I foresee the introduction of the acceptance of every fellow European to eat less animal protein will be rather slow implemented along the time frame.

In order to advance this mode of reasoning one step, let us consider the following relationships: According to KIEFFER (1984), the nitrogen in a human of 70 kg weight is around 2,100 g. Let us now assume that this human has had during life an averaged weight of 60 kg and that he stuck to the nutritional advice of not eating more than 0,85 g protein per kg of body weight. With an average human life expectancy of 75 years, this person would have consumed ~ 1.400 kg of protein in his life, equivalent to ~ 230 kg of nitrogen, 1 kg of protein being equivalent to ~ 0.165 kg of nitrogen in protein. This simply indicates that in the language of economics, food is a consumable, albeit an extremely important one. More or less all what humans are eating has to go back to the (human) environment. If this fellow human had eaten during his lifetime a diet being composed of 2/3 of animal protein and of 1/3 of primary protein, and taking into account a transfer efficiency of 85% for nitrogen in primary production and - already elevated! - 20% for nitrogen in animal protein, the remainder being loss to the environment, then the total amount of nitrogen "made use of" in this human life would have been ~ 860 kg, out of which ~ 230 kg would be linked to human excretion and the remainder would be "nonpoint-source loss" (i.e. ~ 630 kg). If the diet had been according to the nutritional advice, i.e. 1/3 of animal protein and 2/3 of primary protein, with otherwise unchanged assumptions, he would have "made use of" ~ 560 kg of nitrogen, out of which ~ 230 kg would be linked with human excretion, the remainder (~ 330 kg) being nonpoint-source loss. If he would solely rely on primary protein - a solution e.g. practised in strict Buddhism - he would have "made use of" ~ 270 kg of nitrogen, and the biggest share of that would be linked with human excretion, nonpoint-source loss being only ~ 40 kg. Had that statistical fellow human always eaten 30% protein more than shown, the use of nitrogen as well as the losses to the environment - depending on the way he fed himself - would also have been 30% bigger!

(The nonpoint-source losses mentioned relative to a vegetarian diet are not intended as a strict measure, as consuming fish - e.g. tuna - has in fact also a high - if not even extremely high - overall loss of nitrogen, but there the loss of nitrogen and the receiving seas are in most cases in a better equilibrium than e.g. the Adriatic, Baltic, the Black or the North Sea are in regard to N-related inland activities).

In discussing the activity ***to burn*** the process Incineration is to me the second ***secondary player***. This process is dominated by the sub-process Traffic (9 kt/a), with Process Heat (includes room heating and thermal power stations) with 4 kt/a on the second position. Here too, the evolution of energy consumption over time is of interest, and data in regard to this are assembled in Table 3.

Table 3: Headspecific consumption of energy over time in Austria (various sources).

	1950	1960	1970	1980	1990
kg oil units/pe.a	~ 1,200	~ 1,700	~ 2,500	~ 2,900	~ 3,400

The use of energy of interest is the one which is going to Traffic as well as Process Heat. Having introduced the need to have catalysts in new cars, the goals are set in Austria for the introduction of the '3 litre-car', i.e. the one consuming not more than 3l per 100 km, as well as an improvement of insulation. As with the cars having catalysts, the introduction of both goals will be rather slow to be implemented along the time frame, as is convincing every fellow European that lowering the yearly mileage driven as well as the adequate low setpoint for room heating count, too. As with agriculture incl. Soils, the primary decision-makers are situation not in the area where nonpoint-source pollution is occurring, but in cities and towns, and only in part in rural areas.

My conclusions relative to land-water interactions.

One assumed cornerstone of science is that the results of reasoning and experiments are independent from the values and the preferences of the individual(s) undertaking scientific reasoning. However, on this I can only agree in part. The great advancement introduced by Galileo Galilei into natural scientific reasoning was the disregarding of experience (i.e. aspects of the historic dimension were no longer the cornerstone of good work) as well as the introduction of the experiment. In the experimental situation, the - outside! - observer has to conceive of a model which is containing the essential elements (or where he is believing that it is containing the essential elements) and then he has to quantify and establish the relations between these essential elements by measurement. Thus the principle of *intersubjectivity* was introduced (i.e. in general what can be measured or modelled) and it was split off from the remaining part of the *whole*. At his point in time, the historic pole was not truly historic, but dogmatic, and thus in his time he had to blow the tune to march along the way he foresaw.

One of the outcomes of this is that in considering our position(s) towards various issues at present, we are no longer willing to take care of the feedback loops existing, they are simply discarded in many decisions. Farmers three to two generations ago knew that they had to apply the three-field rotation principle in order to have adequate nitrogen available without having to supplement much from the urea plant. The headspecific amount of meat consumed was lower than it is today. The opening of regional markets to a single world market - not yet completed - has pushed the individual farmer in those areas where primary productivity is poorer in comparison to other areas to abandon the selling of primary products and to convert to 'animal ennoblement' - an expression coined by me according to the term we are using in the German tongue. The driving force for this change lie in the inherent economies, and the mass fluxes associated became hidden, as they were not observed adequately or there was no feedback yet from receiving seas and as both energy and fertilisers were comparatively extremely cheap.

One of the outstanding scholars in describing how economics as a discipline has been and maybe still today is embracing the mechanistic dogma is GEORGESCU-ROEGEN (1971). For me, the following is valid: As long as all measures for economic decisions are expressed in monetary terms and as long as matter and energy are inexpensive, materials fluxes in our societies will be elevated and people all over the world will be striving to have our lifestyles.

When wishing to implant the concept of ***sustainability*** also in Europe into the fields of ***nutrition*** and ***transportation*** in order to decrease the present state of nitrogen fluxes to a level of life still worth living, we may primarily be in need of opinion leaders as well as the possibility to gain access to the individual riparian fellow in river catchments.

Remember: **Everyone of us is living in a river catchment, and in many inland areas the net atmospheric transport route is negligible compared to the one via rivers, who are the main export tracks to the receiving seas!.**

Humans are in regard to nutritional elements (e.g. C, N, P, ...) "flow-through" systems and we have developed and implemented a water-based disposal system for human excreta.

The impact of total nitrogen on the water environment of an individual fellow human due to his nutrition will be dependent
a) ~ linearly proportional on the quantity of protein consumed ➻
➻ beware of over consumption of protein;
b) strongly on the share of animal protein as part of the overall protein consumption because of the low transfer efficiencies ➻
➻ limit the consumption of protein of animal origin;
c) on techniques of utilisation of and/or of wastewater treatment of human excreta ➻
➻ reconsider the closing also of these cycles;
d) on the transfer efficiencies of nitrogen in primary and the follow-up agricultural production(s) and in processing of fodder and food ➻
➻ maximise these transfer efficiencies.

The individual riparian fellow is in regard to ***nutrition*** residing in Households, although an ever increasing number of meals are consumed outside from individual homes. In regard to Incineration and the sub-process Traffic, he is taking his decisions based on *reputation*, fulfilling his need for *mobility*. None of these decisions are strongly located areawide, *individual fellow people today* are as the - from my point of view - ***primary players*** crowded in urban centers, towns, and are staying only in limited amounts in rural villages.

The environmental future, also in the land-water interaction of nitrogen, will thus be determined by decisions taken in urban areas and towns, and only in part by those tilling the land.

In order to demonstrate the difference between ***secondary*** and ***primary players***, maybe we should state that

Badly reflected mental decisions - *e.g. too big an animal protein consumption or too big a consumption of fossile carbon* - can be looked upon as a *mental point source pollution* which *is causing known nonpoint-source pollution in mass flux terms.*

In both areas mentioned, ***to nourish*** and ***to burn***, ***education and the orientation of actions - something what the Japanese are calling 'root binding'*** (VOGEL, 1979) - is of need. In order to advance with this, basic needs of people in river catchments have to be fulfilled with the biggest efficiency available. I am not advocating strict vegetarianism, and when you are observing me at the Official Banquet, I will not reject either animal meet nor fish. But let us beware of the limits! In order to arrive at these limits by *root binding*, we have to find the same terms in many languages and state borders, in the River Danube Basin e.g. in 10 major languages, and I am counting Serbo-Croatian as only one language, and at present 13 internationally recognised states with state areas in the catchment bigger than 2,000 km^2. Doing this at a point in time of free trade of agricultural products worldwide requires that these principles of minimising demands be not only applied in the Danube catchment area alone, but more or less allover the world. Mass media, if adequately participating, could have a big impact in speeding up the introduction of these principles shown, both in "Western" as well as in "Central" and "Eastern" European countries.

As a personal post-scriptum.

I am Lutheran, I am not often going to Church, but I well remember that the first prayer I learnt, in German 'Vater Unser', i.e. the Lord's Prayer, contains our human wish to have adequate bread every day, but nothing was said of the adequate quantity of meat we are in need of and nothing about the way in which we are behaving towards the biosphere at present in our (1st world?) societies (TOYNBEE, 1979).

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THE GREAT MISSISSIPPI RIVER FLOOD OF 1993
A VERY UNUSUAL HYDROLOGIC EVENT

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INTRODUCTION:

It is with great pleasure that I stand before this August audience to relate a story that I have partly been a witness to. It is a story of man's most earnest attempts to cope with the effects of devastation. It is a story of the relentless efforts by the United States Army Corps of Engineers to tame a natural disaster. It is a story of Federal, State, and local governments struggling with tragedy. It is a story of the unpredictability of the interaction between climatological and hydrologic factors. To the scientist and engineer it is a humbling story which epitomizes the limitation of our ability to manipulate scientific data and (ultimately) make wise and precise decisions.

In the midst of the Great Mississippi River flood last year, when the storm system stood almost steady in the upper atmosphere above the Midwest of the United States, generating more and more moisture, I was reminded of a comment made by Albert Einstein, Jr., at a hydraulic conference in Pittsburgh, PA in 1967. Professor Einstein, as you may know, was an expert in fluvial hydraulics and had at that time developed the most advanced and sophisticated equations in sediment transportation. He had worked all his life on the theory of turbulence. He said at that conference that he hoped, someday, before he died that he could begin to understand the phenomenon of turbulence. We all smiled. Yet, I felt similarly last year when, after having devoted so many years to the field of hydrology, I found myself wishing that I could one day begin to understand the hydrologic cycle.

THE UPPER MISSISSIPPI RIVER BASIN

To put things in proper perspective, I will describe for you the Upper Mississippi River basin (Figure 1) which has been the theater of most of the disaster caused by the flood. The basin is managed by two Districts of the Corps of Engineers' North Central Division: the St. Paul and the Rock Island Districts. The St. Paul District's portion extends from the Headwaters Reservoirs all the way down to Lock and Dam 10 at Guttenberg, Iowa. The Corps of Engineers constructed at the turn of the century the Mississippi River Head waters Reservoirs project to augment flows in the Mississippi River for navigation. The project authorized by the 1899 River and Harbor Act with later modifications, provided for construction and/or reconstruction of the reservoir dams. The six Mississippi River Headwaters lakes, Sandy, Winnibigoshish, Leech, Gull, Pokegama, and Cross, are located in north central Minnesota between Duluth and Moorhead.

The reservoirs are operated to reduce flood stages in the vicinity of Aitkin, Minnesota. The reservoirs are also in the heart of a very popular resort area. At these reservoir areas, the Corps has placed facilities for swimming, boat launching, camping, picnicking and sanitation and most

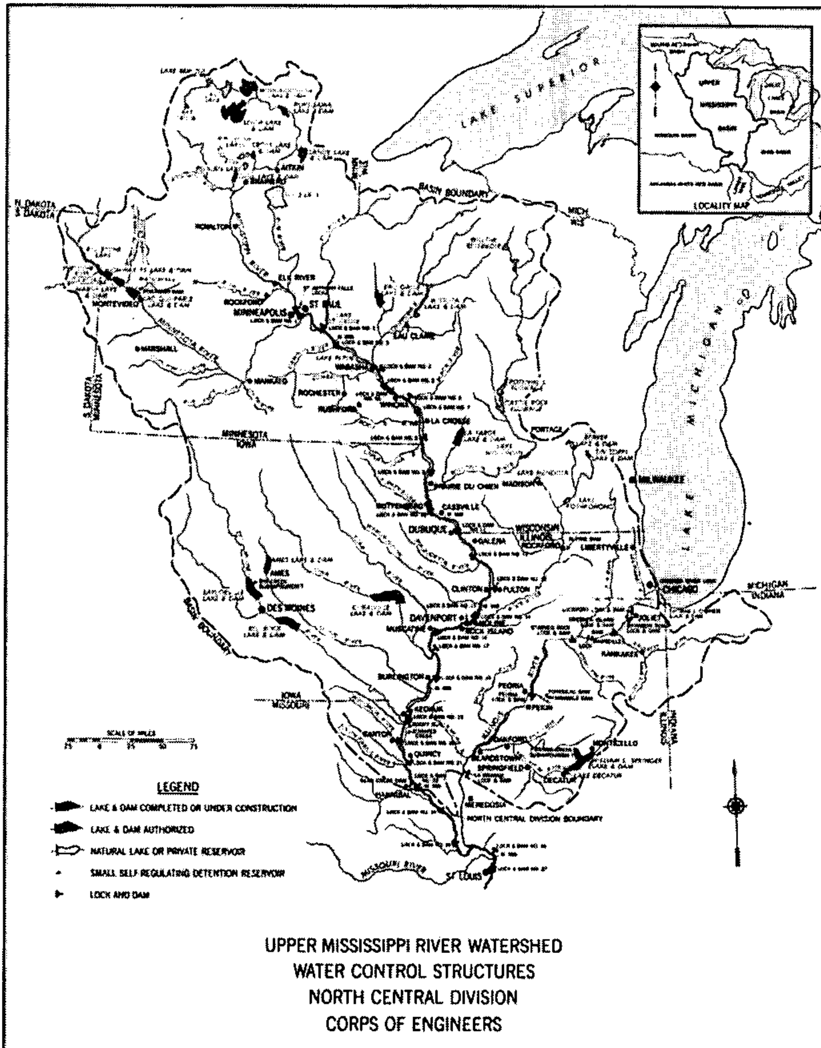
LAKE SUPERIOR
LAKE MICHIGAN
LOCALITY MAP
BASIN BOUNDARY
N. DAKOTA
S. DAKOTA
MINNESOTA
IOWA
WISCONSIN
ILLINOIS
MICHIGAN
INDIANA
MISSOURI
MISSISSIPPI RIVER
MINNESOTA RIVER
MISSOURI RIVER
MINNEAPOLIS
ST PAUL
ELK RIVER
AITKIN
ROCKFORD
MONTEVIDEO
MARSHALL
MANKATO
ROCHESTER
RUSHFORD
WABASHA
WINONA
EAU CLAIRE
LA CROSSE
PRAIRIE DU CHIEN
MADISON
PORTAGE
MILWAUKEE
CASSVILLE
DUBUQUE
GALENA
ROCKFORD
LIBERTYVILLE
CHICAGO
JOLIET
KANKAKEE
CLINTON
FULTON
DAVENPORT
MOLINE
ROCK ISLAND
MUSCATINE
AMES
DES MOINES
BURLINGTON
PEORIA
KEOKUK
CANTON
QUINCY
HANNIBAL
BEARDSTOWN
SPRINGFIELD
DECATUR
MONTICELLO
MEREDOSIA
ST LOUIS
NORTH CENTRAL DIVISION BOUNDARY
LEGEND
LAKE & DAM COMPLETED OR UNDER CONSTRUCTION
LAKE & DAM AUTHORIZED
NATURAL LAKE OR PRIVATE RESERVOIR
SMALL SELF REGULATING DETENTION RESERVOIR
LOCK AND DAM
UPPER MISSISSIPPI RIVER WATERSHED
WATER CONTROL STRUCTURES
NORTH CENTRAL DIVISION
CORPS OF ENGINEERS

FIGURE 1

facilities are designed for handicapped use.

Major tributaries to the Mississippi River within the St. Paul district boundaries include the Minnesota, St. Croix and Wisconsin Rivers. Other tributaries to the Mississippi include the Cannon, (Wisconsin) Chippewa, Zumbro, Black, and Root Rivers. The Minnesota River begins at Big Stone Lake on the border between Minnesota and South Dakota. It passes through Marks Lake and Lac Qui Parle dams which are operated primarily for flood control. Tributaries to the Minnesota River include the Little Minnesota River above Big Stone Lake and the Pomme de Terre, Lac Qui Parle, (Minnesota) Chippewa, Yellow Medicine, Redwood, Cottonwood and Blue Earth Rivers. The Wisconsin River begins a network of interconnecting lakes and swamps in the northern highland section of Wisconsin. Tributaries to the Wisconsin River include, the Yellow, Baraboo, and Kickapoo Rivers. The St. Croix River flows from St. Croix Lake in Northwestern Wisconsin.

Flood control projects along the Minnesota River or its tributaries include Mankato and North Mankato, Henderson, Marshall, and Chaska, Minnesota. Flood Control on the Root River include projects at Rushford and Houston, Minnesota. Flood Control on the Zumbro River and it's tributaries include projects at Kellogg, Rochester, New Haven, Jarrett, and Millville, Minnesota. The Eau Galle Dam just upstream of Spring Valley, Wisconsin was built on the Eau Galle River a tributary of the Chippewa River to provide flood protection.

The Mississippi River between the Missouri River and Minneapolis, Minnesota, has been improved for navigation by a system of locks and dams at 28 locations along with maintenance of a nine foot deep channel in between. Thirteen locks and dams are in the St. Paul District. These locks and dams have changed the river into a series of "steps" which river tows and other boats either "climb" or "descend" as they travel upstream or downstream. The dams are spaced at irregular intervals varying from 15 to 74 Kms, the average length of pools being 40 Kms. The lift of the locks varies from 1.67 to 15 meters. At most of the sites a main lock 33.50 x 183 meters has been constructed, together with the upper gate bay of an auxiliary lock 33.50 x 109.70 meters to be completed when required by traffic. The upper three locks, St. Anthony Falls Upper and Lower Lock and Lock No. 1, have locks 17 x 122 meters, with twin locks at Lock No. 1. The first three dams are located in Minneapolis-St. Paul, the last, within the district, is located in Guttenberg, Iowa.

These dams also create slack-water pools which attract recreational use for fishing, swimming, boating, hunting, and picnicking. A number of harbors were improved along the Mississippi River as part of the Upper Mississippi River 2.74-meter Channel Project. The dredge material from maintenance of the 2.74-meter channel are disposed of in ways that benefit the environment whenever possible. Islands for creation of habitat have been constructed in coordination with the Fish and Wildlife Service.

In addition to the Locks and dams there are flood control projects in Aitkin, Elk River, St. Paul, South St. Paul, Hastings, and Winona, Minnesota and Guttenberg, Iowa.

These projects consist of levees, and/or diversion channels. A flood control project in Prairie du Chien, Wisconsin consisted of the purchase and/or relocation of flood proofing of buildings within the 10-year flood plain.

All in all, the Mississippi River within the St. Paul District drains an area of 207,000 square kilometers, of which 116,000 are in Minnesota, 83,000 in Wisconsin, and the remainder in South Dakota and Iowa.

Downstream from Lock and Dam 10, the Rock Island District is responsible for administering federal water resource development programs in large portions of Iowa and Illinois and smaller portions of Wisconsin, Missouri and Minnesota.

The District operates and maintains 12 locks and dams on its portion of the main stem Mississippi River and 8 locks and dams on the Illinois Waterway. It constructed and operates three flood control reservoirs in Iowa: Coralville Lake on the Iowa River and Red Rock and Saylorville Lakes on the Des Moines River.

The Coralville Lake project is located on the Iowa River upstream from Iowa City in Johnson County, and is a part of the general comprehensive plan for flood control and other purposes in the Upper Mississippi River region. Construction began on this project in July 1949 and it was completed and put into operation in February 1958. The dam controls runoff from 8,064 square kilometers above the dam and provides protection to 4,408 square kilometers below the dam including Iowa City, Coralville, and Columbus Junction. The normal conservation pool at the dam is 208 meters NGVD with 52,053,278 cubic meter of storage. The flood control storage pool provides an additional 516,832,310 cubic meter of storage. The cumulative damages prevented since the project has been in operation (1959 through September 1992) are estimated at $46 million.

The Red Rock Dam and the Lake Red Rock Project on the Des Moines River are chiefly in Marion County, but extends into Jasper, Warren, and Polk Counties. The dam is approximately 96 kilometers downstream from the City of Des Moines.

The drainage area above the dam site is 31,892 square kilometers. A permanent lake of 327,491,595 cubic meter storage area is formed behind the dam. With the flood control pool full, the reservoir storage is 1,831,609,301 cubic meter above the conservation pool of 226 meters NGVD. The net cumulative damage prevented since the project has been in operation (1969 through September 1992) is estimated at $332.5 million. Flood protection is provided to 14,600 hectares of agricultural lands in the Des Moines River basin and to the Cities and Towns of Ottumwa, Eldon, Eddyville, Keosauqua, and Farmington.

In 1958, Congress authorized construction of Saylorville Lake on the Des Moines River about 17.6 kilometers upstream from the city of Des Moines. The principal purpose of the Saylorville project is to furnish needed additional storage to supplement the flood control capacity of the downstream Red Rock Dam and Lake Red Rock and to provide flood protection to the City of Des Moines. The permanent conservation pool forms a lake with storage area of about 111,014,100 cubic meters and extends some 27.2 kilometers upstream from the dam.

The reservoir has a total capacity of 833,839,240 cubic meters and covers about 6,757 hectares. The conservation pool was raised from 253.89 to 254.81 meters in 1983 to provide a water supply for the city of Des Moines and the Iowa Southern Utilities near Ottumwa, Iowa. The

Saylorville Project has been in operation since April 1977. Estimated damages prevented from 1977 to 1992) are $43 million.

Along the Mississippi River, downstream from the mouth of the Des Moines River, levee districts and the Cities of Quincy, Illinois and Canton, LaGrange, and Hannibal in Missouri also benefit from the combined operation of these three reservoirs.

Other local flood control protection projects built by the district include Waterloo, Evansdale, Des Moines, Clinton, Dubuque, Marengo, Marshalltown and Bettendorf, Iowa; Rockford, Fulton, East Moline, Rock Island, Milan, Illinois and Hannibal, Missouri.

THE FLOOD

The Great Flood of 1993 affected a large portion of the midwestern United States, crossing the boundaries of several Corps of engineers Districts, including: St. Paul, Rock Island, Omaha, Kansas City, and St. Louis. Each of these districts experienced some degree of flooding during the spring and summer of 1993. In no single district, however, was the geographic extent of flooding larger than in the Rock Island District, where virtually every major stream exceeded flood stage at least once in the six months from March through August, and numerous historic river stages, flows, and rainfall events were recorded.

The Flood of '93 really started in November of 1992. The snowfall that winter was greater than normal. Then in March, 1993 heavier than normal spring melt saturated the ground. During the period April 1 to July 25, the Midwest averaged over 0.45 meter of rain, with many areas receiving more than 0.76 meter.

In June and July, unusual weather patterns produced a series of extremely heavy periods of rainfall. An abnormal high-pressure system brought drought to the southeast, pumped moisture in from the Gulf of Mexico, and blocked the movement of storms out of the region.

Rainfall during July exceeded 462% of normal for the Missouri River Basin and 433% for the Upper Mississippi River Basin. These conditions, combined with a low pressure in southern Canada, spawned wave after wave of intense thunderstorms across the nine states.

The news media have dubbed this the Great Flood of 1993. That's actually a bit of an understatement. To report that this flood exceeded past record events doesn't tell the whole story: from the Quad Cities of Illinois down past St. Louis, this flood broke the record levels set by the major floods of 1973 and 1965.

It not only broke the records but in some areas it was more than 1.83 meter higher than the previous record. (See Figure 2).

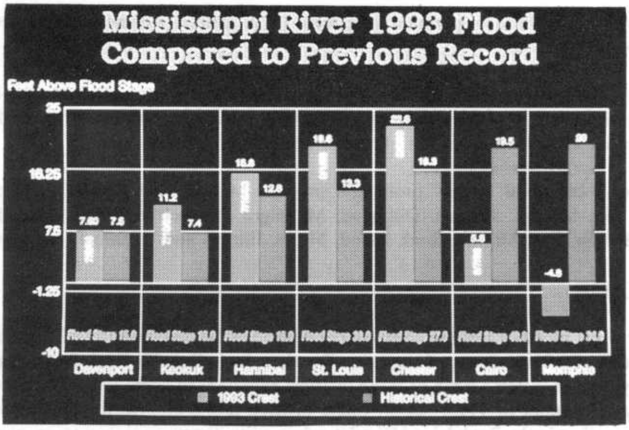

Figure 2

But it was not only levels that made this flood so disastrous, it was the duration of the record levels.

In most areas, the river stayed at extremely high levels for days and weeks, saturating and severely testing the levees that line much of the river. The duration factor prolonged the time that highway, railroad and barge traffic was disrupted, costing the nation millions of dollars.

So what turned the normally slow and gentle Mississippi River into this. The answer is really very simple. Starting in late spring in the upper Mississippi River basin area, it rained, incessantly.

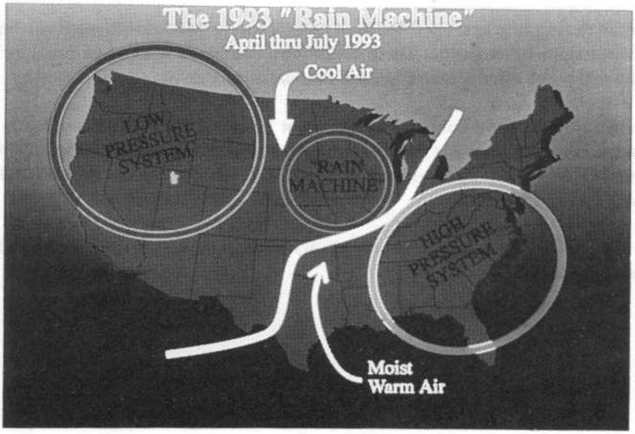

Figure 3

A low pressure area that stretched trom Iowa eastward to southern Wisconsin developed and remained essentially in place for many weeks rather than the few days it normally takes for a front to pass. The result was hot, humid weather in the northeast and wet weather in the upper Midwest. (Figure 3). This front remained in place from April throughout July. The month of July in Iowa was the wettest ever recorded.

These rains fed the Mississippi River, causing it to test flood walls in the Twin Cities and to grow higher and wider as the flood waters traveled downstream toward St. Louis. As the peak level of the flood moved down river, it continued to rain, causing even higher levels and in many cases, extending the duration of record levels.

To get a more detailed look at the flood, let's follow its path, highlighting some specific areas along the way. (Figure 4).

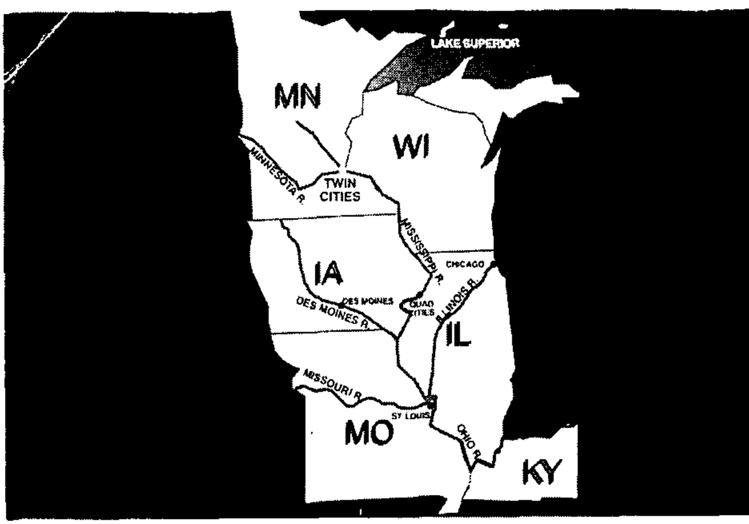

Figure 4

This flood really started in the Minnesota River, which drains southern Minnesota before joining the Mississippi River at the Twin Cities.

Starting in late March, a series of storms brought heavy rainfall toward the region. By late June, these rains had saturated the soil and the Minnesota was soon out of its banks and into towns and farm houses. While this flooding caused millions of dollars in damages, it was only a small precursor of what was to come.

Soon, the floodwaters of the Minnesota reached the Mississippi at St. Paul. This was not a record flood yet but it was the highest level St. Paul had seen in the summer months.

Partly because of a flood control project, the flooding in the Twin Cities was minor, but this flood had not really reached its peak.

The flood peaked in St. Paul on the 26th of June. By the 30th, it had passed down to Prairie du Chien, Wisconsin. Along the way, cities such as Winona, Minnesota, and Guttenberg, Iowa were spared damages because of levees and flood walls built by the Corps of Engineers.

Prairie du Chien is a special case. This historically significant town sits on a low, flat island in the middle of the Mississippi River.

When the Corps examined Prairie du Chien flood problems in the late 1970s, it decided on an innovative course of action. Rather than try to keep flood waters out of the houses, the Corps moved the houses to keep them out of the way of the flood. Because of this partial evacuation of the lowest areas, this year's flooding had minor effects in the area.

We often find that such a non-structural flood control alternative is best for a community. Since the 1970s, we have been a leader in advocating wise use of the flood plain rather than the building of expensive flood walls and levees. Whenever we begin a flood control study, we first examine the nonstructural alternatives such as that implemented at Prairie du Chien.

By the time the crest of the flood reached the Quad Cities, Iowa, it had developed national media interest. On the 9th of July, it peaked at a little over 6.88 meters, breaking a record that had lasted almost thirty years.

Also, the Corps of Engineers became involved gradually over the years by strengthening and raising some of these levees. Maintenance, however, has remained a local responsibility. The Corps has a program that encourages the local entities to keep their levees well maintained by guaranteeing to rehabilitate levees damaged by floods.

These agricultural levees were no match for this flood. Most are only built to withstand a 20- or 50-year flood, while this flood was generally in excess of a 500-year flood in this area.

Quincy, Illinois, is one of the larger cities within this agricultural levee region. It is also the site of a levee breach that caused a particularly large amount of economic disruption and damage.

On the 16th of July when the Fabius drainage district levee gave way, the Mississippi River flood waters quickly filled a five-mile area including the ramp to the last Mississippi River bridge for a 200-mile stretch of the river. The Quincy workers who live in Missouri make up more than a quarter of the total workforce.

While you will find the typically earthen agricultural levee in most parts of this region, the Corps has constructed flood walls and levees to protect the larger towns such as Rock Island, Illinois, Bettendorf, Iowa, Quincy and Hannibal, Missouri.

The Hannibal project is one we are particularly proud of. Many of the houses that Mark Twain wrote about in his famous Mississippi River novels are quite close to the river and very flood prone. Fortunately, we just finished a project there this spring.

Even so, this flood forced us to quickly add a three foot extension on the top of the newly constructed flood wall. It was very close for a while. But our new project held back the mighty Mississippi River, leaving the historic treasures intact.

After peaking in the Hannibal/Quincy area during the third week in July, the worst of the flood passed on down toward St. Louis, Missouri. The results were much the same as the upper part of the river. Most of the agricultural levees were overcome by the flood.

Regarding navigation, it was noted previously that the Corps of Engineers operates 29 locks and dams on the Mississippi River between the Twin Cities of Minnesota and St. Louis, Missouri.

The purpose of these navigation structures is to maintain a nine-foot depth for barge traffic up and down the river during periods of low flows. They give us no control over flood waters.

At most of the locks below Dubuque, Iowa, the flood waters washed over the lock walls and flooded the control building. Navigation was, of course, impossible. We did our best to get our facilities operational as soon as the water receded, but the barge traffic was still suspended from late June until mid-August, costing the shipping companies and barge operators millions of dollars.

Other forms of shipping were also disrupted as railroad lines were washed out and bridge closures blocked trucking routes.

As we usually do in a flood, we fought this one as it happened. We distributed more than 33 million sandbags and miles of plastic sheeting to help local communities protect themselves from this flood.

We also stationed at critical areas up and down the river dispensing technical assistance. In most cases this involved advising local drainage districts in the best way to shore up and raise their levees as the flood waters rose. We worked in partnership with the National Guard and the local drainage districts to keep this flood from causing any more damage than it did.

While the Mississippi River locks and dams were not usable for flood control, three of the Corps of Engineers flood control dams in Iowa played a key role in mitigating the damage caused by this flood. We operate two of these reservoirs, Saylorville and Red Rock on the Des Moines River and the other one, Coralville on the Iowa River. The Des Moines and Iowa Rivers are major tributaries to the Mississippi River and their drainage basins received some of the heaviest precipitation during this flood.

This precipitation quickly filled the reservoirs and threatened to drastically reduce our ability to provide additional flood control storage. For the first time since they were constructed, water went over the emergency spillway at both Coralville and Saylorville. When this happens, we lose a measure of control over the outflow downstream. As the waters reached the top of these dams, some careful decisions had to be made over downstream release.

Saylorville Dam is perhaps the best example. It is located 11 miles north of Des Moines and can be used to regulate the flow of the Des Moines River as it passes through the city. As the reservoir behind the dam filled, it was necessary to increase the flow through Des Moines to prevent flooding of areas upstream of the dam. In early July, we had to carefully regulate the flow through Saylorville, insuring that it was not too much for the downstream flood control levees in the city.

Once the reservoir started spilling over the emergency spillway, we had to keep in mind that amount of water as it combined with our controlled outlet flow.

Of course, the dam saved millions of dollars in additional flood damage to the city. If the dam had never been constructed, vast portions of the city would have been underwater.

Unfortunately, Des Moines was a victim of this flood, as its water treatment plant was flooded out, suspending water services to this city of a quarter million people.

The water treatment plant was flooded by the Raccoon River, which drains the area west of the city. Since the Raccoon River enters the Des Moines River downstream of Saylorville Dam, we had no control over the flooding at the water treatment plant.

The situation in Des Moines brings up another aspect of our flood response and recovery efforts. Once the Des Moines water problem was declared a national disaster, we could be brought in under the auspices of the Federal Emergency Management Agency (FEMA). We often provide engineering support to FEMA when natural disasters occur. In this case, we were tasked to provide potable water to Des Moines citizens and to put the water treatment plant back in operation as soon as possible.

Working closely with the National Guard and the City of Des Moines, we quickly began distribution of a million and a half gallons of water per day. Within 48 hours from the flooding of the water treatment plant, we were providing enough potable water to supply everyone with 2-1/2 gallons of water per day. We contracted to have the water trucked from outlying areas to more than 100 water supply sites located in Des Moines schools, shopping centers and community centers. We awarded other contracts to provide a half million gallons of bottled water per day and tankers of non-potable water for fire fighting.

Additional contracts were issued to set up reverse osmosis water purification units and other water purification units. These units converted river water to potable water for use by local hospitals. The Corps also contracted for 2,000 portable toilets for use at the distribution sites and other public areas. The Corps' second FEMA tasking, to get the water treatment plant on line, was challenging. Since it was impossible to get to the plant with ground vehicles, helicopters were used to airlift parts in and out and to bring in sandbags to increase the height of the protective levee. Corps divers checked clear wells for flood damage and cleaned the sedimentation tank. The plant was back on line one week after it had shut down, although water was not pronounced safe to drink until July 30.

In summary, the Corps' response to this flood kept it from becoming a disaster of even greater proportions. We estimate that our flood control projects that were in place at the start of the flood prevented an estimated $2.5 billion in damages.

We have calculated that if our three dams in Iowa had not been there to retain many of the flood waters, The Mississippi River crest would have been 0.61 meter higher at Quincy, Illinois, and one and a half feet higher at Hannibal, Missouri. That much more water would have had disastrous consequences.

Our flood fighting efforts also made a difference. We immediately set up a 24-hour emergency operations center at Division office in Chicago and at our Rock Island District headquarters as well as at field centers in Quincy and Des Moines. We brought in Corps employees from other Corps districts and divisions to provide the necessary expertise to help local communities fortify their levees. We were there doing all we could to help the local people attempt to win their dramatic battles with the tremendous force of this flood.

Unfortunately, more than two dozen non-federal levees in our area eventually succumbed to the flood waters, flooding more than 190,000 acres of farm land and several small towns.

But there were many success stories as more than half of the federally constructed locally maintained levees were not overtopped.

Repair Activities

As to the status of emergency repair in the Division, most of the damages occurred in Rock Island District where most of the flood was located. There are about 32 projects eligible for repair amounting to a total cost of $49 million. Of these projects, four are completed, nine are 50% completed with all the breaches closed. Pumping stations at these nine projects are being repaired and at some the equipment is being replaced. Meanwhile, pumping capability is made available at these locations and final repairs involving erosion remedy and shaping are approved for construction and will start shortly. Work is scheduled to start soon at the other 19 locations. So far $30 million have already been expended.

Damages Prevented

Though the final figures are not available yet, our latest estimates indicate the following. In the St. Paul District, the reservoirs were operated to the extent possible to reduce damages on the Minnesota and Mississippi Rivers. Total damages prevented during the flood was $2.8 million. Total damage prevented by Corps projects including levees, local projects, and emergency projects was $118 million. In the Rock Island District, the three reservoirs were operated to protect the Iowa, Des Moines, and Mississippi Rivers. The total damage prevented was $795 million ($2 million on the Iowa, $298 million on the Des Moines, and $495 million on the Mississippi). The Corps projects including levees and emergency works prevented $110 million dollar damages.

COORDINATION WITH OTHER OFFICES:

Very intense coordination between four other Divisions and the Headquarters office in Washington took place during the entire flood which affected not only the Mississippi, but also the Missouri River to a great extent and to a lesser extent the Ohio River. Close coordination regarding optimum releases from our reservoirs had to be orchestrated to ensure that the damages be mitigated to the greatest extent possible. Televideo conferences took place several times between the Division Commanders from the North Central Division, the Missouri River Division, the Ohio River Division, the Lower Mississippi Valley Division, the Southwest Division, and the Director of Civil Works from the Chief of Engineers office in Washington. Teleconferences among the Water Control Managers from these respective offices took place several times a week to share and coordinate information on the regulation of the Reservoirs, to monitor the hydrometeorological conditions, the impact on navigation, the ongoing damages, the distribution and allocation of resources and manpower throughout the various offices as need be.

POST FLOOD REPORT:

We have been actively working on the preparation of a Post Flood report which will relate in minute detail the information regarding the flood, the cause of it, its occurrence, its magnitude, intensity, and duration. The report which is due for release in October of 1994, will cover in five Appendices and a Main Report the entire story of the flood. The Appendices will address the Upper Mississippi, the Middle and Lower Mississippi; the Upper Missouri and the Lower Missouri River. Those who would like to be on the mailing list may submit their request to the North Central Division office in Chicago.

WORKSHOP 1: Educational renewal

The workshop will focus on new educational challenges. What insights are needed to change attitudes towards waste handling so as to promote improved water quality?

Tomorrow's professionals have to communicate across sectors and disciplines in order to cope with the multi-sectoral and increasingly complex issues related to the protection of water quality.

The workshop will address the whole sequence from educational philosophy to the implementation of new educational efforts and developments on all levels, from pre-school to university, from the general public to professionals and politicians.

The Global Rivers Environmental Education Network (GREEN)

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Abstract

Green originated as a water quality monitoring project in the Great Lakes
region of North America in the mid 1980's. By 1989, workshops in 18 countries were being held to lay the foundation for a global network. Today GREEN has programs involving tens of thousands of students in 130 countries around the world.

Each watershed project is unique, and how it develops depends upon the goals and situation of the local community. Students investigate the health of their local river studying chemicals, biological and physical parameters, as well as the history. The information and data gathered are used to identify water quality issues, helping students discover how human behavior and other forces impact water quality. As they share cultural perspectives, students teachers, citizens and professionals from diverse parts of the world are linked by a common bond of interest in and concern for water quality issues.

Young citizens learn how to apply science to their daily lives and how they can effect change through their actions. As they realize that their work is part of an international effort to improve watersheds, they begin to believe in themselves as vital stewards of the environment--a belief that is the foundation for a sustainable future.

Learning about different societies' perceptions of water encourages students to develop cross-cultural sensitivity. Hearing of others actions can prompt local efforts to solve critical river issues. Some of the ways that GREEN brings people together are through the GREEN Newsletter, computer conferences on EcoNet, and the Cross Cultural Partners Program.

GREEN's programs promote international cooperation while building foundations for real world environmental concerns. It is only through this heightened cooperation and understanding that we will move toward a more trusting, caring, peaceful and ecologically sound world for future generations.

INTRODUCTION

Through the University of Michigan's innovative GREEN (Global Rivers Environmental Education Network) project, teachers all over the world are taking students down to their local river and teaching them to monitor water quality, analyze watershed usage, identify the socioeconomic determinants of river degradation, and present their findings and recommendations to local officials. These students are also exchanging their data and insights with other students in other cultures throughout the world. GREEN is designed to empower students, not only to learn in depth about their local environmental problems, but also to act on their discoveries, and to share their knowledge in a global, cross-cultural context.

PLANNING

What is GREEN?

"Globalization" is a word you commonly hear in educational circles these days. It refers to the widely acknowledged need of schools to equip their students for an interdependent world, linked by a closely coupled world economy. This shrinking world is brought closer together by massive environmental problems and issues that transcend national and even continental boundaries -- issues that we can address only through an unprecedented degree of global cooperation. One major challenge that will increasingly confront environmental educators is to develop curricula and instructional strategies that present local environmental issues in a global perspective--but without overwhelming the students or making them feel hopeless. How can we educate and empower students to take action on local issues, while simultaneously developing within them a global, cross-cultural perspective on these issues? How can we best educate this first generation of truly planetary citizens to assume responsibility for their shared, imperiled home?

One promising new approach to meeting this challenge is the Global Rivers Environmental Education Network (GREEN), recently initiated by Professor William B. Stapp and graduate students of the University of Michigan School of Natural Resources. Still in its early stages of development, GREEN is an international network that seeks to bring secondary school students, teachers and communities around the world closer together through the bond of studying and improving our common river systems. The network is an expanding global communication system that invites participants to reflect on ways that land and water usage and cultural perceptions influence river systems and visa versa, encouraging them to learn about and become involved in complex, real-world concerns that extend across all boundaries. In this way, GREEN works to achieve three interrelated goals:

- it acquaints students with the environmental problems and characteristics of their local watershed, giving them "hands on" experience in the theory and practice of chemical, biological, and sociological research;

- it empowers students through community problem-solving strategies, thereby enabling them to see the relevance of subjects they learn in school to the "real world;" and

- it promotes intercultural communication and understanding, and thereby fosters awareness of the global context of local environmental issues, and of the significance of cultural differences in choosing effective problem-solving strategies.

Why Rivers?

Rivers were chosen as the central focus of the project primarily because they are a reliable and informative index of the environmental quality of their watersheds. But rivers also form a nexus for relating chemistry to biology, and for relating the physical sciences to the social sciences and humanities, since rivers bind together the natural and human environment from the mountains to the sea, and from farmland to the inner city. In fact, 85% of the world's human population lives on or near a river. For these reasons, the study of rivers forms a coherent curricular framework for the study of a wide range of environmental issues and problems. Rivers also contain a historical perspective on cultures and history, forming an ideal basis for learning about cultural diversity, and for engaging in cross-cultural dialogue.

Through involvement in a network on local rivers, students share information, techniques and different approaches to problem-solving. They also can learn that their investigations have a purpose and are valued by their peers elsewhere in the world. The intention of this process is to motivate the students to further their understanding and work to resolve some of the water quality problems that they have discovered. GREEN is therefore a program designed to bring individuals closer together and encourage them to develop a sense of responsibility for their communities and their planet simultaneously.

Origin and Development of GREEN

The roots of the Interactive Water Quality Monitoring Program, adapted throughout GREEN, are from a biology class at Huron High School on the banks of the Huron River, Ann Arbor, Michigan, in 1984.

In 1984, a concessionaire was permitted to operate a windsurfing program at a local park on the Huron River. Then in 1985, the local Public Health Department noted that several persons who had been active in this park had contracted Hepatitis "A", including a student from Huron High School.

Student concern about the river water quality spurred a biology class to want to learn more. Working with Prof. William Stapp and Mark Mitchell of the University of Michigan School of Natural Resources, Dale Greiner, their teacher, acted on the students' interest in testing the river water. William Stapp had been active in designing pro-active environmental education programs with teachers in the area for over twenty years at that time. The challenge of student-oriented water monitoring was a natural evolution for him in his work with students and community problem-solving. Working collaboratively with graduate students from the University of Michigan and Huron High School, Dr. Stapp designed a two-week model water quality monitoring program based on the National Sanitation Foundation Water Quality Index that was appropriate for secondary school students. This was the seed of GREEN.

The classroom program continued at Huron High for the following two years during 1985-86, while the program expanded to two other high schools and communities on the Huron River, above and below Ann Arbor. All three communities conducted their two-week program simultaneously and the students shared results of their water quality monitoring, gaining a perspective on the changing water quality in the river.

In 1985 and 1986, the three high schools classes convened at a congress at the end of the monitoring period. They shared their test results, collected aquatic macroinvertebrates as indicators of water quality, and evaluated and recommended ways to improve the educational program. Many students continued to show their commitment by: working with the city to post areas of questionable water quality; requesting the city to lower water levels to allow river clean-up activities; preparing letters to government officials regarding the results of river monitoring; and making presentations at national and international conferences.

In 1987, Friends of the Rouge expressed an interest in transferring the Huron River monitoring model to their region. The Rouge Program was developed so that students from diverse socioeconomic classes--from rural areas through wealthy suburbs to inner city Detroit--could exchange information on the progressively deteriorating water quality of the river that connected them--and in the process learn about each other as well. The program was initiated with 16 high schools in 1987, and has expanded to 60 high schools in 1994.

During the five years that the Rouge Program has been in existence, the following new components have been added to the Huron River model: establishment of a Rouge River Advisory Committee made up of educators, community leaders, and natural resource professionals; linking classrooms with community organizations and citizens by an interactive computer conference program; staging of an extensive youth congress at the end of the program to bring together students from all participating schools; a social studies simulation game on watershed management; initiating a heavy metals testing program; and involving selected schools in cross-cultural partnerships.

The Next Step: GREEN

The very fact that constraints and resources exist for water monitoring programs is actually incentive for a network of programs to be developed so that the successes and failures of the individual programs can be shared. After extensive experience with a variety of water monitoring programs and school scenarios, the concept of an international community of such programs was a natural, if not ambitious, step for the School of Natural Resources. The concept of GREEN was crystallized in 1989, as the result of a seminar of graduate and undergraduate students led by William B. Stapp in the School of Natural Resources at the University of Michigan.

IMPLEMENTATION

Components of the GREEN Network

Using communication to solve environmental issues and empower students to undertake these challenges is the backbone of GREEN's philosophy. The network presently disseminates a semi-annual international newsletter to over 2100 educators, ministry officials and other resource persons in 125 countries. A series of GREEN International Computer Conferences has been established on EcoNet, an international communication system within the Institute for Global Communications that serves participants working for environmental preservation and sustainability. In addition, GREEN has created the Partner Watershed Program to link classrooms between nations to share their cultures, water data, and land issues.

The GREEN Newsletter:

The GREEN Newsletter is the most extensive communication tool of the Network due to the accessibility of the mail system. Each newsletter focuses on a particular theme of interest such as: how to start a water monitoring program, low-cost monitoring techniques, or models and methodologies for student action taking. In addition, each issue highlights exciting programs that serve as examples for local water monitoring and student problem-solving for different parts of the globe.

The GREEN International Computer Conferences:

The GREEN Conferences have established an international database of student-collected water quality data, and the exchange of ideas and concerns between students, teachers and other professionals. Participants from a range of different nations are able to communicate their experiences and receive almost instantaneous response from international participants.

The GREEN International Computer Conferences are hosted by EcoNet, an interactive computer network based at the Institute for Global Communications in San Francisco. The network has over 3000 active participants in more than 80 countries. In addition, the GREEN conferences are networked through EcoNet into the international Association for Progressive Communication (APC), a consortium of computer nodes on each continent. Thousands of users in other nations can access GREEN due to APC's extensive networking system.

In addition, through GREEN and EcoNet, individual watershed programs use the networking capabilities to host local computer conferences. GREEN anticipates a significant number of watershed-wide computer conferences opening up on EcoNet throughout the United States (and corresponding watershed conferences on the other APC networks) as more programs develop their telecommunication abilities. These conferences allow the students to enter their data and communicate interactively between schools within the same watershed, and also access the international GREEN conferences

The Partner Watershed Program:

The Partner Watershed program has sparked remarkable interest among the network. In the pilot program in the spring of 1991, GREEN partnered schools involved in watershed projects in different countries to develop the cross-cultural sharing inherent in the network. The pilot student-to-student links were hosted by watersheds in the United States, Canada, Mexico, Hungary, Australia, New Zealand, and Taiwan. Using local water quality issues as a medium for discussion, students exchanged personal cultural perspectives and concerns for the environment, along with ideas for ways to improve their environment. Students communicated by mail and computer to share their thoughts.

The goals of this cultural exchange program are to stimulate greater international awareness in students, while at the same time, motivate students to develop concern for improving their local waterways. GREEN is presently expanding the program to other nations and developing research strategies for evaluating the impact of the program on the participants.

The Dissemination/Clearinghouse Role of GREEN

GREEN not only acts as a network but as a clearinghouse. The international GREEN Office provides materials in both English and Spanish. Participants can join GREEN as an individual school involved in monitoring or as a watershed-wide program that involves schools within the same region. The GREEN office has made an effort to document the successes of these programs, and incorporate innovative activities into curricular materials for dissemination.

International participants are encouraged to contact active GREEN programs near them to create local networks. GREEN supports collaborative work between educators with similar resources and water quality conditions. One example of this is the work of one educator/organizer, Rob O'Donoghue in South Africa. Rob has taken the challenge of low-tech monitoring and developed methods for creating 'home-made' equipment with fairly reliable results providing a model for educators with similar conditions.

Budgetary Considerations:

The funding for GREEN has been incremental and quite small considering the scope of the program. The initial workshops internationally were funded from a variety of foundations, corporations and the University of Michigan. After that initial summer, the bulk of the funding was received from the General Motors Foundation. To date, the GM Foundation continues to sponsor the infrastructure of GREEN, while other proposals have been accepted for the development of specific programs within the Network. Other funding sources are continuing to be cultivated.

GREEN is also working to become more self-sufficient through the sales of curricular material, subscriptions, sponsoring workshops, and consulting fees. Many of the watershed programs that exist are funded by local businesses, or foundations, and these programs occasionally sponsor GREEN workshops to enhance their teacher training.

PRODUCT

GREEN as an education program will always be in the process of evolving and developing. However the structure of the network has been created and is currently actively growing.

Future Needs and Directions

There are a plethora of programs that GREEN could develop under the concept of student environmental monitoring. Currently, a student-based *Heavy Metals Monitoring* program is in the early pilot stages at the University of Michigan. An *Air Monitoring* program was initiated in 1991 with the assistance of the Technical Education Research Committee in Boston, Massachusetts. Students are learning to monitor ground-level ozone within this project. *Groundtruthing* from satellite photographs is another hands-on approach to classroom science that GREEN has been developing curricula for with the Aspen Institute for Global Change. *Soil Monitoring* is another dimension of environmental monitoring that GREEN could research and support. *Brackish water monitoring* is another area of work that some participants have expressed interest in seeing further work. One further development within GREEN is the proposal for a *River Jordan Project* to link the different cultures in the Arab-Israeli Region to recognize their common resource of water.

One significant project to develop is extensive research into low-technology monitoring. Most nations within GREEN do not have the resources or access to the field kits available in the United States, Europe, and Australia. However the components in these field kits can be substituted with chemistry lab equipment given the proper instructions. GREEN wishes to focus more intensively in this area to better meet the need of all participants.

Research

The realms of programs within GREEN offer a rich resource for research in: environmental education; telecommunications within the classroom; cross-cultural communication between students; teacher changes in teaching practices: and school support of interdisciplinary educational projects. Student action-taking is another area within the scope of education that has received little attention. GREEN will strive to find further resources for research into the effects and changes that environmental monitoring programs encourage in the educational field.

Regional Development of GREEN

Truly, the value of a network is its relevance to local participants. Over the long term, GREEN plans to establish regional offices in each region of the world to strengthen the international network. Experience from other international organizations shows that developing a decentralized regional infrastructure is the most productive and culturally sensitive way to achieve GREEN's goals. Each office will identify regional needs and resources. It will set the priorities of the region and commit to utilizing the local expertise and resources of the area to help resolve local water quality issues.

Presently, GREEN has selected country coordinators in each of the 130 nations in the network. These coordinators are chosen to assist in the dissemination of the *GREEN Newsletter.* But more importantly, these individuals will determine their basic needs and priorities for water quality monitoring and draw upon local resources that can enhance their nation's programs. They may also initiate local GREEN workshops for teachers within their nation, further disseminating and strengthening their programs.

Training Development

GREEN intends to offer a selection of training sessions for its participants. International Workshops and Congresses provide opportunities for teachers and students to discuss their educational practices and concerns about rivers and water quality directly. For students, such interaction may be the most powerful experience in raising their cultural awareness and environmental sensitivity. At the workshops, teachers and students may not only share their monitoring data, but also develop action strategies and design future cooperative projects.

CONCLUSION

The concept of student environmental monitoring is an exciting one. The prospect of students, teachers, researchers and other professionals communicating about their local environment concerns nationally and internationally is significant. It is GREEN's vision to reach this potential so that students can be empowered to become active learners and problem-solvers through a successful networking system incorporated into their educational process.

For more information about GREEN contact:

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Ann Arbor, Michigan USA 48104

Our Uniting Water: Water, Environment, Education
an international program for children of 6 to 16 years and their teachers
Ir. Ben van Bronckhorst, Globetree Foundation, Stockholm, Sweden

Summary
The following is background material to my presentation of the work done with/in the Globetree Foundation on changing water attitudes and developing another approach to water related issues. The operational idea is: to reach adults through (their) children, and practically prepare the generations for another way of dealing with water and the environment.
More in particular, I will tell about and show work in progress, in the three (soon four) learning projects Globetree develops within this - SIDA supported - program: "Our Uniting Water" - Water, Environment, Education, 1993 - 1996. While each learning project is designed in accordance with local needs and possibilities, water is the integrating component.
I will also refer to our Uniting Water Ceremony, telling about its effect, most recently in the International Ministerial Meeting on Drinking Water and Environmental Sanitation - implementing UNCED Agenda 21, March 1994 in Noordwijk, the Netherlands.
Last but not least, I will refer to our Circumnavigation as an example of putting the drama of water and the environment (litterally) on a world stage.

Globetree's Water Program was initiated in close cooperation with Prof. Dr. Malin Falkenmark whom we cannot thank enough for her invaluable support.

Aim and Method
Our Uniting Water seeks to involve children, the world over, in the process of finding practical solutions to the large variety of water related questions, by:
* Learning about water in nature and society
* Participation in solving problems associated with water
* Sharing knowledge, experience and feelings with one another and adults
* The Uniting Water Program rests on science and uses art as a main tool

The Program contributes to implementation, in the realm of children, what is stated in the UN Documents The Child's Rights, and Agenda 21 - and follows up the recommendations made since the UN Water Conference, Mar del Plata, 1977.

Main target groups in Sweden and international:
* Children in the school age, 6 - 16 years
* Teachers and teacher candidates
* Adults working with children outside schools

Program components:
* Schools and free time education - participating individuals, classes and schools
* Colleges of Education - courses for teachers candidates and staff
* Professional support - developing a Water Quality Research Network
* Future Meetings - Children's Dialogues with Experts
* Uniting Water Ceremony - Children's concern about water and the world
* Learning projects - science based activities embedded in cultural activities
* Networking - communication among children and teachers world wide

Future Meetings
Since 1986 every two years in Stockholm. The United Water Program was initiated in Future Meeting 1990. Since 1992 Regional and local Future Meetings are organized in various other places in Sweden and internationally.

Our Uniting Water Ceremony
Created in Future Meeting 1990, the Uniting Water Ceremony has since been presented by children in various international conferences related to water and the environment. The children collect water from all countries in the world and make their Uniting Water Book.

Learning projects in Sweden:

* North Sweden	Lule Älv och Östersjön
* Middle Sweden	Mälarvattnet i världen
* South Sweden	Under havet möts alla öar

Learning projects abroad:

* Brazil 1992-95	Children's Ecological Village, Tatui SP
* Kenya 1994-97	Children and women grow their own school, Homa Bay
* India 1993-98	Joint Management of Common Heritage, Varanasi, UP
* Indonesia	Creativity, Life Style, Environment, Bandung, West Java

Blue Wave Network
The Blue Wave Network emerged from Future Meeting 1992. It combines children and teachers and encompasses: Personal Development and Leadership, Creativity and Communication, Environmental Education and Eco-technology.

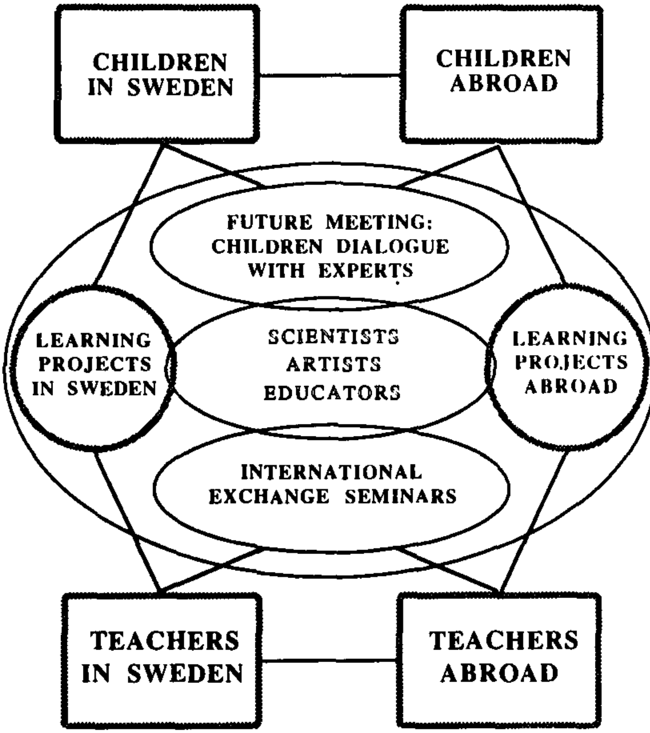
International Water Quality Research Network
In cooperation with the Royal Institute of Technology in Stockholm, an international network is build up for research on the management of pathogens and poisons in water. Involved academic institutions develop their work in association with the learning projects. Based on student work and staff investigations, the WQ network functions through electronic communications. Research institutions in Brazil and Indonesia are already involved.

Blue Wave - The Children's Messenger:
Globetree and Atlantic Sail Ventures organize a single handed, non-stop sailing around the world. The sailing, realized by Skipper Dennis Ören with his rebuilt Baltic Trader "Vega," aims at involving children in activities associated with two important UN Documents, the Child's Rights and Agenda 21.

Starting in 1995 in New York, on the occasion of the 50th jubilee of the UN, the sailing will first deliver Our Uniting Water to the UN General Assembly as a gift., In the spring of 1996, some 250 days later, the journey will finish in New York.

On the way to New York from Stockholm, as well as on its return to Sweden, the ship will visit several ports, to meet groups of children and teachers who take part in the venture. The Vega will keep in touch with all participants world wide, through satellite communication and electronic mail. During the sailing, children send one another messages about their own work with and for water in the world, and good examples of water and environment related projects will be shared.

Presently, some 150 schools, free time groups, educational and research institutions and various organizations are involved in this endeavor.



Globetree's working model
GLOBAL LEARNING

Globetree's vision is:
CHILDREN AND ADULTS COOPERATE
FOR OUR COMMON FUTURE.

GLOBAL LEARNING aims to realize that vision.
It provides a framework for international educational programs
on people and their environment.
Learning with and from one another is at the base of all programs.

1. Children and teachers cooperate in LEARNING PROJECTS. Learning projects can be small or big and locally or globally oriented. Learning projects should be tailored to school classes and/or schools.
Children and teachers bring forward their findings, conclusions and ideas in LIVING EXHIBITIONS or in INSPIRING PERFORMANCES. In the first place the children address a local audience - people in and around their school. In the second place they may address a wider audience, organizing bigger events such as Future Meetings. Essential thereby is to establish and maintain good two-way communication between generations.

2. Children groups doing learning projects meet periodically in FUTURE MEETINGS. These Future meetings are locally or nationally organized and can have regional or even global relevance. The children groups bring experiences, knowledge and ideas from their learning projects to the Future Meeting.
Future Meetings provide a platform to present the children's findings and visions. They combine living exhibitions of the children's work and ideas with an orchestrated artistic presentation of their concerns and hopes.

3. Central in Future Meeting is the children's DIALOGUE WITH EXPERTS. The questions and ideas they bring are presented to scientists, technologists, administrators, enterpreneurs, in general persons whose work influences the children's future.

4. Teachers share their experiences in INTERNATIONAL EXCHANGE SEMINARS. Those seminars can take place in relation to Future Meetings or are organized separately.

5. Special UPGRADING SEMINARS are organized in which specialists in selected fields share their knowledge and introduce new methods and techniques in teaching.

6. A group of scientists, artists and educators supports the entire process. That support is given as EXPERT BACKUP; practical advice to learning projects.
It also takes the form of REFERENCE, to review the findings, ideas and questions of children and/or teachers. The group, finally, GUIDES the process in Global Learning.

7. Globetree implements a Global Learning program on CHILDREN, WATER, ENVIRONMENT. The program follows the conclusions and recommendations of the International Conference on Water and the Environment, Dublin 1992. It is carried out in the perspective of Agenda 21, Rio de Janeiro 1992 and The Convention on the Child's Rights, New York 1990.

8. Instrumental to Water, Environment, Education is the BLUE WAVE NETWORK, with members and affiliates in some 30 countries.

9. The present Global Learning program encompass over 100 scientific, educational or professional organizations and institutions in Sweden and abroad.

10. Globetree directly supports 4 larger learning projects within the Water Program; in Brazil, India, Indonesia and Kenya. Indirect support is given to several other learning projects, within the Blue Wave network.

NETWORK OF PARTICIPANTS AND SUPPORTERS

SWEDEN

Schools:

Auraskolan; Barkaröskolan; Bergsbyskolan; Björkskogsskolan; Bolidenskolan; Boskataskolan; Brandbergskolan; Djupviksskolan; Eriksdalskolan; Finningeskolan; Frejaskolan; Frillesåsskolan; Furulundsskola; Grästorpskolan; Grävlinge förskolan; Götaforsskolan; Hammarkullsskolan; Holsbyskolan; Hållängetskola; Jernvallsskolan; Karlaskolan; Kråkbergsskolan; Kyrkskolan; Kävingeskolan; Lekenskolan; Lindbladsskolan; Lindbosskolan; Lännaskolan; Mariaskolan; Marie-fredsskolan; Murbergsskolan; Naturskolan i Öckerö; Råvekärsskolan; Segevångs-skolan; Stackgrönanskolan; Tunaskolan; Ursvikensskolan; Virsbiosskolan; Vittsjöskolan; Våxtorpsskolan; Yttre Ursviksskolan; Åkersskolan; Öjebynsskolan; Örbyskolan; Östratornskolan.

Universities and University Colleges

Chalmers Tekniska Högskolan; Folkhögskolan Biskops-Arnö; Högskolan Gävle/ Sandviken; Högskolan i Halmstad; Högskolan i Jönköping; Högskolan i Luleå; Högskolan för Lärarutbildning i Stockholm, Kungliga Tekniska Högskolan (CITEC and Kemisk Teknologi)

Organizations and Institutions:

Barnombudsmannan, Stockholm; Barn och ungdomsgrupp, Surahammar; Bibliotekstjänst, Lund; BioFocus Foundation, Stockholm; BRIS - Barnens Rätt i Samhälle, Stockholm; Etnografiska Museet, Göteborg; FAWA - Foundation for African Women Advancement, Stockholm; Framtidsjorden, Stockholm; Global Ghana Help Fund, Stockholm; Greenkids, Göteborg; Handikappinstitutet, Stockholm; IDEA - Innovations for Development Association, Stockholm; IVL - Institut för Vatten- och Luftforskning; Karagwe Föreningen, Borlänge; Kommunförbundet, Stockholm; Kultur och Fritid, Västerås stad; Kriminalvårds-styrelsen, Stockholm; Marinungdom, Stockholm; Miljövårds-bredningen, Stockholm; Natur-historiska Riksmuséet, Stockholm; Naturskolorna; Naturvårdsverket; NordNet, Stockholm; Reggio Emilia Institutet, Stockholm; Rädda Barnen, Strängnäs; SISU - Svenska Institutet för Sociala Uppfinningar, Stockholm; Sjöfartmuséet; Göteborg; Skogen i Skolan, Umeå; SMHI Sjöfart, Norrköping; Statens Institut för Handikapp-frågor, Härnosand; Statens Invandrarverk, Norköping; Statens Kulturråd, Stockholm; Stiftelsen Håll Sverige Rent; Stiftelsen Västerhavet, Göteborg; Stockholm Environment Institute; Stockholm Låns Landsting; Stockholms Universitet, Meteorologiska Institutionen; Studiefrämjandet; Svenska FN-förbundet; Utbildningsradion, Stockholm; Turistnämnden, Torsås ; WWF-Världs-naturfonden; Växthuset, Norrtälje.

INTERNATIONAL
Schools

Centro Educativo Morelia, Morelia, Mexico; Children's Environmental Village, Tatui, Brazil; K. Donelatisschool, Klaipėda, Lithauen; Laurel Springs School, Ojai, USA; Projecto Alfa, Tatui, Brazil; Santiago College, Santiago, Chile; School N 273, St. Petersburg, School N 734, Moscow, Russia; Szkola Podstawowa, Saczow, Poland; Taman Mini, Jakarta, Indonesia; Tartu Nature School, Tartu, Estonia; Ukaliussak-skola, Nuuk, Greenland; 5th Secondary School, Tartu, Estonia; Trinity College and Hillwood College, Kandy, Sri Lanka; Twenty schools in Homa Bay and Migori, Kenya; Fifty schools in Bandung, Indonesia.

Universities and University Colleges:

ITB-Center for Environmental Research, Bandung, Indonesia; ITB-Development Technology Center, Bandung, Indonesia; Kazakh National University, Alma Ata, Kazakhstan; Lamar University -Center for Creativity, Innovation and Leadership, Beaumont, USA; UNESP - Faculdad de Biociencias, Botocatú Campus SP, Brazil; UNUD - Biology Study Program, Denpasar, Indonesia.

Organizations and Institutions:

American Museum for Natural History, New York; Approtech ASIA, Manila, Philippines; The Calling, New York, USA; Centro del Bambú, Masaya, Nicaragua; CIRAN - Center for International Research and Advisory Networks, The Hague, the Netherlands; Ecofondo, Popayan, Colombia; Fundesco, Quibdó, Colombia; Fund for Ecological Education, Alma Ata, Kazakhstan; Gaia Foundation, London, England; Giriharja Puppeteer Foundation, Jelekong, Indonesia; Grupo de los Cien, Mexico City, Mexico; Hazelwood Foundation, England; INSEA - International Society for Education through Arts, Lodz, Poland; Institute of HeartMath, Boulder, USA; Inter-national Association for Water Quality, London, England; International Water Resources Association, Urbana Ill, USA; IRC, International Center for Water Supply and Sanitation, the Hague, the Netherlands; National Council for Development Communication, Varanasi, India; Neo-Humanist Association PCAP, Rio de Janeiro RJ, Brazil; Sanggar Pari Purna, Bona, Indonesia; South Nyanza Bongu Organizat-ion, Homa Bay, Kenya; Stichting Universele Opvoeding, Naarden, the Netherlands; Water Supply and Sanitation Collaborative Council, Geneva, Switzerland; WMO - World Meteorological Organization, Geneva, Switzerland.

Status: 940720

Globetree activities from 1982 - present

Stiftelsen Globträdet/ The Globetree Foundation (established 1982).
* Creates and organizes innovative programs, rooted in both art and science
* Aims at practical involvement of children in local and global sustainable development of people and their environment.

1982-1985: "Artists inspire children's environmental work".
Cooperation with the Indonesian Environmental Forum (Walhi)
1982: International Workshop in the Stockholm Ethnographic Museum.
1983: International Workshop in the Bandung Conference Center.
1984: Artists in Indonesia and Sweden make children's programs.
1985: Tour of the Giriharja Wayang Golek puppeteer group in Sweden with a newly created performance on humans and the living environment.

1986 -1992: Seven years plan: Framtidsmöte/ Future Meeting.
1986: Future Meeting: "What is of life importance for the future?", 600 children from Sweden and from 16 other countries stay in tents on Gärdet and perform in Stockholm's Concert Hall. Guest of Honor: Minister of Development Cooperation Lena Hjelm-Wallén.
1986: International Workshop in Hensbacka Forestry School, 70 children and adults meet to design future contents of Future Meeting.
1986: International Scientists Meeting: "A scientifically sound and comprehensive base for educational programs on the living environment"
1987: Publication of a teacher's reference book: "Water at Work"
1987: Local Future Meeting in Luleå.
1987: Mask dancer I Made Sija from Bali helps to prepare Future Meeting 1988.
1988: Local Future Meeting in Västerås.
1988: Future Meeting: "From where do we come and how do we meet?", 700 children and youth from Sweden and 12 other countries present their concerns in Stockholm's Concert Hall. Guest of Honor: Victor Soler-Sala of Unicef.
1988: International Workshop at Wik's Folk Highschool, 30 children and adults meet to design future international cooperation.
1989: Publication of the teacher's manuals:"Livet speglad i vatten" (Falkenmark) and: Människan och miljön" (Brennan).

1990 - 1996 Our Uniting Water
1990: Future Meeting: "Our Uniting Water" 600 children and adults from 16 countries. Guest of Honor: Mrs. Birgitta Dahl, Swedish Minister of the Environment.
1990: International Workshop at Älvkarleby Youth Hostel.
1990: Our Uniting Water at Action for Our Common Future. Guest of Honor: Mrs. Gro Harlem Brundtland, UN Commission for Environment and Development.
1990: Our Uniting Water Ceremony at World Environment Day in Mexico City, with children from Centro Educativo Morelia. Guest of Honor: World Environment Day Chairman Mr. Miguel Alemán Velasco.
1990: Our Uniting Water Ceremony at the inauguration of Safe Water 2000 in New Delhi, India. Guest of Honor: Vice President Shri Shankar Dayal Sharma.
1991: Children perform their Uniting Water Ceremony in the first Stockholm Water Symposium. Her Majesty Sylvia, Queen of Sweden, received the children's Uniting Water.

1992: Our Uniting Water at the inauguration Ceremony of the UN Conference on Water and the Environment, at Dublin, Ireland. Guest of Honor: The Taoseach Mr. Charles J. Haughey.
1992: Future Meeting in Homa Bay, Kenya. 300 children from 18 schools perform for an audience of 5000. Guest of Honor: The District Commissioner.
1992: Inauguration of the Children's Ecological Village in Tatui, Brazil, in association with UNCED in Rio de Janeiro: "While you talk we work on our Park".
1992: Future Meeting: "The Blue Wave", 600 children and adults from Sweden and 30 countries stay in tents on on Gärdet. They exhibit their work and perform in a Big Tent for an audience of 800 among which participants of The Stockholm Water Symposium. Guests of Honor: Stockholm County Governor Mr. Ulf Adelsohn and the Swedish Minister of the Environment Mr. Olof Johansson.
1992: Round Table discussion at Svartsjö Castle, 80 children and adults shared questions and ideas. Guest of Honor: Mrs. Inga B. Agnér, Mayor of Ekerö.
1992: International Workshop at Svartsjö Castle, 60 children and adults set the stage for cooperation on Water, Environment and Education in the coming seven years. Formation of the Blue Wave Network.
1993: Inauguration of the project: Creativity, Life Style, Education, in Bandung, Indonesia, with a Creativity Seminar attended by over 500 persons. Guest of Honor: Ir. Sarwono Kusumaatmatja, Indonesia's Minister of the Environment.
1993: Globetree receives SIDA support for its International Water Program.
1993: Children hand over their Uniting Water to the Awardee of the Stockholm Water Prize 1993, Dr. Madhav Atmaram Chitale.
1993: Exchange Seminar at the Children's Ecological Village, Tatuí SP, Brazil. Scientists, artists and educators from the Americas, Europe and South East Asia participate.
1994: Children present their Uniting Water to the Ministerial Conference on Water and Environmental Sanitation - Implementing Agenda 21, at Noordwijk, the Netherlands. Guests of Honor - Mr. J.G.M. Alders, Dutch Minister of Housing, Planning and the Environment and Mr. J. Pronk, Dutch Minister for Development Cooperation.

(Scheduled):
1995: Children's Meeting and workshop in the Children's Ecological Village in Tatuí SP, Brazil.

1995-1996: "The Children's Messenger."
1995: The Uniting Water is presented to the United Nations in New York on the occasion of its 50th jubilee.
1995: The Children's Messenger starts from New York.
1996: Return of the Children's Messenger in New York.
1996: Future Meeting in Stockholm, Report of the Children's Messenger.
1996-1999: Meeting Place Globetree
Activity calendar in preparation.

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EDUCATIONAL RENEWAL

*Dr. Felipe I. Arreguín-Cortés**

Introduction

The distribution of water around the world is unequal, and when compared with the distribution of the world´s population, this difference is more noticable. For example, water available, per capita, in cubic meters, is 109 in Canada, 15 in Russia, 10 in the United States, 4 in Mexico and 0.16 in Saudia Arabia and Jordan.

It has been estimated that 3,400 million people have access to only 50 liters per day, and the United Nations reports that 40,000 children die each day as a result of diaherric diseases and other causes resulting from lack of water. The current cholera epidemic is a manifestation of this shortage. During the last decade, there was a 7% fall in irrigated land; the world's grain reserve fell from 101 days in 1987 to 54 in 1989. Sandra Postel (1989) reported that 61 million hectares of irrigated land has difficulties with salinity.

To this severe situation we must add yet another complication: pollution. The water of many rivers, lakes and oceans is so deteriorated that measures for protection are urgently required.

This situation generates new challenges to formal and non-formal education. An analysis of these challenges requires the classification of the educational and of human surroundings, that is from the primary environment, the home, to the world scene. See Table 1.

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Formal education

Preschool. At this level, the study program must include training on how to use and save water in urban and rural areas, how water is polluted by cities and industries and notions of the hydrological cycle at a regional level.

Elementary school. Efficient water use and the improvement and conservation of water quality may be formally introduced for the home, municipality, industry and the rural environment. The concept of the hydrological cycle can be expanded to a national level.

Junior high and high school. Concepts in efficient water use, and improvement and conservation of water quality in the home, municipality, industry and rural areas can be consolidated. The fundamentals concerning water-saving devices (for toilets, showers, faucets, washers, pools and car washes), detection of leaks within the home and xeroscaping should be included (Arreguin, 1991). Industrial applications which should be discussed include recirculation, reuse and water use efficiency in heat transfer, power generation and process applications. The world hydrological cycle, and the basic concepts of sustainable projects at rural, regional and national levels should be considered within the education programs.

University. Consideration should be given to all the basic concepts of efficient water use: home and industry with water-saving devices, regulations, use restrictions, reuse, recirculation and reduced consumption; efficient water use techniques in agriculture: field, systems and administration; watershed using optimization techniques from lineal programming to decomposition and multilevel hierarchies.

For the rural population, technology must be adapted to local and environmental needs. The analysis of current and future pollution at a global level must be included within the study plan, to propose preventive or substitute measures.

Construction of new waterworks has been severely restricted. Within the educational program, emphasis must be placed on the maintenance, conservation, rehabilitation and modernization of existing structures (Lotti, 1992) from the municipal to the national level.

Most curricula at this level include the study of municipal and industrial wastewater treatment. However, the concepts of pollution prevention through cleaner industrial processes, nation-wide rural conservation techniques and pre-treatment of industrial and municipal wastes must be stressed. Studies in recirculation and reuse methods must deal, in-depth, with the physical and chemical characteristics of the industrial processes and the degree of degradation to determine the treatment required. These studies will be applied directly for the benefit of industry and agriculture.

The computer figures as an important ally in improved water use. New concepts in expert systems, and artificial intelligence will be applied to water administration in cities and industries nation-wide. Command-and-control technology allows for real-time process monitoring through the use of sensors, executive programs and feedback systems (G. Bugliarello, 1987). Computer assisted design technology makes the design, operation and maintenance of complex hydraulic systems possible. Important advances, including the development of strategies for computer design and administration, programs, networks, work stations, field stations and robots will impulse efficient water use (Bugliarello, 1987).

Postgraduate. At this level, where research and teaching are, necesary and closely linked working with advanced treatment techniques, efficient water use, and recirculation and reuse for city and industry must continue.

Non-point pollution at the rural, regional, national and global levels must be studied. This may be the greatest single challenge in the future.

From a regional and national viewpoint, the financial aspects, the operation of complex hydrological systems and the exploitation of fossil water must not be ignored.

Finally, the effects of global warming must be contemplated within the national and global scope.

Non-formal education

For the success of efficient water use, and conservation and improvement programs, the participation of a well-informed society is essential. Communication and education efforts must be developed for this purpose.

The variety of means to place the objective, goals and results before the public eye include notices included with bills, publicity campaigns in the press and on radio and television, billboards on the nation's highways and public transport systems; distribution of water-saving devices; creation and operation of ecological awareness centers where the community may receive training in and exposure to concepts in the rational development of water resources. Improvements in the ecosystem are achieved by the education and participation of society in recovering areas where production has fallen through reforestation, construction of dams for the control of runoff and sediments, preparation of terraces and general environmental sanitation (Comisión Nacional de Ecología, 1990).

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Table 1. Suggested topics by educational level and sector.

	Environment / Level	Home	Municipality	Industry	Rural	Regional	National	Global
Formal education	Preschool	Water use and savings.	Water pollution.	Water pollution.	Water use and savings.	Hydrological cycle.		
	Primary	Efficient water use.	Efficient water use. Improvement and conservation of water quality.	Efficient water use. Water pollution.	Efficient water use. Improvement and conservation of water quality.	Hydrological cycle.	Hydrological cycle.	
	Secondary-Preparatory	Efficient water use.	Efficient water use. Improvement and conservation of water quality.	Efficient water use. Water resue.	Sustainable projects.	Sustainable projects.	Sustainable projects.	Hydrological cycle.
	University		Efficient water use. Maintenance and conservation. Pollution prevention techniques. Expert systems and artifical intelligence. Command-and-control technology. CAD technology.	Efficient water use. Maintenance and conservation. Recycle/Reuse. Expert systems and artifical intelligence. Command-and-control technology. CAD technology.	Efficient water use. Appropriate technology. Maintenance and conservation. Conservation techniques.	Efficient water use. Maintenance and conservation. Expert systems and artificial intelligence. Command-and-control technology. CAD technology. Conservation techniques.	Efficient water use. Maintenance and conservation. Expert systems and artifical intelligence. Command-and-control technology. CAD technology.	Efficient water use. Immediate and long-term pollution. Generation of products. Pollutant reduction processes.
	Post-graduate		Efficient water use. Advanced treatment technology.	Efficient water use. Recycle/reuse. Advanced treatment technology.	Appropriate technology. Public communications.	Financial aspects of water. Complex hydrological systems operation. Public communications. Fossil water.	Global warming. Financial aspects of water. Complex hydrologicla systems operation. Public communications. Fossil water.	Global warming. Public communications.
Non-formal education	General public	Community participation	Sector development		Ecological development		Ecological sanitation	

The Living Water of Life

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Because in the end we will only take care of what we love, (to paraphrase a quote by Baba Dioum) an effective water awareness program should include materials that emphasize the beauty and wonder of water, and appeal to the senses and the emotions.

There seems to exist (at least in California) a lot of good training material on the subject of water conservation that deals with the science and the practicalities of water management. However, we have not been able to find any materials that evoke feelings of delight and appreciation for the waters of the world. Therefore, we have developed a water awareness training program that emphasizes the emotional appeal of water.

The following text, *The Living Water of Life,* is a script which is intended to be produced as a slide show or a video, augmented with water imagery and background music. It is appropriate for presentation to all levels of the general public, from young children to adults. (We have also developed a curriculum guide to accompany this material for use as a lesson or training program, which is not included here.)

The Living Water of Life

The water of the earth is one single entity; there is only one body of water. We have the same water now that was always here since the earth began.

Water endows all the earth with the gift of life. All living things need water to survive— it is the magic ingredient upon which all life depends.

The best of men is like water;
Water benefits all things
And does not compete with them.
It dwells in the lowly places that all disdain—
Wherein it comes near to the sacred.
[Lao Tse, The Book of Tao, Lin Yutang,.(New York; Modern Library, 1942.), 586 ff.]

By learning the true beauty and wonder of water, we can gain a deeper awareness of this precious element, and discover the splendor and poetry of the earth.

Unfortunately, today our water is in danger. Cities dump tons of waste into the ocean, and factories empty toxic chemicals into rivers, lakes and bays.

Smoke from cars and industry mixes with water vapor in the air which falls to earth as acid rain, that adds to the pollution of our water supply. Our water has become too dirty to drink, and too impure to sustain aquatic life.

In addition, as populations continue to increase, the demand for water goes up. In many places people are using it faster than it can recycle itself.

Our challenge is to figure out how can we prevent the water from becoming polluted in the first place, which can only be done by each of us rediscovering the glory and richness of the earth, and renewing the sacred trust that exists between ourselves and the miracle of nature.

The American Indians see no barriers between the human mind and the realms of nature. But in Western culture our focus has been on industrial development, with which we have had considerable success.

However, in the process we have lost touch with that larger community of life— whose reflection we see in the world of nature. We have developed a philosophy of materialism that has narrowed our sense of the joy and the magic of the natural world.

The human mind has the capacity to interact with the universe beyond the capabilities of the five senses: we can reach out in communion with our universe in ways that may seem strange to us today, but that are familiar and ancient in the history of humankind.

We can develop a new awareness of the priceless value of water, by recognizing that it is a vital, fundamental and magnificent element of life. Each drop of water has its own personality, its own voice, its own spirit reality. Each communicates its unique mystery that we never quite comprehend but always understand.

Come to the water all you who thirst.
[Isaiah 55:1]

We can rediscover the voices that speak to us in the raindrops, reminding us of the divine mystery whence all things emerge into being.

Three-fourths of the earth's surface is covered with water, although only a small amount is fresh water, and most of that is frozen in glaciers. The small amount that is left supports all the living things of the earth— water is present in every cell of everything alive. For all living creatures all over the world, water is life. It is the crucial ingredient and the everyday miracle that gives life to all the creatures of the earth.

Every function of life, from movement to reproduction, feels the influence of water. Where there is no water there is no life, and where there is life there is always water.

There is no new water; the same water keeps moving between the sea, air and land. Water changes its form over and over in a never-ending cycle that will go on forever. It rises into the air from oceans and lakes as vapor, and as it rises, it cools and turns into tiny water droplets to form clouds, which fall back to earth again as rain, or hail, or sleet, or snow, which flows once again back to the rivers, lakes and oceans, moving forever in its endless cycle.

It travels in regular patterns, from root to leaf, from equator to pole, from the sea to the sky, from clouds to the ground and back again.

The same water that once nurtured primitive life still flows through the great rivers of the world today, and will flow through them forever.

Before me
a wondrous river flows
with all my senses
I only see
its joyous, billowing waters…
still would I plunge
in the cooling water,
myself, as I am
ending my pains:
O that its billows
Might drown me in bliss
and quench my fire with its waves!
[Richard Wagner, The Ring of Nibelung, trans., Stewart Robb, (New York: E.P. Dutton & Co., 1960), p. 254.]

The water in this river that winds its way to the sea once flowed through the cells of the ancient plants and animals of the earth, and it will flow again through all the living beings of tomorrow.

The face of the earth has been engraved by the waters' endless flow; it dissolves the surface of the planet; its power has shaped our world.

Over the years, the muddy water of rivers carves away solid rock, cutting canyons deep into the earth.

High in the mountains and in the coldest parts of the world, snow builds up to form deep fields of icy glaciers. As they slide slowly downhill, they pick up boulders and gradually they gouge out great valleys.

As the oceans batter the shore, they break down the rocky cliffs and grind them into the sea.

Water moves in ceaseless migration across the face of the earth, as it has since time began, moderating the temperature of the atmosphere and regulating the earth's climate. It is present everywhere in nature, appearing in various forms.

Water has been a spiritual force in people's lives everywhere on earth, since the beginning of time. It has been an image for veneration by every culture of the world; all the great religions have rites and ceremonies with water.

In Egypt water is birth, regeneration and growth. In Indian tradition the Ganges, like the Jordan, is a sacred river. There are ancient water deities in every culture. The ancient goddess Aphrodite, or Venus, rose from the waters.

Among ancient civilizations water was sanctified as the source of life. It has always been celebrated as a source of physical and metaphysical energy. All over the world there are accounts of creation from water.

God created the heavens and the earth. The earth was without form and void and darkness was upon the face of the deep; and the Spirit of God was moving over the face of the waters.
[Genesis]

The waters of the spring, or fountain of life, rise from the root of the Tree of Life in the center of Paradise.

The river of life rises from the throne of God and the lamb flows through the heavenly city, and has fruit trees on the banks.
[Revelations]

Wells, springs and streams have long been worshipped because of their ability to heal. The sound of water calms the mind;

the splash of a garden fountain, the mountain waterfall, the sound of the surf, all move us in deeply emotional ways.

Immersion in water symbolizes the return to the primordial state of purity; death to the old life and rebirth into the new. It represents immersion of the soul in the world. It washes away, purifies, regenerates, revivifies and infuses with new life.

Baptism comes from Greek term "to plunge, to immerse, or to wash." It refers to any rite of immersion in water.

Verily, verily I say unto thee, except a man be born of water and of the spirit, he cannot enter into the kingdom of God.
[John 3:5]

Christian baptism resembles ablution rites of other religions.

Washings were frequently preliminary procedures in religious ceremonies, where they were use as an initiation ritual, to wash away the old and sanctify the new life. It is a purification ceremony that washes one clean of dirt, both literal and spiritual.

"Then almost lost from view, he descends into the ocean…Bathing himself in the mysterious depths he shouts mightily for joy, for water is his nourishment. He remains one and the same, yet he comes forth strengthened out of the depths, a new sun, and shines his light upon men, having been cleansed in the water…
[Melito of Sardis; 2nd Century theologian]

The purifying properties of water have been ritually important ever since the rise of civilization in the ancient Near East. Water cleanses the earth's surface, it bathes us, nourishes us, and comforts us.

He leadeth me by the still waters; there he restoreth my soul.
[Psalms 23:1-2]

The ancients considered the moon to be a source of dew, which represents grace. Dew is a sign of divine intervention, it is the moisture that heralds the return of the soul. It is a benediction and a blessing; it is spiritual refreshment and the light of dawn.

The American Indians listen and watch the process of life and become connected with the natural world, experiencing a oneness of all life, in order to live in harmony with the universe.

We can discover a new level of beauty, majesty, and wisdom in our lives too, by developing a partnership with nature. We can create a new intimacy with the larger earth community, including the mythic and sacred world of the spirit.

Listen to the sounds of nature and see its grandeur. Discover the poetry of the earth— find the true meaning and reality of life in the music of nature.

Listen to the voices of the sea, the rivers, the wind and the rain. Feel the beauty and harmony and sense the interconnectedness of all life.

Feel a new sense of unity, and come to an understanding of the vast web of interrelations between all natural phenomena— hear it, see it, sense it: we are all part of the interwoven community of nature.

Experience an expanded connection with all the world as it is pouring into us and we into it, filling us with a sense of wholeness.

We are all a part of nature and it is part of us; we are inextricably bound together— both physically and spiritually.

We are composed of nearly 75% water. And the water that flows all around the world is the same water that flows in our veins; the world, and your body, are made of the same elements.

From the water we came, and the water joins us all.

The ocean, the river, the rain shower is a part of each of us; a part of our being. It is a part of the atmosphere of the earth, our surroundings, and we are a part of it. All of life is interconnected.

There is only one body of water.

The community of Earth is a single community of which we are all a part.

HOUSING AND WATER POLLUTION IN URBAN AREAS OF SOUTH BENIN (WEST AFRICA) : A CASE STUDY OF LACK OF ENVIRONMENTAL EDUCATION.

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ABSTRACT

Cotonou is the biggest city in the south of Benin. Located on sandy dunes and marshes, the city is ill-drained. The level of ground water which is not very deep, raises rapidly after the first rains of the wet season. Waste disposals scattered everywhere in the town area are not removed. People use to bury them . Besides, liquid waste is thrown anywhere . So that ground water is heavily polluted by the decay of solid wastes and the percolation of liquid waste.

The author presents some results of biochemical analyses of water from wells from many parts of the town showing that many water diseases may occur from the use of heavly polluted ground water.

Due to financial difficulties, only a few number of the inhabitants of the city are able to pay for potable water distributed by the public water supply. Moreover, people think that as water is a natural resource, a gift of God, they do not have to pay for using it. They prefer to use polluted water from wells rather than to pay for potable water from public water supply system.

Presumably that they do not know that solid waste buried in the permeable sandy dunes and liquid waste thrown in the marshes may pollute ground water they fetch from wells. Indeed, there is no programme of environmental education, so that people endanger their health by using polluted ground waters for domestic uses.

The author suggests that a programme of environmental education must be carried out, focusing on the water pollution mechanisms, the cost of potable water and the danger of using polluted water and its cost for the whole community.

KEY-WORDS: Housing, Waste disposal, Water pollution, Price of potable water, Environmental Education.

1- INTRODUCTION : LOCATION OF COTONOU CITY

Cotonou is not the Capital of Benin, but then it is the most populated city with 700,000 inhabitants which is 16% of the population of Benin. It is the centre of all administration and the whole economic activities of the country, but then its location is not compatible with the metropolitan role.

Cotonou represents a typical African city badly organised whose development is not mastered, and environnemental problems become more and more difficult to solve.

The city extends over about 60 km² between the Atlantic Ocean and lake Nonhoue. It is situated on a littoral sand of 4 m in altitude on the average, separated by longitudinal marshes and cut accross by ancient channels which serve as outlets to the lake. These marshes and channels were progressively filled in to get land for building without any provision for the drainage of surface water. Very often, if not always, the filling in is done with house hold waste matter. In this way the marshes and the channels become the rubish dumps of the Cotonou City, without taking account of the undergroud water which is used widely by the population for its various domestic needs.

The urban structure is made of three types of settlements.

(a) The so-called residential zones, occupied by the affluent classes made of the well paid government workers and expatraits. They are the zones provided with flats and good water drainage systems which are not always taken care of. Here, all houses are provided with pipe borne water. All these residential zones are always situated on emerged sites : in the south (Haie Vive, Patte-d'oie, Les Cocotiers), in the east (Cité Vie Nouvelle, Habitat) and in the west (Cité Houéyiho).

(b) The popular zones which are called the African city. They are made of all parts of the city, planned but then, no style of building is imposed on the inhabitants. They are situated on the emerged land as well as in the marshes. The heterogeneity of the living standard of the inhabitants introduces a mixture; where the slumps and flats embrace each other. Apart from the public lights which are not well cattered for, there is no concrete programme of public services. There is a great disparity in the access to pipe borne water acording to the standard of living of the individuals in these zones. Common access to public utilities seems to be the handicap for the improvement of the system here, so that the common houses are unevenly equiped. In this way, the public supplied water pipes which were functioning until the beginning of the 1960s have disappeared due to lack of maintainance.

(c) The suburbs, extending towards the east on the Porto-Novo road and towards the west, where it progressively absorbs the nearby villages; such that today the city extends for over 40 kilometers from east to west. In these zones, town planning is still in progress, while water supply is practically non-existent. This unprogrammed and uncontrolled development does not respect topographic constraints either. Houses are often built in the marshes and in the perennial water bodies, the main objective being to be near the town centre as much as possible. Recently there is a tendancy of movement from the congested parts towards the plateau situated at the north of lake Nonhoue around Abomey-Calavi but again it is an individual initiative not directed by the urban town planning institutions.

2- MANAGMENT OF WASTE MATTER AND WATER POLLUTION

Household waste matter production is estimated to be 1.5 kg /person/day, ie $3.8.10^5$ tons/year. for the whole city.

The refuse dump service, not efficient, the population in the perennial water bodies and marshes pour their waste matter in the open places where there is no building. At other places, the waste matter is thrown on the passes and footways, blocking them. More than 300 open rubish dumps have been identified in the planned zones, ie outside the suburbs that are not planned. In some zones of the city, waste matter is buried in the compounds or on the paths and footways.

The amount of human excreta thrown about is estimated to be $0.24.10^5$ tons/year, and the urine 3.10^5 tons/year.

Cotonou city has not got a system for the evacuation of human excreta and water drainage. Seventy percents of the inhabitants of the popular zone (see b above) use pit holes which are pumped out from time to time. The use of sceptic holes is not common except in the residential areas (10 % of the inhabitants). The other part of the population throws excreta on the open places (plots not yet built). This is the general pratice in the suburbs where pit holes are even rare.

3- GEOLOGICAL STRUCTURE AND WATER POLLUTION

The geological structure of the city site is characterised by thick sandy layers with weak clayey bedrocks beneath, hence the infiltration of runoff is very rapid. In other words the rise of the water in the lakes and the marshes results in the general rise in the water table at the beginning of the rainy season. The household waste matter and the human and animal excreta consequenthy pollute the underground water a lot. The following tables show the amount of chemical pollutions and BOD level (biological oxygen demand) in 31 wells in the agglomeration of Cotonou anlysed in mid-July and September 1992. None of the wells attends 6 meters in depth, some are surface wells.

TABLE I : LOCATION AND CHARACTERISTICS OF 31 WELLS IN COTONOU CITY WHOSE WATER WAS ANALYSED

PLOT	LOCATION	WELL	DEPTH	HEIGHT	DIAMETER	DEPTH OF WATER LEVEL
653	Jéricho	1	3.20	0.73	0.80	0.86
907	Aïdjêdo	2	3.42	1.23	1.24	0.97
974	Hindé	3	3.11	0.74	1.20	0.82
889	Dantokpa	4	3.15	1.05	1.02	0.75
794	Missité	5	2.34	0.95	0.97	0.34
1020	Aïdjêdo	6	0.50	w.l.	0.40	ND
1093	Minonkpo	7	5.43	0.73	1.24	1.74
1060	Vodjè	8	3.20	1.15	1.00	1.37
465	St Jean	9	2.90	1.33	0.75	1.00
748	Cadjèhoun	10	2.27	0.67	0.87	0.77
36	Guinkomè	11	4.77	0.99	1.20	1.37
377	Gbéto	12	3.63	0.57	0.95	1.43
520	St Michel	13	2.38	0.78	0.94	1.13
1274	Houéyiho	14	1.20	0.34	side 1.5	0.47
2236	Sètovi	15	3.92	0.83	1.32	1.52
1955	Zogbo	16	3.55	0.76	0.94	0.36
527	St Michel	17	2.72	0.57	0.16	0.22
14	PK6	18	3.52	0.96	1.00	1.38
99	Zone Ind.	19	1.86	0.46	0.80	0.63
	Akossombo	20	2.00	0.90	0.90	0.83
1505	Ste Rita	21	2.48	1.09	0.81	0.10
1452	Midédji	22	4.91	0.49	1.10	1.72
	ex-Agier	23	4.30	0.78	1.17	1.85
85	JAK	24	ND	ND	ND	ND
	Agbota	25	3.34	1.00	0.82	1.24
353	Sénadé	26	3.10	0.66	0.97	1.18
52	Abokico.	27	1.76	0.93	0.85	0.18
1397	Ste Rita	28	ND	ND	ND	ND
	Agla 1	29	3.74	0.93	0.95	1.14
	Agla	30	3.52	0.80	0.89	1.54
	Agla	31	2.52	0.93	0.96	0.10

From AISSI Marie-José, CPU/UNB 1993 quoted by ADJAMONSI P.; 1994

Most of the wells have above the internationally assigned norms for fluorine ammonium, nitrates and nitrites.

TABLE II : CHEMICAL ANALYSIS

WELLS	Fluorine	CHlorine	Sulphates	Sodium	Ammonium	Nitrites	Nitrates	$CaCO_3$	BOD
1	3.2	54.56	48.82	111.0	2.5	0.1	215.82	42.5	8.5
2	0	38.79	26.4	61.2	60.0	1.0	38 43	73.75	8.5
3	0	63.72	138.3	62.4	0.4	0.3	123.65	44.55	1 4
4	0	37.15	58.94	48.8	1.0	0.0	42.64	21.45	7.5
5	0	41.85	41.85	67.6	0.8	0.9	104.72	54.4	1.5
6	0	105.5	22.13	160.2	2.8	0.08	22.49	84.9	9
7	0	46.8	49.6	70.6	0.35	0.05	230.66	51.95	1
8	0	53.19	51.1	76.6	0.3	0.5	109.64	65.9	7
9	0	41.02	63.75	24.81	0.7	0	27.31	30.85	7.5
10	0	21.54	20.37	29.8	0.4	0.25	48.8	48.3	7.5
11	0	33.42	25.03	73.4	0.15	0.1	147.12	42.85	0.5
12	0	43.38	41.62	61	0.15	0.25	186.4	60	8.5
13	0	51.05	33	28.2	5	0	27.87	54.05	6
14	0	37.3	21.66	36.8	0.65	0.3	34.44	30.25	8.5
15	0	22.51	19.74	14.4	0.35	0.32	89.89	14.95	6.5
16	0	64.6	51	103.6	0.2	0.25	127.89	39.4	4
17	0	33.76	25.88	72.6	2	0	41.12	77.95	9
18	0	26.58	13.19	37	0.55	1.5	41.2	36.95	2.5
19	0	16.65	6.35	17.6	0.7	0.025	21.51	31.95	6.5
20	0	119.3	111.8	163.4	4.5	0.025	21.15	36.55	7
21	0	63.35	93.36	78.4	0.2	0.4	143.98	64.5	5
22	0	44.57	0	63.2	0.1	0.15	129.29	27.3	5
23	0	25.16	32.27	21.2	0.15	0	35.95	52.15	6.5
24	0	21.25	15.5	18.4	0.1	0	22.98	75.85	12.5
25	0	18.55	20.68	10.2	0.5	0.5	67.26	55.8	8.5
26	0	31.8	11.34	35.4	18	10	57.98	58.05	4
27	0	25.11	18.18	32.8	0.1	0.25	54.78	39.7	8.5
28	0	22.33	10.66	0	0.35	0.26	74.12	27.75	7
29	31.45	112.1	99.52	45.4	0.35	0.4	270.36	0	1.5
30	0	25.53	12.7	28.4	0.35	0	21.94	9.15	2.5
31	0	24.83	13.04	27.2	0.3	0.05	46.03	29.25	11.5

From AISSI Marie-José, ibd.

Twenty six wells out of thirty-one (84 %) are well above the BOD accepted norm of 2 mg/l.

Bacteriological characteristics were analysed. For the Enterobacters only the well n° 12 (located at Gbeto at the centre of the city) has more than the limit of 10/100ml of water. The Escherichia Coli were found in 18 wells (58%) and some have many of them notably wells N° 6 but worst of all N° 26. The Clostridia sulfito-recductors were found in eleven wells with a record level for the well N° 6 (1400/100ml of water).Salmonella infected fifteen wells (48.40 %) again with a record for the well N° 6 (3100/100ml of water). On the countrary the wells N° 26 and N°11 were at the top for Shigella sonnei, (1500 and 1100 respectively per 100 ml of water) for seven wells whose water was infected by this germ.

TABLE III BACTERIOLOGICAL ANLYSIS

Wells	Enterobact.	Esche.coli	Coli.tot.	Shigel.	Salmo.	Staph.	Clost.
1	0	0	16	0	25	375	275
2	0	25	96	0	25	3100	0
3	1	125	37	0	25	1375	250
4	0	50	50	0	75	1825	750
5	0	0	18	0	200	400	125
6	0	5150	11	0	3100	1	1400
7	0	0	0	0	0	0	1
8	0	0	5	25	25	75	50
9	0	25	19	0	0	600	175
10	0	75	9	0	50	150	175
11	2000	200	138	1100	0	ND	ND
12	27000	100	1	0	400	ND	ND
13	1	75	140	0	1225	3825	750
14	0	100	38	0	50	1150	350
15	0	75	4	0	0	70	0
16	0	290	20	0	15	90	0
17	0	75	30	0	0	600	1250
18	200	300	46	0	0	ND	ND
19	5300	900	168	600	400	ND	ND
20	0	35	181	0	30	185	0
21	0	95	403	0	10	5	0
22	0	15	1	0	0	15	0
23	0	100	2	0	0	ND	ND
24	7300	600	181	200	400	ND	ND
25	3600	400	403	900	200	ND	ND
26	5600	2000	146	1500	800	ND	ND
27	7900	500	126	400	200	ND	ND
28	0	30	1	0	5	20	0
29	0	125	5	0	5	55	0
30	1	0	2	0	5	55	0
31	0	35	1	0	0	10	0

From AISSI Marie-José, ibd

4 - WATER BORNE DISEASES AT COTONOU

Bacteriological and chemical charts so serious cannot be without consequences for the health of the population, when we know that more than 20% of the inhabitant of the popular zones (see b p.2 above) use water from the wells for their water requirements, and more than 50% use it for washing.

The table IV gives the image of the water borne diseases at Cotonou without any distinction between the social classes or the structure of the urban population.

TABLE IV : OCCURRENCES OF WATER BORNE DISEASES 1990-1992

MONTHS	BD			IA			BILH			IP			POL			DIAR			OTHERS		
	90	91	92	90	91	92	90	91	92	90	91	92	90	91	92	90	91	92	90	91	92
J	32	45	50	81	24	114	5	74	5	649	954	1052	0	1	0	59	246	433	5	8	14
F	28	56	46	115	35	29	7	66	11	597	838	767	0	0	1	63	168	398	2	4	13
M	48	60	50	134	55	54	10	44	4	679	943	757	0	0	1	99	195	240	3	17	5
A	20	48	78	92	33	66	4	89	1	673	848	763	2	0	2	54	230	324	11	1	7
M	40	33	23	70	30	59	6	81	5	585	778	748	0	1	2	120	204	348	2	9	18
J	51	40	26	78	49	101	3	61	11	567	920	805	0	0	0	141	252	187	3	9	12
J	41	38	45	50	46	75	3	43	3	561	857	789	0	0	1	56	192	343	5	4	11
A	38	39	49	52	40	53	2	73	5	633	788	829	1	1	0	153	262	265	0	13	5
S	20	27	37	83	26	59	3	70	2	690	906	820	0	1	0	55	315	320	6	8	15
O	41	37	27	75	24	48	3	46	0	595	739	729	0	2	0	54	177	320	0	0	11
N	43	39	20	98	27	49	5	61	1	631	1035	721	0	0	1	45	224	405	0	7	2
D	18	19	33	88	21	22	3	39	3	659	896	698	0	0	2	123	152	307	3	2	5

KEY : BD : Bacillar dysentery. IA : Intestinal amoebiasis.
BILH : Bilharziosis. IP : Intestinal parasitosis
POL : Poliomyelistis. DIAR : Diarrhoea.

From AISSI Marie-José, ibd

The magnitude of the problem from the point of view of public health is self evident. Only a radical change in the commercial politics of the society in the distribution of pipe borne water can help to reduce these water borne diseases. However, such a change todays seems improbable. It is not probable to think of free distribution of pipe borne water or a distribution on a non-commercial basis, with the supposition that water pipelines will be extended to all the urban population, knowing that only 40 % of the population is covered now. On the other hand, we can think about educating the people as a possible solution.

5 - MAJOR APPROACHES OF ENVIRONMENTAL EDUCATION TO FIGHT AGAINST WATER POLLUTION.

The low rate of the use of pipe borne water by the inhabitants of Cotonou city is due to many factors.

(a) The cost of water. Traditionally, water is considered to be a gift of nature or God. One cannot refuse to give water to anybody who asks for to drink, even if he is an enemy. According to the same logic, water itself cannot be bought, for it is divine.

(b) The distribution of pipe borne water is little extended. Only 26 % of the population are suscribers (the others buy water from the suscribers at a rate of 800 % of the original price). The rate for subscription and the regular water rates are too high to meet the purchasing power of the average classes. Under such circunstances, resorting to underground water becomes an obligation. It is therefore important to protect the underground water in fighting against practices that will pollute it. In view of the failure of institutional measures, education against water pollution may be the most efficient method.

The content of the educational measures may be three kinds.

(a) The notion of potable water : chemical and biological properties. The population does not always associate sickness with the quality of drinking water. But rather often, it associates it with mystical and spiritual causes. By the use of technical charts and cartoons, we must explain to the people things that water must contain and what it must not, to make it good for consumption from the chemical and biological points of view. It will be necessary to describe forcefully the symptoms of different water borne diseases.

(b) The notion of pollution deserves a particular attention, not from the point of view of what constitutes pollution, but from the point of view of the mechanisms of pollution, ie how it is caused. Here, we must insist on water pollution, ie surface water or runoff, water in the marshes, perennial water bodies, and underground water in the water table. Demonstrating each with an illustration will be useful.

(c) The notion of pollution of the water table or the underground water, which supplies water to the wells must be clearified by descriptions illustrating the hydrogeology of the site of the city : the geostratrigraphic profile, the notions of permeability, infiltration or percolation, the movement of water in the soil and the transportation of chemical materials and germs must all be described and explained. Finally, we must insist on non-polluting methods, the elimination or recycling of waste matter, controlled incineration, etc ..

The expected objective is a better management of household waste to help reduce the pollution of the underground water whose domestic utilization will continue to be extended for a long time among the middle class people of Cotonou city , because of the weakness of the revenue level and the perspectives of stagnation of the standard of living of the people within the decades to come.

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BRIDGING THE GAP BETWEEN KNOWLEDGE AND UNDERSTANDING

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NB This script is a digest of the talk which will be accompanied by a slide presentation.

Severn Trent Water (STW)

Severn Trent Water is the major Company and largest core business within the ST Plc Group. It deals with municipal and industrial water and waste water. Severn Trent International (STI) utilises the expertise of STW in order to negotiate additional business world wide especially in America and Europe. STI is engaged in water supply and waste management services to a population of over 15 million outside Britain.

The two other core businesses within the group are Waste Management and Support Activities e.g. Technology, Systems, Laboratories and property. The education section deals mainly with the business of STW but can and does act as a support and consultancy service to all other core businesses.

Business Facts

STW is the second largest of the ten major water companies in Britain serving a population of over 8 million. It covers the "heartland" of England and is unique in that it has no coastline. Consequently, an expertise has developed in the disposal of sludge to land which has been gained over a number of years. 205 water treatment works supply an average of 1987 Ml of water per day. 1062 sewage treatment works treat an average of 2800 Ml of sewage per day. Over 175,000 tonnes of sludge is disposed of per year.

Vision and Aims

From the global vision of ST Plc the Education Sections aim is to

> "... enhance the image of STW and increase understanding of the importance of water as a precious resource..."

Target Audiences

Within the STW region there are 2.5 million school pupils/students, 6500 schools, colleges and universities; over 100,000 teachers working in 19 Local Education Authorities. Other important audiences such as school governors and parents are obviously included.

Major Objectives

These cover six areas:-

1 To open a regional network of education centres which are specially designed classrooms in order for pupils (mainly between 7-11 years) to experience a day with STW investigating environmental issues surrounding the work of the Company.

2 To develop a comprehensive school liaison programme which includes information packs, projects, classroom resources, work experience explaining the work of the Company.

3 To stimulate and support curriculum related challenges.

4 To expand for the very young (5-9 years), the Water Safety Campaign.

5 STW is divided into 15 administrative districts. The objective here is twofold, one to disseminate the main central programme and two, to co-ordinate the major elements of these varied local programmes.

6 To develop an assessment and evaluation programme covering all the work of the education section.

Key Messages

Severn Trent Water:

(a) is an efficient, innovative, modern and quality water company

(b) puts its customers first

(c) actively cares for the environment

(d) is a world leader proud of its record of success

(e) embraces the concept and responsibilities of corporate citizenship by working in partnership with the communities it serves

(f) water is a precious resource, essential for life, to be used and enjoyed but treated with respect

Environmental Education and Awareness Raising

At the Education Centres resident environmental experts, who are also teachers, act as providers for the programmes surrounding that site. Schools book in for a day's activity which is so co-ordinated that it fits in with the current project underway in the visiting school.

The pupils investigate the WHAT, the WHY, the HOW of STW undertakings, and the underlying environmental issues, together with understanding the exacting externally set standards and targets it has to achieve. These are based on accurate unbiased facts and first hand practical experiences. The skills of Environmental Education are set in a learning spiral opened up through problem solving situations. These allow the pupils the freedom to explore environmental education THROUGH, ABOUT and FOR the environment. This will hopefully lead to a change of attitude and values, not only about the Company, but will also enable the recipients to develop an appropriate, concerned personal action programme in the future either as individuals or within a group.

Conclusion

The Education Section's major objective is to educate our young customers of the future about the work of the Company. Using STW resources in such a way that they build into a deliberate three pronged Company Community Relations programme. This programme also involves two other sections within STW's marketing department, namely, Come and See, and Recreation and Conservation. Together the three sections account for over 5 million visitors to STW sites and recreational facilities a year. The programmes pursued are deliberately aimed at explaining the concept that understanding based on knowledge and involvement will foster within our customers a trust and confidence with STW that will allow us "... permission to thrive as a company within, and for, the varied communities which we serve...".

All three programmes are mindful of the QVI factor:-

Q for Quality	:	of the programmes reflecting the high quality of our product.
V for Vitality	:	from being at the leading edge of business/educational developments similar to STW's lead in technology and innovation.
I for Impact	:	upon as wide an audience as possible creating a positive image change which can be measured.

By persuing the aim of educating our customers of the future the Company is gradually bridging the gap between knowledge and understanding. At the same time it is changing perceptions in a positive way about what the Company does and how it cares for the environment which is the key source of its product.

A NEW EDUCATIONAL PROGRAM ON ENVIRONMENTAL EFFECTS OF WATER PROJECTS IN IRAN

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ABSTRACT

A new post-graduate education program is developed as part of the growth and upgrade plan for the personnel of the Iranian Ministry of Energy. The purpose of the program is to train experts in assessing the environmental effects of various water projects. The program which is unprecedented in terms of its contests and format, consists of 12 short courses to be taken by the students within 4-6 years as part of their work-study career. The implementation of the program is expected shortly after its final review by those who are likely to get involved in it.

INTRODUCTION

In developed countries, it has been many years since water resources development projects have been regarded as more than just technical-economical undertakings. Among other considerations which have come into the picture environmental considerations have been playing an increasingly important role.

In developing countries, on the other hand, attention to the environmental effects of water projects has been rather limited until recently. This lag in moving to the so called "environmental age" only partially stemmed from a lack of appreciation or understanding of the environmental consequences of water projects. There was a more justifiable reason for the developing countries to be reluctant to and apprehensive about fully considering environmental constraints in their water projects: the development of the necessary base projects has been far from complete and environmental considerations should not hinder these projects specially in a country where the industrial and other pollutants are not present to a large extent. With recent industrial development and growing environmental concerns in most developing countries, however, the consideration of the environmental effects of water projects has become almost imperative.

The general idea in this matter which has been stressed in several UN-sponsored symposiums is that water resources projects must follow two types of goals: Socia-economic development and environmental-ecological development. Because these aims are sometimes in contradiction to each other, a balance and compromise must be made between the two goals in all phases of development so that a compatibility would be achieved between the water project and the environment in the long run. All costs for protecting the environment must be accounted for as part of the total project costs. These figures must be derived based on environmental impact assessment of the project.

Rational environmental planning and management of water projects is only possible when the project is planned, designed, constructed, operated and maintained with an environmental view. Therefore, environmental considerations must be integrated into the educational programs of those who would get involved in water projects. A more progressive and direct idea would be to train individuals in an education program specifically designed for consideration of the environmental effects of water projects. This paper discusses the development of such a program in Iran.

THE NEED FOR THIS EDUCATION PROGRAM IN IRAN

For many years the water resources projects were designed and implemented in Iran without a full scale environmental impact assessment and this negligence did not face any considerable objections. Recently, standards of water industry of Iran added some environmental statements to the required steps and procedures for water projects studies and designs. However, there is currently no specific and organized education program to offer the required skills to the professionals of the water industry to enable them to integrate the environmental issues in their traditional work. The existing official academic graduate and undergraduate programs on environmental sciences and engineering are too general and too theoretical for this purpose.

Meanwhile, environmental impact statements have become an indispensable part of water project studies and, hence, a pre-requisite to obtaining loans or credits from many international sources for vital national water project in Iran.

In light of the above discussions, one can easily conclude that there is a need for an educational program in Iran which can train individuals to become specialists in environmental assessment of various water projects.

BACKGROUND OF THE PROGRAM DEVELOPMENT

In Iran, the Ministry of Energy is in charge of water resources development. Recently, the education office of the Ministry completed the compilation of a new post-graduate education program on nine general categories as part of its work-study plan for upgrade of the knowledge and skills of its employees. The nine fields were as follows: Irrigation and Drainage, Operation and Maintenance of Reservoirs and Canal Networks, Hydraulics, River Engineering, Surface Water, Groundwater, Water Resources Planning and Management, Watershed Management, and Environmental Assessment of Water Resources Projects.

The people in the office of education were originally not inclined to undertake or even consider any programs related to the environmental issues because they did not feel that the need for such program is imminent. However, based on the arguments presented in the previous sections and several examples of the ill effects of existing water projects in Iran, the author was able to convince them of the necessity and urgency of the program.

The author was appointed to develop the education program for the environmental effects of water projects. The program which is rather unprecedented in Iran, was designed to train specialists who are able not only to assess the environmental effects of various types of water projects but also to prescribe ways to minimize the possible harmful effects of them.

The individuals admitted to the program are selected from currently employed personnel of the Ministry of energy who are qualified for the growth and upgrade program, hold a B.S degree in related subjects, and are involved in related works. The students are expected to take 2 to 3 courses a year and within 4-6 years complete the program. The graduates of the program will be recognized as having an M.S. equivalent degree.

After initial reviews and revisions, the program was presented to the education office in late 1993. It was then circulated among regional water authorities and other related organizations under the Ministry of energy to collect the views and feed-back of the people and organizations who are likely to be directly affected by the program. The final approval of the program for implementation is expected shortly after this phase.

CONTENTS OF THE PROGRAM

The program is basically a post-graduate activity consisting of 12 short courses which are designed in form of 2-4 weeks theory plus practical work workshops. The course list of the program is as follows: <u>Part A. General Subjects:</u> 1- Introduction to the environment; 2- Assessment and control of water quality; 3- Water and wastewater treatment processes and methods; 4- Water and wastewater facilities; <u>Part B. Specific Subjects:</u> 1- Introduction to aquatic eco-systems; 2- Environmental assessment methods in water projects; 3- Urban, industrial, and agricultural wastewater; 4- Quality assessment and control of surface runoff;
5- Quality assessment and control of groundwater; 6- Quality assessment and control of lakes and ponds; 7- Environmental consequences of dam construction; 8- Urban wastewaters and the environment.

As an example of the topics covered in these courses the contents of the specific course No.2 " Environmental assessment methods in water projects" is listed here: Environmental protection laws and regulations, Environmental statements in standards of water industry of Iran, Determination and classification of possible harmful effects of various water projects on the quality of water and aquatic eco-systems, Detail assessment of the effects of irrigation using wastewater, rainwater harvesting, flood distribution, hydropower stations, artificial recharge of groundwater, wastewater disposal ponds, etc., Report development methods to reflect the environmental effects of water projects such as check lists, matrices, PADC method, network method, UNEP/Unesco method, Review and discussion of examples of environmental impact statements, Practical group work on developing EIS for a project assigned by the instructor.

EXPECTED PROBLEMS IN IMPLEMENTATION OF THE PROGRAM

Having practically no background in the country (except for a few similar courses in environmental engineering programs in Iranian universities), the program is likely to face problems in finding knowledgeable and experienced instructors and in presenting successful pilot or example projects. Also most of the candidates for entering one of the nine education programs are likely to be ineligible or unwilling to enter the environmental program. In face of these anticipated difficulties, the program will probably be the last one of the nine programs to actually get started.

CONCLUSIONS

While the urgency of using extensive and costly environmental protection measures in water projects in developing countries is still rather arguable, the current lack of considerable objective activities in this regards underscore the need for quick adoptation of some related basic policies in Iran. The implementation of the education program outlined in this paper seems to be fundamental in providing the basis for a better environmental management as related to water projects.

As a side benefit of this new education program, it is expected that the graduates of it would be able to help the Iranian Environmental Protection Agency and the Ministry of Energy to reach common grounds in setting realistic and appropriate environmental protection standards for water related activities in the country.

It is needless to say that the worth, the benefits, and the weaknesses of the program in practice can only be judged objectively after the program has been implemented for a while and its graduates get involved in practical real-world challenges in their career.

PLANNING AND DESIGNING COURSES OF STUDY FOR LAND AND WATER MANAGEMENT FOR COLLEGE/UNIERSITY STUDENTS

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A PREAMBLE

Water affects the life of Indians in many ways. In early times, there was a divinely reverence for water, for its benevolence and yield. In the industrial age, water has become a commodity, much misused than used, much degraded than revered. It is equally true of land, another respected resource as the **mother**. The young generation has sadly not learned to value land and water, as they should be. It is because social experience has much changed, when compared to three or so decades ago, with increasing population and demand. There is the need therefore to reorient them to the fact **Land is Culture** and **Water is Life**, and one without the other is unthinkable. And that there is deterioration in both, an **integrated outlook** is important. For the young generation, there is no better choice than educational renewal, to reorient, rebuild and reconstruct a respect and reverance so that both become much valued, socially and economically, and 'used' the best way they can be.

THE CONTEXT

The context has two aspects to it.

1. There is an absolute need to educate and make young people aware of **Water Quality Deterioration, Restoration and Conservation** and the factors responsible for them. This becomes even more significantly necessary when literacy is not quite 100 per cent: in fact, there is much gap, and spatial variations in literacy, in a state like Tamil Nadu are quite alarming. There is always the question: how could we design a system for education, where necessary, and educational renewal, where such a system already exists and needs revamping? This paper concerns itself with the undergraduate and graduate students and the course of study on Water Resources Management, with an express focus on integrated land and water management. The intention is on developing knowledge and skills on land and water management so as to enable the students find positions in either academia or industries or more generally in planning and policy making bodies. As of now, there are courses related to land and water management offered in colleges and universities: **Water Resources Management in graduate Applied Geography Courses, Resources Analysis and Management in collegiate geography, Economic and Policy Studies and irrigation management courses in graduate engineering courses.** In the last few years, there has been greater emphasis in these courses, in the focus of **ecosystem and interactance concerns** and more especially on (a) Water as an Ecosystem, (b) Water as a System and a Component and (c) Water as related to Environment and Economy.

2. A relevant remark is in order to focus on the need for a course of study on Land and Water Management in the collegiate/university education in Tamil Nadu, which is a state of the Indian Union. In the last 25 years, there has been a persistently worrying problem of water scarcity, drought and declining agricultural production because of an unresolved inter-state river water dispute, in relation to the Cauvery, the major source of water for the state. Having nearly completely developed the irrigation potential in the state, depending to a large extent on the annual receipt of water flow in the Cauvery and the 15 other river systems in the state, the water scarcity in recent years (owing primarily to the inter-state dispute and the drying up of the largest river system) has made the people of the state acutely aware of the need to redress the problem and solve the water scarcity. Additionally, a great fall in the area under paddy, the staple of the people of Tamil Nadu, and a sweeping change over to sugarcane in the delta which was, until a few years ago, the **granary of South India**and the **rice bowl of Tamil Nadu** has made the people, of not only the delta but the entire state, responsive to water scarcities. However, this awareness has only resulted in a frustration never before encountered and faced in Tamil Nadu. It is because the Cauvery, a major source of drinking, irrigation and industrial waters, has now been lost as water rarely ever runs in it.

The adjacent state Karnataka, where the Cauvery originates, has followed its own **big push to irrigation development** in the last two decades. This has resulted in the construction of large reservoirs and the impounding of waters of the Cauvery and its tributaries. This in turn has caused a strife between the upstream Karnataka and downstream Tamil Nadu, turning it into an aggressive and violent action in which millions of mandays, properties and human lives have been lost in the clashes, in 1992. This incident, and the continuing water scarcities, necessitate educational inputs so that a new path may be paved for an amicable, negotiated solution to the water conflict and the continued perception of scarcities and the need to find negotiated settlements. Also, to be kept in mind, is the fact that water resources are deteriorating in quality, due to increasing pollution by the industries, especially along the rivers.

TRENDS IN EDUCATION AND TRAINING

The generation of students, graduated three or four decades ago, was very familiar with the then British (and also European) pattern of university education. University, having primarily been an examining body, laid down the syllabi for various subjects. It was left to the affiliated colleges to instruct these subjects through lectures and laboratory classes and also workshops and assignments in professional colleges. The syllabus was often described in a few lines and textbooks were rarely prescribed. It was left to the teachers to interpret as to how many books they should refer to. The question papers set in the earlier years, gave some guidance both to the teachers and the students as to the coverage needed on various topics.

It was not unusual to find questions set on an unimporant aspect of a topic in the syllabus that had hardly merited a tiny fraction of the teaching time of instructor or learning time of the student. There was thus some ambiguity as to the coverage needed for the examinations. Textooks in the subjects were a few and generally students depended on the notes prepared during the lectures, with some supplementation from the few books available from the library.

Specificity of subject coverage was obtained through prescribing particular textbooks for a given course. However, the time frame for covering the course remained the same for all the students irrespective of differences in their learning abilities. Specialists were, and are, concerned about this non-differentiation between students of different and varying learning abilities. In their desire to make students learn, self-paced education, programmed education and such other devises, developed elsewhere, were adopted.

The Modular Approach

Basically, in the modular approach advocated here, the idea was that a student should attempt a particular piece of study only after he/she thoroughly learnt the background pieces which provided the necessary learning material. So, if a topic could be divided into distinguishable segments, each segment being self-contained by covering a few specific concepts or a portion of the topic under study, the student could proceed to mastering segment by segment. Each individual, however, could be given the appropriate time to do it at his/her own pace.

For a degree in a particular subject, say economics, each student was required to do a core, which was common to all students, but given a chance to follow his/her interests through electives consituting a proportion of the total work load, and sometimes through the device of major and minor areas of study. Specifically, the M.Sc. Applied Geography of the Madras University Department offers the course with core (Compulsory) and
electives (in the final year, for two courses (Student Options) from among a list of eight such electives, one of which is Water Resources Management taught at the fourth semester).

Clearly defining the contents to be learnt, thus, leads to flexibility to meet students' needs and abilities. Such a clearly defined and demarcated step to reach educational objectives specified on particular subjects is called a module. This appears to hold promise in an educational renewal context of a course on Land and Water Management.

Nature of Course

In the Collegiate institutions, there are two streams of study, namely, the Semester (in autonomous colleges alone) and the Annual (in other, non-autonomous colleges). In the Universities, semester is the usual pattern (Figure 1). The colleges also have grad courses in both autonomous and non-autonomous colleges. As such, graduates in the Universities have 20 weeks to study the material, the undergraduates in the collegiate often take 36 weeks to study. However, the hours allocated for a single course is as much as 78 hours, inclusive of snap tests, question-answer sessions, seminars and model examinations for the graduates in a semester. It is as much as 150 hours, inclusive of in-class learning, field learning and project learning, with almost equal time allocation (one-third each) for the undergrads. There are 8 well-defined units in the annual undergrad syllabus while only 6 well-defined units in the semester syllabi. Additionally, the language of instruction in the Universities where grad students study

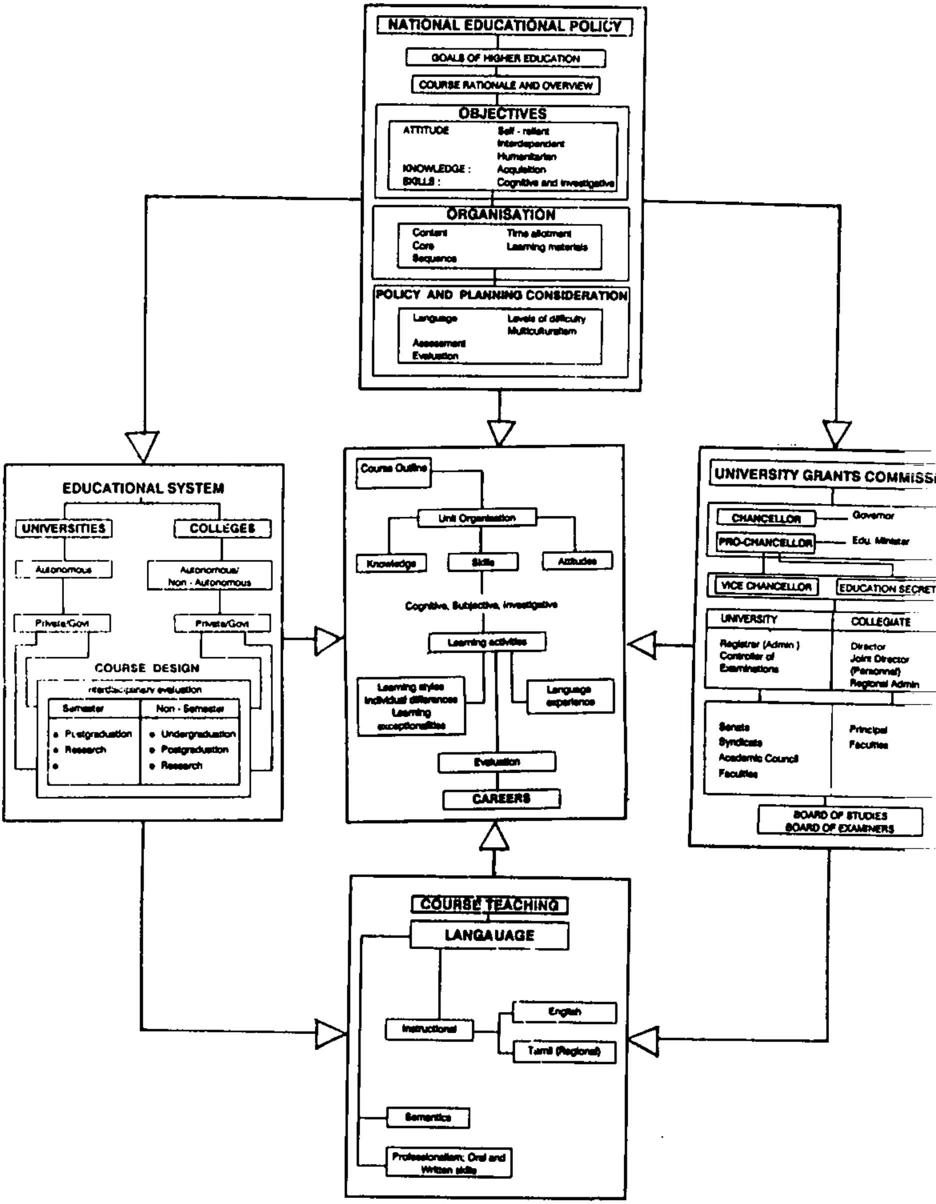

Figure 1 : A schematic of Higher Education components in an Educational Renewal Context. The scheme speaks of both University and Collegiate systems and types of streams.

is English whereas it is both English and the Regional Language (Tamil) in the collegiate, undergrad courses. Parallel media, in the undergrad studies, are a rule than an exception (also see Figure 1).

Levels of Difficulty

The semantics of teaching at the undergrad level varies therefore with the medium of instruction. Regional language is preferred by a large majority and there is political encouragement to learning in one's own mother tongue. The difficulty in understanding the subject matter taught in the classroom may depend however upon the ability of the teachers to use the languages to the advantage of the students. Teaching in regional language has yet to become advantageous, primarily because of shortages in source texts for teaching. English has long been a medium of instruction, the teachers have some proficiency in it. Graduates at the University have acquired in-depth knowledege and skill related to land and water management as the difficulty levels are low because of age and language skills already acquired. There is yet the lack of field kowledge and practical experience, primarily because of adherence to time-tabled activities in the classroom than outdoors. For the collegiate students, the difficulty levels are high, both because of semantics and slow pace in the annual, non-semester pattern. For those of the undergrads in the semester stream, the problem is slight but skills acquired is limited as professionalism in teaching is limited as well. Lack of laboratory and field equipment facilities further compound the problem necessitating replanning and redesigning the course towards an educational renewal at the colleges and the universities.

Modular Approach to Educational Renewal in Land and Water Management

The purpose of collegiate or university training is to impart knowledge, skills and attitudinal changes defined on the basis of specific tasks to be performed by the students. Being profession-oriented, the course content has necessarily to be very specific (Tables 1and 2, for undergraduate and graduate students). Although, no doubt, coverage needed for the grad and undergrad students will be determined by the level of professionalism to be imparted and the levels of difficulty encountered by the students (in grasping, in understanding concepts and language used in discourses), they are likely to have some overlaps. That is, the content for a group higher in the hierarchy, will be different from the one for an immediately lower group, but not necessarily 100 per cent different. This means that the contents for one level (grad) may be derived from that of the lower level (undergrad) by subtracting some portions and replacing it by others. Here again, the modular approach will be particularly helpful, because devising courses for different groups can be basically done by dropping some modules and replacing them by others.

Table 1 : Land and Water Management: Graduate Course of Study for Autonomous and University (Semester)

Unit	Topical Descriptions
1	Land and Water Management Basics and Strategies, Land Use Classifiction and Water Requirements, Methods of Estimation for Agricultural, Industrial and Domestic Uses. 6 hours
2	Surface Water Flow and Estimates, Geo-Chemistry of Surface Water, Groundwater Hydraulics, Aquifers Determination, Quantity and Quality of Yield, Groundwater Movements and Water Cycles, Barriers to overcome Water Quality Deterioration. 6 hours
3	Problems and Problem Management:Indicators of Environmental Imbalance, Direct and Indirect Influences, Positive and Negative Effects, Preventive and Corrective Measures for Mitigating Environmental Imbalance. 6 hours
4	River Basin Approach: Maximising Local Resources -Strategies, Investment Choices in Water Projects, Operation and Maintenance, Management Efficiency, Decentralisation, Participatory Management, Creation of Autonomous Self-reliant Abilities. 6 hours
5	Domestic Credit Mechanisms, Private Sector Participation, Donors and Donor Assistance, Environment Education, Technology Transfer. 6 hours
6	Land, Water and Land Use: Water Resources and Land Use Policies, Policy Changes, Framework for National Policies and Institutions. 6 hours

Source: Authors Formulations.

Even in the same hierarchical level, it is possible that some particular batch of students may need slightly different coverage on a particular segment than another, due to his/her backgorund. This can be usefully addressed in the modular approach by suitable selection from a set of modules on that particular subject.

In order to take advantage of the above mentioned possibilities of the modular approach, the requirement is that the division of the content of the course on land and water resources management should be done carefully. That is, the definition of each module should be so done that the various modules can be suitably combined to address the

Table 2: Land and Water Resources Management: Undergraduate Course of Study for Collegiate Institutions.

Unit	Topic Description
1	Water as a focus of Resource Development Interest, Global Water Resources, Oceans: Crisis, its Dimensions and Properties, Distribution of Surface and Groundwater, Relationships between Fresh Water and Salt Water, Intrusion of Salt Water in Coastal Aquifers. 8 hours
2	Water as an Ecosystem: Factors Disturbing Ecological Balance, Land-Water Linkages, Human Landscape Activities: Industrial, Agricultural, Hydro-Electrical, Cultural and Social, Traditional Knowledge and Problem-Solving. 8 hours
3	Environmental Imbalance: Deterioration of Water Resources, Siltation and Storage Capacity, Quantity and Quality of Water, Deterioration of Soil and Public Health, Pollution: Land and Bio-Diversity Degradation. 8 hours
4	Demand and Supply Management, Water Demand Estimation, Rural and Urban Water Supply, Positive and Negative Efficiency, Water-logging, Land Permeability Degradation, Environmental Effects of Dams, Water Withdrawal. 8 hours
5	Conservation and Planning,Environmental Considerations in Management Strategies, Factors Related to Environmental Aspects, Preventive and Corrective Measures, Environmental Education. 8 hours
6	Community Participation:Community's Potentials, Water-Sanitation-Health, Women and Education, Sustainability of Water Projects, Need for National Planning and Support. 8 hours
7	Regional and Inter-regional Water Projects: Problems and Issues, National and Regional Analysis, Water Disputes, Conflict Analysis and Resolution, Cost-Benefit Analysis. 8 hours
8	Technology Transfer: Technology of Choice, Issues, Roles and Place of Technology, Supportive Softwares, Training of Policy Makers, Communities, Professionals, Politicians and Sub-Professionals. 8 hours

Source: University Syllabus and Modifications by Authors. needs of the different groups of graduate and undergraduate students at the two different levels of hierarchy.

Polydisciplinary and Multicultural Groups

The state is multiculural, even within the larger cultural milieu. There are within the groups of students, polydisci-plinary groups, primarily because they come from different subject streams. These cause considerable problems: differences in motivation to learn and make a career out of education. In the context of Land and Water Management (restructured), we must learn to understand and respect disciplinary differences, say, as between geography and engineering, if we are to work with them effectively. It is true however that different disciplines do not in fact share a common language. If we are to undo **paradigm blunders**, we are going to have to use a common language: by a common language, we refer to the use of same words with the same meaning (semantics under course teaching in Figure 1). For example, there are two words/phrases we use in participatory approach to irrigation management, **turn over and irrigation management transfer** but the two mean the same thing when the phrases may be construed by the learners as very different.

This problem needs to be carefully looked into, in teaching land and water management course to the multicultural students.

FRAMEWORK FOR HIGHER EDUCATION IN TAMIL NADU

Higher education is basically a state subject. Colleges and universities offer undergraduate, graduate courses and research facilities are maintained by both the government and private sectors. All the colleges are affiliated to the universities of their respective regions. Higher education in Tamil Nadu, like in all other university / collegiate systems, is governed and controlled by regulatory mechanisms. These mechanisms are shown below. In educational renewal, they are important because they must be amenable to newer approaches. It is often observed that the educational mechanisms stifle newer ideas, by being closed to changes because of the rigidity of application of rules. However, signs of change is clear, what with newer courses and newer approaches. It is now more of reception rather than rejection of newer courses.

Administration

The hierarchy of the University Administration (Table 3) is of the following order:

Syndicate is an approval authority.
Senate deals with financial matters.
Academic Council concerns itself with the academic programmes.

Table 3: Academic Administration at the University

Authority	Functions
Senate	Supreme governing body of the University, it has power to review action of syndicate and the academic council. Exercisespowers in making statutory amendments and repeal the same, if necessary. Prescribes, in consultation with academic council, conditions for approving colleges and institutions in which provision is made for courses of study, admission of students, appointment of teachers, affiliating colleges to the University and to confer degrees on students successful in examinations and also on eminent persons, honouris causa, for their contributions to society.
Syndicate	Holds, controls and administers the properties and funds of the university and teaching posts to conduct examinations, appoint examiners in consultation and consideration of the recommendations of the board of studies and to approve and publish results of the examinations. Refers matters to academic

	council, board of studies or a board of examiners, a faculty or any committee or persons for decisions and action.
Academic Council	Makes regulations, amends or repeals the same as regards courses of study, divisions of subjects of study in university, colleges, approved laboratories and affiliated colleges. Advises senate and syndicate on all academic matters with a view to promoting academic excellence. Recommends to the senate schemes for constitution or reconstitution of departments of teaching, promotion of research in university and reviews instruction and teaching and research at university.
Faculty	Considers and reports on any matter referred to it by the senate, academic council, syndicate and the Vice Chancellor. Drafts regulations in regard to courses of study and examinations prescribed by university and to lay such regulations before the academic council.
Board of Studies	Advises Vice Chancellor and syndicate on all matters concerning research programmes undertaken at university departments and departments of research in affiliated colleges and centres of research recognised by university and formulates rules governing research degrees. Collects requests from various departments of research for courses of study and research students in fields falling under the purview of different faculties and makes recommendations in regard to such requests. Plans for inter-disciplinary programmes. Makes recommendations with regard to general guidelines to be followed in making selection of research students for admissions and award of fellowships. And idenifies areas of research and recommends them to syndicate.

Source: Madras University Calender 1985.

The functions of these bodies are given in table 3 and it is self-explanatory.

Planning and Designing Course in Land and Water Management

The two key elements in land and water management are: Land and Water. Through a variety of processes, interactions between these two basic elements result in imprints over the surface of the earth. A dynamic equilibrium results as the earth system constantly change to maintain a balance in the environment. These systems interact at a range of

scales from global to microscopic. Because human beings affect and are affected by the earth's system, it is important for students to recognise the significance of the land and water management in sustaining human life. The focus of the course design is as follows:

1. Course rationale and overview
2. Course objectives

3. Knowledge and Skill objectives
4. Policy and Planning considerations

Course Rationale and Overview

The study of land and water management provides a logical link between an understanding of physical and social environments. Water is viewed as a highly variable and mobile resource but it is often the mainspring for extensive development of a nation. The rationale of the course is mainly on the existing ecosystem and interactance concerns and, more especially, (a) water as an ecosystem, (b) water as a system and a component and (c) relations between water, environment and economy. The overview of the land and water management is designed to help the students develop some realistic conceptions of the significance of the system of hydrology in their daily lives. Students shall be provided with opportunities to learn the key elements of hydrology: world's water, basic concepts of source, availability, need, potential, interactions between communities and societies, and the three concerns above.

Course Objectives

The course in land and water management shall provide students with opportunities to:

* Develop a conceptual framework for organising information about land and water.
* Explain the processes that help to maintain the existence of order in physical world.
* Evaluate the effects of human activity on land and water in various locations.
* Assess the effects of historical, political, economic, environmental and cultural factors on the use of land and water.
* Appropriate the degree of inter-dependence among land and water.
* Conscientise the effects of human attitutdes and values in the use of water as an ecosystem.
* Evaluate their attitudes, values and responsibilities with respect to the use of their environment.

Policy and Planning Considerations

This course shall be offered at intermediate or advanced level of study. Students should seek intermediate level courses as being of practical value in their present and future lives. These courses help students to undertake a successful and independent life to manage and to develop a positive approach towards land and water as environmental systems. The primary focus of advanced level courses should be on the development of academic skills and knowledge that will prepare students for entry into University for research, industrial employment involving issue analysis and problem-solving.

There are a few policy considerations in respect of course of study such as land and water management: to what extent, such courses, or their introduction, reflect the needs and also determine the placements, is the foremost. Many a new course in the university/collegiate system, even while reflecting new needs, does not lead to or determine commensurate employment. With increasing scarcities, and water becoming a precious commodity in many sectors - obviously agriculture, industry and domestic use - there would be need for skills, knowledge and application. It is however difficult to guess the exact demand for such people. With environmental consciousness increasing, the expertise would be much appreciated is beyond doubt: urban water supply, sewage disposal, sewage treatment, water quality control and water management are some of the fields which could accommodate the grads and undergrads.

Planning for a specific levels of placement in each of the specialisations relating to water management therefore requires considerable thought and action. This is an area where industry and university/collegiate nexus need to be developed, to assess and evaluate the needs and match them with the production of expertise. There are signs of these becoming common as well in the Indian educational scene.

THE REPRISE

This paper has dwelt on the basic problem of planning and designing of a course of study for graduate and undergraduate students, with a view to generating an educational renewal as regards Land and Water Management. It has in a sense considered three strands of ideas: the existing curricula, the new ones to make possible educational renewal and methodology to do so, given the problems and constraints in the academia of Indian educational system. The framework for higher education in Tamil Nadu is pertinent to the particular course of study advocated in the paper as well as to general situation. The paper stems from existing experiences and the general levels of difficulties one faces in teaching the course and reorients the focus on integrated land and water management as a field of practical analysis and problem-solving.

WATER POLLUTION CONTROL THROUGH PEOPLE'S PARTICIPATION

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Introduction :

Man has been deriving all kinds of natural resources for his sustenance from nature since the very beginning of his existence on the earth. In the beginning he needed these to fulfil his natural needs of breath, hunger, thirst and shelter. With the growth of civilization and increase in population, man has started using more and more of the natural resources to fulfil his increasing natural and acquired needs for better living, better modes of transport, etc. Now his these needs have overtaken his natural requirements. In order to fulfil these, he has started using the natural resources on an increasing scale and releasing more and more of wastes into the environment which have degraded the air, land and water mass.

The freshwater has always been the most important natural resource for mankind. It has been the basis of all life on the earth and a precondition as well as a limiting factor for any social and technological development. As an effective solvent for the residues of human activities, it has been the receptor and transporter of the waste generated by man. Continued abuse of such a precious natural resource through the socio-technologic developmental efforts has caused serious problems of water quality degradation, shortage of fresh and clean water and general environmental pollution.

Due to the large number of pollutants and variations in their level with place and time, it is difficult to measure and quantify the pollution accurately. In spite of this, efforts are made to quantify it. On the basis of this quantification, pollution control plans are made and implemented. Since pollution is dependent upon place, these plans too should vary from place to place. However, quite often this simple fact is ignored and plans/technologies which have proved successful at some place are implemented elsewhere.

In the present times when developmental expectations and needs as well as the population pressure are rapidly mounting, specially in the less developed countries and the deteriorating global environmental scenario is causing a concern in the environmentally conscious and literate societies, the responsibilities and participatory roles of individuals, groups and societies need to be reviewed and redefined with respect to the necessity of public awareness, education and people's involvement in the

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solution of these problems. An interaction between the latest and the most appropriate of the technological approaches of solving the environmental problems and the socio-economic and cultural bases of the people is necessary for achieving a sustainable/lasting solution.

Keeping above in mind the Sankat Mochan Foundation, an NGO based in Varanasi, India, has been trying to generate environmental awareness in masses and enlist people's participation in keeping Ganga water clean and free from pollution through its Swatcha Ganga (Clean Ganges) Campaign. This paper emphasises the need of environmental awareness and education for masses and the role of people's participation in the management and protection of environment and also presents a brief account of the experiences based on the activities of the Foundation.

Wastewater - Water Pollution and the Traditional Technological Approach :

Most of the old civilisations and the urban settlements of the world have grown along the banks of fresh water bodies like rivers. During early stages of urban development, water was considered as an unlimited gift of the nature. The recourse taken on the basis of this belief was that dilution was the solution to the pollution problems. This led to the accumulation of non-biodegradable substances in the fresh water bodies. The sophisticated treatment facilities for the wastewater and the infrastructure subsequently developed to tackle the situation have several limitations on the environmental front besides the associated economic constraints. As a consequence most of the fresh water bodies including the major rivers of the world are now under severe threat of losing their utility as fresh water sources fit for bathing or drinking.

An approximate cost estimate for complete provision of water supply and sanitation in urban areas of the developing world by the year 2000, calculated according to UNICEF model, amounts to US $ 357 billion. China alone releases 37 billion cu.m of sewage per year without treatment meaning that 2000 medium/large treatment plants would be needed. It is of course unrealistic to believe that this can be achieved in a near future. In India majority of the 3000 and odd cities have only partial or no sewage treatment facility. Billions of dollars would be required if the entire urban sewage is to be treated using the traditional approach.

Most rivers in India including the holy Ganga are at present faced with the problem of pollution due to sewage and wastewater and in view of the short time frame and economic constraints it would be hardly possible to solve the problem of these rivers using the present technological approach. It could be noted that this traditional approach still heavily relies on large scale end-of-the-pipe solution instead of source control and reaction instead of prevention. The answer for the future would certainly lie in developing and implementing radically novel, cost effective, ecologically sound and sustainable solutions based on the present state of knowledge comprising of the understanding of the cyclicity of material flows in nature. This approach of environmental management, aiming at fulfilment of the local needs, should be coupled with enlistment of local support, information flow, local wisdom and participation to ensure social and cultural acceptability and sustainability of any environmental management programme.

Environmental Awareness, Education and People's Participation :

The less developed nations, faced with the need for environmental protection and management should, be capable of selecting the right approach as they cannot afford the luxury of trying and changing various approaches. In such cases the role of environmental awareness and education to cause a behavioural change and people's participation in managing the environmental problems becomes immensely significant. This change would not only encourage the people to proact and prevent the environmentally damaging activities but would also enable them to understand their environmental needs, risks and stakes. It would also assist them in making suitable choice of the alternatives and approaches for arriving at a sustainable environmental management programme.

The three essential elements for enlisting people's participation are raising of consciousness and awareness, creating action influencing attitudes and gaining problem solving cooperation. They would influence human attitude and behaviour in a positive direction to maintain the environmental quality by discouraging those acts which diminish the quality of environment and encouraging those which enhance it. This may, however, require a motivation of people to act upon these attitudes.

Awareness or consciousness raising basically involves in and depends upon 'information'. The information flow to the various sections of society or stake holders makes them aware regarding the phenomenon of damage to the environment and its relevancy to their lives. This also enables them to identify and feel the changes and degradation in quality of environment and relate these to some of the activities responsible for the same. The type and mode of information depends on the class and level of the target groups. No single approach will be effective for the entire community. A judiciously planned campaign and communication system, therefore, has to be identified. The information flow may also create a higher level of awareness and 'understanding' about the 'magnitude' of pollution and environmental damage.

The objective of the environmental 'education' is to develop 'knowledge' and understanding of the 'consequences of human activities' on the environment, the quality degradation and pollution. This should enable the target groups to understand the *what, where, why* and *hows* of the process of environmental damage. A higher level of education is to exploit or use the 'wisdom' of the people. The local wisdom and the education can be helpful in finding out strategies of 'preventing' the damage and evolving or 'deciding' the suitable approach for 'restorative or curative' solutions. This level of perception among the people is an ideal situation where the individuals, groups or people's organisations could assume an active role and successfully participate in the environmental management programmes including even the decision making and implementation.

Till late the people's participation was considered to have a slowing-down effect on the developmental or welfare projects. But it is amply clear now that success of any environmental programme would largely depend on the participation of the people. This bears on the notion that 'people's participation' is the means of solving acute problems and latent conflicts. This implies that the people or the members of the target groups of population are suddenly recognized as potential partners in implementation and management of the programmes, whereas such involvement was not considered feasible, or practicable in the process of planning the existing programmes. The bureaucratic and technocratic elites are now of the opinion that the people have actually the potentiality of active engagement once the specific efforts become imminent failures. The levels of participation would depend on the existing organizational structure of the authority and level of people's environmental awareness, education and willingness and opportunities provided for their participation. The manners, ways and means of participation would depend on the nature of environmental programme and its stage. The participation could be in terms of materials or expertise, experience or skills, etc. An open discussion and general participation should be necessary in problem definition. The people's participation in decision making, planning, implementation and monitoring could depend on the ability of the individuals or voluntary organisation of people which could be considered as adequate vehicle or channel of proper representation. The participation in benefit sharing depends on the objectives of the project. In case of environmental projects the benefits are usually qualitative and indirect. The motivation for the participating people does not come simply from the point of view of material benefits but also from their sense of belongingness, social obligation and respect and responsibility towards the environment. These qualities could be inculcated only through a well conceived and carefully designed awareness campaign. The structure of these campaigns could be site specific but it is essential to incorporate the traditional environmental and cultural values to provide an internal motivation and sense of participation to the people.

Some environmental values are inherent to every great culture and its serving population. In the context of Indian mythology and culture every component of the natural environment has been described as a god or goddess with well conceived form and functions. The rivers and oceans, wind and fire assume special significance and respect. The human code of conduct towards these objects, all the plant and animal lives on earth have been vividly defined along with the concept and consequences of disrespect to these elements. In spite of conceptual differences in the west and east, some common traits of environmental perception link all the civilizations and cultures. These perceptions, values and respect for the objects which constitute the environment can be utilised for making any education and awareness programme more effective and meaningful. The need for change in the human behaviour towards the nature and environment calls for developing programmes for raising awareness, education and mobilisation of people's participation in such a way that the cultural values, habits and the ethics are amalgamated with the scientific facts and information.

Ganga at Varanasi - A Special Case of Water Pollution :

The river Ganga is said to be the lifeline of India on which hundreds of million people rely for their physical needs. The river has been regarded as sacred and divine from eternity to which millions in India look for spiritual and religious purification and take bath and sip its waters for the same. The city of Varanasi, situated on the bank of this great river, is one of the oldest living cities in the world and has a special significance from the socio-cultural and spiritual points of view. It has drawn thousands of pilgrims from historical periods and now has developed into an international tourist centre.

The flow of sewage into Ganga at Varanasi results in the pollution of this holy river and very high levels of disease causing bacteria harmful to the large community which have been traditionally using river water for outdoor and religious bathing and drinking. Other activities like disposal of dead animal and human corpses, defecation on the river bank, etc. also add to some extent to the deterioration of the river water quality. This situation is not only injurious to health of millions of users but is highly agonizing to those who understand and are concerned with the dangers of the pollution. The people who hold Ganga in high spiritual esteem and are traditionally and culturally linked with the river are internally stirred due to the conflict between the scientific facts about pollution and cultural and emotional bonds.

The phase I of the Government's clean up project employing the traditional technical approach of solving the pollution problem has not yielded the desired improvement in the water quality of Ganga at Varanasi.

The people consider Ganga as holy, regard her as mother and purifier of sins. They have a deep respect for the river and many consider her as unpollutable. But paradoxically the river water is polluted and not clean at present. The responsible factors can be enumerated as the total reliance of the decision makers on the traditional technical approach of problem solving, unsatisfactory planning and implementation of the projects, low level of environmental awareness and education in all sections of the society and lack of meaningful people's participation.

Ganga Clean-up and People's Participation at Varanasi :

India has a long tradition of voluntary socio-cultural work by non-government people's organisations and committed individuals. In spite of policy statements there has been some apathy towards people's participation in national developmental programmes. The Ganga Action Plan (GAP) launched by the Government of India in 1986 has been an ambitious environmental programme which was declared by the Government of India to be the people's programme. Unfortunately the GAP has failed to recognise the role and effectiveness of people's participation. The common masses who wanted to and could have been drafted into the project to make it a people's movement have hardly known about the contributions they could make. A negligible number of NGOs or voluntary organisations have been involved. People consider all GAP decisions as government decisions and hardly join hands with the bureaucratic machinery. The bureaucracy still intends to achieve success by traditional technological approach alone rather than involving the people.

In spite of this negative scenario, a few voluntary organisations have been working successfully for building linkage and ensuring people's participation in the clean up programme. The Sankat Mochan Foundation (SMF), a non-sectarian, non-government organisation established in 1982, launched its Swatcha Ganga (Clean Ganges) Campaign (SGC) for restoring and preserving the Ganga by creating awareness among the people and motivating them to take responsibility for keeping the river clean at Varanasi. The campaign incorporated a scientific understanding and environmental concern with the fabric of culture and traditions of India. The SGC was the first environmental effort of its kind in the Ganges basin and a forerunner of the GAP. When the SGC started its education programme, the mass awareness about the pollution in Ganga was almost absent and no organised efforts had been made so far. No government projects of water pollution control were operational. The SGC designed awareness programmes and messages for the society which had a widely varying structure on socio-economic, educational, professional, linguistic, religious, age and sex bases. The Campaign employed means and strategies such as to effectively reach all the target groups. The messages had to bear in mind the in built faith and cultural relationship of the people with the holy river and care about the people's unlimited reliance and faith on the river water and its infinite capacity of purifying the objects. Many would not believe that the river could be polluted and as such they would not care to object to the acts causing the pollution. The programmes tried to convey the message without hurting the sentiments of the masses and simultaneously generating the necessary awareness and motivation. The programmes included meetings with community, social, religious and political leaders, open conventions, exhibition, poster, leaflets, poetry, folk music and songs, stage plays and media articles. The educational programmes for children and students included slide shows, debate, painting and dance-drama competitions for evolving creative thinking in them regarding the pollution of the river. In 1992, the SMF organised an international seminar and based on its recommendation a state-of-the-art laboratory (Swatcha Ganga Research Laboratory, SGRL) was established. This laboratory now regularly monitors the river water pollution and effectivity of the GAP schemes and has generated a data base which provides a reliable information about the water quality of Ganga at Varanasi. The SGRL also provides opportunity of training in water quality testing to school and university students.

Besides the long term awareness and educational programmes the SMF has also been taking immediate steps to stop the pollution of Ganga. These include initiating legal and media pressure, presenting technically sound alternative to the government, affecting people's opinion for political action and initiating people's direct action. The SMF and the Clean Ganges Campaign have effectively worked as catalytic agents, educators, public interest watch groups and activists for influencing the decision making and the people's behaviour. The campaign has been able to evolve significant public interest and successful in influencing the action of the GAP functionaries to some extent which in turn have led to a some what better utilisation of project resources allocated for Varanasi in GAP Phase-I. The impact has been wide spread, the efforts have received wide recognition including that by the UNEP which awarded the 'Global 500 Roll of Honour' to the president of SMF in 1992 at Rio. But the water quality available to the users at Varanasi on the bank of the Ganges is still far from satisfactory, the struggle of the SGC is still on and there is still a long way to go.

Conclusions :

Socio-technical development and environmental pollution go together. The more the development, the higher is the pollution. Developed and developing countries both are facing this problem alike.

Due to space and time dependent nature of environmental pollution, the control measures must be tailor made for a specific place. All cultures and related civilizations of the east and west advocate for reverence towards nature and its components. Orientals had a more closer relationship with nature which of late has started eroding due to onslaught of consumerism. There is a need to revive and restore their old faith for solving current environmental problems. The awareness programmes of the Clean Ganges Campaign (SMF) establish this view.

Above mentioned approach would be more effective if greater opportunities are provided to people's participation in environmental management. The people need to be made aware and educated about the *what, where, why and hows* of the process. The environmental awareness generation and education are long term and continuing processes and this responsibility should be given to NGOs and voluntary organisations.

The Ganga Action Plan launched by the Government of India has not made serious efforts to mobilise the sentiments of people and solicit people's participation in the Ganges cleaning process. The people and the NGOs can play an effective role in identifying local needs and problems, suggesting effective solutions for them and monitoring the projects. One of the reasons for the partial success of the Ganga clean up programmes at Varanasi is the inadequate people's participation. This situation and attitude need to be changed.

The socio-cultural and scientific approach of the Clean Ganges Campaign (SMF) has been effective and meaningful in generating mass awareness and educating people at Varanasi. Such efforts should be encouraged for protecting our rivers and environment.

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WORKSHOP 2: Greening of industry

The workshop will discuss aspects of the necessary transformation of products and processes to protect environmental systems from further deterioration. What are the prospects for self-regulation carried out administratively or through the market?

Relevant subfields include business environmental policy and strategy, issues of business ethics and responsibility, "green networks and partnerships", and the use of environmental auditing and other evaluations of non-monetary performance. Case studies will be presented, indicating how specific companies have been able to modify or transform their policies and practices.

THE ROLE OF LIFE CYCLE ASSESSMENTS AND ENVIRONMENTAL REVISION APPROACHES

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Knowledge about human threats to the environment seems to grow faster than our ability to solve them. Therefore, decisions in the environmental arena must often be taken with greater uncertainties present than those in other areas. Furthermore, very small safety margins may sometimes exist. The need to safeguard the environment for future generations emphasizes the need not only to discuss the problems, but to make priorities for identifying cost- and environmentally effective strategies to solve them and take actions to enforce the resultant measures.

Past and present efforts to protect the environment are to a large extent characterized as single-issue approaches. Each problem has been dealt with on a case-by-case basis. With regard to problems caused by point source pollution from easily identified emissions, this was an effective way of reducing environmental impacts. Today the situation is more complex. Much pollution now originates from a large number of non-point sources easily transported from one country to another. Furthermore, each of us contributes to this total environmental pollution through our daily patterns of living. The different non-point sources are difficult to identify, and the way in which they interact in impacting the environment is not well-known.

The increasing environmental problems of more complex and global character will most certainly entail great implications for several sectors of society in enforcing remedial actions. Therefore, it is important that all areas of sectoral interest should be coordinated in their environmental ambitions, in order to get necessary interactions and responses to proposed solutions. It is likely that there may be an unanimous view with regard to the ultimate objectives of a better environmental quality. However, it is equally likely that there may be a disagreement about the pace, means and time required to achieve them.

Life-Cycle Assessments (LCA) offers a new concept to deal with the future complex environmental issues. However, there are no shortcuts or simple answers to all questions posed. The rapidly emerging interest to adopt a holistic approach to combat environmental problems will most likely identify a lot of gaps in our knowledge about all new aspects that needs to be dealt with. Also, available data that may be used are in many cases intended for other purposes. It is most probable that LCA's will never be mature enough to gain full credibility, nor will all aspects entailed in an LCA find a general accepted solution. Despite all difficulties, there is no argument for waiting to use LCA until it is getting better. It is by no means hard to find difficulties and uncertainties in the present LCA concept, if one wants to use such arguments for motivating unwillingness to conduct an LCA. One has to decide whether it is worth while to seek a holistic life-cycle approach to environmental aspects despite all difficulties. To make use of LCA today may be more a question of will and ambition instead of undisputed knowledge. The whole idea of LCA ought to be to make the best use of present scientific and technical knowledge and to make use of the results in an intelligent and humble way. Such an approach will most likely gain credibility in the long run.

There are also other means for industry to adopt in order to be able to more holistically work with environmental issues, *environmental revision or environmental auditing* being the most wellknown approach at present time. The reason is the increasing need for a constantly updated overview of a company's total environmental protection work. But there is also a need in many cases for a systematic, documented and objective assessment of how well the organization, the management routines and the equipment for environmental protection are functioning. This can be achieved by exercizing regular environmental audits. An audit of this kind has to examine and assess whether the environmental protection work is in accordance with company policies and legal requirements. It should also further improve the environmental work by making it easier for management to obtain an overview of the environmental protection routines.

The great need to introduce environmental aspects into world business calls for a search for a common ground with regard to terms, definitions as well as management systems and tools. This task has recently been undertaken by the International Stadardization Organization (ISO) which now coordinates a huge global effort to produce environmental standards in the field of environmental management systems and tools. The resultant upcoming series of such environmental standards (the ISO 14000 series) will encompass environmental management systems, environmental auditing and life-cycle assessments, which most likely will have a great impact on future global environmental work in the business sector.

ENVIRONMENTAL REPORTING - IS YOUR ORGANISATION ADDRESSING THE NEW CHALLENGES IN PUBLIC INFORMATION?

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Introduction

Environmental reporting is relatively new and in its infancy. It is growing in importance. That is the case in the United Kingdom, in Europe and in the United States as well.

The number of firms producing separate Environmental Reports is growing. The content of reports is improving. Awareness is being raised. And organisations have to ask, "How is my organisation responding to the challenge of environmental reporting?".

The presentation will deal in turn with:-

- WHY have an Environmental Report?
- WHO is the audience?
- HOW has Severn Trent Plc approached ER?
- WHAT are some of the issues?
- WHAT are the lessons?

Why have an Environment Report?

Turning then to the first area - Why have an Environmental Report? What are the reasons?

The last few years has seen a growth in demand for companies and organisations to provide more information. In addition organisations see themselves in a changing position regarding their corporate responsibilities.

The Annual Report and Accounts is no longer adequate as the only vehicle by which organisations report. Most responsible organisations understand that mere compliance with minimum standards is not enough. Stakeholders demand more.

Organisations, and the employees that work within organisations, recognise that they have a role in corporate citizenship: that there is a need to have a view on corporate citizenship, on corporate values, on environmental performance etc. Not just from a "feel good" factor, but also because it makes sense. Firms see these issues can lead to Respect, Enhanced Image and, ultimately to some form of Competitive Advantage.

In 1993 Deloitte Touche Tohmatsu International, in conjunction with others, produced a report on corporate environmental reporting entitled "Coming Clean" [1]. The report is based on an international survey of both report makers, and report users. It analyses the motives and views of over 70 companies in Europe, America and Japan that have produced freestanding Environmental Reports.

Information in the Deloitte's Report, gives some clues as to Why organisations produce separate Environmental Reports. The results are shown for Europe, North America and Japan. Many firms see environmental reporting as a "Duty to the Environment". The report suggests that this "Duty" was a more comfortable reply than responding to "Campaigner Pressure".

There is some indication that "Shareholder Pressure" is a factor. And "Competitive Advantage", particularly in Europe, is an issue affecting business thinking. The strong showing for "Public Relations" does suggest that increasingly organisations are seeing the Environment Report as a mechanism for demonstrating good corporate citizenship.

<u>Who is the audience?</u>

The "Coming Clean" report looked at the relationship between the forms of communication that take place and the various audiences.

Corporate Environmental Reports appeal to a whole spectrum of audiences. The wide appeal, however, creates its own difficulties.

To produce a corporate Environmental Report to appeal to all audiences is extremely daunting and possibly, almost impossible. It may be, therefore, that for this reason organisations have tried to be more focused.

The identification of employees, communities, shareholders and environmentalists, as "Very Appropriate Audiences", is helpful. Severn Trent seeks to use its Environmental Report as a means of communicating with these four important stakeholder groups.

Indeed, it will be recognised that employees live in communities. In Severn Trent the vast majority of employees are also shareholders in the Company. And as a Company whose business is at the very heart of protecting the environment, it is not surprising, that many Severn Trent employees are, at heart, environmentalists too.

In contrast the British Airways Report, for example, is produced primarily for its employees, although BA does release it to wider audiences.

How has Severn Trent Plc approached ER?

Severn Trent has its headquarters in the heart of the United Kingdom.

The Company deals with water supply, sewerage and sewage treatment, together with waste management.

Annual sales are of the order of one billion pounds sterling, 12 billion Krona or 1½ billion dollars. About 80 per cent of sales come from the water and sewage business in the United Kingdom, ten per cent from waste management activities, and the remaining ten per cent from other water related activities, including operations in Europe and the USA.

10,800 people are employed throughout Severn Trent of whom 300 are based in Europe (excluding the UK) and 800 in the USA.

The Company is the most profitable of the water companies privatised by the UK Government in 1989 and is one of the Financial Times top hundred companies.

The Severn Trent Group comprises six Business Units. Severn Trent Water provides water and sewerage facilities to about eight million people in the United Kingdom. Severn Trent Water International provides water and sewerage services to markets principally in Europe and North America. Biffa Waste Services is one of the top four waste management companies in the United Kingdom. Severn Trent Technology is a Business Unit which supplies some of the technologies needed in the core water and sewerage businesses.

Severn Trent Systems develops packages and markets computer based systems to other utilities worldwide. And finally Severn Trent Property, a property development business.

Severn Trent's UK water business provides services to about eight million people, but across the whole of the Group services are now provided to nearly twenty million people.

About eighteen months ago Severn Trent produced its first Environmental Report [ii]. The event was marked by a series of presentations to key customers, shareholders, representatives of the media, politicians, influencers, as well as some financial analysts and a number of environmentalists.

Some 5,000 copies of the report were sent out to a wide range of individuals and organisations.

The report gives a very clear public statement on the Company's position on environmental matters. It includes a statement of environmental policy and the Company's objectives expressed as five statements of "Care".

The report also sets out an Action Plan containing 21 actions the Company is committed to undertake with timescales and responsibilities identified. The Action Plan is one means by which external audiences will measure the Company's progress.

There is also a commentary section in the Report which with the help of text, graphs and pictures shows "what has been achieved so far".

At the launch of the Environmental Report the Company committed itself to:-

* produce an Environmental Report each year with updated Action Plans;

* produce Actions Plans including tasks and timescales for achievement;

* produce facts and numerical information on environmental performance;

* set targets to improve performance;

* audit achievements and report on the audits that are undertaken;

* ensure polices applied wherever the Company operates.

Environmental management is a business challenge. The Company will be judged on its success in managing its environmental agenda. And that judgement will be just as important as the business results achieved.

The audiences that read future Environmental Reports will form a judgement on the extent to which the Company has fulfilled actions and commitments given.

What are some of the issues?

The publication of an Environmental Report is the end product. Some of the issues in putting policy into practice and fulfilling the commitments are as follows:-

* Timing of the ER.
* Environmental Protocols.
* Data Collection.
* Data Verification.
* Environmental Audits.

Report timing

Severn Trent will produce its Environmental Report to coincide broadly with the publication of the Company's Annual Report and Accounts.

It is important to demonstrate to customers, to shareholders, to communities, and to all interested parties, that not only does Severn Trent operate in a way that demonstrates ability to manage the Company as a business, but also to manage that business in a way that shows due regard to environmental performance.

The Company's next Report will be published in July to coincide with its Annual Report and Accounts. The presentation in Stockholm will include an analysis of the 1993/94 Report, which at the time of writing, has still to be produced.

Environmental Protocols

Reference was made earlier to care statements. They are:-

* Care in Business Planning.
* Care in External Relations.
* Care in Operational Activities.
* Care in Human Resources and,
* Care in the Procurement of Materials and Services.

The Company is developing frameworks within which it can manage activities consistent with these five care statements.

The frameworks have been called "Environmental Protocols".

Management protocols will cover the roles and responsibilities in environmental management. They will set out details and standards for reporting across Severn Trent Group. The Protocols will also establish how companies in the Group will operate within the environmental agenda.

And other Protocols deal with matters such as Research and Development, Purchasing, Acquisitions, Training and Audit.

But, Managing a business is just one dimension. Equally important is how businesses are operated.

Here the Protocols will cover standards on emissions to air, to water, on waste management, on noise, on energy consumption and so on.

Each of the businesses in the Severn Trent Group already have operating procedures of varying degrees of detail. But Severn Trent see the role of Protocols as setting the Group environmental framework within which its companies' own detailed procedures operate.

The Protocols will be formally adopted within the Group in 1994.

Data Collection and Verification

Data Collection and Data Verification are linked. This is currently one of the most important areas being addressed by the Company.

The Company's first Environmental Report said many of the things that were being done. Some numerical information was provided in the report. But the report did not contain as many "hard" facts as might have been wished.

The Company's interim financial report [iii], published in December 1993, contained a reference to environmental care and the need to measure accurately performance.

Quantification is central to the way Severn Trent manages its business, and environmental management is no exception to the need for better quantification.

Information is required not only for report production purposes - it is also needed to help the very process of environmental management.

Information helps to evaluate the environmental effects of activities, and to determine, whether they are significant. It will enable quantification of objectives and targets. And there is a need to measure achievements. Such an approach will enable the production of credible Environmental Reports, containing hard facts, which demonstrates progress.

The author suggests that for a Company as large and diverse as the Severn Trent Group, this is a daunting task. Potentially the volume of information that can be collected is very large. But that means a focus on information which appears to be most significant, in terms of environmental effects.

Some data covers the quality of the core business products and services, which are the water supplied, the sewage treated and the liquid and solid wastes disposed of. Much of this data is currently available and frequently published. But it is not sufficient simply to meet product quality standards. The Company needs to monitor the way it operates so that environmental effects are minimised.

The other part of the data system relates to performance data.

The performance information is structured around seven categories of environmental effects. They follow the outline of environmental effects included in the British Standard BS7750 - on Environmental Management.

The process of defining, and collecting environmental data, is not easy. Requests for more information are not always well received. But the ability to measure accurately performance, and to report responsibly, is important. Data is an area where specific effort has been directed in producing the 1993/94 Environmental Report, and the presentation will include instances of numerical information.

The author believes the credibility of Environmental Reports is enhanced if external verification of the Report can be obtained.

To help with verification Severn Trent has engaged a firm of Environmental Consultants, ERM, to certify the correctness of the information in their report.

A three stage verification process has been adopted.

Stage one involves checking that the data definitions proposed are clear and that the methodology for collection is robust.

Stage two checks that the data included in the outline report supports the report content.

The final stage is included to ensure that the information (and context) in the report accurately reflects the data collected and involves a sample check on the data.

Severn Trent will include a verification statement in their 1993/94 Report.

Environmental Audits

Severn Trent is committed to undertake Environmental Audits.

Currently discussions are on-going within the Company on how that audit should be organised and should operate across the Group. In some cases environmental audit is already taking place.

The standards against which audit will be conducted are the environmental Protocols referred to earlier. The Protocols will be the "benchmarks" against which performance will be judged.

What are the lessons?

Several lessons have been learned over the last eighteen months.

Firstly, the environmental agenda is here to stay and environmental reporting is gaining credibility.

Environmental management is a business issue and should be addressed in a systematic and businesslike way. A start has to be made and it is important to take the first step.

The environmental agenda is increasingly becoming more complex and demanding more. There is no scope to window dress. The author believes that in developing environmental protocols as statements about the way Severn Trent expects to operate, is one way of addressing, in a businesslike manner, the issues that exist.

It is important to focus on the areas of greatest impact: for this reason much of the content of the Environmental Report deals with the main areas of business - that is water and sewage treatment, and waste management.

Also it is important to think about WHO your audiences are. The potential audience for the environmental report is wide and diverse. The audience focus is a serious issue that has to be addressed, and the audience is becoming more sophisticated and demanding more.

It is beneficial to ask a sample of the Audience what they expect to see in an Environmental Report from your organisation. Encouraging feedback helps to focus on the issues <u>your</u> audience wish to see <u>you</u> address.

Furthermore, data and measurement will be the order of the day in underwriting the credibility of future Environmental Reports.

And finally, the author warns about not getting started unless your organisation is serious and is prepared to be compared and benchmarked against other reports. Environmental reporting is not for the faint hearted.

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A GAME-THEORETIC ANALYSIS OF THE EFFECTIVENESS OF SELF-REPORTING SYSTEMS FOR THE ENFORCEMENT OF ENVIRONMENTAL REGULATIONS

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Abstract

A game theoretic model is developed to assess the effectiveness of an enforcement procedure for environmental regulations that contains a self-monitoring and self-reporting system for a firm. In particular, a framework for more effective and efficient enforcement of environmental regulations, called the *review strategy*, is proposed. To activate the review strategy, or any other effective enforcement scheme, the environmental agency must have reliable monitoring data on actual discharges by an operator or firm, thereby allowing the agency to allocate its resources most efficiently. Unfortunately, in many countries of the world, environmental agencies are faced with resource constraints that prevent frequent monitoring; therefore, they often require operators to monitor their own discharges and report them to the agencies. In this case, operators could have incentives to under-report monitoring results, particularly if the agencies carried out little or no inspection to verify self-reported data. A game model of a reporting system is developed in which the operator has two decisions – Comply/Violate and Report Truth/Falsify – while the agency has one decision – Verify/Accept. The model and its equilibria are analyzed to determine the relationship of the operator's reporting choice to parameters such as the cost of compliance and the benefit of undetected violation. It is shown that by setting the severity of penalty and the monitoring frequency appropriately, the agency can deter false reporting by the operator. Therefore, a truth-revelation mechanism is realized, enabling the agency to utilize effective and efficient enforcement schemes such as the review strategy.

1. Introduction

In the face of the global environmental crisis, one of society's most important objectives must be to induce individuals to act responsibly toward the environment. Unfortunately, avoiding *the tragedy of the commons* by means of the voluntary actions of individual decision makers may not improve damaged environments rapidly enough. If so, it is inevitable that individuals' actions will be constrained by regulations that limit environmental consumption and result in socially and biologically acceptable loads. Yet there seems to be no perfect scheme to achieve the desirable state of full compliance to environmental regulations by every individual.

Based on the idea of deterrence, much research has been conducted to improve enforcement, especially in the area of criminal law. Unfortunately, for environmental regulations such as control of direct discharges, the deterrence approach may suffer practical difficulties. Usually, environmental agencies in charge of direct industrial discharges have many scattered firms to police, with limited budgets and other resources. Additionally, environmental quality monitoring, laboratory testing and on-site inspection are very expensive and time-consuming. Moreover, given that relatively small penalties are the norm, deterrence of violations by the threat of heavy fines and penalties is rarely practical. It is, therefore, crucial for environmental agencies to achieve compliance with reduced enforcement effort, such as fewer inspections and less monitoring.

Fukuyama *et al.* (1994a,b) proposed a cooperative enforcement policy called the *review strategy*. The review strategy minimizes the risk of misjudgment by an environmental agency even when data is incomplete and noisy. The review strategy also induces the operator to comply over the long term, with less enforcement being expended by the agency.

In this research, we focus on *self-monitoring* and *self-reporting* systems, as effective data collection procedures for the review strategy. In a self-monitoring and reporting system, a regulated operator monitors its own discharge and reports it to the regulatory agency. If the agency can implement an incentive-compatible self-reporting system, the effectiveness of the review strategy is enhanced, and mutual trust and cooperation between the agency and the operator are strengthened.

In Ontario, Canada, a long-term multi-sector project called Municipal/Industrial Strategy for Abatement (MISA) has been conducted by the Ontario Ministry of Environment and Energy, industry, and other interested groups, in an attempt to identify and build more cooperative and more cost-effective environmental enforcement relationships (Ontario Ministry of Environment and Energy, 1992). From the beginning, the MISA project has included self-monitoring and self-reporting by industry as an essential component.

As an initial step, we analyze game-theoretically the basic structure of truth-revelation in a self-monitoring and self-reporting system. First, earlier work by the authors which forms a basis for the self-reporting game is summarized. Specifically, in the next section, a 2×2 non-cooperative game model called the Enforcement Dilemma, that captures the central conflict between an environmental regulatory agency and a regulated operator, is introduced. In the same section, the review strategy is presented based on the repeated Enforcement Dilemma, and its efficiency is explained. Then, the self-reporting system is introduced and modeled as an extensive form game, and some fundamental insights from a game-theoretic perspective are given. In the final section, some future directions for the research are suggested.

2. Enforcement of Environmental Regulations

An environmental agency with limited resources chooses its enforcement effort level – at one extreme lenient enforcement, involving minimal costs and disruption; at the other, strict enforcement, placing a substantial burden on all concerned. Under lenient enforcement, an operator in violation is rarely caught, and may lose its incentive to strive to comply. Concerned about the operator's loss of incentive, the agency may decide to enforce strictly, even while the operator is attempting to comply. This attitude of the agency could discourage a cooperative operator from pursuing a full compliance effort – unless its compliance effort is reflected in reduced enforcement strictness, the operator gains little by complying voluntarily with the standards. As a result, both sides hesitate to cooperate – instead they remain at an inferior confrontational position, where the operator's compliance is sustained only by the agency's costly enforcement efforts.

2.1 Enforcement Dilemma

Scholz (1984a,b) provides a 2×2 game model of the enforcement conflict in environmental regulations. This model is equivalent to the well-known Prisoner's Dilemma game. In Fukuyama *et al.* (1994a), we analyzes a more general 2×2 game of enforcement called the Enforcement Dilemma. Figure 1 displays the Enforcement Dilemma between a regulated operator and a regulating agency. An environmental agency (called Agency in the top row) regulates waste discharges from a facility (named Operator in the left column). Operator chooses its compliance effort level, represented by a variable c (where $0 \leq c \leq 1$; $c = 1$ means full effort (Comply), and $c = 0$ represents minimum effort (Violate)). Compliance effort by Operator can be any activity that makes Operator's compliance more certain, such as self-monitoring, checking and maintaining a treatment system, investment in better treatment technologies, employee education, and the choice of environmentally friendly raw materials.

Likewise, Agency chooses its enforcement level measured by a variable e that satisfies $0 \leq e \leq 1$. The choice $e = 1$ means the strictest possible enforcement strategy (called Strict Enforcement),

		AGENCY	
		Lenient Enforcement $(1-e)$	*Strict Enforcement* (e)
OPERATOR	*Comply* (c)	Cooperation $(0, 0)$	Deterrence $(-c_O, -c_A)$
	Violate $(1-c)$	Exploitation $(b_O, -d)$	Confrontation $(b_O - c_O - p,\ b_A - c_A - d)$

Comply : Maximal Compliance Effort
Evade : Minimal Compliance Effort
Lenient Enforcement : Minimal Enforcement Effort
Strict Enforcement : Maximal Enforcement Effort

b_O : Benefit of Violation
c_O : (Extra) Cost of Strict Enforcement to Operator
p : Penalty for Violating during Strict Enforcement
b_A : Bonus (Reduction in Damage) for Catching Violation
c_A : Cost of Strict Enforcement to Agency
d : Social Damage if Operator Violates

Figure 1: Enforcement Dilemma game model.

while, $e = 0$ represents the least strict enforcement (called Lenient Enforcement). This distinction between the two contrastive enforcement approaches to social regulation, cooperative (or lenient) and deterrent (or strict), can be found elsewhere (e.g., Nonet and Selznick 1978; Scholz 1984a,b). Strict Enforcement represents an enforcement program characterized by extensive inspections, strict interpretations of rules, quick prosecutions, and a generally harsh approach, while Lenient Enforcement stands for minimal inspection, non-intrusive monitoring, and generally allowing Operator some latitude.

The Enforcement Dilemma game has four outcomes: Cooperation, Deterrence, Exploitation and Confrontation. Each outcome is a result of a specific choice of options for each player. For example, if Operator chooses Comply while Agency chooses Lenient, then the outcome, at the intersection of this row and column, is Cooperation. The players' payoffs at each outcome are also shown in Figure 1; the first entry in parentheses is the payoff for Operator, the second for Agency. These payoffs include costs and benefits relative to the Cooperation outcome with payoffs $(0,0)$. For example, when Agency chooses Strict Enforcement while Operator chooses Violate, the Confrontation outcome, with payoffs $(b_O - c_O - p, b_A - c_A - d)$, is realized. Here, Operator gains from minimal compliance (b_O) but suffers extra costs due to the strict attitude of Agency (c_O), and faces possible detection and penalty (p), while Agency pays enforcement cost, c_A, suffers from damage caused by Operator's minimal compliance (d), reduced somewhat because of the likelihood of detection (b_A). The payoff for both Agency and Operator in Confrontation is assumed to be negative, so Confrontation is worse for both than Cooperation (which has payoffs of $(0,0)$). This is a plausible assumption meaning that compliance is preferable to detected violation for Agency, and also that penalties for detected violations are severe enough that Operator would prefer to comply rather than to be detected in a violation.

Consider a non-cooperative play of the Enforcement Dilemma – each player in the game decides its option selection without knowing the other's final choice. The fundamental stability definition for non-cooperative games is the Nash (1951) equilibrium. The Nash equilibria for the Enforcement Dilemma is shown in Figure 2. For each point in this graph, there is always a unique Nash equilibrium except for the transitive cases indicated by the dotted lines. The vertical axis, b_A/c_A, represents Agency's Cost-Effectiveness for Strict Enforcement, while the horizontal axis, b_O/p,

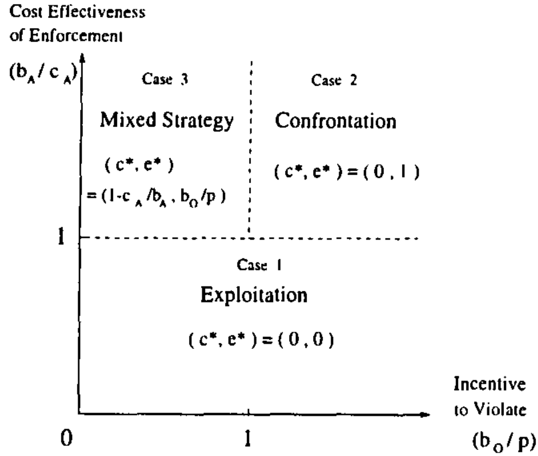


Figure 2: Equilibria in the simultaneous game.

measures Operator's Incentive to Violate. The decision variables with asterisks, c^* and e^*, in Figure 2 represent Nash equilibrium strategies for Operator and Agency, respectively. There are three possible Nash equilibra in the Enforcement Dilemma: Exploitation (Case 1), Confrontation (Case 2), and a mixed strategy equilibrium (Case 3). The analysis of this game is given in detail in Fukuyama *et al.* (1994a). The equilibrium results are analogous to those of Kilgour *et al.* (1992). The following itemized statements describe these three possible cases of equilibrium.

Case 1. Agency always prefers Lenient to Strict Enforcement, because $b_A/c_A < 1$ so that the enforcement cost exceeds the benefit of detecting violations. Thus, Agency always enforces minimally and Operator, facing no risk of Strict Enforcement, always chooses minimal compliance.

Case 2. Strict Enforcement is worthwhile for Agency but, nonetheless, minimal compliance is preferable to Operator. Operator's large violation gain is not sufficiently reduced by the certainty of detection to deter Operator from violating.

Case 3. The only difference from Case 2 is the greater value of Operator's Incentive to Violate (the horizontal axis of Figure 2). In Case 3, the total cost of violation for Operator is high relative to its benefit, Incentive to Violate is low, and some more-than-minimal compliance effort is Operator's response to the more-than-minimal enforcement by Agency.

One hopes that Case 1 occurs rarely in real-world enforcement situations. When Case 1 takes place, the game encompasses no real dilemma – there is minimal enforcement effort by Agency and minimal compliance effort by Operator.

It is noteworthy that in no case does Operator choose maximal compliance effort. Moreover, except for unusual Case 1, the Cooperation outcome, is strictly better for both players (Pareto-efficient). In other words, non-cooperation play of the Enforcement Dilemma never realizes the socially preferable outcome of Cooperation. At best, some level of compliance by Operator can be realized (when the cost and benefit conditions are right), but it is sustained only by the deterrent effects of Agency's occasional use of Strict Enforcement. Similar results can be found in other research applications of deterrence theory. (See, for example, Brams and Kilgour (1988) for arms control, and Becker (1968) for deterring crime).

2.2 Repeated Game Modelling

Unfortunately, it is not easy to apply this approach directly to enforcement of standards for direct discharge from industry; usually one environmental agency is in charge of enforcing regulations on hundreds or even thousands of operators, under very limited budgets and manpower. Inspection and monitoring have very high costs, resulting inevitably in an enforcement system highly dependent on operators' self-monitoring and self-reporting, bolstered with occasional inspection opportunities. Thus, an agency rarely achieves an enforcement level high enough to deter every operator from reducing its compliance effort below what is required to meet permissible limits of discharge. More cost-effective enforcement programs are required especially to induce cooperation from operators with minimal enforcement resources.

One such cooperative enforcement policy is the Tit-for-Tat strategy (Axelrod, 1984) in repeated games (Aumann, 1985) proposed by Scholz (1984a,b). The Tit-for-Tat strategy induces cooperative behavior from operators with minimal enforcement by building a long-term relationship between the agency and the operator. Accordingly, Fukuyama *et al.* (1994a) propose the review strategies, which were originally introduced by Radner (1985) within a spirit of Tit-for-Tat.

Modelling the enforcement conflict as a repeated game is appropriate, especially in environmental regulations, as the relationship between an environmental regulatory agency and a regulated agent does not usually end after one interaction. When this is the case, the decisions are not temporally independent, but can anticipate future costs and benefits due to an opponent's future responses. The repeated game model captures this dynamic aspect of conflicts.

A main lesson learned from repeated game modelling is that *implicit collusion* may occur even though explicit mutually binding agreements or contracts are not available. Under perfect information, in which each decision maker can observe all previous actions of the opponent, a player may know that deviation from an expected cooperative pattern will lead to retaliation by the opponent from the next period on. If so, the player may have no incentive to deviate from the pattern. When retaliation against such deviation is also preferable for the opponent (i.e., it provides greater utility than not retaliating), and the retaliation damage is greater than the deviation profit, the retaliation is called a *credible threat*; the Pareto-efficient Nash equilibrium is continuous mutual cooperation.

In regulation of direct discharges, however, there is asymmetry of information. A regulatory agency rarely observes the choices of the regulated operator using practical levels of inspection and monitoring, while the regulated operator can observe the agency's choices with almost no effort. The agency's strategies are visible as inspection frequencies and attitudes, while the operator's strategies consist of actions affecting the environment. Under this asymmetric information structure, the agency cannot obtain perfect history of choices made by the operator which is required for the Tit-for-Tat strategy to be effective. By a feasible program of monitoring and inspection, Agency can only get partial or noisy data about the operator's compliance decision, that are affected by exogenous random factors, such as inspection inaccuracies and fluctuations in other environmental parameters.

To make credible any threat that would support cooperative implicit collusion in the repeated game, it has to make the data as accurate as possible. Unfortunately, accurate inspection almost always means high costs and other difficulties for the agency. Faced with limited resources, an agency must make do with less data or less accurate data, and it must use this data as efficiently as possible.

By taking into account the accuracy of information gathered by a decision maker, we propose in

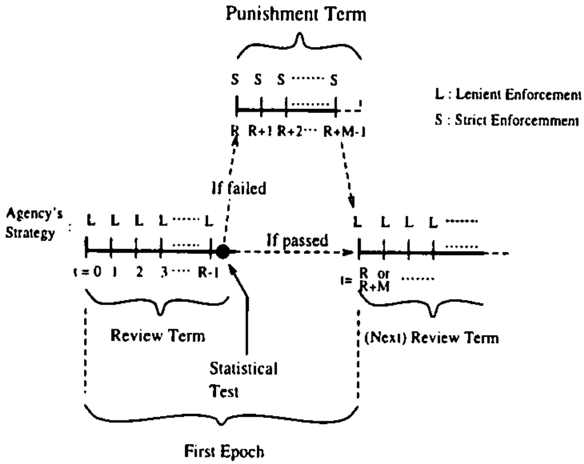


Figure 3: Review strategy for agency.

Fukuyama *et al.* (1994a) effective repeated game strategies, called *review strategies*, that enable Agency to create credible threats even though information may be inaccurate.

2.3 Review Strategies

Under a review strategy, Agency, because it is unable to observe Operator's strategy directly, uses an environmental quality measurement, q_t, as a signal of Operator's decision at each period t. This environmental quality measurement depends not only on Operator's strategy but also on exogenous factors, such as inspection errors and stochastic environmental effects:

$$q_t = q(c_t, \beta_t), \tag{1}$$

where c_t is Operator's level of compliance effort (recall that $c_t = 0$ means *Violate* and $c_t = 1$ means *Comply*) and β_t is a random variable representing exogenous factors. Agency's strategy to induce cooperation from Operator is built on this imperfect information about Operator's actual compliance effort level.

Cooperation realized by the review strategy consists of the review strategy for Agency and the best response for Operator. For precise mathematical definitions of these review strategies, refer to Fukuyama *et al.* (1994a). Figure 3 illustrates a review strategy for Agency. The horizontal axis represents time (left to right direction). The Enforcement Dilemma game is played at discrete time points beginning at time $t = 0$. Agency first inspects Operator's behavior, using the environmental quality measurement, q_t, for a certain number of periods. This monitoring interval, called the *Review Term*, consists of R consecutive periods. At the end of a Review Term, Agency judges Operator's compliance level. This judgment is based on a statistical test applied to the monitoring data gathered during the entire Review Term. If Agency judges that Operator has chosen Violate in at least one period during Review Term (i.e., the statistical test shows significant violation levels), Agency chooses the Nash equilibrium strategy for M periods (Punishment Term). After this interval, Agency again uses only passive measurements of environmental quality for another R periods. This is the next Review Term.

However, if at the end of a Review Term Agency judges that Operator has consistently chosen

Comply (i.e., the statistical test does not show significant violation), Agency does not impose a Punishment Term, but proceeds directly to the next Review Term. In other words, Agency simply continues to monitor Operator's behavior, using the Lenient Enforcement strategy. This alternation of Review and Punishment Terms continues indefinitely.

Consider now Operator's best response to Agency's Review Strategy. During a Punishment Term, Agency chooses its one-period Nash strategy in every period no matter what Operator chooses. Therefore, Operator, faced with Agency's unconditional use of one-period Nash strategy in the Punishment Term, optimally chooses its one-period Nash strategy also. Consequently, the Pareto inferior Nash equilibrium of the one-period Enforcement Dilemma game occurs at every period of the Punishment Term. A strategy for Operator must also describe what Operator would do if Agency did not use Lenient Enforcement at some period during Review Term. In this case, Operator optimizes myopically during the remainder of Review Term and for M' additional periods (*Wariness Term*). In other words, facing the deviation from the expected review strategy by Agency, Operator chooses its optimal Nash strategy in the one period game.

Specify the class of statistical test as follows:

$$\begin{cases} \text{Pass} & \text{if } \sum_{t=0}^{R-1} q(c_t, \beta_t) > \sum_{t=0}^{R-1} q_t^* - B \\ \text{Fail} & \text{if } \sum_{t=0}^{R-1} q(c_t, \beta_t) \leq \sum_{t=0}^{R-1} q_t^* - B \end{cases}$$

where $q_t^* \equiv E[q(1, \beta_t)]$ is the expected environmental quality measurement at period t if Operator chooses maximal compliance effort (Comply) in period t, denoted by $c_t = 1$, and B is the *measurement allowance* term of the test. The interpretation is that if the accumulated sum of environmental quality measurements during a Review Term exceeds the standard (which includes the measurement allowance, B), then the result is Pass and a new Review Term begins; otherwise, the result is Fail and the current epoch does not end until a Punishment Term is completed. This relatively simple statistical test has desirable characteristics, especially when applied to inaccurate data; the accuracy of the statistical test increases with the total amount of data.

Fukuyama *et al.* (1994a) demonstrate that this review strategy has the following properties:

> *When both decision makers' interest rates are low enough, and Agency's Review Term and Operator's Wariness Term are long enough, Agency's review strategy induces Operator to Comply always, yielding utilities for both players that are close to the Pareto-efficient level. Furthermore, the probability that the test results in Fail is close to zero.*

Many numerical examples about effectiveness of the review strategies are presented by Fukuyama *et al.* (1994a,b,c). Figure 4 is one example, showing the relationship between compliance effort level and its utility level of Operator under a review strategy. In Figure 4, the environmental quality function is assumed to be given by $q_t(c_t, \beta_t) = c_t + \beta_t$ and the error factor β_t is assumed to be independently and identically distributed with mean 0 and variance 0.4. The other parameters are specified as shown in Table 1.

In Figure 4, each line represents a review strategy with a different measurement allowance setting, and a solid circle on each line represents a optimal compliance effort point for Operator under the review strategy. Almost full compliance effort can be the best strategy for Operator when Agency uses the review strategy with the measurement allowance $b = 0.5$. Recall that the property of the review strategies given above only says that the utility of Operator in full compliance can be closer to the Pareto efficient with increase in the Review and Punishment Term lengths. In other words, by increasing the lengths of the terms infinitely, Agency can decrease Operator's utility gap between the one gained by repeated Comply and the one by the optimum strategy. Yet, it is sometimes difficult for Agency to set long review and punishment terms. Recall that during the review term, Agency cannot take any further actions even though it finds some obvious evidence of

Table 1. Parameter settings

Payoff Parameters								Review Strategy Parameters			
b_O	c_O	p	b_A	c_A	d	δ	γ	R	M	$b\ (= B/R^{\rho})$	ρ
600	750	500	1000	500	900	0.95	0.95	8	16	$0 \sim 0.5$	0.8

One-period Nash equilibrium is Confrontation.
δ and γ are the discount rates for Agency and Operator.

violation; any extra actions in the review term destroys the credibility of the review strategy and the effectiveness of the strategy disappears. Also, Agency may face highly limited resources which do not allow it to set the expensive punishment term to be arbitrarily long. When the Review Term and the Punishment Term cannot be set long enough to meet the theoretical conditions of the review strategy, there may exist some incentive to save some compliance effort by Operator. In the case of Figure 4, the compliance effort gap between the global optimal strategy (i.e., at the solid circle) and the utility gained by full compliance (i.e., at the point of 10 in the horizontal axis) is not negligible. Fukuyama *et al.* (1994c,d) focus on this practical limitation of the review strategies and propose a penalty system as a supplemental system of the review strategies. A numerical example shows that introducing a penalty (which can be quite small) into a review strategy can supplement its practically limits and therefore maintain it as being effective and efficient.

3. Game-Theoretic Analysis of a Self-Reporting System

3.1 A Model of Self-Reporting

As summarized in the previous section, review strategies are proven to be effective and efficient enforcement schemes for an environmental agency. Certain practical problems associated with the review strategy can be overcome by introducing a (small) penalty into the enforcement process. In review strategies, the statistical test plays an important role, because the effectiveness of the policy depends crucially on the appropriateness of decisions based on the data. (For example, changing the measurement allowance has a strong effect on Operator's optimal compliance level (solid circles) in Figure 4). Among many statistical tests available, we chose a simple test given in (2), which has two key features: 1) the test depends only on the accumulated data, and 2) the test contains an explicit measurement allowance. When environmental quality data is independently and identically distributed, the first property guarantees the accuracy of the test given enough data [by application of Chebyshev's inequality; see Fukuyama *et al.* (1994a)]. The second feature, the measurement allowance, can balance the tendency for "false alarms" against the incentive for violation. Although the first feature guarantees increasing accuracy in the test, it does not necessarily mean no misjudgments. Figure 5 shows the relationship between probability of punishment and measurement allowance for the example specified in the previous section. The line at the top of the figure is the case of zero measurement allowance. It is clear that when there is no measurement allowance, Operator in full compliance nonetheless faces a punishment probability of about 50%. However, by changing the measurement allowance, this probability can be made quite small (see the lowest line for which $b = 0.5$). Note that the level of measurement allowance has little effect on the probability of detection if Operator's compliance level is low.

All of these desirable characteristics of the statistical test, and review strategies in general, depend on the assumption that environmental quality data are reliable. This assumption may be dubious, however, if an environmental agency with limited resources and hundreds of discharge sites to regulate requires each operator to self-monitor and report its discharge levels.

The Ontario Ministry of Environment and Energy is in charge of more than 160 industrial direct dischargers and uses self-monitoring systems extensively in compliance assessment (Ontario

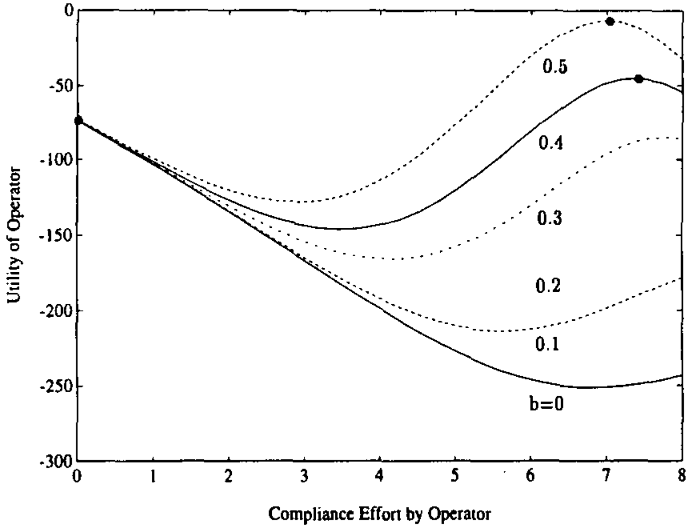


Figure 4: Optimal strategy of Operator under a review strategy.
(• = optimal point)

Ministry of Environment and Energy, 1992). Most dischargers monitor their effluents on an agreed-upon basis, and report the data to the Ministry at regular intervals. The agency uses auditing techniques such as split-sample-comparison and verification sampling to ensure the reliability of the self-reported data.

Yet, it is questionable whether auditing activity has a significant deterrent effect against careless self-monitoring and data falsification. An environmental agency needs an incentive-compatible self-reporting system in which operators always make reasonable efforts to obtain accurate monitoring data and to report the data without modification. In the next subsection, a game-theoretic model having a self-reporting system is presented and analysed.

3.2 The Self-Reporting Game

Figure 6 shows a game model of a self-reporting system. There are two decision makers, Operator and Agency. As in the Enforcement Dilemma above, Operator represents an industrial firm producing water or air-borne discharges, and Agency is an environmental agency in charge of regulating Operator's discharge. We assume that Agency uses a self-reporting system requiring that Operator monitor its discharge and report the data to Agency. The first of Operator's two decisions is whether to Violate or Comply. Again, Violate does not necessarily mean intentional violation, but rather minimal compliance effort, which may result in violations of environmental standards. In the same way, Comply means maximal compliance effort by Operator. Operator's second decision is whether to report the true monitoring data to Agency (*Report Truth*) or to falsify the data (*Falsify*). The first option, Report Truth, does not necessarily mean that the reported

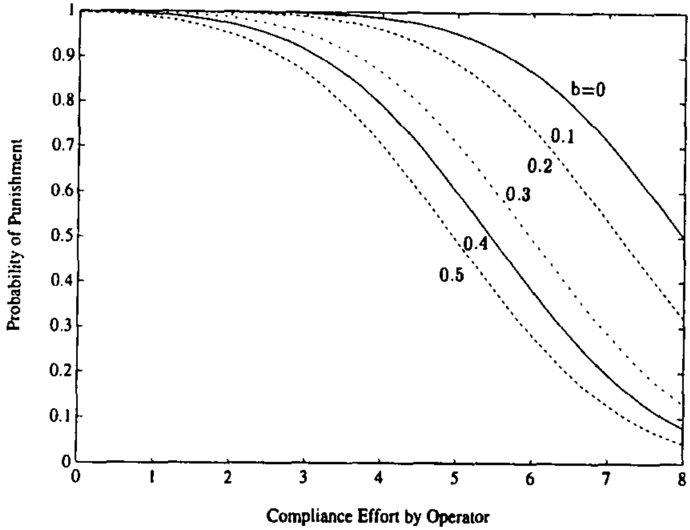
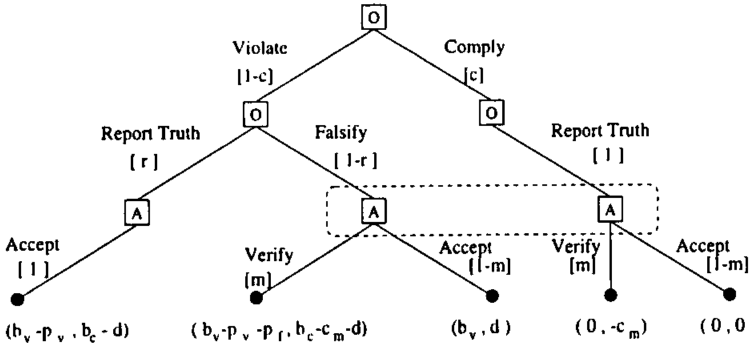


Figure 5: Compliance effort level of Operator and the probability of Punishment.

data indicates the precise discharge levels. The measurement of direct discharge is almost always affected by factors such as dilution and measurement and laboratory errors. Therefore, it may happen that the data reported by Operator under the Report Truth alternative will not agree with attempts at independent verification. Simply put, the option of Report Truth is taken when Operator self-monitors its discharge with care and reports the resulting data without modification. Operator's other option, Falsify, means intentional falsification and/or fabrication of data, and may also include improperly gathered data resulting from Operator's lack of due care or due diligence. By carelessly applying proper monitoring procedures, or by using improper procedures, Operator may obtain data (without any explicit falsification) that are far different from what should have been obtained.

Agency, on the other hand, has only one decision, – to verify the self-reported data (*Verify*) or not (*Accept*). The verification process is assumed to be perfect; it enables Agency to determine precisely all of Operator's decisions – Violate or Comply, and Report Truth or Falsify.

To interpret the game illustrated in extensive form in Figure 6, start from the top node, and read downward. A square node means a decision point, and a solid circle an outcome of the game. The top square with symbol *O* means that the first decision of the game belongs to Operator, who initially decides whether to Violate or Comply. If Operator chooses Comply, the game moves to the lower right sub-tree, but if Operator chooses Violate, it passes to the lower left sub-tree. The second decision also belongs to Operator, who decides whether to Report Truth or Falsify. Note that if Operator chooses Comply first, it has no incentive to falsify; therefore the Falsify option is not shown. If Operator decides to Violate initially and therefore moves to the left hand tree, Operator decides whether to Report Truth (left branch) or Falsify (right branch). Note that, because Operator chose to Violate initially, the Report Truth option in this sub tree implies admission of Violation. Thus, if Operator chooses the left path each time, Agency needs not to



Operator		Agency	
b_v	: Benefit of Violation	b_c	: Benefit of Catching Violation
$-p_v$	: Penalty against Violation	$-c_m$	: Monitoring Cost for Auditing
$-p_f$	: Penalty against False Report	$-d$	: Damage Caused by Violation

Figure 6: Self-Reporting Game.

monitor, for it knows that Operator is in violation.

After these two consecutive decisions by Operator, Agency decides whether to Accept or Verify. Note that two of these decision points are enclosed by a dotted line, which means that Agency cannot know the prior decision made by Operator. In other words, Agency must decide whether to Verify or Accept with no information about Operator's Violate/Comply decision. When Operator chooses Violate and then Report Truth (left node), Agency can infer Operator's prior decisions. The game has five possible outcomes (solid circles). For example, if Operator chooses Violate first and Falsify second, and Agency chooses Verify, then the game results in detected violation. The expected utility payoff of each outcome (von Neumann and Morgenstern, 1953) for Operator and Agency is adjacent to each terminal node; the first entry in parentheses is the payoff for Operator and the second for Agency. The cost and benefit factors included in these payoffs are given at the bottom of Figure 6. Note that all symbols represent positive numbers, so a payoff parameter with a negative sign represents a cost. The case in which Operator chooses Comply and Agency chooses Accept is assumed to be the base case with payoff $(0,0)$. For example, if Operator chooses Violate and Falsify, and Agency chooses Verify, then Operator's payoff is $b_v - p_v - p_f$, the benefit of violation minus the cost of penalty for violation ($-p_v$) and for falsification ($-p_f$); Agency receives $b_c - c_m - d$, reflecting the damage caused by the violation, ($-d$) and the verification monitoring costs ($-c_m$), and also the benefit of detecting violation and falsification (b_c).

In the Self-Reporting Game, the players' strategic choices are represented by decision variables c, r and m, the first two for Operator, the last for Agency. If the decision variable is neither 1 or 0 (i.e., if the decision is a mixed strategy), it is interpreted as the probability that Operator chooses the strategy. For example, if $0 < r < 1$, then r is the probability that Operator chooses Be Truthful (so that $1 - r$ is the probability of Falsify). The expected utilities for Operator and Agency, respectively, are calculated as follows:

$$\begin{aligned} U_O(c, r; m) &= [b_v - m(p_v + p_f)] + r\{m(p_v + p_f) - p_v\} \\ &\quad + c\{m(p_v + p_f) - b_v\} - rc\{m(p_v + p_f) - p_v\} \qquad (2) \\ U_A(m; c, r) &= m[\{(b_c - c_m)(1 - r) + c_m\}(1 - c) - c_m] + (1 - c)(rb_c - d) \qquad (3) \end{aligned}$$

Table 2. Best Response of Operator.

Case 1) when $\lambda > \mu$ (i.e., $b_v < p_v$)

m	$0 \cdots$	μ	$\cdots \ \lambda \ \cdots \ 1$
$(c*, r*)$	$(0,0)$	$(1,r)$; $r \in [0,1]$ or $(c,0)$; $c \in [0,1]$	$(1,r)$; $r \in [0,1]$

Case 2) when $\lambda = \mu$ (i.e., $b_v = p_v$)

m	$0 \cdots$	$\lambda = \mu$	$\cdots \ \ 1$
$(c*, r*)$	$(0,0)$	(c,r) ; $c, r \in [0,1]$ or $(c,1)$; $c \in [0,1]$	$(1,r)$; $r \in [0,1]$

Case 3) when $\lambda < \mu$ (i.e., $b_v > p_v$)

m	$0 \cdots$	λ	$\cdots \ \mu \ \cdots \ 1$
$(c*, r*)$	$(0,0)$	$(0,r)$; $r \in [0,1]$	$(0,1)$

Rational behavior by Operator and Agency in this game involves maximizing their expected utilities given by (2) and (3), respectively.

3.3 Analysis of the Self-Reporting Game

We analyze here equilibrium behavior in the Self-Reporting Game. First, we consider the best response by Operator. The *Best Response* of a decision maker is the choice that yields maximal utility, as a function of the opponent's strategy. Recall that we are more interested in how to induce honest reporting than how to achieve full compliance effort by Operator in this game; Operator's incentive for full compliance effort is induced by the review strategies presented in the previous section. Let (c^*, r^*) denote the best response of Operator. Two important parameters, λ and μ, that affect Operator's best response are defined as follows:

$$\lambda = \frac{p_v}{p_v + p_f}, \quad \mu = \frac{b_v}{p_v + p_f}.$$

λ measures the relative harshness of penalty for violation, and μ Operator's incentive to violate. Therefore, the relationship between λ and μ represents Operator's incentive to violate given that its choice Comply or Violate will be known by Agency for certain. For example;

- $\lambda > \mu$ means that there is no incentive to choose Violate, given Agency will learn the actual decisions of Operator;
- $\lambda < \mu$ means that there may exist an incentive to violate, even when Agency will learn for certain Operator's actual decisions.

The *best response of Operator* is summarised in Table 2. There are three cases: $\lambda > \mu$, $\lambda = \mu$ and $\lambda < \mu$, depending on Operator's cost and benefit structure. In each table, the first row is Agency's level of verification monitoring m (which ranges from 0 to 1). In Case 1 and Case 2, where Operator has no strict incentive to violate, Agency can induce Operator to choose Report Truth for certain only when $m > \mu$. In Case 3, Operator chooses Report Truth when $m > \lambda$ ($> \mu$). However, note that Case 3 represents a situation which should not be accepted by Agency – even knowing that violation will be detected for certain, Operator still has no incentive to Comply.

Table 3. Nash equilibria of the Self-Reporting Game.

A)	when $b_c - c_m < 0$		
1)	when $\lambda > \mu$	$(c^*, r^*) = (0,0)$	$m^* = 0$
2)	when $\lambda = \mu$	$(c^*, r^*) = (0,1)$	$\lambda = \mu \le m^*$ (implying $m^* = \lambda = \mu$)
3)	when $\lambda < \mu$	$(c^*, r^*) = (0,1)$	$\lambda \le m^* \le 1$ (implying $m^* = \lambda$)
B)	when $(b_c - c_m) = 0$		
1)	when $\lambda > \mu$	$(c^*, r^*) = (0,0)$	$m^* = 0$
2)	when $\lambda = \mu$	$(c^*, r^*) = (0,0)$	$m^* = 0$
		$(c^*, r^*) = (0,0)$	$m^* \le \lambda = \mu$
		$(c^*, r^*) = (0,r)$; $r \in [0,1]$	$m^* = \lambda = \mu$
		$(c^*, r^*) = (0,1)$	$\lambda = \mu \le m^*$
3)	when $\lambda < \mu$	$(c^*, r^*) = (0,0)$	$m^* = 0$
		$(c^*, r^*) = (0,r)$; $r \in [0,1]$	$m^* < \lambda$
		$(c^*, r^*) = (0,1)$	$\lambda < m^*$
C)	when $(b_c - c_m) > 0$		
1)	when $\lambda > \mu$	$(c^*, r^*) = (1 - \frac{c_m}{b_c}, 0)$	$m^* = \mu$
2)	when $\lambda = \mu$	$(c^*, r^*) = (c, r)$; c and r satisfy $\frac{\partial U_A}{\partial m} = 0$	$m^* = \lambda = \mu$
		$(c^*, r^*) = (0,1)$	$\lambda = \mu < m^*$
3)	when $\lambda < \mu$	$(c^*, r^*) = (0,1)$	$\lambda \le m^*$

Table 3 is the list of Nash equilibria of the game. The equilibrium of this game does not provide much information about Operator's compliance; we already know from the Enforcement Dilemma that Agency cannot achieve maximal compliance effort by Operator within the framework of the one-period deterrence game. The point we focus on here is when Report Truth can be induced. In that sense, the best response of Operator given above is attractive.

The Nash equilibrium of this game varies depending on the parameters λ and μ as well as $(b_c - c_m)$. The value of $(b_c - c_m)$ represents Agency's incentive to provide verification monitoring given that Operator already chose Violate. For example, $b_c - c_m < 0$ means no incentive for Agency to catch Operator in a violation. Therefore, Case A (and Case B, which is a transitional case and therefore can be neglected) has little meaning. In Case C, Operator chooses Report Truth precisely when $\lambda < \mu$.

4. Conclusion

Ensuring continuous compliance to environmental regulations is an important task for agencies charged with maintaining a healthy ecosystem over the long term. Unfortunately, agencies usually have limited resources and too many potential violators to police, and comprehensive and accurate monitoring and inspection may be infeasible or unaffordable. Facing these problems, environmental agencies require effective enforcement with which cooperative behavior by operators can be induced.

Fukuyama *et al.* (1994a) propose an efficient enforcement scheme called the *review strategy*. This review strategy was proven to be an effective and efficient enforcement scheme over the long term. Therefore, using review strategies, an agency can allocate its scarce resources efficiently among many operators; operators in compliance are rewarded with a cooperative approach by the agency, while operators not meeting standards are punished. While the review strategy provides effectiveness and efficiency in theory, it entails some practical difficulties – for instance, the review strategy does not guarantee that full compliance by an operator be the best compliance strategy. This problem becomes more serious when considering the fact that an environmental agency can rarely set very long review and punishment terms that may be required. In Fukuyama *et al.* (1994b), a penalty system is incorporated into the review strategy, and it is demonstrated that appropriate penalties (that can be relatively small) can enable review strategies to achieve efficiency and effectiveness in practical situations when they are accompanied with an appropriate statistical test setting.

The research reported here is an extension of this work – it addresses the problem of how we can integrate self-reporting systems with effective enforcement schemes such as the Review Strategy. To activate a Review Strategy, or any other effective enforcement scheme, the agency must have reliable monitoring data on actual discharges by operators, allowing the agency to allocate its resources most efficiently. Unfortunately, in North America, Japan, Europe and elsewhere, environmental agencies are faced with resource constraints that prevent frequent monitoring; therefore, they often require operators to monitor their own discharges and report them to the agency voluntarily. In this case, operators could have little incentive to put extra effort into obtaining a better monitoring and may even have incentives to under-report monitoring results, particularly if the agency carries out little or no inspection to verify self-reported data.

A game model of a reporting system is developed, in which the operator has two decisions – Comply/Violate and Report Truthful/Falsify – while the agency has one decision – Verify/Accept. The model and its equilibria are analyzed to determine the relationship of the operator's True/False reporting choice to parameters such as the cost of compliance and the benefit of violation (and evasion). It is shown that by setting the severity of penalty and the monitoring frequency appropriately, the agency can deter false reporting by the operator. Therefore, a truth-revelation mechanism is realized, enabling the agency to utilize effective and efficient enforcement schemes such as the Review Strategy.

Yet our research on self-reporting has just started and many problems remain to be solved. Recommended main future research includes analyses of enforcement systems from the viewpoint of moral hazard existing in operators. Also, effectiveness of the self-reporting system combined with effective enforcement strategies such as review strategy should be examined. Other reseach related to enforcement of environmental standards is presented in a set of papers edited by Hipel and Fang (1994) and references contained therein.

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TECHNOLOGY PROCUREMENT FOR MARKET TRANSFORMATION. A CUSTOMER TOOL FOR SUSTAINABLE DESIGN AND MANUFACTURING.

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There are immense technology improvements to be made, not only to have products giving better service in their basic use, but also to achieve far reaching goals for a better environment at the same time. Many of these improvements are realized only under a distinct pressure, a demand pull, from the customers to deliver products with such performance. Yet, on many markets this demand pull is only seldom used, since strength and knowledge is unevenly distributed between the acting parties. The stronger part is normally the supplying manufacturer and the weaker one is the customer.

On some markets there have however been made substantial changes after customer initiatives. Among the more well known, the market for paper products is one and the market for detergents is another. Products which require investments, such as white goods for households, building materiel, vehicles, installation materiel etc, can also be subject to a demand pull but requires an articulation of customer will. The goal is to have a full "Market transformation", initiated by a demand pull and followed by a supply push as more manufacturers find that customer focus has shifted. The demand pull is, in its turn, initiated by e.g. "Technology Procurement".

The market is a good instrument for distribution of goods but can be a bad allocator of resources. This phrasing is just a general description of common knowledge and practice in most countries and has been more well put by the Czech author and president Vaclav Havel in the words: "The market is a good servant but a bad master". The possibility to influence and change the marketplace is hardly new to economists and definitely not beyond controversy. What might be new is the environmental concern, as a reason for the "intervention", and the modes of activity. The "intervention" is nowadays more conform to market way of function. Thus different taxes and financial instruments are frequently argued as clean and silent mechanisms. It has, however, lately been debated if these are effective at all[1] and in this paper the more active method of

[1] "A paler shade of green", Bronwen Maddox, Financial Times, May 94. Referring to, among others, OXERA, an Oxford based forecasting group, which has showed that

establishment of a demand pull, as trigger for supply push, will be advocated.

Only during the last few years we have experienced such demand pull as a factor of growing importance when working with goods having an impact on the environment. Markets have for a long time been treated both in analysis, and in deed, according to "laissez faire" but will more and more be dealt with "en faissant" That is to say that when you are acting for one goal, you could at the same time serve another one. When you are acting to get better performance in the function of the product you could at the same time act to save the environment.

Evidence of Market Transformation.

Market transformation has been seen in many industrialized countries where demand for commodities has been shifted dramatically during the last years towards more green products. Basically the environmental consciousness of people is the driving force and the swing can be very quick. The change in demand for paper from the chlorine bleached qualities to non-bleached, recycled quality came very quickly and was significant. The same thing seems to happen with detergents and with office equipment. The basic mechanism is demand pull trigged by environmental awareness

The build up of market shares in Sweden for environmentally adapted detergents[2] has been very fast, from less than 1% in 1990 to approximately 70% in 1994[3].

	1990	1991	1992	1993	1994
Market share (%)	<1	6.7	18.8	51.6	≈ 70

The market for environmentally adapted paper today holds a market share of approximately 60%[4].

A market research[5] carried out by NUTEK on the actual situation and intentions of computer companies, suggests the willingness to respond to demand for energy efficient products to be very high.

energy demand is not very much responsive to price changes.

[2] Those which have some kind of an eco-label

[3] Kemisk-Tekniska Leverantörsförbundet.

[4] Skogsindustrierna

[5] Made by Stellacon Konsult February/March 1994. Figures are showing ranges of answers from different companies

PRODUCT	%1994	%1995
PCs	0-55	20-100
Printers	10-50	90-100
Monitors	10-50	50-100

It is notable that the producers and suppliers of office equipment act more on the perceived demand from key customers which they think will ask for energy efficiency. There is so far not a general demand for such a feature established on the market, but demand pull seems to have resulted in a supply push on a type of market where the turn-over of models is fast and the growth in volume is rapid.

These examples are however from markets where products are bought frequently or repeatedly and the customers can almost day by day correct their choice. Products which require an investment are bought more seldom and often involve more people in the decisions. The Market Transformation in such cases obviously requires methods adapted to such a situation. A typical customer buys a refrigerator 3-4 times during his life. How can we make sure that we are there with the right product when he is ready to make his choice?

Modes of Market Transformation

Analytically speaking the market can be transformed in three ways:

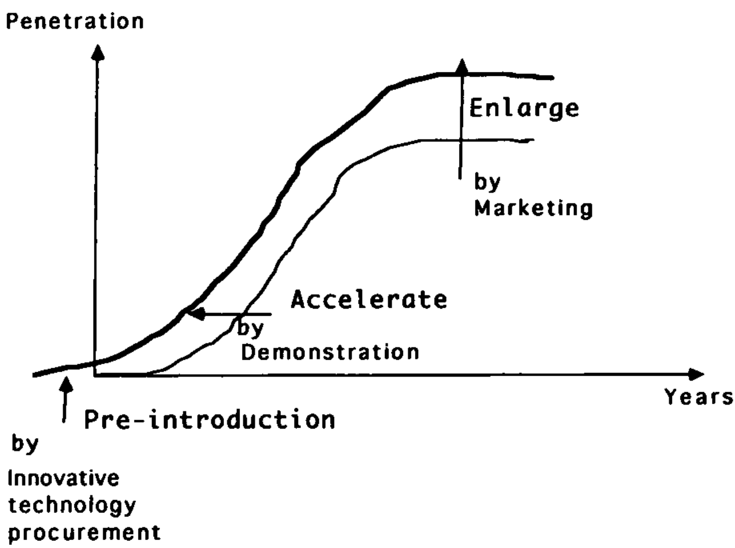
* by preintroduction of products into the marketplace
* by acceleration of their penetration to the market
* by enlargement of the market share

Preintroduction means that the product is delivered to the market earlier than anticipated under a "laissez-faire" scenario. **Acceleration** means that the distribution of the product is made more quickly than would otherwise occur and thus the market reaches its saturation faster. **Enlargement** means that the penetration of the product makes the market reach higher level of saturation.

Preintroduction and acceleration can successfully and significantly be affected by governmental programs for technology procurement and demonstration. Enlargement, however, is mainly a matter for the companies on market since they will have best position and can act in their own interest. Governmental involvement in market enlargement will tend to be costly and less cost effective.

There is a growing governmental awareness around the world that market forces could be used more to work on government will. Especially by skilful use of the governments own demand for products in procurement programs. This type of programs have been more known under the US description "Golden Carrot"[6]. Unfortunately, there is also a tendency to use the instrument for promotion of national industry under which circumstances the instrument will be more blunt, since the force of competition is not fully used.

Market transformation and associated activities



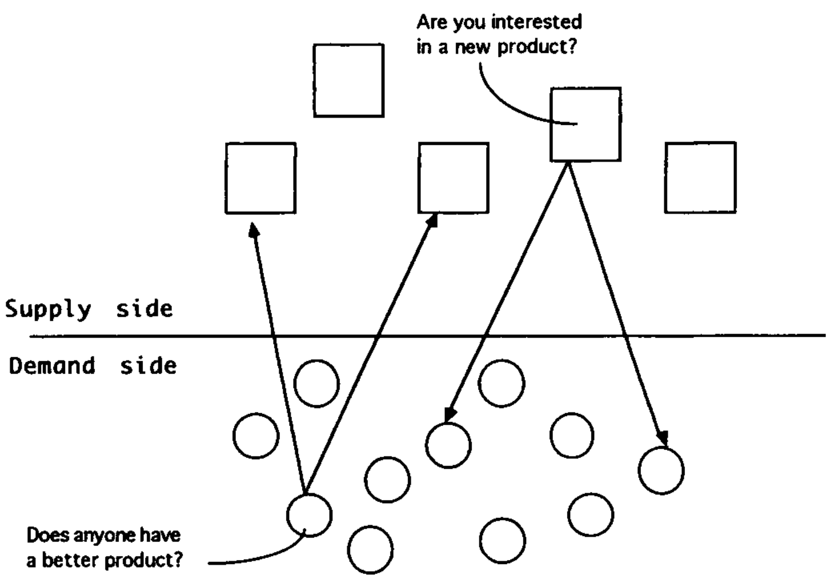
Technology Procurement.

A tool for preintroduction, which has been shown to be effective, is technology procurement which is a way to establish confidence between manufacturers and customers for new products. Technology procurement is for this reason based on two important

[6] The most well-known project is the one for super-efficient refrigerators/freezers (SERP) sponsored by US electric utilities. Golden Carrot projects are also frequently mentioned in the US Climate Change Action Plan.

assumptions:
* The purchaser of equipment must be directly involved in the process and to a reasonable extent share the risk for the new products. It is the existence of purchasers and the prospect of large deliveries that makes the supplier interested
* The costs for development should be carried by the manufacturers and the products should be made available to the market without lengthy delay. It is the ability of the supplier to deliver and to take responsibility for the function of products that makes the purchaser interested

The traditional rule of supply and demand interactions on the market is for manufactured goods rather that of supply push than that of demand pull. The manufacturer tries to find out customer reactions by different methods of market research. Some customers try to find some better products and far too often the two sides do not meet[7]. Both parties basically know that technology can be improved but you have to find the right timing to make the technology competitive and massproduced.



[7] This is a completely normal situation on many markets and do not justify intervention. The reason for intervention in favour of energy efficiency is instead true market failure where optima will not be sought, nor maintained under perfect market conditions. A popular description of this failure is illustrated by the pay-back gap. See Appendix 1.

The role to be played, in order to make this market work more properly, then has to do with the matching of the two perspectives.
* The first step is to **gather** a significant demand by bringing a number of purchasers together. Such a demand can be significant either because of the volume it represents or because of the type of customer that it is representing. It has to reflect an upcoming demand impressing enough to the supplying companies to compete for. And it has to be a true market, not something only wished for by governments.
* Next the demand has to be **articulated**, meaning that the performance characteristics asked for have to be defined and put into a specification. This is a process with a lot of fine tuning where you have to find the right level of performance. Not too trivial and easily achieved, and not too futuristic and hard to get.
* The requirements have to be **communicated** to the potential suppliers. In the case of a formal procurement this is a well structured procedure with Requests for Proposals (RFP) put up for tenders. All steps covered by a formal legal framework. There might, however, be procurements made by more than one entity and at different occasions using the same basic requirements.

Having arrived so far the procurement procedure is generally, and in simple cases, carried through. Depending on the type of market, products, distribution, etc, there might still be need for activities to reinforce and secure the demand.
* A logical step has to do with **focusing** of interest on the new products. This is especially necessary when there are many actors involved in the process of buying, i.e. consultants giving advice to a contractor building for a customer. All these persons have to agree on the choice but are reached through different channels and are often having very different attitudes to the products.
* Finally the focus can be **amplified** by someone having an interest either in the business of the new products, such as a retailer, or in the image that the use of these products can give them.

As the procurement works with demand, all incentives are also aimed at the purchasers. The incentive for the suppliers is the future market for advanced products. It means that we are making full use of the market forces in their ability to deliver. Thus there is a clear distinction between this programme and most others based on Supply Side activities and subsidies for national industry.

THREE CASES OF VARIED PROCUREMENT.

1. The Case of combined refrigerator and freezers

This procurement[8] was initiated by some of the major building companies in Sweden which have a large stock of flats built during the sixties that is now in need for thorough retrofit. The companies equip the flats with combined refrigerator and freezer though the tenants are responsible for the costs to operate the equipment. In spite of this split incentive many of the companies argue that, when they are providing the equipment, they want it to be modern and to comply with a general view of environmentally friendliness.

The performance requirements in the RFP meant improvements with 25% measured to the best product on market at that time, 35 % to the average sold and 55 % to the average installed. The winner in the competition actually performed even better by beating the RFP desired level with another 10%.

Tenders came from five interested companies and three of these met the mandatory level of performance according to the RFP. It was however obvious that most companies did not feel accustomed to the process and also, at first, were a bit uncomfortable with this situation.

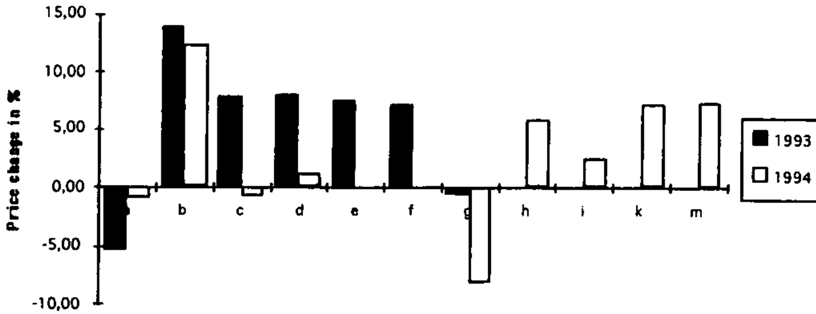
The deliveries in the procurement first series are very small compared to actual market. In the end they were 780 units on a market of some 100 000 units a year. The delivered products also had a remarkably higher price compared to the those already put to market (see below). The programme compensation to the purchasers did not fully cover this price difference.

If the leverage effect is working fully, the benefit to customers of less energy use is thousandfold to the programme cost and thus easily justified without lengthy calculations. There is however a risk that the customers will have to pay more for this new equipment than they will save on their electricity bill. Thus the market has been tracked and vintages of combined Refrigerator and Freezers, 1991-94, have been investigated. The first year is the one where the design obtained by the Swedish program for technology procurement first occurred. In this analysis the ten best of the products have been put together for each year, Average price and average performance for these have been calculated. It is indeed relevant to say that when the new models hit the market the

[8] See Appendix 2 for basic facts

price is high. The supplier seems simply to be cream-skimming. But as the competitors catch up, the price drops (See Appendix 3).

It is remarkable that competition brings forward more manufacturers with similar design very quickly and that the average price is not very much changed. In real term prices, it has actually dropped from 1991 to 1994. It is also interesting to see how specific designs (a-m[9]) are changing prices in an attempt which seems aimed to catch different categories of consumers on the market. The table below shows changes in price since introduction.



<u>2. The case of office equipment.</u>

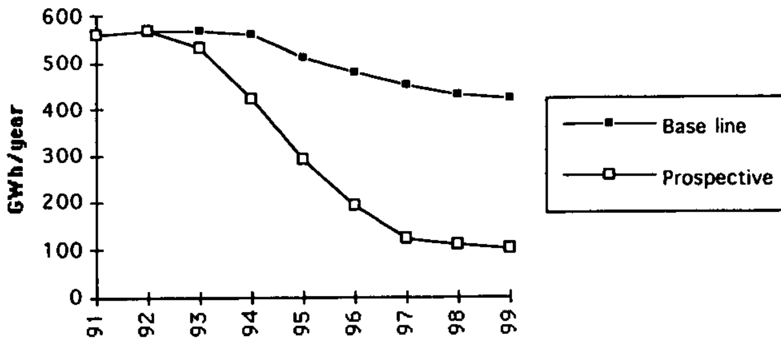
A small country has to get powerful friends in order to have impact on big business. Sweden has developed a strong contact with the U.S. and its agency for environmental protection, EPA. In this case the procurement is less formal and more indicative. EPA has its Energy Star programme with its own performance level and Sweden has its programme for environmentally adapted offices with a tougher performance level. This programme is in Sweden a cooperation between the government agency, NUTEK, the office workers union, TCO, and an environmental organization, SNF.

The estimated impact from the higher performance requirements compared to a base case, with a growth in use of equipment and an inherent improvement, is remarkable and shows that energy use (see below) can be lowered to less than 25 % [10].

[9] See appendix 3

[10] Kontorsapparater, Energianvändning och Besparingspotentialer, Oktober 1993, Eje Sandberg, AIB.

Energy use in office equipment



Such equipment is not more costly and rather easily adapted but still not obtainable. "We can do it but somebody will have to ask for it", as it was stated from one of the supplying companies.

One of the features according to the Swedish requirements is the "power down" for equipment when it is inactive. Measurements made on site in a Volvo office shows that this function reduces the energy use by 60% without any problem in the working performance but rather a feeling of satisfaction knowing that there is no unnecessary field impact in the working area.

3. The case of Lighting.

Lighting in commercial areas can be improved from both an energy perspective and from other perspectives related to ergonomical issues such as flicker in light, electric and electromagnetic field, glare, etc. One of the key elements is the use of High-Frequency Electronic Ballasts. These reduces the energy loss by some 15-20% and further enables improved control of lighting according to occupancy or to daylight.

The Swedish Programme issued a formal procurement for HF-Ballasts to bring up volume, thus reducing prices, and to secure performance levels. The procured batch was 20000 units, but with the options for enlargement it ended in 46000 units. Almost simultaneously a demonstration programme was launched for office lighting where requirements was laid down for the fixtures and a programme enabling important buyers to get more hands-on experience from new lighting designed to their own circumstances.

The units procured had their advantage mostly in the volume/price relationship. In the actual installations the reduction in energy use has typically been in the size of 50%.

As a result spreading of HF-Ballasts has multiplied by 10-20 in 3 years. They have captured approximately 30% of its relevant market today. Interviews show expected continuance in market growth.[11]

	1990	1991	1992	1993
Thousand Units sold	10-20	50	100	200-250

Interviews also show that energy efficiency only ranks number two in arguments for choosing these ballasts and is only one of nine important arguments[12].

Technological development.

The notion that more efficient products are more costly is correct, if looked upon as a technical change "ceteris paribus". It has been shown that changes in energy efficiency of e.g. refrigerators means use of thicker or more expensive insulation material, more expensive compressors, more expensive refrigerants, new condenser or evaporator design, etc.[13] In these studies the cost estimates have been made either from an analogy between different sizes of units or from engineering studies and dialogue with the manufacturers. The answer then depends on how the question is asked and on the assumptions concerning why a manufacturer should make the changes. The result then rather reflects a case when a functioning production line should be abandoned and replaced. Most such changes are however made when retooling in the production and when advantages of scale, or from learning, can be used fully.

The market is also more oligopolistic than perfect and a lot of the changes are made in the continuous battle between manufacturers over market shares and images. This means that the changes will occur if it can be made an advantage in this battle and will never do if the opposite is more likely. The only true valorization of technology shifts are from the market, e.g when procurements are

[11] Energianvändningsrådets rapport 1993/94 .

[12] Att påverka marknader effektivt, SIPU Utvärdering AB, maj 94.

[13] Study on Energy Efficiency Standards for domestic refrigeration appliances. Commission of the European Communities. Final report of the GEA group, WG 106. 1992

made. It seems more to be a case of interaction between "lead users"[14] on the demand side and "first mover"[15] on the supply side.

Concluding remarks.

Participating bidding companies have stated that once the procurements are set, they prefer this kind of government involvement to many others. Firstly because it improves productivity in their own R&D efforts. They do not have to search in the dark, but get the demand clearly on paper. It is also an activity with no discrimination between companies, which is deemed to be fair and equal. The role of an impartial government agency also takes away the negotiating incentive which otherwise is the natural response to new requirements put up from one purchaser only.

For the government it is truly more cost effective to use market forces as leverage both for R&D and for delivery, than to give subsidies to cover costs in supplying companies or to subsidize use of equipment which in the end might be bought because of the subsidy rather than the usefulness. It is further more positive to work with a pull for better products than trying to ban the less good ones by standards.

It seems reasonable to assume that Technology procurement is a well functioning instrument which can be applied in many cases where environmental concern calls for "greening" of design and manufacturing. The upcoming huge demand for new equipment in the Baltic Sea area could form a powerful basis for improvements tailored not only to the countries with economies in transition but also to the other countries in the area. Natural areas for these procurements should then be energy efficiency, renewable energy generation, logistic systems and reduction of water and air pollution.

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[14] The "Lead user" theory is quoted from von Hippel in "Technology Procurement for innovation in Swedish construction". Hans Westling. The Swedish council for Building Research.D17:1991

[15] Industrial Market Structure and Economic Performance. Scherer and Ross. Houghton Mifflin Co. 1990.

The Pay-Back Gap.
An extra kWh required for the energy system can be obtained either by building new power or by reducing demand. The choice should be made according to which is the cheaper solution of the two. Since the suppliers of power and the end-users of energy have different economical perspectives there is a systematic bias between them, which leads to a tendency to overspend on supply and to disregard the demand opportunities. The supplier calculates and acts with a lower rate of return than the user. The difference is known as the pay-back gap, which shows the amount of overspending on supply. Narrowing of that gap should be a goal, if we want to have truly cost-effective energy systems.

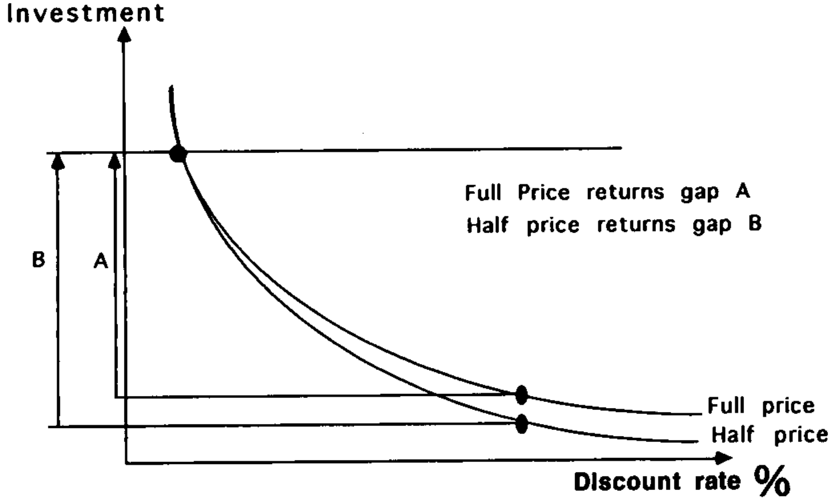
The more pronounced the supply monopoly, the lower the risk for the supplier. In such cases the supply side calculations are made at low discount rates and high investments are justified. The interest to participate in enhancement of the energy efficiency, especially from the utilities, might however be drastically changed with some of the measures, such as the deregulation where their role as profit maximizing entities will be stressed.

It is important to note that this pay-back gap exists regardless of the pricing and whether this is cost-based or not. If the demand side values its opportunities at a high discount rate this will easily outweigh the differences a wrongful pricing can impose. The sum the customer is prepared to invest to offset the use of a kWh priced at half its value is indeed half the sum compared to if the price was according to the true value, but the pay-back gap is far bigger than this difference

Illustrating example: Assume that he has the option of an investment that yields a return of $10 per year during ten years. The investor using a rate of 6% is prepared to invest $74 to get the $10 per year while an investor calculating at 60% only spends $17. The "pay-back gap" in this case is $57. (See B in figure below) Assume the $74 "supply side" investment as a reference and the yield for the customer $20 per year because the correct price should be twice as high. This changes the "demand view" to spend $34 investment. The pay-back gap narrows with $17 to $40. (See A in figure below)[16].

[16] The $74 as reference case means that this is the value calculated at an appropriate discount rate higher than the 6% used. This higher discount rate corresponds to calculation under a risk on a deregulated market. In the context above this is made only to simplify the illustration

Of course the customer seldom calculates using a high discount rate but he acts as if his rate were higher, since he does not have the time or the necessary knowledge (or confidence) to make the right and rational decisions.



The correct pricing is an important but not sufficient condition to achieve energy efficiency.

------------------------------------APPENDIX 2------------

Facts about the refrigerator/freezer procurement:

POTENTIAL, MARKET:

Units installed (Millions)	1.5-2.0
Units sold per year (Thousand)	100-150
Energy Use (of total electr. end-use)	appr. 1%
Energy use in units:	
Average in installed kWh/liter,year(*)	2.0
Average in sold today	1.4 kWh/liter,year
Best in market 1990	1.18kWh/liter,year

MARKET STRUCTURE

Centrally influenced, 3-5 companies and major organizations have influence on the choice for about 80% of the demand by procurement or by recommendation

CRITERIA AND RESULT IN PROCUREMENT

Mandatory level	1.0 kWh/liter,year
Desired level	0.9 kWh/liter,year
Winning model	0.79kWh/liter,year

INCENTIVES

Tender compensation (SEK/Company)	100 000
Specific incentive for the first 500 units:	
Meeting mandatory level (SEK/unit)	1000
Meeting desired level (SEK/unit)	1500
Entries (Companies)	5
Accepted entries (Companies)	3

COST FOR PROGRAMME

Tender compensation (SEK)	300 000
Specific incentives (SEK)	1200 000 (**)
Administration and testing (SEK) appr.	500 000
Incremental cost for unit (SEK)	< 1200

EXPLANATORY NOTES

* Adjusted volume=Refrigerator volume+2*freezer volume

** 800 units were accepted.

-----------------------------------APPENDIX 3-----------

The following table shows how Performance and Price for the ten best Combined Refr./ Freezers have changed during a four year period.[17]

	1991-------		1992-------		1993-------		1994-----	
POS	Perf.	Price	Perf.	Price	Perf.	Price	Perf.	Price
1	0,8	9450_a	0,8	9450_a	0,8	8930_a	0,8	9375_a
2	1,1	6735	0,8	6490_b	0,8	7400_b	0,8	7400_b
3	1,2	5490	0,9	6400_c	0,9	6900_c	0,8	7300
4	1,2	7685	0,9	6900_d	0,9	7450_d	0,9	7970_h
5	1,2	6375	0,9	7250_e	0,9	7800_e	0,9	8540_i
6	1,2	7225	0,9	7650_f	0,9	8200_f	0,9	9070_k
7	1,2	7890	1	6400	0,9	7535_h	0,9	8700_m
8	1,2	7160	1	6900_g	0,9	8330_i	0,9	6350_c
9	1,2	7235	1	5690	0,9	8460_k	0,9	6995_d
10	1,2	7660	1	7000	0,9	8100_m	1	6350_g
AVER:	1,15	7291	0,92	7013	0,88	7911	0,88	7805
Change %:			-20	-3,81	-23,5	8,50	-23,5	7,06

[17] Performance is measured as kWh/l,year and price is given in actual SEK that year. Small letters a-m show same manufacturer and design between the years.

ENVIRONMENTAL ASSESSMENT OF WATER SERVICES INVESTMENT

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Summary

Anglian Water is geographically the largest of the 10 regional water companies in England and Wales. The Company was privatised in 1989 and now provides water services to over 5 million customers in East Anglia and the English East Midlands.

The region served by the Company includes the country's most sensitive wetland based National Park (the Norfolk and Suffolk Broads), nationally important estuarine and coastal habitats, 12 Ramsar sites (one owned by Anglian Water), 9 EC Special Protection Areas for Birds, more than 700 Sites of Special Scientific Interest, three Environmentally Sensitive Areas, five Areas of Outstanding Natural Beauty, more than 1600 Scheduled Ancient Monuments and many more sites of regional and local significance.

To meet the needs of providing water services with due care for the environment, the requirements of customers and agreements with the UK Government, the Company embarked early in this decade on a ten year, £4 billion investment programme. A large proportion of this expenditure is aimed at providing new sewage treatment and sewerage systems and is already leading to measurable improvements in the environmental quality of the region's streams, rivers and coastal waters.

While ultimately leading to improvement of the water environment, construction and operation of new water service facilities have the potential for damage to areas of nature conservation, heritage and landscape importance. In response to an Environmental Policy commitment to develop and provide services in such ways as to avoid adverse impacts on the environment a programme of environmental screening of capital projects has been developed.

Environmental screening of the Company's projects is now well established. The system is computerised and includes extensive external liaison with environmental organisations and field surveys. Sites and features of environmental value are identified and measures introduced to mitigate the effects of schemes where adverse impacts are identified. The screening programme is described and statistical information on the results presented. Examples of practical constraints and mitigation are presented. The benefits of the work are described including those of providing reassurance of the commitment of the Company to environmental issues to regulatory authorities and customers in a region where market surveys have indicated that customers have an unusually high concern for environmental issues compared to other parts of the UK.

The author concludes with a consideration of other aspects of the environmental work of the Company with emphasis on land management practices for environmental and amenity purposes, the development of a "Caring for the Environment Award Scheme" to encourage positive environmental work by other organisations through financial support,

environmental reporting and the work of Environmental Action Teams established by the Company.

Introduction

Sustainable management of the water environment is at the heart of the business activities of Anglian Water. The Company abstracts water from the environment, treats it and supplies it to customers. After use it is treated again and recycled back to the environment. Careful custodianship of water is, therefore, very much in the interests of the Company and its customers. In recognition of this, and of its central role in environmental protection, Anglian Water adopted an Environmental Policy in May 1990.

Anglian's Environmental Policy was one of the first to be adopted by a UK water company. Since its introduction the Company has been actively developing environmental initiatives and performance indicators and is reporting on these. This work has received considerable recognition. The Company has received local and national environmental awards and, most notably, was placed overall fourth in the UK and premier water company in the category of "Community and Environmental Responsibility" in a poll of business leaders published in the October 1992 edition of the "Economist" magazine.

The Company's main contribution to environmental improvement is its investment programme. Around £4 billion is being invested over a ten year period on improving sewerage and sewage treatment systems and the abstraction, treatment and distribution of drinking water. This investment is leading to significant and quantifiable improvements in the environmental qualities of streams, rivers and coastal waters. These improvements clearly bring major environmental benefits to the region but, to be consistent with the Company's Environmental Policy, the investment behind them must be undertaken sympathetically. In this context the local and wider impacts of the associated civil engineering works and subsequent operation of the new facilities are subject to the process of environmental assessment.

The environmental assessment processes adopted by Anglian Water are unique to the Company and have been effective in helping the Company achieve the ideals of its Environmental Policy and in enhancing its environmental reputation. Routine work in this area includes responding to nature conservation, landscape and heritage challenges associated with progressing the capital programme. It is this work, and its results, which form the basis of this paper.

The Anglian Water Region

Anglian Water is geographically the largest of the 10 regional water companies in England and Wales. The Company's 27,500 km^2 region extends from the Humber Estuary in the north to the Thames Estuary in the south and from the east coast to Oxfordshire in the west. The Company was privatised in 1989 and its core business is the provision of water services.

Table 1 - Anglian Water - Water Service Facts

Water Supply	Population served	3.9 million
	Water supplied	1,118 million litres per day
	Water treatment works	157
	Length of water mains	33,000 km
Sewerage Services	Population served	5.6 million
	Sewage treatment works	1082
	Length of sewers	28,900 km

A rich variety of landscapes including the UK's only wetland national park, the Norfolk and Suffolk Broads, give a clue to the diversity of natural and man-made features to be found within the Anglian Water region. Toward the centre of the region lie the flat and intensively farmed "fens" of Lincolnshire and Cambridgeshire. These give way to the drier heaths and forests of Breckland and the undulating countryside of the Lincolnshire Wolds. The region boasts an attractive and interesting coastline. The Wash is the country's largest estuary and is of international importance for wild birds. The coasts of north Norfolk and Suffolk have been designated heritage coasts for their rugged beauty.

The Anglian region contains many individual sites of environmental sensitivity. A large proportion of these attract statutory protection and are of national and international importance. Not least amongst them are reservoirs constructed for water supply which are owned and operated by the Company. Rutland Water in Leicestershire is a EU Special Protection Area for birds, a Ramsar site (a wetland of international importance) and a Site of Special Scientific Interest (SSSI). Grafham Water in Cambridgeshire, Pitsford Water in Northamptonshire and Foxcote Reservoir in Buckinghamshire are also SSSIs. Table 2 presents information about legally protected sites of environmental sensitivity within the region served by Anglian Water.

Table 2 - Sites of Environmental Sensitivity

Sites of Wildlife Value	**Anglian Water Region**		**Owned by Anglian Water**	
	Number	Area* (km^2)	Number	Area* (ha)
Sites of Special Scientific Interest	719	1470	28	2598
Wetlands of International Importance	12	811	1	1540
Special Protection Areas	9	793	1	1339
National Nature Reserves	31	216	0	0

* Approximate

Sites of Landscape, Amenity and Heritage Value	**Number in Region**	**Approximate Area - km^2 (or Length - km)**
National Parks	1	303
Areas of Outstanding Natural Beauty	5	1510
Environmentally Sensitive Areas	4	1600
National Trails	1	(150)
Heritage Coasts	2	(131)
Scheduled Ancient Monuments	1600 *	-

The sites listed in the table above represent only the most significant, or largest, of a rich variety of areas enjoying legal protection within the region. Local Nature Reserves, Conservation Areas, Listed buildings and tree preservation orders are other statutory designations which apply. Alongside these the Anglian region contains many thousands of sites of local environmental sensitivity. These include sites of nature conservation, landscape and heritage significance.

The environmental sensitivity of the region gives particular impetus to the Company's environmental assessment and conservation work. The potential of each of Anglian's capital projects to affect areas of environmental sensitivity is considered and, when work within one of these areas is unavoidable, liaison with environmental regulators and local interest groups, helps to ensure that the work is acceptable and includes any necessary mitigation measures to protect environmental interests.

Environmental Assessment - Statutory and Policy Obligations

The Company's Environmental Policy statement published in 1991 acknowledges a general duty of care to the environment and specifically to conservation. The following extracts from the statement apply:

- "Anglian Water recognises that it has a general duty of care for the environment, in which it operates. It intends, therefore, to provide services and develop its commercial interests in such ways as to limit or avoid adverse impacts on the environment and to minimise the consumption of non-renewable resources in doing so within practical restraints".

- "Anglian Water also has statutory obligations to further conservation of the natural environment, to protect and conserve buildings and sites of historic and architectural interest, to have regard to amenity, to secure public access to and to provide appropriate facilities for recreation on waters, and associated land under Anglian Water control. The Company is fully committed to the Code of Practice on Conservation, Access and Recreation (issued under section 5 of the 1991 Water Industry Act)."

In common with the other regional water companies Anglian Water's main statutory responsibilities toward conservation are set out in section 3 of the 1991 Water Industry Act. In summary these are:

- to further the conservation and enhancement of natural beauty and the conservation of flora, fauna and geological or physiographical features of special interest.
- to have regard to the desirability of protecting and conserving buildings, sites and other objects of archaeological, architectural or historic interest.
- to take into account any effect which the proposals would have on the beauty of, or amenity in, any rural or urban area or on any such flora and fauna, features, buildings, sites or objects.

The Company complies with other conservation related legislation. Of most significance is the 1981 Wildlife and Countryside Act. This Act enables English Nature (the UK Government Agency responsible for wildlife conservation) to designate any area of land which is of national importance for nature conservation as a Site of Special Scientific Interest (SSSI). The Company owns or has an interest in 28 SSSIs and about 10% of its total landholding is of SSSI status compared to 6% for the country as a whole. Under the Act a consent from English Nature is required, by the owner or occupier, for operations within an SSSI which may affect its special interest.

The Anglian region contains more than 1,600 Scheduled Ancient Monuments. The 1979 Ancient Monuments and Archaeological Areas Act requires that a consent be obtained, from the Secretary of State, for work affecting Scheduled Ancient Monuments. Other legislation and government advice of relevance to heritage issues includes the Policy and Planning Guidance Note 16, which provides advice on how the archaeology should be taken account of in the planning system, the Planning (Listed Buildings and Conservation Areas) Act 1990 and the Town and Country Planning Act 1990.

In the UK the EU Directive on Environmental Assessment was implemented via the Town and Country Planning (Assessment of Environmental Effects) Regulations 1988. These require environmental assessment of certain types of projects (listed in appendices) where environmental effects are considered likely to be significant. The regulations suggest that a test of "significance" is when site of importance for conservation is likely to be affected by the development. The regulations require an "Environmental Statement" to be submitted with the planning application for appropriate developments. Projects listed in the regulations which require environmental statements "where significant environmental effects are anticipated" and which are applicable to the water industry include deep drilling for water supplies, the installation of long distance aqueducts, installations for the disposal of industrial and domestic wastes, waste water treatment plants and sludge deposition sites.

Anglian Water regularly supplies environmental information to planning authorities in support of planning applications for new water services projects. Several "Environmental Statements" within the meaning of the regulations have been prepared, and are in the course of preparation, for coastal sewerage and sewage treatment systems.

Environmental Assessment - The Process

Procedures

The environmental sensitivity of the region and responsibilities toward conservation were amongst the initial drivers of the Company's environmental assessment work. A quality standards procedure was introduced in 1989 requiring certain types of projects (identified by means of a flowchart) to be referred to the Company's conservation team for assessment of their potential to damage areas of conservation value.

During 1993 a revised procedure was introduced by the Design and Construction Environmental Action Team (one of a series of Environmental Action Teams established by the Company to promote Environmental Policy initiatives). This requires routine assessment of a wider range of environmental effects. It is applied to projects at each stage in their development. The assessment is undertaken by the project manager with the support of specialists within the Company. Conservation issues are identified as part of this process and where necessary the project manager seeks advice, through established mechanisms, from the Company's conservation team.

Routine Conservation Screening

Conservation issues routinely taken account during assessment or screening processes mirror those outlined in Section 3 of the 1991 Water Industry Act. In simple terms they are:

- Nature conservation - flora, fauna, geological or physiographical interests
- Heritage - sites, buildings or objects of archaeological, architectural or historic interest
- Landscape - safeguarding natural, or man made beauty

Each of these issues is considered in two respects:

- **protecting**, or introducing mitigation measures to protect, features of conservation value which may be impacted by the project
- adapting the scheme to provide positive environmental **enhancement** through, for example, habitat creation

A computerised system for recording and maintaining a database of information about projects screened, and in the process of being screened, has been developed. This facilitates the ready generation of statistics for reporting purposes and is the major tool employed in the process of checking the progress of individual projects and the overall position of the conservation screening programme. The system which is known as the Integrated Conservation Database System (ICDS) was developed internally and incorporates information about the Company's landscaping and habitat creation programmes.

Environmental Protection

Dealing cost effectively with conservation constraints is considerably facilitated if constraints are identified during the earliest stages of the project planning process. Appraisal of engineering options to meet a particular need can be influenced in a significant way by conservation constraints. The most direct route for a pipeline, for example, may be entirely inappropriate because it crosses an important archaeological site. The cost of measures necessary to mitigate the effects of damage to the site, and to scientifically record features of archaeological interest before they are destroyed by pipelaying works, may rule out the favoured engineering solution when compared to others. The cost of conservation must be considered as an integral part of project planning and costing.

Within Anglian Water key conservation constraints are identified at project appraisal stage by the appraisal engineer working with the Company's conservation specialists. This would normally be undertaken by means of reference to records held by the Company of environmentally sensitive sites and areas and, where necessary, through appropriate external liaison. Special consideration is given to those projects which impinge on sites of high conservation value. Such sites are many and various. Annex B of the Code of Practice on Conservation Access and Recreation lists 13 specific, or general, "Sites of Importance for Conservation". These are:

- National Parks
- Areas of Outstanding Natural Beauty
- Sites of Special Scientific Interest
- Environmentally Sensitive Areas
- Nature Reserves
- Areas of Special Protection for Birds
- Special Protection Areas (for Birds)
- Ramsar Sites
- Conservation Areas designated by a local planning authority
- Heritage Coasts
- Listed Buildings
- Ancient Monuments
- Sites in which operations would have a major environmental impact

SSSIs and Scheduled Ancient Monuments have had the greatest significance for Anglian Water in influencing project development. Where a scheme impinges on, or appears likely to affect such a site, detailed discussions with the appropriate regulatory body (English Nature and English Heritage in the capacity of advisor to the Secretary of State, respectively) occur to determine the appropriateness of the proposed development in relation to the protected site. The issue of a "consent" by these regulators would normally be subject to appropriate mitigation being incorporated into the project.

At design stage, details of new projects are routinely submitted to external conservation organisations for comment. The projects submitted include many new pipeline proposals, new sewage and water treatment developments and water resource proposals. The organisations consulted depend on which, if any, sites of importance for conservation may be affected by the scheme. For nature conservation issues consultees include English Nature and the local Wildlife Trust. For information on heritage issues the County Council would normally be consulted as holder of the Sites and Monuments Record. (The Sites and Monuments record provides information about known sites of heritage value within a specified geographical area. It is normally, but not exclusively, held and maintained by County based local government organisation - the County Council). Other consultees may include English Heritage, the Countryside Commission, the Broads Authority, the Royal Society for the Protection of Birds and local authorities.

Archaeology has become of particular significance to Anglian Water. The region contains an extraordinarily diverse and rich heritage manifested in an abundance of sites of archaeological interest. These often coincide with pipeline routes. When it is not possible to re-route then it is the practice of the Company to arrange a level of archaeological investigation acceptable to the County Archaeologist prior to work commencing. This allows a site of interest to be recorded and documented before it is destroyed through construction work. Anglian Water is one of the region's largest investors in archaeological investigations.

In appropriate cases, normally when issues have been identified by external consultees field surveys of, for example pipeline routes, will be arranged and undertaken either by internal staff or commissioned from specialist landscape, ecological or heritage consultancies. The comments of external consultees and information drawn from site inspections are incorporated into a report which is submitted to the project manager for action with ongoing support and assistance from the Company's conservation specialists.

Environmental Protection - The Results

Anglian's investment in coastal sewerage and sewage treatment schemes has involved the construction of a number of new waste water treatment centres on greenfield sites. The planning of these has included major environmental assessments and the submission of environmental statements to planning authorities. Significant in the assessment process is a consideration of conservation issues. A brief summary of features of conservation interest arising from major environmental assessments completed in the recent past is presented below.

Table 3 - Major Environmental Assessments - Conservation Issues

North Norfolk Sewerage and Sewage Treatment Scheme - The construction of sewerage systems and central treatment facilities at West Runton for communities in North Norfolk.	• The sea outfall is being tunnelled to avoid damage to a geological SSSI (the West Runton Cliffs SSSI) and an offshore chalk reef which is home to a rich variety of plants and animals including the famous Cromer Crabs. • The new works has been constructed in a Victorian farmstead style. • Roman remains affected by the sewerage system were subject to archaeological recording.
Cleethorpes Sewerage and Sewage Treatment Works (STW) - The construction of a new waste water treatment centre and sewerage system for Cleethorpes on the Humber estuary.	• Archaeological investigations of the site of the new STW revealed the presence of ancient salt workings. Radiocarbon dating of charcoal indicated their origins in the late Bronze Age. This makes it the among the earliest industrial sites of any type in Britain. • Effluent will receive secondary treatment and be disinfected using ultra-violet illumination before being discharged to a coastal SSSI and RSPB nature reserve. • The STW will be screened by more than 15,000 trees and shrubs.
Dovercourt and Harwich Sewerage and Sewage Treatment Scheme - The construction of a new treatment centre and associated sewers near Harwich in Essex.	• The sewerage system was designed to avoid damage to specific areas of botanically rich wet grassland. • One of the key elements of the assessment were studies into the impact of the effluent from the treatment centre on the Stour Estuary SSSI to which it discharges and agreeing appropriate arrangements with English Nature and the RSPB. • The site of the treatment centre is elevated. The site and the access road to it will be landscaped using native trees and shrubs.

Major environmental assessments which result in environmental statements being submitted in support of planning applications are relatively few. By far the largest number of projects considered in a routine manner are pipelines. Summary information about the conservation screening programme in respect of pipelines is presented in the table below:

Table 4 - Environmental Assessment of Pipeline Schemes (schemes involving action to take account of archaeology and/or wildlife)

Year Ending	Schemes	Pipeline Length (km)	Archaeology	Wildlife
31/3/1994	391	740	84	32
31/3/1993	180	325	65	34
31/3/1992	140	230	40	26

Anglian Water is currently laying around 750 km of new pipeline each year. If this were not undertaken in a considered and sympathetic manner then damage would result to the natural and man-made heritage of the region.. It is not surprising that pipelaying forms the most significant part of the conservation screening programme given that the total area of land disturbed by pipelaying amounts to between 750 and 1,500 hectares per annum (assuming average working widths of between 10 and 20 metres). Brief case studies relating to some recent work follow:

Wildlife on the Clapham to Bromham Pipeline - Phase two of the Bedford Southern Orbital Sewer project involved building a new pipeline from Clapham to Bromham. Consultation revealed the preferred route to pass through important species rich water meadows adjacent to the River Great Ouse including an area designated a Prime Site of Nature Conservation Importance (PSNCI) by the Wildlife Trust for Bedfordshire and Cambridgeshire. Technical reasons and the location of archaeological remains limited options for route alterations so a full botanical survey of the meadows was commissioned to determine a method which would create least impact. The survey revealed specimens of mousetail (*Myosurus minimus*), a nationally scarce species typically associated with seasonally wet habitats. Prior to installing the pipe all patches of mousetail across the meadows were marked and fenced to protect them from the impacts of construction. Within the PSNCI turf along the pipeline corridor was stripped, stored and carefully re-laid once the pipe had been installed, thus conserving the meadows' botanical value.

Newts on the A1 Trunk Road - The relocation of sewers along the A1 between Huntingdon and Peterborough has become necessary in advance of road widening works. The area is a well-known "hot-spot" for the great crested newt, a rare species protected by European and national law. In order to avoid damaging newt habitat the entire 20 km route of the pipeline was surveyed to assess areas where there was risk of encountering newts. In some places it was possible to avoid harming newts by postponing work to the spring when newts migrate to ponds to breed. Where delay was not possible newts were trapped and removed from the pipeline corridor before the commencement of work. Newts were prevented from accidentally straying back into danger by newt proof fencing along the corridor edges.

Aiding Geology at Benniworth Cuttings SSSI - Cuttings on the disused railway line near Donnington-on-Bain in Lincolnshire show exposures of rock around 140 - 130 million years old. They were laid down in an ancient sea which during the early Cretaceous period encroached over Lincolnshire and Norfolk. These rock strata contain fossils of a variety of animals, including clams and other molluscs, which are related to species known from Arctic regions. Some species were first recognised in the cuttings at Donnington, and in recognition of this geological importance the site has been designated a Site of Special Scientific Interest. The water main supplying Donnington-on-Bain runs through the cutting. In liaison with English Nature the main's replacement was carefully planned and at the request of English Nature main-laying machinery was diverted to clear vegetation to re-expose the geology for study.

Ely Water Supply Pipeline Archaeology - The construction of a 16 km water supply pipeline from Isleham to Ely in Cambridgeshire provided archaeologists with an opportunity to learn more of the archaeology of the rich Fen Edge environment. Anglian Water commissioned the Cambridge Archaeological Unit to undertake fieldwork before and during soil stripping, which led to the discovery of the remains of two early Bronze Age settlements. At Isleham a mass of rubbish pits, full of pottery, flint and butchered animal bone, was found associated with a round house on the edge of the chalk island as it rises out of the Fen. The site had previously been known as a scatter of finds in the farmer's field, but excavation revealed substantial proof of settlement dating from around 1800 BC. Further west along the pipeline route the former prehistoric course of the River Snail was revealed. In the peats which filled the old channel were found fragments of human bone and remains of an auroch - the massive wild predecessor of the domestic cow. Thousands of flints, including arrowheads, knives, and scrapers, weighing several kilograms were recovered from the grid of test pits dug by the unit on the river banks. Also revealed were a number of pits containing huge quantities of burnt flints, which the archaeologists believe to be the remains of an industrial process. In all, these discoveries portray a fuller picture of early Bronze Age life than had been previously known for this region. The information from around the river in particular provides important evidence about how Bronze Age societies might have used and manipulated the natural landscape.

Environmental Enhancement

The Company's statutory and Environmental Policy commitments require not only that features of conservation value be protected during capital works but that a positive effort be made to enhance the environment. The Company's major contribution to this work is through habitat creation and landscaping. The screening of projects as part of the environmental assessment process enables identification of opportunities for such work.

Landscaping

Landscaping accompanies many of the Company's new developments. It helps screen new developments from vantage points and, therefore, plays a role in environmental protection. Through, however, the predominant use of native species landscaping promotes wildlife conservation and, used to sufficient extent, positively enhances the local environment. During the 1992/3 planting season landscaping was undertaken alongside 24 capital schemes, involving over 45,000 trees and shrubs and 3.1 km of hedging. In all the Company planted over 100,000 trees and shrubs during the year and is the largest private investor in landscaping in the region.

Table 5 - Tree/shrub and hedging projects carried out in association with capital projects during the 1993/4 planting season

Site	Total no. plants	Total length of hedging / metres
Alton Water Centre Phase II	2520	290
Bardney STW	1610	0
Barrow Nitrate Removal Plant	1850	270
Belmont Booster Station	285	40
Binham Borehole	1030	170
Bowthorpe Borehole	440	25
Brackley STW	4320	330
Broadholme STW	2690	0
Clapham WTW	2555	0
Claxby STW	910	180
Emneth Hungate Service Reservoir	2095	0
Gt Horkesley Iron Removal Plant	1095	55
Holywell Cottages PS	735	130
Manby Sourceworks	2730	225
Mentmore PS I	475	80
Mentmore PS II	150	30
Old Leake STW	2750	330
Pilsgate Borehole	445	0
Pulham Market PS	305	30
Saltersford WTW MAC Scheme	545	80
Sandhouse WTW	2775	330
Tilbury STW	7740	160
West Walton Sludge Disposal Site	4215	295
Woodbridge Reservoir	1210	135
TOTAL	**45,480**	**3,185**

Sensitive design is a further method employed to enhance the environmental setting of new water service developments. An architect and landscape consultancy have reviewed good and bad practices amongst current Anglian Water designs. They are now preparing a Manual of Good Visual Design which will offer advice to engineers on steps they might take to minimise visual intrusion. Topics covered in the manual include site selection, choice of building materials and styles and treatment of site boundaries. We hope to publish in late summer 1994.

Habitat Creation

Opportunities are sought for habitat creation in conjunction with capital schemes. These range from wetlands to wildflower meadows.

A number of wildlife ponds have been developed. Recent major extensions at Huntingdon STW provided an opportunity to construct a pond as the focus of a new wildlife conservation complex comprising of a wildflower meadow, trees and shrubs and a pole mounted owl nesting box. At Dunstable STW a new pond was constructed following demolition of redundant filters. The pond includes an island and has been profiled to maximise its value for wildlife. The margins have been planted with aquatic species and an osier bed complements an impressive wildlife resource.

Two bird scrapes have been constructed alongside capital projects, one at Marston STW alongside the re-furbishment of grass plots and the other at Dunstable STW as part of a major reconstruction of the works. The scrapes were designed to be flooded and emptied with treated effluent to provide as complex a matrix of pools (with varying depths) and muddy shoreline as possible. Muddy shorelines provide good feeding areas for waders and flooding in the winter attracts wintering wildfowl and kills vegetation which has grown up on the scrape during the summer. Bird hides and a range of associated visitor facilities allow regular use of these facilities by local birdwatching enthusiasts.

Environmentally Positive Practices

In addition to its environmental assessment activities Anglian Water has developed a range of environmental initiatives consistent with Environmental Policy commitments. These provide local and wider environmental benefits to the region and assist in the process of raising environmental awareness, and reassurance of the Company's commitment to the environment, amongst customers, employees and other stakeholders including regulators. Market research suggests that Anglian's customers are supportive of environment related expenditure. Individual initiatives to provide environmental benefit on the Company's land include:

- work with the Hawk and Owl Trust to set up a regional network of barn owl nesting boxes in an effort to help combat the decline of the species. Over the last 50 years the United Kingdom barn owl population has declined from 12,000 pairs to only 3,800 pairs. This is partly due to a loss of suitable nest sites. Surveys of water and sewage treatment sites show that many offer ideal hunting ground and provide excellent locations for artificial nest sites. A total of 106 nest boxes have now been installed on 36 of the Company's sites.

- a programme of scrub clearance at Marham Fen in Norfolk to allow wild plants to grow and flower. Work over the past few years marks the beginning of a major initiative with the British Trust for Conservation Volunteers and the Norfolk Naturalists Trust to prevent dense overpowering scrub from stifling vulnerable grasses, herbs and flowers.

- the planting of a new reed bed on land adjacent to Whitlingham STW near Norwich. With help from the Broads Authority rank vegetation has been cleared on Whitlingham marsh adjacent to the River Yare. Pot grown reeds have been planted to form a valuable new wildlife habitat.

- the development of major environmental teaching areas for local schools comprising a range of habitats and teaching facilities at Cotton Valley STW in Milton Keynes, Etton water treatment works near Peterborough and Bedford STW.

Much of the Company's estate is of importance for wildlife. A number of Anglian's reservoirs are SSSIs. They are important overwintering sites for wildfowl and provide good feeding areas for passage migrants. Some smaller sites are also SSSIs. These include Tetney Blow Wells in Lincolnshire and Newbourne Springs in Suffolk for their botanical interest. Chantry STW in Suffolk and Wing water treatment works in Leicestershire are both SSSIs for their geological interest.

Despite the conservation importance of so much of Anglian's land and water careful management ensures that the Anglian estate provides first class opportunities for recreation. More than one million people visit Anglian Water reservoirs each year. Some come to take part in active watersports and others to simply enjoy a pleasant day in the countryside. The management objective for water supply reservoirs is to maintain an appropriate balance between environmental, recreational and water supply uses.

Management of the Company's sites of importance for nature conservation is often arranged in partnership with a local wildlife trust. Anglian has seven nature reserve agreements with local wildlife trusts across an area of approximately 650 hectares. These range from major reserves such as that at Rutland with the Leicestershire and Rutland Trust for Nature Conservation to smaller reserves such as that at Newbourne Springs managed in partnership with the Suffolk Wildlife Trust.

Conservation of the region's man made heritage in the custodianship of the Company is an important objective for Anglian. At Flag Fen near Peterborough the Fenland Archaeological Trust is excavating what is considered to be the best preserved bronze age site in the Country on Anglian Water land. The Trust have developed a bronze age landscape and the whole "archaeology park" is open to the public.

A historic buildings survey has recently been completed. Records of the condition and importance, historically and architecturally, of pre 1950 buildings owned by the Company are now held centrally. From these records a conservation programme is being prepared.

One of the Company's most important contributions to promoting environmental initiatives by others is through its Caring for the Environment Award Scheme. For 1994 the scheme is open to entries from voluntary, charitable and educational organisations promoting any scheme likely to produce environmental benefits within the Anglian region. In 1993 the scheme was based on conservation. More than 70 entries were received from voluntary, charitable and educational organisations seeking support for projects which, to meet the key objectives of the scheme, had to provide positive nature or heritage conservation benefits and increase public awareness of conservation issues.

Table 6 - Anglian Water Conservation Awards 1993 Winners

Award	Organisation	Project
£10,000	The Friends of Buckden Towers Historic Gardens Group	Buckden Palace Grounds Restoration Project
£5,000	The Northamptonshire Wildlife Trust	Dormouse Project
£2,500	The Wildlife Trust for Bedfordshire and Cambridgeshire	Re-creation of downland habitat on the Pegsdon Hills
£1,000	Fairlawn and Brookfield Schools	Pocket Park Project, Wellingborough
£500	Skegness and District Environmental Action Group	Cow Bank Nature Reserve, Skegness, Lincolnshire
£500	Chetwood County Primary School	School Pond and Wildlife Area

Conclusions

- Anglian Water is investing heavily in improving the quality of the water environment. New sewerage and sewage treatment systems are producing benefits for the region's streams, rivers and coastal waters.

- While producing major environmental benefits Anglian's investment in water services projects has to be undertaken with due care for the environmental sensitivity of the region.

- In response to this Anglian Water has developed an effective environmental screening programme. The emphasis of the routine elements of this programme are on protecting and finding opportunities for the enhancement of features of nature conservation, heritage and landscape importance.

- The Company has initiated a range of environmental initiatives on its land and in the local commuinities in which it works. These provide positive environmental benefit and reassurance to customers and regulators that the Company takes a positive role in and is committed to the environment.

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The views expressed in this article are those of the author and not necessarily those of Anglian Water.

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GREENING OF INDUSTRY IN ASIA AND JAPAN

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1. INTRODUCTION

Asia, especially Asian metropolises, has become the growth center of the world economy. The bright lights of Asian cities are attracting the attention of many people. However, Asia's cities are also experiencing the blight of rapid urbanization and industrialization. Examples of problems encountered in these areas include unemployment and underemployment caused by rural-urban migration of unskilled workers, the formation of sprawling shanty towns, and poor health conditions caused by deficient sanitation and increasing pollution. As symbolized by Bangkok's traffic congestion and air pollution, Asian metropolises are less healthy, less efficient and less productive than they should be. Because of the important role that Asian metropolises play in the development of Asian countries, there is an urgent need for measures to make economic activities in these cities more sustainable. One possible measure is to increase the sustainability of local industries through the adoption of cleaner production (CP), which will increase the competitiveness of local industries through the efficient use of energy and material with less waste production.

Local enterprises in general and small and medium-size enterprises (SMEs) in particular play an important role in the creation of job opportunities for growing urban populations and help urban residents to become healthy consumers of local products. Nevertheless their production processes are often inefficient and wasteful of raw materials and energy. This situation is reflected in poor industrial hygiene and pollution of surrounding living environments, which impair the health of workers and citizens. It also impedes the improvement of productivity in local enterprise and the economic development of communities.

Traditionally, the problem of industrial pollution has been tackled by means of a curative approach based on the use of waste treatment technologies, which are often called "end-of-pipe (EOP) technologies". These technologies impose a net cost on industries and their use is likely to erode the competitiveness of local industries. This is the reason why wastes are often dumped into the nearby environments without any treatment in many developing countries.

The need to shift environmental protection policies from cure to prevention and from waste treatment to CP is apparent both from our increasing awareness of the finite nature of global resources and the global environment, and also from the urgent need for economic development to overcome north-south and south-south economic disparities. This intentional shift is called in this paper as "greening of industry".

"Cleaner" is a comparative expression and "cleaner" today may not be "cleaner" tomorrow. Therefore the greening of industry through development and use of CP is an endless task requiring the establishment of a permanent system to facilitate the development and use of additional cleaner processes. At this moment few Asian countries have specific policies, strategies or mechanisms for promoting CP in local enterprises. National and metropolitan governments will therefore need to take the necessary steps to promote CP.

Based on the above-mentioned understanding, the author is now conducting an applied research project on the greening of industry, especially that of SMEs, as the chief expert of Asian Productivity Organization (APO)'s "Basic Research on Productivity and Environment". This research is being conducted over a two-year period from 1993 with the participation of 10 national experts, one each from the following countries: Republic of China (Taiwan), Hong Kong, India, Indonesia, Japan, Republic of Korea, Mongolia, Nepal, Singapore and Thailand. The objectives of this comparative research are to identify in each country the promoting and inhibiting factors for the greening of industry and to work out country-specific strategies for its promotion. This paper is based on the interim results of the said research.

2. CP INTRODUCTION IN JAPAN

With the aim of facilitating other Asian countries to develop and introduce their own CP promotion policies and strategies, the author tried first of all to review the process of CP introduction in Japan and supply the review results to national experts as reference material.

There has been a good deal of progress in industrial pollution prevention and control in Japan over the last forty years. This is evident from greatly improved air and water quality. As shown in **Fig.1** and **Fig.2**, this improvement has been achieved by CP technologies rather than by EOP technologies even though practically no explicit CP policy has been adopted by the government.

In fact, process changes for CP purposes have received no favorable treatment from the government while EOP facilities have enjoyed various favorable treatment including tax reduction and exemption. After the heavy investment in EOP facilities in the early 70's to comply with the stringent environmental regulations introduced in

1970, many enterprises noticed that EOP was too expensive and that CP should be adopted as much as possible to maintain and improve their competitiveness in the market fulfilling at the same time the responsibility as corporate citizens.

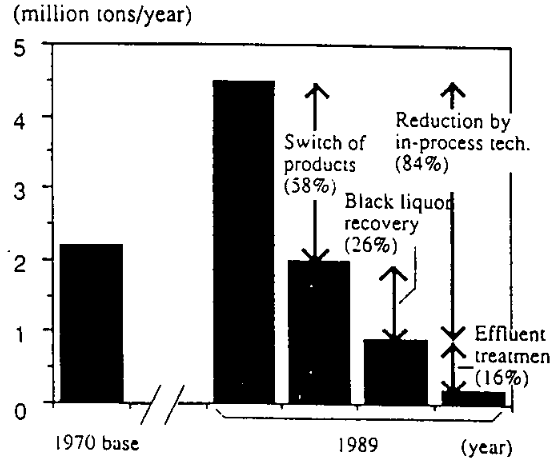

Fig.1 Reduction of COD Discharge from Pulp and Paper Industry in Japan

Source: J.Nakanishi, "Technological Measures to Eliminate Pollution in the Last Two Decade in Japan", Ministerial Meeting and Second Senior Level Cleaner Production Seminar (October 27-29, 1992, Paris-France)

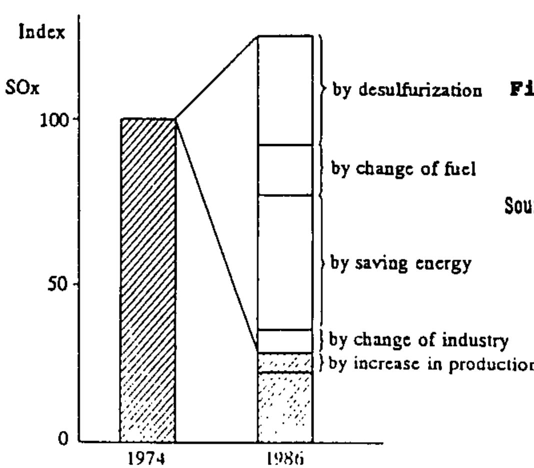

Fig.2 SOx Emission Reduction in Japan by Measure

Source: White Paper on the Environment, by Environment Agency (1992)

Therefore, the major driving force for the introduction of CP in Japanese industries has been the cost consciousness of enterprises in the achievement of higher productivity and better compliance with environmental regulations. This means that in the case of Japan, the existence of "stick", namely stringent enforcement of environmental regulations, has played the crucial role for CP promotion. In addition to the cost-consciousness of enterprises under the influence of "stick", the followings can be pointed out as the major underlying factors which have facilitated the successful use of CP technologies in Japan:

(1) Integration of Environmental Concerns into Industrial Development Policy: Japan's rapid progress in carrying out pollution control measures in the 1970s owes much to the conscious efforts of the Ministry of International Trade and Industry (MITI) to build environmental considerations into industrial and energy policy and operations rather than by treating them as an "add-on". Although MITI and the Environment Agency often differ over the degree to which environmental measures should be taken, once agreement has been reached, MITI's contribution is generally positive. Indeed, since the 1970s it has promoted pollution control technologies and assisted in the development of an environmental sanitation and pollution control industry. Although in the early years of the government's efforts to address environmental problems, there was a tendency to react on an ad-hoc and unsystematic basis, which was obviously an inefficient and costly procedure, the current strategy is clearly to adopt a preventive rather than curative approach.

(2) Self Control in Industry: One of the contributions of MITI is the introduction of a self control system for industry through the promulgation of the Law for Establishment of Organization for Pollution Control in Designated Factories in 1971. According to the Law, all factories above a certain size and with certain processes have to appoint pollution control managers who have expertise in pollution control. They are required to pass national examinations in order to acquire credentials. At present, about 63,000 pollution control managers hold these positions. They bear the responsibility of in-plant control. In the case of serious or deliberate environmental non-compliance, they may even be arrested based on the Law. Accordingly they have strong motivation to comply with discharge standards set by relevant laws or Voluntary Agreements (mentioned in (4) below). They are also motivated to perform in such a manner that the benefit would be maximized and the cost would be minimized for their factories because they are themselves factory staff. They usually achieve this goal through close cooperation with process engineers. This situation facilitates the development and deployment of CP technologies in industry.

(3) Pricing Policies of Water and Energy: In the 1950s and

the 1960s, charges for industrial water and electricity had been set at low rates to promote industrial growth, and large consumers were treated favorably. However, in the 1970s, a progressive charging system for both water and energy users was introduced stimulated initially by the first oil crisis. In fact, taking Yokohama City as an example, in the 20 years from 1960 to 1980, basic charges for large users of electricity and industrial water increased almost four times in real terms (See **Table 1**).

Table 1 Electricity and Industrial Water Price in Yokohama
(in current prices)

Electricity charge for business use

	Basic charge (yen /kw)	Consumption charge (yen /kwh)
1960	330	2.65
1980	1,175	13.85
1992	1,175	10.83

Water charge for business use

	Basic charge ($0\text{-}10m^3$, yen)	Excess charge (yen /m^3)	
1960	115	$10{,}001\text{-}30{,}000m^3$	15.5
		$30{,}001m^3$-	15.0
1980	460	$10{,}001\text{-}30{,}000m^3$	255
		$30{,}001m^3$-	275
1992	570	$10{,}001\text{-}30{,}000m^3$	315
		$30{,}001m^3$-	325

Supported by these pricing policies as well as technical and financial assistance from government, industry has been encouraged to improve energy and water use efficiency throughout their production processes. Energy consumption per unit of GNP for Japan is far below other OECD countries (65% of average consumption for OECD countries in 1989) as shown in **Fig.3**. Consequently air and water pollution loads have declined. Indeed, the decline in industrial air pollution is probably due more to energy efficiency improvements than to specific environmental regulations.

(4) Voluntary Agreements (VAs): Local governments quite often enter into negotiations with each major plant to arrive at a detailed written agreement on pollution control measures. The first major agreement was made between Yokohama City and a thermal power plant in 1964. Since then about 2,500 cases of agreements are concluded annually and the number of valid agreements as of September 1991 amounts to about 37,000. In these so-called "Environmental Pollution Control Agreements", quantitative discharge levels are described based on discussion between local governments and industries. Local resident groups may also

be involved in the agreements. These levels which are more stringent than discharge standards set by the central government are not regulatory but depend on voluntary compliance by the industries. In fact, in Japanese society almost all industries comply with these agreed discharge levels because industry is more afraid of public denunciation and a consequent fall in public esteem than penal regulations. These agreements are renewed periodically and at the time of plant renovation. Accordingly, they work as incentives for the development and use of new industrial processes that would integrate productivity improvement and pollution prevention.

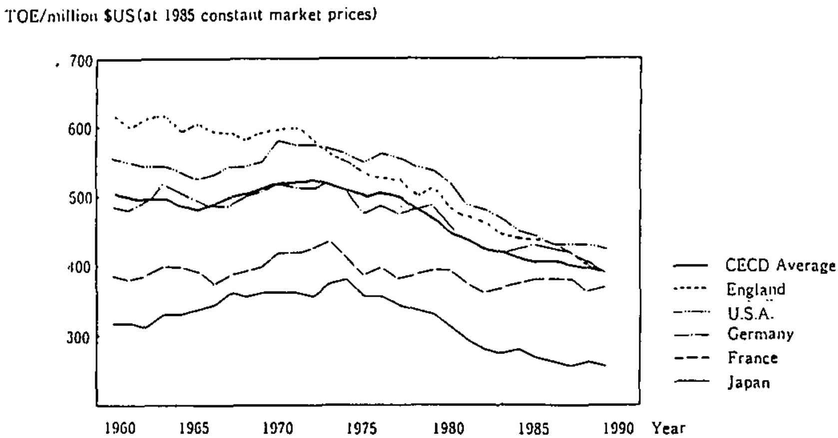

Fig.3 Primary Energy Consumption per Unit of GNP in Japan and Other OECD Countries (1960-90)

(5) Japan Environment Corporation (JEC): JEC was established in 1965, financed entirely by the government, in order to evaluate investments and provide financial support for pollution prevention and control measures. JEC's works consists essentially of site construction and financing. Site construction and transfer includes building of facilities for collective use and provision of industrial sites to which factories can be transferred. Factories transferred apply primarily to SMEs which have, over the years, gradually expanded in sites adjacent to residential areas, causing air and water pollution, ground subsidence, solid waste, noise, vibration and smells that pose threats to human health and public welfare. This intermingling of industry, commerce and housing became increasingly serious during the 1960s, and it became clear that separate industrial estates, at some distance from residential areas, were required. Economies of scale in

site acquisition and infrastructure development have made assistance from the public sector indispensable, and JEC now performs this role.

When collective methods cannot be used, JEC provides soft loans for pollution control measures within factories. Total loans committed by JEC in Fiscal 1990 were 74 billion yen (approx. 700 million US dollars). So far more than 6,000 factories have been given soft loans by JEC. JEC's soft loans have been provided almost exclusively for EOP facilities because other financing scheme has been available for process modification and modernization. Anyway the existence of various soft loan schemes for pollution prevention and control has worked as a "carrot" for the development and deployment of CP measures in Japan.

3. SITUATION OF ASIAN COUNTRIES FOR THE INTRODUCTION OF CLEANER PRODUCTION

As mentioned earlier, the author is now conducting a two-year applied research project on CP with the participation of experts from 10 Asian countries.

Each expert has selected two industrial sectors for case studies. The industrial sectors selected are strategically important to economic development, as well as environmental management, in the countries concerned. In the case of Hong Kong, for example, the textile BDF (bleaching, dyeing and finishing) and electroplating industries have been selected for case studies because of their crucial importance as processing industries. The two industries provide fundamental support services to Hong Kong's two largest manufacturing industries, namely the clothing and textiles and electronics industries, which together contribute about 66% of Hong Kong's total exports as shown in **Table 2**.

The existence of strong pressure for a shift to CP was also taken into account in the selection of the two industrial sectors. In the case of Hong Kong, the two industries selected face the challenges of complying with a series of legislative environmental standards. The options available to the industries in order to achieve compliance are the installation of EOP treatment facilities, and/or a shift to CP in order to minimize or avoid the generation of wastes. The adoption of the former approach alone usually requires considerable capital investment and space, which is extremely limited in Hong Kong. Compliance through EOP alone is extremely difficult -- and in some cases impossible -- for SMEs, which constitute the majority of the industrial establishments in Hong Kong. As a result, companies in the selected two industries are being "forced" to think seriously about CP, which can significantly reduce their waste treatment costs and space requirement.

Table 2 : Four Major Manufacturing Industries in Hong Kong

Industry Type	Export in 1992	% of Total Export	No. of Workers in 1992	% of Total Industrial Employment
1.Clothing & Textiles	HK$ 94.4 billion US$ 12.1 billion	40%	239,947	42%
2.Electronics	HK$ 60.3 billion US$ 7.7 billion	26%	60,653	11%
3.Watches & Clocks	HK$ 15.5 billion US$ 2.0 billion	7%	18,995	3%
4.Plastics	HK$ 7.5 billion US$ 1.0 billion	3%	35,347	6%
Total	HK$ 177.7 billion US$ 22.8 billion	76%	354,942	62%

Source:C.M.Lin, "Preliminary Report on Cleaner Production in Hong Kong", First Coordination Meeting of Basic Research VII on Productivity and Environment (23rd-26th June 1993, Seoul, Rep. of Korea)

Although research has not been finalized yet, some interesting findings have already emerged in the form of interim results. These findings show the potential for -- as well as the difficulty of -- sharing experience among Asian countries. According to the interim results, progress toward the greening of industry through the introduction of CP in Asian countries can be summarized as follows:

a. In many Asian countries, the major part of industrial pollution is caused by SMEs. The nature of SMEs makes the use of CP difficult. In addition, many SMEs are unregistered and therefore outside of the government control. Their physical, financial and human resources are very limited. Business activities are carried out by owner-operators who have little knowledge about or interest in pollution prevention and control. Few have any idea about CP. Inadequate accounting systems make it difficult for them to perceive the benefits of CP.

b. In Hong Kong, it is usually very difficult for SMEs to obtain space for the installation of EOP treatment facilities, since many SMEs are located in flats in multi-story buildings. In theory it appears that more and more SMEs are taking interest in CP because of the government's increasingly stringent pollution control measures. However, in practice the introduction of CP in SMEs is an uphill task because of the aforementioned characteristics of these enterprises.

c. The installation of an ion exchange system costing US$50,000 would not be especially difficult for a Hong Kong SME in the electroplating industry, but it would be virtually impossible for most electroplating enterprises in India, since the average capital of such enterprises is around US$5,000.

d. Japan has dramatically reduced BOD/COD load from industrial sources, primarily through the reduction of the pollution load from the pulp and paper industry (see Fig.1). However, the CP technologies that played a crucial role in this success may not be applicable to developing countries. For example, black liquor recovery, which has been very effective as a CP technology for reducing the pollution load from the pulp and paper industry in Japan, is useful only for larger firms. Countries such as China and India have large numbers of small pulp and paper mills whose main raw material for pulp production is not wood but agricultural residues, such as rice straw, wheat straw, cotton linter and bagasse.

e. The major concerns of the Republic of Korea, which is a newly industrialized country, are the maintenance and improvement of competitiveness in international markets. One source of worry is the implications of the Montreal Protocol, since unless successful CFC substitutes can be developed, strategic industries may simply be wiped out because of their inability to develop cleaner technologies. The same concerns are prevalent in the Japanese refrigerator industry. Manufacturers fear a loss of international competitiveness due to the successful launching of non-CFC refrigerators by German manufacturers.

f. The textile industry is vital to less developed countries in terms of values added and job created. Natural dyes are preferable to artificial dyes from the viewpoint of making this industry environmentally friendly, but the brightness of artificial dyes is more attractive to customers and makes products more competitive in the market. It will thus be necessary to make natural dyes more competitive by modifying consumer behavior through environmental education.

g. As a small island country with very limited land space for the final disposal of solid wastes, Singapore is making every effort to minimize its wastes. The construction industry is becoming a new target for this waste minimization drive. Because of Singapore's economic level, its construction industry is generating large amounts of construction waste, the dumping of which shortens the life of municipal landfills. For example, concrete panels are generally discarded after a single use. Exactly the same situation exists in Japan, which means that these two countries can share their experience in the area of construction waste minimization. In India, however, the situation is completely different. India's economic level is so low that every piece of metal, brick and wood from construction waste is recovered and reused. The remainder is used as filling material, leaving practically no construction waste.

h. Japanese CP software and hardware may not be appropriate for other Asian countries. In Japan, environmental regulations and their stringent enforcement by local governments have played an important role in the promotion of CP. Regulations have been flexible enough to leave the choice between EOP and CP to the decision of individual industries. Even SMEs have substantial financial resources that enable them to invest in CP. The situation is completely different in India, where local authorities have very few law enforcement officers. For example, New Delhi has only 3 inspectors for 80,000 factories. As mentioned in Item c above, the financial resources of Indian SMEs are very limited.

i. Although Japan's experience has limited applicability, as discussed in Item h, it nevertheless offers useful information that can be used to promote CP in Asian countries. Japan's experience such as self control in industry, pricing policies of water and energy, and voluntary agreements (VAs) mentioned respectively in (2), (3) and (4) of Item 2 above deserves special attention.

The comparative research shows that Japanese approaches for the greening of SMEs, which have depended on "stick and carrot" policies of government sector and responsiveness of private sector basically are relevant also to newly industrializing economies such as Korea, Taiwan, Hong Kong and Singapore. However, in the case of less developed countries, neither stringent enforcement of environmental regulations nor technical and financial assistance to the private sector is easily achievable making the adoption of "stick and carrot" policies very difficult. In addition, the responsiveness of SMEs to such policies is very limited. Capacity building of both public and private sectors is seriously needed as the prerequisite of SMEs' greening.

4. CONCLUSIONS AND RECOMMENDATIONS

4.1 CONCLUSIONS

Japanese experience shows that the most important factor for the promotion of CP in SMEs is the stringent enforcement of environmental regulations. Forced by stringent laws and regulations, Japanese enterprises including SMEs have tried to achieve the required environmental goals in a cost-effective manner which is in many cases the development and use of CP measures. Without stringent law enforcement, few industries would feel the necessity of CP measures. Although law enforcement has been stringent, Japanese environmental policies have been flexible enough to leave the selection between EOP and CP to the decision of industries as long as pollution load discharged by each enterprise is within the pre-established limit. This approach has been very instrumental for the promotion of CP in Japan.

Japanese experience also shows that incorporation of cleaner processes into production can be easily achieved at the time of new plant setting up and plant/process renovation. This implies that in economies which are undergoing rapid transition involving the accelerated setting up of new plants and plant/process renovation, technological decisions promoting CP are relatively easy and inexpensive to adopt.

Difficulties frequently encountered in the use of CP in SMEs are the lack of expertise and financial resources. In Japan, these difficulties have been overcome to some extent by the existence of specialized supporting industries and financial schemes for SMEs. Possibility of space economization has also contributed a lot to the use of CP because Japanese SMEs usually suffer from severe shortage of space.

Asian professionals who are seriously dedicated for the industrial development and environmental protection are increasing their recognition about the importance of CP for the sustainable industrial development. They are recognizing at the same time the existence of many unfavorable factors in their society which work against the development and deployment of CP.

In many Asian countries, the major part of industrial pollution is caused by SMEs. The nature of SMEs makes the use of CP difficult. Many SMEs are unregistered and therefore outside of government control. Their resources are very limited. Business activities are carried by owner-operators who have little knowledge about or interest in pollution prevention and control. Inadequate accounting systems make it difficult for them to perceive the benefits of CP. Although some of these characteristics are shared with Japanese SMEs, Japanese experience should be carefully evaluated before its application to other Asian countries.

It should be borne in mind that some Japanese experience is not relevant to other countries while some other experience has high potential to be exploited as possible measures for the promotion of CP in other countries. Given the economic and cultural diversity of the Asian region, there is certainly no single formula that can be applied for the development and the use of CP in Asian countries. It should be noted, however, that this diversity provides challenges as well as opportunities for establishing cooperative efforts in the development and use of CP in this region. Making the most of this diversity, cooperative mechanism among Asian countries should be explored in order to promote CP technology transfer from industrialized countries to developing countries as well as among developing countries.

APO's research on CP is expected to clarify the opportunities for and barriers to CP in 10 participating countries, which will be instrumental for the formulation of country specific strategies for CP promotion. It is hoped that both central and metropolitan governments of Asian countries would utilize the results of APO's research and make the utmost efforts to establish a social climate which would help their industrial sectors develop and deploy CP. They should adopt, among others, a policy of preferred procurement of environmentally friendly products and services.

International organizations such as OECD and UNEP are requested to strengthen their efforts for the promotion of CP through the creation of international market for environmentally friendly products and services and the transfer of CP promotion know-how respectively.

4.2 RECOMMENDATIONS

Appropriate CP promotion strategies will differ form country to country and from industry to industry. One factor that has a major influence on the choice of strategies is the level of industrialization in countries, which is commonly expressed using the classifications as industrialized countries, newly industrialized countries, rapidly industrializing countries, developing countries and countries in transition. Another key factor that must be taken into account when preparing strategies is the size of countries and enterprises. CP promotion strategies will also be influenced by differences in industrial policies. In some countries industrial policies are oriented toward exports and/or dependence on direct foreign investment (DFI), while in others policies focus primarily on domestic enterprises and markets.

The following are general recommendations for CP promotion and should therefore be carefully evaluated before implementation in the field.

a. The use of low-cost simple improvement measures prior to the introduction of sophisticated measures. Good housekeeping is the starting point for CP, and simple measures can yield substantial savings of energy and materials and reductions in waste. The payback period for such measures is often less than one year.

b. The incorporation of cleaner processes into production processes when new plants are set up and old plants and processes are renovated. In economies that are undergoing rapid transition involving accelerated plant establishment and plant/process renovation, it is relatively easy and inexpensive to make technological decisions that promote CP.

c. The establishment of a National Standing Committee for CP Promotion to formulate, implement and monitor a CP Promotion Action Plan, and the identification of an existing institution which could work as the National CP Center and as the secretariat of the Standing Committee. The chairpersonship of the Standing Committee should be shared among the agencies responsible for industrial development and environmental management.

d. The rationalization of water and energy pricing systems (full cost recovery and a progressive charging system) with a credible timetable for introduction.

e. The creation of domestic and international markets in which the polluter pays principle (PPP) is applied to the greatest possible extent. The improved internalization of the cost of environmental pollution will encourage pioneer firms that try to develop and deploy CP technologies. The behavior of multinational corporations (MNCs) may also favor such pioneer firms. Generally speaking, MNCs are eager to protect their corporate image as environmentally friendly companies. They will therefore try to weed out dirty suppliers. Cleaner suppliers will improve their competitiveness in international markets.

f. The creation of favorable markets for environmentally friendly products and services through measures that include eco-labeling and preferential procurement by governments and multinationals. The OECD and other international organizations should take the lead in encouraging eco-consumerism and eco-auditing in industrialized countries as a means of expanding markets for environmentally friendly products and services from the developing countries. In this regard, actions to be taken by WTO (World Trade Organization) on the issue of trade and environment and the moves of ISO (International Standard Organization) in the field of environmental management system deserve special attention.

g. The identification of strategic industries from the viewpoint of GDP contribution, job creation and pollution load. This should be followed by consultation and negotiation with target industries regarding why, how and when their pollution output should be reduced. Incentives for CP development and deployment (information services, technical advice, financial assistance, etc.), procedures to monitor compliance with regulations, and penalties for non-compliance should also be studied and negotiated.

h. The establishment of a pollution control manager system. All firms above a certain size and with certain processes should be required to have pollution control managers. These people should be trained in CP and life cycle assessment (LCA), as well as environmental regulations. They should be responsible for plant control and environmental auditing and subject to severe punishment in cases of environmental non-compliance.

i. The exploration of external aid possibilities for the transfer of CP promotion measures and CP technologies. CP promotion includes the establishment of CP committees and CP centers, the introduction of the pollution control manager system, and the use of voluntary agreements (VAs).

j. The incorporation of CP concepts into the directives of OECD's Development Assistance Committee (DAC). Pollution control experts in governments and industries have been heavily exposed to EOP technologies and tend to think that EOP is more dependable than CP in terms of meeting media-specific discharge standards. In some cases, they completely forget the potential for CP approaches. A business alliance of pollution control specialists in developed countries, manufactures of EOP pollution control facilities, and multilateral and bilateral aid agencies thus tends to promote EOP methods in developing countries. This alliance should be blocked, since it is working against the sustainable industrial development in developing countries. The DAC will be asked to correct this tendency by incorporating CP concepts into its directives.

k. The reinforcement of CP curriculums in university engineering education. Education in sanitary engineering has been based almost exclusively on EOP concepts. Chemical and mechanical engineering courses have placed little emphasis on the need for CP and the ways in which chemical and mechanical engineers can contribute to CP. The principal developers and deployers of CP technology in industry are chemical and mechanical engineers, and these people should therefore be well prepared for this task through university programs that include CP curriculums.

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ECO-FRIENDLY INDUSTRIAL PRACTICES IN TAMIL NADU: INDUSTRIAL AND AGRICULTURAL NEXUS

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INTRODUCTION

India faces growing scarcities in water. Competing demands for water among domestic, agricultural and industrial uses have, in recent years, accelerated the water scarcities. This has ushered in a potential for the use of waste water in agriculture, after due treatment. Estimate indicates that as much as 2.8 million ha of land in India could be irrigated with the treated domestic and industrial water.

Effluent irrigation is widely practised in many parts of the country, particularly in Tamil Nadu, the southernmost state of India.

Irrigation with treated waste water has two-fold advantages:

1. It helps in the safe disposal of the effluent, without environmental degradation, and

2. It also helps in agricultural production as a source of irrigation water and nutrients.

However, for reasons known, the long term effects of waste water based irrigation on environment need to be studied and assessed, in regard to the sustainability of the agro-ecosystems.

THE FOCUS

This study focuses on an eco-friendly cyclic practice in operation connecting the industrial (sugar and paper) and agricultural sectors in the state of Tamil Nadu. This paper explains the cyclic practice existing and the pros and cons of the practice.

The Objectives

The objectives of the study are:

1. To examine the nature of the eco-friendly cyclic practice, creating a nexus between agriculture and industry, and its economic benefits and

2. To assess the long term effects of the use of treated effluent irrigation on soils, plants and groundwater quality.

THE METHODOLOGY

The study has used the well known documentary collation for data, from official sources. Personal interviews were held with the industrial personnel as well as beneficiary farmers, on a free associational basis, using a structured schedule of questions. Field observations were made on the basis of an experimental design, involving control and experimental samples: samples included treated effluent, soil profiles, plant and groundwater from both normally irrigated (control) and effluent irrigated (experimental) farms. Samples were chosen from fields which use effluent irrigation over a period of time: 3, 4 and 15 years. Suitability of currently treated effluent was analysed, as also the long term effects of the same on soils, plants and groundwater quality. Comparisons were made between the control and experimental samples to assess differences.

THE CYCLIC PRACTICE

Figure 1 portrays the cyclic practice, connecting industrial and agricultural complexes through irrigation. The Seshasayee Paper Mills at Erode used for long bamboo and softwood from nearby forests as raw materials, depleting the forests in the process and generating concerns at the Forest Department of the State Government. In response to Forest Conservation Act, the Paper Mills identified bagasse, the waste from crushed cane at the Sugar Mills as the alternative raw materials. The Paper Mills established the Ponni Sugar Mills to provide bagasse. The general details on the Sugar and Paper Mills are given in Table 1.

Table 1: General Details on Paper and Sugar Mills

S.No	Particulars	Paper Mills	Sugar Mills
1.	Capacity (tonnes/day)	150-160	1,250
2.	Source of water	Cauvery River	Cauvery River
3.	Water requirement (Cubic metres/day)	40,000	9,000
4.	Waste water let out (Cubic metres/day)	30,000	4,500
5.	Type of effluent treatment	Aerobic and anaerobic	Primary and secondary

Source: From personnel of mills.

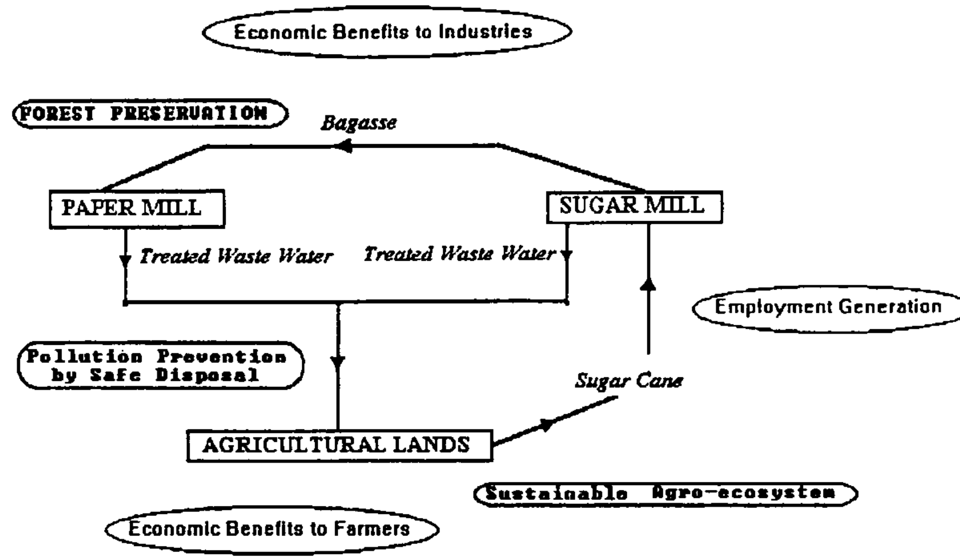

Fig.1. Eco-friendly Cyclic Practice between Industry and Agriculture

As the Sugar Mills is agro-based, and the Paper Mills in turn on Sugar Mills, there arose a shortage of raw materials for both, as the area around was of dry tracts, with limited sugarcane cultivation. In the mean time, the Pollution Control Board began insisting to treat the effluent before disposal. This further developed into a strategy of use of treated effluent in irrigation, through approaching the farmers. This way both the problems of raw materials and safe disposal were resolved. A connection between agriculture and industries was imminent and this was established, in consulatation with farmers.

This led to the Cyclic Practice, wherein the treated effluent from both the industries is now used through 3 lift irrigation schemes constructed at a cost of Rs. 27 million (US $ 843,800). The investment on the irrigation schemes was jointly arranged by the industries and farmers association from the nationalised banks. However, the industries repay the loan on behalf of the farmers. Sugarcane is grown in 600 ha of land, irrigated using the treated effluent.

Industries have stipulated the farmers to grow sugarcane in at least 75 per cent of the area under treated effluent irrigation, to feed the Sugar Mills. The bagasse from the Sugar Mills is in turn used in the Paper Mills. The Cyclic Practice involves the supply of treated waste waters of the industries to agriculture, which in turn provides raw materials for the industries.

ECO-FRIENDLINESS OF THE CYCLIC PRACTICE

The Cyclic Practice is eco-friendly on three counts:

1. Forest Preservation - Forest as a source of raw materials, has given way to agriculture as a source.

2. Pollution Prevention - Effluents from industries are treated for use in irrigation, avoiding environmental degradation from indiscriminate disposal.

3. Sustainability - Continuous use of treated effluent over longer period without strain on the agro-ecosystem.

ECONOMIC BENEFITS FROM THE PRACTICE

There are economic benefits from the cyclic process to industries, agriculture and the area. About 360 farmers benefit from effluent irrigation for sugarcane (and paddy) over 600 ha. Having been dry tracts before, the land has appreciated in value as well as productive capacities. The beneficiary farmers and related details are given in Table 2.

Table 2: General Details of the Lift Irrigation Schemes
(Rupees in millions)

Schemes	Command in ha	Project Cost in Rs.	Running Cost in Rs.	Farmers Benefitted
1.Odapalli (OPLIS)	250	5.5	0.72	192
2.Odapalli-Mukkuparai(OMLIS)	160	8.5	0.35	129
3.Kattur (KLIS)	190	12.5	0.55	49
Total	600	26.5	1.62	360

Source: Industrial Records.

The farmers on an average, receive a net benefit (value of production - direct expenses on inputs) of Rs. 25,000 per ha through sugarcane production. They are also charged a sum of Rs. 2,500 per ha of land under effluent irrigation. On the other, sugar industries receive as much as 60,000 tonnes of cane from the effluent irrigated farms, producing sugar worth Rs.48.0 million, at Rs. 8,000 per tonne of sugar. Similarly, the paper mills get 18,000 tonnes of bagasse from the sugar mills, which is valued at Rs. 27.0 million, at Rs.1,500 per tonne of bagasse.

The industries incur expenditures on treatment, operation and maintenance of the lift irrigation schemes and the treatment plant. In comparison, this expenditure is far less (expenses is about 25 per cent of returns) than the benefits reaped from the raw materials supply from the farmers. This practice also provides for employment to the tune of 300,000 mandays a year, in the industries and agricultural farms. Thus, the cyclic process is, besides being eco-friendly, economically beneficial for collaborating industries and agriculture.

LONG TERM IMPACT OF EFFLUENT IRRIGATION

Although the cyclic practice of using effluent for irrigation has perceptibly high returns for the people and industrial sectors involved, it is recognised that over time continued irrigation with the treated effluent will change the physical and chemical characteristics of soils, trace elements in plants and groundwater quality. Long term evaluation is necessary to determine the sustainability of the ecosystems involved, namely, land, water and vegetation.

It is observed from our investigations (Santhi, 1992) that the quality of effluent is within the standards prescribed for by the Bureau of Indian Standards: pH 5.5 to 9.0, Cl 17 meq/l, So_4 21 meq/l, per cent Na 60 and, BOD 100 ppm. As against these, the treated effluent has the following qualities: pH 7.3, Cl 7 meq/l, So_4 2 meq/l, per cent Na 40 and BOD 100 ppm (Table 3).

Table 3. Suitability Evaluation of Treated Effluent and Water Samples

Parameters	BIS for Irrig.	Drinking Water Std.	Treated Effluent	Groundwater in Farm	Groundwater in Ctrl.
pH	5.5-9.0	6.5-8.5	7.3	8.0	7.5
EC			1.7	1.2	1.0
Ca		3.75	11.0	2.5	2.0
Mg		2.50	2.1	3.8	5.0
Na		0.86	12.0	6.5	1.5
K		0.33	0.5	3.3	1.2
Co_3			BDL	0.6	0.2
HCo_3		0.50	4.0	3.2	0.2
Cl	17	0.70	7.0	0.3	0.4
So_4	21	4.20	2.0	1.5	3.6
SAR			4.7	3.7	1.0
TDS	2100	1500.00	1140.0	705.0	640.0
%Na	60		47.0	41.0	15.0
BOD	100		100.0	-	-
COD	250		-	-	-
Cd	0.01		0.008	BDL	BDL
Cu	0.20		0.004	0.002	0.002
Pb	5.00		BDL	BDL	BDL
Zn	2.00		0.0008	0.0015	0.0013

Source: BIS (1984). Lab Analysis.

Note: Measures for parameters are: mmhos/cm (EC), meq/l (Ca, Mg, Na, K, Co_3, HCo_3, Cl, So_4), ppm (TDS, BOD, COD), mg/l (Cd, Pb, Cu, Zn). BDL is below detectable limits.

As per USSL classification, based on EC and SAR, for irrigation water, the effluent falls under 'good to permissible' range. Effluent is therefore fit (EC 1.7 mmhos/cm; SAR 4.7) for irrigation. The use of sodium and other salts in the process of paper manufacturing makes the effluent used, classified into an irrigation class of high sodium - medium salinity, C3-S2 (Wilcox, 1955). This causes salt accumulation in the long run. The presence of heavy metals in the effluent is also below the permissile limits as shown in Table 3.

The quality of groundwater in the effluent irrigated farm is within permissible limits of irrigation. However, the sodium related parameters like SAR (3.7) and per cent Na (41.0) are greater in the well waters when compared to the control farm wells (SAR 1.0, per cent Na 15.0). Comparing the quality of well water for drinking water standards, it is evaluated as unsuitable due to effluent irrigation (Mg 3.8 meq/l, K 3.3 meq/l and Na 6.5 meq/l: these are above limits). Hence, the industries provide drinking water to these communities at their cost.

Table 4: Evaluation of Characteristics of Soils and Plants

Parameters	Soils				Plants	
	Effluent Irrigated			Control	Eff. Grown	Control
	15yrs	4yrs	3yrs			
pH	8.2	8.0	7.8	7.3	-	-
EC	1.2	0.7	0.6	0.5	-	-
Ca	12.0	10.0	7.8	6.9	-	-
Mg	2.8	1.0	0.9	0.8	-	-
Na	2.2	1.9	1.5	1.2	-	-
K	1.2	1.1	0.8	0.8	-	-
SAR	1.0	0.8	0.8	0.6	-	-
%Na	13.0	11.5	11.0	11.0	-	-
Avail N	196.0	178.0	158.0	132.0	-	-
Avail P	28.0	20.0	15.0	8.0	-	-
Avail K	210.0	195.0	178.0	147.0	-	-
Total N	-	-	-	-	8.6	8.0
Total P	-	-	-	-	0.67	0.37
Org.Mat. %	7.5	4.9	3.8	3.1	-	-
App. Sp.Gr	1.34	1.28	1.26	1.2	-	-
WHC %	30.0	28.0	27.0	24.5	-	-
Cd	0.0004	BDL	BDL	0.0001	0.0012	BDL
Cu	0.0029	0.0018	0.001	0.0013	0.008	BDL
Pb	BDL	BDL	BDL	BDL	BDL	BDL
Zn	BDL	0.0157	BDL	0.0108	0.0493	0.0462

Source: Laboratory Analysis.

Note: Measures: ppm (Total N and Total P), kg/ha (Available N,P,K). Limits to soils: Cd 0.02 mg/l, Cu 0.4 mg/l, Pb 10.0 mg/l and Zn 4.0 mg/l. Soils of farms under study are sandy loams.

The physical and chemical characteristics of the soils indicate that despite a decade or more of effluent irrigation, there is no harmful accumulation in general. As for the nutrient status of the soils, the effluent irrigated soils are rich in nutrients, especially in available N (196 for 15 years, 178 for 4 years, 158 for 3 years and 132 for control kg/ha), P (28, 20, 15 and 8 for 15, 4 and 3 years and control, respectively) and K (210, 195, 178 and 147 for the same). There has been an increase in the nutrient status of the soils over the years, which is a result of amplification (see Pushpavalli, 1990; Rajannan and Oblisami, 1979). However, it has been consistently observed that the EC of the soils has been slightly increasing over the years, due to effluent irrigation. This makes the soil progressively alkaline. Similar observation has been made by Juwarkar and Subramanyam (1987) in an area elsewhere. This is seen from the higher values of TDS, SAR, per cent Na and other salts, attributable to manufacturing process (Table 4). There is no significant heavy metal accumulation in the soils. As for plants, also, there is no significant accumulation of heavy metals as there is no significant accumulation in the soils as well as in the effluent. Crop yields are appreciable: on an average, sugarcane gives 100 tonnes/ha and paddy 5.0 tonnes/ha.

HOW SUSTAINABLE IS THE ECO-FRIENDLY PROCESS?

The study has shown that agriculture and industry are intertwined in their production process such that the industries provide treated effluent for irrigation while the farmers give in return raw materials for the sugar mills and, in indirect ways, the paper mills. The interdependence of the industrial and agricultural relation manifests also a sustainability of the process. In the opinion of farmers and industrial personnel alike, it provides also for long term sustainability. This sustainability is cushioned by the economic benefits from both the sectors.

Is this process replicable in other, similar contexts? It is difficult to answer this question, for, in the first instance, such a proposition requires (a) heavy capital investment, (b) willingness to take risk on the part of the industries and (c) farmers' cooperation for the effort, with or without risk on their part as well. This case however exemplifies an economic success to the industries as well as the agriculturists. Unfortunately, this process, albeit its existence for more than a decade, and a definite replication in another area close to the present one (Pugalur Sugar Mills and Tamil Nadu Paper Mills Limited in Trichy district) has not become widely practised. This is indicative that it is not enough if Government alone takes policy decisions, the industries must necessarily come forward to alleviate environmental degradation. Efforts are needed therefore to replicate it and with minimum decadence to the environments elsewhere in the state.

One of the basic concerns of the cyclic process is that of increasing electrical conductivity, which is an indicator of concentration of soluble salts in the soils, leading to soil alkalinity. This is presently being managed by the addition of gypsum and farmyard manure to the soils. It would however be environmentally sound to decrease the quantity of salts used in the manufacturing process, particularly in the paper mills. It would be very promising to popularise the approaches to the eco-friendly process by declaring a policy decision at the governmental enclaves. A corresponding effort on the part of the industrialists would go a long way in making the living in rural India much more sound. Dry tracts are the most prospective areas for replication of this practice and for reaping benefits.

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TREATMENT OF LIQUID MANURE FROM INDUSTRIAL PIG FARM

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ABSTRACT

The current paper gives an account of the results and experiences of liquid manure (slurry) treatment in Pig farm EKSEKO's treatment plant.Large numbers of animals (30 thousand pigs per year) demand different approaches for slurry treatment.One of the most difficult problems appears to be the management with huge amounts of discharged slurry (400-450 m^3/day; solid content 2-3% TS).Our main aim is to recycle as many organic compounds and nutrients as possible back to agriculture in environmentally acceptable manner.
The high efficiency of solid/liquid separation provides us with a 70% the recovery of organic compounds as COD and 50% of nutrients as TKN.The results of analysis of different slurry and activated sludge mechanical-chemical treatment schemes are presented.
The liquid fraction is submitted to the activated sludge treatment.Pilot plant tests and full-scale activated sludge treatment of liquids were carried out by using the aerobic and anaerobic treatment zones of the same aerotank.The objective was to create oxydizing and deoxydizing conditions for deep nitrogen reduction.
Elaborated treatment scheme allow us to reduce 98% of COD;98-99% of BOD and 94-95% of nitrogen in slurry

KEYWORDS

Pig slurry treatment,centrifugation,activated sludge thickening, nitrification, denitrification, activated sludge treatment.

INTRODUCTION

The industrial production of pork in Pig Farm EKSEKO has been carried out since 1973.The official veterinary policy and higher yields of animals were priorities in the 70ies rather than protection of the surrounding environment.The intensive pig breeding had to frequently face environmental pressures while trying to manage with waste water collection, treatment and disposal in a non-polluting way.
Today a full closed cycle pork production has been developed. 3 thousand tonnes of meat and 40 thousand piglets are produced every year.400-450 m^3 of liquid manure is discharged every day.Useing big quantities of water for flushing manure out of piggery guaranteed perfect veterinary conditions and allowed an easy discharge of manure at the same time.However,such methods resulted in considerable amounts of polluted waste water (slurry).
First attempts to start finding solutions for pig farm waste water treatment were started in the early 80ies when first pilot centrifugation devises were studied in

pig farm waste water purification plant.

The aim of our studies was:

- to elaborate feasible technical and technological solutions in order to use the fertiliser value of the slurry,and extract the fertilising materials for the use on the fields
- to optimize the working process and discharge a sufficient quality of effluent for irrigation purposes (with attention to N compounds).

Jointly with the specialists from VODOKANAL,St-Petersburgh (Mr.P.Avetisjan) the first steps were taken to improve the treatment plant in EKSEKO pig farm.Further development has taken place over the following years.Improvements of activated sludge system were made in cooperation between VODGEO Institute (Mr.V.Kogan) and local specialists.
The high concentration of animals requires special attention to the problem.The land disposal could be a helpful tool of nitrogen elimination from slurry.But it is greatly restricted to carry this out in practice due to complicated area requirements,dependence on climatic factors,hygienic problems and so on.
Different technological methods of slurry treatment were proposed by different companies (DSI slurry system,Promest tech.).A number of technologies are based on nutrient recovery from anaerobically digested pig slurry by centrifugation (Fernandes,1988).The aerobic digested liquid treatment by activated sludge usually followed (Montuelle,1988).Both aerobic composting (Duvoort,1985) and anaerobic treatment (Gorecki,1992) are documented and described for solid treatment.Nitrogen is elliminated from liquid by stripping or by nitrification-denitrification process.Many improved activated sludge processes such as Bio-Denitro (Bundgaard et al,1980) were developed where nitrification -denitrification took place.

THE CHARACTERISTICS OF TREATMENT LINE

I Characterisation of Wastes

The relative amount of discharged slurry is about 12 l/d per animal and the load of nutrients about 33g N/d per animal in the case of nitrogen and about 4 g P/d per animal in the case of phosphorus.
Manure and urine in the piggery are flushed out with water,collected in to a canal system and pumped into balancing reservoir (V=300 m^3).A long retention time of slurry in anaerobic conditions inside the canals affect its quality.The anaerobic degradation process affect the carbonaceous compounds and organic nitrogen (ammonification).Increase of nutrients transmission (Potassum) into the liquid stage is taking place due to the manure dilution.The most essential pollution characteristics of slurry are presented in table 1.

Table 1.The average pollution characteristics of slurry,discharged from pig farming complex EKSEKO

Parameter	Quality	Quantity/day
Flow		400-450 m^3/d
Total solids	2,5 - 3,0 %	10 -13 t/d
Suspended solids	16 - 20 g/l	6,4 - 9,0 t/d
COD	30 - 35 gO2/l	12 - 15,8 t/d
BOD ⁷	18 - 21 gO2/l	7,2 - 9,5 t/d
N-tot	2,5 - 3,0 g/l	1,0 - 1,4 t/d
N-NH⁴	1,2 - 1,5 g/l	0,5 - 0,7 t/d
P-tot	0,3 - 0,4 g/l	1,12 - 0,18 t/d

II Scheme of process for Slurry Treatment at EKSEKO

Figure 1 illustrates the process scheme of EKSEKO's slurry treatment plant.Coarse particles are separated by means of screening and fine-grained compounds,whereas colloidal particles are centrifuged with excess activated sludge .The liquid stream is treated by means of activated sludge process for the combined biological removal of COD and nitrogen.Solids from centrifuge (cake) are composted.

1.Description of mechanical treatment facilities used

Table 2 Technical data of process facilities of slurry mechanical treatment

		Brush-screw screen	Screw -press
Screw diameter	mm	250	300
length	mm	4500	1800
Screen holes	mm	1	1
Motor	kw	2,2	13
Feed rate	m^3/h	30-40	

Type of centrifug	Co-currant (dewatering)	
Bowl diameter	mm	900
Bowl length	mm	2800
Bowl/scroll differential speed	rpm	4
Pool depth	mm	540
Bowl speed	rpm	1200
Hydraulic capacity (pig slurry,2-3%TS)	m^3/h	22-30
Motor	kw	75

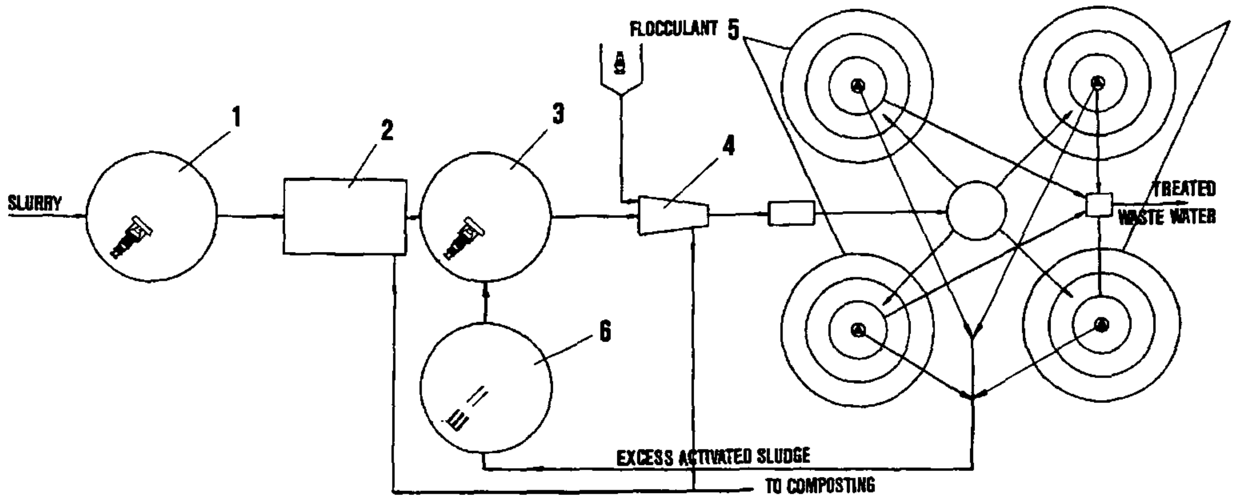

Figure 1.Process sceme for slurry treatment at EKSEKO Pig Farm

1. Balancing reservoir;2. Screw-screen thickener and screw-press;3. Mixer;4. Centrifuge;
5. Activated sludge treatment plant with settlers;6 Aerobic stabilizer.

2.Decription of the activated sludge treatment plant

The liquid from centrifuging is devided between four autonomously working activated sludge tanks.($V=4x960\ m^3$).Activated sludge is sedimented in settling tank ($V=4x170m^3$).The configuration of modified circular activated sludge tank is shown on Figure. 2. The tank is devided into anoxic zone ($V^1= 360\ m^3$) and aerobic zone ($V^2=600\ m^3$).Excess activated sludge (EAS) is pumped from secondary clarifier.Sludge,which containing NO^x is recirculated from the same clarifier back to the anoxic zone.The avarage temperature is 15-19 °C in winter and 35-40 °C in summer.The aerobically stabilized activated sludge is mixed with filtrate from screening (0,2-0,3 kg/kg) before centrifugation.Further treatment takes place in bioponds ($V=40$ ths.m^3; 2 ha).The treatment plant discharges treated waste water in to a store-reservoirs ($V=160$ ths.m^3).It is then used for irrigation of grasslands during the vegetation period.

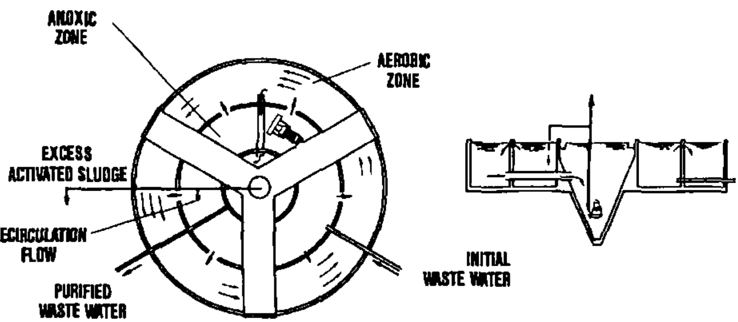

Figure 2. Reconstructed activated sludge treatment plant

MATERIALS AND METHODS

The treatment plant has been studied since1986,when centrifugation stage was started in EKSEKO's treatment plant.The monitoring programme was primarily aimed at evaluating the average performance under practical operating conditions in terms of distribution of organic compounds and nutrients between solids and liquids during the mechanical-chemical treatment.The samples from three check points: feed,centrate and solids(cake) were analysed.The feed rate and polymer dosage were measured by flowmeter.By improving the centrifugation efficiency the following parameters varied: feed rate,bowl speed,bowl/scroll differential,pool depth,point of addition of polyelectrolyte.The averages of results were collected during the period when the described scheme was in operation.The degree of total solid separation was calculated by the following equation:

$$\eta=[(TS^{feed} - TS^{centrate})\times TS^{cake}/(TS^{cake} - TS^{centrate})xTS^{feed}]\ x100(\%)$$

Volume reduction (degree of sludge thickening) was calculated in accordance with the relation $V^1/V^2=TS^2/TS^1$.

While specifying the suitable type of polyelectrolytes (flocculants) for slurry conditioning the floc forming process was visually assessed.More exact choices between some of them were done by CST test (Capillare Suction Time) (Baskerville,1968).
The thickening centrifuge was examined during two months of operation in EKSEKO's slurry treatment plant.The objective of these tests was to investigate efficiency of excess activated sludge thickening centrifuge under real conditions.The thickening centrifuge of co-current design (Table 3) was specially designed for EAS thickening as a separate stage. The parameters which varied during the tests were the nozzle number,the nozzle diameter,the feed rate and the differential speed and pool depth.The performed tests did not provide for addition of flocculants.

Table 3 Technical data of pilot thickening centrifuge

Type of centrifuge		co-currant (thickening)
Bowl length	mm	1060
Bowl diameter	mm	480
Bowl speed	rpm	2575
Bowl/scroll differential speed	rpm	5-10
Pool depth	mm	305;311;316;322
Hydraulic capacity	m^3/h	5-15
Number of nozzles		1 or 2
Nozzle diameter	mm	2,3,4
Motor	Kw	18,5

The modification of activated sludge treatment process began in 1988 when first circular aeration tank was reconstructed according a new sceme (anoxic zone was separated; Figure 2).The optimum tank configuration has been in practised since 1989.The further improvement of facilities and specification of technological parameters have took place.The samples were collected from the following check points: influent waste water (centrate),anoxic zone,aerobic zone.The chemical analyses of samples were carried out by a local laboratory which used standard methods ISO and SFS.Also Standard Methods for Examination of Water and Wastewater (seventeenth edition) were used.

The laboratory pilot plant consists of:
- anoxic reactor (V^1=3,6 l),equipped with a stirring mechanism but no aeration
- aerated reactor (V^2=6,0 l) with stirring mechanism
- final clarifier

Pumps of peristaltic type were used for feeding and recirculating flow

RESULTS AND DISCUSSION

I The Mechanical Treatment of Slurry

1 The specifing of polyelectrolytes for conditioning

The flocculants of kationic type were most suitable for conditioning the solids in slurry and activated sludge (dose=3-3,5 kg/t TS ,Capillare suction time 29-30 sec.)
.The trials were constantly carried out during our practice,for selection of more efficient types of samples amongst last ones.

2.The mechanical treatment of slurry by brush-screw screen and screw press

The slurry (2-3 %TS) was thickened by 6-8 % by brush screw screen.The total solid content in cake was improved by means of screw press.As a result the TS content in cake rose to 22 - 35 % (Table 4).The thickening and pollution separation effect is low and quite largely deviated in correlation with total solid content and anaerobic degradation of slurry. ore, the screening of liquid manure (slurry) is recommendable only as an early stage,followed by improved centrifugation (Table 5;7).The centrifuge protection against mechanical damages,increasing of solid content in cake and reduction of the dosages of polyelectrolytes have been main reasons for implementation of this stage in practice.

Table 4. Average results of pig slurry treatment by brush screw screen and screw press (Q=35-40 m^3/h)

Parameter		inlet content	filtrate content	degree of sep. %
TS	g/l	26,4	22,6	14-16
SS	g/l	18,8	16	15-17
COD	g/l	30	15,5	11-15
TS in cake	%	31(22-35)		

2.The mechanical treatment of slurry by centrifugation

The coarse particles and part of fine-grained solids are separated from slurry by centrifugation.As a result of higher degree of solid/liquid separation during the centrifuging,the moisture content in cake will increase.By useing the centrifugation force 1125×g the 43-45 %TS,60 %SS and 34 %COD reduction can be obtained.360 kg of total solids per hour could be received by centrifuge without chemical conditioning.

Decreasing of the charge of particles by kationic type polyelectrolytes (flocculants) makes the process more acceptable.The average results of solid/liquid separation of chemically conditioned raw pig slurry were presented in Table 5 and the same mixed with EAS,were presented in Table 7. 20-30% of more solid separation was obtained if slurry was conditioned (flocculated) before centrifuging.The interaction between flocculant and particles of sludge depends to a great extent on sludge age.

4.Two staged scheme of mechanical treatment of slurry

The following two staged scheme for mechanical treatment of slurry have been carried out during our practice:

- Two staged centrifugation when coarse particles and parts of fine-grained solids were separated without any chemicals. The separation of conditioned residues from centrate followed in second stage centrifugation.
- Coarse particles were separated by useing the screening and pressing (by screw screen and screw press thickener).During the second stage the fine-grained particles and colloids were separated from filtrate by means of chemical conditioning (flocculation) and centrifugation.

The results of two stage pig slurry treatment are presented in Table 5.

Table 5 Average results of pig slurry treatment by two stage mechanical-chemical treatment method.

	type of floccul.	quantity of floccul. kg/tTS	TS in slurry %	Treated outlet TS g/l	Treated outlet SS g/l	cake TS %	Degree of separ. by TS %	Degree of separ. bySS %
Centrifuge	Z92	3,6	2,7	11,5	3,7	20,9	61	81
Two stage centrifugation	Z92	2,7	2,4	8,5	2,5	21,8	72	86
Screw press centrifuge	Z92	2,6	2,8	11,4	3,7	24,4	64	79

The results show that the implementation of two staged slurry treatment is essential for the purpose of reducing the quantities of polyelectrolytes (around 25%) and increasing the total solid reduction efficiency 10-11%.The results of full-scale experiments (Figure.3;4) indicate that the degree of suspended solids separation is comparable to the same quantities of polyelectrolytes, which are added to filtrate or to centrate (around 5 kg/tTS).Our practical experiences and calculations allowed us to conclude that the centrifugation as an early stage of mechanical slurry treatment is not feasible by the high investment,operation,maintance and energy costs.

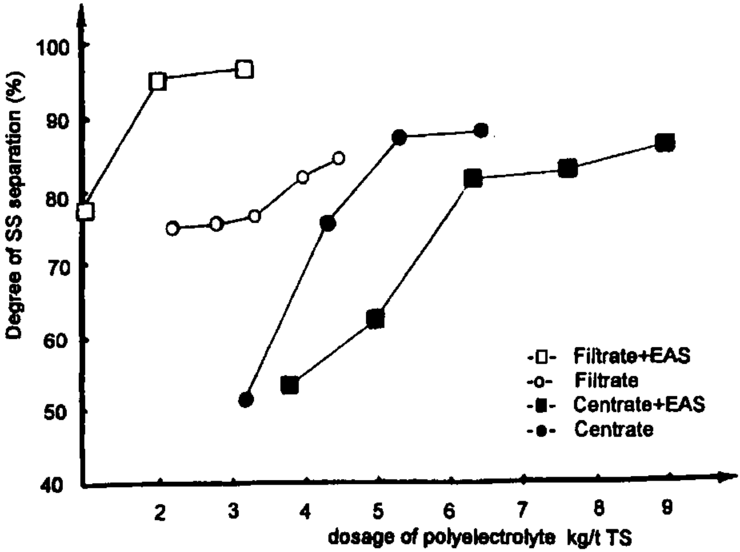

Figure 3.Results of centrifuging experiments.
Degree of SS separation as a function of dosage of polyelectrolyte

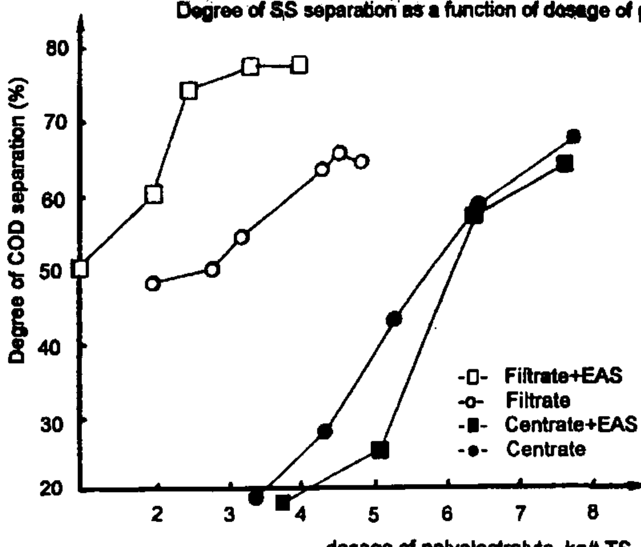

Figure 4.Results of centrifuging experiments.
Degree of COD separation as a function of dosage of polyelectrolyte

5.Separation of excess activated sludge

The excess activated sludge (concentration13-17gTS/l,SVI=120-150 ml/g) accumulates during biological liquid treatment under anoxic and aerobic conditions.

The two following treatment scemes were tested for mechanical EAS separation:

- Excess activated sludge thickening by thickening centrifuges.(Table 3).
- Excess activated sludge dewatering and thickening together with centrate or filtrate during the second stage mechanical treatment (centrifugation).

5.1 The thickening of excess activated sludge by centrifuge

We would like to make the following comments on the results of experiments (Table 6):

Table 6.The selection of results of EAS separation and thickening by pilot thickening centrifuge

Nozzles N1(mm)+ N2(mm)	Feed rate m^3/h	loading kgTS/h	Inlet TS g/l	centrate TS g/l	centrate SS g/l	TS in cake %	Degr of TS sep. %	Degr of thick. %
Pool depth 305 mm;Difer.speed 5								
4+5	6	108	17,9	5,4	1,8	3,8	81	53
2+2	6	99	16,5	6,3	3,2	6,3	69	74
3+0	8	132	16,5	6,8	3,7	4,2	70	61
2+2	10	153	15,3	8,6	5,6	5,5	52	72
Pool depth 316 mm;Difer.speed 5								
3+3	6	103	17,2	11,7	9,9	5,9	40	71
4+3	6	103	17,2	9,0	6,8	4,2	61	58
3+0	10	160	16,0	8,9	6,6	5,8	52	72
Pool depth 322 mm;Difer.speed 5								
3+0	10	153	15,3	10,9	9,3	5,9	35	74
3+0	15	230	15,3	11,9	10,6	6,0	28	75
2+3	15	236	15,7	11,2	8,2	5,0	37	68

- optimal feed rate for pilot centrifuge (Table 3) was 100 kgTS/h (5-6 m^3/h)
- The 70-75 % of activated sludge thickening (5-6 %TS in thickened sludge) and over 80 % of suspended solid separation (3-3,5 gSS/l in centrate) can be obtained during the centrifugation (pool depth 305 mm)
- During higher feed rates (150-200 kgTS/h or 10-15 m^3/h) the degree of thickening is increaseing whereas the solid content in centrate increases sharply as well.
- The conditioning of activated sludge before centrifuging is increasing the degree of solid separation,provided high amounts of polyelectrolytes are used (13-15 kg/tTS).

5.2 The centrifugation of EAS together with slurry

The two stage of sludge treatment during which EAS is mixed and conditioned together with centrate or filtrate (EAS dose 0,3 kg/kgSS) before the second stage centrifuging,has been practiced under real conditions.The results are listed in Table 7.

Table 7 Average results of pig slurry and excess activated sludge treatment by two stage mechanical-chemical treatment method.

	type of floccul.	Dosage of floccul kg/tTS	TS slurry %	Treated outlet TS g/l	SS g/l	cake TS %	Degree of separ. by TS %	by SS %
Centrifuge	Z92	4,7	2,4	8,6	2,1	14,7	68	92
Two stage centrifugation	Z66	3,4	3,4	8,5	3,7	13,7	80	87
Screw press centrifuge	Z66	3,5	2,9	7,8	2,0	16,4	77	94

The degree of SS and COD separation as a function of polymer consumption were performed in Figure. 3 and 4.The conclusions of the above experiments are as follows:

- the EAS treatment improves solid separation efficiency 8-13 % without remarkably increasing the polyelectrolyte consumption. (0,7-0.9 kg/t TS)
- the 30-40 % higher moisture content and clay-like structure in cake are accompanied by that.
- much higher degree of SS reduction is obtained when mixing EAS with raw slurry or filtrate discharged from screening stage.Good interaction between activated sludge flocs and coarse particles of manure takes place.

II The Liquid Treatment by Activated Sludge Process.

The treatment methods used in nitrogen removal are single sludge modifications of the nitrification-denitrification processes.The same biomass is used for combined carbon oxydation,nitrification and denitrification without any external carbon sources

There is a transformation of complicated organic compounds in the influent into more elementary substances,favourable for denitrification,during the anoxic processing,but also for ammonification of organic nitrogen and denitrification.In aerobic phase of the processing,both oxydizing of organic compounds and nitrification (denitrification) take place.The operation parameters of full-scale processing of mechanically treated slurry with activcated sludge are presented in Table 8.

The laboratory pilot plant experiments have been carried out in a parallel way.The operation parameters and technological characteristics of full-scale processing and pilot-plant experiments of mechanically treated slurry with activcated sludge are performed in Table 8 and 9.Our results allow us to conclude that simultaneous nitrification-denitrification can take place also in aerated zone because of the creation of specific oxydizing/deoxydizing conditions.The anoxic zone,oxygen regime and recirculation between aerobic/anoxic zones are influenced by creation of the required conditions.We have obtained 40 % of nitrogen reduction in aerobic zone by mass balance in full-scale plant operation and 51 % of the same thing in laboratory pilot plant experiments.

Table 8 Average results in activated sludge process

Parameter		Full-scale plant	Pilot -plant
<u>Influent Characteristics</u>			
Qo		110 m3/d	1,3 l/d
SS	g/l	1,94	3,7
COD	gO^{2}/l	9,9	11,8
BOD^{7}	gO^{2}/l	5,0	6,0
TKN	g/l	1,68	1,76
$N\text{-}NH^{4}$	g/l	1,54	1,0
pH		7,6	7,5
<u>Results from anoxic zone (X^{1})</u>			
SS	g/l	10,53	8,72
COD filtr.sample	gO^{2}/l	0,75	1,01
TKN filtr.sample	g/l	0,19	0,36
$N\text{-}NH^{4}$	g/l	0,15	0,18
$N\text{-}NO^{2}$	mg/l	ND	ND
$N\text{-}NO^{3}$	mg/l	2,0	2,1
<u>Results from aerobic zone (X^{2})</u>			
SS	g/l	9,93	8,68
COD filtr.sample	gO^{2}/l	0,59	0,59
BOD^{7} filtr.sample	gO^{2}/l	0,05	0,12
TKN filtr.sample	g/l	0,11	0,14
$N\text{-}NH^{4}$	g/l	0,05	0,03
$N\text{-}NO^{2}$	mg/l	0,3	0,8
$N\text{-}NO^{3}$	g/l	0,051	0,065

Table 9.Technological characteristics of activated sludge process

Characteristic		Full -scale plant	Pilot plant
Anoxic zone		0,38	0,40
Hydraulic retention time (ox)	d	5,5	4,6
(an+ox)	d	8,7	7,7
Sludge age	d	19,6	11,8
Recirculation	%	1000	600
COD load	gCOD/gMLVSS d	0,14	0,22
BOD^7 load	gBOD^7/gMLVSS d	0,07	0,11
Sludge concentration	gMLSS/l	9,9	8,68
SVI	ml/g	150	110
Temperature	oC	30-33	25-26
Diss.oxygen	mgO^2/l	1,3-1,5	2-2,2
BOD/TKN ratio		3,0	3,4
CODan/COD ox		1,3	1,7
REDUCTONS			
COD	%	94	95
BOD^7	%	99	98
N-tot	%	90	89
NITROGEN LOADS			
gN/kgMLVSS d ox		55	79
gN/kg MLVSS d an		124	139
NITROGEN RATES			
gN/kgMLVSS d ox		27	35
gN/kgMLVSS d an		40	21
gN/kgMLVSS d an +ox		21	29

The sludge floc morphology of activated sludge was described as being large, and irregulary shaped.Both open and compact flocs can be found by viewing sludge microscopically.The filamentous microorganisms are present in tolerable quantities.

Activated sludge is very sensitive to short-term temperature changes as it happen in spring.Quick changes of ammonium as a result of unpleasent conditions for normal activated sludge development give rise the sludge collapses.The foam forming activated sludge thus starts to develop.

Often the reasons for activated sludge collapses are not given satisfactory explanation.

CONCLUSIONS

1. To reduce the running costs of used facilities (equipment,machines etc.),of matherials (chemicals as flocculants etc.) and energy the following facts are to be taken into consideration:

- remove the pig slurry out of the collecting canals as fresh as possible (minimize anaerobic degradation)
- keep the level of total solid content in slurry constant (around 5 - 6 %)
- avoid the use of water for removing slurry (try to keep leakage of water in the system of water supply network)

2.To make the mechanical treatment economically acceptable,the next activities are need to be done:
- in the early stage to use coarse particle separation from slurry without polyelectrolytes (flocculants)
- in the second stage centrifugation is the most efficient way to dewater excess activated sludge (thickened or not) together with filtrate from early stage separation which leads to:
    - reduction of flocculant quantities (dosages)
    - remarkable protection of centrifuges.
    - improvement of solid content in cake.

3.The anaerobic/aerobic activated sludge process of the centrate from mechanical slurry treatment in certain conditions without additional carbon source leads to the reduction of:

COD = 95 %

N-tot = 85-90 %,

even if the influent suspended solid content is around 2 g/l and BOD⁷/TKN relation is 3 - 3,5.

4.Products rich in nutrients (biologically treated liquids and compostable solids) as the results of treatment of slurry from industrial pig farms could be:
- useful in reasonable manner and acceptable time as inorganic and organic fertilisers to improve field production
- costeffective and replace remarkable amount of commercial fertiliser.

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WORKSHOP 3. Hazardous waste management

The workshop will focus on the management of hazardous waste from the viewpoint of both restoration and prevention.

What methods are available for mitigation of the leaching of water-borne pollutants from existing waste sites? What are the main criteria and methods for the necessary step-by-step minimization of dry waste in different world regions? How can the pollution from discarded consumer products be minimized?

The workshop will cover hazardous wastes of different origins. Both short-term control measures and long-term strategies and technologies will be highlighted.

HAZARDOUS WASTE MANAGEMENT IN ESTONIA

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Abstract.

A brief review is made of current hazardous waste generation rate, previous treatment facilities and legislation in Estonia. Particular attention is given to the abandoned army bases and firing grounds in the context of land and water protection.

Waste generation

Though the figures on solid waste in Estonia are very rough, it is estimated that in 1993 Estonia produced about 380 000 tons of municipal waste. This stream of garbage, consisting of residential and commercial waste, is a mixture of food and yard waste, valuable metals, reusable glass, recyclable paper and plastics. It also includes potentially hazardous substances.
According to the Ministry of the Environment, in 1992 Estonia generated about 15,2 million tonnes of industrial waste of which about 9,61 million tonnes were classed as hazardous under Estonia´s 1992 Waste Law. The majority of hazardous wastes are generated by oil-shale mining and the chemical and power generation industries which use oil-shale products. For example, more than 8 million tonnes of oil-shale ash which is considered Class 4 hazardous waste (Estonian Classifier of Waste, 1991) is produced annually by two large power plants near Narva.

Table 1.
Hazardous waste generation in Estonia, 1992 (tonnes):

Class 1	especially hazardous waste	60
Class 2	hazardous waste	12 400
Class 3	moderately hazardous waste	1 400 000
Class 4	waste of minor hazard	8 200 000

Types of facilities

Most of the hazardous waste generated by industry is disposed of without any environmental protection precautions. The main disposal method for hazardous waste as well as for garbage is dumping on the uncontrolled landfills. Hundreds of our landfills are either actually causing groundwater and surface water contamination or may soon be doing so. Lining material such as clay or plastic is hardly ever used to prevent the pollution of groundwater.
In recent years few privately-owned hazardous waste disposal companies have been set up. However, they are only able to handle relatively small amount of waste. AS "Masp" is treating and disposing mercury-containing lamps (about 400000 lamps per year) and incenerates oily wastes and sludges, AS "Epler&Lorenz" and AS "Sakkur" are also specialized in the inceneration of nonchlorinated oily wastes (both having a capacity of 600 - 1 000 tonnes per year). AS "Kesto" is collecting lead/acid batteries. After pre-treatment batteries are exported for recycling to Sweden. AS "Baltskade" was set up as a joint venture with the Swedish company Skadeservice AB for the treatment of oily wastes and contaminated land. AS "Siku" deals with treating of toxic chemicals.

Waste management plans

The long-term aim of the Estonian Goverment is to achive self-sufficiency in environmentally-sound treatment and disposal of hazardous wastes. But the Goverment budget has been limited. Other countries (mostly Finland, Sweden and Denmark) have aided Estonian environment protection with the investment of 150 million EEK (1992). The Danish Goverment is currently financing a feasibility study

concerning the proposal for a nation-wide hazardous waste management system in Estonia. The study is being carried out by the Danish environmental consultancies, Chemocontrol A/S and Blukon Miljo ApS in cooperation with Estonian companies AS "Masp" and geo-technical engineering firm AS GIB. The study is expected to be completed in the spring of 1994. According to the study estimated annual amount of hazardous waste which could be managed through such special treatment and disposal facilities amounts to 15 000 tonnes of waste for inceneration, 1 200 tonnes for physico-chemical treatment and 12 000 tonnes for landfill.
The Danish/Estonian feasibility study is investigating the possibility of using cement kiln incineration of certain wastes and of using physico-chemical treatment units at metal processing plants.

Waste management licencing

According to the Waste Law all companies are responsible for the proper treatment and disposal of the wastes they generate. The wastes may be handled only by companies which hold a waste management licence. The aim of licencing is to guarantee such a treatment of hazardous waste, which is harmless to human health and the environment. At the same time, licencing enables to assess the suitability of enterprise for waste treatment and direct hazardous waste treatment according to State programs.

Military environment

In the territory of the Republic of Estonia there were more than 500 military areas belonging to the armed forces of the former Soviet Union. The total area they covered was about 85 000 hectars, which forms 1.8 % of the territory of Estonia. Solely in Tallinn there were 174 military units occupying the area equal to 872 hectars.
The largest military base, Aegviidu artillery range, covered more than 33 000 ha. Extensive areas were related to military airfields in Tapa (771 ha), Tartu (682 ha), Pärnu (731 ha), Amari (930 ha) and Haapsalu (799 ha).
According to the environmental assessment the damage to Estonian environment caused by military bases amounts to approximately 15,3 milliards Estonian kroons.

On nearly all territories released from Soviet Army an extensive pollution with oil products, chemicals, demolition and household wastes has been discovered.

The most dangerous to the environment were airfields and their fuel depots. For example, the fuel dispersed from Tapa airfield has polluted almost all of the town territory: the drinking water is unsuitable for using within the area of 16 km2.

In Tartu military airfield thousands of tons of fuel have been spread on the ground surface. As a result, the upper layer of the ground (about 20 ha) has been saturated with oil products. The pollution has penetrated into the depth of 3,5 meters and reached the wells of the upper groundwater level. The same situation can be observed in Amari, Pärnu and elswhere. Within the framework of joint project by Estonian and Danish ministries of environment the oil pollution elimination has been started in 1993 in Tapa and Pärnu military airfields and in Viimsi and Randvere fuel depots. Also other projects are being worked out to limit the distribution of pollution. Abandoned training and offensive chemicals such as smoke mixtures, chloropicrin, napalm and others are also of great danger to the environment. In the island of Naissaare and Astangu depots near Tallinn large amounts of munition and explosive are still stored.

As regards big firing grounds the nature has been damaged by direct military activities. About 1 000 ha in Pakri island and 500 ha land in Utsali firing grounds have been disturbed by shell crabers, fires have devastated much of vegetation. Unexploded mines, shells and aerobombs can also be found in firing grounds.

During the years 1993-94 reclamation works have been carried out in Hiiumaa, Viimsi district and Vilsandi wildlife preserve. Destruction of mines and shells has been completed in Naissaare and Aegviidu firing grounds.

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PCB-CONTAMINATED SEDIMENTS IN LAKE JÄRNSJÖN, EMÅN RIVER SYSTEM - REMEDIAL ACTIONS.

ABSTRACT

Järnsjön, a lake in river Emån, Sweden contained approx. 400 kg of PCB before remedial actions was started. This PCB was slowly leaching out from the sediments into a river classified as a resource of national importance, mainly due to its rich biological life with otter and wels(*Siluris glanis*).The Järnsjö sediments were the primary source for ongoing discharge of PCB to the river. Without any remedial action the sediments will cause problems during several decades.

An alternative for the remediation has been selected that includes vacuum dredging within a protective barrier of silt screens. Dredged material is dewatered and disposed of in a special landfill. This remedial action is estimated to cost appr 40 million Swedish kronor. (6 - 8 million dollars).

Remedial activities in lake Järnsjön could however lead to an additional load on Emån. Restrictions on and protective measures against such releases during remediation of Järnsjön were therefore important issues.

The remediation has started and in 1993 half the lake has been dredged. This part contained approx. 75 % of the PCB. The sediments is now placed in a landfill. Limits on turbidity and PCB in water measured at the closest downstream station were according to given permits 5 NTU and 70 ng/l (weekly mean). During the operation the NTU and PCB-values never exceeded these limits. As a mean for the whole period (930401-931231) the turbidity-value was 1,9 NTU and the PCB-value 10 ng/l.The remediation will be concluded in 1994.

OVERVIEW OF CHEMICAL (HAZARDOUS) WASTE CONTROL AND TREATMENT IN HONG KONG

by

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Abstract

Hong Kong's environment has been deteriorating for some time. The deterioration is partially as a result of the improper disposal of chemical (hazardous) waste. In the past, such waste was discharged directly to the sewers and surface waters without any form of treatment. The chemical waste arising from 1992 was estimated to be 120,500 tonnes per year. This amount of waste is 3.2 times higher than that from 1982. In Hong Kong, most industries are comprised of many small factories which are located in multi-user high rise industrial buildings with employees of less than 20 workers. Since most waste producers would not be able to treat their waste due to the lack of technical expertise, financial resources, and space required for the installation of in-house waste treatment, a centralized chemical waste treatment facilities is established by Hong Kong government.

Moreover, a new legislation has been introduced to ensure that the chemical waste is handled in a manner that protects human health and prevents environmental pollution. To have a more effective legislative controls, chemical waste producers are required to register with the Environmental Protection Department, license is needed for waste collection and disposal, and trip ticket system is designed to track the waste movement from the source of production to the place of final disposal. In this paper, the enforcement of the legislative chemical waste controls and the treatment processes used in the Chemical Waste Treatment Centre will be presented. Moreover, the difficulties and constrains faced by Hong Kong government in introducing this new controls will also be discussed.

I. Structure of Hong Kong's Industries and their Chemical Waste Production

The territory's small size limits the amount of land which could be made available for industries and precluded the development of heavy or land-intensive industries. Over 90% of industries are located in multi-user high rise factory buildings, so called "flatted factories", with a land size of less than 100 m^2 and a total of employees of less than 20. Thus, we can say that the majority of industries in Hong Kong are characterized by small-scale firms and operated under cramped conditions.

According to the latest available trade statistics, about 90% of Hong Kong's manufactured products are exported. Manufactured products such as clothing, electronic products, watches and clocks, textiles, and plastic products (particularly toys) have accounted for the bulk of this output. The major export markets were the United States (27.2%), China (23.5%), Germany (8.4%), and the United Kingdom (5.9%). In 1991, the territory was the world's second largest exporter by value of clothing and watches, and the third largest exporter of toys.

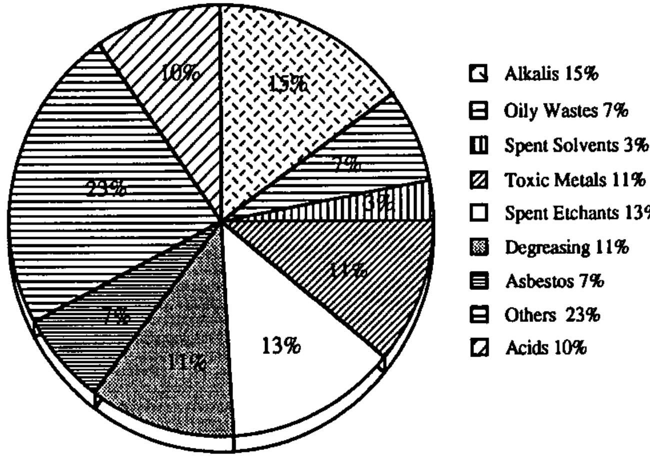
Based on the data from Hong Kong Environmental Protection Department (EPD), the major waste producers in Hong Kong are printed circuited board manufacturers (24%), electroplaters (20%), metal industries (18%), tannies and leather finishing manufacturers (8%), asbestos removal (7%), and others like printing and publishing etc. (23%). The total amount of chemical wastes produced by the above factories was estimated to be about 120,500 tonnes in 1992. This amount of waste is 3.2 times higher than that in 1982, and 1.3 times higher than that in 1987 (Table 1). The eight major streams of chemical waste are alkalis, spent etchants, spent degreasing solution, acids, toxic metals and metallic compounds, oily wastes, asbestos, and spent solvents (Figure 1).

In the past, such wastes were discharged directly to the sewers and surface waters without any form of treatment. As a result, the Hong Kong's environment is greatly deteriorated. Since most waste producers are lack of technical expertise, financial resources, and space required for the installation of in-house waste treatment, it would be virtually impossible to request them to treat their own wastes. Therefore, the establishment of a centralized chemical waste treatment plant would be the best strategy (in terms of technically feasibility and cost effectiveness) for the control of chemical wastes.

Table 1. Historical Chemical Waste Arising Data Comparison (from Ref. 3)

Chemical Wastes	1982	1987	1992
Aqueous Wastes			
acid waste	6,490	20,000	12,300
alkali waste	7,810	35,000	18,300
heavy metal waste	387	1,500	12,600
copper bearing etchant	-	12,500	16,200
cyanide waste	141	100	2,500
oil/water mixture	7,687	12,000	2,200
Solvent Wastes			
non-halogenated solvent	3,571	1,500	1,300
halogenated solvent	1,558	1,300	1,600
Oily Watses			
mineral oil	2,950	5,600	6,400
fuel oil	2,051	50	-
Solid Wastes			
plating bath sludge	115	10	-
paint waste	442	640	1,000
hazardous metal oxide	1,408	-	-
tannery waste	499	400	1,100
toxic waste	322	-	-
Other Wastes			
tank cleaning sludge	720	1,000	-
asbestos waste	-	-	8,000
miscellaneous wastes	549	700	37,000
Total Annual Tonnage=	36,700	92,300	120,500

All units in tonnes/year
Marpol waste excluded



Chemical Waste Arising of 1992: 120,500 Tonnes

Figure 1. The Major Streams of Chemical Waste

II. Framework of Chemical Waste Control Scheme

In parallel with the development of the centralized facilities, Hong Kong EPD realized that the implementation of Waste Disposal Regulation (Laws of Hong Kong Chapter 354) seems equally important. The regulation was enacted on 18 March, 1992 under the Waste Disposal Ordinance. The main objective of this legislation is to establish a comprehensive program which ensures the chemical waste is properly managed by all parties from *cradle to grave.*

Basically, the framework of this legislative control is based on 4 main elements: (1) identification of the nature and characteristics of the waste; (2) registration of chemical waste producers with Hong Kong EPD and their legal obligations; (3) licensing of waste collection, transport and disposal; and (4) tracking the waste movement from the production point to the final disposal point by trip ticket system.

2.1. Waste Identification

Hazardous waste can be divided into three categories: Chemical, biological, and radioactive wastes. Chemical waste is defined as *"any substance or thing being scrap material, effluent or unwanted substance or byproduct arising from the application of or in the course of any process or trade activity, and which is or contains any substance or chemical specified in Schedule 1 of the Waste Disposal (Chemical Waste) (General) Regulation if such substance or chemical occurs in such form, quantity and concentration so as to cause pollution or constitute a danger to health or risk of pollution to the environment".*

More specifically, the Schedule itself is divided into two parts. Wastes which contain substances or chemicals listed in Part A of the Schedule are particularly hazardous and would require advanced preparation work to be carried out at the reception point. Part B of the Schedule covers the majority of chemical wastes such as acids, alkalis, toxic metals, mineral oils and organic solvents. Figure 2 is a flowchart to assist person to determine if the waste is chemical waste. If the waste contains one or more chemical in the Schedule 1, then the person needs to check if the waste is on the list of chemical waste streams. If yes, the waste is chemical waste. If not, the person should seek advice from EPD.

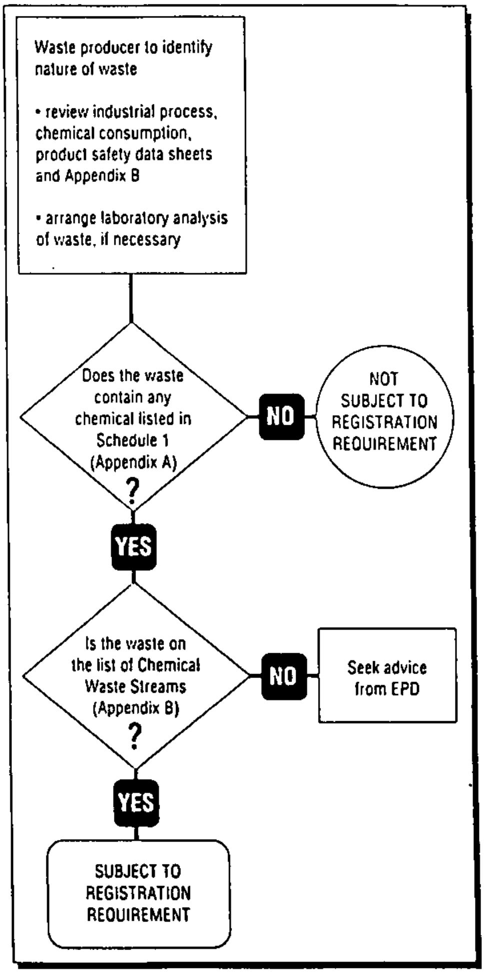


Figure 2. Procedure for Chemical Waste Identification (from Ref. 1)

2.2. Registration or Notification of Chemical Waste Producers and their Obligation

Any person who produces chemical waste is defined as chemical waste producer, and is required by law to register with Hong Kong EPD. Any one who fails to produce information will receive a maximum fine of HK$100,000 and an imprisonment for 6 months. The chemical waste producers have the obligation to ensure their wastes are proper packaging, labeling, and storing before transportation to disposal facilities. The requirements can be summarized as follows:

- Chemical waste should be packed and stored in suitable containers in accordance with specific containers.

- Mixing of different types of chemical waste in a container is not permitted.

- Correctly design labels must be filled out complete (including type and amount of each chemical in the waste) and attached to the waste container.

- Storage of waste in the working area is allowed if the total quantity does not exceed 50 litres.

2.3 Licensing of Waste Collection, Transportation and Disposal

According to the chemical waste regulation, any person who wishes to collect and dispose of chemical waste should apply for a Waste Disposal Liscence from the EPD. The licensing system is developed to limit the provision of waste collection and disposal services only to qualified and responsible operators.

2.4 Waste Tracking System

As shown in Figure 3, the trip ticket system is designed to track the waste movement from the production point to the final disposal point. A waste producer needs to complete in triplicate a form and keep one copy as a record of consignment before the waste will be accepted for collection. The waste collector will retain a further copy of the form upon delivery of the waste to a reception point. The manager of the reception point is required to retain the original copy. By executing this system, the EPD can highly prevent the occurrence of illegal disposal of waste.

III. Chemical Waste Treatment Facilities

Enviropace Limited has been contracted by the Hong Kong Government to build and operate a new Chemical Waste Treatment Centre on Tsing Yi Island. Enviropace Limited is a joint venture company composed of Pacific Waste Management Limited, China International Trust and Investment Corporation, and Kin Ching Besser of Hong Kong. In addition to building and operating the CWTC, Enviropace also provides containers, collection services, and consultation for waste producers. So far, about 1500 producers have been contacted.

Because of the dynamic and the fast growing of Hong Kong industries, a wide range of chemical wastes is generated. The characteristics of chemical wastes are thus fluctuated due to the variation of seasonal, fashion-oriented, economy-driven, etc. Due to these reasons, the treatment processes installed in the CWTC should be designed with higher flexibility in order to treat a wide variety of chemical wastes (Figure 4). The capacity of the CWTC is designed to receive 100,000 tonnes of chemical wastes annually and to treat three main types of wastes: (1) oily water waste, (2) inorganic aqueous waste, and (3) sludges and residues. The following is a brief description of the facilities of this treatment centre.

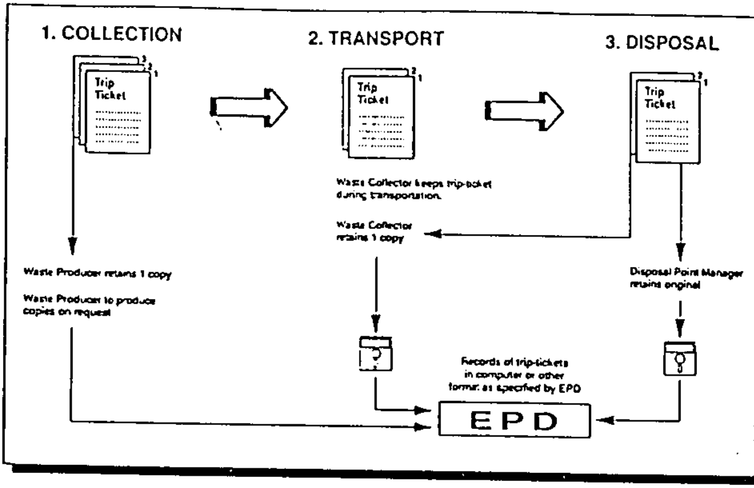


Figure 3. Waste Tracking System (from Ref. 2)

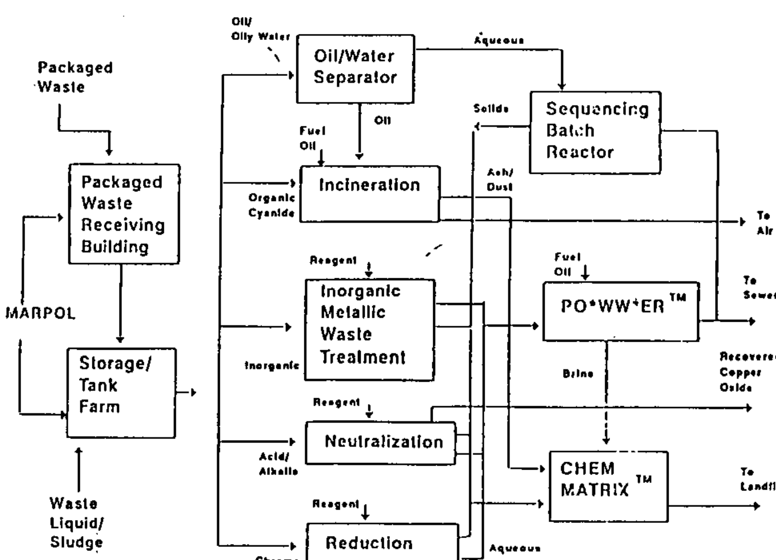


Figure 4. A Variety of Treatment Processes Used in Chemical Waste Treatment Centre (CWTC)

3.1. Packaged Waste Receiving Building

Chemical wastes generated from factories will be packaged in containers and wastes from the shipping activities (i.e. MARPOL wastes) will be collected in a barge. All packaged wastes will be sampled and analyzed to verify theirs identity in accordance with the trip-ticket before reception. After that, both packaged wastes and MARPOL wastes are stored in a tank farm for subsequent treatment.

3.2. Oily Water Separation

Oily water separation process is designed to separate oil and water by gravity. Emulsion breaking chemicals will be injected into oily waters like MARPOL wastes to enhance the separation. The recovered oil is then used for fuel in the incinerator and the water layer is sent to the biological treatment system for further treatment. The waste water is first conditioned in a feed tank for pH adjustment, and then fed to a Sequencing Batch Reactor (SBR) for biological treatment. The cleaned water is further processed in a carbon adsorption system for final water polishing. The treated water has to meet the regulatory Discharge Limits as stated in Table 2.

3.3 Physical/Chemical Treatment

Physical and chemical treatment system is designed for the treatment of inorganic aqueous wastes, and comprised of neutralization of acid and alkaline, oxidation/reduction process, and precipitation of toxic metals. All of these processes greatly reduce the volume of the waste, recover many metals, and change them in a more stable form. The treated water is then reused throughout the facilities for such things as boiler feed water make-up, rinsing, washing and chemical reagent mixing.

Table 2. Effluent Discharge-Environmental Control Limits

Parameters	Control Limits
pH	6-10
Temperature (^oC)	43
Suspended Solids (mg/L)	100
COD (mg/L)	600
Grease and Oil (mg/L)	20
Toxic Metals (mg/L) Cd Hg Total Cr As, Cu, Pb, Ni, Ag, Zn Ba, B, Mn, Sn	 10 0.1 0.05 1 2 5
Cyanide (mg/L)	0.1
Sulfides (mg/L)	10
Phenol (mg/L)	0.5
Detergents (mg/L)	15
Residual Chlorine (mg/L)	1
Nitrogen (mg/L)	100
Polychlorinated Biphenyls (ppb)	3

After the physical and chemical treatment, the wastewater might require advance treatment before discharge. This final polishing involves a proprietary process known as PO*WW*ER™. PO*WW*ER™ system consists primarily of an evaporator that reduces influent wastewater volume, a catalytic oxidizer that oxidizes the volatile contaminants in a vapor stream from the evaporator, a scrubber that removes acid gases formed during oxidation, and a condenser that condenses that vapor stream leaving the scrubber (Figure 5).

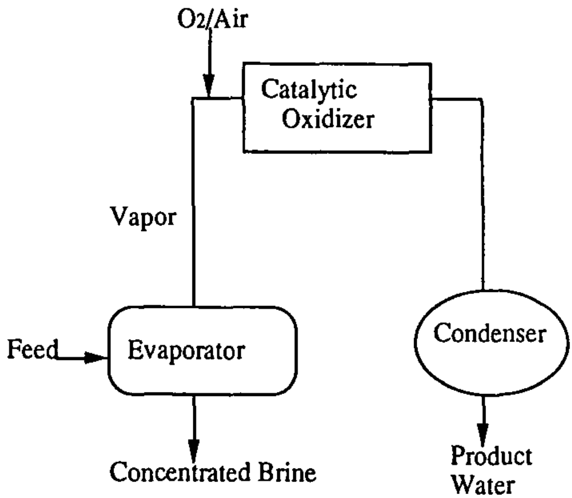


Figure 5. Advanced Wastewater Treatment- POWW**ER™ System**

3.4. Incineration and Stabilization

The incineration system is comprised of a rotary kiln, a secondary combustion system, and an air pollution control system. The rotary kiln/secondary combustion chamber is designed to have a Destruction and Removal Efficiency (DRE) of 99.99% for RCRA (Resource Conservation and Recovery Act) wastes, and 99.9999% for waste containing polychlorinated biphenyls. Chemical wastes received at the CWTC which require incineration are stored in tanks according to their chemical make-ups. The wastes are then blended to ensure the proper feed to the incinerator. Contaminants which remain in the gas phase after secondary combustion are removed in a dry scrubber system. Air emission from the stack is constantly monitored to meet the Stack Emission Limits (Table 3).

All residues such as incinerator ash, scrubber solids, precipitates from physical and chemical treatment, sludges from biological treatment are chemically stabilized by adding specific reagents (e.g., pozzolanic materials) prior to disposal in an off-site landfill. The stabilized materials have to meet the Environmental Control Limits as stated in Table 4.

Table 3. Stack Emission-Environmental Control Limits

Parameters	Control Limits (mg/m^3)
Particulates	75
Hydrogen Sulfide	5
Carbon Monoxide	150
Acidity (as H_2SO_4)	100
SO_2	750
NO_x	500
Hydrogen Chloride	38
Heavy Metal I (e.g., Hg, Sb, Cd)	3
Heavy Metal II (e.g., Pb, Cu, As, Ni, Zn, Cr)	10
Total Heavy Metals	10
Total Hydrocarbons (as C)	35
Dioxin/Furans: PCDD's PCDF's	0.1 mg/m^3 TCDD equivalent
Smoke/Opacity	10%

under the reference condition of dry stack gas at standard temperature of 0^oC, pressure of 1 atm., and 12% of CO_2.

Table 4. Stabilized Residues-Environmental Control Limits

Parameters	Control Limits (ppm)
<u>Part A: Stabilized Residues (TCLP Leachate)</u>	
pH	8-12
Solids	<30%
Toxic Metals: Cd	0.5
Hg	0.1
Total Cr	10
Total of Cu, Ni, Pb, Zn	25
Sulphide	10
Ammonia-Nitrogen	10
Cyanide	5
<u>Part B: Stabilized Incineration Residue</u>	
Total unburnt hydrocarbon	0.5% by wt.
PCB's	1
TCDD equivalent	0.001

IV. Constraints and Difficulties in Implementing Chemical Waste Controls

In making the first attempt to introduce this legislation control on chemical wastes, many difficulties and constraints are found and needed to be faced by Hong Kong government. These difficulties and constraints included: (1) lack of public environmental awareness; (2) unwillingness of polluters to pay their cost; (3) significant variation in waste generation; and (4) short of local waste management expertise.

4.1. Lack of Public Environmental Awareness

Pollution control is a considerable cost to industry. In a community such as Hong Kong, which depends more than most on the export market, any additional cost is initially seen as undermining industry's competitive position in the world market. Thus, from the point of view of waste producers, any control requirements would be regarded as a potential burden. As a result, they are reluctant to cooperate with any environmental officers.

4.2. Unwillingness of Polluters to Pay their Treatment Cost

All countries seeking to develop a hazardous waste management have to face a same problem-funding problem. The approach to this problem in Hong Kong is an interventionist approach, in which both the capital and operating costs are paid for by Government in order to solve a pressing pollution problem. The original thought of the Government is to pay for the operating fee only the first few years, and after that polluters are required to pay their operating costs. A plan to charge a levy on industries to recover the HK$ 200-300 million operating costs has been proposed and is waiting for approval by Hong Kong Executive Council. The most headache question is that "once this free of charge service is started, how can the Government change the mentality of the polluters and ask them to pay their own treatment cost?"

4.3. Significant Variation in Waste Generation

The development and implementation of chemical waste controls in Hong Kong is somewhat different from other countries like Europe and US. The factories in Hong Kong are small in size and operated under crowded conditions. In a high rise factory buildings, it is not unusual to have more than three different types of industries in the same storey. The type of waste production could vary significantly within the same building.

Moreover, industrialists in Hong Kong are very well known for their quick change of their production line to cope with the needs and demand in market. Their products can also be changed from season to season. Thus, the authority has potential problems on the enforcement of the registration because of the difficulty to identify the source of chemical waste from a multi-occupancy building. Also the significant variation in waste production posts a great technical problem in operating the treatment facilities of Chemical Waste Treatment Centre.

4.4. Short of Local Waste Management Expertise

During the processes of introducing the legislation controls and developing a centralized facilities for the treatment and disposal of chemical wastes, we find that we are short of local expertise and services supporting staff, such as laboratory technicians for waste identification and analysis; experienced person in handling and storage of chemical waste; qualified company for waste collection, transport, and disposal; and management expertise in setting up regulations and standards.

V. Conclusion

Due to the severe deterioration of the waters in Hong Kong area, the Government has taken steps to conduct a comprehensive chemical waste program. This program includes the establishment of a centralized chemical waste treatment facilities and the introduction of a comprehensive legislative chemical waste control. To ensure the legislative controls more effective, chemical waste generators are required to register with the Environmental Protection Department, license is needed for waste collection and disposal, and trip ticket system is designed to track the waste movement. To Hong Kong who has no experience in chemical waste management before, this was not a easy task. Many problems and difficulties are found and needed to be tackled.

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ACTION PLAN FOR CONTROLLING AND CLEANING UP SITES WITH HAZARDOUS WASTE IN LITHUANIA.

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Summary

Since its establishment in 1991 the Lithuanian Environmental Authorities have focused on environmental problems in relation to sites with hazardous wastes with financial assistance from Danish and European Funds. The sites are municipal and industrial landfills, oil storage facilities, storage of pesticides, and former Soviet military sites. Previously no effective environmental regulations were applied when establishing landfills. Some of these landfills therefore exposed ground and surface water to high risks.

Starting off from zero the Environmental Authorities have today established a system for managing the polluted sites involving registration and evaluation procedures, as well as an action plan for the "cleaning up" activities.

This paper describes the methods applied, the difficulties experienced, and gives examples of environmental damages and remediation activities.

Short Description of Lithuania

Lithuania is located east of The Baltic Sea and covers 65,200 km². The population is 3,76 million. Mean surface altitude is 100 meter above sea level with a climate between maritime and continental. Precipitation varies over the country from 500 to 800 mm/year. Vilnius, the capital of the country has 550,000 inhabitants. Lithuania regained her independency on March 11, 1990.

38% of the Lithuanian territory is occupied by arable lands, 11% by pastures, 33% by forest, 3% by lakes and rivers and 15% by urban areas.

The climate and the geological conditions favour the formation of groundwater, which is found throughout Lithuania in quaternary alluvial, fluvial glacial deposits, permean limestone and devonian dolimite. Groundwater is the only source used for drinking water an is abstracted from about 20 aquifers.

International Co-operation

In total four international projects have been or are being implemented on the subject "Cleaning Up of Hazardous Wastes" with financial assistance from the Nordic Investment Bank, the Danish Environmental Protection Agency, and the PHARE programme of the EU.

These projects have been implemented through the Lithuanian Ministry of Environment, with assistance from the Geological Survey of Lithuania providing data on groundwater resources and water supplies. The Danish firm I. Krûger Consult AS has been the main consultant on projects which also employ local as well as international consultants. In 1993 the international co-operation resulted in the establishment of "Baltic Consulting Group" a Lithuanian/Danish/Swedish owned company which is specialised in environmental planning.

Landfills and Dump Sites

Through search in central archives and contacts to all municipalities in Lithuania all known old and existing landfills or dump sites have been registered. For sites which were suspected to contain hazardous wastes all available data was collected such as geographical coordinates, type and quantity of waste, period of operation, drainage for surface water, present use of area, future plans, and conditions for nearby water supply wells.

In addition hereto data from central organisations was collected. The Geological Survey of Lithuania provided hydrogeological data and location of all wells within 2 km from the sites, while the Ministry of Environment provided data on surface water qualities as part of the risk evaluation.

Former Soviet Military Sites

After the withdrawal of the Soviet troops in August 1993 280 military sites were left behind ranging from large military airbases with oil storage facilities to border posts. In the spring of 1994 200 of the sites with expected environmental damage were surveyed by specialist teams. The purpose of the registration is to estimate the total costs of remediation. Besides risks and damage to water resources due to hazardous waste deposits, damage to soil, forests, flora, and fauna is also evaluated. The registration of problem areas within the military bases have been complicated due to lack of detailed maps or aerial photos.

Evaluation Principles

As only limited information was available for the approximately 1000 potential point sources polluted with hazardous wastes it was necessary to establish a system for giving priorities to the sites. This system should provide a rough classification to make clear which sites needed to be investigated and "cleaned up" urgently.

Based on previous experiences from Denmark and adjusted to Lithuanian conditions, a simple analytical model for the classification of the sites was established. The model was based on a rough quantification of the degree of hazard of the wastes to landuse, groundwater and surface water.

The degree of hazard of the wastes was given values from 1 to 4 (a high value indicating a high degree of hazard) depending on type and volume.

The landuse sensitivity was given values depending on type of landuse and distance to target. An example of a "worst" case (value 4) is a nursery within 50 m from the site, while the landuse sensitivity is considered low (value 1) if the "target" consists of industries or transport facilities more than 200 meter from the site.

The vulnerability of the groundwater resources was equally divided into four groups. Highest vulnerability (value 4) was given to reservoirs, where the site was located within the catchment area of a well field and where no natural protection (clay layers) existed. Lowest vulnerability was given when no drinking water abstraction was located "downstream" the site and when the reservoir was protected.

For surface water the highest vulnerability (value 4) was given to rivers with high quality of water, low flow and located less than 50 meters from the site. Lowest vulnerability was given to rivers with poor quality of water and high flow.

For each potential target; landuse, groundwater, and surface water, the priority factor for a given site was calculated as hazard class multiplied by sensitivity/vulnerability. Priority factors thus ranked between 16 and 1 and provided the internal classification within each target, e.g. worst case with respect to groundwater, worst case with respect to surface water, etc..

To establish an overall classification it was necessary to combine the three priority factors through a relative weighing of the targets. The weighing was chosen as groundwater 40%, surface water 30%, and landuse 30%.

636 landfills have been registered and were then classified into four groups as follows:

Group A: (Score > 8)
Group A consists of 22 sites and is characterized by a high risk potential to man and environment. Highest priorities must be given to carry out detailed and comprehensive investigations in order to determine the extent of remedial measures for the sites. Detailed and comprehensive investigations are necessary. May often lead to remedial measures. Group A includes the most hazardous sites comprising large landfills and industrial sites in or around major cities. All group A sites contain substantial quantities of chemical waste presenting a high risk to water resources and landuse.

Group B: (Score 2.5 - 8)
Group B consists of 114 sites. Investigations are needed to determine further actions for the sites. Of the 114 sites, the top 26 sites are in hazard class 3, which means that significant quantities are deposited on most of these sites.

Group C: (Score > 0 - 2.5)
Group C consists of 118 sites. Need for small scale investigations which are expected to lead to monitoring programmes. Nearly all of the group's 118 sites are in hazard class 1. These sites are generally landfills with moderate to small quantities of household and demolition waste. Even though chemical wastes are rare, their type and quantity should be verified, and, depending on the site's sensitivity, possibly further investigated.

Group D: (Score 0)
Group D consists of 382 sites. The sites are not considered to expose any risk to man or environment. However, additional site visits are needed to confirm volume and type of wastes. Waste deposited in Group D wastefills is considered to be non-hazardous. The sites of Group D are typically very small landfills with small amounts - often only a few hundred m^3 - of household and demolition waste. A site visit should be made to these sites to verify this. If the preliminary evaluation of a site proves to be true, no further action will be implemented. If not, preliminary investigations and re-classification of the site should be carried out.

The above classification is the first rough classification based on existing data. The classification must not be regarded as a static list. Continuous data collection from the sites is recommended to take place and the classification to be updated accordingly.

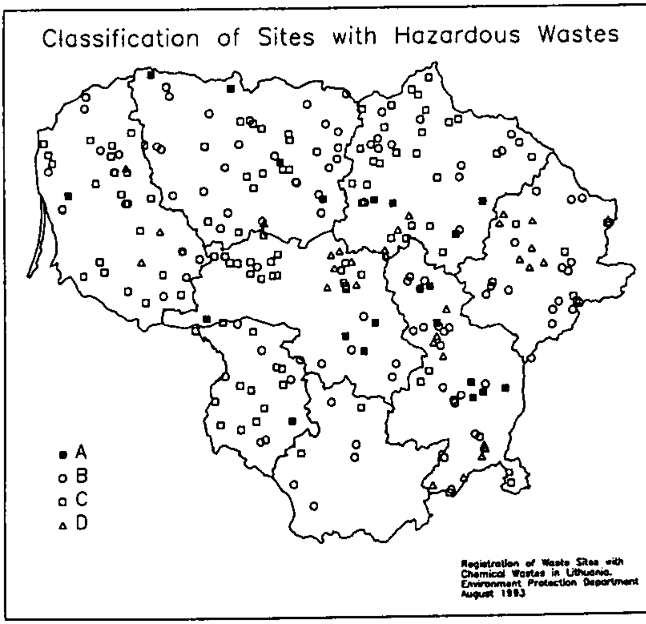

Fig. 1. Distribution of class A, B, C and D landfill sites.

<u>Cleaning Up Activity</u>

As the awareness of environmental problems is increasing - also among regional/local authorities - more and more sites will be registered and classified in the management system. Proposal for administrative/legislative measures concerning the distribution of responsibilities for further investigations and current updating of the classification has been prepared by a Danish/Lithuanian group.

For one Group A site detailed investigations have documented the need for remediation; on the former Soviet airbase in Siauliai in Northern Lithuania recovery of free phase jet fuel was therefore initiated in March 1994.

The former Russian military airbase in Siauliai, which covers an area of 11 km^2, is the largest airbase in the Baltics. The base is located within the city zone area and covers about 17% of the city area.

Spills and leakages of oil products from tanks, pipelines, workshops, etc., have occurred on the premises of the airbase during the past. Large quantities of jet fuel have been detected in the upper groundwater zone and serious oil pollution has occurred in nearby small streams and lakes. Important groundwater resources in the deep seated upper devonian aquifers (150 - 200 m) are threatened by pollution. After preliminary investigations the authorities expect that more than 2,000 tons of oil products have accumulated in the ground.

The aim of this project is to minimize the threat to the groundwater resources used to supply the city with water (approx. 150,000 inhabitants), by pumping up the major part of the free oil phase.

The upper layers in the area consist of sand and gravel, which form the upper aquifer with the water table situated 1 - 10 m below surface. The lower aquifer system consists of permean limestone located 50 - 70 m below surface. Less permeable layers of clay with sand and gravel separates it from the main upper devonian aquifer on which the supply to Siauliai City is based. One of the city's three major well fields (pumping 20,000 m³/day) is situated downstream the airbase.

Oil skimmers are placed at oil/water interface level thus skimming (separating) oil from the groundwater. Figure 2 shows a schematic illustration of the location of the skimmer.

The total project cost is approx. 550,000 US$ and the project is expected to be completed by 1998.

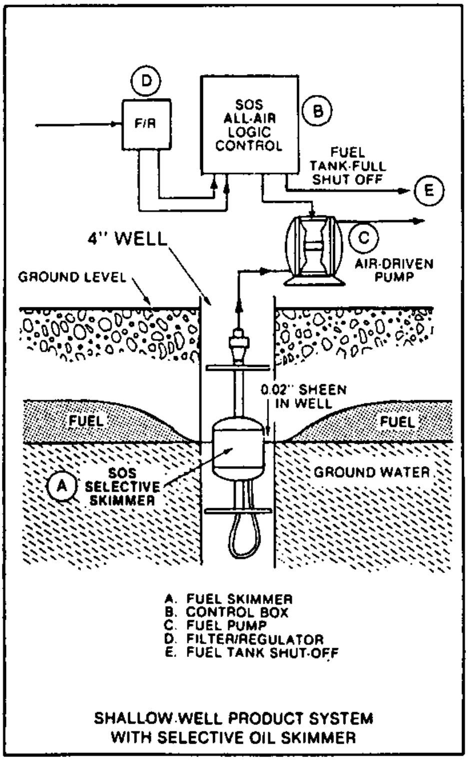

Fig. 2. Method for recovery of free phase jet fuel at Siauliai airbase, Lithuania

Conclusion

Within relative short time and with limited financial resources registration as well as a first classification of point sources for water pollution have been carried out in Lithuania.

During the last three years the Lithuanian-Danish co-operation on "groundwater protection" projects has developed from a planning phase to actual remediation projects.

The planning projects have shown an urgent need for detailed investigations of polluted sites which will provide the number of sites to be monitored or remediated.

HAZARDOUS WASTE DISPOSAL PATTERN FROM TANNERIES IN TAMIL NADU STATE IN INDIA

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ABSTRACT

The tannery waste consist of toxic inorganic and putrescible organic materials. In view of its severe pollutional problems and the increasing demand for good quality of water for domestic and other industrial purposes it has become essential to treat the waste to acceptable level prior to its disposal. Accordingly the Government have decided to accept the proposal of Tamil Nadu Leather Development Corporation (TALCO) for setting up of Common Effluent Treatment Plants (CETP) to serve 741 tanning industries in the state. This paper explains about the Common Effluent Treatment Plants being setup by TALCO and Tamil Nadu Pollution Control Board (TNPCB) at various centres in the state for cleaning the hazardous waste from tanneries before discharging them into various sources. Water samples from 20 bore wells and open wells in and around the residential areas located near the tanneries were collected and water samples tested for ground water quality assessment.

Introduction

Among the variety of industrial wastes, tannery waste can create serious pollutional problems in the receiving bodies. One of the important problems associated with the leather industry is the proper treatment and disposal of the obnoxious waste water produced in tanneries. Vegetable and chrome tanning are the two different major processes employed by these industries. In the process of leather making, large volumes of liquid wastes with high content of organic matter and minerals are discharged from the tanneries. Discharge of these wastes without proper treatment leads to bad environmental sanitation in regions where the tanneries are located. When the wastes are let out on barren lands without adequate treatment, they present unsightly appearance, emit bad smell and pollute ground water. Discharge of these wastes in rivers renders them unsuitable for municipal water supply, recreation, aquatic life and agriculture. The dissolved oxygen in the river water is depleted by chemical action and bacterial decomposition of organic matter present in the waste. The suspended matter settles and forms sludge blankets creating obnoxious conditions. The wastes also impart intractable colour to the water. Discharge of untreated waste into municipal sewers often results in chocking and interferes with proper maintenance of sewers and operation of sewage treatment plants.

Medium and large scale isolated tanneries with sufficient land area and financial capacities have set up independent effluent treatment plants. Whereas small scale tanneries located in clusters and not having enough land and financial capacity to construct individual effluent treatment units need to set up Common Effluent Treatment Plants.

Description of the Study Area

Fig. 1 shows the Palar river basin which is located in North Arcot Ambedkar district in Tamil Nadu and also in parts of Andhra Pradesh. The total area of the basin within Tamil Nadu is about 10656 Sq. Km. Among the river basins, the Palar river basin is very important from ground water devleopment point of view. This river is non perennial. It flows only for about one or two weeks in a year during normal monsoon season. Hence continuous monitoring of ground water quality in this basin is an absolute must in order to preserve the environment. There are nearly 574 tanneries located in this district spread over five major towns on the banks of Palar river, which forms nearly 75 percent of the total tanneries in the State and they discharge their tannery effluents into the Palar river. The ground water in these locations are very highly polluted. The Palar river is also considered to be one of the highly polluted rivers in Asia.

Out of the number of industries which are located in these five major towns, tanneries constitute 90 per cent and the rest are chemcisals, sugar, soaps, leather goods and paper industries. The surface water and also ground water are getting contaminated and rendering it unsuitable for drinking or for irrigation in several parts of the river basin. Ground and surface water pollution due to tannery effluent and other industrial wastes is considered to be the primary cause for the reported occurrences of various water borne diseases including skin diseases confronted by human population and poor production capability of agricultural land in this region. Some of the wells have been abandoned by the public due to heavy contamination of the ground water. Industrial effluents which are untreated or partially treated are let out into the river and extensive application of fertilizers and pesticides in the agricultural areas are the main source of pollution which needs special study, monitoring and control.

Ground Water Sample Analysis from the Study Area

Ground water samples have been collected from the wells located nearby residential areas situated in and around these cluster of tanneries and the Geo-chemical analysis of ground water from representative wells is presented in Table 1. This table indicates high values of pH. Hence the water is highly alkaline and unfit for drinking purposes. The total dissolved solids of the ground water samples from all the 10 wells are well beyond the desirable limit of Indian Standards Institution (ISI) for drinking water quality. Hardness of the water in 8 wells exceeds the maximum permissible limit of 600 ppm for drinking water. Also SAR values for 9 wells indicates

Table 1: Geo - Chemical Analysis of Ground Water Near Tanneries in Palar Basin

Well No.	EC µS/cm	pH	Ca ppm	Mg ppm	Na ppm	K ppm	HCO3 ppm	CO3 ppm	SO4 ppm	Cl ppm	NO3 ppm	TDS ppm	SAR	TH
1.	2820	8.8	44	124	403	6	537	0	178	624	60	1805	7.0	618
2.	6300	8.6	488	214	414	11	165	0	413	1602	248	4032	3.9	2097
3.	5500	8.3	312	233	506	4	561	0	192	1276	434	3520	5.3	1735
4.	2690	8.7	96	165	529	9	543	0	154	1347	651	1722	7.6	916
5.	5700	9.1	288	44	850	2	390	0	355	1361	211	3648	12.3	900
6.	3800	8.6	168	157	391	33	775	36	7	865	87	2432	5.2	1063
7.	4430	10.3	128	279	333	2	1171	120	29	694	50	2835	3.8	1463
8.	2445	8.6	120	73	345	6	665	0	192	411	37	1565	6.1	605
9.	1360	8.7	120	60	49	30	421	36	5	191	12	870	0.9	546
10.	2990	8.9	48	107	416	23	433	30	158	673	12	1914	7.7	559
Desirable (ISI)		6.5-8.5	200	100	-	-	-	-	150	250	20	500	-	300
Maximum Permissible		-	450	150	-	-	-	-	400	1000	45	2000	10	600

that the ground water is fit for lift irrigation except for one well which exceeds a maximum permissible limit of 10 ppm. The NO_3 values for most of the wells are well above the maximum permissible ISI limits of 45 ppm. The values of Cl for 9 wells and the values of SO_4 for 7 wells exceeds the desirable limits of 250 ppm and 150 ppm respectively. In general the values of pH, total hardness and dissolved solids of the ground water samples in the table indicates that they are beyond the permissible limits for drinking water quality.

Common Effluent Treatment (CET) Plants

Small scale tanneries in clusters wherever feasible need to put up CET plants. It has been organized by various agencies to set up CET plants to cover the needs of small and medium scale tanneries in eight different towns in Tamil Nadu. The treatment capacity of CET plants ranges from 1000 to 35,000 cubic meter per day. The pilot CET plant in Ranipet under UNIDO assistance to cover 70 tanneries and 1 main CET plant to cover 90 cluster of tanneries, 2 mini CET plants (to cover 8 and 15 tanneries) in Vaniyambadi tannery cluster in Tamil Nadu State (Fig. 2) under central and state assistance have already been commissioned. The CET project at Pallavaram with chrome recovery and reuse system (Fig. 3) near Madras city sponsored by UNIDO and CET plants at Ambur, Ranipet and Peranampet are under various stages of implementation.

The CET plant concept envisage pretreatment of effluent at the individual tanneries. The minimum requirements of pretreatment are screening and grit removal. In many of the clusters, inadequate land space is the main constraint even to provide pretreatment facilities in individual tanneries. Initially after screening in individual tanneries, effluent is collected through a common drain leading to the CET plant. Prerequisite to set up a CET plant is establishment of an individual co-operative society by the concerned tanneries of cluster to be benefited. The co-operative society is responsible both for construction of the CET plant and also for its day to day operation and maintenance.

These projects envisages collection of effluent from the tanneries in two streams. The soak and pickle will be collected as one stream, the other wastes as another stream. The two streams of trade effluent will be conveyed through cement lined open channels/pipes (HDPE and stoneware) of collection net-work to the Common Effluent Treatment plant by providing lift and pumping stations. The soak and pickle, predominantly salt waste will be treated in the solar evaporation ponds. The other streams will be treated in a biological treatment system comprising primary treatment, anearobic lagoon followed by aerated lagoon and finally clarified for final letout to Palar River.

Of the 574 tanneries officially listed as existing in the North Arcot Ambedkar district which are located in and around five major towns along the banks of Palar River, 516 are to be covered by the various CET plants under construction. Of them, 306 are to be covered by CET plants being put up by the Tamil Nadu leather Development Corporation (TALCO) with the financial support of the respective tanners associations while 210 are to be covered by CET plants to be put up by the Tamil Nadu Pollution Control Board (TNPCB). Of the remaining 58 tanneries, five were closed either due to court order on petitions filed by the public on environmental grounds or due to administrative reasons. Of the remaining 53 tanneries which were located in isolated places, 26 have put up individual Effluent Treatment Plants (ETP). Two tanneries have submitted proposals for ETPs while 25 are not covered either by CET plants or ETPs. Procedural delays and frequent changes in the original designs have contributed to escalation in the cost of all the projects. The commencement itself was delayed by two years due to difficulties in land acquisition.

The following components of the project work have been either fully completed or partially completed in the above six project centres to be commissioned as early as possible : 1. Construction of main CET plant 2. Collection and transportation system in various zones 3. Interconnection net work from individual tannery to the collection and trasnportation system. 4. Construction of pumping stations and lift stations. 5. Equalisation tank for one day capacity 6. Diesel generator sets for the main plant and for pumping stations for use in the event of power failure.

Financial Support to CET Plants

To provide treatment plants for tannery effluent in various cluster areas with a view to prevent health hazards on the ecological and the environmental point of view and to bring all the tanneries under the umbrella of such treatment plants in various places, Government of India has approved a Rs. 1023 crore ($ 330 millions) Industrial Pollution Control Project to prevent and alleviate environmental degradation caused by industrial operations. The World Bank is extending a credit of Rs. 443 crores ($ 143 millions) which will be matched with a provision of Rs. 580 crores ($ 187 millions) by India and State Governments for the project.

The Project (Phase II) is a sequel to a similar $ 267 million project (Phase I) of which $ 156 millions was loan from the World Bank. While in Phase I four different states were covered under the project, in Phase II, the pollution control boards in four other states are bring strengthened. The major component of phase I was the investment part under which loans were disbursed to individual indsutrial units for setting up pollution control equipment. The schemes applicable to all states in Phase II include loans to indiviual units for installation of pollution control devices, establishment of Common Effluent Treatment plants andintroduction of clean technologies with minimum waste generation and training of staff.

The loans to the industrial units and for the Common Effluent Treatment Plants would account for $ 125 millions of the

World Bank aid component. As much as $ 19.5 millions would go to the State Board and $ 2 millions for clearing house for clean technologies and waste minimisation programme. The Centre has to provide Rs. 31 crores for a grant of Rs. 50 lakhs for each Common Effluent Treatment Plant. The capital cost of CET plant is shared by the tanneries based on their average production capacities. Based on the recommendation of Central Government, the Government of Tamilnadu has approved the following pattern of financing implementation of CET projects in various centres in Tamilnadu. Financial assistance to the extent of 25 percent from the Central Governemnt and 25 percent from the State Government on capital investment is provided as subsidy/grant to the CET plants. Cluster of tanneries coming under CET plant contribute 15 percent of the capital investment and the balance of 35 percent is borrowed as loan from banks and financial institutions at an interest rate ranging from 15 to 22 per cent per annum.

Government of Tamil Nadu has also released sanction of Rs.360 Lakhs ($ 119 millions) for implementation of CET projects in the following centres : 1. Vaniyambadi (117) 2. Ranipet (108) 3. Ambur (100) 4. Pernampet (73) 5. Dindigul (47) and 6. Trichy (26). The number of industries located near these towns are indicated in brackets. Nearly 70 per cent of the total industries concentrated in the above first four towns which are located along the banks of river Palar are as shown in Fig. 1.

Formation of CET Companies

The Government also directed that the above financing pattern will be applied to the following Common Effluent Treatment Projects being set up / to be set up in the State for implementation by TALCO and TNPCB by setting up companies in collaboration with the respective Tanners association. With a view to helping small and medium tanners spread over the length and breadth of Tamil Nadu and to avoid pollution caused by the effluents of the tanneries following companies have been incorporated under the companies act : 1. TALCO Vaniyambadi Tanners Enviro Control Systems Ltd. (VANITEC) 2. TALCO Ambur Tannery Effluent Treatment Company Ltd. (AMBURTEC) 3. TALCO Ranipet Tannery Effluent Treatment Company Ltd. (RANITEC) 4. TALCO Pernampet Tannery Effluent Treatment Company Ltd. (PERTEC) 5. TALCO Dindigul Tanners Enviro Control Systems Pvt. Ltd. (DINTEC) and 6. TALCO Trichy Tannery Effluent Treatment Company (TRYTEC). The Government have decided to accept the proposal of Tamil Nadu Leather Development Corporation for setting up of Common Effluent Treatment plants for tanneries under its control at the above six towns and to avail central assistance for this purpose. The technical details of these plants are indicated in Table 2.

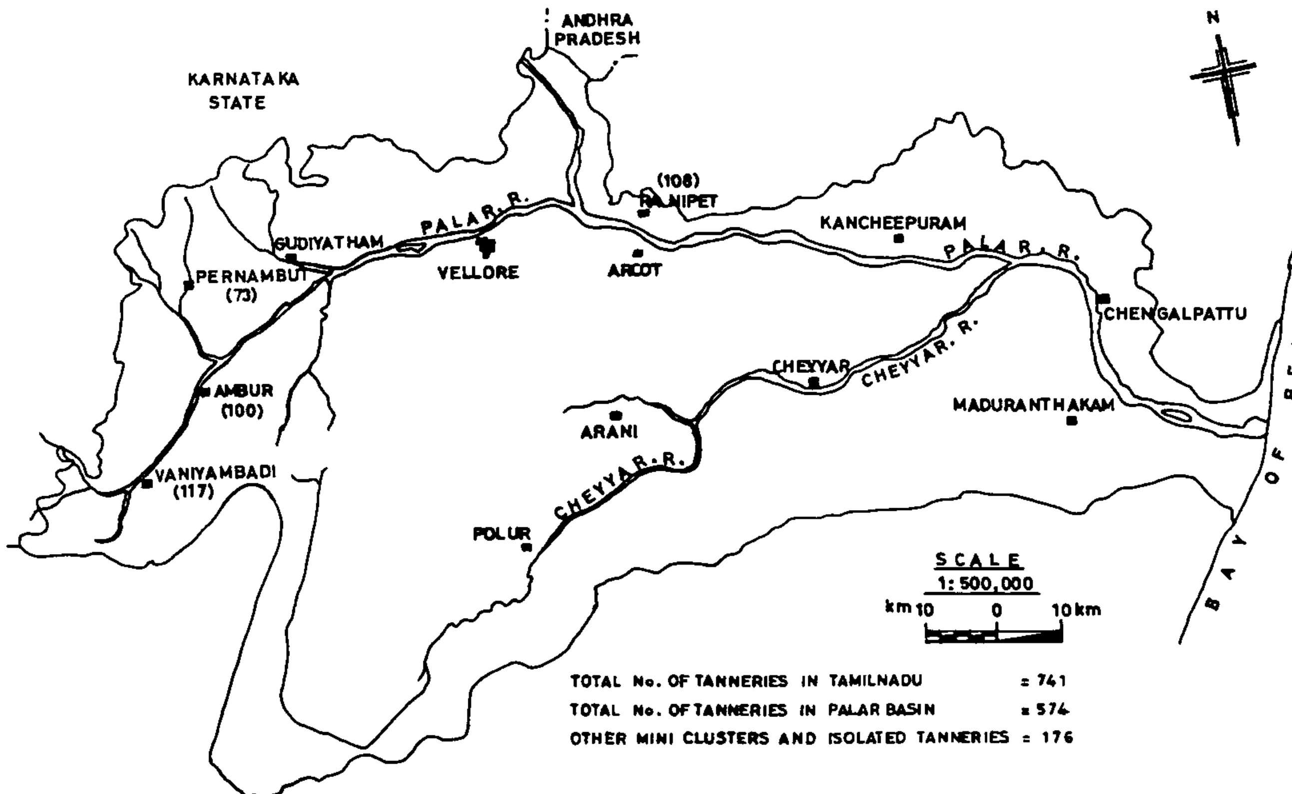

FIGURE 1. PALAR RIVER BASIN

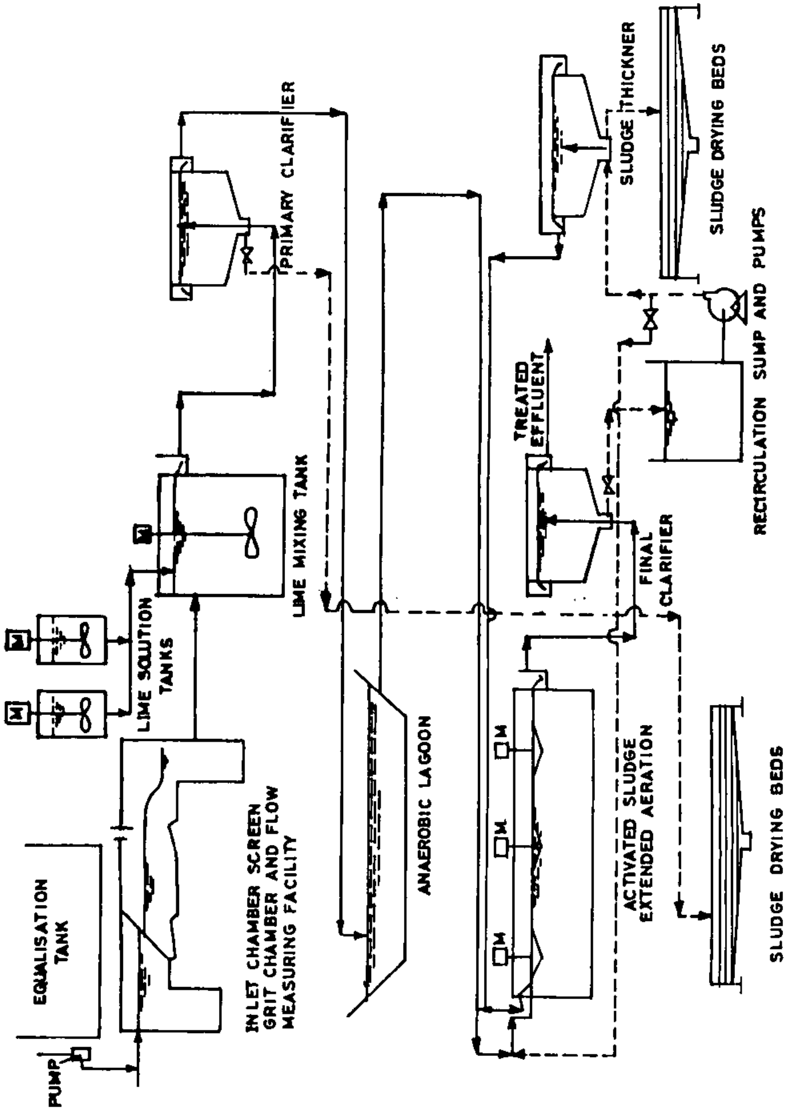

FIGURE 2. COMMON EFFLUENT TREATMENT PLANTS FOR TANNING INDUSTRY

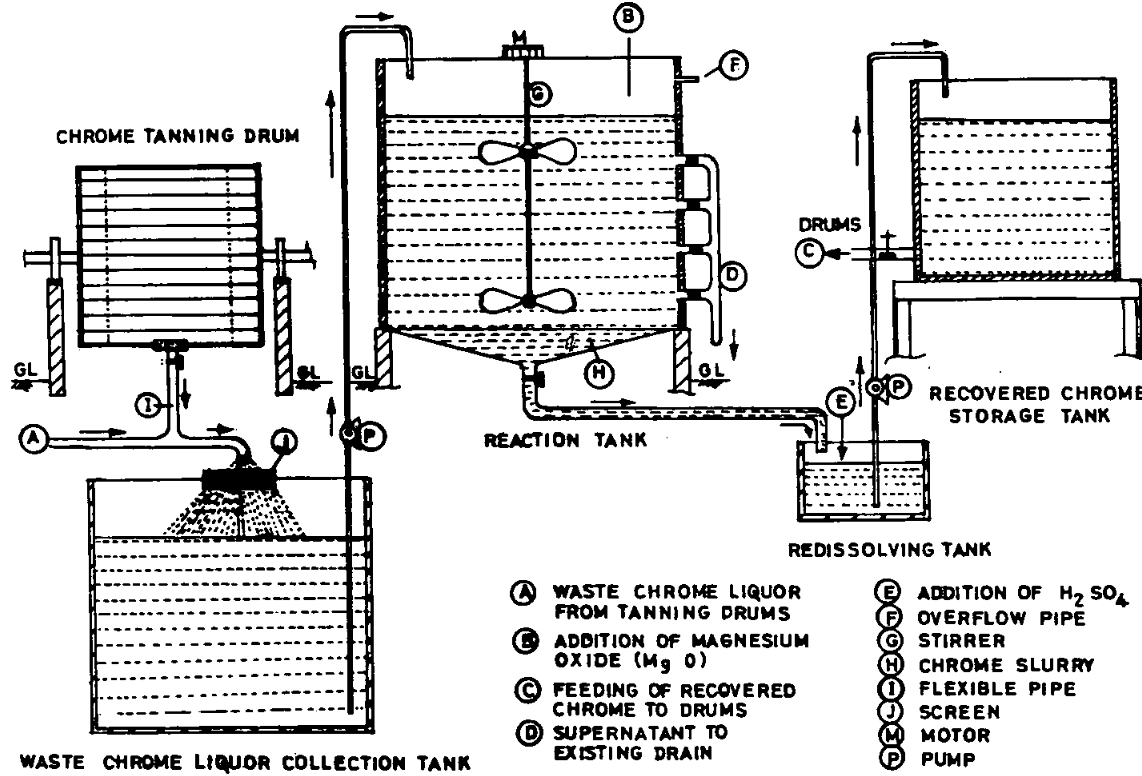

FIGURE 3. TYPICAL FULL SCALE CHROME RECOVERY SYSTEM

Table 2 Details of Common Effluent Treatment Projects

Name of the Project Centre	No.of tanneries in the centre	under CET Projects	Processing capacity in Kg/day	Quantity of effluent in m^3/day	Project cost (Rs. in lakhs)
Vaniyambadi	117	109	1,06,500	4,050	370
Ambur	100	65	1,12,000	3,370	297
Pernampet	73	72	1,03,000	3,100	231
Ranipet	108	70	1,05,000	3,600	300
Dindigul	47	39	90,000	2,700	270
Trichy	26	26	37,000	1,100	130
Total	471	381	5,53,500	17,920	1,598

Treatment processes adopted in CET Plants

Treatment processes commonly adopted under Indian Conditions comprises of four steps namely:

i. Segregation of certain sectional waste streams like soak liquor, chrome liquor etc, or mixing of suitable sectional waste water from different processes.
ii. Primary treatment in individual tanneries or in a centralized place wherever CET plant is established.
iii. Secondary biological anaerobic/aerobic treatment and
iv. Disposal of solid wastes from the treatment plant.

The primary treatment units are mostly similar, either equalisation cum settling tanks with sludge drying beds or separate equlisation tank and settling tank with sludge drying beds. A full scale chrome recovery system, sponsored by UNIDO is being implemented in Pallavaram tannery cluster near Madras city. The treatment flow diagram of chrome recovery and reuse system is indicated in Fig. 3. Secondary biological treatment combinations depend upon the location, availablity of land and final mode of treated effluent disposal. The following secondary biological treatment combinations are widely adopted in India.

i. Anaerobic lagoon followed by aerated lagoon
ii. Anaerobic lagoon followed by extended aeration
iii. Two-stage activated sludge process or extended aeration system

Chrome Recovery and Reuse System

Basically it is not difficult to remove chromium from the waste chrome tanning liquor because it is present in its trivalent form, which is generally insoluble at a pH of 6 to 12. Mixing the chromium containing liquor with liming liquor from the pretanning operations followed by proper pH control and settling removes the chromium. Also, during biological treatment, the residual chromium will be precipitated or combined with the protein containing sludge in the system. The disposal of large volume (about 100,000 tonnes per year) of chrome containing sludge from the tannery effluent treatment plants is a serious problem in India. The value of the chromium salt (BCS) wasted per annum is more than 300 million Indian Rupees (i.e about 10 million U.S. Dollars). Therefore, it was considered worthwhile to develop an appropriate chrome recovery and reuse system in tanneries.

The process flow diagram of the commercial scale chrome recovery and reuse system is shown in Fig.3. The chromium containing waste water including wash water from the chrome tanning drums is segregated, screened and collected in a tank. From the collection tank the waste chrome liquor is pumped to the main reactor. A calculated quantity of Mgo is added to the liquor in the reactor and stirred slowly. During this stirring period the pH gradually rises to the required value of about 8. After stabilization of the pH, stiring is stopped. The precipitated chromium settles to a compact sludge which is only 8 - 10 percent by volume of the exhaust chrome liquor. The supernatant liquor is decanted at various levels from the reaction tank. The settled chrome slurry is dissolved with sulfuric acid in the same treatment tank or after collecting in a separate container. The regenerated chrome liquor is collected in a storage tank and reused in chrome tanning process. The required quantities of MgO and sulfuric acid are estimated mainly based on pH measurements during the reaction.

Conclusions

The deteriorating ground water quality in Palar river basin as indicated in Table 1 is mainly due to the discharge of untreated effluents from tanneries and other industries located in that region. The major source of pollution is from tannery effluents. The progressive effects of industrial contaminants are noticed in the ground water and it is also evident from the increased salinity of the water where the alluvial aquifer is mainly tapped for urban and rural water supply as well as for irrigation.

Tannery effluent management has become a matter of increasing concern in India. Setting up of an effluent treatment plant is a difficult task in view of the complex nature of the tannery effluents. Main constraints are unpredictable seasonal and daily variations in quality and volume of tannery effluent discharge, selection of appropriate technology, finance for high capital investment, high operational and maintenance cost, frequent power failures and breakdowns, inadequate trained manpower for operation and maintenance, sludge disposal problems, difficulty in meeting pollution control standards and absence of an acceptable formula in sharing the operation and maintenance costs of Common Effluent Treatment Plants.

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LEATHER INDUSTRY AND ITS SOLID WASTE MANAGEMENT PROBLEMS

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Introduction

Tanning is a process by which animal skins and hides are converted into leather. The hides, after removal of flesh and fat, are treated with chemicals which cross-link the microscopic collagen fibres to form a stable, durable material. Tanning and its allied operations are a source of considerable environmental impact. The unsafe disposal of solid waste, air and water pollution, odours, poisoning from toxic gas are the problems that have been experienced to a greater extent in the industry. The tremendous use of chemicals in this industry leads to other problems like occupational health, generation of hazardous waste and constraints with disposal of untreated sludges. Questions of chemical safety, contamination of land and groundwater, inadequate provision for solid wastes and sludge disposal,spills and accidents involving chemical substances, and the general nuisance of odour are taken into account more and often by regulatory and planning authorities. The tanning industry has also been subject to important changes. Tanning technology now available has less impact on the environment than those of traditional processes. However, many obstacles remain to its widespread introduction.

The Study Area

The North Arcot-Ambedkar (N.N.A.) district is located in the northern part of Tamil Nadu, India bounded on the north and north west by Chittoor district of Andhra Pradesh, on the west by Dharmapuri district, on the south and southeast by Sambuvarayar district, and on the east and northeast by Chengalpattu-MGR district. It lies between 12° 15' to 13° 15' N latitudes and 78° 29' 30" E to 79° 59' E longitudes.

History of Tannery

Long ago, leather tanning was a cottage industry employing rural labour in the process of tanning raw hides and skins that were available locally. The tanning ingredients were lime, tanning bark from shrubes and trees like Pongan, Avaram, Konnan, Velan, myrabolans and vegetable oil like pungam oil. The process of vegetable tanning took 40 days to convert a raw tide into semi tanned. The semi tanned hides were exported to U.K. and other countries during pre Independence times. After Independence the tanners were allowed free trade and were quoting their own rates and exporting semi finished leather to U.K. and other places at competitive prices. From the 1950s onwards the advent of tanning chemicals like Sodium Sulphate, Sulfuric acid and other dangerous chemicals like Chromium (Trivalent) the tanning process had shortened by 3-4 days and this enabled the tanners to have quick turnover for their finances. Gradually machineries were introduced in tanning and the government banned the export of semi-tanned hides and skins and wanted only finished leather to be exported.

Tanneries in India and Tamil Nadu

According to 1989 Directory of tanneries there were 1,059 Tanneries in India. Of these, Tamil Nadu contributes 567 tanneries, which is, 53.5 per cent. In Tamil Nadu, tanneries are located in N.A.A district, Madras, Anna Dindigul district, Trichirapalli district, Periyar district and Coimbatore district. There are 567 tanneries in Tamil Nadu out of which 347 Tanneries that is 61 percent are located in N.A.A district. Commercial tanning is about a century old in South India. Tanning industry is predominantly situated in the towns of Ranipet (98) Vaniyambadi (93), Ambur (76), Peranambut (49), Melvisharam (13), Vellore (1') and Gudiyatham (7) in N.A.A district and in Madras (103), Dindugul (46), Trichirapalli (27), Erode (41) and Coimbatore (3).

In general, there are four type of raw materials processed in this study area namely hides (buffalo/cow) and skins (sheep/goat). The sheep skins are more processed in this area (28%) followed by goat (27%), buffalo (26%) and cow (20%). Each centre has distinguish from its specialty of leather goods. Vaniyambadi deals the skins of sheep (70%) and goad (27%); Ranipet process mainly buffalo hides (60%) and cow (31%); Ambur specialised for goat (54%) and Pernambut centre manufacturing mainly hides of cow (30%) and buffalo (24%).

The Growth of Tanneries in N.A.A District

More than three fourth of the units in the study area were engaged in Vegetable Tanning (E.I-East India Tanning) followed by Chrome tanning (wet blue) and shoes units. The first E.I tannery was registered in 1898. The tanning existed more than 400 years, initially it was small cottage work. For the analytical purpose, the growth of tanneries was grouped into five decadal year. The E.I tanning was the prime tanning process in this study area and it growth was steady. This tanning started the sixties and three fourth of total units belonged to this process in the seventies. Later the progress came down due to introduction of chrome tanning. The first chrome tanning was started in the study area in 1967. According to the DIC registers, the growth increased gradually. The chrome tanning steadily increased and its share in the sixties was 20 per cent and, in the seventies, it rose to 76 per cent. Recently, the prosperity of chrome tanning has come down due to various problems like environment, water, local people agitation and government policy.

The Data and Measurements

The data pertaining to tanneries for Vaniyambadi, Ambur, Pernambut and Ranipet were collected from the District Industrial Centre (DIC) at Vellore, where the tanners register the year, type of tannery and capacity. The data pertaining to waste from the tanneries which include hair, flesh, blood, organic and inorganic content from goats, sheeps, cow and buffalo have been measured.

A total number of 340 respondents employed in the study area of North Arcot-Ambedkar district, in order to find out the extent of affected and non-affected farmers, farmers' awareness of tannery effluent problems, sources of pollution, tannery waste application, amendments applied by affected farmers, management practice by affected farmers. The tanning industries are mostly clustered in four areas of N.A.A. district namely, Vaniyambadi, Ambur, Pernambut and Ranipet. Hence, these four areas are selected for the survey on the basis of panchayat union villages. For each block 8 villages are chosen and used 85 samples invariably affected and non-affected farmers. The location and extent of areas affected by tannery effluents are assessed based on soil and well water nearer to tanneries are tested and concentration of chemicals are assessed. The soil and well water are tested at frequent intervals in all the areas of tannery to monitor the quality of water.

Tanning Process and its Wastewaters and Solid Wastes Generation

The chemicals used for tanning are derived from traditional vegetable products, or specifically prepared by chemical suppliers. There is no single process for producing leather depending on the circumstances prevailing, different options for unit operations will be used. However, in this study area there are two major tanning process existed. They are,

- Vegetable tanning process (East India Tanning Process or E.I Process
- Chrome tanning or wet blue tanning process.

Irrespective of tanning process, the pretreatment operation are collectively known in this industrial parlance is 'beam house process'. These include:

Beamhouse Operation

Pretanning Operation

Curing of Hides and Skins: Preservation of hides and skins from putrefaction is called curing. In this process the common salt (sodium chloride) is smeared on the flesh side of the skin or hide. Preservation by chilling is not being done. In the beamhouse operation hide/skins is prepared for tanning by cleaning and conditioning, and ensuring the correct moisture content. Typical steps are:

Soaking: The hides and skins undergo dehydration as a result of curing process. To facilitate absorption of process liquors, the hides and skins are rehydrated by immersing the stock in water and is called soaking. The major objectives of soaking are as follows:

* Removing the dirt, dung, blood and most of the salt used in curing.
* Softening and swelling the fibres to bring the hides/skins back to 'green hides'.
* Removal and dispersal of inter fibril proteins.

The chemicals primarily used are sulphide, sulphite and hydroxide, hypo chloride of sodium, wetting agents, emulsifiers, surfactant and enzyme preparations.

Fleshing: The flesh swells in the lime liquor and is scrapped off after liming operation. This is done in fleshing beam and cutting off separated flesh is remitted with a sharp knife. Here, the fat tissue from the flesh is physically removed from the fresh side of the hide.

Liming: The hides and skins, after soaking, undergo a process of loosening and removal of hair. It is done by mixing 10 per cent lime with 2 per cent sodium sulphide. Some units use enzymes also. In this segment the hair dissolves into a pulp. It opens the fibre structure and 'plumps' the hide. Here, pit liming is the rule.

Dehairing: In this process hair has been rendered sufficiently loose by suspension of lime (calcium hydroxide) and sodium sulphide or by adding both. After 4-6 hours, the hides and skins are piled on a slant beam with hair side up in which the workman shaves off the loosened hair with dehairing knife until all the hair is removed.

Deliming: Removal of lime from the hide is necessary to avoid interference with subsequent turning stage. Copious washing is given and neutralising chemicals also are added. The stock after liming will be highly alkaline. Before the pelt is taken for tanning, it is necessary to free it from lime and to reduce its swelling to the required level. Deliming and reduction of swelling process are done together. In the deliming process, the salts like chloride or sulphate of ammonium or boric acid are added. 'Disulfide' is done through oxidation by treatment with hydrogen peroxide, otherwise sulphide may generate toxic hydrogen sulphide gas. Upto this stage, the skins and hides are ready for vegetable tanning process. For chrome tanning process, the delimed hides and skins are to be undergo bating and pickling process.

Bating: This is an enzymatic process which improves the grains of skin and stretch of leather. The left out hair-roots and pigments on the surface of the skin or hide is not desirable for quality leather. In this process, the delimed hides and skins are put into a drum with water containing bate of 0.5 per cent for 30 minutes/12 hours. This process is called bating in which the reaction between the enzyme contained in the bate reacts on the degraded protein of the skin or hide left embedded inside the fibres after unhairing. The bate is composed of 50 per cent wood flour as a carrier, 30 per cent deliming agent (ammonium chloride and 3% pancreatic enzyme).

Pickling: The acidification treatment of delimed pelts with sulfuric acid is known as pickling. It is also the final beamhouse operation in which the pH is adjusted. The skin is sterilised, ends the bating action and improves penetration of subsequent tanning material.

Tanyard Operation

Vegetable Tanning

This process though eclipsed, employed for sole and saddlery and some specialty leathers. Duration of process is six weeks (pit). This process involves natural tannins.The delimed 'pelts' are allowed to infuse several vegetable tanning materials like the barks of avaram, konnam, babul, wattle, and myrobalan nuts and dividivi pods. This process involves 10 to 15 days. Immediately after this process, tanned hides and skins are coated with soluble vegetable oils. The leather processed upto this stage is popularly known as East India Processed (E.I.P) leather. In this 'natural' process there is no addition of any chemicals whatever and can be declared as 'eco- friendly'.

Chrome Tanning

Conversion of pelt into leather with the use of chromium salts was first introduced in Europe and U.S.A. at the end of the nineteenth century. In chrome tanning, there are two methods, namely 'two bath process' and 'single bath process'. In the two bath process, the pelts are first treated with chromic acid solution in the first bath and then in second bath with hypo (sodium thiosulfate) as reducing agent. In this process the unreduced chrome will occur as hexavalent chromium which is more toxic substance than trivalent chromium. This process has been now given up. Instead, the single bath process is common. Basic chromium sulphate is used in the single bath process which is simpler than the two bath process. In this process, the effluent chromium is present in trivalent only. In India, almost all tanneries widely practice the single bath process only.

After pickling, the pelts are put in a basic chrome powder solution up to 4 to 6 hours in drums. Salts like sodium bicarbonate, sodium formate or sodium acetate are used to neutralise the excess acidity as chrome tanning is carried out in acidic range (pH 3.5) for further processing like fat- liquoring and dyeing.

The amount of tanning materials fixed in is not a criterion for evaluating quality of leather. Twenty per cent fixation of Fe_2O_3 or ZrO_2 is very common but quality wise they cannot compete with the fully tanned chrome leather containing 4 to 4.5 per cent of Cr_2O_3. Sometimes, leather containing 2.5 per cent Cr_2O_3 is much superior than leather containing more than 8 per cent Cr_2O_3.

Hazardous Tannery waste

The solid wastes, disposed in river Palar and its tributaries, ponds and open land, have brought about a rapid deterioration of their physical, chemical and biological qualities. The solid wastes gave rise to noxious odours from the decomposition of organic matter. The groundwater also became saline and hard due to the presence of inorganic salts, and acquire some toxicity from the chromium, sulphides and ammonia in the wastes. Release of nitrogenous compounds will stimulate aquatic plant growth, contributing to eutrophication of water bodies. Pathogenic micro-organisms such as B.anthraxes may also occur in water course that receive tannery waste discharges.

Impact of Solid Waste on Environment

The solid wastes produced during various tanning operations are not properly disposed of and they cause a number of problems. The Salt dust, lime waste and chemical waste stored in heaps outside the tanneries are washed away during rains and cause groundwater pollution. Hair and lime sludge, if discharged along with the effluents, choke the drains. Raw and green fleshings, limed fleshings, splits and trimmings putrefy easily and give rise to noxious smells. In most tanneries, it is the foul odour which emanate from some of these putrescible solid wastes which account for much of the smell traditionally associated with tannery wastes. Vegetable tan bark and vegetable tan sludge discharged into effluent stream cause problems in the effluent treatment. Vegetable and chrome tanned shavings and splits do not easily decompose. They are not utilised, they present a problem of disposal. Primary and secondary sludges obtained during the treatment of tannery wastes are also putrescible. Aesthetically the solid wastes lower the whole quality of life.

Sources of Tannery Waste

Solid wastes: Solid wastes discharged from the tanneries are classified into four categories, namely, (a) non-proteinous wastes, (b) non-collagenous protein wastes, (c) untanned collagen and (d) tanned collagen. Thirty per cent of protein substances are let out from the tanneries in the form of effluent sludge, fleshing, trimmings and shavings, which appear as solid wastes. By-products like glue, gelatine, textile and artificial industries consume some of the wastes from tannery. The quantum of solid wastes differs from one process to another, according to the input of raw materials. Sources of production of solid wastes in a tannery and the alternate recycling uses are given in table 1.

In practical terms, however, bulk of the waste is discharged as such. Use of saltish water *affects* end products. The quantity varies with pit/drum systems. In an average a tannery with capacity of 1 tonne per day in a year will discharge 12,000 M^3 of effluent.

The tanneries receive hides and skins in fresh or salted form. The salted hides/skins are trimmed to remove edges that might cause difficulty in tanning. The surface curing salt from hides/skins is dusted before soaking. In this process, the impurities such as blood and dung are removed. The soaked pelts are then treated with lime and sodium sulphide which are used to remove hair. In the unhairing of (lime sulphide, enzymes or diethylamine) will determine whether the hair will be recovered as a solid waste or pulped into the effluent. In the lime pits, lime sludges are let out into the effluent drains or removed as solid wastes. In the fleshing process, the waste of flesh with a certain amount of hide pieces are generated. After deliming and bating the pelts are treated in tanning agents are vegetable, chrome and other agents. Spent tan liquor sludge is generated in vegetable tanning. After the tanning process, the leather has to be sent to a number of machine operations such as shaving, splitting, buffing and trimming, which give rise to solid wastes such as split pieces, trimmings and buffing dusts. In the settling of waste waters from different sections of a tannery and the biological treatment of tannery wastewater, the sludges are let out as solid wastes. To some extent, the solid wastes are utilised for by-products production but a large part of it is discharged due to lack of market.

Soaking effluent: The effluent consists of dirt, dung, blood, soluble protein, proteolytic and other bacteria and a considerable amount of salt accounts varying from 11,200 to 41,000 mg/l as chloride. The amount of soak wastes discharged ranges from 250 to 510 litres per 100 kg of hides. The Total Solids, Dissolved Solids and Suspended Solids are range from 22,000 to 93,000, 19,000 to 87,000 and 2,500 to 6,200 mg/l, respectively.

Table:1 Sources and Uses of Solid Wastes from Tanneries

Solid Waste	Place of Production	Possible Application
Non-proteinous wastes		
Used Salt	Salt dusting	Regeneration for salting/pickling
Lime sludge	Lime pits	As material of construction/soil conditioner
Spent tan bark	Tannin extraction	Carton industry; as fuel
Tan liquor sludge	Vegetable tanning	Reduction of chrome tan liquor boiler compounds
Fat	Defatting of hides/skins	Soap industry
Primary/biological sludges	Effluent treatment	Tipping or composting
Non-collagenous Protein		
Lime protein	Lime Yard	Casein substitute animal food
Pig bristle	Beam house	Brushes
Tail/body hair	Beam house	Carpet Industry; cushions
Untanned Collagen		
Untanned trimmings/shavings/lime split etc.	Beam house	Glue, gelatine, protein degradation products
Fleshings	Beam house	Glue/gelatine
Tanned Collagen		
Chrome tanned shavings	Chrome tanning	Glue, gelatine, protein degradation products
Vegetable tanned leather shavings	Vegetable tanning	Artificial fibre leather/boards
Formaldehyde tanned leather	Sulphochloride tanning	Artificial fibre leather
Whitenings	Finishing of russet leather	Recovery fat, artificial fibre leather
Tanned splits	Splitting after finishing	Leader board
By-products of skiving, levelling by splitting and fabrication	Stitching and cutting of leathers	Fibre leather, sole patches, mosaic leather

Source: Sastry, C.A. (1984)

Liming effluent: The spent lime liquors contain pH 9.8 to 11.6 which is highly alkaline and consists of sodium sulphide, high ammonia nitrogen and organic matter, and suspended and dissolved lime. The amount of lime liquor discharged varies from 330 to 690 litres per 100 kg of hides. The BOD and COD ranges significantly from 1,920 mg/l to 10,000 and 3,950- 20,130, respectively. The chloride content is less than that of soaking 300 to 2,800 mg/l. The other parameters like Total Solids, Dissolved Solids and Suspended Solids range from 22,560 to 48,400, 15,960 to 40,200 and 2,100 to 6,600 mg/l respectively. In context of the pollution, this section of tannery waste is the strongest in chrome tanning and next to vegetable tan liquor in case of vegetable tanning.

Unhairing and Fleshing effluent: The effluent discharge from this operations are continuous and consists of hair, flesh part, fat and sulphides. Suspended Solids are more in this waste water which are often clog the drainage.

Deliming effluent: The quantity of effluent discharged is ranges 140 to 480 litres/100 kg of hides. The Total Solids, Dissolved Solids and Suspended Solids ranges from 5,870 mg/l to 25,600, 4,600 to 21,300 and 650 to 4,200 mg/l respectively.

Vegetable tanning effluent: The spent vegetable tan liquor with a dark brown colour is acidic in nature. The discharge is intermittent and its quantity ranges from 103 to 210 litres per 100 kg of hides. Considerable amount of Total Solids, Dissolved Solids and Suspended Solids are present in this process which varies from 9,820 mg/l to 20,000, 6,500 to 15,000 and 1,100 to 3,300, respectively. The tannins is high in the wastewater.

Chrome tanning effluent: High acidity is in spent chrome liquor. The quantity of spent chrome liquor is about 200 to 260 litres per 100 kg hides. The trivalent chromium accounts for a considerable amount in this wastewater ranges from 2,000 to 3,000. The Suspended Solids is ranges from 1,100 to 3,300 followed by Total Solids 9820 to 20,000 and Dissolved Solids is from 6,000 to 40,000 mg/l.

The foul smelling materials and production of putrescible organic material like lime sludge, limed fleshing, green fleshings and soak pit sludges which cause noxious smells are generated in the process like soaking, liming, deliming and fleshing. In soaking, the clean of salt and rehydration of the skin induce bacterial growth and protein putrefaction.

The total solids contributed by the tanneries in any given day is 2,970 tonnes, while suspended solids amount to 655 tonnes, total ash 1,659 tonnes, sulphate 611.3 tonnes, chlorides 873.3 tonnes, nitrogen 43 tonnes, phosphorous 30 tonnes and settled solids 27 tonnes. The largest quantities of solid wastes are of total solids in Vaniyambadi (92 tonnes/day) in Ambur (2,667 tonnes/day), in Pernambut (73 tonnes/day) and in Ranipet (138 tonnes/day).

Recovery and Use of Byproducts

Large quantities of solid wastes are produced in a tannery. As far as possible attempts should be made to separate, reclaim and use all solid wastes in a tannery such as hair, fleshings, trimmings, shavings, lime sludge, tan bark, tan liquor sludge and tanned trimmings and shavings. Environmentally sound processes of utilisation or disposal of solid wastes are shown in table 2.

Table 2 : Environmentally Sound Utilisation of Solid Wastes in a Tannery

Solid Waste	Environmentally Sound Utilisation Practice
Salt dust	Purification and reuse
Green fleshing	Drying and immediate use for glue and animal feed manufacture
Hair	Washing, drying and utilisation for carpet drugged industry
Lime sludge	Utilisation for building construction/soil conditioning
Limed fleshing and trimmings	Utilisation for glue and gelatine manufacture, animal feed
Vegetable tan bark	Using as fuel
Vegetable tan sludge	Fertiliser/soil conditioner
Vegetable and chrome tanned shaving and splits	Manufacture of leather boards reducing chrome liquors
Effluent sludges	Dewatering and incineration

Source: Sastry, C.A. (1984)

Solid Waste Generation and Process Modifications to Reduce Waste Concentration

Solid wastes discharge from a tannery include (i) such constituents of raw hide or skin which must be removed during leather processing like hair, non-collagenous protein, fat from the hide and salt used for preservation; (ii) solid waste arising out of washing of floor and machines and (iii) the chemicals used in the process. It is normal for tanners the practice of use surplus quantity of chemicals in various processes. By good house keeping also the quantity of solids discharged can be reduced considerably.

The quantity of solid wastes (pollutants) which are inevitable in tannery waste water in N.A.A. district is given in Table 3.A and 3.B.

Table 3.A The Quantity of Tannery Solid Waste

Solid Waste	Tonnes/Day
Hide salt	150g/kg
Hair protein	40g/kg
Hide protein	25g/kg
Hide fat and carohyrate	15g/kg
Dirt and manure	5g/kg
Organic substances	2g/kg
Organic solids (premises)	3g/kg

3.B Solid Waste Generation in North Arcot-Ambedkar District

Tonnes/Day

Fleshings	1004.24	Hide salt	654.94	Total solids	2969.00
Trimmings	524.00	Dirt/Manure	218.35	Chloride	873.25
Solid Treatment Waste	523.95	Hair Protein	174.65	Sulphate	611.28
Chrome Split Waste	523.95	Hide Protein	109.15	Nitrogen	43.66
Finished Trimmings	139.72	Hide Fat	65.50	Sulphite	30.57
Buffing Dust	43.66	Organic Solids	13.10	Chrome	21.83

Source: Field Work

Thus the total quantity of inorganic pollutants that are inevitable is 655 tonne/day of hide or skin processed and the quantity of organic solids is 319 tonne. In a normal tannery, the solids are more than the theoretical minimum. Therefore, there is a lot of scope for reducing the quantity of solids discharged from a tannery by following some of the suggestions that follow. Given the measurement above, the total generation of hair is 840.3 tonnes, flesh 331.33 tonnes and blood 55.8 tonnes per day. Over the calendar year, the solid wastes become enormous in quantities. Goats and skins contribute more hair (705.1 tonnes/day), while buffaloes contribute more flesh (114.37 tonnes/day) and cow more blood (24.9 tonnes/day) than others. As for hair, Ambur has the largest waste generation of hair (760.7 tonnes/day, Pernambut 19 tonnes/day and Ranipet 10.3 tonnes/day. Even in flesh as solid waste, Ambur generates 253.5 tonnes/day, followed by Ranipet 21.3 tonne/day, Pernambut 8.6 tonnes/day and Vaniyambadi 8 tonnes/day. The contribution of Ambur in blood as solid wastes is 49.5 tonnes/day while that of others are 4 tonnes/day (Ranipet), 1.5 tonnes/day (Pernambut) and 0.84 tonne/day (Vaniyambadi).

There are other solid wastes from the tanneries and they are as follows: Trimmings account for 524 tonnes/day, fleshings while tanning 1004.2 tonnes/day, chrome shavings 436.6 tonnes/day, chrome split wastes 523.95 tonnes/day, buffing dust 43.7 tonnes/day, finished trimmings 139.7 tonnes/day and solids in treated sludge 524 tonnes/day. Ambur contributes the largest quantities in all of these when compared to other fours.

Waste Reduction During Hide Preservation

The salt applied to a hide/skins as preservation agent; it is 45 per cent of the total weight, about one-third binds itself to the hides/skins, half can be dusted and the balance one-sixth drains off during preservation. The salt bound on the hide finds its way into the effluent from soaking. The dusted salt often becomes solid waste. The salt pollution can be minimised by reusing the used salt in curing. The centralised freezer plant may be set up at each zone in order to avoid the salt pollution.

Waste Reduction During Beamhouse Operations

Modifications of the beamhouse processes such as use of biodegradable surfectants and restrictive use of bactericides during soaking and alternative methods of dehairing are worth adoption. Liming is a low cost, well buffered alkali for unhairing and it has been traditional to use it in excess. Normal tannery practice uses a great surplus of lime and sulphide (upto 50 g.lime and 30 g. sulphide for a kg salt weight). This dosage can be greatly reduced without reducing the unhairing effect. Some studies suggested that the lime levels can be reduced to as low as 0.5 per cent without the use of caustic soda, using either sulphide or sulfhydrate as sharpening agent.

Waste Reduction During Pickling and Chrome Tanning

In of chrome tanning process, a reduced concentration of the chromium in the solid wastes can be achieved by (i) improving the fixation of chromium, (ii) reuse of chrome liquor, and (iii) precipitation of chromium from the chrome liquor with an alkali and redissolving and reusing the chrome precipitate.

Biological Sludge Disposal

During treatment of tannery wastes by conventional methods, biological sludges are produced in large quantities reaching 15 per cent of the green weight of hides in terms of dry matter. Sludge separated needs further processing without which the disposal process would not be completed. Sludge processing involves thickening, chemical conditioning, filters through vacuum filtration and eventual disposal.

Effluent sludges, obtained from vegetable tannery after drying on sand beds are being used successfully as fertilisers. The use of sludges containing chromium for agricultural purposes is becoming increasingly difficult. Divergent views have been expressed as to the effect of chromium bearing tannery effluents and sludges on plant life and soil productivity.

The dry sludges which are retained in the solar evaporation ponds are disposed indiscriminately into open places, road sides, river course and in lakes. Most of times the huge dry sludge are incinerated into open place without proper safe guard. The solid particles are 830 mg/m^3, heavy metals 34 mg/m^3 and chloride 5,520 mg/m^3 founded in the air sample.

Solid wastes Disposal Methods

The methods for disposal of solid wastes from tanneries vary considerably from area to area and country to country. In general where tanning industries have long been established, there usually has been a simultaneous growth in industries which can use these wastes. This pattern is specially helpful to the tannery industry in the case of obnoxious rag and limed fleshings, trimmings, and splits which are lifted by glue, gelatine and fat rendering units in the study area. The growth of synthetic adhesives and other sources for making glue and gelatine the demand for raw or limed trimmings or fleshings is reducing and there is immediate need to find newer uses. In many areas in the world, tanners can no longer receive payments for these materials from glue and gelatine factories and are often forced to bear transport costs themselves. In the study area there are 40 glue/gelatine units.
Solid waste discharged into the fields, zone wise, are as follows. According to 33 per cent of total respondents, the effluent are directly let out into the land and field. In Vaniyambadi this is more (46%) followed by Ranipet (38%), Pernambut (28%) and Ambur (19%). In Pernambut (42%) and Ranipet (34%), the tanks and small ponds were filled with polluting effluent asphyxiating to deaths of fish and other aquatic life. The arable land surrounded by the tanks and ponds which are sources for irrigation faced pollution problem. During the rainy season the pollution was not severe because the salts were diluted in fresh water, while in summer the pollution was very high because the water got evaporated leaving behind salt which was concentrated in lakes and ponds. In the study area 3,697.62 ha of land have been deteriorated severely and 10,710.17 ha have been moderately affected according to electrical conductivity value in the well water samples.

Agricultural Hazards

From the investigation of farmers through questionnaire, it is observed that there were 259 affected farmers and 81 non-affected farmers, that is, 76 per cent and 24 per cent, respectively. In the study area, the total area under cultivation by the sample respondents was 490.82 ha. Out of this nearly 388.48 ha had been affected by tanneries. Remaining 107.34 ha were unaffected because the terrain was located on down slope side and groundwater was not contaminated due to underlain impervious granite igneous rock. In this study, Ambur agricultural land was affected by 122 ha (80%) followed by Vaniyambadi 96 ha (79%), Ranipet 87 ha (69%) and Pernambut 78 ha (75%). Based on the survey, 303 farmers were affected by tannery pollution which accounted 76 per cent to total respondents. Considerably on the area basis in Ambur 81 per cent of farmers were affected due to tannery pollution followed by Vaniyambadi (78%), Pernambut (75%) and Ambur (69%).

The reasons for the statement of unaffected farmers were their holdings and wells located at elevated uplands, wells being shallow or underground geological formations without any lineaments. Most people assured that the pollution was primarily due to tannery only. They indicated that, before the establishment of tanneries, the water was potable and yields of the crops were high particularly rice and sugarcane. Once the Palar river basin area was considered as the second important granary for paddy in Tamil Nadu before on set of pollution land. This evidenced how the pollution had encroached fertile agricultural land into swampy desert.

The subsoil water is polluted and has become brackish so much as to make it unfit for consuming in several villages. It affected crops growth (poor germination) in general. Almost all types of crops are in any way or the other affected and replaced by less value crops. Before the advent of establishment of tanneries, the soils were so fertile and the crops commonly cultivated were paddy, turmeric, banana and betal vine which produce are value-rich.Recently, only coconut sugarcane and ragi are cultivated in this area which are tolerant crops, though reduction in quality and as well as quantity was apparent.

Particularly, in Ambur, the Ambur Sugar Mills reports show that the tannery effluent has affected this surroundings of this mill, about 2,000 ha. The rate of this pollution encroaches this area about 40 ha per year. Since the Ambur Sugar Mills located in the centre of this area, sugarcane production and supply is substantially affected, diminishing day by day.

Farmers' Cognisance on Crop Performance Over Years

The yield of crop has been decreasing tremendously in the past few years. During the survey it was found that 120 people (46%) complained that the yield was declining for the past 5 years and 102 people (39%) averted losing their yield from the past 5 to 10 years. About 37 farmers (14%) experienced yield decline for the past 10 years and above.

In the polluted areas the paddy crop yield was poor when compare to non-polluted area. During the Thaipattam (Dec-Jan) the water was more polluted due to increased evapotranspiration. Because of this reason the paddy productivity was less in polluted areas (3.88 tonnes per ha) and however it was 4.42 ha in non-polluted areas. Besides in polluted areas the farmers were to use various amendments to ameoliorable the salinity. In non-affected areas the production was 118.58 of tons per hectare, while in polluted area the production was 73.42 tons per ha, though best care was bestowed. The ragi crop is tolerant to salinity. The productivity was meager between polluted and non-polluted areas at 2.03 tons per ha and 2.33 ha respectively. Coconut is acclaimed to be a pollution tolerant crop to some extent. However, yield differences exist between polluted and non-polluted areas, 11,829 nuts per ha and 16,971 nuts, respectively.

Health Hazards

Pollutants dissipate in the working environment and pose health hazards. Many of these chemicals are toxic and produce chronic and effects on living organisms including man. Sudden respiratory distress, difficulty in breathing, respiratory cancer, lung cancer, asthma, bronchitis, cough, eye irritation and general malaise have all been found to be associated with polluted air. Invariably all households buy potash water on payment of one rupee per pot of about ten liters for culinary purposes. Respondents are accepted that they brought potash water from inside the village and the rating was Vaniyambadi 60 percent, Ranipet 69 per cent, Ambur 59 per cent and Pernambut 41 per cent. Tannery owners employed a few lorries in Ambur and Vaniyambadi and supplied potash water during summer season. Only Vaniyambadi and Ambur got this fairly and the scoring was 27 per cent and 19 per cent respectively. If rainfall is satisfactory the municipal provided water will be supplied.

<u>Health of People</u>: The health of people in this study are is not satisfactory. Both tannery workers and non-workers were affected with one or the other health problem, which mainly ascribed

to poor environmental conditions. The sludges are indiscriminating disposed and on contact cause skin irritation, eye irritation,allergy and Asthma. The sludges were burnt in open space and the nauseating smell of the effluent made air less suitable for living.

Common ailments: There were abdomen pain, skin irritation, joint pain, fever, head ache, abortion, head ache and kkk syndrome in this area. In all the four study area, maximum respondents complained abdominal pain as the commonest ailment and suggested abortion to be of causative ailment.

Tannery Solid Waste Application to Crops

Considering the farmers, about one-fourth of farmers (29 per cent) used the solid wastes in their fields as manure and rest 71 per cent did not use. The soil waste is composed of hair, flesh and other chemicals. There were two major reason why the tannery waste is used as manure. The reason one was its manure value and second is on account of its manure bill. Among tannery waste users about 47 per cent of farmers applied tannery wastes for the benefit of replacement of fertilizer. In Vaniyambadi area recorded high percentage of tannery waste application (62%). Among remaining 3 zones the value was Ranipet 55 per cent, Ambur 41 per cent and 31 per cent in Pernambut. In Vaniyambadi 69 per cent used tannery waste for the consideration of cost reduction. It was 59 per cent in Ambur, Ranipet 45 per cent and Pernambut 38 per cent.

The practice of applying tannery waste as manure, some places gave good yield in crop production while in some places the yield was depressed. Among the tannery waste users about 53 per cent of farmers claimed that the yield increased after application of tannery waste. Among all zones Pernambut farmers informed that the crop productivity was more in their fields due to application of tannery waste (65%) followed by Ranipet (59%), Vaniyambadi (44%) and Ambur (41%). The yield was poor that is about half of production only could be obtained in the areas of Ambur 59 per cent followed by Vaniyambadi 56 per cent, Ranipet 41 per cent and Pernambut 35 per cent. The pollution tolerant crop, ragi was predominantly grown after the application of tannery waste. The seedlings were brought from the unpolluted areas and transplanted in the polluted areas. The reason for either decrease or increase in crops yields with the use of tannery waste was, the salt content in the tannery waste varied from process to process. All the tannery wastes were not alike in chemical composition. The tannery solid waste obtained from chromium process was found to be more saline and toxic when compared with vegetable tanning process.

Use of Amendments

Due to the tannery pollution, soil and water particularly the agricultural land became less fertile for crop raising. In order to augment the fertility of soil of the polluted fields the farmers applied various amendments the mitigate to pollution effect. About 60 per cent of farmers in all areas used amendments like gypsum 26 per cent, followed by pressmud 7 per cent, coirpith 15 per cent and tank silt 14 per cent. Among all amendments gypsum application was more popular in this area.

The application of gypsum in all four areas were comparatively alike, about 20 per cent. The use of coirpith was more in Vaniyambadi area and in Ambur region. Coirpith is the fibrous dusty waste in coir fibre industry. It is available in plenty and free of cost where coconut cultivation is predominant and rope making is popular. It is capable of absorbing water many times of its own weight. Use of coir pith, keeps the field moist comparatively for a longer time and by doing so, it prevents the capillary rise of salts from deeper layers of soil to surface. Tank silt is the solar-sedimental particles of both organic and inorganic matter brought forth during rains. Its application improves soil texture, retains more soil moisture and nutrients.

Press mud application as amendment was found to be popular in Ambur zone where a Sugar Mills has been located. It is the solid waste from Sugar Mills industry. Press mud is the filtered sediment of the crushed cane juice, chiefly composed of soil, fibre and lime. The lime content in the press mud mitigates the ill-effect of both problem soil and irrigation water. Its application in other zones of the study area was negligible. Practice of trash mulching is prevalent in sugar can growing areas. It is the withered parts of leaves and leaf sheaths of cane and amounts to 10 per cent of total bio mass. After the harvest of cane, these trashes are harvest cane, these trashes are spread evenly and the ratoon crop is raised. It is a source of organic recycling of wastes. During field investigation irrespect of study zones, the farmers practiced trash mulching widely. Adopting this practice, the farmers revealed that it conserved soil moisture, increased soil fertility and nutrients status and prevented the attack of borer insects on young crop. In sustainable agriculture, the recycling of organic wastes finds a prominent place. It conserves eco system.

Public Perception of Environmental Hazard

From the observation, it was found that Ambur had the most knowledgeable population where 89 per cent of the respondents had prior knowledge of the consequence of solid waste disposal. The people of Ranipet (80%) and Vaniyambadi (78%) also had a good knowledge of the same. Compared to the other areas the people of Pernambut were slightly less knowledgeable (65%). A large percentage of the respondents of Ambur (94%) felt that solid waste disposal in the environment was hazardous. A high percentage of the respondents of Vaniyambadi (81%) and Ranipet (77%) also revealed of the same opinion.

The untreated solid wastes affect the following: health, mind, land, surface water, groundwater, agriculture yields, drinking water quality, taste, acidity, alkalinity, salinity and water logging. Sixty-seven per cent of the respondents in the study area felt that the untreated solid waste had a severe impact on their health. Seventy seven per cent that it polluted the land. They felt that the groundwater (84%) and surface water (58%) was also severely affected. Eighty nine per cent of the people perceived that agricultural yields were most severely affected. Sixty nine per cent felt that drinking water quality was affected. The irrigation water quality deteriorated into alkalinity (50%), salinity (30%), acidity (13%). The water logging (8%) was also perceived Pernambut residents were of the view that untreated effluent disposal was hazardous.

Awareness of Farmers' Forum

The North Arcot-Ambedkar district farmers has an association called the North Arcot District Agriculturists Association. They have members at various places like Vaniyambadi, Ambur, Thuthipet, Periavarikkam, Oomerabad, Pernambut, Vellore, Melvisharam and Ranipet. They realised that the farmers' prime source of employment and living were land and water which were already made unfit for cultivation. The drinking water, the admittedly very basic necessity for not only the human being, but also for all living species, had already become unfit for human consumption in this stretch of about 100 km from Vaniyambadi to Ranipet.

They also knew that the tanneries used very powerful variety of chemicals, such as sodium dichromate, sulfuric acid, sodium chloride, chromic acid and sodium bi-carbonate. In the manufacturing process, and in the effluent water discharge carried, the evil effects of these chemical constituted the main source of salinity, both in field and in well water. They felt that these effluents were let into earthen pits abutting the tanneries which at the time of rain got mixed up with rain water, over flowed to the adjacent agricultural lands and thus damaged lands as well as standing crops. They say that the effluent flowed into nearby irrigation tanks and on stagnation, it soaked under ground, percolated down the earth, polluted the sub-soil water sources/springs and thus all wells, agricultural as well as domestic, contained contaminated water which was saline and brackish. Drinking water caused variety of harmful and serious diseases.

Some authorities did show lip sympathy while some made quick bucks and easy fortunes from the multimillionaire tannery owners, while the farmers were reduced to abject poverty. They came to know that tanneries did not follow factory/industrial/panchayat/ municipal laws in the matter of effluent treatment, and the enforcing authorities either seldom cared at these lapses to the community or pleaded helplessness against money power of the tanners. They made appeal in to mass media through feature/articles in leading dailies like The Hindu, Indian Express and fortnightly India Today. They were aware and even appreciated need to promote industrial production and earning foreign exchange. They however criticised that their only means of eking out a living had been jeopardised.

They noted that the protected water supply schemes of Vaniyambadi, Ambur, Vellore, Arcot, Ranipet and Walajapet municipalities had their sources in polluted, contaminated Palar river which was dry for most part of the year. Interestingly, they quipped that the Office of the Deputy Registrar of Co-Operative Societies, located at Ambur was shifted to Thirupattur for the simple reason that the water at Ambur was smelt bad and unhygienic. They questioned whether could make such an exodus.

They asked that region may be saved from all the miseries if the rich tanners who are mindful of large profits, spent a portion of their profits for disposal of solid wastes by constructing concrete tanks and acted according to the direction of the government. Few tanneries who had constructed cement tanks made holes at the bottom of the tanks to percolate the effluent water. The farmers and the local residents of the affected area have now and then done various agitations, meetings and processions. But, they could not get any positive solution from the government and tanners alike.

Summary and some suggestions

Solid waste is more hazardous than liquid waste. When liquid waste is diluted, the effect would be less. When solid waste which are disposed in the open environment would be leaching and chemical will percolate to the subsoil would give result of ground water pollution. It gives a stink, an uneasiness (unaesthetic) and give rise to health problems. Solid waste disposal problem affects agricultural, cattle and human being.

* More fund is utilised for waste water treatment than solid waste. The agency ignores the problem, knowings and unknowingly.

* The direct disposal of solid waste from tannery should be in a landfill area or through incineration. The fallow land/wasteland can be choosen for this.

* Wastelands could be ideal place for dumping solid waste and can make agro forestry environmentally friendly. Land fill park can be created.

* Tanners are baseless here. The western country becomes affluent but here developing country India became effluent. Money makes many thing here. Political party play major role here. If at all cry for environmental protection for environment of affluent nation, they can do. Not to buy Indian leather. The N.G.O. can play in this regard.

* Tanning is commeralised one here. The vegetable tanning is vanished here because those days vegetable extract brought from Javadu hills. Now the species are extincted (eg.gullnet, wattle etc).

* And also the process of vegetable tanning is 40 days, but chrome tanning involves only less that 3 to days and the quality of leather also superior.

* Vegetable tanning affect environment less when compared to chromium tanning in which heavy metal chromium highly toxic both for agricultural and health point of view.

  - Hence the Government should encourage the use of vegetable tanning.
  - Leather should be replaced by synthetic material
  - Vegetable tanning solid waste could be used as green manure
  - Chromium sludge could be used as bricks
  - The sludge from the treatment plant and from solar evaporation pond should be properly disposed especially near by Javadu hill slope areas where the underground rocks are impermeable igneous type.
  - For the tanning process, instead of chromium, zircon and aluminium may be advised to use as tanning materials which are harmless to environment for some extent.

- For the curing process, instead of salt smearing over the hides/skins, Centralised Airconditioning Plants can be promoted with substantial aid by both Central and State Government.
- Government officers should be stringent towards any corrupt person, particularly, from the Departments like that of Tamil Nadu Pollution Control Board (TNPCB).
- Sludge should be recycled along with bulk materials with town wastes i.e. human excreta (dump fills)
- The majority of owners, PROs and workers should be trained proper tanning process. They should know about the hazardous chemicals and solid waste management.

The tanning industry needs to adopt improved technologies and operations, while the authorities must provide a predictable legislative framework within which investment decisions can be taken. Both these sectors require technical advice and assistance from planning and service authorities and from research and industry associations.

For tanning industry the correct choice of tanning and treatment technologies is as important as the question of physical planning and siting of the plant. Good performance also requires a safe working environment and precautions against malfunction. The conditions in turn depend heavily on training, supervision and regular monitoring.

Within the government sector, contributions must come from industrial and urban planning authorities (assessment and approvals), environmental agencies (pollution control), service authorities (disposal), public and occupational health organisations (safety), and industrial training and information units. Regulatory action is as effective as its enforcement allows it to be. Environmental improvements therefore depend on continuing surveillance.

Other sectors have important subsidiary roles. Professional and trade associations can advise members on legal requirements, on the selection of specific technologies and services, and provide training and information. Industry associations play a vital role in sponsoring codes of practice, design standards and commercial practices. Associations are a focal point for government seeking to consult on proposed regulations, for the media, and for research and development.

The Central Pollution control Board is responsible to execute these acts with the help of the State Pollution Control Boards. Recently, the Central Government has decided to set up a cell to ensure effective implementation of anti-pollution measures. The Government has been decided to enforce strict provisions of Environmental Protection Act, 1986 and Forest Conservation Act, 1980. All industries both Public and Private sectors would have to observe strict discipline for protecting the environment and treating effluents. All large units would have to seek Environment p73 Ministry's Clearance Certificate (EIA/EIS) before going into production.

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MODELLING OF HAZARDOUS WASTES USING DECISION THEORY

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ABSTRACT:

This paper will utilize decision theory to model and evaluate hazardous wastes in water and land. Analytic Hierarchy Process (AHP) will be used to set priorities and devise best alternatives to deal with hazardous wastes. AHP is a multicriteria-multiobjective decision tool which helps the analyst organize thought and intuition in a logical manner by designing a hierarchy of the components of the problem. In this study, three hazardous sites were evaluated using AHP with reference to the Hazard Ranking System. The author recommends this methodology for an integrated land and water management.

INTRODUCTION:

The nature of the disposal problems of hazardous wastes involves both cleanup of abandoned waste dumps that pose a threat to public health and the proper siting and construction of new hazardous waste treatment facilities. Each of these tasks must account for a number of complex chemical processes and environmental conditions in order to pass a sound judgement.

Models which attempt to address these questions are relatively new and not validated. However, these models enable both analysts and policy makers to better understand the components and the extent of the environmental problems related to hazardous wastes. The most well known models in this regard are, the Hazard Ranking System, USGS Solute Transport and Dispersion Model, and the Chemical Transport and Fate Model.

Based on the American experience, the Resource Conservation and Recovery Act (Public Law 94-580, October 21, 1976), or RCRA, governs the disposal of all sold wastes in the U.S. Solid waste is defined very broadly as all solid, liquid, semisolid, and contained gaseous material resulting from essentially all human activities. RCRA has resulted in a number of policies associated with siting of new waste disposal facilities and governing the disposal of all newly generated wastes. The Toxic Substance Control Act of 1976 (Public Law 94-469) provides for the control of the production of hazardous materials through agency and industry testing of the potential risks associated with both "old" and "new" chemicals as defined by the Act and with authority to ban the production of chemicals found to cause "unreasonable risk or injury to health or the environment.

The Comprehensive Environmental Response, Compensation, and Liability Act of 1980 provides for the establishment of a fund to clean up releases of hazardous substances from spills and from abandoned waste disposal sites.

Each of these pieces of legislation provides for a complex set of regulatory powers and has resulted in a number of regulations at different government levels. Thus, the combination of these and other pieces of legislation has effectively resulted in counter-active policies to control hazardous substances. Of more importance, the estimation of the potential impacts associated with waste cleanup and waste disposal options becomes critical to the rational implementation of policies and regulations.

The objective of this study is to evaluate three hazardous sites using AHP with reference to the Hazard Ranking System.

1- The Complexity of modelling

The nature of the environmental interactions involved in hazardous modelling makes the modelling a very difficult task. Figure (1) illustrates the complexity of hazardous waste modelling.

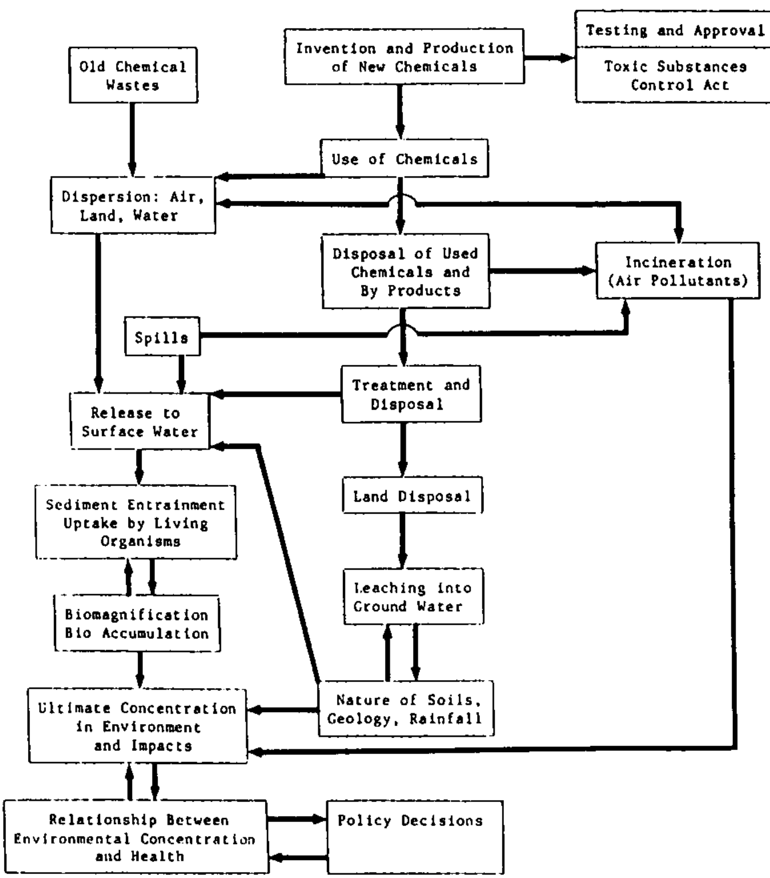
Gordon (1985) summarized the complexities involved in the fate of hazardous wastes as outlined below. Once a release has occurred, the propagation path that the pollutants follow varies greatly.

In the case of land disposal, most experts seem to agree that an absolutely secure landfill is impossible. Once release takes place, the variability of the environment complicates the calculation of the rate of movement of the pollution plume. The nature of soils and geologic formations will vary widely from one place to another; that is, these layers are not homogenous. The greater the heterogeneity of these formations, the more variable will be the transmission of the pollutants. This effect is further complicated by the potential uptake of some of the chemicals through the process of adsorption. Finally, the rate of the overall movement will be affected by the amount of leaching, which in turn is related to the amount of rainfall over time.

Moreover, the surface water fate of hazardous pollutants is also complex. Pollutants can be diluted, absorbed onto sediments which settle to the bottom, then stirred up with sediments and released into the water; or as water moves to and from the ground water system, they can interact with that system as contributors or they can receive further pollutants from that system. If the pollutants remain in the water, they may combine with other chemicals or be taken up by the aquatic vegetation and plants.

In the face of these uncertainties, the policy decisions which one might take often involves more art that science. Some are convinced that professional judgement, or in tuition, is much better at yielding a reliable result.

Figure (1) Complexities of hazardous waste modelling



2. Methodology

This paper will utilize decision theory to evaluate different hazardous sites. Specifically, **Analytic Hierarchy Process** (AHP) will be used to assess the risk arising from hazardous waste sites.

AHP, as described by Aziz (1992), is basically designed to capture the perceptions of people closely involved with certain pertinent issues via a procedure designed to arrive at a scale of preferences among sets of alternatives; it could therefore be considered as a multiobjective-multicriteria model. To apply the approach, a complex unstructured problem needs to be first broken down into its component parts. After arranging these parts into a hierarchic order, numerical values representing subjective judgments on the relative importance of each part are assigned. To come up with the final outcomes, those judgments are then synthesized (via the use of eigen vectors) to determine which variables have the highest priority. The structure of the hierarchy used to analyze this problem is shown in Figure (1).

The assumptions adopted by AHP are simple. First of all, there must be a finite number of possible actions, that is, a_1, a_2,.....a_n are positive actions, where n is a finite number. Analysts are supposed to assign a finite number of value to rank (scale) the importance of attributes. The scale might either be numeric or subjective. However, we have used the Saaty's scaling method, ranging from 1 to denote **equal importance** of two attributes to 9 to represent an **absolute importance** of one attribute over the other. Table (1) below describes the ranks and their definitions.

The AHP is based on two basic ideas, namely, pairwise comparison and consistency of thought. After the problem is decomposed ito a tree or "hierarchy" of components of various levels, pirwise comparison is carried out from the top level to lower levels. The after each comparison, a check of "consistency" is made to enable the analyst to revise his/her weights so as to obtain a consistency value below o.1. These comparisons are derived from standards or experience using intution and judgement.

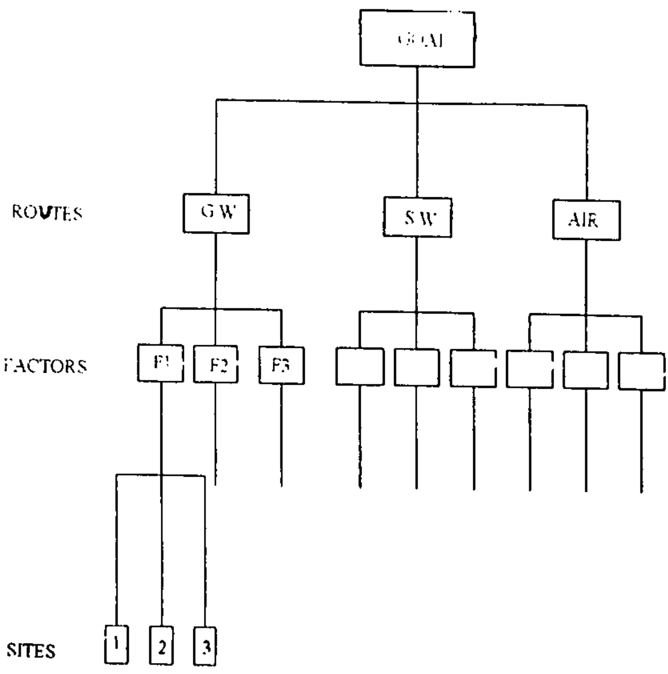
TABLE 1: THE SAATY'S RANKING SYSTEM

Intensity of Importance	Definition	Explanation
1	Equal importance	Two activities contribute equally to the objective
3	Weak importance of one over another	Experience and judgment slightly favor one item over another
5	Essential or strong	Experience and judgment strongly favor one item over another
7	Very strong or demonstrated importance	An activity is favored very strongly over another.
9	Absolute importance	The evidence favors one item over all
2,4,6,8	Intermediate values between adjacent scale values importance	When compromise is needed
Reciprocals of the above, non-zero	If activity i has one of the above non-zero numbers assigned to it when compared with activity j, then j has the reciprocal value when compared with i	A reasonable assumption
Rationals	Ratios arising from scale	if consistency is to be obtained using such values

3. STRUCTURE OF THE HIERARCHY

To conceptualize the problem of hazardous waste, the factors, components, and issues related to hazardous waste are decomposed in a hierarchy. The hierarchy consists of "Goal", "Routes",
"Factors", and "Sites", as shown in Figure (2) below.

Figure (2): Structure of the Hierarchy in modelling hazardous wastes



The structure of the hierarchy may be described as follows. In the first level of the hierarchy, "Goal" is defined. The goal is to assess the level of hazardous wastes at three sites. The second level defines the various routes for potential hazardous wastes. These are groundwater, surface, and air. The third and fourth levels specify the factors associated with the upper level of the hierarchy. Besides, a separate level were assigned for three different sites under study as an example.

The weighing used in AHP were based on the U.S federal standards (see Appendix for details).

4. ANALYSIS OF RESULTS

Based on the results of AHP, the weights for the components of the hierarchy tree were estimated based on eigen value estimates under the condition that "Consistency" is less than 0.1. The following tables show the weights for "Factors" and "Sites" for all Routes. It was shown that the weights for the "Factors" associated with Groundwater Route has the highest value.

Table (2) Weights for Factors and Sites for Groundwater Route

Ground Water Route (0.444)	Site A	Site B	Site C
F1 : Route Characteristics (0.287)	0.225	0.043	0.019
F2 : Containment (0.076)	0.057	0.012	0.007
F3 : Waste Characteristics (0.057)	0.043	0.009	0.005
F4 : Targets (0.024)	0.017	0.005	0.002

Table (3) Weights for Factors and Sites for Surface Water Route

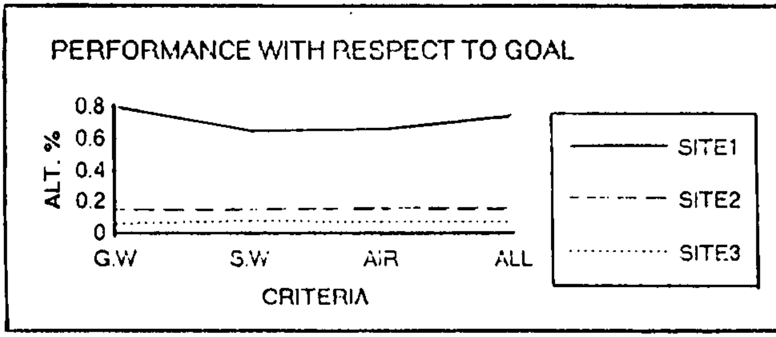
Surface water Route (0.489)	Site A	Site B	Site C
F1 : Route Characteristics (0.312)	0.215	0.058	0.04
F2 : Containment (0.081)	0.058	0.016	0.007
F3 : Waste Characteristics (0.057)	0.048	0.013	0.009
F4 : Targets (0.024)	0.018	0.005	0.003

Table (4) Weights for Factors and Sites for Air Route

Air Route (0.067)	Site A	Site B	Site C
F1 : Route Characteristics (0.005)	0.002	0.002	0.002
F2 : Containment (0.076)	0.001	0.001	0.001
F3 : Waste Characteristics (0.057)	0.031	0.007	0.004
F4 : Targets (0.024)	0.013	0.003	0.001

The performance of all these factors is illustrated in Figure (3).
Site (1) has the highest weight followed by sites (2) and (3).

Figure (3) Performance of all Routes with respect to Goal



CONCLUSIONS

This study utilized decision theory to assess different hazardous sites. Analytic Hierarchy Process (AHP) was used to weigh the components of the problem. It was shown that AHP can help in decision making for an integrated water and land management and it serves as an efficient tool for policy analysts, engineers, and planners. Dealing with environmental problems may involves both science and art; AHP enables the analyst to come up with sound judgements using both tangible and intangible factors.

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WORKSHOP 4: The agricultural conflict

The workshop will deal with the tendency in most of the world to try to increase agricultural production: Uncautious use of agricultural chemicals threatens to increase water pollution further, both in the post-Communist societies, with their already severely degraded water quality, and in the South, with its rapidly increasing population to feed. In the West, there is a conflict between agricultural production and difficulties in securing acceptable market prices.

The workshop will clarify the present situation in terms of visible effects of pollution and the threats of escalation from intensified use of chemicals.

FARMERS FOR A SUSTAINABLE FUTURE
A CONSENSUS ENVIRONMENT POLICY

Bo Dockered, President of The Federation of Swedish Farmers, S-105 33 Stockholm, Sweden.

The IFAP - the International Federation of Agricultural Producers - represents some 500 million farmers from all regions of the world through its 80 member organisations from 60 countries. I say this just to give you an idea of the significance of a consensus environmental policy adopted by this organisation.

In the IFAP Environment Committee, which I have had the privilege to chair, we approached problems relating to environment and production from a systems- or structure-oriented point of view rather than looking for concrete measures to improve farm practises.

The principal result of the work of the Environment Committee so far is a consensus document containing a series of policy proposals that place the farmer at the centre of a policy for attaining sustainable economic, social, and ecological development. This document was recently adopted by the IFAP General Conference held in Istanbul in May. The document is available here today and I hope that you will have the opportunity to read it. I feel it is a very important document and the IFAPs work to help attain a sustainable and environmentally sound agriculture will be of great relevance to the kind of future the generations coming after us can expect.

It is an enormous task that the farming community of the world is facing. But what really makes me optimistic is the fact that farmers hold the key to many of the environmental problems. This makes it both possible and necessary for agriculture to assume the leadership in the change process. Policy work is about leadership and it takes both scientific knowledge and a working policy implementation to make things change.

The environmental issue is on top of the political agendas of the world. It is simply the biggest issue in politics with all its' implications taken into account. The environmental issue in a broader sence is closely related to issues concerning solidarity between developing and industrialised countries and also to the problems of creating a balance between rural and urban areas. Not to mention the development in all parts of the world.

So, with the right policy framework, agriculture will be able to ensure the continued development of a food- and raw-materials system that is environmentally sound, productive, and profitable, and that will meet the needs of the rapidly expanding world population. It will encompass the conservation of the rural environment with its wildlife habitat and genetic biodiversity. It will be able to provide renewable raw materials for industrial and energy use. And it will ensure the viability of rural areas.

I would like to mention some of the guidelines or principles that forms the backbone of the IFAP consensus document; principles that are very important for the future for world agriculture.

Secure land tenure is a key component in sustainable agriculture. Good stewadship of the land is closely tied to ownership. This is why farmers all over the world need clearly defined property rights.

The natural complementarity and interdependence of rural and urban areas must be re-established. It is therefore essential to reinforce the economic, social, and ecological balances between these two areas. Waste management is only one example that underlines the necessity of recycling. The waste from the cities have to be brought back to the soil. But only in such a way that fertility is improved. It is essential for the whole of society to respect and to appreciate the role of the rural areas in order to create a balance. Only in this way will we be able to start off on the road to sustainability and recycling in a broader sence.

Poverty in rural areas is one of the really important obstacles to achieving sustainble development and an environmentally friendly agriculture. Farmers must recieve fair prices for their products. And they must have access to financial and technological means to improve their production.

It is of outmost importance to support the development of agriculture in the developing countries. Therefore it is quite alarming that the percentage of aid going to agriculture has decreased sharply for many years according to recent OECD-statistics. Partly, I think, this is caused by a current political trend that is very negative to agriculture in general and to agricultural support in particular. Historically, agriculture has been a very regulated industry, highly dependent on political decisions. Now, this draws a lot of critisism from laissez-faire-politicians and supply side-economists. And, subsequently, it becomes politically impossible to support even developing country agriculture.

This a very short-sighted and populistic attitude that does not take into account that we are using up and destroying natural resources at an increasing speed. Nor does it take into account the fact that aid money give the best effect when it is used to support agriculture in developing countries.

A much higher degree of solidarity with the developing countries is in fact a corner stone in the development of the global community. In many parts of the world, basic problems of poverty must be solved before we can expect a sustainable agriculture. This means that the industrialised countries must give more emphasis to agriculture in their aid-programs.

Farmer-owned cooperative enterprises are a vital link to the marketplace. And they can help enhance farmers' incomes and give farmers good control of their businesses. And this is increasingly important considering that big multinational corporations are trying to achieve full control over the food-chain, from plant-breeding companies to supermarkets. If we are not able to meet the competition from the multinational food industry, the farmer will be reduced to a tractor driver without any voice and influence on the development. In the end, this will damage the farmers ability to exercise a good stewadship of the land.

The use of agricultural products as renewable raw materials for industry and energy has huge potential, both for the environment and for rural development. In fact, probably nothing could contribute more to environmentally sound development than that. It can help reduce the greenhouse effect; it is ecologically safe; and it has an enormous employment potential. Furthermore it could help bringing the grain production in the industrialised countries down, so that less of its surplus is dumped on the world market. This in turn would be beneficial for the agriculture of the developing countries.

They wouldn't have to compete with heavily subsidised export from the rich world.

However, the large-scale implementation of bio-energy cannot be left to the market forces alone. It will require that the environmental costs of fossile fuels are taken into account. In this way a functioning market for biofuels could be created. Of course this presupposes the support of a public energy policy.

Green balances needs to be introduced on all levels of political and economical decisions- making. Not only when it comes to the handling of environmental issues by agriculture. But also when it comes to structural matters involving all of society. It is good that an increasing number of the worlds political and industrial leaders are realising that the tradional economics in its pure form is a tool that simply will not do the job.

In international trade, both developing and industrialised countries must have fair access to markets. Another important issue relating to trade is the international harmonisation of trade and environment regulations. The World Trade Organisation will work with this. But I think it is important that the farmers of the world, through their organisations, become involved in the harmonisation process.

Sustainable agriculture does not mean a return to low-technology methods. Rather, it means agriculture that is highly dependent on ecological data, sophisticated information, and the rapid development of new tools and equipment. These ways and means must be adapted to a small scale utilisation of natural resources. The extension services must concentrate on agriculture on the family farm-level. And the scientists must provide new, safe and ecologically sound systems for cultivation and other production. Here it is very important that the farmers are very clear in their demands and that they are not just being defensive, which often has been the case.

Although agriculture holds the keys to many of the big environmental problems and therefore has a leadership role, one must remember that it is the responsibility of society as a whole to ensure a more sustainable development. This will require cooperation across the various sectors of society - including farmers, government, agroindustry, research, and consumers.

We know that, however important, market orientation alone cannot solve every problem on the road to a sustainable and environmentally friendly agriculture. We also need to create environmental incentives, and finally we need to develop the rural economy, whithout which there will be no functioning infrastructure for agriculture.

If we want to bring about important changes worldwide, I am convinced that we have to work on a policy level. If we don't, we run the risk of ending up quarreling over details. That is why I choose to put most of my efforts in policy work. Social and economic systems certainly affect the conditions for farmers, and thus, they also affect the ecological systems. And, in turn, they will also have a decisive effect on efforts concerning water management.

It is really a big challenge we are facing. But the possibilities are even bigger. Already we are witnessing the first steps towards an agricultural production built on the principles of recycling and sustainability. We can see the necessity for agriculture to assume the leadership role. And the goal is clear. We must be able to feed a rapidly growing world population and at the same time produce renewable energy and industrial raw materials in an environmentally friendly, resource efficient and sustainable way.

CONFLICTS IN WATER USE: SUSTAINABILITY OF IRRIGATED AGRICULTURE IN DEVELOPING COUNTRIES

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1 INTRODUCTION

Irrigated agriculture in developing countries faces important challenges in the coming decades. On the one hand, it has to provide a major share of the required increases in food and fibre production to meet the objectives of poverty alleviation and development. On the other hand, it is threatened by water shortages arising out of increasing competition from domestic, industrial and other sectors. This situation is further worsened by dwindling financial resources available for capital expenditures as the cost of new schemes increase.

In this context, it becomes necessary to evaluate the economic, financial and environmental sustainability of recent developments in irrigated agriculture. This paper presents empirical evidence with regard to one such development, namely rice-wheat rotation in Asia. The paper argues that high yield growth rates in rice and wheat in Asia during the 1970s and early 1980s were achieved through policies and practices which encouraged the use of groundwater for meeting high water demands of a rice-wheat rotation. However, such policies and practices have resulted in environmental degradation of land resources, declining water tables and increasing financial crises for irrigation agencies. Hence, irrigated rice and wheat will become uneconomic during the 1990s as a consequence of declining crop yields and rising costs of water, and environmental degradation. This paper outlines policy imperatives and institutional changes to improve the productivity of irrigated agriculture in a sustainable manner and to encourage water conservation and recycling in industrial and urban household sectors.

2 CONFLICTS IN WATER USE AND IRRIGATED AGRICULTURE

2.1 Threat to Water Availability for Irrigation

According to a recent estimate, by 2025, thirty four countries will face water scarcity, i.e., per capita availability of fresh water supplies will be less than 1000 m^3/person/year. The two most populous countries in the world, India and China, will have less water than is considered essential for meeting the demand for households, agriculture and other sectors. For example, 1.5 billion persons in India will have less than 1400 m^3/person/year of water available by 2025. In China, the estimated availability is slightly higher, i.e., 1700 m^3/person/year in 2025. Compared with these, per capita availability in the USA will be 7170 m^3/person/year in the year 2025.

Rising demand for urban and industrial water supplies poses a serious threat to irrigated agriculture. The share of industries and households in total water demand is estimated to increase from around 33% in 1993 to around 45 to 50% in the year 2025 (Table 1). In developing countries (FAO 1993a), the share of households, industries and power generation may be around one-third by 2025, but there are many regions and river basins where the share of non-agricultural demand will exceed 40 to 50% of estimated freshwater requirements.

However, the challenge for irrigated agriculture does not come only from competition from other water users. Equally important is the squeeze on financial resources. Despite massive investments in the past, public irrigation systems are facing dwindling financial resources for new projects and for managing existing projects. This is due to the reluctance of irrigation agencies and governments to raise irrigation charges to cover O&M and capital costs. International agencies are also reluctant to give more money for irrigation in view of rising real costs, falling foodgrain prices in the international market, and opposition from environmentalists.

Table 1. Rising share of non-agricultural demands for water in the world.

	Percent of Total Demand	
	Demand in 1993	Estimated Demand in 2025
1. Households	6–8 percent	15–20 percent
2. Industries	26 percent	30 percent
3. Agriculture	66–68 percent	50–55 percent

Source: *Sustaining Water: Population and the Future of Renewable Water Supplies.* Robert Engleman and Pamela LeRoy. Population Action International, Washington DC., 1993.

Declines in financial resources have been accompanied by declines in irrigated areas. According to available statistics, there has been a sharp decline in the rate of growth in irrigated area in Asia during the 1980s (Rosegrant and Svendsen 1993). For example, in South Asia the growth rate in irrigated area dropped from 2.8% during 1975–80 to 1.8% in 1980–85, and to 0.1% in 1985–88. Growth in irrigated area in East Asia through the mid-1970s was over 2% annually but virtually stagnant in the 1980s.

The overall decline in the rate of growth in aggregate irrigated area in Asia has been accompanied by a sharp decline in lending for irrigation by international donors (Rosegrant and Svendsen 1993). Average lending and assistance for irrigation in South Asia was highest in 1980–82, at $820 million, before declining by more than one-half to $397 million in 1986–87. In Southeast Asia, lending for irrigation from the World Bank, Asian Development Bank and the Japanese Overseas Economic Cooperation Fund declined from an annual average of $630 million in 1977–79 to $202 million in 1986–87, a decline of two-thirds.

Total public expenditures for irrigation for many countries in Asia also declined significantly during the 1980s. Annual expenditures in China and Sri Lanka were cut nearly in half between the late 1970s and the late 1980s. Declines from peak expenditure levels in the late 1980s in Bangladesh, India, Indonesia, the Philippines and Thailand range from 15% to 40%. These declines in public expenditures were accompanied by massive expansion of private sector tubewell irrigation in India, Pakistan and Bangladesh. In India for example, net area irrigated by tubewells increased from 4.5 million hectares in 1970–71 to 1.3 million hectares in 1984–85 and continues to increase steadily.

2.2 Food Security, Poverty Alleviation and Irrigated Agriculture

According to recent estimates, the demand for food in the developing countries is projected to more than double by 2025 (Blake et al. 1994). Even if the area under irrigation increases, average yields of foodgrains will have to more than double by 2025 if domestic production is to meet most food needs in developing countries. Raising productivity in future will require a wide range of policies and programs to ensure that farmers have the means and incentives to attain these yields on a sustainable basis.

Despite the twin challenges of reductions in available water supplies and in financial resources, irrigated agriculture will have to meet 70 to 75% of the additional foodgrain requirements in many developing countries in order to avoid large scale hunger. Besides, irrigation will be needed for fibre and cash crops to meet the objectives of self-sufficiency, employment creation, poverty alleviation and development. Thus, it is essential that water-use efficiency in irrigated agriculture be improved with a view to producing "more food with less water". To do this will require:

(i) A review of current policies and practices which have encouraged water-intensive crop rotations such as rice-wheat in arid areas of Asia;
(ii) Introduction of a comprehensive Performance Assessment System which provides a consistent set of indicators of productivity, equity and sustainability of irrigated agriculture in various agro-ecological and management situations; and
(iii) Evaluation and adoption of performance-enhancing management practices with respect to water allocation, technological improvements, and information processing.

3 IMPLICATIONS OF CURRENT PRACTICES AND POLICIES FOR SUSTAINABILITY OF IRRIGATED AGRICULTURE

Although the term sustainability is widely used these days in reference to irrigated agriculture, there is no apparent consensus on what the term actually means. We propose the following definition: A sustainable irrigation system is an irrigation system which generates outputs that are valued and used by people, and where the potential for production of available natural resources is not reduced by short-term operation and maintenance of the system.

3.1 Environmental Sustainability of Rice-Wheat Farming

Rice-wheat rotation

The rice-wheat cropping system is a dominant agricultural system in five Asian countries, namely, China, India, Pakistan, Bangladesh and Nepal. In these countries it is estimated that rice-wheat rotation is practiced on over 23 million ha. About 28% of rice and 35% of wheat areas of the five countries together are under rice-wheat system. Considering that rice-wheat cropping is practiced essentially under irrigated conditions, about 35% to 50% respectively of the irrigated rice and wheat areas are under rice-wheat cropping. These countries have a total population of 2.33 billion, accounting for 43% of the world population. With the total arable land area of only 298 million hectares, their share of the world's total arable land is only 20% and the disparity between population and land area is expected to worsen in the future.

Many (e.g., Abrol and Gill 1993) have expressed their concerns about the sustainability of the rice-wheat farming system. Continuous rice-wheat cropping is said to be over exploitive of the natural resource base as there are potential degradations in soil health and fertility, and in water supply and quality. Under intensive rice production systems, particularly irrigated rice, there is generally stagnation or even a decline in yield. China and Southeast Asia experienced substantial declines in the rate of yield growth in rice during the period beginning 1982 (Rosegrant and Svendsen 1993). By contrast, rice yield growth increased dramatically in India (3.23% p.a.) during the 1980s, and was slightly higher in the rest of South Asia.

Yield growth for wheat in Asia was 4.4% during 1974–82, before declining to 2.7% annually after 1982. The decline has been more spectacular in China (from 5.66% p.a. during the 1970s to 2.88% p.a. during the 1980s) than in India (from 3.47% p.a. in the 1970s to 2.92% p.a. in the 1980s). It is interesting to note that in China a quarter of the area under wheat-rice irrigation has a rotation of two crops of rice to one of wheat. The area under rice cultivation has also increased substantially in Pakistan, with the result that pressure on available water resources in the Indian subcontinent has significantly increased over recent years.

Water requirements

Water requirements for paddy cultivation vary and depend largely on soil type. The average crop requirement under the conditions of Pakistan's Punjab for example, is 1600 mm which includes water needed for land preparation, intentional drainage and deep percolation (Bhatti and Kijne 1992). However, the main irrigation application was found to be around 1300 mm during actual measurements on a fairly large number of farms. This implies a productivity of only 0.14 kg rice per m^3 water for average yields. Here it is standard practice to flood paddy fields with up to 10 cm water. Large amounts of water are required to do this, particularly in the rice-growing areas consisting of medium to light textured soils that have high infiltration and percolation rates (Tabbal et al. 1992). Up to 40 cm of water can be saved on loamy sand by reducing the duration of ponded water to 1 week at transplanting, and maintaining near-saturated conditions thereafter without adversely affecting the crop (Narang and Singh 1988).

Profitability

Profitability of rice-wheat cropping, when adjusted for currency depreciation, probably declined in many areas during the 1970s and 1980s, notwithstanding a decrease in production costs. Such declines in profitability are probably greater where support prices, as for wheat in Pakistan and Bangladesh, are so low as to constitute a disincentive for farmers to adopt or continue rice-wheat cropping. In some areas of the Indian sub-continent where aromatic rice is grown in the rice-wheat sequences, or where sugarcane is incorporated in rice-wheat rotations, the profitability is comparable to that of alternative crop rotations.

There are a number of reports that suggest productivity and input use efficiency are declining under intensive rice-based cropping systems, including the rice-wheat system. In order to maintain yields, increasing input levels are needed to balance the negative effects, as revealed from farm-level data from Indonesia, Philippines and Thailand. The analysis of the yield gap between farmers with grain yields in the top third of the yield range and those in the lower two-thirds of the range indicate that on many farms this farming system is under-productive.

Waterlogging and salinity in Pakistan Punjab

Pakistan's Punjab province provides an example of an irrigation system where the sustainability of irrigated agriculture is threatened because of interaction between irrigation and the environment. In a large part of the study area, the rice-wheat farming system is practiced. At present this area is not one of the most severely affected parts of Pakistan, but one where salinization processes have begun and may grow worse, unless there can be some remedial management intervention (Kijne and Vander Velde 1992).

Salinity and waterlogging have long afflicted extensive areas of irrigated farmland in the country. Waterlogging has been greatly reduced by the installation and operation of public sector, deep tubewells through SCARP (Salinity Control and Reclamation Project) programs begun in the 1960s. More recently, the rapidly growing exploitation of groundwater for irrigation by the private sector using shallow tubewells—now about 300,000 countrywide—has greatly enhanced the "vertical drainage" effect of the SCARP wells. In some command areas today, water tables range between 4 and 8.5 m deep. Capillary transport of dissolved salts from the water table to the rootzone is rather weak when the water table is deeper than 2 m from the soil surface. Thus, the link between waterlogging and soil salinity depends on the depth of the water table. Contrary to parts of India Punjab where water tables continued to rise as a result of (over-) irrigation, the root cause of soil salinity in parts of Pakistan Punjab is the widespread reliance by farmers upon pumped groundwater for irrigation. Tubewells, frequently pumping marginal to poor quality water, have become the widespread response of many farmers to increasingly inadequate and unreliable deliveries of good quality canal water from the distributary and watercourse systems.

The incidence of salinity, however, is still on the increase. It has been calculated from the total amount of water entering Pakistan and its salt content, and the total discharge into the ocean and its salt content, that more salt is entering the country than leaving. Annually the surface irrigation system adds 20 million tons of salt to the Indus Basin, which is equivalent to 1.25 ton/ha of irrigated land. Moreover, based on an estimated 50 billion m^3 of pumped groundwater per year (which seems high compared with the estimated annual usable groundwater recharge) with an average electrical conductivity of 0.9 dS/m, an additional 30 million tons of salt are added to the top soil each year.

Canal Water and pumped groundwater in Pakistan

Findings from IIMI research in Pakistan on the operations and performance of distributary canals in the LCC system over several years show that the long-standing system performance objective of equity in water distribution is now rarely achieved and almost never sustained. When distributaries are operating at or near full supply levels, outlets in the tail reaches seldom obtain more than a fraction of their authorized discharge at the watercourse head. This is in contrast to the outlets in the upper reaches which commonly receive much more than their design discharge. We surmise that the principal reason for the inequitable distribution pattern is that maintenance efforts have been insufficient. Accumulation of sediment in the canals and cross-sectional shape change due to embankment erosion, have reduced their conveyance capacity. As a result, water-levels near the head are relatively higher, permitting greater flows out of head outlets to watercourses. A consequence is that farmers in the command areas of tail watercourses receive, on average, much less water. The delivery performance ratio is the actual flow delivered to a watercourse as fraction of the design discharge. Equity of water distribution would imply that all outlets to watercourses receive the same fraction of the design flow as enters into the distributary canal.

Although modest relative to the average annual canal withdrawals of about 129 billion cubic meters, annual usable groundwater recharge in the Indus Basin is estimated to be about 29 billion cubic meters, or slightly over half of the average annual recharge to the aquifers which underlie the Indus plains. Agriculture in Punjab Province has access to slightly over 66 billion m^3 canal water and about 24 billion m^3 groundwater. In areas with extensive groundwater exploration, water supplies at the watercourse level are now typically of the order of 6 to 8 mm/day. As a result, cropping intensities in Punjab canal commands now commonly exceed 125%. For large areas of the province, however, there is mounting evidence that as a result of current levels of groundwater pumping aquifer exploitation already exceeds recharge.

The inadequacies of the public tubewells, along with the demonstrated benefits of tubewell investment, provided incentives for private sector investment. From the 1960s, while continuing investment in public tubewells, the Pakistan government encouraged private investment through increased credit availability, fuel subsidies, and extending the electric grid. Between 1964 and 1976, private tubewell use grew by around 38% annually.

The performance of private tubewells has been far superior to that of the public wells. About 90% of the private tubewells are operating at any one time compared with just over a third of the public tubewells, with a smaller down time because of the growth in small repair shops and availability of parts. Moreover, although public tubewells account for only about 10% of total irrigation water supplies, they require more than half of the total operation and maintenance expenditure in the irrigation sector.

Where farmers have access to water from a canal, a public tubewell and from a private tubewell, they can apply irrigation water more or less at any time they want. They can more easily trade water, either through buying and selling or on some other basis, and they can move water across previously impermeable watercourse command boundaries. In short, the entire irrigation system has become a complex conjunctive management environment.

Conjunctive use of canal water and groundwater in irrigation

A critical aspect of conjunctive use is that groundwater and surface water are not necessarily equally exchangeable. Only when water quality is not a limiting factor is it possible to conclude that surface and groundwater could be of similar agricultural value, where the only differences between them are related to the relative reliability of the two sources and the relative cost of using each.

In Pakistan groundwater often constitutes a high percentage of total water used conjunctively in irrigated agriculture in many canal commands. In this context, there seem to be two key areas in a farmer's irrigation decision-making matrix where information and a capacity to use it effectively are critical—water quality differences between available surface water and groundwater, and total water availability in the period of peak demand in each season.

Flexibility in timing and amount of irrigation supplies is particularly important in the management of salt affected soils. For many farmers irrigation supplies are now more flexible as a result of the availability of tubewell water for irrigation. A comparison between users of tubewell water and non-users showed that on average the users irrigated 1.5 times more often than the non-users, and the total depth of water applied by the users was some 20% higher. It is important to supply water more frequently under saline conditions: it was shown that with more frequent irrigation permissible levels of salinity in soils and irrigation waters are higher.

Restoring equity in delivering canal water

It is desirable to deliver less canal water to canal head-end watercourses and redirect flows to tail-end outlets to restore equity in distribution. This action may also provide tail-end farmers with a better mix of irrigation water to leach the accumulated salts from their fields. The expected response from head-end farmers is however, a refusal to accept a lower percentage share of good quality surface water. Should head-end farmers actually accept to receive less canal water, one likely consequence would be that cropping patterns in the downstream watercourse command areas would change to become more like those in distributary head reach areas. The processes of salt accumulation in the root zone and deterioration of groundwater quality would continue at a slower rate downstream, but increase in upstream locations (Murray-Rust and Vander Velde 1992). It appears then, that every area that benefits from obtaining more surface water can only do so at the explicit expense of other areas which have less canal water—so the solutions are far from simple! The central issue is the ratio of surface water to groundwater used conjunctively in irrigated agriculture. A groundwater contribution of some 70% in the mixture of canal water and groundwater for irrigation is not sustainable in the long run. For sensitive crops the maximum amount of groundwater that can be added to canal water for irrigation is only 22%. If groundwater of an electrical conductivity of more than 2.7 dS/m is used for irrigating sensitive crops, yield reductions of more than 10% should be expected.

For many problems, ranging from inequity of water distribution to salinization of top soil due to insufficient leaching, technical solutions have been known for years. Although the rice-wheat farming system in Pakistan Punjab may not be unsustainable, present conditions are such that the level of productivity, expressed as yield per unit of water used, is bound to remain low.

Declining water tables in India Punjab and other states

With the advent of high-yielding, short-straw rice varieties, the area under rice in India Punjab has more than tripled from 1975 to 1987 (Narang and Singh 1988). In the Indian states of Punjab, the proportion of gross cropped area under wheat and rice increased from 58.7% in 1980–81 to 70.5% in 1990–91 (Malik 1994). In some districts, area under rice-wheat rotation exceeds 80% of the gross cropped area. In Punjab and Haryana (two advanced states in North-West India), area under rice increased from 0.7 million hectares in 1970–71 to 2.7 million hectares in 1990–91. Given the climatic conditions in the region, cultivation of rice-wheat requires extensive supplementary irrigation. The available network of surface water irrigation system in the region is designed to provide only protective irrigation to a part of the available agricultural land and is insufficient to meet the heavy water requirements of rice-wheat cropping pattern. To meet the time specific irrigation requirements of the water intensive cropping pattern, the farmers in the region have resorted to intensive exploitation of relatively more reliable groundwater resources through installation of private tubewells. In the Punjab, the number of tubewells increased from 0.6 million in 1980–81 to 0.8 million in 1990–91 while in Haryana the number increased from 0.33 million in 1980–81 to 0.5 million in 1990–91. About 60% of the net area irrigated in the region is irrigated by tubewells (Malik 1994).

During this period, almost the entire increase in numbers of tubewells was for electricity-operated tubewells. This was a consequence of government subsidies on electricity used for agricultural purposes. Under the prevailing electricity tariff structure, farmers are charged for electricity at the flat rate of Rs 29 per horsepower per month. Given this flat rate, farmers would like to pump out as much water as required for rice-wheat rotation, subject to availability of water and power. In 1991–1992 this amounted to an average subsidy of Rs 0.88 per Kwh compared with the actual average cost of supply of Rs 1.23 per Kwh.

As a consequence of large increases in rice area and number of tubewells, the groundwater resources in large parts of North-West Indian states of Punjab and Haryana are showing clear signs of overdevelopment. Of the 118 development blocks in Punjab and 108 in Haryana, about 56% of the blocks in Punjab and 29% in Haryana have been classified as "dark" (Malik 1994a). Another 16% of the blocks in Punjab and 15% in Haryana have been classified as "grey". The water table in large parts of the region is falling rapidly. A finer classification of the distribution of dark and grey blocks suggest that the proportion of dark and grey blocks is much higher in those districts where rice is a major crop. In rice growing districts 89% of the blocks are classified as either dark and grey while in non-rice growing districts, only 29% of the blocks fall into these categories.

Another way to estimate the impact of rice-wheat rotation on groundwater table is to observe actual changes in water tables in selected regions. Based on such data, the average current depth of the water table in the study region has been estimated to lie 15 meters below the ground surface, and the average rate at which the water table is lowered has been estimated at 1 meter per year.

3.2 Financial and Economic Viability of Rice-Wheat Rotation

Public irrigation investments have become an enormous drain on government budgets because cost recovery has fallen short of even modest targets. In Indonesia, Korea, India, Pakistan, the Philippines, and Bangladesh, irrigation receipts were less than the costs of Operations and

Maintenance (O&M). Using a moderate estimate of capital costs in these countries, the 1984 actual receipts averaged less than 10% of the full costs of the irrigation services. Average implied subsidies were 90% of total costs of irrigation.

In Mexico, assumed cost recovery from users of public irrigation systems averages around 11% of capital and O&M costs. In Pakistan, gross public revenues from irrigation services in 1984 were approximately 1 billion Pakistani Rupees (1 US$= 30 Pakistani Rupees) compared to outlays for O&M of irrigation works of Pakistani Rupees 2 billion and annualized capital charges on past irrigation investments of Pakistani Rupees 5.9 billion. In India in 1988–89, revenues from water charges were Indian Rupees 1.1 billion (1 US$= 31 Indian Rupees) compared to Indian Rupees 15 billion on current expenditures for large and medium-size irrigation projects (World Bank 1991). Annual irrigation subsidies were of the order of $0.6 billion in Pakistan and $1.2 billion in India. Estimated irrigation subsidies in Egypt are over $5 billion per year.

In many developing countries, electricity prices for agriculture are subsidized. Electricity tariffs cover between 10 to 25 per cent of the average cost of delivering electricity to rural areas for water pumping. For example, during 1982–90 in Andhra Pradesh in India, a flat rate of Rupees 0.05 (US cents 1.5) per Kwh was charged for electricity used for agricultural purposes. Since October 1990, electricity has been supplied free of charge to consumers having pumpsets up to 5 horsepower (hp), and Rs.100 ($3) per unit of horsepower per annum for consumers having pumpsets of 5 to 10 hp. For those with pumpsets above 10 hp, a metered tariff has been administered at the rate of Rs 0.50 per Kwh subject to a minimum of Rs 150 per annum per unit of horsepower. The average cost of supplying electricity to low tension consumer was calculated at Rs 0.81 in 1990–91, indicating an estimated subsidy of Rs 0.76 per Kwh. These subsidies have resulted in losses on regional electricity schemes amounting to Rs 3.5 billion per year in Andhra Pradesh (Rajagopalan and Demaine 1994).

The high cost of subsidies for supply of power to agriculture have resulted in financial losses for electric utilities in many countries. In India for example, the gross subsidy involved on account of the sale of power to agriculture was estimated at Rs 8.3 billion (US$ 270 million) in 1993–94 (Government of India, Economic Survey 1994). These subsidies, increasing at the rate of Rs 1.0 billion per year, have become unsustainable.

4 POLICY IMPERATIVES AND INSTITUTIONAL CHANGES

The experience in many developing countries has shown that the fragmented, "Command-and-Control" approach to management of water resources has failed, both economically and environmentally. This highlights the need to use economic incentives and fiscal instruments to achieve economic efficiency in the use of the resource. Furthermore, it is necessary to show that improved economic management of this resource will help to improve the environment. Consequently, a policy package is urgently required which contains a judicious mix of legislation and regulation—water tariffs, pollution taxes, effluent charges and groundwater extraction charges—together with the provision of tax benefits or investment support for water conservation and effluent treatment plants.

4.1 Economic Incentives and Institutional Changes to Ensure Efficient Water Use in Urban and Industrial Sectors

The foremost requirement in each country is to create an institutional setting within an effective legal and regulatory framework to ensure optimum use of water resources. This would require defining water rights and allocation for surface water and groundwater, legislation on groundwater withdrawals, protection of water quality, and so on. The regulatory framework should take coordinated actions regarding prices charged by utilities, pollution charges and taxes, and competitiveness of entry to water service industries. Even where such regulations are present, implementation of these is not very effective. Concerted efforts are required to set and enforce environmental standards so that potential health hazards can be avoided.

The Dublin Conference on Water and the Environment held in January 1992 emphasized that "water has an economic value in all its competing uses and should be recognized as an economic good". This implies that water rates (or tariffs) should reflect its scarcity value or its value in alternative use. If water tariffs are raised to reflect their real costs, a substantial saving in water use will result. This is true not only in industrialized countries—in the USA, Canada, Israel—but also in developing countries. In Bogor, Indonesia, water prices were trebled in order to encourage households to conserve water. This resulted in a 30% drop in the average monthly residential water use between June 1988 and April 1989. In Jamshedpur, the Steel City of India, it is anticipated that a 100% increase in water tariff will reduce water demand in industries by 49% through investments in water conservation and recycling of treated water (Bhatia et al. 1994).

4.2 Price Policies for Rice, Irrigation Water, and Electricity for Water Pumping

In India, the central and state governments have encouraged rice-wheat rotation by (i) assuring increases in procurement and support prices for paddy and wheat, (ii) subsidizing electricity for groundwater pumping, and (iii) providing subsidized surface water. If the subsidies on pumping groundwater and use of surface water are to be eliminated, the incentives of high procurement and support prices will have to continue to maintain current profitability levels.

At current subsidized electricity rates, there is no incentive for farmers to reduce groundwater irrigation in rice-wheat rotation, even if less water is used. This situation is reversed however, if electricity is priced at its economic cost. Under these conditions even a 12% reduction in water use for paddy will result in an increase in Net Economic Value, inspite of a reduced crop-yield. Thus, significant economic gains can be achieved under water-conserving farming practices, even if such conservation results in reduced crop yields, demonstrating the implications of including or excluding the resource cost of making a financial and economic comparison of the alternative farming systems. Economic analysis which excludes the value of the externalities consequently overstate the value of resource conserving farming practices, and if the cost of depleting natural resources is taken into account, resource conserving farming practices compete more closely economically and financially with conventional farming practices.

4.3 Performance Assessment and Improved Management Practices

In the context of the threats of water shortages and declining financial reserves, the productivity of existing irrigation systems will be the primary determinant of sectoral performance in the short run, and the sustainability of physical resource base in the long run contribution of irrigation. The International Irrigation Management Institute (IIMI) considers the introduction of performance assessment methodologies an effective and necessary first step in bringing about changes in irrigation management practices. Consistent use of performance indicators generates information which provides the basis for defining and evaluating improved operational procedures for existing systems and for determining what further investments in irrigation, if any, are justified.

Enhancing the productivity level requires changes in the management of irrigation systems. These management interventions are characterized by an impact on one or more of the following: the type, amount, timing, and/or quality of the performance information that is provided to those responsible for irrigation system management; and the matching of operational responsibility with operational capability and/or authority (Kijne and Levine 1991). The interventions may be with respect to policies, organizational structure, management procedures, and/or management capacity. The combination of relative rigidities of the physical system and relatively rapid changes in needs, prevalent in much of the Indian subcontinent, suggests the existence of rather large discrepancies between managerial actions and needs. Most management interventions require some change in institutional arrangements, occasional changes in organizational structure will be required, and sometimes there will be a need for changes in system hardware. Generally, large irrigation departments suffer from a lack of accountability, and changes in institutional arrangements that provide for greater individual and technical accountability are desirable. Without proper techniques for monitoring the physical performance of irrigation systems, it is impossible to evaluate the potential benefits that might accrue from further investments to improve them. Identifying and evaluating indicators for irrigation performance has started only recently. Bos and others (1993) presented a framework that irrigation managers can use in assessing performance of irrigation. The authors recommend a specific set of indicators that they believe are practical, useful, and generally applicable, such as equity of water distribution, timeliness of delivery and reliability.

Thus, indicators have been identified that can be used by irrigation agencies to evaluate the potential for further investments to improve the performance of an irrigation system. They can also be used to measure and reward line agency staff for good performance, and to identify poor performance. Performance accountability is rare, but it is unlikely that without some incentive to improve performance, irrigation staff will not make the required management changes. The first step towards improving irrigation performance lies in convincing irrigation departments of the benefits of using performance indicators. Not a simple task, as performance assessment is complex. We feel that performance assessment is necessary to improve institutional arrangements such that irrigation management becomes more conducive to increasing the level of production. Alternative institutional arrangements that are worth considering should be participatory—joint management of irrigation systems by public organizations and farmer groups for example, have shown considerable promise.

IIMI has developed effective methodologies for assessing and improving the performance of irrigated agriculture. IIMI's Performance Assessment System evaluates the contributions and impacts of an irrigation scheme in terms of production, self-reliance, employment, poverty alleviation, financial viability, farmers' profitability and environmental sustainability. The application of such a comprehensive assessment procedure will enable policy makers and irrigation managers to implement effective management practices and allocate necessary financial resources to this important sector.

A five-year Performance Assessment and Improvement Program has been initiated at IIMI. The two principal objectives of this program are (1), to developing and applying a comprehensive performance assessment system, and (2), to evaluate performance-enhancing management practices and interventions. The major components of the performance assessment systems are:

- to identify the objectives and performance indicators;
- to develop practical and cost-effective methodologies to measure performance over large irrigation systems;
- to measure the performance in selected systems;
- to develop and specify the targets or assessment norms/standards against which the actual values of performance indicators are to be compared;

- Compare the "actual values" of performance indicators with targets and assessment norms to derive conclusions regarding the "performance level" of the scheme/sub-scheme (or a group of schemes) for a given year and/or changes over time;
- Select "appropriate" indicators for a given scheme.

Field research for quantifying various performance indicators has been initiated in six selected irrigation systems: (i) Chishtian Sub-division of the Fordwah-Eastern Sadiqia Irrigation System, Punjab, Pakistan; (ii) Mahi Kadana Right Bank Canal, Gujarat, India; (iii) Muda Irrigation Scheme in northern Malaysia; (iv) Rahad Irrigation Scheme in Sudan; (v) Moulouya ORMVA in Morocco; and (vi) Rio Tunuyan system in Argentina.

Each of these systems differs in terms of agro-ecological conditions, rainfall, crop pattern, performance efficiency and management structures. It is expected that in-depth studies of these systems will provide generic conclusions regarding the determinants of the performance of irrigated agriculture. This research will also suggest a set of performance-enhancing recommendations regarding water delivery and allocations (e.g., fixed rotation), decision-support systems, and water conservation activities.

5 CONCLUSIONS

During the next twenty five years, substantial quantities of fresh water supplies will be diverted from agriculture to industrial and households in many regions. It will be necessary to implement legislative measures and increase industrial water tariffs to encourage water conservation and recycling.

Irrigated agriculture will face twin challenges of water shortages and dwindling financial resources in the coming decades. Despite these challenges, irrigated agriculture will have to provide 70 to 75% of the additional foodgrain requirements to developing countries. This will not be possible without (a) substantial improvements in the productivity of existing irrigation schemes, and (b) investments in new irrigation projects. It is essential that water-use efficiency in irrigated agriculture should be improved with a view to producing "more food with less water". This would require: (i) A review of current policies which have encouraged water-intensive crop rotations such as rice-wheat in arid areas of Asia; (ii) introduction of a comprehensive performance assessment system which provides a consistent set of indicators of productivity, equity and sustainability of irrigated agriculture in various agro-ecological and management situations; (iii) evaluation and adoption of performance-enhancing management practices with respect to water allocation, technological improvements and information processing. The areas which have been identified for further research include those listed below which, it is hoped, the discussions during the Stockholm Water Symposium may provide some answers:

(i) What will be the effects of changes in output and input prices on the environmental and economic implications of rice-wheat rotation in India, Pakistan, China, Mexico and Bangladesh?
(ii) How to get irrigation agencies to change, and accept greater accountability?
(iii) How to provide incentives to farmers to conserve water along with similar conservation measures in industry?

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ORGANIC FARMING - ONLY SOLUTION TO MANY PROBLEMS

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Organic farming is the agricultural system which aims at the cultivation of the land in such a way that the soil biology is kept dynamic with living activities and in good health. At the same time, it keeps environment clean, maintains the ecological balance and provides stability to the production level without polluting soil, water and air. In this method the use of chemical is kept at the minimum, i.e. to the level of bare necessity. This method is self-sufficient and self-dependent as compared to modern chemical farming and relies more on biological inputs. It is concerned with the best use of natural resources and in maintaining the balance between physical and biological components of soil and biosphere. In this system, soil is not only considered to be a physical medium for standing crop but also as a shelter of innumerable living entities. In fact it is the only means to achieve the stable/sustainable target of production. It is feasible by adopting multi-dimensional approach which involves co-ordination and interaction between several major or minor factors, the cumulative effects of which are astonishing (Shroff, 1992, a, b, c; 1993 a and b.; Shroff and Menon, 1994).

I. Top Dressing of Biofertilizers :

The enormous potential of biofertilizers in enhancing the productivity of soil is unquestionable. However, sometimes their potentials are not reflected when used by the farmers because of erratic and inconsistent results and as a result the farmers are reluctant to use biofertilizers as a regular practice even at subsidised rates. This has necessitated to review and reinvestigate the whole aspect of biofertilizer application methods in tropical situation like that of India.

Biofertilizers are conventionally used as a *seed inoculant* at the time of sowing in all *Kharif* (Monsoon) and *Rabi* (Winter) crops. Seed inoculated biofertilizers do not survive under rainfed tropical situations as a result of which no effect or variable effects are observed (Gaur *et al* 1984; Subbarao, 1976).

The major constraints in this respect are the high soil temperature during *Kharif* planting and moist heat energy emitted from the soil during the start of monsoon which make the biofertilizers ineffective. The other factors which also adversely affect the efficiency of biofertilizers have been reviewed by Alexander (1985), Rupela and Saxena (1990), Vyas and Shroff (1991) and many others. In addition to technical difficulties in supplying biofertilizers in a viable form to the farmers during hot summer months, there is a major management problem. By the time it reaches to the users, it almost becomes a zero culture (Sathyam, 1991). To rectify the technical snags and management problems in transport and storage during hot summer months, radical changes in the method and time of inoculation of biofertilizers were planned to be investigated *de novo*.

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Table 1

RESPONSE OF SOYBEAN VAR JS 71-05 TO DIFFERENT METHODS OF BIOFERTILIZER TOP DRESSING.

Yield in q/ha

Tr. No.	Treatment	1991	1992	Mean of two years
1.	Seed Rh	14.68	13.55	14.11
2.	Seed Rh+Gr Rh 15 dae	18.05	17.62	17.83
3.	Seed Rh + Liq Rh 15 dae	16.06	15.23	15.64
4.	Seed Rh+Pellet Rh 15 dae	14.68	13.59	14.13
5.	Liq Rh 15 dae	15.87	13.07	14.47
6.	Gr Rh 15 dae	17.85	17.35	17.60
7.	Pellet Rh 15 dae	15.87	13.48	14.67
8.	Seed Rh+Gr Rh 35 dae	15.27	12.40	13.83
9.	Seed Rh+Liq Rh 35 dae	17.05	12.40	14.72
10.	Seed Rh+Pellet Rh 35 dae	15.07	11.61	13.34
11.	Gr Rh 35 dae	15.67	12.03	13.85
12.	Liq Rh 35 dae	18.44	12.14	15.29
13.	Pellet Rh 35 dae	14.87	11.74	13.30
14.	Liq Rh at sowing	13.88	11.37	12.62
15.	Check	11.27	9.76	10.51
16.	Check Gr 15 dae	11.51	10.56	11.03
17.	Check Liq 15 dae	10.67	9.90	10.28
18.	Check Pellet 15 dae	12.37	9.80	11.08
19.	Check Gr 35 dae	11.03	10.12	10.57
20.	Check Liq 35 dae	10.97	9.86	10.41
21.	Check Pellet 35 dae	11.17	10.08	10.62
22.	Check Liq at sowing	10.98	10.15	10.06
	S.Ed.	2.284	1.074	1.262
	C.D. at 5%	4.63	2.17	2.52

Material and Methods :

Two experiments were conducted at the Indore campus of Jawaharlal Nehru Krishi Vishwa Vidyalaya during the *Kharif* seasons of 1991- 92 to 1992-93 in a Randomised Block Design with three replications. The usual practice of growing Soybean (*Glycin max*), a legume-oilseed, was adopted. Fertilisers (NPK) were applied at the rate of 10:30:10 kg/ha, instead of the usual recommendation of 20:60:40 kg/ha. The sowing was taken up with the onset of monsoon. The usual soil temperature during sowing ranges between 30° to 35°C with fluctuations depending on distribution of rains. Soil analysis report was found to be representative for the area. In the first experiment, 14 different methods of application of biofertilizer (Rhizobia) were tried with 8 checks (given in Table 1). The treatments were usual seed inoculation with rhizobia culture (Seed Rh), the granular rhizobia (Gr Rh), liquid rhizobia (Liq Rh) and pellet rhizobia (Pellet Rh) were given in the standing crop as a 'Top Dressing' at 15 and 35 dae* and also in combination with seed inoculation. Appropriate checks for seed inoculation, granular, liquid and pellet application at 15 dae and 35 dae were kept for comparisons. Seed inoculation was done at the rate of 5 g commercial culture (count 10^9/g) per kg of seed and for top dressing 1.5 kg/ha commercial culture was taken. Granules of biofertilizer were prepared by mixing culture in 50 kg/ha solarized FYM. For solarization of FYM, it was put into polycoated empty fertilizer bags in which 5 litres water was added and kept overnight in a shade. After closing the mouth of the bags next day, it was kept in the sun for 15 days during the month of April/May. During this period average minimum and maximum temperatures were 22°C and 42°C respectively. For liquid suspension preparation per hectare, 1.5 kg culture was mixed with 100 litres of water and stirred thoroughly to make homogeneous suspension. The pellets were prepared by taking granular biofertilizers mixed with equal quantity of soil from the field where it was to be applied. Top dressing of granules, liquid suspension and pellets were done by opening a furrow by shovel of bullock driven two tine seed-cum-fertilizer drill by the side of the crop rows 15 dae and 35 dae. Liquid suspension was put into furrow by specially designed tank with delivery system mounted on seed-cum-fertilizer drill.

Results and Discussion :

In the year 1992 treatments No. 1 to 8 were found to be significantly superior to all checks, whereas during 1991 treatments No. 1 to 11 were found to be superior to checks No. 18 to 21. Combination of treatments, viz., Seed Rh+Gr Rh 15 dae and Liq Rh 35 dae were found to be significantly superior to seed inoculation during 1991, whereas during 1992 combination of treatments, viz., Seed Rh+Gr Rh 15 dae and Seed Rh+Liq Rh 15 dae were found to be superior to seed inoculation. During 1992 treatment Gr Rh 15 dae too was found to be superior to seed inoculation at sowing. Further, the results revealed that the combination of treatments, viz., Seed Rh+Gr Rh 15 dae was found to be significantly superior to seed inculation alone in both the years. During 1992, combination of treatments, viz, Seed Rh+Liq Rh 15 dae and Gr Rh 15 dae alone and during 1991 Liq Rh 35 dae were found to be significantly superior to seed inoculation. Hence, it may be concluded on the basis of experiments of two years that the seed inoculation in the legume crop like soybean at the time of sowing may not always give significantly superior performance in comparison to check(s). Seed incoculation coupled with Gr Rh 15 dae was found to be significantly superior to seed inoculation as well as to all checks.

The average of two years *Kharif*, 1991 and 1992 (Table 1) indicated that the treatments No. 1 to 12 (except No. 10, i.e. Seed Rh+Pellet 35 dae) had been significantly superior to all checks. The treatment combination, viz. Seed Rh+Gr Rh

* *dae = days after emergence*

15 dae, was found to be significantly better than seed inoculation alone and seed Rh+Pellet Rh 15 dae. Application of Gr Rh during 15 and 35 dae was significantly superior to liquid and Pellet Rh.

Little information is available on the method(s) of application of biofertilizers other than seed inoculation. On chick pea the soil inoculation with rhizobia (Anonymous, 1952) at IARI, New Delhi and liquid suspension application in the furrow at ICRISAT, Hyderabad, India (Nambiar *et al.*, 1984) in groundnut, *Arachis hypogaea,* were observed to give superior performance.

Hence, it is concluded that the use efficiency of Rhizobia can further be increased under tropical situations by changing the method and time of application of seeds inoculated with rhizobia along with granular rhizobia application as top dressing during 15 dae. Even granular rhizobia treatment alone at 15 dae was found to be significantly superior to rhizobia used alone as a seed inoculant.

II. Response of Biofertilizers at different Fertilizer levels :

Material and Methods :

To find out response of biofertilizers at different fertility levels on the yield of soybean variety JS71-05, second set of experiment was conducted at Indore during Kharif 1991, 1992 and 1993. The details of the treatments are given in Table 2. Biofertilizers, viz., Rhizobia (Rh), Phosphorus solubilizing microorganism (PSM) and Mycorrhiza (VAM) were given at the time of sowing as *seed inoculation.* Moreover, inoculated seeds were mixed with 1000 kg of compost per hectare at the time of sowing. Compost is an organic source of nutrients and an ideal carrier of biofertilizers which sustains biofertilizers against plausible adverse conditions.

Results and Discussion :

Spectacular response from biofertilizers Rh and PSM alone or in combination, (without any fertilizers or) with phosphatic fertilizer (half dose of P_2O_5) in all the three years caused significantly higher yield in comparison to that in control. Maximum yield of 27.36 q/ha was obtained with the treatment F+Rh+PSM. Rh as well as PSM without fertilizer and with half dose of P_2O_5 gave significantly higher yield in comparison to that of control.

Application of FYM appeared to have enhanced the use efficiency of biofertilizers. Ahmed and Jha (1977) also reported pronounced effect of PSM when FYM was mixed in the soil. The results of this innovative experiment also clearly indicated that the use efficiency of biofertilizers increased when applied even with a small dose of compost.

It was further boosted when two or more of them (Rh+PSM, Rh+VAM, Rh+VAM+PSM) were applied together, suggesting synergism. The use efficiency of chemical fertilizer, particularly that of phosphorus, also increased with the application of PSM and VAM, which act as phosphorus and mineral solubiliser and prevent their fixation. They also bring fixed phosphorus into soluble forms. Thus, it is inferred that dependence on chemical source of phosphorus in the form of fertilizers can be reduced to half without affecting the yield of crops.

Table 2

RESPONSE OF BIOFERTILIZERS AT DIFFERENT FERTILITY LEVELS ON THE YIELD OF SOYBEAN CROP VARIETY JS 71-05

Yield in q/ha

Tr. No.	Treatment	1991	1992	1993	Mean of three years
1.	Control (without fertilizer)	14.56	21.53	28.38	21.49
2.	Rh	18.31	23.56	29.94	23.93
3.	VAM	16.12	22.46	30.20	22.92
4.	Rh + VAM	19.87	25.56	3072	25.38
5.	PSM	19.41	25.49	28.64	24.51
6.	Rh + PSM	21.13	26.76	29.16	25.68
7.	VAM + PSM	18.31	22.96	31.51	24.26
8.	Rh + VAM + PSB	19.88	26.42	30.99	25.76
9.	NPK (F) 20:30:40	17.07	22.91	30.46	23.48
10.	F + Rh	19.26	25.04	30.46	24.92
11.	F + VAM	18.95	23.90	30.20	24.35
12.	F + Rh + VAM	21.76	26.82	30.20	26.26
13.	F + PSM	20.20	26.47	30.20	25.62
14.	F + Rh + PSM	22.07	26.94	33.07	27.36
15.	F + VAM + PSM	19.40	24.94	30.20	24.84
16.	F + Rh + VAM + PSM	20.51	26.50	32.03	26.35
	S. Em.	0.875	0.311	0.624	0.646
	C.D. at 5%	2.490	0.888	1.778	1.827

III. Response of Soybean to Top Dressing of Biofertilizers :

Material and Methods :

On getting clue from detailed experiments, simultaneously a third set of experiment was conducted during 1992 and 93. The details of treatments are given in Table 3, where biofertilizers (Rhizobia @ 1.5 kg/ha and phosphorus solubilizing microorganism (PSM) @ 3 kg/ha) were given as top dressing alone or with half dose of chemical fertilizers. The usual cultivation practice was adopted.

Results and Discussion :

Rhizobia or PSM (alone) gave significantly better performance with half dose of chemical fertilizer or without chemical fertilizer. However, combining Rhizobium + PSM with half dose of chemical fertilizer gave synergistic effect in significantly increasing production in comparison to application of Rhizobium and PSM applied separately. The same trial was repeated during 1993. Granular application of biofertilizers in combination with half dose of chemical fertilizers gave significantly higher yield in comparison to half and full dose of chemical fertilizers, indicating increase in the use efficiency of chemical fertilizers also.

Table 3

RESPONSE OF SOYBEAN VAR. JS 71-05 TO TOP DRESSING OF BIOFERTILIZER

Yield q/ha

Tr. No.	Treatment	1992	1993	Mean of two years
1.	Full fertilizer, 20:60:20 NPK kg/ha	19.44	23.38	21.41
2.	Gr Rh	16.11	28.12	22.16
3.	Gr PSM	16.77	27.64	21.21
4.	Gr Rh+PSM	18.27	27.65	22.96
5.	Check	14.16	21.98	16.81
6.	Half fertilizer (F) (10:30:10)	16.11	18.56	17.34
7.	F + Rh	19.33	27.98	23.66
8.	F + PSM	18.88	27.64	23.26
9.	F + Rh + PSM	20.55	29.24	24.91
	S. Ed.	1.197	1.232	1.214
	C.D. at 5%	0.399	2.52	2.42

Management of Organic Nitrogen :

The essence of organic farming in relation to management of plant nutrients is not only an organic manure farming, but it involves an approach to strike and maintain a balance between crop plants and its soil physical and biological environment, which consists of soil, water, air, soil organic matter, flora and fauna present in the soil, their interaction with one another, and the physical and physiological influences impinged upon them by the physical environmental factors (Shroff and Menon, 1994a).

The dependence on chemical - fertilizer source of plant nutrients can be reduced to a great extent, even for nitrogen if **Integrated Nutrient Supply Management** is adopted (Shroff and Menon, 1994a; Singh *et al.*, 1994). The inference drawn (Anonymous, 1994) reveals that the cropping system and biofertilizers can contribute around 50 per cent requirement of nitrogen and other nutrients, whereas the organic manure, availability of which is limited, can contribute to 25 to 30 per cent. On the basis of this knowledge, available information on crop rotation/crop sequence, inter and mixed crops, green manuring inter-crop (cowpea) use as mulch, biofertilizers, etc., certain experiments/demonstrations were laid out and their results reviewed *de novo* to verify the facts.

IV. Crop Sequence :

The crop sequence of Legume - cereal/millets has a definite role in making available organic/biological nitrogen fixed by legumes, the benefit of which is derived by a subsequent crop of wheat/rice. Yield of wheat, followed by a legume crop like green or black gram, is higher in comparison to sorghum-wheat sequence (Table 4).

Effect of legume like pigeonpea or black gram with or without rhizobial treatment on the yield of subsequent crop of wheat and rice followed by chickpea resulted in a distinct increase in yield levels when preceding crop was inoculated with Rhizobia (Table 5) (Rao, 1980; Singh and Jain, 1984).

Table 4

RESIDUAL EFFECT OF N FIXED BY LEGUME ON SUBSEQUENT CROP

Preceding crop	Succeeding crop	Yield (q/ha)
Sorghum *(Sorghum bicolor)*	Wheat *(Triticum aestivum)*	36.60
Green gram *(Vigna radiata)*	Wheat	38.80
Black gram *(Vigna mungo)*	Wheat	45.70

Table 5

EFFECT OF LEGUME (WITH AND WITHOUT RHIZOBIAL TREATMENT) ON YIELD OF SUBSEQUENT CROP

Legume	Inoculation status	Subsequent crop	Yield of cereal (q/ha)
Pigeonpea	Not inculated	Wheat	20.75
(Cajanus cajan)	Inoculated	Wheat	24.15
Black gram	Not inoculated	Wheat	20.25
	Inoculated	Wheat	21.25
Chickpea	Not inoculated	Rice	25.15
(Cicer arietinum)	Inoculated	Rice	27.15

V. Influence of Companion Legume Crop on Grain Yield of Sorghum :

Material and Methods :

Studies were carried out at Indore under the auspices of All India Coordinated Sorghum Improvement Project to study the benefit of growing sorghum with companion legume as a intercrop. The objective of this investigation was twofold (Anonymous, 1988-1990) :

i) Assess the benefit of biological nitrogen (N transfer) to sorghum crop by a companion crop legume and

ii) Quantification of the nitrogen made available by cowpea which has an enormous potential to fix nitrogen through symbiotic rhizobia (Subbarao, 1975).

Although much of the fixed nitrogen is translocated to grains, the nitrogen released by nodules through decomposition during life time or after harvest of legumes may be available to companion or subsequent crop which influences the yield (Singh and Jain, 1984). Any legume achieves peak of fixed nitrogen by the time of flowering, and if at that time it is cut and used as a mulch the fixed nitrogen can be utilized by the companion crop.

Results and Discussion :

Sorghum grown with cowpea (fodder) (*Vigna cylindrica*) used as a mulch after 45 days recorded significantly higher grain yield in comparison to that of sole crop (Table 6). Maximum gain in yield (130%) was observed at lowest fertility level, viz., 20:10:10 kg/ha of NPK. It was closely followed by yield gain with 40:20:20 kg/ha of NPK.

This suggested that the companion crop cowpea (fodder) used as mulch contributed 20 to 30 kg N/ha and also provided cover, protecting the microbial activities and loss of water from soil surface. On comparison of the results of sole crop of sorghum and sorghum+cowpea (fodder) it revealed further that at low and medium fertility level there was substantial gain (5 to 7 q/ha) in sorghum grain production when grown with cowpea.

Although the grain yield of sorghum exhibited increase when grown with pigeonpea, it was negligible. Pigeonpea is known to exert maximum competition with sorghum plants and hence some decline in the yield of sorghum is observed (Rao and Willey, 1980; Singh and Jain 1984).

However, it was interesting to note that pigeonpea yielded about 600-700 kg grain/ha when grown with sorghum as a companion crop. Thus, the *total grain produced* per unit area and economic return were more in sorghum-pigeonpea intercropping as compared to sorghum alone.

Sorghum+FYM 5 t/ha too affected the yield at different levels of fertility in comparison to sole crop of sorghum at the same fertility levels.

It is concluded that the companion legume crop is advantageous in increasing the production and economic return per unit area at the same fertility level, followed by sorghum+FYM 5 t/ha, in comparison to sole crop of sorghum.

Table 6

INFLUENCE OF COMPANION LEGUME CROP ON GRAIN YIELD OF SORGHUM

Yield in kg/ha

Tr. No.	Treatment	1988	1989	1990	Mean of 3 years	Percentage increase
1.	Sorghum+Cowpea 80:40:40	3388	4074	3577	3680	104
2.	Sorghum+Cowpea 40:20:20	2688	3056	2851	2865	128
3.	Sorghum+Cowpea 20:10:10	2358	2328	2341	2342	130
4.	Sorghum+PP 80:40:40	2694	3457	2824	2992	87
5.	Sorghum+PP 40:20:20	2423	3000	2432	2618	117
6.	Sorghum+PP 20:10:10	1933	2047	1636	1872	104
7.	Sorghum+FYM 5t/ha 80:40:40	3152	3760	3510	3474	99
8.	Sorghum+FYM 5t/ha 40:20:20	2681	2323	2283	2429	108
9.	Sorghum+FYM 5t/ha 20:10:10	2068	1834	1911	1938	108
10.	Sole Sorghum 80:40:40	3557	3472	3515	3515	
11.	Sole Sorghum 40:20:10	2084	2442	2170	2232	
12.	Sole Sorghum 20:10:10	2092	1783	1510	1795	
13.	Sole Sorghum No FYM, No NPK	1672	1513	708	1298	
	C.D. at 5%	643	830	802		

VI. Integrated Nutrient Supply Management :

Material and Methods :

The encouraging results of crop sequence of legume-cereal, legume inoculated with rhizobia/PSM, on subsequent crop and companion cropping prompted to laid out a large scale demonstration at the College of Agriculture, Indore during *Rabi* 1993-94. The crop sequence followed was soybean (inoculated) and wheat, soybean (inoculated) and linseed, *Linum usitatisimum*. The details of the demonstrations are given in Table 7 and 8.

Crop History of Preceding Crop :

The preceding crop soybean was given only 16 kg P_2O_5 through rock phosphate (on the basis of soil analysis). Nitrogen and potash (through chemical fertilizers) were not given. Granular biofertilizers consisting of Rh 500g, Azo 500g and PSM (Nafed) 1500g mixed with seed was given at the time of sowing as seed treatment. This method differs from seed inoculation because in case of seed inoculation the biofertilizers are given on seed surface.

Again Rh 500g, Azo 500g and PSM 500g in granular form were drilled 20 days after the emergence of the seedlings, with two tine bullock driven drill at a depth of 10-12 cm between the rows of soybean in the rhizosphere. Growth of weeds was restricted either by operating bullock driven small blade harrow or by cutting/pulling out weeds and using it as a mulch. Damage from insects was well within threshold value, hence no plant protection measure was required. On an average, yield of 16.62 q/ha was obtained at 60% cost in comparison to conventional cultivation practice. Moreover, cost-benefit ratio was 1:3.79. The soil analysis report (Table 8) revealed that after harvest the amount of available phosphorous increased from 7.86 to 13.18 kg/ha because of the use of PSM. With this knowledge, large scale demonstrations on wheat and linseed were laid out. The details of the demonstrations are given in Table 7 and 8. It may be noted that no chemical fertilizer was used.

Table 7

INTEGRATED NUTRIENT SUPPLY MANAGEMENT

S. No.	Particulars	C R O P/Variety			
		Wheat Tall Sujata	Wheat Dwarf WH 147/Lok-1	Linseed ILS 252	Linseed ILS 73-25
1.	Area (ha)	3.00	3.50	5.50	6.50
2.	Date of sowing	2nd Fortnight Oct. 1993	1st Fortnight Nov. 1993	1st Fortnight Nov. 1993	2nd Fortnight Nov. 1993

S. No.	Particulars	CROP/Variety			
		Wheat Tall Sujata	Wheat Dwarf WH147/Lok-1	Linseed ILS 252	Linseed ILS 73-25
3.	Biofertilizers at sowing, Granular form per ha	Rhizobia 500g Azotobacter 500 g Azospirillum 500 g PSM (phosphine) 1500 g Application of granular form in wheat as well as in linseed			
4.	Biofertilizers as Top Dressding, Granular form per ha	Rhizobium 500 g Azotobacter 500 g PSM 500 g Application of Granular form by broadcast method in wheat			
5.	Irrigation	2	2	1	1
6.	Legume as companion crop	Self sown Soybean 10% Chick pea2%	Self sown Soybean 10% Fenugreek 2% Mustard 1%	Self sown Soybean 10% Mustard 1%	Self sown Soybean 6% Fenugreek 2% Mustard 2%
7.	Interculture	Weeds and Soybean pulled out at 40 days stage and used as a green mulch			
8.	Yield q/ha	14.40	20.85	9.61	7.46
9.	Cost - Benefit Ratio	1:3.39		1:4.73	

Note: No application of NPK in the form of chemical fertilizer. Fenugreek (Trigonella foenum graceum). Mustard (Brassica compestris) Brown Sarson.

Table 8
SOIL ANALYSIS REPORT
1993-94

Crop	Soil Analysis at	pH	EC	OC%	Available Nutrients kg/ha N	P	K
Soybean	Before planting	8.0	0.20	0.48	190.31	7.86	600.00
	After harvest	7.9	0.18	0.49	192.79	13.18	664.74
Wheat/ Linseed	Before planting	-do-	-do-	-do-	-do-	-do-	-do-
	After harvest	7.8	0.20	0.52	207.60	12.00	649.00

Results and Discussion :

The yield of tall durum wheat var **Sujata** was 14.90 q/ha, while the dwarf wheat (aestivum) gave 20.85 q/ha and the yield of linseed (var ILS 252) was 9.61 and linseed (ILS 73-25) was 7.46 q/ha. For the above level of production of wheat and linseed the requirement of nitrogen was around 50 to 60 kg/ha. Available nitrogen level in the field was low, which indicated that 50 to 60 kg of nitrogen per hectare was contributed by Azotobacter Azospirillum and legume (companion crop) rhizobia. Soil organic carbon, which is the source of energy for microbial life and also a direct source of organic nitrogen and other nutrients in a balanced form, too must have contributed in fulfilling the requirement of nitrogen nutrition. The results indicated that nitrogen up to the level of 50 to 60 kg/ha can be managed from biofertilizers, companion legumes and organic matter/carbon present in the soil. Soil analysis report also revealed that available nitrogen status had increased from 192.79 to 207.60 kg/ha - an indication of enough nitrogen fixation and presence of residual nitrogen after crop harvest (Table 8).

Results of experiments and large scale demonstrations revealed that there is sufficient scope to harness **organic source of nitrogen** for legumes as well as for cereal/millets. To achieve the goal of **integrated nutrient supply management,** the following steps are suggested :

(a) Sequence crop, legume-cereal/millet.

(b) Legume as companion (inter/mixed) with cereal/millets/oil seed.

(c) Use of mixed biofertilizers, preferably in granular form.

(d) Use of organic manure (FYM/compost). If not available in full then it may be used even in smaller quantity.

(d) Chemical fertilizers response gets enhanced on use of granular biofertilizers and on adoption of companion planting.

SUMMARY

The following conclusion is drawn on the basis of different sets of experiments:

1. Use efficiency of Biofertilizers gets enhanced when applied in granular form at the time of sowing or even as 'Top Dressing' 15 dae.
2. Use efficiency of biofertilizers is further boosted when two or more are applied simultaneously.
3. PSM and VAM, both phosphorous (mineral) solubilizers, enhance the use efficiency of phosphorous whereby its dose can be halved, without affecting the crop productivity.
4. Compost/FYM application even in smaller quantity is found to pronounce the effect of biofertilizers, vis-a-vis that of chemical fertilizers.
5. Results of the different sets of experiments over years and their verification on large scale on farm demonstrations make it clear that the **organic sources of plant nutrients have an enormous potential.** If this potential is judiciously harnessed, then **dependence on chemical fertilizers can be reduced** without affecting the crop productivity.

Thus **organic farming** approach will not only be sustainable, with enormous potential even for high crop production, but would be a **solution to many problems.**

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CHEMICAL POLLUTION AND SALINITY INGRESS IN THE IRRIGATED AGRICULTURE OF DEVELOPING COUNTRIES

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1.0 The present tendency in major countries of the world is to try to increase production, particularly of the foodgrains, to meet with the challenge of feeding the hungry mouths being added every year as per problematic demographic pattern of growth in the developing countries. It is also for meeting with the needs of supplying these foodgrains to the developing nations on humanitarian grounds, which indirectly awards political and other control over them by the developed countries of the world. This is planned by providing maximum possible infrastructural support of water, fertilisers, pesticides etc. to land. This rush after increasing agriculture production have resulted in many places in deterioration of land and water use in quality as well as on economic returns. Apart from creating the conditions of scarcity of available water, free from chemical hazards from polluting industries not only for drinking water but have posed problems even for the purpose of agricultural development in the coming decades. Whereas the problems created by chemical pollution from the industrial wastes or from the use of sewage effluent etc. are within the reach of solution in a time bound manner through proper legislative measures, the problems created in the irrigated commands on a long term use of ground water require lot of scientific efforts to set right the water balance in quality and required quantity for its safe and productive use. In fact planners of the economic development of the world have apprehended severe shortage of water required for drinking and agricultural purposes at the beginning of the next century if timely remedial measures to curb chemical pollution, ingress of saline water and factors contributing to the degeneration of the water quality are not timely taken. General public awareness has appeared at global level through efforts of environmentalists and ecologists to control pollution in all economic sectors but particular reference and stress is needed for a major sector like irrigated agriculture of developing countries to take timely remedial measures in this regard before it is too late.

2.0 India occupies 2% of the world's area but has about 16% of population of the world's population. The livelihood of the almost three quarters of population depends directly on agriculture or agro industries. 30% of India's GNP

(Gross National Product) is derived from agriculture area which in turn, depends on land and water resources. It is, therefore, imperative to manage properly its scarce land and water resources to ensure sustainable economic growth. So far as land is concerned, India has the geographical area of 328 million hectares,out of which present cropped area sown is about 141 million hectares. The present population of the country is 870 millions - the second largest in the world, next to the China only. This gives cropped areas of one hectare for 6.2 persons, which is not an unsustainable figure if proper measures are taken.

2.1 So far as water is concerned, although India possesses 4.9% of the total average annual runoff in the rivers of the world, the per capita water availability from the surface as well as from the groundwater sources is assessed as 3200 cubic metre per year compared to the availability of more than 17,500 cubic metres in U.S.S.R., 6500 cubic meters in Japan and 6200 cubic metre in USA. The continuing decreasing of the scares land and water resources of India, by chemical pollution, defective water management, faulty economic policy of subsidy on fertilisers, pesticides etc. will, however, reduce the figure of 3200 cubic metre further, making water's availability more scare. With this situation, great care will have to be taken in expanding industries & granting subsidy on basic agriculture inputs like fertiliser, pesticides for the promotion of their use for achieving the increased agriculture production through irrigated commands of various projects not only in India but in other developing countries also.

2.2 With all the above hazards pointed out, role of irrigation in economic development of developing countries has not been under estimated by the planners of any country including India and its growth is planned accordingly.

3.0 IRRIGATION GROWTH

Irrigation, being the main primary input for development of irrigated agriculture of any country, has received its due priority in planning of the development programme of the developing countries by the authorities in charge of the same. In India, Planning Commission has taken care to ensure allocating funds on priority basis for irrigation sector keeping it in the core sector of planning. The international bodies like World Bank, Asian Development Bank, UNESCO, World Health Organisation, FAO assigned priority in development of water resources as a main item in the most of their programmes of development of agriculture and health, in developing countries of Africa and Asia. The spontaneous growth of irrigation during the past 30 years from the pre-independence level of 22 million hectares to 80 million hectares irrigation potential created by the end of 7th Five Year Plan confirms this fact.

4.0 STATUS

Chemical pollution, particularly, on drinking water and salinity ingress in the irrigated commands is a world wide problem. Recent survey indicated that out of the 756 million hectares cultivated and 91 million hectare irrigated area in 24 countries, over 50 million hectares are affected by salinity. Salinity is a potential input to about 50% of 20 million hectares of irrigated land in Western USA, with cropped production already limited by salinity of about 20% of this land.

4.1 In India, estimated 3.3 million hectares of otherwise cultivated land is unproductive due to salt problems 3.3 m ha under saline soil conditions and 0.24 under alkali soils (Ref. Report of Working Group chaired by Mr. C.G. Desai, Adviser (Irr. & CAD), Planning Commission, Govt. of India, New Delhi while large area suffers from the decreased productivity due to indiscrete use of chemical fertilisers, pesticides and various organic points disturbing the salt balance of the soil. This is also contributed by the use of sewage effluent, sludges etc. coming out from severage treatment plant of municipality and other local bodies and chemical treatment plants of private industries.

5.0 EFFECT ON PRODUCTIVITY

So far as, irrigation project is concerned, a surface water irrigated system falls pray to faulty water management, improper use of land and water and lack of timely measures such as providing adequate drainage to prevent water logging etc. In the absence of strict managerial control, the farmers use excessive water on their fields, resulting thereby in suffocating the root zones of the plant which affect productivity and at the same time brings ingradient salts at the surface to create saline conditions for unhealthy growth of the plants. In case of irrigated agriculture through tubewells, over exploitation of the ground water particularly in area already recharged with water containing high chemical ingredients like Fluorides, is the main cause for resulting in salinity ingress disturbing the salt balance of the soil completely. This has happened along the coastal belt of Saurashtra region of Gujarat for reclamation of which a special World Bank assisted project of Prevention of salinity ingress in coastal regions is in progress. The productivity of the soils in the irrigated commands growing high water requiring crops like Sugarcane, Paddy have gone down considerably. The Ukai Project in Gujarat is one among many such effected projects having their irrigated commands deteriorated due to excessive water application and indiscrete use of chemical fertilisers and pesticides.

6.0 ROLE OF FERTILISERS

The use of fertilisers in India from the year 1962-63 to 1991-92 is depicted in Table No.1 showing Fertiliser consumption Vs. foodgrains production for these years. It depicts very interesting research studies on use of fertilisers in India. Whereas fertilisers consumption has increased nearly 25 times during the last three decades, the foodgrains production has not kept pace with it. Foodgrains production increase is mainly due to the outcome of High Yielding Variety of crops associated with simultaneous spontaneous growth of irrigation. The Table reveals that the use of fertilisers has remained constantly increasing from year to year. The foodgrain production by and large, remained at a slow growth, indirectly implying possibility of some more doses of fertilisers than required by the plants. With the good weather condition and irrigation facilities available, about 150 million tons of foodgrains could be produced with the use of 7710 thousand tonnes of fertilisers in the year 1983-84 while with practically 50% more use of fertilisers in other years, the increase in foodgrains is marginal which indirectly hints at possibility of undue use of fertilisers to some extent. The average consumption of fertilisers in 1990-91 in India is 75.2 kg. per hectare of aerable land against the average of 300.7 kg. per hectare in China, 451.7 kg. per hectare in Korea & 387.3 kg per hactare in Japan. Sometimes because some advanced rich farmers use more than 200 kg./ha of fertilisers per hectare, as in Punjab, an impression is created that Indian farmers have attained the level of International development of Agriculture Technology. This impression is, however, belied by the figure of the average fertiliser's consumption. Whereas it may be true for farmers of Punjab & Haryana, by and large, in general it is not true.

6.1 This higher dose of fertilisers is creating problems to disturb the salt balance which in turn effects the productivity of land. In India, fortunately because of the financial limitations of the farmers to purchase chemical fertilisers, the situation is not alarming but where the farmers are rich, the situation does require immediate attention as it has happened in Ukai Kakrapar project (Gujarat State, India) where the productivity of sugarcane during the last 10 years has come down to the extent varying from 20% to 40% because of excessive use of chemical fertilisers and excessive water applications. At the global level, Uphratis and Tigres rivers of Iraq one time had highly productive irrigation commands but it is said that excessive use of chemical fertilisers, pesticides have brought down the level of production of their soil to an alarming level. It is, therefore, necessary to take a lesson from these countries by the developing countries of the world and safeguard the future of their agriculture production by resorting to timely measures on monitoring the use of chemicals, controlling chemical pollution, salinity ingress and such other adverse effects affecting the growth of agriculture in their country.

7.0 SCARCE LAND AND WATER RESOURCES

The total annual precipitation in india is assessed as 400 M.Ha. meter today of which utilisable runoff is assessed as 70 M. ha. m. only which is totally inadequate to meet with its demand of Agriculture, industries and domestic needs. The total irrigation potential of the country from surface as well as Ground water is assessed as 113 million ha only. It is therefore, imperative to find out and tap all available alternatives to meet with this scarcity. The net area sown in India is practically stagnant at level of 141 ha for the last two decades. It is therefore imperative to find out and tap all available alternatives to meet with this scarcity. The net area sown in India is practically stagnant at level of 141 m.ha for the last two decades. It is therefore necessary to have more intensive cropping to meet with targets of agriculture production required to feed nearly 1.2 billion population expected by turn of century.

Use of effluent water, recycling, after treatment, sewage waters, use of brakish water, resorting to special crops resisting chemicals etc. are some of the measures being practiced to meet with the challenges of scarce water and land.

8.0 EFFLUENT WATER IRRIGATION

The need of utilising effluents for the cause of irrigation is being realised in the country in view of the growing demand of fresh water in other sectors. Attempts are also being made to treat such waters before giving for field use. Because of the very high initial cost of establishment of such plants, the effluent water is being directly disposed off by some industries and is used by the farmers, which creates problems on crop, soil ecology and human health. Since the total check on the use of raw effluents for irrigation is unavoidable, it is necessary to have a defined policy to minimise the risks involved with the use of this.

8.1 Water Resources and their Pollution

Pollution problem is more severe with surface waters. However, this also extends to ground waters because of agricultural intensification, urbanisation and industrialisation. Pollution from industrial sources is expected to increase as the use of water for industrial purposes increases. A rough estimate of the industrial water requirement pattern indicates an increase of water demand by 20 fold by the turn of the century.

Low flows during summer combined with increased water withdrawals and increased disposal in the river systems are likely to aggravate the pollution problem further. Fertiliser, petrochemical, tanneries and rayon industries have been identified as the worst polluters of the water (Tables 2 & 3) resources both in the ground and on the surface.

8.2 Agricultural Fields

Agricultural fields depending upon the type of water used for their irrigation could be divided into two categories. Firstly, the fresh water; irrigation from canal, tubewell and small tanks, posing practically no danger to pollution: and secondly, the contaminated water - irrigation from effluents of industries and cities. Various hazardous contaminants observed in these effluents are nitrate, phosphate, fluoride, chromate, cynide, boron, chromium, nickle, copper, zinc, arsenic, selenium, molybdenum, cadmium, mercury, lead and alcohols. The intensive use of these waters results into water logging, salinity and pollution of soil and crop with hydro carbons, heavy metals, etc. Besides use of effluent water other practices like the use of herbicide, pesticide, etc. are also contributing greatly to the pollution of water resources.

8.3 Industries

Intoxicating smokes and hazardous effluents are emitted out in the air and drains from the industries. These toxic elements are recycled to the surface and subsurface layers alongwith the precipitation and irrigation, affecting the quality of surface and subsurface water. Nature and extent of the problem of soil and water pollution, however, varies with the industrial unit and its treatment facilities.

8.4 Urbanisation

City refuge and effluents contain lot of contaminating ingredients both of the organic and inorganic nature. Besides, infectious and contagious diseases causing organism are also found in it. Amounts of disposal available from various cities and towns of India are given in Table 2 & 3.

8.5 Water Resources System Pollution-Ground Water Pollution

Groundwater surveys conducted in the country indicate a sever problem of groundwater contamination with minerals and heavy metal contamination in the industrial wastes. Hydrocarbons and alcoholic substances which are very harmful for biological system are found in the groundwater near petrochemical industries and sugar factories. When such a water is utilised for irrigation, this contaminates soils and the crop as well.

Major rivers like Ganga and Yamuna are facing acute pollution problem mainly because of industrial and urban growth on their banks. Similarly many other river systems of the country are facing grave problems of contamination.

9.0 IMPACTS OF POLLUTED WATER ON IRRIGATION AND AGRICULTURAL SYSTEM

Salt Balance Study

Soil is composed of physico-chemical and biological ingradients. When these are present in a balance, the soil exhibits its productivity highest. The soil is rendered unproductive and problematic when the composition is un-balanced. Polluted waters obtained from the effluents of industries, cities, or towns contain very high doses of contaminants which can alter the productivity of soil considerably. The permissible limits of the contaminants in the soil increase with 3-4 waterings of such polluted water. Permitted level and normal range of inorganic pollutants present in the soil are shown in Table 4.

Table - 4 : Recommended maximum allowable level and normal range of pollutants

Elements	Permitted level of addition g/ha year	Normal range in soil mg/kg
B	4500	-
Cr	20000	-
Ni	1400	2-100
Cu	5600	2-60
Zn	11200	25-200
As	200	5-100
Sc	100	1-2
Mo	100	1-5
Cd	100	1-2
Hg	40	
Pb	20000	10-150

9.1 Effect on Vegetation

Vegetation comprises all those organisms which manufacture their food from sunlight. Unlike human beings, these are also very sensitive to adverse conditions. With the injudicious use of contaminated polluted water to irrigate,such a situation is very easily invited. Most of the lands around cities and towns are being rendered non-vegetative and barren because of soil pollution. Consequently, an ecological imbalance is created in and around the cities and industries. Most of the crops and plant species are not able to survive under the contaminated condition and are, therefore, vanishing. It might be due to the plant's reduced immunity caused in the wake of excessive accumulation of minerals and toxic elements in the plant body.

9.2 Effect on Crop

Composition of crop is also considerably changed in the areas receiving contaminated irrigation water. Very high concentration of Nitrate, Zinc, Lead, Boron, Arsenic, Cadmium etc. is reported in the vegetables, specially leafy when grown with sewage water. A WHO report, based on the survey conducted in UK during 1975 indicates that the uptake of metal in daily diet is increasing at an alarming rate. With the continuous use of such food grains and vegetables an alarming situation for human health may arise by the turn of century.

9.3 Effect on Animal

Animal health, in general, is very poor in the areas receiving irrigation water from sewerage or industrial effluents. It may be because of the infectious condition prevailing within the locality. Some of the animal species, viz. sheep, goat, buffalos and cows find it difficult to survive in the polluted environment. However, the health of the pig is normal and in some of the cases it is good.

10.0 FISCAL MEASURES

In order to achieve the targeted food grain production by ensuring required input of fertilizers, pesticides and water, a considered policy of providing subsidy in the price structure of these items has been provided. Water charges are highly subsidized which has resulted in waste of water due to indiscrete application at fields and created problems of water logging and salinity. Similarly high dose of subsidy on fertilizer, pesticides and other agriculture chemicals have resulted into unwarranted use of fertilizer by the rich farmers. The original idea of promoting use of fertilizers by providing subsidy was to encourage small and marginal farmers who have financial limitations but the studies of flow of subsidy amongst the farmers have revealed that it is a group of richer farmers who have availed of these higher dose of subsidy-as much as 85 percent of this amount of subsidy has gone into the hands of such richer farmers,while the poorer farmers have continued to use organic fertilizer to the extent available in their reach. It is high time to cut down the subsidy of fertilizer, pesticides to prevent its indiscriminate use posing thereby disturbance in the salt balance of the soil affecting productivity. Simultaneously power tariffs for agriculture use for ground water development also need detailed review as like water charges these are also subsidised. Such fiscal measures, howsoever unpleasant they may be, are over due now for preserving the quality and productivity of land and water in the developing countries.

11.0 OTHER PREVENTIVE MEASURES

In order that undesirable salts do not pass on from one irrigated land to another irrigated land, it is necessary to build up inland reservoir where such salty water is collected and the salt deposited are periodically removed to maintain these reservoirs for long term use. Similarly for prevention of sea water ingress into the irrigated track judicious use should be made of available ground water in the command areas by restricting the pumping hours of lifting to optimal limit of depression and constructing regulators so that there is no scope for sea water to enter into the land creating salt problems.

The most important measures, however, required to be carried out by the project authorities in charge of the irrigation command is to have salt balance studies carried out periodically - Ist before commencement of irrigation on completion of the project and to have periodical review of the status of salt balance of soil in irrigated command say by period of five years so that on the course correction in application of irrigation as well as timely remedial measures could be taken up through resorting to use of gypsum treatment, cropping pattern of salt resisting varieties etc. could be implemented in time.

12.0 CONCLUSION

The ultimate objective of any developing activity is to provide healthy environmental conditions for good human health while fulfilling its target laid. Various factors like quality and quantity of food, surrounding atmosphere, social structure and economic activities of the masses for industrial and other sectors contribute a great deal to the human health. Crops cultivated with contaminated water contain a very high dose of chemicals which are not conducive for sound health and they are therefore not acceptable even from health standard prescribed by World Health Organisation and other authorities. The ecology is adversely affected because of the contamination of crop, soil, animals and agriculture products which have not only varying amount of organic and inorganic chemicals but have many pathological contaminants. It is likely to endanger the physico- chemical and biological properties of the soil as well as the chemical composition of agro-products. Therefore while formulating the policy for the utilisation of city effluents, industrial waste, re-cycling sewage water, adequate attention needs to be given to protect the environment and crops from the evil effects of effluents. Pollution Control Boards set up by Government should have wide powers for regulation and enforcement. Systematic research studies for salt balance need also to be taken up to find the curative treatments of evil effects in a scientific way which would provide timely action, as remedial measures taken in time would ultimately result not only in saving in the cost but would also ensure success of its objective.

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Table 1- Fertiliser consumption vs foodgrains production 1963-63 to 1991-92

Year	Fetiliser consumption (all nutrients) ('000 tonnes)	Grss cropped area (million hectares)	Gross area under HYV crops (million hectares)	Gross irrigated area (million hectares)	Weather (for purpose of agricultural production)	Foodgrains production (milloin tonnes)
1962-63	452	156.8	-	29.5	Average	80.2
1963-64	544	157.0	-	29.7	Average	80.6
1964-65	773	159.2	-	30.7	V.Good	89.4
1965-66	785	155.3	-	30.9	V.Poor	72.3
1966-67	1101	157.4	1.9	32.7	V.Poor	74.2
1967-68	1539	163.7	6.0	33.2	Good	95.1
1968-69	1761	159.5	9.3	35.5	Average	93.0
1969-70	1982	162.3	11.4	37.0	Good	99.5
1970-71	2257	165.8	15.4	38.2	V.Good	108.4
1971-72	2657	165.2	18.2	38.4	Average	105.2
1972-73	2768	162.2	22.3	39.1	V.Poor	97.0
1973-74	2839	169.9	26.0	40.3	Poor	104.7
1974-75	2573	164.2	27.3	41.7	V.Poor	99.8
1975-76	2894	171.3	31.9	43.4	Good	121.2
1976-77	3411	167.3	33.6	43.6	Poor	126.4
1977-78	4286	172.3	38.9	46.0	Good	131.9
1978-79	5117	174.8	40.1	(50.6)48.3	Good	109.7
1979-80	5255	169.7	38.4	(52.6)49.2	V.Poor	129.6
1980-81	5516	172.6	40.1	(54.1)49.9	Poor	133.3
1981-82	6067	177.0	46.5	(56.0)51.6	Poor	129.5
1982-83	6387	173.4	47.5	(58.2)52.1	Poor	152.4
1983-84	7710	180.2	53.7	(58.6)53.9	Good	145.5
1984-85	8211	176.4	54.1	(60.5)54.1	Average	150.4
1985-86	8474	178.8	55.4	(62.3)54.7	Poor	143.4
1986-87	8645	176.7*	56.2	(64.4)55.7	Poor	140.4
1987-88	8784	171.8*	54.1	(66.1)56.2	V.Poor	169.9
1988-89	11040	180.1*	60.1	(68.2)59.3	V.Good	171.0*
1989-90	11568		61.2	(71.4)	Average	176.2+
1990-91	12546*		63.9+	(74.2)*	Good	182.5t
1991-92	12814*		69.1t	(76.8)t	Average	171.0+

* = Provisinal, + = Anticipated achivement, t = Target, () = Cumulative utilisation,
Source : (Economic Survey, G.O.I.)

Table 2 : Statewise Waste Water Collection and Treatment Situation in Class I Cities

Sl. No. State	No. of Class I city surveyed	Population	Sewarage		Water Supplied (MLD)	Waste Water(MLD)		
			Population with sewerage facility	Population without sewerage facility		Generated	Collected	Treated
1. Andhra Pradesh	13	40,63,441	12,00,778	28,62,663	433.77	347.01	254.26	246.29
2. Assam	1	2,00,677	0	2,00,377	34.05	27.22	-	-
3. Bihar	11	25,57,148	6,86,109	18,71,039	387.12	309.69	195.93	126.65
4. Gujarat	7	35,64,535	26,12,725	9,51,809	583.74	538.18	538.18	521.86
5. Haryana	2	2,27,248	31,189	1,96,059	18.16	14.52	2.84	-
6. Karnataka	11	35,17,497	23,12,524	10,04,973	467.61	398.73	398.73	374.99
7. Jammu & Kashmir	2	5,87,460	0	5,87,460	102.83	82.26	-	-
8. Kerala	5	14,67,046	3,14,581	11,52,465	192.42	154.00	43.12	-
9. Madhya Pradesh	11	30,06,558	6,40,568	23,63,990	394.05	315.40	118.09	40.86
10.Maharashtra	17	1,11,17,117	60,69,160	50,17,957	2265.73	1812.58	1104.10	860.67
11.Manipur	1	1,00,366	0	1,00,366	12.30	9.84	-	-
12.Orissa	4	6,01,414	1,73,685	4,27,729	92.53	74.02	24.82	-
13.Punjab	4	13,06,300	6,02,813	7,03,813	247.69	198.15	140.40	27.70
14.Rajasthan	7	19,02,212	5,82,388	13,19,824	243.80	195.04	68.96	-
15.Tamil Nadu	17	73,09,746	30,06,060	43,03,686	404.88	323.90	159.30	52.98
16.Uttar Pradesh	22	70,59,754	40,76,485	29,83,269	1079.20	863.36	575.12	2.27
17.West Bengal	5	77,83,887	6,53,687	71,30,200	679.73	543.78	61.02	34.05
18.Delhi	1	36,47,023	27,35,268	9,11,755	885.30	708.24	531.00	444.92
19.Chandigarh	1	2,32,940	2,32,940	0	113.50	90.80	90.80	22.70
Total	142	6,02,52,039	2,69,20,970	3,40,89,108	8638.48	7006.74	4306.67	2755.94
			43.4%	56.6%			59%	37%

Report of Indian National Committee for I.H.P. of CSIR, New Delhi 1981

Table 3 : Statewise Waste Water Collection and Treatment Situation in Class II Towns

Sl. No.	State	No. of Class II Towns surveyed	Population	Sewarage		Water Supplied (MLD)	Waste Water(MLD)		
				Population with sewerage facility	Population without sewerage facility		Generated	Collected	Treated
1.	Andhra Pradesh	17	11,21,533	0	11,21,533	111.14	88.89	0	0
2.	Assam	5	3,15,066	0	3,15,066	10.03	18.02	0	0
3.	Bihar	9	6,09,563	0	6,09,563	66.68	53.34	0	0
4.	Gujarat	18	12,23,887	1,59,999	10,63,888	118.80	95.04	20.00	20.00
5.	Goa,Daman & Diu	1	59,258	29,629	29,629	7.50	6.00	3.00	3.00
6.	Haryana	9	7,04,821	3,84,040	3,20,781	110.83	88.66	51.71	0
7.	Himachal Pradesh	1	55,368	41,526	13,842	14.00	11.20	8.40	0
8.	Karnataka	9	5,87,056	1,96,161	3,90,895	44.47	35.57	14.38	14.38
9.	Kerala	7	4,63,704	0	4,63,704	57.87	40.30	0	0
10.	Madhya Pradesh	14	8,70,877	53,922	8,16,955	145.97	116.77	25.42	11.53
11.	Maharashtra	19	12,95,968	1,69,207	11,26,761	381.75	305.40	18.98	15.06
12.	Orissa	1	72,674	0	72,674	8.50	6.80	0	0
13.	Punjab	8	5,05,020	1,51,689	3,53,331	62.98	50.38	14.31	2.40
14.	Rajasthan	7	4,88,251	22,510	4,65,741	52.84	42.27	2.30	0
15.	Tamil Nadu	27	17,56,660	1,01,290	16,55,370	162.35	129.87	3.12	0
16.	Uttar Pradesh	20	13,41,435	2,80,952	10,60,483	122.70	98.16	29.00	0
17.	West Bengal	18	12,98,791	0	12,93,791	54.56	43.65	0	0
	Total	190	1,27,69,932	15,90,925	1,11,79,007	1532.97	1226.32	190.62	66.77
				(12.46%)	(87.54)		(100%)	(15.54%)	(5.44%)

Report of Indian National Committee for I.H.P. of CSIR, New Delhi 1981

Impact of Agricultural Practices on Groundwater Quality in the Anglian Water Region.

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Abstract : The author demonstrates the adverse effect of agricultural activities on groundwater quality in the Anglian Water Region using nitrate and pesticide data from Anglian Water's database. The author discusses the current National Rivers Authority (NRA) and Ministry of Agriculture, Fisheries and Food (MAFF) aquifer protection policies, emphasising the objectives and potential benefits of the schemes in the short and long term. The actions taken by Anglian Water to uphold the quality of their supplies by treatment and/or blending are reviewed. It is shown that Anglian Water's strategy has effectively dealt with agricultural contamination to enable compliance with European Community (E.C.) water quality legislation.

1. Introduction

The Anglian Water region is located in the east of England and covers an area of 22,000 km^2 or 17% of the total area covered by England and Wales. Topographically the "low" country of the UK, river flows are slow and a large proportion of the area relies on a comprehensive land drainage network. The region is very rural and accounts for 40% of the total land under crops in England and Wales.

Traditionally East Anglia is the "bread basket" of England with intensive arable farms producing both animal feed and milling cereals, as well as large quantities of other crops including sugar beet and root vegetables. Winter and spring wheat and winter barley account for 64% of crops grown in the Anglian Water area.

The region contains highly productive aquifers, laid down as marine sediments between 70-200 million years ago during the Jurassic and Cretaceous geological time periods. These aquifers provide 54% of Anglian Water's total water supply. The groundwater locked up within these predominantly chalk and sandstone aquifers is exploited via production boreholes at 150 locations throughout the region . The abstractions from these boreholes are licensed by the National Rivers Authority (NRA), the statutory "guardians of the water environment" in England and Wales.

The intensive nature of the agriculture in the Anglian region means that high yields and quality are required from the crops. To achieve this farmers use artificial fertilisers and pesticides extensively, with applications of nitrogen typically being in the range 200-300 kg/ha N per annum. Pre- and post-emergent residual herbicides are used in most management regimes. As the leaching of nitrate and pesticides occurs throughout the catchments in the region it represents a "diffuse" source of pollution.

A proportion of these applications are leached through the soil of the farming catchments and contaminate the groundwater.This is particularly exacerbated when catchments are predominantly sandy, well draining soils overlaying unconfined aquifers. Many Anglian

Water boreholes abstract from such aquifers because of their high yields. The paleo-history and its weathering influences on these systems contributes to their fast flows and high outputs.

Where groundwater is vulnerable to nitrate leaching and rising concentrations are detected in abstracted water, pesticides are also often detected. Nitrate leached from agricultural soils into groundwaters is derived from two sources, from applications of artificial nitrogen fertilisers, organic manures and sludges or from soil microbial activity.

Modelling studies conducted for the UK government have clearly shown that nitrate applications impact on the groundwater and they have pointed the way forward to reducing nitrate contamination in the future. In anticipation of the E.C. "Nitrate Directive" 1991 the UK government set up, under provisions given in The Water Resources Act 1991, Nitrate Sensitive Areas (NSAs) and Nitrate Advisory Areas (NAAs) Their purpose is to encourage practices that result in lower applications of nitrate in agricultural catchments.

Nitrate Vulnerable Zones (NVZs) were proposed by MAFF in May 1994 and set up under the EC "Nitrate Directive" 1991. Unlike the NSAs, which are voluntary, NVZs are to be compulsory and operated according to MAFF's Code of Good Agricultural Practice, 1991.

The NRA's policy and practice for the protection of groundwater gives priority to identifying and defining, by modelling, source protection zones for public water supply boreholes in the UK. The highest risk zones are due to be designated in 1994. They will enable resources to be made available to control substances, including pesticides, that threaten the quality of the groundwater in designated areas. These areas will represent the capture zones of the abstracting boreholes, thereby ameliorating the implementation of legislation designed to prevent contamination from agricultural and other sources.

2. Current Legislation

EC Drinking Water Directive

The EC Drinking Water Directive (80/778/EEC) stipulates a Maximum Admissible Concentration (MAC) for nitrate of 50 mg/l and for individual pesticides of 0.1 μg/l and 0.5 μg/l for total pesticides in final waters for public water supply purposes. In 1989 Anglian Water implemented an extensive capital programme incorporating nitrate and pesticide control schemes to ensure compliance with EC standards by the end of 1995.

The Water Resources Act, 1991

In anticipation of the EC Nitrate Directive, 1991 and to assist the government in establishing action plans, a pilot Nitrate Sensitive Area (NSAs) scheme was introduced in 1990. Ten areas were designated under the NSAs (Designation) Order and Amendment 1990 under the provisions of section 94 of the 1991 Water Resources Act. All NSAs are areas where the nitrate concentrations in drinking water exceed or are at risk of exceeding 50 mg/l. Two of these NSAs are located in the Anglian Water region: Sleaford and Branston Booths. Both are linked to areas in the Lincolnshire Limestone outcrop.

In addition to the NSAs a further 9 areas nationally, known as Nitrate Advisory Areas (NAAs), have been defined although not covered by the legislation. In these areas an intensive advisory campaign is being conducted. Five of the NAAs are located in the Anglian Water region.

In May 1993 MAFF, in consultation with the water companies, proposed additional areas as candidate new NSAs. These were formed under the EC Agri-Environmental regulation No. 2078/92 introduced in June 1992. Six out of a national total of thirty candidate new NSAs are sited in the Anglian Water region.

EC Nitrate Directive, 1991

The introduction of the EC Nitrate Directive (91/616/EEC) requires member states to identify and designate all known areas of land that drain into receiving waters where nitrate concentrations exceed or are expected to exceed 50 mg/l NO_3 or where there is evidence of nitrate limited eutrophication as Nitrate Vulnerable Zones (NVZs). Under the Directive action programmes are to be agreed by 1999 with regular reviews of status at least every four years.

The objectives of the Directive are the reduction of nitrate concentrations in surface and groundwaters to a concentration which will not interfere with the potential use of these waters for drinking water abstraction and in restoring and preventing eutrophication of water bodies. The land application of nitrogen compounds and certain land management practices are controlled within the NVZs.

The UK designation of NVZs and the establishment of an action programme is planned by 1995 with implementation by 1999. The NVZs will be operated according to the Code of Good Agricultural Practice (CGAP), 1991 (MAFF, 1991) which is currently voluntary but when the NVZs come into force land management practices associated with nitrate will be statutory within them. To date there are no plans to make the CGAP statutory for pesticides within the zones or elsewhere. Harder evidence will be required concerning the impact of diffuse applications of pesticides on groundwater, before agricultural pesticides usage is controlled. (Perscom, NRA)

There are 34 Anglian Water groundwater sources within NVZs. Such sources typically abstract from karstic aquifers, recharged from agricultural catchments, where the aquifer water table is shallow and the soil covering the aquifer is thin and permeable. The overburden is usually glacial drift material, typically sands and gravels. Applications of nitrogen in such catchments can lead to leaching of the readily available nitrate, created from such applications, into the groundwater because of the rapid recharge characteristics of the overburden and fissured nature of the aquifer.

Anglian Water has the greatest proportion of land affected by NVZs of any water company in England and Wales. A combined area of 3,000km^2 is proposed as NVZs in the Anglian region, 16% of the total land area. This represents 55% of the total NVZs proposed in England and Wales.

Groundwater Protection
Protection of groundwater resources in the UK are the responsibility of the NRA under the Water Resources Act 1991. The NRA has powers under the following legislation to fulfil its responsibilities;

The EC Groundwater Directive 1980 prohibits the direct and indirect discharge of List I substances (80/68/EEC) and limits discharges of List II substances. It does not address "diffuse" agricultural pollution.

The Control of Pollution Act (COPA), 1974 deals with the disposal of waste to land. This includes "point source" agricultural contamination due to the disposal of pesticides and fertilisers but does not cover contamination from normal agricultural management practices.

The Environmental Protection Act (EPA) relates to the application of Integrated Pollution Control (IPC) to those industries designated on the basis of the prescribed substances list.

Under the Water Resources Act (WRA) 1991, the NRA has powers to control the direct and indirect discharge of the majority of trace and all sewage effluent into controlled waters. There is provision under the WRA 1991 for the definition of statutory water protection zones by the NRA although there are no current plans to make them statutory.

3. UK Policy and Practice

In 1992 the NRA published its policy and practice for the protection of groundwater. The NRA has given priority to defining source protection zones using steady-state groundwater models. The policy recognises that all sources including springs, wells and boreholes are liable to contamination and need to be protected. The policy defines various categories of Groundwater Source Protection Zones as discussed below (NRA, 1992).

Zone I (Inner Source Protection) This area is defined by a 50 day travel time from any point below the water table to the source and as a minimum 50 metre radius from the source.

Zone II (Outer Source Protection) This zone is larger than zone I and is the area defined by a 400 day travel time from any point below the water table to the source.

Zone III (Source Catchment) This zone covers the complete catchment area of the groundwater source and all water within it will eventually discharge to the source.

Zones I and II are not defined for confined sources where the aquifer is confined beneath substantial covering strata of very low permeability since in such cases the cover will prevent infiltration.

Of the 150 Anglian Water groundwater sources, 90 are unconfined and the majority of these abstract from chalk aquifers with relatively high recharge rates via highly fissured fast flow strata. The groundwater protection zones modelled for the NRA in these systems tend to be very irregular and the influence of the pumping well can extend to a considerable distance. For Anglian Water this means that monitoring of the groundwater can be difficult because of the high number of spatial and temporal variations within the system, consequently contamination from point and diffuse sources can enter the aquifers via recharge water over a large catchment area and be transported to the sourceworks relatively rapidly.

The NRA intend to release the final groundwater protection zone maps in 1994, although it is not planned to make the zones statutory or to increase monitoring within the zones. However, the NRA will directly and indirectly, by seeking the support of other bodies, including Anglian Water, promote practices (if necessary by using its powers) that protect the groundwater resource within the zones. The protection zones will be used primarily by the NRA during the assessment of planning applications.

Future Practices

The results of the Pilot Nitrate Scheme (NSAs and NAAs) set up in 1990 have been summarised in a MAFF publication, "Solving the Nitrate Problem" 1993. The conclusions point to the way forward in reducing nitrate leaching by changing crop management practices. Farmers are, not surprisingly, very receptive to ideas that have compensation payments attached to them or no financial risk. Since the introduction of the pilot nitrate schemes farmer awareness of the nitrate problem and the need to target fertiliser applications has been greatly increased. Nitrate leaching is significantly increased when permanent grass land is ploughed up, fertilisers are applied before crop establishment in the autumn or heavy applications of animal manures are made, which is exacerbated if the soil is sandy and permeable. These practices will be controlled when the CGAP is made statutory within the proposed NVZs.

Farmstat

The Water Research Centre (WRc) utilise data on pesticide applications to crops. This data is derived from that sent to MAFF as returns from farmers, assimilated on a parish basis. WRc contractors analyse the data using a statistical computer program, FARMSTAT. This enables subscribers to the service to request summary information on pesticides.

Anglian Water and the NRA are collaborating on a project to investigate pesticide usage in catchment areas that are considered vulnerable to pesticide leaching into the groundwater. In principal the NRA are prepared to liaise with the farmers in such catchments and make pollution prevention visits to try and persuade landowners to make changes to reduce the use of persistent pesticides and alter crop management regimes to reduce leaching.

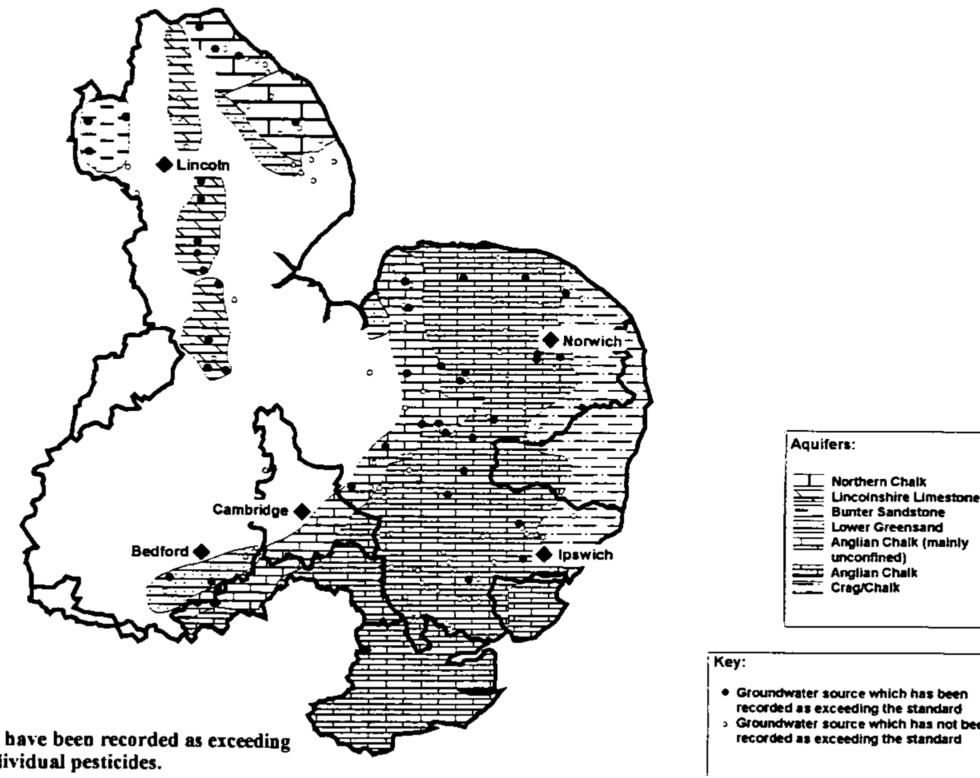


Figure 1.
Groundwater Sources which have been recorded as exceeding the standard (0.1ug/l) for individual pesticides.

4. Occurrence and Impact of Pesticides and Nitrate on Groundwater Quality

Pesticides

Agricultural applications of pesticides in the Anglian Water region are high due to the large area of crops grown. In 1993, 5,770 tonnes of active pesticide ingredients were applied to arable and grassland in the region and 61.5 tonnes were applied for non-agricultural uses (Hearn, 1993). The pesticides found in the groundwater by Anglian Water are all herbicides used to control weeds in pre- and post emergent crops. Figure 1 shows Anglian Water sources that have exceeded the 0.1 µg/l standard for individual pesticides. The majority of these are the vulnerable outcrop or poorly confined sources which also have elevated nitrate concentrations. Particular pesticides, notably atrazine, have also been used extensively for weed control on railways and roads. Atrazine use for non-agricultural purposes was banned in 1992 because of the evidence that such usage could lead to rapid leaching of the pesticide into groundwater systems via soakaways. It has largely been replaced by diuron and glyphosate based pesticides. Table 1 shows pesticide concentrations for three commonly detected pesticides in Anglian Water raw waters. In total 18 individual pesticides have been detected at 45 sourceworks throughout the region. Figure 1 shows those sources which have exceeded the 0.1 µg/l standard for individual pesticides in the final water.

Using the Groundwater Ubiquity Score (GUS) proposed by Gustafson (Gustafson, 1989) it is possible to classify pesticides in order of leaching potential. A GUS of <1.8 indicates an improbable leacher, 1.8 - 2.8 a transition leacher and >2.8 a probable leacher. It can be seen from Table 1 that those pesticides found in Anglian Water sources generally fall into the probable leacher class.

Pesticide	GUS Index	Concentration Range µg/l
Atrazine	3.15	0.05 - 0.56
Isoproturon	3.28	0.02 - 0.38
Mecoprop	2.74	0.02 - 0.22

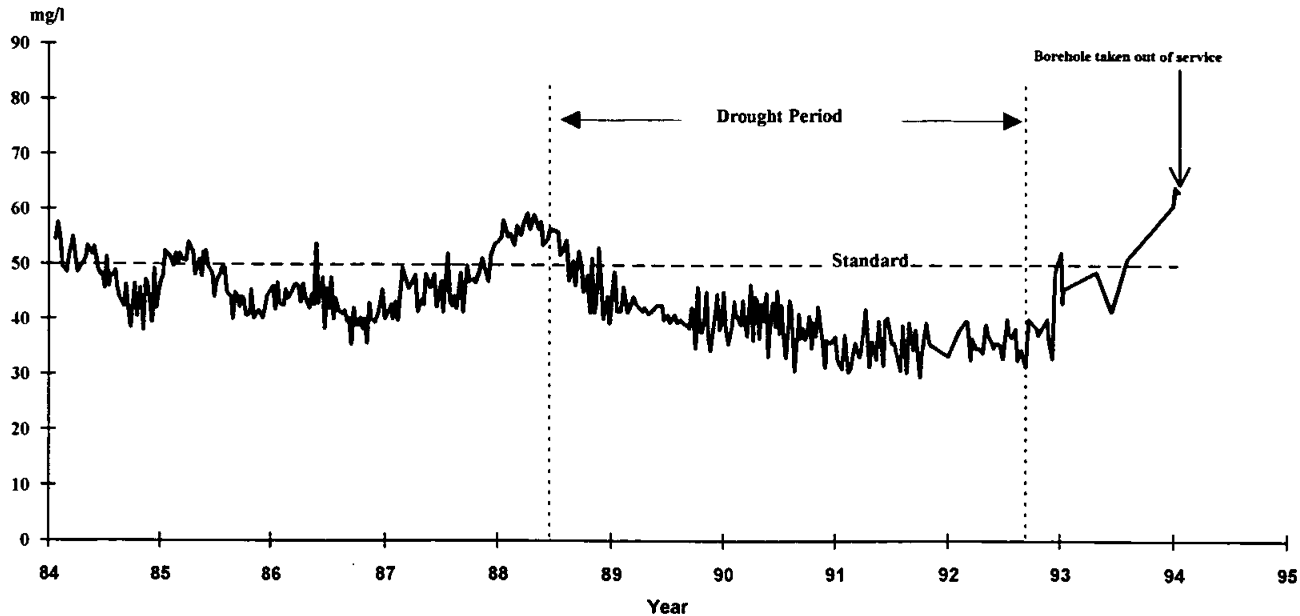
Table 1. Typical Pesticide Concentrations in Anglian Water Raw Waters (1990-94)

Nitrate

Nitrate contamination of groundwater is widespread in the Anglian Water region. Many groundwaters are very pure because of the natural purification afforded by percolation through the overlaying soil and rock strata. This is particularly true when the aquifer is confined by an impermeable layer such as clay. In these circumstances the water held in the aquifer is low in oxygen and contains only minerals such as calcium and magnesium salts. Nitrate is not present due to the reducing conditions which prevail.

Unconfined aquifers are in continuity with the surface ie. in outcrop situations or with permeable cover and are, as a result, more prone to contamination from applications of nitrate and pesticides at the surface. Figure 2 shows nitrate in the raw water at a source abstracting from an unconfined chalk aquifer in the county of Suffolk. The data demonstrates the seasonal trends in nitrate before the start of the drought in the summer

Figure 2. Nitrate Variation in an Anglian Region Chalk Aquifer



of 1988. The effect of the higher winter and spring rainfall is to leach nitrate retained in the soil during the drier summer and autumn months into the groundwater resulting in a concentration peak in the spring. In addition to the impact of artificial nitrogen applications on the groundwater it is recognised that naturally occurring nitrate resulting from soil activity is also contributing to nitrate concentrations. It has been estimated that 100kg/N/annum can be released when permanent grassland is ploughed up and changed to arable. The CGAP recommends that this practice is avoided (MAFF, 1991).
On average, data trends before the drought demonstrated a rising concentration of nitrate of between 1-2 mg/l/annum in vulnerable aquifers throughout the region.

Figure 3 shows the nitrate concentration ranges in the final water across the Anglian Water region expressed through the public water supply zones. The nitrate standard (50mg/l) was exceeded in 25 zones in 1993 but these were covered by an Undertaking given to the government which allows for the standard to be exceeded until works are completed or the Undertaking expires. Anglian Water's compliance with the nitrate standard increased significantly from 92% to 96.8% of treated water samples examined in 1993.

5. Synergistic Effects

The period August 1988 to August 1992 represented one of the driest sequences of weather in the Anglian region this century with a rainfall return period in excess of 1 in 200 years. This has had a profound effect on nitrate leaching in the area. Nitrate "locked" in the soil in the dry years has been leached rapidly as a highly concentrated "slug" by the heavy rainfall events (with a return period in excess of 1 in 100 years) that followed the breaking of the drought. This has resulted in significant increases in nitrate concentration at some sources, particularly where the aquifer cover is thin and permeable and the flow within the aquifer is fast fissure as found in the chalk sources. Figure 2 shows the range of the drought, during which nitrate concentrations declined. The graph shows that following the end of the drought nitrate concentrations rose rapidly to above the nitrate standard at this source. As a consequence of this one borehole was temporarily taken out of service. Two sources that have shown similar rises following the drought are of particular interest because they are situated within the region's two pilot Nitrate Sensitive Areas established in 1991. The increasing post-drought nitrate concentrations indicate the considerable potential for nitrate leaching from historical land use practices in the region.

6. Anglian Water's Treatment Strategy

To comply with the regulations for pesticides and nitrate Anglian Water embarked on an extensive capital work's programme following privatisation of the water industry in 1989.

Nitrate
The design standard used for engineering works for nitrate removal has been to reduce the nitrate concentration to a mean of 40 mg/l with a maximum of 45 mg/l. Plants have been installed where the raw water nitrate concentrations have been above 50mg/l. The

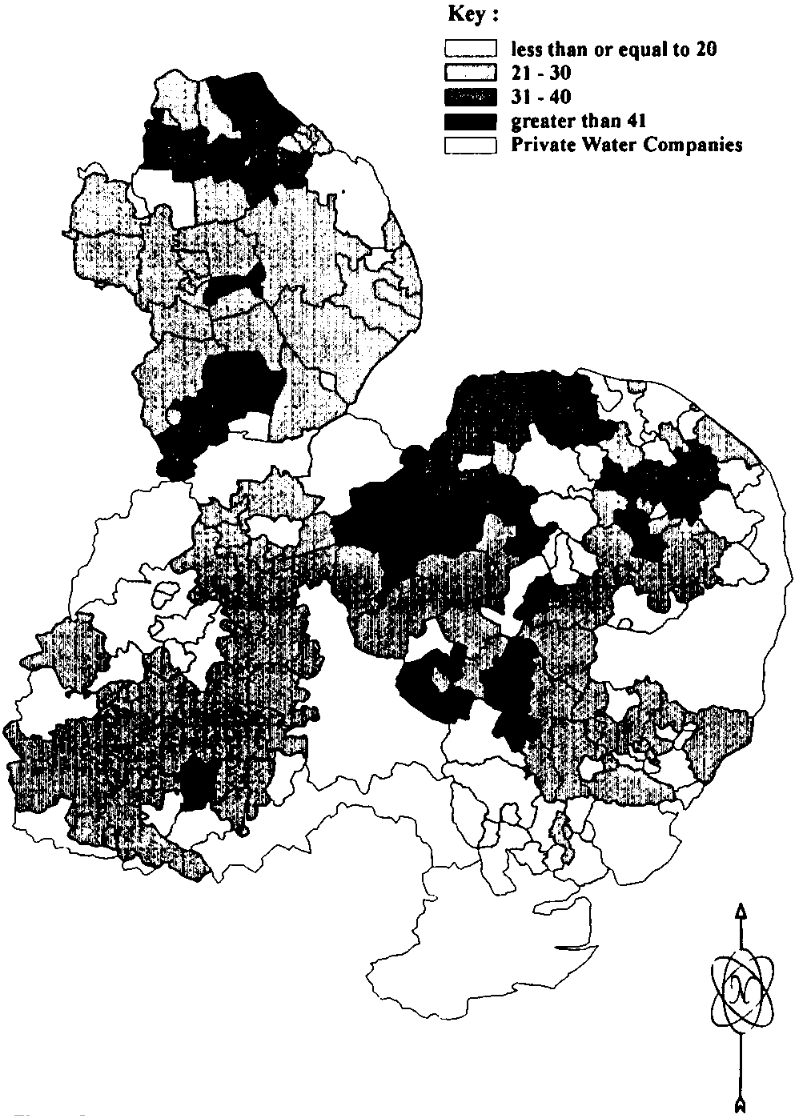


Figure 3.
Mean Nitrate Values (mg/l) by Supply Zone for the Anglian Water Region 1993

policy is to preferentially develop groundwater sources that are low in nitrate; such sources frequently contain high iron concentrations and are generally exploiting confined aquifers. It is much cheaper to remove iron from the water than it is nitrate. Where the use of high nitrate waters is unavoidable, removal of nitrate from the raw water is accomplished by means of ion exchange resin plants and/or blending. Nitrate removal by means of membrane technology was evaluated by desk studies but was considered to be unreliable.

Our preferred control strategy for nitrate control is blending. Anglian Water have a number of nitrate blending schemes where water from low nitrate sources is blended with water from high nitrate sources to achieve compliance with the nitrate standard.

Pesticides
Where sources have exceeded the standard for individual or total pesticides in the final water, Granulated Activated Carbon (GAC) adsorbers are installed. Unlike nitrate, pesticide concntrations in the groundwater are reasonably constant with time once established. This enables a precise removal process to be calculated for a given concentration and required source works output. The specification for these plants is a nominal contact time with the GAC media of 15 minutes which facilitates adsorption of the pesticide compounds onto the carbon. When the carbon is exhausted it is removed from the adsorption shell and regenerated.

Costs
The 1990-95 Anglian Water groundwater treatment plans include 29 nitrate removal and/or blending schemes and 5 sources have been closed at a total capital cost of £80 million. There are also 25 schemes for pesticides removal at a total capital cost of some £140 million. In addition to the capital costs there are substantial running costs associated with nitrate and pesticide removal schemes.

7. Conclusions

Agricultural practices in the Anglian Water region have had an adverse impact on groundwater quality.

Anglian Water has developed a successful strategy to deal with groundwater contamination derived from agricultural activities.

Changes in legislation, which are not completely scientifically based, have required significant expenditure to ensure drinking water quality complies with the standards.

The UK government and the National Rivers Authority have introduced legislation and policies to reduce the impact of agricultural practices on drinking water quality to enable future compliance with the E.C. Directives.

Acknowledgements

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AGRICULTURAL CONFLICTS : IMPACTS OF AGRICULTURAL RETURNS ON SUNGEI LINGGI RECEIVING WATERS

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ABSTRACT

Significant deterioration of the water quality of the Sg. Linggi had been observed since 1961. From various extensive studies performed between the period of 1975 to 1990, the major contributing pollutional sources had been traced to various agricultural activities and practices as well as agrobased industrial discharges. Nevertheless, it still remains the principal source of water supply for the state of Negeri Sembilan, Malaysia, in satisfying the domestic needs of more than 250,000 consumers, apart from the industrial and commercial useage. Due to the vital decision of maintaining its present beneficial use, concerted efforts were made to study, evaluate, monitor, recommend, and institute various mitigative measures for remedial purposes (*Johari*, 1992). This paper attempts to present some of the efforts made and the rational approach taken in assessing possible alternatives in the final decision-making process on mitigative measures viable for implementation and the measurable benefits resulting from the adoption of the new agricultural development policy by the state government. Computer simulation modeling was used as a means to model the system, to establish the cause-effect mechanism, and to produce predictive scenarios.

Keywords: agricultural practices, water quality, river pollution, environmental impact, computer simulation models, modeling.

Importance of the Sg. Linggi

The Sg. Linggi Water Treatment Plant (SLWTP) extracts water totally from the run of the river yield of the Sg. Linggi. With a normal operating capacity of 17.5 million gallons per day (MGD), it provides 50 percent of Seremban's needs for water supply and is the only source of treated water for the District of Port Dickson (*Johari*, 1989). The watershed, however, is highly urbanised and densely populated, accounted for by the town of Seremban - a major commercial and industrial centre, and to a lesser extent by its sorrounding suburban towns. The Senawang industrial estate is located within the watershed boundary south of the town of Seremban, as shown in Fig. 1.

Current Water Quality Status and Pollutional Sources.

Sg. Linggi is in a state of serious pollution with a significant degradation of its raw water source observed since 1961 (*Binnie & Partners*, 1979). Various point and non-point sources of pollution had been identified, which is chiefly attributable to agricultural activities and practices - agricultural runoffs, agroindustrial discharges, pig waste effluents and other husbandry activities, followed by to a lesser extent, residential discharges. It is recorded that there is at least a total of more than 200,000 standing pig population (SPP) within the watershed accounted by about 45 pig farms of various sizes. 95 percent of the farms are practising on-site waste treatment employing some form of biological oxidation pond processes, with direct discharge to the Sg. Linggi.

Based on an extensive analysis of water quality parameters performed by the Linggi Taskforce (*Linggi Taskforce*, 1989), the Sg. Linggi is regarded as not suitable to be utilised as a source of drinking water as measured by the standards set by the National Surveillance Programme (*MOH*, 1984).

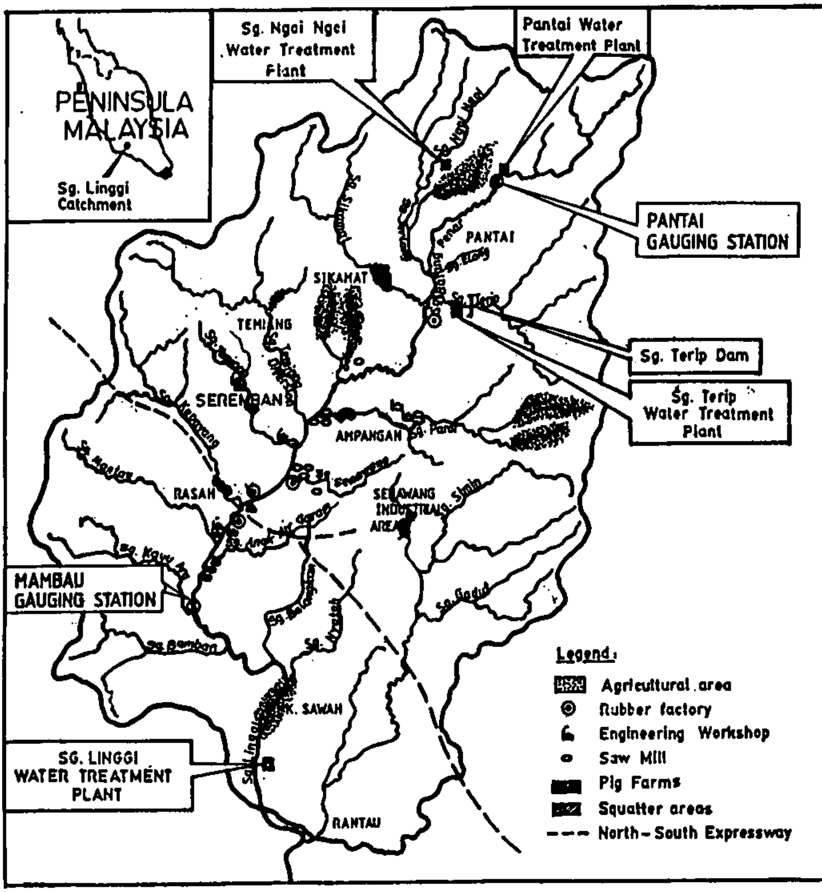

Fig.1 Sg. Linggi Catchment

It is envisaged that the socioeconomic developments within the watershed will continue in the foreseeable future. Parallely, however, the Government is equally concerned and committed to introduce mitigative environmental control programmes in the quest to improve the water quality conditions of the Sg. Linggi. Based on the conflicting objective, a decision was made to propose and evaluate possible solutions and programmes to sustain a certain level of development within an acceptable environmental condition.

STUDY METHODOLOGY

A twelve months study was conducted beginning mid-1991, which consists of a six month data collection programme, selecting and determining various mitigative environmental control actions, formulating a watershed-wide agricultural constrained development programme, promulgating policies and legal provisions to support such programmes, and selecting the most appropriate computer simulation model to enable the needs to describe the cause-impact phenomenon between agricultural activities and water quality resulting therefrom. Through predictive modeling, the effectiveness of the control actions were subsequently measured.

Selection of the Computer Simulation Model

The selection of the appropriate computer simulation model to be used in the study were based on the problem formulation and objectives, specific requirements and degree of details required, predictive capabilities, model limitations, level of sophistication required, ease of understanding and use, hardware and computer time requirements, and particularly - extensive proven application. Various watershed and stream water quality models were assessed and a decision was finally made based on the above screenings to use the stream water quality model QUAL2E-UNCAS which is further described.

The Enhanced Stream Water quality Model QUAL2E-UNCAS

The Enhanced Stream Water Quality Model QUAL2E and QUAL2E-UNCAS (Brown, L. C., and T. O. Barnwell, 1987) permits simulation of several water quality constituents in a branching stream system using a finite difference solution to the one-dimensional advective-dispersive mass transport and reaction equation. The conceptual representation of a stream used in the QUAL2E formulation is a stream reach that has been divided into a number of subreaches or computational elements equivalent to finite differences. For each computational element, a hydrologic balance in terms of flow (Q), a heat balance in terms of temperature (T), and a materials balance in terms of concentration (C) is written. Both advective and dispersive transport are considered in the materials balance. Mass can be gained or lost from the element by transport processes, external sources and sinks (e.g., waste discharges or withdrawals) or by internal sources and sinks (e.g., benthic sources or biological transformations). The equation is solved for the steady-flow, steady state condition in a classical implicit backward difference method. The specific equations and solution technique are described in detail in the QUAL2E computer program documentation (USEPA, 1987).

Prototype representation in QUAL2E consists of dividing a stream in a network of "Headwaters", "Reaches", and "Junctions". The fundamental reason for subdividing sections of stream into "Reaches" is that QUAL2E assumes that some 26 physical, chemical and biological properties (model input parameters or coefficients) are constant along a "Reach". The question that must be addressed in order to define a "Reach" is what constitutes "significant" change in these model inputs - "significant" in the sense of their impact on simulation results, not necessarily in the sense of change in the inputs themselves.

Mass transport in the QUAL2E computer program is handled in a relatively simple manner. There seems to be some confusion about QUAL2E's transport capabilities as it is sometimes called a "dynamic" model. However, in all of the computer programs in the QUAL series, there is an explicit assumption of steady flow; the only time-varying forcing functions are the climatologic variables that primarily affect temperature and algal growth. A more proper term for this capability is "diel," indicating variation over a 24- hour period. The forcing function used for estimating transport is the streamflow rate, which, as mentioned above, is assumed to be constant. Stream velocity, cross-sectional area, and depth are computed from streamflow.

One of the most important considerations in determining the assimilative capacity of a stream is its ability to maintain an adequate dissolved oxygen concentration. The QUAL2E computer program includes the major interactions of the nutrient cycles, algal production, benthic and carbonaceous oxygen demand, atmospheric reaeration, and their effect on the dissolved oxygen balance as shown in Fig. 2. In addition, the computer program includes a heat balance for the computation of temperature and mass balances for conservative minerals, coliform bacteria, and non- conservative constituents such as radioactive substances. Chlorophyll a is modeled as the indicator of planktonic algae biomass in QUAL2E.

Field Investigation and Data Acquisition

A 6 months field investigation and data collection programme was conducted by the project team to measure and determine various groups of parametric values significantly impacting the Sg. Linggi. This also serves as inputs to the selected computer model. Basically, the parameters are grouped either as hydraulic inputs or water quality inputs.

The hydraulic parameters includes flow datas (headwaters, incremental flows, point and dispersed flows), velocities, and stream depths, Two hydraulic stage-discharge control stations were used to provide datas to be utilised in the calibration and validation process of the model as well as in the computation of the incremental flows, i.e., the Pantai and the Mambau Gauging Stations as located in Fig. 3.

BOD (Biochemical Oxygen Demand) and DO (Dissolved Oxygen) represents the two major water quality parameters selected in the study based on the magnitude and contribution of the organic pollution and its direct effect on the depletion of the dissolved oxygen (acting as the surrogate measure of the environmental health condition) of the Sg. Linggi. Sixteen water quality monitoring stations were established along the Sg. Linggi for the purpose of sampling and analysis. The

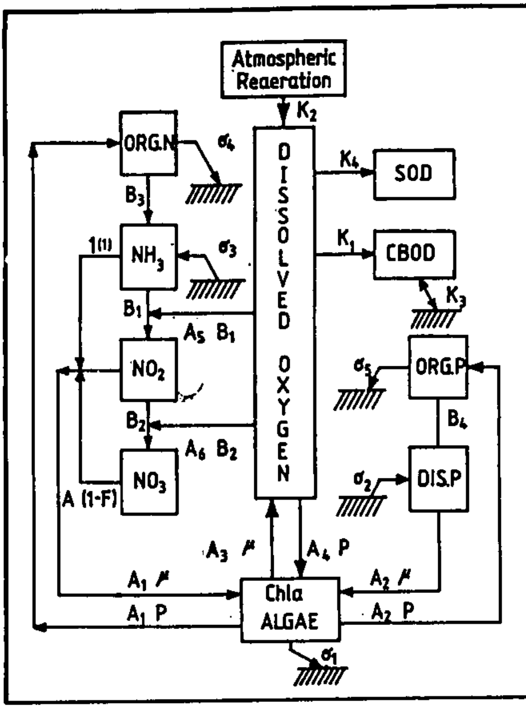

Fig.2 QUAL2E Schematic of DISSOLVED OXYGEN BALANCE

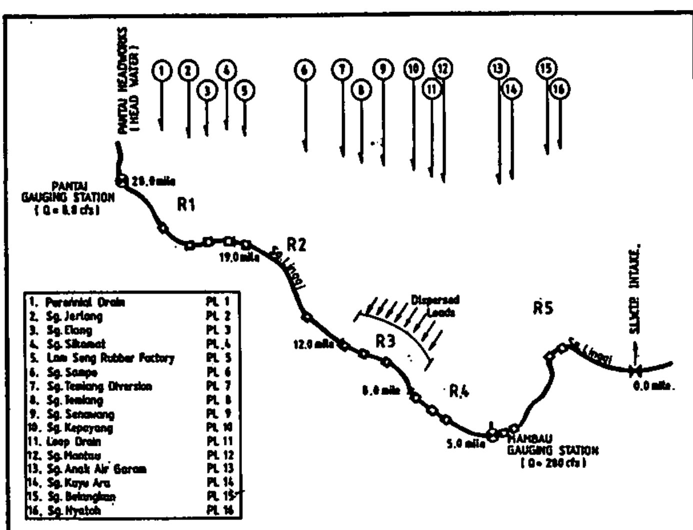

Fig. 3 PROTOTYPE RIVER SYSTEM REPRESENTATION IN QUAL2E MODEL SIMULATION

frequency of sampling and analysis was on a biweekly basis. Basic environmental parameters, i.e., pH, temperature, conductivity as well as DO were measured on site, while samples for BOD were collected and transported to the Sg. Linggi Research Laboratory for analysis. The techniques used in the sampling, transportation, sample preparation and preservation, and analysis were in strict conformance to the Standard Methods of Examination of Water and Wastes (APHA, 1976).

The hydraulic coefficients and the water quality reaction coefficients were determined both in the field (insitu) as well as in the Laboratory. The coefficient values were checked against the typical range of established parametric values as part of the testing and screening process. A certin degree of judgement was made where necessary and appropriate in the screening process.

RESULTS AND DISCUSSION

Modeling Technique and Application

The Sg. Linggi is modeled from its headwaters, the Pantai headworks to the SLWTP intake, a total distance of 28.0 miles, along its main stem. Valid simplifications were made to the system for the purpose of reducing undue complexity of the system, hence computational needs, while maintaining its intended analytical objective.

Sixteen major point loads which were all of agricultural origin and of significant importance were identified in the system as shown in Fig. 3. They comprised of 3 direct discharge outfalls (PL1, PL5, and, PL11) and 13 tributaries of the Sg. Linggi. Incremental loads due to groundwater (incremental) inflow and surface runoffs emanating from the adjacent agricultural lots were modeled. In addition, municipal discharges originating from open drains and sewers serving the town of Seremban were simulated as dispersed loads along river reach R3 from RM 12 to RM 8.

The hydraulic (depth, velocity, and flow) and water quality (dissolved oxygen) parametric values acquired in the data collection programme were used in the calibration and validation of the model. During the calibration process, values of the hydraulic and reaction rate coefficients were varied or "tuned" within an allowable range with sufficient justification. Any abnormalities in the parametric values were examined in detail before the final value is considered acceptable.

The "testing" of the model on the hydraulic simulated output was accomplished by comparing the simulated and observed flows at the Mambau Gauging station. From the model output, it can be observed that the computed flow, 282.4 cfs at Mambau is significantly close to the measured value of 280.0 cfs. The statistical accuracy is within 1.0 percent. Similarly, the simulated velocity and depth profiles were tested to be within 3.5 to 4.0 percent of the observed values respectively. These are statistically acceptable values, and hence the profiles were accepted in the modeling exercise. This calibration step is very important since the hydraulic and hydrologic components of the system represents the vehicle or transport chassis that determines the migration and fate of the pollutants within the system.

The validation result of the model can be observed from Fig. 4. The simulated concentrations are plotted as continuous lines, whereas the concentrations from the data acquisition programme are represented as single observation points in the plot since they originate from discrete sample analysis.

Statistical analysis was performed on the simulated profile to determine the validity of the model. Various tests were applied using the SAS statistical package (SAS, 1982). The correlation coefficient, R, was computed to be 0.99, and the coefficient of determination, R^2, was computed from the simple regression of the predicted to the observed DO values to be 0.98, with a standard error of estimate of 0.24. Applying the null hypothesis test at the 1.0 % significance level proved that there is a significant correlation between the predicted and the observed dissolved oxygen profiles.

From the calibration and validation processes above, the model is accepted as sufficiently capable of predicting the impacts of pollution to the Sg. Linggi due to various causative factors, and is subsequently applied to provide scenarios resulting from various potential mitigative measures as described below.

The water quality impacts specifically attributable to the agricultural and agricultural related activities could be observed from Fig. 5. The resultant DO profile excludes impacts due to nonagricultural pollutional sources. Notably, it could be assessed that in comparison with Fig. 4 (i.e., the total combined loads originating from both agricultural and nonagricultural sources), the more significant source impacting the raw water quality is agricultural in nature. This is depicted by the recorded minimum DO level of 2.2 mg/l as compared to 1.5 mg/l for the combined loads. Correspondingly, a stretch of 10.0 river miles (from RM 7.0 to RM 17.0), possess a DO level lower than the acceptable limit of 5.0 mg/l, which accounts for 80.0 percent of the total stretch of 13.0 river miles observed.

The adoption of the proposed agricultural masterplan resulted in the predicted DO profile as simulated in Fig. 6. The masterplan essentially involves several environmental mitigative measures involving the relocation of all pig rearing farms away from the watershed to Bukit Pelandok, Port Dickson - a gazetted regionally centralised pig farming area with advanced controlled waste treatment facilities, resiting of the Lam Seng rubber processing factory to a suitable site downstream of the SLWTP intake point, and the significant reduction and conversion of the open extensive agricultural farmlands to other form of developments less damaging to the raw water quality, i.e., the healthy conditions of the Sg. Linggi (*SEPU*, 1992). It is important to note that this is determined surrogately by the targetted dissolved oxygen minimum level of 5.0 at any point along the river. It is envisaged that at this level the raw water quality shall be able to meet the criteria and standards required for the purpose of supporting aquatic life within the river regime, recreational use with body contact, and be used as a source of drinking water requiring conventional treatment only. Such beneficial uses requires a raw water quality conforming to the Class IIA standards as recommended by the report published by the Department of Environment (DOE) in 1986 (*Goh, et al.*, 1988).

From fig. 6, it could be observed that there is a significant reduction of the DO sag along the Sg. Linggi Dissolved Oxygen profile, depicting an increase in the DO levels along the total stretch of the river. As can be measured there is a pronounced reduction of the maximum DO sag at RM 8.5 (the most critical point

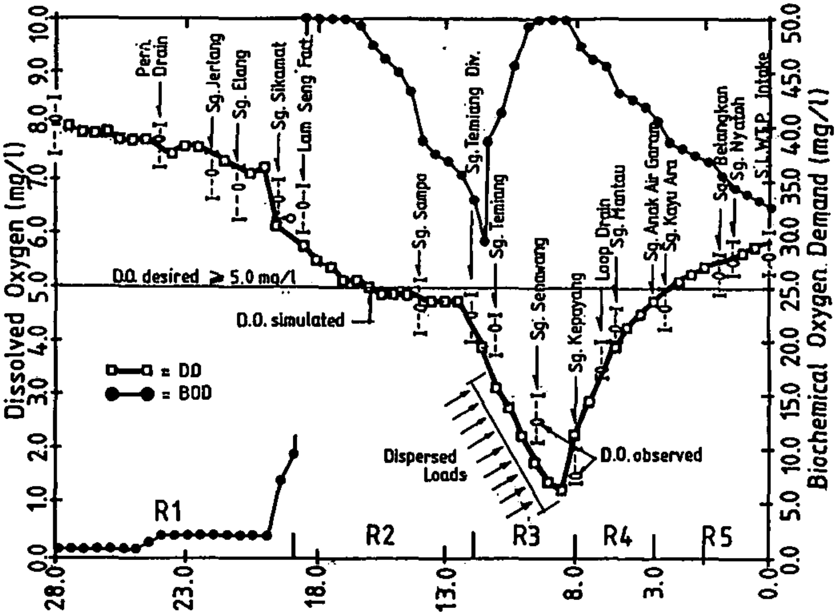

Fig. 4 Sg. Linggi Dissolved Oxygen Simulated Profile

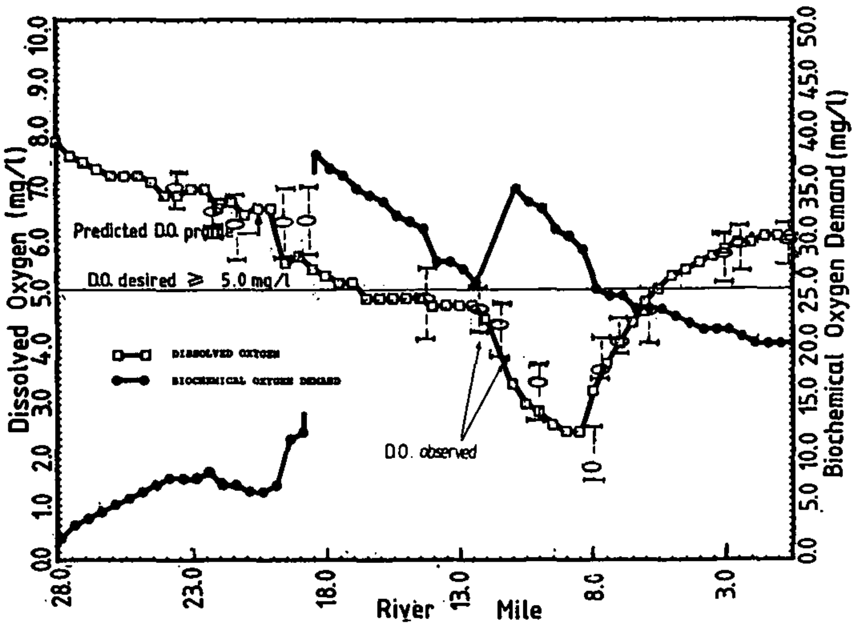

Fig.5 Environmental Pollution Impacts Due to Agricultural Activities

along the river) from a DO level of 1.5 mg/l to 3.5 mg/l, amounting to a 60 percent improvement in the DO level. It could also be observed that the critical stretch, whereby the DO is below the targetted acceptable level of 5 mg/l had been significantly reduced. Without the introduction of the agricultural masterplan,a stretch of 13.0 river miles, i.e., from RM 4.0 to 17.0, is below the acceptable level as compared to a stretch of only 3.5 river miles, i.e., from RM 11.0 to RM 7.5 after the implementation of the proposed agricultural masterplan. Quantitatively, the agricultural reformation programme had successfully improved a total of 8.0 river miles. This significantly translates to an 80.0 percent predicted improvement in the healthy condition of the river.

Parallel to the abovementioned agricultural reformation programme, the State Government is also currently embarking on a mammoth attempt to implement the Greater Seremban Sewerage Masterplan Project, it being one of the strategy as contained within the State Environmental Masterplan to improve the general quality of life (*SEPU*, 1992). The project is envisaged to be completed by 1994. The project in essence attempts to collect and divert sewage and sullage generated by the urban town of Seremban and its suburban sorroundings to a central sewage treatment plant. This environmental mitigative measure had been modeled in earlier studies to assess its predictive impact upon the raw water quality of the Sg. Linggi (*Johari*, 1993). From the study, it could be observed that there is a significant reduction of the DO sag along river reaches R3 and R4. However, this mitigative measure by itself is insufficient to achieve the desired water quality standard as predicted by the model, where the DO is below the minimum level of 5.0 for a stretch from river mile 17.0 to 7.0, a distance of 10.0 river miles.

The combined effect of the agricultural reformation programme and the sewerage masterplan could be observed from Fig. 7. The predicted DO profile shows that all along the Sg. Linggi, the water quality conforms to the stipulated standard as measured by the DO predicted values, thus meeting the criteria of the Class IIA standards as recommended by the Department of Environment.

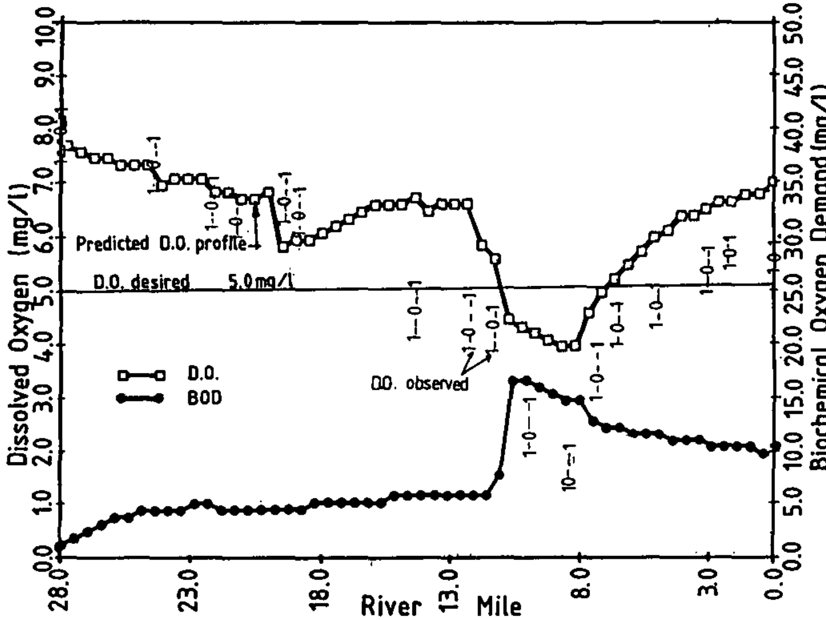

Fig.6 Mitigative Environmental Control Action 1

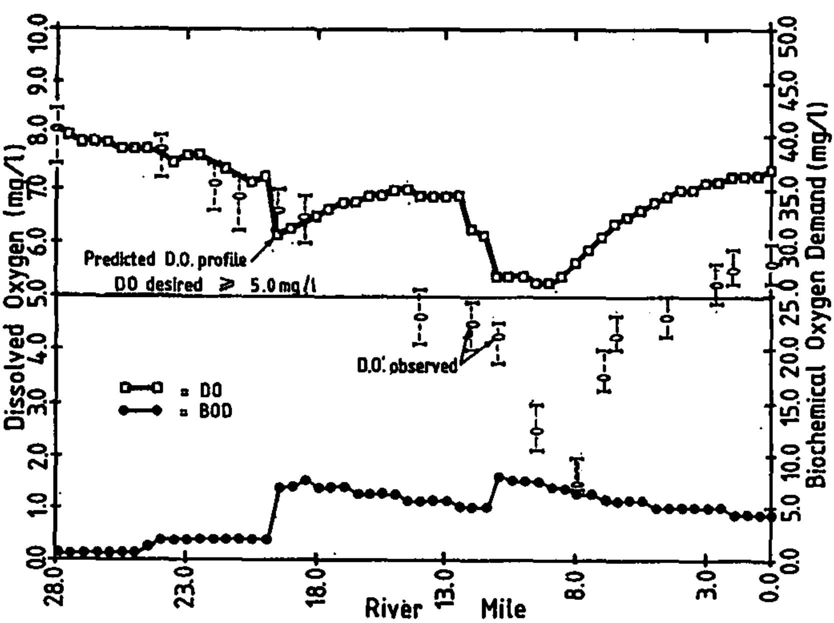

Fig.7 Mitigative Environmental Control Action 2

CONCLUDING REMARKS

The study demonstrates a systematic and rational technique of identifying and assessing sources of pollution, its nature, and resultant impacts, which could then assist decision makers to consider judgementally, the appropriate and viable mitigative control actions worth implementing in achieving the dual objective of sustaining development within predetermined environmental quality requirements.

The study also demonstrates the utility and importance of computer simulation models in the field of environmental impact assessment, wasteload allocations, and assimilative capacity evaluations.

It can be observed that through water quality simulation modeling a more rational basis for making water quality control decisions, which should include a defensible, credible, predictive framework within the larger framework of economic analysis could be made.

ACKNOWLEDGEMENTS

The authors would like to express their appreciations to the members of the Sg. Linggi Taskforce who had diligently executed their functions in the six months field and laboratory data acquisition programme. A general mention of thanks is also due to personnels involved in rendering various assistance towards the completion of this paper.

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WORKSHOP 5: Financing options - privatization

The workshop will continue the discussion from the 1993 Stockholm Water Symposium about the financing and management of important projects in Western countries, post-Communist areas and countries in the South.

What is Western Europe's experience of privatizating of the water industry? Is privatization a solution for the future? Trends and tendencies, advantages and disadvantages, in different countries.

PRIVATE SECTOR PARTICIPATION (PSP) IN THE MANAGEMENT AND FINANCING OF WATER AND WASTEWATER SYSTEMS

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A. MANY DIFFERENT FORMS OF PSP ARE INCREASINGLY BEING IMPLEMENTED THROUGHOUT THE WORLD

1. **PSP in the sector is an established practice and is spreading throughout the world.** Throughout the world, there is a strong growing trend towards the participation of the private sector in the management and operation of water and wastewater enterprises and increasing reliance on private finance for sector investments. Numerous examples of past failures in public provision, combined with growing evidence of more efficient and user friendly management by private sector operators, has led to a significant increase in private involvement in financing and operations. Private water utilities have been in operation successfully for decades in many parts of the world. In the United States of America, some 40% of the water and wastewater sector is in private hands, even though the tax regime is slanted in favor of public ownership. In France, local governments own the infrastructure, but a growing number of governments - now accounting for about 75% of all urban water connections in the country, (though less for sewerage), have opted to delegate the operation to private firms under management contracts, leases or concessions. Similar arrangements are spreading in Spain and Italy and are also being adopted in cities of Latin America, East Asia and Africa. In Germany, private firms serve only about a quarter of all users, but even municipally-owned utilities farm out a large share of their work, and a dynamic industry of specialized sub-contractors has developed. To accelerate the modernization of the water sector in the eastern states of Germany, private entry is encouraged. In the 80s, all water and wastewater enterprises in England and Wales were converted into fully private stock companies. Their shares were floated on the stock market, transferring full ownership to private investors and limiting the public sector's role to one of standard-setting and regulation. PSP has already taken hold in the transforming economies of central and Eastern Europe. Water supply and waste water services in Gdansk, Poland, and Brno in the Czech Republic, are managed by private joint venture companies with foreign and local interest.

2. **PSP can take several different forms.** PSP in the municipal water and wastewater sector may be divided into three different areas:

- supply of services and goods to utilities (equipment, construction, consulting services) to utilities; this form of PSP is standard in all market economies where a private sector industry is in place to serve water and wastewater utilities on the basis of competition in price and quality

- specialized firms providing services in utility management and operations and management which could range from only one small (meter reading only, for example) or the entire utility;

- provision of investment finance in various forms, including straight commercial lending and equity contributions as part of concession contracts or Build, operate and transfer (BOT) arrangements.

1/ This paper contains the author's personal views and not necessarily those of the World Bank, although they reflect many of the stated policies and current strategies of the World Bank.

3. PSP come in a variety of contractual forms which over the past have evolved in response to the needs of both the private and the public sector. They range from simple service contracts over concession or Build, operate and transfer (BOT) arrangements to full fledged private ownership as in the U.K. model (see Annex 1).

4. **Under any form, PSP remains a public/private partnership.** Providing water and wastewater services is clearly a business with extensive natural monopoly features. It cannot be left in the hands of the private sector unsupervised. Even in countries that have opted for extensive PSP, central and/or local governments retain a commanding role in providing guidance, regulation and oversight for the water sector. Simple service contracts are assigned and supervised by the contracting agency, usually the utility. Full management and operation of systems is provided by the private sector under contract with local government which retains regulatory power. Full privatization in the U.K. required the creation of strong regulatory capacity at the national level to ensure that private sector companies in full command of all aspects of utility management and operation and asset ownership provide services efficiently and at a fair price to the public. The regulatory role of the government is needed to ensure that externalities (environmental, public health, urban and regional development) are handled properly. But there is clear realization that the state needs to do everything by itself: the day-to-day operations of a utility consist largely of industrial and commercial processes that private firms tend to handle in a more efficient way than public enterprises. Private participation does not mean that the public sector disengages entirely or loses control, but that it opts for a new division of labor between public and private partners based on comparative advantage.

B. ADVANTAGES OF PRIVATE FIRMS OVER PUBLIC AGENCIES

5. **Public sector management of utilities has a generally disappointing record.** With the exception of a few countries that have a strong public service tradition in high-income economies (eg. Germany, Switzerland), public water utilities (municipal or national) worldwide have performed poorly in terms of service reliability, productivity, attention to customers, financial management, or the selection and implementation of investment projects. More often than not, political considerations have prevented governments from being successful in regulating their own enterprises or holding them to acceptable performance standards. The main reasons why local governments turn to the private sector is for essentially two reasons:

- allow the introduction of efficient management practices which they feel they can't assure, if operation stays in public hands;
- tap private financial markets for lack of investment resources available in the public domain.

6. **Private Firms don't suffer from constraints often placed on public utilities.** Private firms and contracts between private firms and a public regulator can provide many features which are not possible with public agencies, including:

- consistency of objectives and transparent disclosure of obligations and performance targets due to longer term and specific contracts which can be upheld in court;
- freedom from civil service laws and regulations which allows more flexible employment practices geared to quality rather than quantity and more direct command structures;
- the profit motive which compels private firms to be as efficient as possible to make a profit while being held to high standards of efficiency and productivity;

- contracting practices based on competition which force private firms to offer and deliver high levels of efficiency to win contracts;

- economies of scale, as private operators usually serve many customers and thereby gaining expertise and experience.

7. **If regulated properly, PSP leads to higher efficiencies and possibly lower prices to the public.** Numerous examples throughout the world demonstrate that putting service management and operation into private hands leads to higher efficiencies and often lower prices. Enlisting the private sector to leverage the financial and managerial resources of the state and introduce efficiency incentives can help countries attain better service coverage and quality faster and at a lower cost to users. The PSP experience in countries like France or Spain provides a consistent record of tighter management (shown for instance by sharp reductions in water losses) and reliable service whenever reputable private firms are called to operate waterworks formerly handled by municipal enterprises. Perhaps the most compelling example of what the private sector can do is in Buenos Aires, the capital of Argentina. The government faced a crisis it was not able to solve by itself: reform a highly inefficient and inept public enterprise and mobilize large amounts of funds to expand service coverage and rehabilitate existing systems which were in an advanced state of disrepair. After rigorous competitive bidding, the government signed in 1992 a concession contract with an international/local consortium of private firms to refurbish, expand and operate all water and wastewater systems. The winning bidder committed himself to investments of about $500 million during the first five years of the concession, and still was able to reduce the existing tariffs by about 20%. Encouraged by this example, many cities in Latin America (Lima, Peru and Caracas, Venezuela, for example) are considering dismantling their inefficient public enterprises and opting for complete reform by inviting a private operator.

C. STEPS AND CAVEATS IN SECURING PRIVATE PARTICIPATION

8. The process to acquire private participation in a municipal utility will be different for each city, but certain key steps and potential stumbling blocks will be similar. They are discussed below.

9. **Define the local government's objectives clearly.** A local government interested in pursuing PSP options should first have a clear vision of its own strategic objectives. These are likely to include improved operating efficiencies and cost reduction, modernization of the service, rehabilitation of the existing infrastructure and/or the mobilization of private capital for new investment. The PSP option suitable to a given city depends largely on the relative priority ranking of these objectives. Municipalities which seek efficiency gains in running an existing system but do not require major investment finance may consider service contracts, a management contract or a lease. Those mainly interested in raising investment finance should consider a BOT if it is for a self-contained facility (eg. treatment plant), a concession if it is for a more comprehensive investment and rehabilitation program, or possibly a sale of shares. Clearly, these objectives are not entirely independent. A well designed concession will not only provide financing but is also a powerful incentive for operational efficiency. Conversely, the recurrent cost savings achieved through service contracts or a lease will free resources for investment. A management contract with a reputable operator may also ease access to loans or bond finance as lenders will feel more comfortable about the utility's prospects. Nevertheless, each form of PSP emphasizes a different set of objectives and must be selected in accordance with the needs of the municipality.

10. **Build internal consensus on a PSP option.** There is not really one "right" PSP arrangement. A key factor of success is that the municipality (i.e. its elected officials, local opinion and stakeholders such as the employees) should be comfortable with the terms and conditions of the private involvement considered. The initial steps for a municipality seeking PSP should be to pinpoint the tasks and risks it wishes to retain or unload, identify the form of contract most conducive to these objectives, and build an internal consensus on this strategy. This strategic step is often

overlooked as municipalities rush into details or react to unsolicited proposals which eventually results in delays or, if a suboptimal contract is signed, in frustration and dissatisfaction at a later stage.

11. **Adopt realistic targets for service level, investment and tariffs.** PSP secured competitively will most likely result in lower costs for a given service level[2/]. However, the best PSP deal will not succeed if the underlying objectives and economics are faulty. For instance, tendering a BOT for an over-dimensioned treatment plant with overly ambitious treatment levels will result in user charges that the local population should not be asked to pay and may not be able to afford. Adopting affordable service objectives, and spelling them out clearly, is key to obtaining responsive, comparable bids. Also any investments should be justified by their own merits independent of the source of financing: the fact that an investment is financed and carried out by the private sector does not change its quality. It follows that privately financed and implemented projects must be subjected to the same rigorous selection and justification process as any other investment.

12. **Sort out labor impacts at an early stage.** Employees and unions are apprehensive of any privatization. Their concerns may well be exaggerated. In the water sector, firms value staff with long experience with the network and customers, as shown by the low employee turnover even in privately managed utilities. The experience of private firms taking over waterworks in France, Spain or the UK shows that they tend to retain a large proportion of the existing workers. Higher wages and performance-related pay in the private utility may also elicit worker support. Even so, the very purpose of private participation is to enhance productivity, which means doing the same job with fewer people. Many water enterprises are undoubtedly over staffed, and they perform in-house a number of ancillary tasks that can be competed for and that a private utility should not be asked to take under a franchised monopoly. Whether they opt for PSP or not, municipalities will face tough labor decisions and have to balance the interests of workers with local rate payers. Detailed social plans should be prepared with employee information and feedback before tendering a lease or concession - not doing so will scare bidders away or derail the transfer at a later stage. Appropriate severance payments will be required, and workers should be helped to set up small contracting firms. Any labor liabilities or employment requirements placed on the contractor (such as for instance a commitment to downsize the work force only gradually, through retirements) should be made clear in the bidding documents.

13. **Acquire PSP through a transparent competitive process.** In a market economy, competition is key to get the best proposal the market can offer. Often the argument is heard that private firms are not overly eager to invest in countries with macroeconomic and regulatory risks, and will not commit resources to prepare detailed proposals unless they are assured a deal and/or are able to cushion their risks with clear rents. Competitive tendering would thus, it is argued, not attract bids from the best firms, leaving municipalities worse off than a sole-source negotiation with a reputable partner. There may be some truth in this for most transition countries, however, there are various methods to introduce competition - starting at the domestic level. Spontaneous privatization, whereby the management and workers of an enterprise take over its assets, does not result in any of the benefits of privatization unless attendant changes take place in operational and attitudinal terms. The tendering process and bid evaluation criteria depend on the PSP option considered.

14. **Avoid arrangements that will restrain competition in future procurement.** Competition for service contracts awarded by a public utility should be open, with no preference given to a particular set of suppliers or contractors. In transition economies, contracting preference issues arise

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2/ However, private provision often <u>reveals</u> costs that were hidden or repressed in a public enterprise. For instance, many public enterprises run down their assets through insufficient maintenance, pay suppliers late, or do not quite meet the sanitary or environmental standards they are supposed to. A private concession holder bound to a contract will not have the same regulatory or accounting slack. The tariff outcome of privatization will thus depend on the extent to which the public utility accounted for its costs properly and recovered them. A privatization scheme associated with higher service level objectives (eg. the introduction of sewage treatment) will bring higher costs and tariffs.

in the case when contracting firms are established as part of the restructuring of municipal utilities, mainly by spinning off their large engineering and construction departments. In addition to financial assistance provided as part of an employee severance agreement, these firms can be given initial contracts with the waterworks to get them started. However, they should compete on even terms for all subsequent work[3/]- otherwise, savings in the utility's payroll will be offset by the extra costs of uncompetitive contracting. This argues against plans which call for the local government or water and waste water enterprise to take permanent equity positions in spinoff firms created to absorb redundant workers.

15. **Watch for mixed incentives.** The contractor's incentives in a service contract paid on output (eg. meter reading), or in a concession regulated with a price cap, are straightforward: provide the output required at the lowest possible cost. In management services or lease contracts however, conflicts of interest may occur. The operator often takes part in system expansion, but does not pay for it. His judgment may be slanted in favor of capital-intensive options (eg. plant automation) that may have negative overall returns in a low-wage economy but would cut his own operating costs. More critically, the main international players in utility management are vertically integrated groups with interests in engineering and supplier industries. In a concession, insider procurement does no harm - the concession holder may only waste his own money. In contrast, when a lease holder administers a capital works funds as an agent to the municipality (especially if the fee for this service is calculated as a percentage of the amount invested), tight supervision is required to address the risks of gold-plating, insider procurement or over-invoicing. This supervision should be designed up-front, possibly using independent consulting or audit firms, and embedded in the lease contract. Ukrainian municipalities have scant experience of competitive procurement and need guidance on this matter.

16. **Most importantly, local governments should retain independent expert advice.** Once a municipality has defined broadly the forms of PSP most suitable to its situation and unless it is limited to simple service contracts, the next essential step should be always to retain the assistance of experienced legal, technical and financial advisors for the full duration of the contracting process[4/]. The reason for this is simply that the municipality, even if it has competent legal and financial staff, is unlikely to have any prior first-hand experience in dealing with private utility operators/investors. In contrast, the private firms across the table have gone through these steps many times before, and they are likely to engage top-notch advice on the matters to be negotiated. Municipalities may hesitate to pay the high fees for quality advice, but the benefits derived from more favorable contractual conditions for a large concession or lease are likely to be many times greater than the fees at the beginning. Local governments should be wary of studies provided free of charge (or as an equity contribution) by a candidate private partner or contractor. These studies lack the independence of judgment needed to form a balanced partnership.

3/ EMOS, the water company of Santiago in Chile, was successful in helping former employees set up shop as sub-contractors through a one-off separation grant and initial contract, then letting them compete for business. A key element in EMOS's strategy was that former employees established several competing firms for each of the activities restructured, rather than just one spin-off company that would have had a much greater lobbying power to keep a protected market.

4/ The advisors should be hired under detailed terms of reference. Their tasks should include: an early market sounding to ascertain private sector interest; baseline review of the existing system and its operating costs and potential productivity gains; demand forecast; investment program and feasibility study; financial analysis to anticipate the cost and tariff implications of proposed service improvements; definition of regulatory arrangements; employee transfer or compensation arrangements; assistance in the bidding process (including preparation of draft contracts and bidding documents, pre-qualification of bidders and bid evaluation), and continuing advice through negotiations and closure with the selected bidder.

D. PREPARING THE GROUND FOR PSP

17. **International capacity for private utility management is limited.** There are only a relatively small number of experienced international firms, most of them French or British, which are capable of operating a utility and offering their services abroad. Their capacity to take on new contracts has clear limits. Currently their services are in high demand, as many countries are seeking foreign investment and private participation in the infrastructure sectors. Given this favorable position, these firms tend to pick only the very best deals, and they are unlikely to get involved in a large number of cities in any given country. While there is no doubt that most of the countries in transition are of interest to these companies, they will probably hesitate in getting involved under present economic conditions and, if they were to get involved would be interested initially in only one or two cities which offer them an especially favorable environment.

18. **Domestic private utility industry essential.** Private participation will hinge on the emergence of capable local firms offering utility services. The development of such firms would sharply enhance the political feasibility of private participation[5]. A domestic industry of contractors and service firms with sufficient experience and financial strength to take on service contracts, concessions or BOTs will take time to develop. This in turn will depend mostly on how fast the government will create an overall business friendly environment and private firms acquire the capacity to offer these services. Measures that would contribute to this development include the privatizing of engineering and construction enterprises and the adoption of open, competitive rules for public procurement. The development of local expertise in matters of utility management and operation requires special know how which local companies can probably acquire best by forming joint ventures with foreign firms.

19. **Non-discrimination in financial support or taxation.** In providing financial support to the sector, it is essential that the government does not discriminate against private service provision. The level of grant support for a wastewater treatment plant, for instance, should depend on its environmental merits and not whether it is built with municipal or private money. Provision of subsidies or the issuance of sovereign guarantees for external lending should be made available on an even footing, independent on whether they involve the private sector or not. Similarly, national and local tax regimes should not slant decisions against private participation alternatives.

20. **Steps to prepare for PSP.** While in many countries the climate for PSP may not be favorable at the present time, efforts should be made to prepare the ground for PSP.

National governments through sectoral ministries should:

- introduce private sector friendly policies which encourage PSP in the sector and the emergence of a PSP capacity in the sector.
- provide assistance to local governments and water and waste water enterprises in understanding the potential advantages of PSP and the way PSP can be implemented.
- support pilot operations, even if they are small, through grant resources and/or by using a sovereign guarantee to support well conceived PSP pilot operations;

Local Governments and Water and Waste Water Enterprises should:

- consider PSP options, but seek expert advice, before going ahead and use competition to contract private sector;

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[5] Having a local or foreign-based utility operator makes very little difference for domestic employment, contrary to a frequent belief. International utility firms employ very few expatriates, for obvious cost reasons.

Foreign assistance institutions should provide grant resources to:

- assist the government in preparing and disseminating policies and information supporting PSP;
- provide advice to interested local governments and Vodokanals and assist them in preparing PSP operations.

Foreign PSP firms should be prepared to:

- help disseminate advantages of PSP; and
- consider competing for PSP opportunities in cooperation with local firms or individuals.

CONCLUSIONS AND RECOMMENDATIONS

21. The World Bank supports private sector participation in any of its forms. This support is not given out of an ideological bent, but out of the conviction that the private sector has important advantages to offer, where public provision of service cannot reach acceptable levels of efficiency. In terms of financing investments, PSP is unavoidable, as the large amounts of financial resources required in the future cannot be provided by the public sector alone. PSP contracts, however, should be acquired under terms fair to both parties. To ensure that, local governments in countries without a strong experience in dealing with the private sector should obtain expert advice to make sure that the acquisition process is transparent and competitive and that contracts are fair to both parties.

Annex: Different Forms of Private Sector Participation

Private firms can be brought into the operation and/or development of water and wastewater services in different ways, which vary by their scope and the extent of responsibilities and risks assumed by the firms and the contracting authority.

Under a **service contract**, a utility hires a private firm to carry out specific tasks (eg. leak detection, meter reading, water quality measurements) while retaining full responsibility and risk for service provision. Subcontracting is especially advisable for activities that have large peaks (for instance, construction), or when the in-house level of activity is insufficient to reach an efficient scale of operation (for instance, water quality laboratory, or vehicle fleet maintenance). Even for other activities (for instance, meter reading) private contractors working under competitive pressure are often more cost-effective than utility departments.

A **management contract** is a service contract where the utility or its municipal owner hire a management team from a private firm. It can be used to bring in new management systems, organization and skills, or as a preliminary step to restructure a dilapidated utility before a concession. Compensation is cost-plus-fee, and the contracting municipality retains most of the operational and commercial risks of the utility, though some risk-sharing may be built into the contract using performance bonuses or contingent fees.

In a **lease contract**, a private firm takes over the operation and maintenance of the system, collects user charges, and is compensated with an agreed portion of the revenues. The municipality remains responsible for system expansion and replacement of major assets and recovers part or all of its costs from its own share of user charges. The lease holder may also administer investment funds as agent to the municipality, without taking related financial risks. In Guinea, water supply owned by a state enterprise (SONEG) and leased to the operating company (SEEG) from 1989 for 10 years. This arrangement has resulted in significant increases in bill collection.

In a **concession** or build-operate-transfer (BOT) scheme, private investors arrange the financing and construction (or rehabilitation) of either a self-contained facility (eg. a treatment plant) or a complete water/sewerage system, then operate it for the period of the concession. For a treatment plant-type BOT, the investor is compensated by the public utility under a "take-or-pay" obligation, and the public utility retains the commercial relationship with the end-users and assumes the related risks. In a system-wide concession, the investor bills and retains user charges for the concession period.

Full private ownership (the model in England and Wales), involved the sale of all utility shares to private investors. A national agency regulates the performance of the private utilities and has jurisdictions over tariffs.

Joint-venture companies in which local government and a private company share ownership. An option which has gained considerable popularity in Central and Eastern Europe. The joint venture may either own the assets or (most often) be given a franchise by the local government as in one of the lease or concession arrangements described above. An issue with joint venture arrangements is a built-in **conflict of interests** with the local government being on both ends of the franchise contract, as regulator, owner of the infrastructure and also a key shareholder in the operating company. The main issue here is how local governments would react to breech of contract by a firms that is partly owned by it. Nevertheless joint ventures seem to be the only feasible alternative for political reasons and there are some highly successful experiences with mixed-capital water enterprises, especially in Spain (eg. Alicante, Murcia).

RESTRUCTURING OF METROPOLITAN WASTE WATER MANAGEMENT IN A CHANGING POLITICAL ENVIRONMENT - A SOUTH AFRICAN EXPERIENCE

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FOCUS

The East Rand is part of the Pretoria-Witwatersrand-Vereeniging (PWV) metropolitan area and is situated due east of Johannesburg, South Africa. The sub region has approximately 2.5 million residents and provides for about 11% of the South African gross domestic product. The East Rand Regional Services Council (ERRSC), a regional Governmental body, became responsible for the provision of regional services and upgrading of backlog infrastructure in 1986.

The area of jurisdiction of the ERRSC included 22 local authorities, covering approximately 3000 square kilometres. Amidst the growing crisis due to severe economic recession, drought and political transition which resulted in uncontrolled urbanisation, tariff boycotts, violence and crime, general collapse of municipal services and infrastructure in some areas; the ERRSC was to decide on extensions at several waste water treatment plants.

At the time (1989), waste water generated in the East Rand was treated at 22 water care works of which 3 were owned by the provincial administration and the remainder owned by 9 local authorities. Plant sizes varied from 0.4 Ml/d to 83 Ml/d with plant technology based mainly on biological nutrient removal (BNR), activated sludge or conventional biofilter (fixed film reactor) plants.

In order to optimally decide on future extensions and functional responsibility, the ERRSC decided that a comprehensive strategic plan for waste water conveyance and treatment be developed to inter alia achieve the following objectives :

- To develop and compile a long term **strategic plan** for the management of waste water in the East Rand Region, which had to provide for the present situation and future development of the system up to the year 2010.
- To investigate and to make recommendations in respect of the most feasible **management structure** for implementation and execution of the waste water management strategy.
- To investigate and to make recommendations in respect of a feasible sewage treatment **tariff structure**.

The initial project, involving a multi disciplinary approach, commenced November 1989 and was completed during August 1990. More than 3 000 project hours were spent to achieve the objectives.

The project commenced with the definition of the system, its boundaries, environmental forces, sub-system elements and interdependencies. A formal strategy formulation process model was used and an analysis included the following:

- Environmental analysis - direct and broader.
- Resources analysis - resources conversion.
- Systems analysis - sewerage and treatment systems.
- Mission and objectives definition and description.
- SWOT (strengths, weaknesses, opportunity, threats).
- Mission success factors determination.
- Development of generic strategic alternatives.
- Decision modelling, risk and sensitivity analysis.
- Compilation of strategic plan.
- Management structure, analysis and design.
- Development of tariff structure model.

After completion and approval of the recommendations of the initial project, a further investigation was conducted to prepare for implementation. Inter alia, the human resources development plan outlined mainly the proposed management and organisational structure, which incorporated the transfer of approximately 700 people into a newly established company.

SITUATION ANALYSIS

Approximately 116 204 Ml of waste water was conveyed to and treated at the 22 waste water treatment plants in the East Rand region during the 1989 financial year. The following quantities of pollutants were removed :

- Carbon as C.O.D. = 92 853 tons
- Ammonia as N = 3 716 tons
- Phosphorus as P = 938 tons
- Total suspended solids = 43 434 tons

The removal of the pollutants resulted in the land disposal of approximately 19 300 tons of sludge. The total cost for treatment alone amounted to R40 800 000 ($11 200 000).

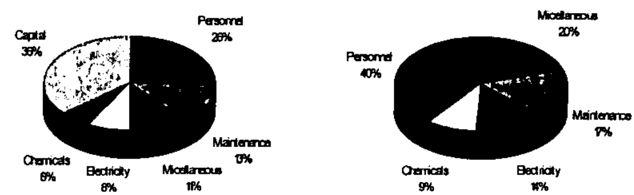
Various operational and process problems were experienced during 1989 which resulted in an unacceptably low compliance of effluent in terms of the General Standard of the Water Act. Only 37,3 Ml/d (12%) of the 318 Ml/d waste water treated resulted in more than 95% of compliance.

Figure 1 summarises some of the important salient features with respect to the treatment of waste water in the East Rand Region. **Figure 2** presents the average financial costing structure of East Rand water care works.

Figure 1 : Salient features for 1989

RESOURCE	AVERAGE
1988/1989 Ml/d treated	318 Ml/d
Operators : No. legally required	110
Operators : No. employed	58
No. of employees / Ml/d treated	2,05
Balance on loans / Ml/d treated	R 191 023
Depreciated value / Ml/d treated	R 1 006 154
Replacement value / Ml/d treated	R 1 302 950
Conformance with general standard	Only 37,3 Ml/d of 318 Ml/d
Average performance rating	66,4%
Annual $FeCl_3$ consumption	5 588 ton/a
Annual $Fe_2(SO_4)_3$ consumption	1 612 ton/a
Annual chlorine consumption	163 ton/a
Annual power consumption	30,06 million kW
Average power consumption	259 kWh/Ml
Total perceived plant capacity	460 Ml/d
Perceived spare capacity ratio	1,45 Ml/d
Average total unit treatment cost	35 c/kl
Average plant size (treated)	15,6 Ml/d

Figure 2 : Costing structure of East Rand Water Care Works



The average unit cost of treatment for the region amounted to $95/Ml and was considerably higher than the average cost of treatment in the neighbouring Central Witwatersrand ($68/Ml) and Pretoria region ($76/Ml).

The situation analysis yielded the following conclusions :

- Approximately 148 Ml/d (35%) of the perceived design capacity reserves existed within the East Rand.
- Oversupply of operators and supervisors in certain categories in a regional context.
- Oversupply of well equipped laboratory facilities.
- A well developed maintenance and repair infrastructure has been established.
- Excessive unit treatment costs are mainly due to under utilisation of established treatment capacity.
- A large number of small plants (twelve plants with a capacity of 20 Ml/d or less, i.e. about 30% of present capacity) exist, or are extended in small unit sizes, with an implied higher relative initial capital investment per Ml/d as well as relatively high operating and maintenance cost. Economy of scale thus not well utilised.
- Capital cost as well as operating and maintenance cost advantages through standardisation of equipment and processes (even on a per works basis) not utilised.

- The absence of central control inhibits negotiating power of the owner of water care works with regard to supply of equipment and construction of new plants as well as supply of consumables.
- The absence of a central body limits owner of plant regarding distribution of experience and skills in terms of procurement, as well as operating and maintenance of various equipment types and process configurations.
- Lack of role definition in top management structure at plants. Absence of works manager responsible for cost and effluent quality.
- Lack of easily accessible and discrete costing information in respect of waste water conveyance and treatment.
- Plant performance in respect of compliance with the requirements of the General Standard was unacceptable, as not a single works complied fully during the year with the requirements. (Only 12% of the effluent complied 95% of the time for 1989).

STRATEGIC ALTERNATIVES AND DECISION MODELLING

The strategic analysis included a SWOT analysis (i.e. the development of the mission statement for the functions, appraisal of resources, systems and environmental factors, development of a cruciform (SWOT) chart, agreement on mission success factors and analysis of the planning gap). Technical personnel of councils co-operated with the development of the strengths, weaknesses, opportunities and threats (SWOT) as well as the mission success factors.

The following mission statement for the function was developed in co-operation with the technical departments, top management of local authorities and the ERRSC:

"The mission of our organisation is the conveyance and treatment of municipal waste water at the lowest operating and maintenance cost, through effective and efficient employment of all resources and in compliance with legal, social and environmental constraints, to the short term and long term benefit of the whole East Rand Region and other participating bodies."

The integration of the environmental, resources and Systems analysis results, the mission success factors and the mission statement, resulted in the development of the generic strategic alternatives.

The development of strategic alternatives were based on the following underlying assumptions :

- That all regional sewage pump stations be eliminated and replaced with gravity sewer linkages, based on the drainage district concept.
- Strategies to be developed within the concept of drainage districts, the boundaries of which coincide with the defined watersheds.
- First order economic assumptions in respect of strategic decision making to be cost of capital = 18% per annum, rate of inflation = 15% per annum and loan period to be 20 years. It is also assumed that the East Rand region could afford the service.
- That the General Standard for effluent would remain.
- Siting criteria for new and existing works to be in accordance with the governmental requirements.
- That waste water flow and load prediction to take place in accordance with the flow and load prediction model. The average growth is to be based on 3,1% per annum.
- That costs for waste water treatment be in accordance with the economy of scale models for capital, operating and maintenance costs.

Figure 3 and 4 graphically present the economy of scale functions developed for the decision making model. Also presented are actual results from various plants analysed.

Figure 3 : Economy of Scale Function for Capital Expenditure of Water Care Works

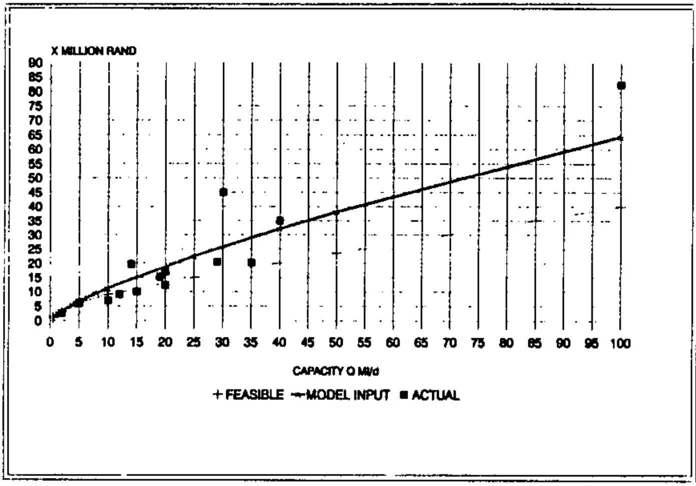
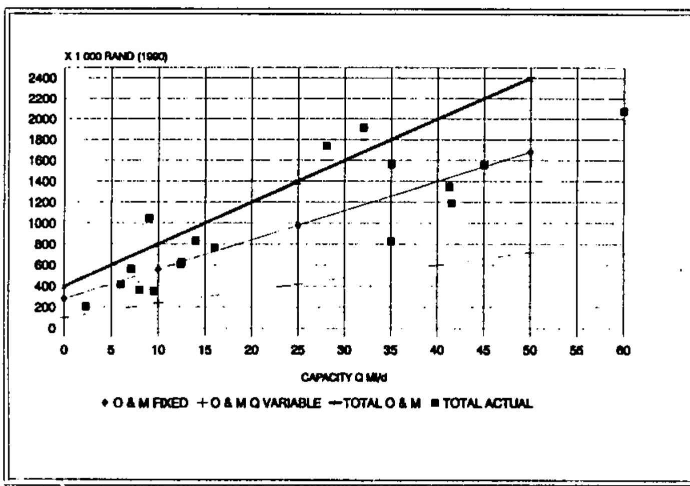


Figure 4 : Economy of Scale Function for Annual Operating Expenditure of Water Care Works



The figures **clearly** indicate the presence of economy of scale for both capital, operating and maintenance costs for these plants.

The three strategic alternatives considered were **status quo extension**, **regional extension** and **portfolio extension**. Financial and non-quantitative decision modelling were used to evaluate the alternatives. In addition, the alternatives were subjected to a detailed financial sensitivity analysis. The most feasible strategic alternative was found to be the one of rapid **regionalisation**. In summary, the best strategy with regard to the extension and construction of treatment facilities over the next twenty years was found to be as follows :

- Addressing urgent needs first.
- Phasing of projects to develop experience curve effect and build management team and expertise.
- All communities to be supplied with water borne sewerage systems.
- All sewerage systems to be feasible to gravitate and all main- and most local pump stations to be eliminated.
- The region to be divided into five major drainage districts.
- The five drainage districts to eventually be served by five regional water care works and all existing local water care works to be phased out in accordance with the strategic development plan.

The cost implications for the ERRSC region were estimated as follows (1990 values):

Total nominal treatment cost (1990 - 2010)	(N.V.)	=	\$1735 million
Total present value cost (1990 - 2010)	(P.V.)	=	\$310 million
Total capital requirements (1990 - 2010)	(P.V.)	=	\$82 million
Average unit treatment cost (1990 - 2010)	(P.V.)	=	\$70/Ml
Average unit treatment cost (2010)	(P.V.)	=	\$68/Ml

Effective implementation of the proposed strategy could lead to an actual reduction in present value treatment cost from \$102/Ml (1989) to \$68/Ml (2010). Implementation of the proposed strategy could lead to a conservative saving of more than \$100 million U.S. dollars (18%) compared to the status quo option.

MANAGEMENT STRUCTURE

In order to establish the most suitable management structure to "drive" the proposed strategy, detailed investigations were done, considering the following :

- Analysis of existing organisational structure.
- Evaluation of alternative structures.

Several alternative management structures were investigated, including the following :

- Operation management of water care works by selected local authorities by means of an agency basis or contract basis.
- Privatisation of water care works. Several options of "contracting out" were considered.
- Transfer of all water care works resourced and systems to a water care corporation similar to the Metro boards in the USA.

The analysis was based on the application of the fundamental theories of management and organisational design, which resulted in the development of quantitative and qualitative design criteria. In terms of the macro analysis the industry was found to be **stable** in respect of task certainty and **simple** with regard to task understanding. Based on the above, the best or "ideal" management structure was found to be that of an independent organisation under the management of ERRSC and participating local authorities.

TARIFF STRUCTURE

Several sewer tariff structures in use at the time were evaluated. Detailed quantitative analysis yielded that, a flow and load based production type formula, best suited the specification. The formula was accepted as a result of the following:

- Based on production costing principles.
- Fair and unbiased adjudicator of expenses.
- Unit parameters used in the formula are also the design inputs to process design and control.
- Level of complexity in regional context acceptable.

- Already in use at the time, for costing more than 30% of waste water in the region.

The formula may be expressed as follows :

$$Cn = Ct\ (0.29*Qn/Qt + 0.26*CODn/CODt + 0.15*Nn/Nt + 0.16*Pn/Pt + 0.14*Sn/St)$$

where :

Cn	=	Monthly tariff charge for local authority
Ct	=	Monthly cost for all participants
Q	=	Waste water flow in kl/d
COD	=	Chemical oxygen demand in kg
N	=	Ammonia in kg
P	=	Phosphate in kg
S	=	Suspended solids in kg

Values for the waste water characteristics are obtained by measurement, sampling and analysis derived from the monitoring stations.

STRATEGIC PLAN 2010

A detailed strategic plan was compiled and approved by the ERRSC for implementation. The proposed strategic plan for waste water conveyance and treatment for the East Rand Region contained the following topics : Situation analysis, SWOT indicators, mission success objectives, mission statement, key environmental assumptions, statement of policy, strategic development plan, resource development plan, research and development requirements, the 20 year financial plan and implementation requirements.

The strategic plan summarised all the work done as well as future actions required and provided valuable information with regard to the following:

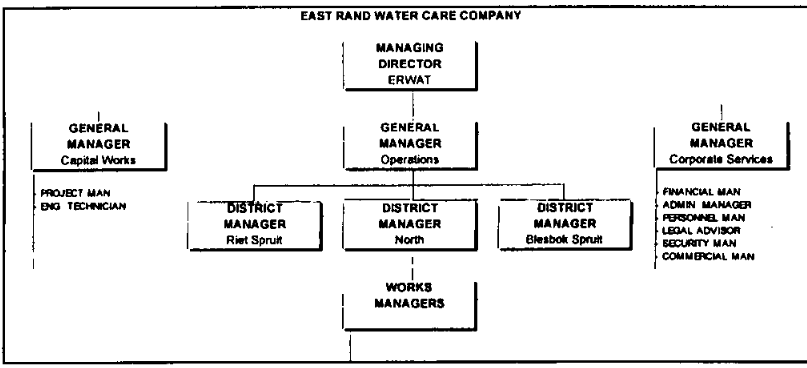
- Long term tariff prediction model.
- Long term flow and load capacity prediction model.
- Long term plant capacity model capable of predicting where, when, what size and at what cost, future facilities would be required.
- Critical success factors formulated in action plans.
- A framework for implementation.
- Long term financial plan.

The effectiveness of the financial plan is demonstrated by indicating a moderate and regular increase in cash flow whilst plant loadings double in the next 20 years.

IMPLEMENTATION

The acceptance of the Strategic Plan 2010 resulted in the establishment of an independent non-profitable company in October 1992. The company was named East Rand Water Care Company (ERWAT) and is currently managed by a small board of directors, representing the participating local authorities and ERRSC. **Figure 5** presents the top management structure.

Figure 5 - Top management structure



It was a prerequisite that by regionalising the service, no personnel employed by the local autorities will be retrenched or demoted. Resource optimisation should be by means of normal labour turnover. The South African local authority industry is highly unionised and special mechanisms were designed and set up to accommodate the various stakeholders before, during and after the transfer of the personnel to ERWAT. More than 600 employees were involved. Modern job grading and renumeration systems were implemented.

Since the inception of the company, management accepted the guidelines of the strategic plan and is currently busy with the updating of some together with detailed investigations originally areas identified in the plan. The predicted results of the plan are achieved and for the 1994/95 financial year the predicted average unit treatment cost should be $94/Ml (1990 PV) which is well within the predicted cost curve. A fully electronic management information system was implemented and the results confirm the economy of scale benefits and the prediction by the economy of scale model for annual O&M costs for water care works.

Currently ERWAT is focusing on bottlenecks and inefficiencies at several plants, confirming the opportunities that exist to optimise existing facilities before new extensions are added.

CONCLUSION

The strategic plan 2010 for waste water conveyance and treatment for the East Rand region is the first of its kind in South Africa, involving 22 local authorities and 22 water care works. The methodology employed to execute the project achieved the desired objectives and is recommended for future use. Twenty one out of twenty two local authorities accepted the strategic which resulted in the establishment of a private and independent company. The East Rand Water Care Company (ERWAT) successfully took over the metropolitan function of waste water conveyance and treatment and restructured the function into a competitive system, whilst also accommodating the important political, constitutional and institutional issues during the transition to a non racial and democratic society.

Part of the success of the acceptance was probably due to the detailed involvement of all responsible parties. Special attention was given to the pre-implementation phase. The project also yielded valuable planning and design information, some of which was presented in this paper. Valuable planning tools were developed, including flow and load prediction models, economy of scale functions for capital, operating and maintenance functions.

Finally, the project emphasised the importance of the effective optimisation of the economy of scale function against the cost of providing spare capacity at various sensitivities for rate of growth.

This project demonstrated the benefits of effective application of strategic management methodologies in order to decide if a function should be regionalised or not.

EFFECTS FROM SELLING OUT ALL ACTIVITIES IN WATER AND WASTE WATER.

Jan Lundgren
SKANSKA NORRLAND AB, Härnösand entreprenadservice
(previously with municipality of Härnösand)

It is a great honour for me and for the city of Härnösand to be given the opportunity to present to you some information dealing with the contracting of technical services in the community of Härnösand, Sweden.

First, some basic facts about Härnösand:

- Location, about 450 km north of Stockholm

- Climate, snow 4-5 months/year

- Population, about 28000 inhabitants

- Water price, about 10 % above average in Sweden

- Political majority, coalition of non-socialist parties

The process of contracting technical services in Härnösand started in the autumn of 1991, partly as a result of the outcome of the election in 1991 when a non-socialist coalition took over after the social-democratic majority. One of the ambitions of the new majority was to "try alternative ways for operation of municipal services, in order to reduce cost and to stimulate local business". Some specific areas were mentioned, including water and waste water services.

The municipal board then, in december 1991, decided to make tender documents and to ask for tenders within the specific areas mentioned earlier. Complementary political decisions were then made early in 1992 giving some restraints to the work e.g. in the areas of taking-over personnel and organisation of work.

A special municipal organisation was thus set up in the beginning of 1992 to implement the decision by the municipal board. A number of smaller groups were formed to carry out the work. A great deal of preparational work was done and presented in separate reports as a basis for the tender documents. Examples of special studies that were made cover:

- prime cost

- legal aspects of contracting municipal services

- personnel aspects including questions of pension

- remaining municipal organisation ("customer's organisation")

Specialists and consultants in separate areas were engaged in this work which also included visits in other municipalities with experience from contracting technical services, both in Sweden and abroad.

A special study was also carried out dealing with organisation and dividing of services into different parts, so called positions. This work was based on the existing organisation of the technical office. It was stated that since operation of services would be handed over to contractors, also resources for this operation would have to be handed over. Such resources include personnel, store facilities, machines, transportation facilities, repair shops etc. The outcome of this study was that tender documents were separated into 6 positions, as follows:

- Pos 1A Street services, water and waste water supply

- Pos 1B Mapping and land measuring

- Pos 2 Community parks

- Pos 3 Public buildings

- Pos 4A Commercial harbours

- Pos 4B Public harbours

The preparational work was finished by the end of 1992 and was discussed by the municipal board and accepted to form the basis for tender documents.

The operational work with preparing the tender documents started late in 1992, about one year after the first political decision. The tender documents were organised in 6 different parts, one for each position, and 2 overlapping parts, common for all positions. The tender documents, as well as the contract documents, were prepared in accordance with Swedish standards such as AB 92 and AMA. An important separation was made between operation of services and preventive maintenance & reinvestments. Tenderers were asked to present a fixed price for operational services. For maintenance & reinvestments, on the other hand, the municipality had defined the standard by determining the yearly total cost for this within each subarea. On-going maintenance & reinvestment projects carried out with own personnel or with sub-contractors were to be taken over by the contractor.

The tender documents were prepared in the spring of 1993 and were, after negotiations with unions and political decisions, sent out for tenders early in the summer of 1993. Tenderers were originally given about two months to deliver tenders, this time was later somewhat extended.

Special emphasis was laid on quality aspects and on assuring quality during operation in the tender documents. Different requirements were set up including business concept, organisation, economy, taking-over resources, information etc.

Five tenders concerning pos 1A were delivered by the end of time for tenders. A preliminary evaluation of the tenders was done by a consultant engaged by the municipality. Since sevaral of the tenders were not complete, a series of supplementary tender information had to be delivered and negotiations had to be carried out before the final choice of contractors could be done. A basis for decision including contract documents was presented in february 1994, a little more than two years after the first decision.

Contract documents were signed with three different contractors. One major contract covered positions 1A, 3 and 4A. Separate contracts were signed for position 2 and 4B, respectively. Position 1B was proposed to remain in municipal opereation. Contracts were signed for a period of 4 years, starting June 1st 1994, with a possibility of prolongation one year. The political decision to accept the contracts was taken in april 1994, and thus the contracts have been into force since about 2 months by now.

The changes in the municipal organisation as a result of contracting the technical services have been substantial. The staff of the technical office has been reduced by about 80%. A new organisation formed to serve as a "customer's organisation" has been set up.

The conclusions that can be drawn from the Härnösand example are so far limited to the process of changing from municipal operation into operation by a contractor. Knowledge and experiences are gathered from the problems arisen during this period. The coming years will indicate, in the shorter run how the contract partners will manage the cope with the ambitions expressed in the tender documents, and in the longer run if contracting technical services will give the inhabitants of Härnösand better service at a lower cost.

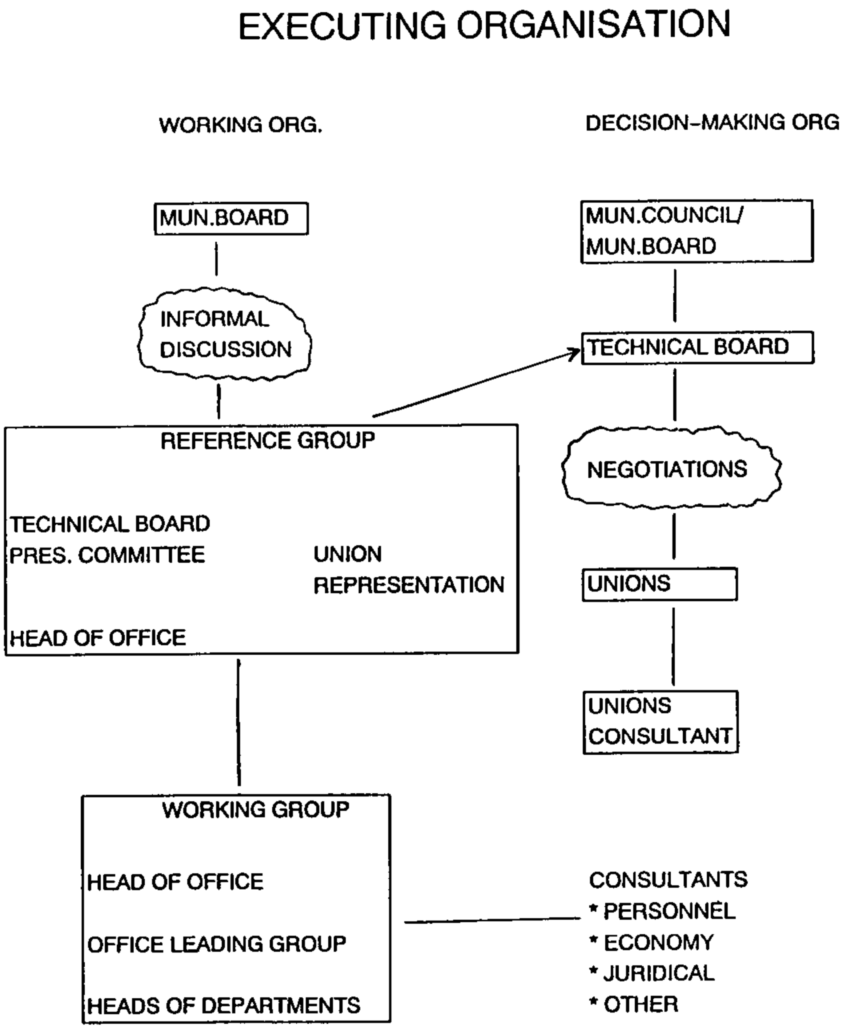


FIGURE 1. EXECUTING ORGANISATION

ORGANISATION OF TECHNICAL OFFICE

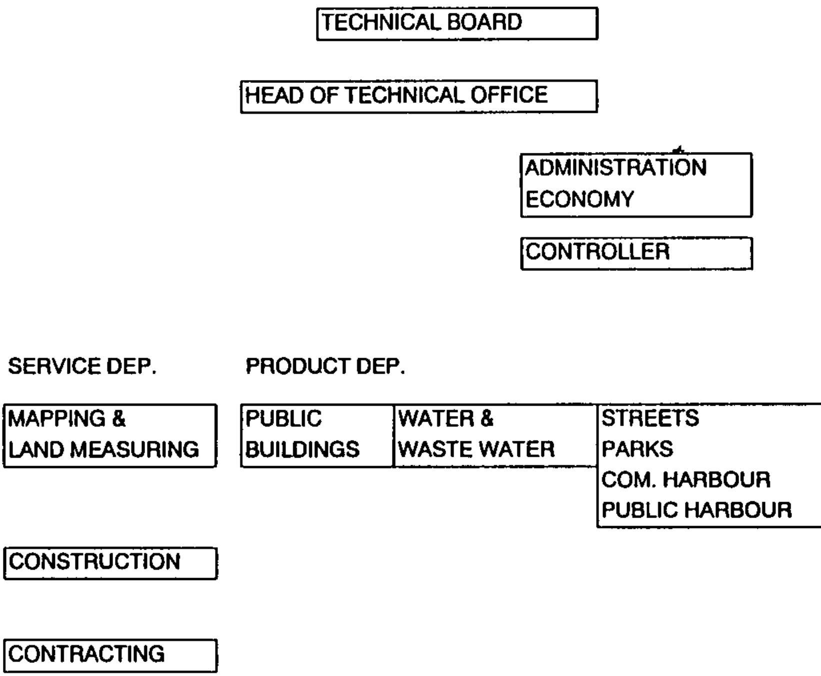


FIGURE 2. OLD ORGANISATION

All positions - general reguirements

1. Invitation to tenderers

2.–6. Tender formulaes position 1A–4B

7. General requirements

Position 1A - Table of contents

A.	SCR	Water&Waste water
B.	V1	List of treatment plants, pipe systems incl. volumes etc.
CD.	V2	Description of water treatment plants
E.	V3	Supervising system
F.	V4	Summary of legal regulations (vattendom)
G.	V5	Description of water distribution system
H.	V6	Description of waste water treatment plants
IJ.	V7	List of sedimentation tanks
	V8	List of water meters
K.	VG9.1	List of personnel
	VG9.2	List of premises
	VG9.3	List of machines & transport resources
L.	VG10	Municipal budget 1993
M.	V11	Water & waste water regulations, water rates
N.	Vk1	Areas of operation
	Vk2	Water distribution network
	Vk3	Waste water system network
O.–Ö.		Appendices dealing with street service

Figure 3. Tender documents

Härnösand - "customer's organisation"

Head of office, 1p

Administration & economy, 2p

W & WW, street service, parks, 5p

Mapping & land measuring, 7 p

Public buildings, 3–4 p

Commercial and public harbours, 2–3 p

Figure 4. New organisation

Härnösand - conclusions:

- A long distance run
- Unchanged requirements during time of change
- Like selling a company without shares - with differences in system
- Make a choice, develop existing organisation or contract
- Define a clear decision process
- Employees conditions for work ("trygghetsregler")
- Suitable time for taking over
- Enough time for negotiations
- Questions that you can´t affect
- A careful preparational work
- Customer´s competence (work together if necessary)
- Openness to unions

Figure 5. Conclusions

PRIVATIZING BUENOS AIRES' WATER SUPPLY AND SEWERAGE SYSTEM

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The Economic and Policy Backdrop

1. By 1989 Argentina had reached the end of the road of its previous economic policies. The Alfonsin government had lost the control over the economy. The public sector deficit had risen to 22% of the country's gross domestic product, annual price increases of 4900% were approaching hyper-inflation, physical output was plummeting, the foreign debt had not been serviced for over a year, and public morale was at an all-time low. The crisis reached such proportions that the Alfonsin government prematurely handed over the presidency to the president-elect Carlos Menem.

2. The Menem government moved quickly to stabilize the economy. Improved tax collections and expenditure cuts reduced the public sector deficit. In early 1991 a decree was passed, strictly linking public expenditure to revenue. Starting in 1990 an aggressive privatization program was launched, raising direct revenue from sales, and eliminating the need to subsidize money losing operations. Under its forceful Minister of Economy, Mr. Domingo Cavallo, a "Convertibility Law" was passed fixing the Argentine peso at parity with the US dollar and abolishing all exchange and capital controls.

3. President Menem's strong commitment to privatization was far-reaching. In the course of a little more than three years state enterprises with assets exceeding US$ 18 billion were privatized. By the deadline of 1992 most of airlines, electricity, natural gas, railways, telephones and a few water supply and sewerage companies had been transferred from pubic to private management. In the process, the Government received substantial revenue from sales.

4. Without doubt, the strong and unwavering commitment from President Menem and Minister Domingo Cavallo was necessary for the massive privatizations that took place. It is equally certain that the stabilization of the economy and the convertibility law contributed to the relative success of the entire privatization program. The speed of the program meant that the development of the regulatory regimes for many of the public services was late. Such legislative and regulatory regimes are necessary to ensure that the new private operators of natural monopolies such as water supply and sewerage systems are not taking unfair advantage of the consumers. The risks for abuse of monopoly powers are lower for services such ports, railways, power generation, telecommunications and toll roads where competition is easier to create.

The Obras Sanitarias de la Nación (OSN)

5. Obras Sanitarias de la Nación was created in 1912 with the mandate of constructing and operating water supplies and sewerage systems in the entire country. In 1980 the Argentine provinces were made responsible for water supply and sewerage and the role of OSN was reduced to providing potable water and operating the sewerage system of the capital of Buenos Aires. However, it proved incapable of the task.

6. By 1991 OSN only supplied potable water to 6.0 million (70%) out of the some 8.6 million in the Distrito Federal and 13 surrounding municipalities. Sewerage service levels were lower: only 4.4 million (51%) of the same population was connected to the public sewerage system. There was practically no treatment. Part of the raw water was captured in the Río de la Plata where the raw water was periodically threatened by backup of contaminated water. Another part of the water supplied was from wells in the periphery. This groundwater showed rising levels of contamination caused by the lack of sewerage in these areas. Existing facilities were aging rapidly and annual investments of about US$ 10 million were insignificant compared to the annual depreciation.

7. Operations were inefficient. Metering was scarce and was not used to control water consumption. Unaccounted water exceeded 50% due to the lack of metering and due to the lack of maintenance of the old system. The best operated water companies elsewhere in the world have managed to reduce the unaccounted water to 8% of the water produced. The fact that OSN had been left in 1980 as the residual of a national institution had saddled it with about 8,000 employees. Staff productivity was commensurately low with about 8 staff per thousand water connections. The most efficient water companies in Europe now manage to operate with 1.6 staff per thousand water connections.

8. The financial situation was precarious. The richest urban region in Argentina was barely breaking even on a cash basis and was in deficit if reasonable depreciation had been charged. The fact that the national government was attempting to control public investment meant that investments were negligible. On technical and financial grounds the situation was becoming untenable. It was also becoming a public health risk because of the contamination of both groundwater and surface water, due to the absence of sewage treatment. The risks associated with the fragile public health situation were brought home when cholera returned to the continent in 1990 after an absence of more than one hundred years. The decision to privatize OSN was well justified.

The Stages towards Privatization

8. In order to make effective the decision to privatize the Government could identify four distinct stages:

(a) A series of initial activities to define which type of privatization form would be optimal;

(b) The preparation of background materials and bidding documents;

(c) The pre-qualification of bidders and the actual bidding and contracting;

(d) The orderly transfer of services from public to private management.

Initial Activities

9. Once the decision to privatize was taken, the question remained what form of privatization would be optimal. Early on several options were considered: **service contracts** where outside private contractors would be responsible for improving particularly deficient areas of operations, or one **management contract** where an outside firm would be in charge of the operations of the entire system; or a multi-year concession where a private operator would be made responsible for all operations and maintenance plus for financing new investments.
A **lease contract** ("affermage") was also considered where a private operator would lease the facilities but where the public sector would remain responsible for financing and executing new investments.

10. A thirty-year **concession** was selected. It was felt that the operating difficulties were such that neither service nor management contracts would make much of a difference. At best, these types of contracts could only improve operations and maintenance. They could not hope to improve investment efficiency since the private contractor would have no incentive to economize on investments, let alone the possibility to influence them. And finally, only a full concession would oblige the private operator to obtain outside financing for the necessary works.

11. The exact form of concession remained to decide. In order to introduce competition it might have been advantageous to split the entire Buenos Aires Metropolitan Area into two or more service areas with different concessionaires. (This is the solution selected for the city of Paris with two different management contracts). However, in the case of Buenos Aires there is no natural dividing line. Any division was also likely to result in one area with a relatively wealthy population, and another with lower-income population. This, in turn, was thought to complicate the bidding process. The decision was taken to bid and contract for one large, undivided concession.

12. Another question was how much of the OSN activities to include in the concession. The long history of OSN had left it with a series of auxiliary activities such as production of chemicals, transport services, repair shops, laboratory services for outside users in addition to the core operations of managing the Buenos Aires water supply and sewerage operations. The decision was taken to include only the core operations in the concession. Stormwater drainage, industrial pollution control, and approval and certification of sanitary devices were explicitly excluded from the concession.

13. Finally, it was decided to establish a special **Privatization Committee** to manage the privatization. It was simply going to be do much for OSN itself to remain responsible for the daily operations of the existing system and manage the privatization. To this end, a thirteen member Privatization Committee was formed where OSN had two representatives, the Buenos Aires municipality one, the province of Buenos aires one, the Ministry of Economy three, the National Congress two, and the OSN labor unions had two representatives. This committee was assisted by the World

Bank that provided continuous technical advice and that financed some of the consultant contracts associated with the privatization.

14. The World Bank had also financed and supervised a substantial twinning arrangement prior to the decision to privatize. A German consultant firm had been contracted to diagnose the problems of the existing OSN operations; to propose solutions; and then help to implement corrective measures. Although this consultant contract was cut short by the decision to privatize, the work of the consultants had supplied the Privatization Committee and prospective bidders with much valuable information on the state and location of existing installations.

Preparation of Background Information and Bidding Documents

15. The Privatization Committee employed two international consulting firms in order to prepare proper background data for bidders and draw up the bidding documents. One of the two consultant firms was responsible for the technical preparatory work, another for the financial aspects and presentations to prospective investors/operators. In retrospect, the dividing line between the two firms was somewhat unclear. It would no doubt have been equally effective to have employed one firm only provided that it would have been large enough to supply all the services required.

16. The consultants' work covered a wide range of questions. Possible technical and financial scenarios for the development of the concession were examined. The technical and financial feasibility of the entire concession was tested since this was no doubt going to be the first question a prospective bidder would focus on. The expansion plan of service coverage and quality was drawn up. It included considerations on when sewage treatment would be phased in, and how soon it was reasonable to expect complete coverage, and what the water quality standards should be. An estimate of the associated investment and operating costs was made and was incorporated in cash flow projections for the entire concession. This preparatory information proved invaluable as a basis for the Privatization Committee for judging the quality and realism of the future bids.

17. The consultants also prepared a prospectus for investors where the existing systems was described, where the service targets were defined, and providing information on the rationale for the decision to privatize, on the legal and institutional background for the concession, and, of course, describing the general terms of the bid, including the timetable.

The Regulatory Regime

18. At the time of the bid, the regulation of the contract was only imperfectly defined. The Menem administration no doubt attached higher priority to privatizing quickly using the political window of opportunity that existed early. The regulatory regime was set up as an "Ente Tripartito de Obras y Servicios Sanitarios (ETOSS)". The ETOSS board had two representatives each of the central government, from the Buenos Aires municipality, and from the Province of Buenos Aires. It was to be financed out of a surcharge on the water and sewerage tariff of 2.7% in order to give it the necessary financial and institutional autonomy *visavi* the political administration. At the time of the bid, the

exact procedures of the ETOSS were largely an unknown. This certainly implied a risk for the bidders.

The Bidding Documents

19. The bidding documents are of great importance for the success of the privatization. Commensurately great care was taken in preparing them. Apart from giving the necessary background information the documents contained a draft of the concession agreement. In essence, the objective of the concession was to comply with certain targets of coverage of water and sewerage services during the course of the 30-year concession. For instance, the share of the population with house water connections was required to rise from the existing 70% to 90% by year 10 and then to 100% by year 30. Similarly, the share of the population with sewerage was to rise to 73% by year 10 and then to 90% by year 30. Equally important, the share of the sewage treated was to rise from the present 4% to 73% with primary treatment and 14% with secondary treatment by year 10 and to 93% with both primary and secondary treatment by year 30.

20. The evaluation criteria were also clearly specified. First, the technical responsiveness of the bids were to be evaluated. Second, the technically responsive bids were to be evaluated financially. The bidders were simply asked to propose a constant Adjustment Coefficient (K) by which the existing tariff would be multiplied during the concession. Certain criteria were clearly specified that would justify adjustments of the tariff. Ordinarily, such adjustments would only be possible after the initial five years of the contract.

The Pre-qualification of Bidders

21. Given the size of the consortia bidding for the concession were pre-qualified. A distinction was made between the bidding consortium and the actual operator of the system. The Argentine government was justifiably anxious in ensuring that only seasoned operators would be attracted. To this end it specified that the operator partner in any consortium have at least 25% of the total equity of the consortium. Another 10% of the concessionaire share capital was allocated to the employees of Obras Sanitarias de la Nación.

22. Only those operators with experience from managing the water supply and sewerage system in a city with a minimum population of 500 000, and with a minimum 2 000 000 million of population served were admitted. Similarly, only those consortia with a minimum equity of US$ 750 million, and with minimum annual billings from water and sewerage services of US$ 250 million were pre-qualified.

23. Altogether, 12 companies were interested in being pre-qualified but only 5 were ultimately pre-qualified.

The Actual Bidding and Contracting

24. The five pre-qualified consortia were invited to submit bids in June 1992 and bids were opened in September 1992.In all instances the firms devoted considerable time

and effort to their respective bids. Data on the condition of facilities, on market projections and on the regulatory regime were carefully analyzed.

25. In the end, two of the pre-qualified bidders presented a joint proposal with the effect that there were four bids.
The quality of the preparatory work, including the clarity of the bidding documents, was demonstrated by the fact that the variation in K-factor, i.e. the price variation between the lowest and highest bidder, was less than 5%

26. In the technical evaluation of the proposals one was excluded. The disqualified bid contained a technical solution where the technical feasibility was evaluated to be unproven.

27. Out of the three remaining bids that had passed the test of technical feasibility the lowest bidder proved to be from a consortium of Argentine and French companies. The bid price was 27% lower than the tariff at the time of the bid. Although the performance targets in the bid were related to service coverage and quality only, the winning bid envisaged investments over the 30 year period of some US$ 4,000 million. Such investments should be compared to the recent annual investments of about US$ 10 million. Clearly, the concession bids were promising.

28. The award of the bid was made in November 1992. The winning consortium was a Aguas Argentinas where the French company Lyonnaise des Eaux-Dumez subscribed 25.3% of the equity capital that totalled US$ 120 million. Lyonnaise des Eaux was also designated operator. The three European companies Aguas de Barcelona, Generale des Eaux, and Anglian Water subscribed 12.6%, 8.0%, and 4.5%, respectively, thus bringing the total foreign share to 50.4%. The Argentine interests were from Sociedad Comercial del Plata with 20.7%, the Meller group with 10.8%, Banco de Galicia with 8.1%, and the OSN personnel the remaining 10%.

Contracting the Concession

29. The negotiation of the contract proved relatively easy since the contract had been included in the bidding documents.
The contract was signed in early 1993 and Aguas Argentinas formally took over the operations on May 1, 1993. From the beginning of the preparations, the whole privatization had required about two years.

The Transfer from Public to Private Management

30. The transfer of services to Aguas Argentinas proceeded orderly. OSN was much overstaffed. A total of 7,600 employees were transferred to the concessionaire. Out of these, a total of 1,300 employees took advantage of a voluntary early retirement program. The government financed up to US$ 38 million in severance benefits for these and future reductions. Another 2,300 employees left the company through a similar program initiated and financed by the concessionaire, Aguas Argentinas. The end result was a reduction in staff from 7,600 to 4,000 in less than six months.

31. A residual OSN-organization was established to operate for one year in order to allow the concessionaire to become firmly established. This residual OSN organization also enabled non-concession facilities, including a laboratory, a school, and a hospital to be orderly transferred to other entities.

Initial Results from the Concession

32. One year has passed since Aguas Argentinas took over from OSN. It is still rather early to judge whether private management will be a success or not. However, the early signs are positive. From the perspective of the consumers in Buenos aires, the performance of Aguas Argentinas should be judged on the basis of (a) whether it has managed to improve service coverage and quality: (b) whether it has managed to operate more efficiently; and (c) whether it has managed to initiate the substantial investment program envisaged during the first five years of the concession.

33. Regarding service coverage and quality it is still too early to evaluate performance. Much of the effort of the concessionaire has been to reclassify consumers and extend metering. However, the concessionaire has increased the water production capacity from 3.4 million cubic meters per day to 4.1 million, installed or changed 36,000 water meters, and rehabilitated 105 km of the water network and 820 km of sewerage network. At the very least, water service has become more dependable. According to Aguas Argentinas, the technical operation of the facilities was better than expected but the areas of administration, accounting and commercial activities were worse than expected.

34. Regarding operational efficiency the staff productivity has obviously risen substantially. Water production has risen with roughly half the staff. Reportedly, Aguas Argentinas has managed to start generating a small operating surplus after incurring losses during 1993 due to start-up costs.

35. Regarding investments so far Aguas Argentinas has not made any substantial investments. The constraint has no doubt been the possibilities to obtain long-term financing on attractive terms. So far, the consortium has only injected US$ 60 million into the operation, corresponding to half the contractual minimum share capital of US$ 120 million. Aguas Argentinas is may attempt to limit its own capital at risk to the minimum contractual. Remaining funding would likely be sought from sources such as the International Finance Corporation (IFC) of the World Bank group, commercial banks, and, of course, the internal cash generation from operations. The internal cash generation is probably expected to provide at least half of the investment funding. Even in the absence of any assured long-term financing, the concessionaire has not been idle. A large number of small investments to replace and rehabilitate small components have been made. Constraints to higher production and water consumption have been removed through such small investments. It is likely that the investment efficiency has been quite high as a result.

Lessons from the Privatization of the Buenos Aires System

36. The initial results from the privatization are promising. The obvious lesson so far is that privatizations need to be carefully prepared. Success requires complete

commitment from all levels. The Buenos Aires privatization has already provided a powerful demonstration effect to other cities and provinces, both within and outside Argentina. Privatization plans are at the present time advanced for systems as diverse as the provinces of Mendoza, Santa Fé, and Tucumán in Argentina. Similarly, the authorities in Chile seem to be preparing for a possible partial privatization of the country's water industry. The city of Lima in Peru is likewise preparing to privatize its water supply and sewerage system through a concession that should be in place by the end of calendar year 1994. Colombia and Mexico are observing and have taken the initial steps towards greater private sector participation.

EXPERIENCES FROM THE FRENCH MODEL IN FRANCE AND ABROAD

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I. THE « FRENCH MODEL »

The French model is originally based on private water and sewage companies working within a public market place. In France, most important treatment and distribution activity are managed by the private sector. However, the municipalities and the state remain responsible for the provision of water. Public action takes place at 3 levels:

- The municipalities take decisions about investments and retain ultimate responsibility for water quality and security of supply.

  There are about 36500 municipalities in France. Very often, several municipalities join together in order to form a syndicate (district) for providing water and sewage services. Syndicates are also common for running other public services such as bus transportation, waste collection, etc.

- The state fulfils a general policy function. The ultimate political responsibility for water at national level is borne by the Ministry of Environment, together with some other Ministries in particular areas such as the bathing waters, the fishing rivers, etc. Government bodies at regional level control that regulations are followed.

- There are six Water Agencies acting at the level of the river basin, which seems to be the most suitable in this field for taking in consideration the constraints and the problems to be solved, including environmental. These authorities include representatives of both official bodies and the private water companies. They are responsible of fixing the order of priorities in medium-term investment programs, and of turning upstream and downstream users solidarity into actual fact. Water Agencies's role is very important, both as technical advisor and financial support.

Within this context of public control and regulation, the private sector has the possibility to play an important role in the provision of water and sewage services. For over 100 years, municipalities, while remaining responsible under the law for providing water and sewage services, have been free to choose whether they wish to manage these functions themselves or delegate them to a private company. Today, about two thirds of the municipalities have chosen to delegate, representing 70% of distributed water, or 42 million inhabitants, and 35% of the provision of sewage services. As a result, the French water industry holds a very strong and expanding position. It includes the three largest private water distribution firms worldwide.

II. THE DELEGATED MANAGEMENT APPROACH

Under private operation of a water utility, there is only delegated management. The municipality owns assets and keeps the control of- and the responsibility for- the service, and it sets goals to the operating company. The municipality is still the owner and the « boss »: it becomes customer, with a contract that sets objectives in matter of water quality, price and service. Its partner is a professional water company.

The commitment has to be seen as a partnership with the municipality, between public and private interests in order to preserve the public service and to associate the advantages of private management. It is important that the relationship is based on partnership with- and trust to- the municipality. Delegating the management of water distribution is a sensitive matter, close to customers' health. It has to be delegated to a proven competent company. The least local failure would have large consequences for the operating company.

There are many different approaches to form a delegated management contract. Basically the municipalities choose between two types of agreement:

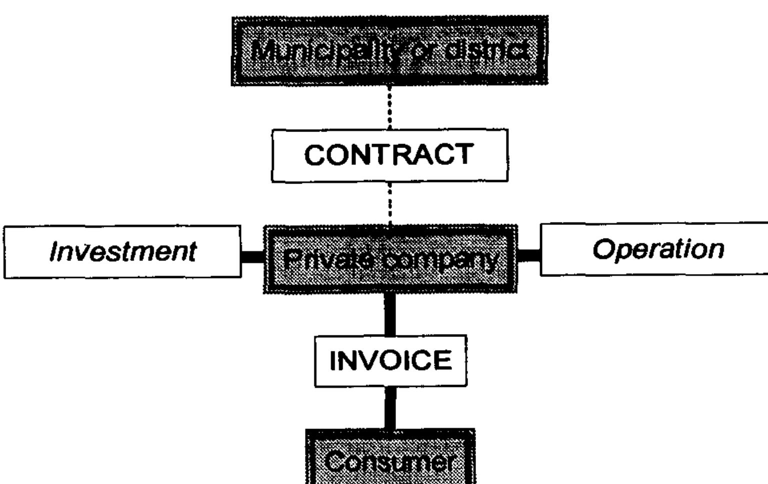
1. Under the concession contracts, the manager finances and builds new plants. It then operates the system. The ownership of privately financed new equipment is normally only temporary. The assets, including those financed by the manager, will revert to the city at the end of the contract.

With the concession contracts, delegating management allows private financing of public assets, an alternative approach for financing investments. This alternative way is provided by the professional water company that brings its own financing sources. The advantage with long-term contracts is that it's possible to smooth the impact of investments. It is important to stress that under this approach the selling of the municipal assets is not a necessity.

2. Under the operation and maintenance contracts, the municipality finances and builds the plants. The manager only operates the system. But as above, it accepts risks, which means takes responsibility of risks related for example to performance (according to specific criteria), operation and maintenance, existing laws and regulations, etc.

When delegating management, a municipality is free to choose the level of delegation which is most suitable in its specific situation. In most cases, contracts are tailored to meet the local needs, laws and regulations, and they combine features from both types of agreement.

One example of the concession model.
The private company finances investment and operation costs. It invoices consumers, applying the water rate decided by the municipality, set in the contract:



A professional water company brings naturally tangible advantages to a city, which means save the city money. A fair price is decided for the service. It must provide savings. This cost of service includes profit for the manager, but profit can be considered as the « cost of increasing efficiency » and the overall cost to the community is still lower.

Investment efficiency is also possible. It means that in addition to providing an interesting financing solution, the manager might be able to review and optimise the investment programme itself. As a result of delegating management, the municipality can focus on core business and save valuable management time for other city services or urbanisation questions.

It is important to stress that R&D and innovation must be a primary concern for an operating company or efficiency will decline. Resource on new technology is naturally shared by all companies within major private groups. For example, the companies within our Group have access to Générale des Eaux's research centre, the largest privately owned research facility in the world devoted exclusively to water and waste water R&D.

What about competition? Obviously, the municipality has the choice whether to delegate or not the operation of its water and sewage utility to a private water company. Because local municipalities can choose between different solutions and different levels of delegation, the system encourages competition. The private water companies are forced to compete to obtain contracts and to keep them and update them. They must develop innovative approaches adapted to local specificity.

The presence of valid competitors with an experience of delegated management creates a real competitive environment. This competitive environment is the main difference between a public operated and a private operated utility. It allows the city to make comparisons. Permanent comparisons together with other forms of benchmarking creates a true incentive to « do one's best » under the life of the contract. This ensures that the manager cannot abuse of his position when adjustments have to be made and the city's interests are at all time protected.

III. INTERNATIONAL PERSPECTIVE

Today, many cities throughout the world wonder about the best way to manage their utilities. A key issue in matter of assets and investments is « what is the optimum balance between public and private financing? ». In order to reach the best investment efficiency, all financing sources must be considered, including private. Another issue is as well « what is the optimum between public and private management? ».

When looking for this optimum balance, the approach of delegated management which is here presented is a working solution. It is today proven in several countries. In France, almost 80% of the population is now supplied by a private company. In USA, the approach is growing more and more. The volume of activity there has been multiplied by four in the last five years in terms of turnover. It is well-known that today a growing number of cities throughout the world are delegating the management of their water and/or sewage utility: in addition to the major cities in France, there are New Orleans, Indianapolis or Houston in USA. The system is also used in countries as varied as East Germany, Greece, Hungary, Italy, Spain, Mexico, Australia or Malaysia.

This delegated management trend has recently increased with the totally new approach taken by the big international banks and financing organisations. Since the beginning of the 90's, they have decided to give priority on infrastructure financing. Fulfilling the basic needs about water, energy, transportation, etc. is today considered a prerequisite toward durable development. And the World Bank points out that priority must be given on service when financing infrastructure. It means thinking about investment efficiency, successful operation, cost recovery, etc.

As background, there is furthermore a huge demand in water and sewage infrastructures. Mainly due to demands for better water quality in a growing number of countries, delays in providing new installations, and the sometimes disastrous management of existing plants. In the EU only, compliance with the new strict wastewater discharge limits set by the may 1991 European directive will require investments of about 280 billions FRF within the next ten years. In the developing countries, the growing urbanisation shows no signs of resting, which amplifies rapidly the needs for water supply or sewage collection and treatment.

IV. CONCLUSION

Delegated management is a proven alternative. It is a well working solution in a number of countries that brings tangible benefits. It allows local governments that are deeply in debt to hand over to a private firm heavy investments, and to get rid of operation risks. It has to be accepted as a realistic alternative.

In Sweden there are excellent general conditions: well working institutions, high level of standards, a professional approach in the technical sector within municipalities. This would make possible to successfully delegate the operation, but not loose control by creating an effective and well working monitoring function within the municipalities. As elsewhere, the optimum balance between public and private financing remains to be found, although the municipalities seem to show no particular difficulties in financing the assets. But as the Swedes have a good tradition of doing well in matter of pure and clean water and wastewater, why another « Swedish model » couldn't also eventually emerge beside the « French model »?

WATER SERVICES PRIVATISATION : MYTHS AND REALITIES

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4ème STOCKHOLM WATER SYMPOSIUM

Privatisation of services is a recent concept in Sweden and it has already been very much studied, analysed and criticised. However, some positive results can be observed: in TÄBY for example and in MALMÖ for transportation and for parks maintenance.

In other countries, the water services managed by private companies follow distinct and different rules. In the UK, the assets belong to the Water Companies who deal directly with the customer. The control is assured by a central government regulator and the Towns and Cities are not involved in this process.

In France, the local authorities own all of the assets and precisely control efficiency with assistance from official departments and organisations. They also always decide on the price of water.

Other modes of management are efficient too and we have many examples around us, like in Stockholm for example. However, without any profit constraint, the situation could be unclear and risk degeneration and slowly become sclerotic.

Privatisation also has its limits and it is important to understand them fully to ensure efficiency and effectiveness for the City, for the Operator and for the Customer.

1. THE AIMS OF PRIVATISATION
WHAT ARE THE GENERAL IDEAS BEHIND THIS CONCEPT?

For everybody, privatisation of services means

- lower costs
- better control
- competition

and these aims correspond to the wishes of the councillors who launch it.

They believe that:

- the quality must be conserved if not improved
- the assets stay within the City's ownership
- the competition is always likely to reduce the price of the services.

1.1 COSTS

It is true that, because of the flexibility and the dimension of its organisation, the private operator's price will be less than the City's price for the same service. It is important also to note that a Private Company, can provide significant technical assistance and, as it is set up not just for one Town but for many, can shed overhead costs between many contracts giving a better specific service at lower price. The example of CAD systems, Information Technology, control laboratory, Research Centre, Training Centre etc are areas where these efficiencies can be bought to bear.

However, another aspect is the real significance of the price. Often in a Town budget, the costs of the Water Services are divided between many different items, distributed among several activities. It is not unusual to see in the accounts: "other expenses" including "sub-contracting" or "assurances" or not to find anything related to financial costs or, again, to realise that some manpower has not been counted here but in the accounts of a different Department. This approach is understandable for a local Authority which has responsibility for the whole city, but it is not transparent when trying to identify the real cost of service and results in an apparently lower price. In this case, the apparent cost after privatisation will seem much higher than before!

1.2 CONTROL

Opinions diverge about the effectiveness of control of a local Authority when its services are privatised. Some believe that the control decreases because the City department looses its technical knowledge and that the operator will manage things in his own way. They think also that the price will be in the hands of the operator and that he will be able to charge what he wants.

Others think that with a strong and skilled specified department, in charge of the permanent control of the operator's activities, the City will be able to exert greater control on this operator than previously on its Gatukontoret.

In fact my experience is that the best service and the best collaboration are obtained with highly skilled civil servants. The men from the City and the company understand each other better, identify the problems together and solve them quicker and more elegantly. The technical ability is maintained on both sides and the City gains efficiency and profit.

In fact, it is not in either partners best interest to have a strong partner and a weak one. The balance is essential because each one has specific responsibilities.

1.3 COMPETITION

We may think that as a result of competition, each tenderer for a service will lower its price to win the contract and in this way will give a better price to the City for managing its service.

In fact, the cost of manpower, vehicles, chemicals etc are the same for everyone and make the service price fixed. If a company decreases its costs it means that it will give poor service or lower quality. Or, if it accepts to lose money to enter a market for example, it will have to compensate for this later, unless it risks going out of business.

It is interesting to note also that competition costs a lot of money to the Municipality and to the private companies. The time, the effort, the use of consultants, the logistics....all are expensive and ultimately will have an implication on the service costs, on the City department running costs and, at the end, on the consumer water bill or tax.

Only four months of activity for tendering for one City service, without taking into account the time of the persons involved, has cost more than 1 million SEK to a private company recently.

1.4 CONTRACTS

It is largely thought that short duration contracts are better for the City. We have seen above how much a tender could cost, and some other arguments show that a reasonable duration should not be less than ten years.

When a Private operator takes charge of water services, it has to set up a new organisation, often smaller but more efficient than the previous one. For this some operation investments are necessary: vehicles, computers, specialised equipment etc.. Often it is also in its interest to modernise some plants to make the operation easier and possible to run with fewer personnel. Generally it is also within the scope of the contract to be responsible for the electrical and mechanical equipment renewals.

All these investments will be supported by the water price, and the longer the contract period the less onerous the financing costs depreciation will be for the consumer. From our experience, we believe that 12-15 years is ideal in this respect.

Another aspect is about the partnership between the City, the operator and the consumer. A confident relationship must be established between them with decentralisation and improved communications. This way of working cannot be organised quickly and it needs time for the operator to find the best solutions how to be closer to the Clients. At the same time, people need to acquire new habits to understand better this new relationship. Here again several years are needed for development.

The last but not the least point is personnel behaviour which needs adaptation to enable good technology transfer. To be efficient, the staff must understand the new organisation they belong to, and every department or company within a private group has to gain knowledge of each other to be able, slowly, to exchange experience and technical culture. In this way, the staff identify with the new company and gain a sense of belonging to it.

1.5 QUALITY

Some concerns have been raised regarding maintenance of quality. It is important to know that if a City is able to provide a very good level of quality for drinking water, waste water treatment and environmental protection, a Private group has access to more resources, skill and ability than a City. In fact, a Private group shares between all its contracts higher profile technologies, human resources, equipment and experience than a City could accumulate and use. These tools are the real power of the private company which it can put at the disposal of its clients.

2. WHAT DOES PRIVATISATION MEAN?

In fact it is essential to really define the terms and to put the right ideas behind them.

When we speak about "Water Services Privatisation", it is a slight misuse of words because, real privatisation would imply that the private operator owns the network, the pumping stations, the treatment plants etc.. and that he has the total responsibility for their management, the water supply and the waste water collection and treatment. In fact, it is not the case and we should more correctly talk about "delegated management". However, the word privatisation is easier to use and is acceptable if we keep in mind its modified meaning.

2.1 BASES

Privatisation must be based on partnership between the City and the operator. A contract between them is essential to define the scope of work, the responsibilities and the price. After that, the day-to-day operation and all relations must be based on transparency and confidence.

These basic ideas will result in consumer satisfaction: the costs will be clearly established by the City, the quality of the service will be maintained or improved and a permanent communication will be established.

2.2 REQUIREMENTS

As seen previously, privatisation of services needs a sufficiently long contract to enable organisation and staff to settle and to allow a moderate price to be charged.

This contract cannot be established without a legal frame. It means that at the level of the Country, laws and decrees must exist to define responsibility, modes of control, limits and organisations to regulate this activity.

The commercial frame of this kind of relation must be fair and honest. The national and municipal regulations for tendering and contracting are clear and straight in Sweden. This is not the case in every country where the political influence on the civil servants is often significant.

It is important for the councillors to be well aware of all aspects of the privatisation, from the very beginning of the process. They should know the different tenderers and their abilities because the elected people have the responsibility of the City and their selection takes into consideration other than just technical or economic aspects of the matter.

However it should not be acceptable that a private company has to pay the City to gain the right to become an operator, as is now the case in some countries.

2.3 RESULTS

Under the conditions outlined above, privatisation brings to the City many advantages:

- The operator uses all the resources within its group for the benefit of the City and the consumers. It could be CAD system, particular technical, managerial and economical software, R and D Centre, training centre, communication....
- The workforce being part of a new organisation will share experiences with other Cities or Countries. The studies and experiments already underway can be used by others with the same problems and the technical ability of some will be extended to outside their usual environment. These areas of competence will be better recognised and known externally.
- The internal communication within the Group will create new links, will encourage efforts and favour better working conditions.
- The financing of new plants and new construction can be possible outside of the City's normal budget.
- The City will benefit from better service based on quality and price.
- All actions will be more transparent.

This privatisation will nevertheless maintain each partners responsibilities. The City will retain the entire decision on price and will remain the owner of all the assets. Controls will be established, based on the contract signed between the two parties. Competition will always be real, at the end of the contract where a tender will be launched to find an operator for the next period of time.

3. WHAT ARE THE LIMITS OF PRIVATISATION?

3.1 CONTROL

As we have seen earlier, the City will always keep decisions on price, ownership of the assets and control on results.

However, and especially in the countries where this way of services management is new, this control could be very onerous and expensive. The City, not being used to privatisation, wants to keep a very close eye on the work because it fears being deceived by an operator promising better results at a lower cost than before. It is a little bit like in a circus where a magician announces unrealistic things, the City wants a private operator, a good price with good results but has no idea how this new operator will be able to manage: it seems unreal.

With this in mind, the City sets up a comfortable organisation to control everything. In a London borough for example, the technical controls of refuse collection by the public department was initially made by one inspector for each vehicle, spending all the day with the workers! After some weeks of gaining confidence in our abilities and became pleased with the results, so consequently this control disappeared. If it had stayed, the economic benefit of the privatisation would have been lost with the cost of this control.

3.2 SUB-CONTRACTING

Sub sub-contracting is another perversion of privatisation. The private operator must implement all the activities of its core business: management, maintenance, works, meter reading, invoicing, communication etc...

He could sub-contract some activities such as: sludge disposal, concrete construction etc.. which are not his speciality and for which others have skill, equipment and are less expensive. However, he must retain all activities where his technology, his experience and his strength are.

Sub-contracting can confuse responsibilities whilst increasing costs by adding profits and overheads of each organisation.

3.3 FLEXIBILITY

Privatisation must be adapted to the culture of each country. It is not worth trying to bring in a different mentality, way of thinking and reactions. It is much more efficient to use the local behaviour and to adapt it to the results which are expected.

It is not possible to change workers'ways of working and customers'ways of living. But it is always profitable to adapt technologies and methods to the local context for the benefit of all.

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Privatisation is not the universal panacea but it is a world wide tendency nowadays. This tendency corresponds to an actual need for the local Authorities to control their activities within the field their real responsibility and to leave to specialised Private operators those where they have more skill and experience. Privatisation is considered a way of reducing costs, it is true if the contract is precise and long enough. There must be a legal frame work within which responsibilities and controls can be developed. Control by the City should not be made to onerous otherwise the economic benefit are to be lost without any return. Partnership is the key word of this concept and a mutual confidence will assure all the expected results.

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FIVE YEARS OF PRIVATE MONOPOLY IN ENGLAND

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Background

1.1 In November 1989 the ten water undertakings, which supply 80% of drinking water and all sewage treatment services in England and Wales, were sold into private ownership. It is only in the UK that a full transfer of all activities and assets into private hands has taken place. Now, five years on, it is interesting to observe how the British model has fared in practice.

1.2 Privatisation in Britain was conceived as a liberating influence. It broke two critical links which hitherto had impeded the management of water services. The first was the constraint on financial management caused by public borrowing and expenditure controls. The second was the confusion between 'ownership' and 'management' which resulted in political intervention in the day to day business management of the services.

1.3 In the 1980s the English companies (or Water Authorities as they were then known) were constrained by financial controls including a financial target which generated a planned level of profit, a performance aim which restricted operational expenditure and an external financing limit which limited borrowing. The price for water was in effect the product of these calculations. Companies were also restricted with regard to sources of borrowing.

1.4 On a wider front government's intervention in day to day management led to a production orientated business subject to public service constraints and attitudes. This fundamentally affected managers' relationships both with employees and customers.

1.5 It would be wrong to imagine that the flotation in 1989 swept all this away at a stroke! The 1983 Water Act had restructured the management of the Water Authorities and exhorted them to operate in a more commercial manner. New Chairmen drawn from private business had commenced the process of breaking down barriers with employees, placing the business priorities on service to customers and demonstrating the inefficiency of Government constraints. Without the changes in outlook and personal skills that accompanied these changes the move to full privatisation would not have been feasible in 1989.

1.6 The 1989 Water Act created the ten new Water Companies and floated them on the London Stock Exchange. They took on the assets and liabilities of the former Authorities with some restructuring of their balance sheets. Commercial freedoms accompanied this but in order to protect the public interest a system of regulation was set up as an integral part of the enabling legislation. The main elements of this are summarised below.

Regulation

2.1 The Director General for Water Services (Ofwat) is the key regulator with responsibility for protecting the interests of customers, promoting efficiency and competition amongst water companies and ensuring their financial viability. His main powers include setting the price levels of the companies (for a five to ten year period) and ensuring that they meet their service obligations. He also has powers of enforcement including, ultimately, the withdrawal of a company's 25 year operating licence.

2.2 The quality of drinking water is monitored and enforced by the Drinking Water Inspectorate (DWI). The companies are required to comply with the European standards and, when necessary, to implement investment and improved procedures in order to do so. The collection and publication of quality data is an important aspect of this process.

2.3 Water and sewage companies can have a major impact on the water environment and this was recognised by the creation of a National Rivers Authority (NRA) in the 1989 Act. This body was set up by splitting off the river management activities from the former Water Authorities thus retaining a body in the public sector to act as an environmental policeman with monitoring and enforcement powers. These relate both to water extraction and the return of effluent to the water environment and include powers to ensure the effective use of regional water resources.

2.4 Other agencies and Government departments also provide community safeguards mainly in relation to environmental impacts and the potential misuse of monopoly powers.

2.5 In many respects it is too early to judge the success of this fundamental change in the management and provision of water services but, as the British water companies face their first major price review, their performance can be evaluated against some key reference points. For this purpose I shall examine the following aspects:
Quality of service and environmental impact
Financial viability and price
The customers' perception

Quality of Service and Environmental Impact

3.1 The Director General for Ofwat has two primary statutory duties. The first one is " to secure that the functions of a water undertaker .. are properly carried out..."

3.2 Under the previous public sector regime the Government specified standards and, through a separate process, determined the level of resources that were to be employed in meeting them. Political and financial priorities were such that there was little match between the resources and the output needs and many service targets were not met. This situation fuelled one of the main arguments for privatisation, that companies should be given the managerial freedom to meet their service obligations at a level of income appropriate to the task.

3.3 Following privatisation capital investment increased in the ten water and sewerage companies from £1.2 billion per annum in 1988/9 to £3 billion per annum in 1992/3, and this progression continues.

3.4 Sewage treatment has been a major recipient of this expenditure in response to the need to improve river quality and meet new standards for sea discharges. In 1988 17% of sewage works failed their discharge consents, by 1991 this had reduced to 6% and that trend continues. NRA reports on river and sea quality demonstrate that these improvements are being reflected in the natural environment. Compliance with the Bathing Water Directive, for example, had improved from 66% in 1988 to 80% in 1993, 1995 is the target year for 100% compliance.

3.5 Drinking water compliance has always been high in the UK with some 99% of samples meeting European requirements. Where specific problem areas are identified companies give 'undertakings', underpinned by a programme of investment and/or remedial actions, to overcome them. Thorough testing and monitoring, all of which is available for public inspection, ensures that performance is kept under continual review.

3.6 The Director General is also concerned that daily service levels to customers are maintained and progressively improved. He monitors progress against parameters such as water pressure, interruption to supply and sewer flooding and measures of administrative efficiency such as the time taken to respond to customers' complaints. Standards vary considerably between companies and league tables of performance are produced annually providing the incentive for companies to learn and improve.

3.7 Privatisation enabled a significant increase in investment in infrastructure and created the management incentive for improved operational procedures. Monitoring reports produced by the independent regulators are demonstrating a steady improvement in standards across the board. It may be too early in the life of the companies to judge whether this progress will be maintained but the regulatory system provides that companies which fail to meet their obligations are subject to prosecutions and enforcement actions and, ultimately, to the loss of their licence.

Financial viability and Price

4.1 The second primary duty of the Director General is " ... to secure that companies.. are able (in particular, by securing reasonable returns on their capital) to finance the proper carrying out of their functions...". His main mechanism for achieving this is the price formula which he sets for a ten year period with the option of a review at five years.

4.2 The rationale behind this duty is that in releasing major public service obligations into private management it is necessary, in the long term interest of customers, to ensure that the companies are capable of properly fulfilling their obligations. The balance to this is provided by a number of controls and sanctions designed to prevent the excesses that monopoly status would otherwise bring. For example two of Ofwat's secondary duties are " to promote economy and efficiency" by companies and " to facilitate effective competition " between them.

4.3 The annual increase in charges that the companies can levy for water and sewerage services is based on a formula (RPI+K) which reflects a judgement of the return that a well managed and efficient company requires to meet the obligations placed upon it.

4.4 The "K" factor covers two broad elements. The first is the expectation of greater efficiency that a given company can achieve in carrying out its current range of activities and obligations. This factor will act to reduce the annual price increase to below the general rate of inflation. The second element of "K" is the requirement placed on the companies to meet higher levels of service and rectify past deficiencies. The impact of European Directives has been particularly significant for Britain in recent years and continues to be so. The need to finance substantial increases in capital expenditure was the single most significant factor in driving up the "K" factors set in 1989.

4.5 The average "K" factor for the ten companies at flotation was +4.5%. The impact of this has been that whereas in 1989 British households were paying, on average, £119 for water and sewerage services this has now risen by 67% to £199. This increase was about twice the general rate of inflation for the period.

4.6 The çompanies' Annual Accounts and observation of share prices show that to date the ten companies have been successful in exceeding their profit projections. Pre tax profits for the year 1993/4 averaged some 28% for the ten companies on a turnover of just under £6 billion. Share dividends range from 7 to 8.5 pence in the pound. How has this been achieved?

4.7 Firstly, the companies have provided services more productively than the Government's original pricing calculation had assumed. Operational efficiencies have contributed to this as instanced by manpower reductions of some 3,000 staff (7%) from 1989 to 1993, at a time when significant new service obligations were being met. Additionally companies have achieved their capital investment programmes in a cost effective manner, the result of strong project management and a competitive contractors market.

4.8 The majority of the companies have also chosen to diversify their interests, primarily by acquisition, into areas such as environmental engineering, waste management and overseas consultancy and operations. These activities are not subject to the controls of the Director General and no cross subsidy by the core water and sewage business is permissible.

4.9 Diversification to date has not been particularly successful in terms of profit generation but this is a very short term perspective. Some commentators take the view that that as the regulatory grip tightens it is those companies that can achieve strong performance in the non regulated areas that will prosper. To quote one of the company chairmen " The difference in the share price of the successful and unsuccessful company will reflect their ability to diversify".

The Customer's perception

5.1 The process of preparation for privatisation in the late 1980s was highly charged politically and in many respects brought the providers of water and sewage services into the public arena for the first time. The emotive issue of selling off the Nation's assets was debated fiercely although the water industry followed a number of other services such as gas and the telephone service into private ownership.

5.2 There was also a growing awareness of the impact of new European Directives raising standards in the water quality and environmental fields. The UK was portrayed as being well behind European quality standards and it became apparent that in order to make good investment deficiencies from the past and also to meet the requirements of the new directives there would need to be a significant short term increase in expenditure by the industry. This coincided with the privatisation process with its fundamental premise that the full price for water would be borne by the customer.

5.3 Price increases have been the catalyst for a number of debates ranging from the supposedly 'excessive' profit levels of the new water companies to the extent to, and pace at, which consumers are prepared to pay for higher quality standards. Almost two-thirds of customers' complaints currently relate to billing and charging matters and it is recognised that people in general are not comfortable with current price levels and the inflationary annual increases. These views are fuelled by the 'high' profits seen to be made by the companies during a period of national recession.

5.4 Companies have sought to allay public concerns and have introduced customer codes of practice, some provisions of which are mandatory, which guarantee efficient and effective procedures for handling customers' interests and compensate those experiencing shortfalls in provision or poor service.

5.5 Reports from the regulators have also given greater public confidence in respect of service standards. The powers given to all the regulators in relation to the collection, monitoring and publication of information should not be underestimated. Performance is stringently assessed and publicised and the customer has a far greater opportunity to be well informed than was ever possible in the public sector regime.

5.6 Ofwats' responsibilities for looking after the interests of customers is given a local focus through regional Customer Service Committees (CSCs) which provide opportunities for the examination and discussion of water related issues and investigate complaints. They report to a recently created National Customer Council which is in a position to press customers' concerns at the highest level.

5.7 The greater public awareness and accessibility to the new water companies has been accompanied by an increasing trend in customer complaints across the industry. Whereas in 1990/91 the companies received some 85,000 written complaints this had risen to 125,000 just two years later. Complaints which are not resolved by the companies can be referred to the Customer Service Committees. Nearly 15,000 such referrals were made last year, approximately one complaint for every 2,000 connected properties.

The Periodic Review and Beyond

6.1 Two years ago the Director General gave notice that he intended to conduct a five year review of the price formula. This led to an extensive exercise during which obligations were examined and costed in detail and the Government and the regulators were pressurised to be more specific in terms of the standards that they were demanding over the next five to ten years. Views were sought from customers in recognition of the general concern over price increases year on year. Finally, the Director General reappraised the financial drivers within the companies openly debating issues such as the rate of return on capital that they might expect, and the pace at which higher levels of productivity could be achieved.

6.2 In the five years since privatisation the ten companies have invested some £13 billion in infrastructure. Figures published by OFWAT in 1993 showed that this might need to increase to £25 to £30 billion over the next five, including major expenditures necessitated by the Urban Waste Water Directive. It is worth reflecting that this would equate to more than £100 of investment per person per annum across the country. Additionally substantial new operating costs totalling some £200 to £300 million per annum were indicated.

6.3 Figures of this nature have led to a debate amongst the Regulators and with the companies and their customers as to the pace that the Nation can afford to proceed with improvements to services. The fact that such a debate has been instigated is in itself a success of the regulatory system. The relevant figures are in the open and those who have a point of view to contribute can put it forward. The Chairman of Ofwat's National Customer Council recently claimed that " this is the first time in any regulated industry that customer representation has played such a key role".

6.4 The process of determining the price formula is commercially critical for each company since the Director General will be making assumptions on productivity and financial returns which are fundamental to the interests of the companies and their shareholders. He will be under political and customer pressure to determine a tough price limit but he has to bear in mind his prime duties to ensure that companies are able both to finance their activities and carry out their service obligations properly. The Investors Chronicle, a City publication, recently put the dilemma in more direct terms "Ofwat has, effectively, to look after the shareholders to look after the customers".

6.5 Commentators expect that the settlement will be a tough one. The water industry in England and Wales is a dynamic one and added pressure on the regulated business could see changes in direction over the next five years with companies becoming more innovative. A City analyst recently suggested that mergers could follow a tough regulatory determination including cross utility mergers, for example with an electricity supply company in a similar geographical area. Tangible benefits in the interests of customers would have to be demonstrated in such cases.

6.6 The outcome of the Review should be announced by Ofwat at the end of July. It will comprise a revised price formula for each company for the next ten years and implicit within this there will be a set of decisions on the extent and pace that the ten companies will implement the European Directives and achieve higher standards of service. I shall report on the announcement and first reactions to it at the Workshop.

ADVANTAGES OF A COMMUNITY-OWNED WATER COMPANY

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What is the best way to make more effective, finance and develop drinking water and waste water management? First I will say that my experiences are mostly from Western Europe and parts of Eastern Europe.

Water is the most important foodstuff in the world. Access to water is essential for all life. We must have water to drink and water is required to cultivate other basic foodstuffs. In order for everyone to have access to water, regardless of the quality of life, it has to be supplied at the lowest possible cost and be of acceptable quality.

The question is naturally how a commodity such as water should be owned and taken care of. Is it a product which can, or must, be managed commercially with the aim of making profits, or should it be provided at cost. Privately-owned companies that operate businesses which do not make profits do not usually survive for especially long.

The last statement would seem to indicate that the provision of water should be a publicly-owned activity. There is, however, an important condition - it must be cheaper and better for the consumer. This naturally depends on how efficiently the business is run. It is quite clear, however, that a publicly-owned water business which is run about as effectively as a privately-owned business or privately-run contract is a better option since no profit mark-up is charged to the consumer. I think everyone will agree upon this. It is also important to stress that it is not price alone which is decisive. The important thing is to achieve the right combination of cost, quality, environmental considerations, and reliability of delivery. Of course you can reach a lot by regulations but the degree of regulations increases with the level of private involvment and what happens with the ambitions to go a little further by developing water quality and water environment.

Privatization moreover only means a transition from one monopoly to another, since the consumer has no alternative supplier. In a publicly run operation, there are greater possibilities for influence since the city itself owns or controls its water organization.

Large amounts of profit are recorded in the accounts of privatised operations or businesses run through large-scale contracts, for example, in England or France. This means that publicly run operations have relatively large margins available in competing with the private sector. The trade association of Swedish water companies, the Swedish Water and Wastewater Works Association, has recently produced a review of the price of water (not sewage) in a number of west European countries. Price depends of course to a very great extent on the practical conditions governing the production of good quality water. Nevertheless, this study provides an indication that the price of water in countries with publicly run water operations compares favourably with others.

I would like to describe the situation in Stockholm and our points of view as regards the ownership and caretaking of water.

Stockholm is situated at the place where one of Europe's largest lakes, Mälaren, flows into the Baltic Sea.

Stockholm obtains its drinking water from Lake Mälaren and discharges its treated wastewater into the Baltic in the inner part of the Stockholm Archipelago.

The water in Lake Mälaren is now so clean that it is possible to swim and fish in the centre of the city. Salmon and salmon trout flourish in Mälaren and in Saltsjön, on the Baltic side, despite being in the heart of our city. Stockholmers regard this as an important symbol, that it is possible to create a good aquatic environment in a waterway that was badly polluted not so long ago.

In the 1930s, swimming was prohibited in Mälaren in the parts, which were in or near the city. Forty years were to pass before this ban could be lifted.

A number of factors made this possible.

- The building and expansion of wastewater treatment plants.

- The introduction of a sewage rate which financed this expansion. Charges were increased as the results of the measures taken began to be seen in our aquatic environment (information is important).

- Discharges from all wastewater treatment plants were relocated so that discharges from the city were no longer released into Lake Mälaren, which is the source of our drinking water. Water is led instead to Saltsjön.

- The creation of Stockholm Water Company, a wholly municipally owned company, responsible for the entire chain - from Lake Mälaren, the source of raw water supply - to the recipient water, the Baltic. This was the beginning of our thinking in cyclical terms in the city, in which each operational sector of our company has to make its contribution towards the fulfilment of Stockholm Water's business idea.

This idea is:

"With the active participation of the city's inhabitants and companies, Stockholm Water is to operate and develop water conservation projects, together with other interested parties so that

- the needs of the inhabitants for water services are satisfied
- a more effective contribution is made to the development of Stockholm as a city in ecological balance".

Stockholm Water's main task is to be responsible for the product *water* on its way from raw water to the recipient water. A task where the result in terms of quality, security, environmental considerations and cost depends on the co-ordination of the entire chain of operations, on the ability to supervise it and maintain competence and decisions as a coherent whole. The result depends then on the various parts being retained as an entity.

To achieve this, we consider that we have to work closely together and have full control over the product at all the various stages. This condition is best met if competence is retained and developed in our own organization.

Besides the specialized operational functions of water and wastewater treatment plants and the network, refurbishment and maintenance work is in many cases of very great importance for the reliability of supply as well as quality requirements and environmental considerations. They can therefore be regarded as being very closely related to the entire chain.

Considerable professional skills have also been developed in these areas of work. This type of operation is mostly carried out within our own organization.

As regards major investment projects, we have not had our own staff for this work since the 1970s and have instead used contractors and other external companies. Otherwise, the principle is that work is carried out externally, if it is more effective to do so.

A large part of the company's operations, which we could carry out within our own organization is therefore purchased externally. This applies primarily to contracts and consultancy services, but also other technical and administrative services.

In 1992 contracts and purchased services of these kinds accounted for 57 per cent of the company's balance sheet total, i.e. (that is) operating expenses and investment.

As regards investment, costs for contracts and consultancy amounted to more than 90 per cent of total costs.

The fundamental idea in our development work is to achieve increased efficiency within the company by all operations being developed on the basis of the concept of competition. As regards those activities falling under the company's holistic view of operations and in many other cases, the concept of competition means comparing operations, for example, with the assistance of key ratios to equivalent operations in Sweden, the Nordic area or in Europe with the aim of being able to demonstrate that we are the best alternative. Competition in the highly developed form of tender procedures should also be used as appropriate.

To sum up the company's strategy is as follows.

1. Our strategy is based on a holistic approach (from raw water to recipient water). Coordinated operations in the same organization are a prerequisite for quality, security, environment and cost considerations.

2. Key functions necessary for the operations of the system as a whole (treatment plants for water and wastewater and the pipeline network) are operated by the company itself.

3. Refurbishment and maintenance closely linked to the quality of the water, security and the environment are carried out within the company.

4. Investments and reinvestment are open to competition, with some minor resources of our own to retain competence and facilitate adaptation to new technology.

5. Investigation, planning and administrative functions require some internal resources for supervising operations. For instance Stockholm Water borrow moeny from where we can get them on the market.

6. Key ratios, decentralization to "profit centres" by management by results and effective reporting systems are developed for supervisory staff, management, the board and senior management.

The situation now differs considerably in various areas of the world. In many places there are well-developed public or private sector operations. In other parts of the world, major political, economic, technical and not least administrative efforts are required to start up and run an effective water supply and to develop the aquatic environment by wastewater treatment etc. Both large-scale and small-scale technical solutions have their place according to circumstances.

In these situations, the choices made are important both in the short-term and in the long-term.

Should private companies be allowed to make their entry and take responsibility for the development and running of operations in order to be able to achieve good results but at the price of higher costs and charges necessary to satisfy the company's short-term and long-term yield requirements? An alternative might be for public companies - water companies and other public sector organizations - which have considerable know-how about practical operations, supported by the World Bank, the European Bank and other financial institutions, to assist in various areas of the world to develop water resources in the places where they are needed. Their task will be to contribute by establishing or developing a water organization in local ownership which step by step can then both run its own operations and pay for its loans by charges from consumers. This will require very close cooperation and determined efforts to make the inhabitants understand and feel a commitment to the need to pay for clean drinking water and a good aquatic environment. Stockholm Water now has several years of experience of such operations from, inter alia, Poland and Latvia.

Moreover, I do not believe that this alternative will lead to any reduction in demand for the services of private companies, but that rather the opposite will be the case. I am convinced that many private companies will play an important role in such a scenario as consultants and suppliers of goods and services where the business idea is not privatization, the takeover of water companies, and large-scale contractual operations but qualified help to self-help in various countries and cities. The commercial potential then often lies in being able to cooperate with the banks, public sector organizations and cities participating in the various development processes. There is no doubt that our combined efforts will be needed to meet the enormous challenge which this involves for all of us and for our future.

Restructuring the technical sector in an competitive environment - the tender for the water and sewerage operations in Malmö

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- Lower water rates for the consumers
- Lower costs for the city.
- Job security for the staff
- International research center in Malmö

These were the most satisfying results of the recently conducted tender for the water and sewerage operations in Malmö. The facts have proven those critics wrong who doubted the benefits of an open tender. We conservatives will never accept ideology as a reason to stop the process of change. Our only objective is the well-being of the inhabitants of Malmö.

During 1992 the first step in restructuring the technical sector according to a client-contractor model was carried out in Malmö. One main purpose was to rationalise and crystallise the municipalities' capacity as an orderer and exploit the market and competitive situation so as to purchase best qualities at lowest prices. The municipality orders services for the technical infrastructure, which includes water and sewage via the Public Works office.

The city board brought up the question of the future structure of the water and sewage operation, and found there was considerable interest in bringing the matter to investigation.

As a result the city board took a decision on June 21, 1993, by which it ordered the public works office to take the initiative to placing the water and sewerage operation on the competitive market.

The tendering is taking place in different steps:

i) In-depth inquiry based on general information illustrating the operations.
ii) Final procurement negotiations based on more detailed information. Last day for submitting these final offers was February 28, 1994.
iii) A proposal based on completed procurement negotiations will be submitted to a final decision by the municipal council.

In Mid May I was presented with results of the tender. Let me first state that I was extremely impressed by the interest and work put down by international and Swedish corporations. Our process has really proven that competition is vivid in this sector. The winner this time was Anglian Water. I am sure that next time another corporation will be the winner when another Swedish municipality follows our example. After that the bid was accepted in the Road and Traffic board and the City board. It is now put forward for the City Council to a final decision.

Malmö enjoys a high standard of water and sewage and the level of the operational organisation's competence is also high. These standards must be maintained and, in the long term, developed to meet the increasingly higher demands of environmental character etc. These issues have been fully addressed in the contract with Anglian Water.

The municipality will continue to be the principal of operations pursuant to current regulations and be responsible for the relations with users e.g. regarding charges.

The change in the water and sewage operational structure entails the taking over by a contractor of the present organisation as regards all personnel linked to the operation. Depending on the extent of the commitments, certain personnel might remain with the municipality and be assigned to the ordering tasks for which the municipality will be responsible.

Alterations to Malmö´s total water and drainage operations concern the following main sections:

Sjölunda sewage works
Klagshamn sewage works
Water supply plants, incl. Bulltofta waterworks, water towers, booster stations etc.
The water mains system with associated plant such as pump stations, compensation depots etc.
Other associated resources incl. water laboratories..

The length of the contract of the contract will be ten years with another five optional.

The organisation now comprises 176 positions, of which 120 are administrative and 56 operational.

The water tender in Malmö follows a tradition of very successful privatizations.

General objectives for contracting out/privatisation in Malmö

- Freedom of choice, increase of competition and the number of alternatives.
- Lowering of costs
- Free capital. Sell certain assets to be able to invest
- Minimise risks
- Increase private employment, change the industrial structure
- Focal point Malmö-Copenhagen
- Individual development. Prospects for individuals are greater in the private sector.
- Strengthening of the competence of purchasing authority.

The reduction of public costs is one very important task for us politicians. We believe that it can be achieved through increased international competition. It cannot be a duty of the municipal community to take part as entrepreneur in that process. On the other hand it is our responsibility to make sure that services that are financed collectively are purchased at the best cost/value. Our overall strategy is to return to basics like health care and education and leave business activities to private companies. We also firmly believe that the Öresund region is going to constitute the foremost growth area in Scandinavia especially when the decision has been made to start building the bridge between Malmö and Copenhagen. For people in the region a greater demand for their labor will increase their possibilities in the future. Municipal law in principle prohibits municipal companies to compete in the private sector especially when it is out of the city borders. This in turn makes it difficult for them to find new jobs for laid-off workers.

Larger tenders 1992-94

	Start	Annual turnover (after tender)
1. Refuse collection.	Sept, 1992	50 MSEK
2. Laundry services	Dec, 1992	55 MSEK
3. Data processing	Nov, 1993	80 MSEK
4. Bus transport	Nov, 1993	250 MSEK

All these tenders included purchase of fixed assets/shares of the municipal company.
Evaluation through a Net Present Value analysis compared to present costs.

Just these four tenders have lowered costs with about 100 MSEK and have added 220 MSEK to the financing of investments.

Over and over again the political leadership in Malmö has shown its firm determination to test the market. What is important is to find what is best for the inhabitants of Malmö instead of an over-reliance on the virtues of doing everything yourself in municipally owned companies.

BASIS OF RELATIONSHIP

THE ROLE OF THE MUNICIPALITY

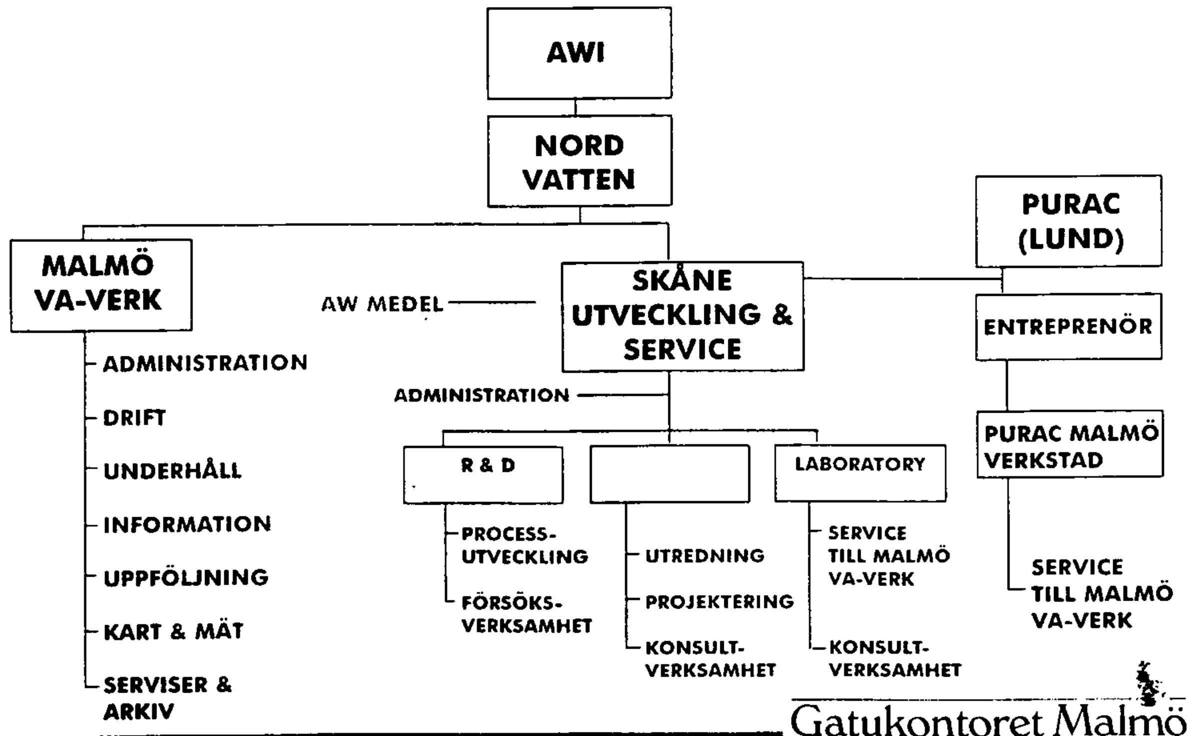
- Authority responsible under the Water Act
- Owner of installations
- Determines water and sewerage tariffs
- Issues invoices for charges
- Management - Strategic planning

THE UNDERTAKING OF THE CONTRACTOR

- Operation and maintenance of water supply and sewerage installations
- Extension of Sjölunda and Klagshamn sewage treatment plants
- Customer service, information, long-term planning

Gatukontoret Malmö

PROPOSED ORGANISATION



ASSESSMENT FACTORS

FINANCIAL ASSESSMENT

- Operating cost (payment)
- Cost of investments in Sjölunda and Klagshamn
- Additional operating costs after extensions
- Scope of re-investment in mains network, achieved with investment capital set aside

Gatukontoret Malmö

OTHER ASSESSMENT FACTORS

- Cost-effectiveness
- Financing terms
- Quality-function-environmental impact
- Experience
- Long-term financial status, reliability and stability
- Quality policy and quality plans
- Adjustment cost
- Reservations (where applicable)
- Research and development

Gatukontoret Malmö

WORKSHOP 6: Integrated approach to land and water

There is a rising call in the international community for proper attention to the two-way interaction between land use and water resources. Land use tends to influence the physical and chemical determinants of water flows, pathways and quality, thereby generating water-related impacts.

The benefit of taking an integrated approach to land and water is that predictable problems related to the water cycle could be avoided or minimized, such as the water-related consequences of land use changes, land degradation as a water-related consequence of land use changes, land degradation due to poor water management, pollution from landbased sources etc.

STRATEGIC ISSUES FOR INTEGRATED LAND AND WATER MANAGEMENT

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ABSTRACT: The author suggests that general strategies for land and water management should be developed on the basis of a greatly broadened data base and integration of disciplines. Both general and specific strategies must be developed for integrated land and water management for each country.

Land and water management should be one aspect of integrated resources management. Such integrated resources management should primarily concentrate on interrelationship between human resources, industrial and agricultural developments and ecological constraints.

Generally, analyses of previous population growth rates permit prediction of trends for the development of human resources. Such predictions are made in relation to definition of a stationary population for each country. The following three planning horizons can be considered for land and water management on a national level (1) pre-stationary population, (2) stationary population, and (3) post-stationary population.

Most countries of the world experience different population growth rates, and have different availability of land and water resources. Long term land use and water resources management strategies should therefore be related to integrated resources management. The integration of planning horizons, available land and water resources and ecological constraints should lead to definition of base line data for development potentials and relevant land use management strategies. Such development potentials and associated distribution of population can be established through relevant land use management strategies on national, state, regional or catchment levels.

Base line data for development potentials can be altered in the future by continuous changes in community perception of water use and changes in water quality which have an impact on availability of water resources. These changes in perception of water use can be effected by new technology, re-use of water, utilisation of water by industry and agriculture, and more efficient use of water.

The urgency for development strategies is related to population growth, availability of land and water resources and existing environmental conditions. Integration of long term population growth with scenarios for distribution of population and optimum use of available resources should significantly contribute to achievement of sustainable development for most countries in the future. The proposed methodology is based on definition of development potentials and integrated resources management.

The proposed approach should secure transition to sustainable development.

1. INTRODUCTION

The term "sustainable development" has been adopted as defined in "A Strategy for Sustainable Living" (Summary IUCN; UNEP; WWF, 1991, p.4) and means *"improving the quality of human life while living within the carrying capacity of supporting ecosystems"*. However, Agenda 21 (UNCED, 1992) did not integrate population growth with available water resources. Implementation of sustainable development requires definition of new principles for dealing with integrated resources management.

There is need, therefore, to optimise development, optimise the use of available resources and link short term decisions with long term requirements for utilization of resources and protection of the environment. These requirements include utilization of land and water resources. There is also the need for strategies which should allow resolution of major issues such as availability and limitation of water resources, population growth, impact on environment through human intervention which may result in violation of ecological constraints and the problem of uncertainty about the future. There is also the need to develop better understanding of sustainable development through integration of the relevant development aspects, such as population growth, limited water resources and land availability and constraints. Once better understanding is achieved, relevant strategies can be developed. All these objectives may be achieved by integrated resources management.

Water resources are not uniformly distributed between continents and countries. For rainfall and run-off of the continents refer Table 1.

CONTINENT	Area	Average yearly rainfall	Run-off		
	km^2	mm	mm	km^3	%
Africa	30 300 000	690	260	7 900	38
Asia	45 000 000	600	290	13 000	48
Australia	7 700 000	465	57	440	12
Europe	9 800 000	640	250	2 500	39
North America	20 700 000	660	340	6 900	52
South America	17 800 000	1 630	930	16 700	57

REFERENCES: 1. all data except Australia, Budyko M. I. (1974)
2. data on Australia, Department of Resources and Energy (1983),

Table 1 - RAINFALL AND RUN-OFF OF THE CONTINENTS

Population projections are one of the major factors in predicting and planning future needs for food, environmental impact of development, and engineering services, including water resources and related issues.

The Brundtland report states that our human world of 5 billion must make room in a finite environment for another equally numerous human world. The population could stabilise at between 8 billion and 14 billion sometime next century (WCED, 1987, p.4). Frejka predicts that world population is likely to stabilise between 7 and 13 billion (Frejka, 1981).

The WCED report (WCED, 1987, pp.107-8) highlight the discrepancies of current management practices which relate to population growth. Most countries are committed in theory to balancing regional development but are rarely able to do this in practice.

In addition, economic activity and opportunity influence population distribution across different regions a country. Further, the report (WCED, 1987, p.108) comments that more attention must be given to the development potential of regions.

This paper presents a strategy for integrated resources management in relation to the following issues:

- long term population growth, and
- land and water resources management.

It is proposed that this integration can be attained by establishment of development scenarios based on development potential. In consequence strategic decisions for development of nations should be followed by relevant strategies for land and water resources management.

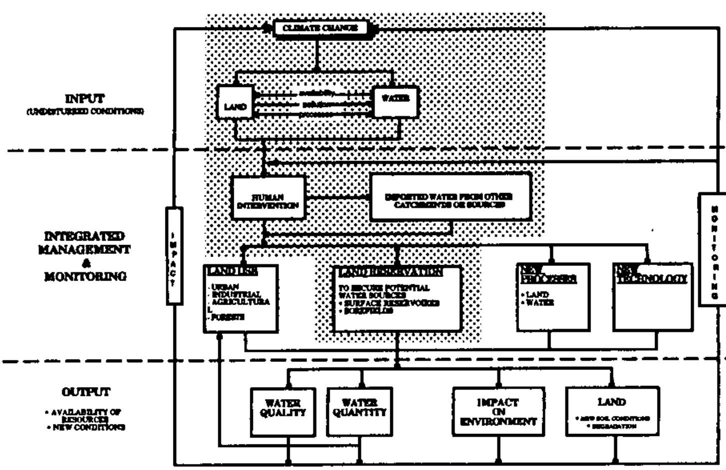
It is considered that these issues can be resolved by adoption of a continuing and consistent pro-active approach.

Water-poor countries and fast growing regions, particularly, should benefit from issues presented in this paper.

2. DEFINITION OF THE PROBLEM

It is proposed that the problem of population growth and land and water management may be resolved by integrated resources management in relation to forecasts of future events. However, there will never be a precised knowledge of future events. As the result, any future development scenario may require revision.

The above assumptions are the result of analysis of an input/output diagram related to integrated management for land and water resources. Refer Figure 1.



NOTE: BASE LINE DATA FOR DEVELOPMENT POTENTIALS

FIGURE 1 - INTEGRATED MANAGEMENT FOR LAND AND WATER RESOURCES
(REGION, CATCHMENT AREA OR BASIN SYSTEM)

Water resources are limited for a defined area or country. Therefore, water management for sustainable development should be related to available land, water and forecasts for an area or country. Limited land and water resources limit number of possible scenarios for future development. Principle objectives of land and water management for developed and developing countries are presented in Table 2.

DEVELOPMENT STAGE OF A COUNTRY	CONDITIONS/ VALUES	PRINCIPLE OBJECTIVES FOR OPTIMUM UTILISATION OF RESOURCES (Note 1)
developed (population almost stabilised)	existing and future	improvements in water quality, quantity and processes
developing (population will stabilise in the future)	existing and future	establishment of development potentials in relation to the above item and securing water sources for future use (borefields and dams - Note 2)
developed and developing	environmental values	protection of sensitive areas

Notes: 1. optimum utilisation of resources

i) natural resources - utilisation at minimum costs

ii) population - distribution at minimum costs and social acceptability

2. borefields and recharge areas may require protection by appropriate land use in order to protect water quality; dams may have closed or opened catchments

Table 2 - PRINCIPLE OBJECTIVES OF LAND AND WATER MANAGEMENT FOR DEVELOPED AND DEVELOPING COUNTRIES

The proposed strategy to be adopted for dealing with integrated resources managament is presented in Table 3.

The adopted specific strategies may be different for different countries as population growth and available resources may be different.

3. STATIONARY POPULATION AND PLANNING HORIZONS

The population growth rate and stationary population of a country can be adopted as bases for prediction of development problems and future demands for food, water, shelter and related resources. Population predictions cannot be treated as precise estimates. *Population predictions are broad indications of the direction in which major trends point.* The term stationary population derives from the observation that at present some developed countries continuously maintain fixed fertility and mortality regimes. This brings the population towards a stable structure defined as a *stationary population* (Ryder, 1975; Stark, 1989, p.541).

It is assumed that population of developed and developing countries will grow, until stationary temporary balances are reached. More detailed projections for various selected countries are presented in Table 4 (Zachariach, 1988).

On the basis of the above data, it can be concluded that some developed countries have already reached or are close to reaching stationary population. However, these projections do not take into account migration of population which may be caused by the greenhouse effect or other migration generating factors.

These migration rates cannot be predicted at this stage. Existing projections will, therefore, require periodical review, as the bases of predictions may change.

ISSUE	ACTIONS/EVENTS
APPROACH	• future events must be better understood • data base must be broadened by integration of disciplines • populations must be made aware of implications of water issues
POSSIBLE OUTCOMES	• future events will never be fully understood • climatic changes • new processes generated by integration of systems • changing social conditions
STRATEGIES	1. stages / review • general strategies must be developed based on trends and broadened data base • specific strategies are to be developed based on the above • strategies are to be revised when trends and data base have been changed
	2. implementation • general levels national, states & territories • specific levels regions & catchments

Table 3 - PROPOSED STRATEGY FOR INTEGRATED RESOURCES MANAGEMENT

The Brundtland report also concludes that several countries have reached or are approaching zero population growth (WCED, 1987, p.56).

COUNTRY/ POPULATION	ESTIMATED MILLIONS IN 1995	IN 2025	STATIONARY POPULATION
1	2	3	4
Australia	17.5	20.2	20
Brazil	164.6	236.0	292
Indonesia	195.8	282.6	363
Japan	126.0	130.0	124
Kenya	30.3	69.8	121
Norway	4.2	4.3	4
Philippines	68.4	105.2	137
Poland	39.7	44.9.	48
Sweden	8.3	8.1	7
Switzerland	6.5	6.3	6
USA	256.3	284.6	279
USSR (1)	298.4	344.2	385
West Germany (1)	59.6	52.8	44

Note: (1) projections needs revision due to changes of boundaries

Table 4 - POPULATION DATA FOR VARIOUS SELECTED COUNTRIES

It is proposed that the long term planning horizons, in relation to water resources and regional development, should be related to population projections. The following three horizons are proposed (Soroczynski, 1989):

i) ***Pre-Stationary Population.***
A pre-stationary population planning horizon is a period of time adopted for planning purposes, however in this planning horizon, stationary population is not considered as a reference.

ii) ***Stationary Population.***
This planning horizon is related to the estimated period in which stationary population will occur. At this level, it is possible to assess whether or not the stabilized population is consistent with the carrying capacity (productive capacity) of the ecosystem. WCED draws attention to this case and concludes that sustainable development can be pursued more easily when the size of stabilized population is at the level of productive capacity of the ecosystem (WCED, 1987, p. 56).

iii) ***Post-Stationary Population.***
This planning horizon deals with a period adopted for planning purposes after a country has reached stationary population. During this planning horizon, population may increase or decrease in size, and these changes may be caused by different rates of migration. Further, when dealing with the future, there is and must be some aspects of uncertainty, because the future is the integrated product of many complex factors. In addition, rates of change and precise timing of future events cannot be exactly defined, especially for long term projections. Such projections can be based on current knowledge and assumptions only and will, therefore, always be limited.

Water resources which are not allocated for use in this planning horizon can be maintained for the benefit of future generations. This principle is consistent with recommendations of WCED (WCED, 1987, p.348).

Further research by demographers is required for the proper establishment of this planning horizon.

The above planning horizons are based on the currently experienced development process in relation to population growth. Since various developed countries and most developing countries do not have a national policy for water resources management, lacking even water supply policy (Casadei, 1987, p.198), adoption of planning horizons related to population growth and time can define reference points for development of strategies. These planning horizons should be periodically reviewed. Further, adoption of planning horizons should allow for development and implementation of strategies based on a more rational approach to utilization of water resources.

In general terms, it is possible to conclude that development of water resources must be related to meeting requirements of growing population and increasing standards of living. At a stationary population level, primary development problems become water management and maintenance of a supply of good water quality and sufficient quantity.

The proposed classification is confirmed by the experience of Switzerland. Population of this country has reached stationary population (refer Table 4). In general terms the country does not have regional development problems.

In relation to water resources management the main concern of this country is maintaining the high quality of drinking water (Hartman, 1989).

4. INTEGRATED LAND AND WATER RESOURCES MANAGEMENT

It is proposed that management practices must establish the development potential of regions and a rational utilization of such development potential. This utilization should be related to population growth and distribution of population and land use. If the above principles are adopted, definition of present and future needs will be better understood and resources will be managed in more rational ways. It is concluded that availability of water should be secured for fast growing regions or regions which have development potential. This availability should be secured by two steps, first optimisation of development of sources within these regions and then the adoption of appropriate long term land use management.

Availability of water determines both the potential and the current level of public health within a country, state or region. Water resources are almost always limited within a defined area. This limitations may, therefore, affect potential for an increased standard of living or restrict economic development.

The effect of a high level of development on water resources and further growth is commented on by Ishibashi (1990, pp.11-12), who discusses the current Japanese experience in the Tokyo Metropolitan area and large cities on the western coast of Japan including Nagoya, Osaka, Hiroshima and Fukuoka. This area is called "The Pacific belt line", and in this region urbanisation and industrialisation are taking place at a high rate. Ishibashi reports that water shortages in this belt are a major problem that will affect the future growth of Japan. Further, Ishibashi presents many possible measures to solve water shortage problems, and one of these measures is related to national planning. He presents this issue in the following way: 'the basic solution to the problem must be to take steps on a national land planning scale such as the restriction of the flow of people into the area, the relocation of industry, and other means' (Ishibashi, 1990, p. 13). Ishibashi concludes in his paper that society must revise its understanding of water and accept the approach that 'water is limited and so should be used in keeping with the amount available in the area'(ibid, p.18) .

Reduction in availability of water resources in relation to population growth for selected countries is presented in Table 5.

These figures give a very rough indication of water availability. Further, it should be noted (WRI, 1988, p. 129) that national statistics on the availability of freshwater are inconsistent because no international standards exist. Lack of such standards makes comparisons very difficult. The availability of water, in relation to human use must take into account climate, location, timing, population, political boundaries and human intervention.

It is clear that the availability of water resources on each of the continents of the earth is different, and that such differences may also occur between regions of one country (eg. Australia).

It should be also noted that the data presented in Table 5 give only general and indicative differences. More accurate result can be derived from relatively small regions or countries, only, and not from large regions or countries, such as Australia. Within a large region or country variation in rainfall pattern and distribution alter results and more detailed data is required to draw appropriate conclusions.

On the other hand, availability of water resources depends on the natural condition of an area or region, human intervention and management of land and water resources. On these bases, integrated management of resources should lead to definition of development potential of regions, definition of scenarios for distribution of people and the securing of potential water sources for future use.

COUNTRY	ANNUAL WATER TOTAL (cubic kilometers)	INTERNAL RENEWABLE RESOURCES PER CAPITA (thousand cubic meters) 1990	2025	stationary population
1	2	3	4	5
WATER-RICH COUNTRIES				
Iceland	170	671.94	566.67	566.67
New Zealand	397	117.49	94.52	99.25
Canada	2901	109.37	90.37	100.03
Norway	405	96.15	90	101.25
Nicaragua	175	47.21	19.02	14.58
Brazil	5190	34.52	21.11	17.77
Ecuador	314	29.12	13.71	12.08
Australia	343	20.48	15.18	17.15
Cameroon	208	18.5	9.16	4.08
USSR	4384	15.22	12.47	11.39
Indonesia	2530	14.02	9.61	6.97
United States	2478	9.94	8.24	8.88
WATER-POOR COUNTRIES				
Egypt	1.8	0.03	0.019	0.014
Saudi Arabia	2.2	0.16	0.05	0.04
Barbados	0.05	0.2	0.17	0.17
Singapore	0.6	0.22	0.19	0.2
Kenya	14.8	0.59	0.19	0.12
Netherlands	10	0.68	0.66	0.77
Poland	49.4	1.29	1.1	1.03
South Africa	50	1.42	0.79	0.53
Haiti	11	1.69	0.96	0.69
Peru	40	1.79	0.98	0.89
India	1850	2.17	1.28	1.1
China	2800	2.47	1.88	1.66

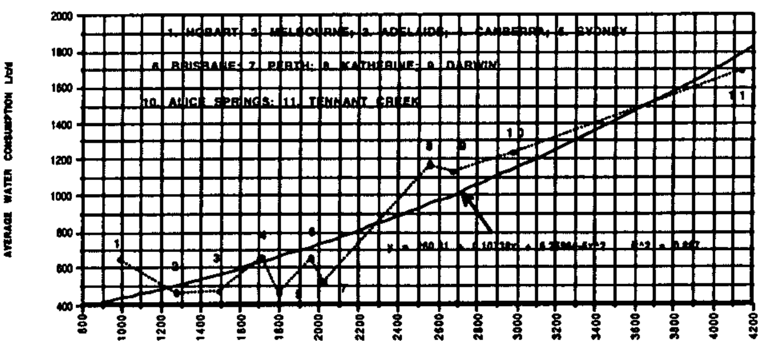
Sources: 1. (WRI 1990) data from Bureau of Geological Survey, France;
U.S. Geological Survey; and Institute of Geography, National Academy of Science, U.S.S.R.
2. Columns 2 & 3 (WRI 1990, Table 22.1)
3. Column 4 calculated based on (WRI 1990, Table 16.1)
4. Column 5 calculated based on (Zachariah 1988, Table 16)

Table 5 - ANNUAL INTERNAL RENEWABLE WATER RESOURCES IN SELECTED COUNTRIES PRE CAPITA IN 1990, 2025 AND AT STATIONARY POPULATION

For a defined urban area, total water consumption is quite easily calculated, if consumption per capita is known. If consumption per capita is not known, total water consumption must be calculated on the basis of assumptions. Unit water consumption depends on the following factors:

i) climatic conditions, including evaporation and probable rainfall pattern over a year
ii) adopted standard of living which includes: type of housing and proportion of detached houses to flats, and the area which requires watering within residential lots and other areas within towns
iii) commercial consumption
vi) industrial consumption
v) agricultural consumption.

It appears that for Australian conditions the evaporation rate is one of the major factors which influence urban water consumption. For the relationship of urban water consumption to evaporation refer to Figure 2. It should also be noted that design assumptions in relation to water consumption vary from 40 L/c/day (UNCED, 1992, p. 25) to approximately 1700 L/c/day (refer Figure 2). Therefore, bases for adoption of appropriate and justified standards require development of firm planning data. It is assumed that it should be possible to develop design data in relation to adopted living standards and climatic conditions in the form presented in Figure 3. It could, therefore, be concluded that differences between upper and lower bounds, for a regional water supply system, could be related to assumed base line design assumptions and subsequent introduction of water conservation measures.



NOTES:

1. all data from main water meters,
2. for towns 8, 9, 10, and 11: i) average lot size is approx. 800 sq. m.; ii) partial water re-use, except 11;
iii) no strict water conservation policy

FIGURE 2 - EVAPORATION / URBAN WATER CONSUMPTION RATES

Base line data and availability of water can be altered in the future by continuous changes in perception of water use and more efficient use of water. These changes can be affected by: new technology, re-use of water, appropriate utilization of water by industry and agriculture, and more efficient use of water.

Standards of living and the relevant water consumption rates for developing countries are and will be the crucial economic and strategic issues for land and water resources management.

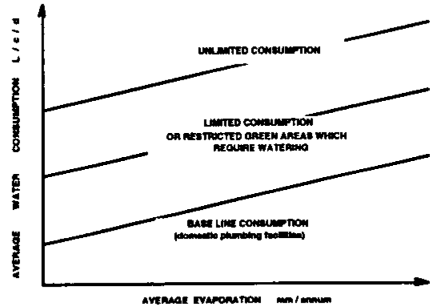


FIGURE 3 - WATER CONSUMPTION - LIVING STANDARDS / CLIMATIC CONDITIONS

5. STRATEGIC DECISIONS

It is proposed that the following two phases of management strategy for integration of population growth with land and water resources should be adopted:

i) definition of base line data for development potential leading to the relevant land reservations

ii) water management, including demand and conservation issues leading to optimum utilization of water resources.

In some cases both phases can be considered and implemented at the same time.

It is proposed that definition of base line data for development potential should be related to the following stages:

- definition of development potential
- definition of possible distribution of population at stationary population and beyond
- reservation of relevant land and water sources for securing development and adoption of appropriate development strategies.

Water management, including demand and conservation issues should be related to availability of water in the future, continuous changes in perception of water use and changes effected by new technology, re-use of water, appropriate utilization of water by industry and agriculture, and more efficient use of water.

For some inland regions or towns, where availability of water is limited and water can not be economically provided, water demand will have to be matched with sustainable yield of sources.

For simplified schematic of land use, water management, environmental constraints and available water for sustainable use refer to Figure 4.

Implementation of strategic decisions requires institutional arrangements. This implementation can be presented schematically, (refer Figure 5), in relation to federal and state government responsibilities. Federal government responsibilities should lie in development of general policies and general management strategies in relation to stationary population and sustainable development of a country. State government responsibilities should lie in implementation of sustainable development by definition of development potentials and relevant land and water management strategies.

In summary, integration of long term population growth with scenarios for distribution of population and optimum use of available resources will be one of the major development issues for some countries. In such countries, Strategic Development Units should be set up in order to advise governments on implementation of strategies to deal with major developments or major water projects. Introduction of land use and zoning for the whole country would probably simplify the decision making process. If such zoning is not currently in use, restriction of development by land use and zoning will have to be introduced, in some cases. For example, control of development can, in this way, be introduced by the restriction in development of industrial land.

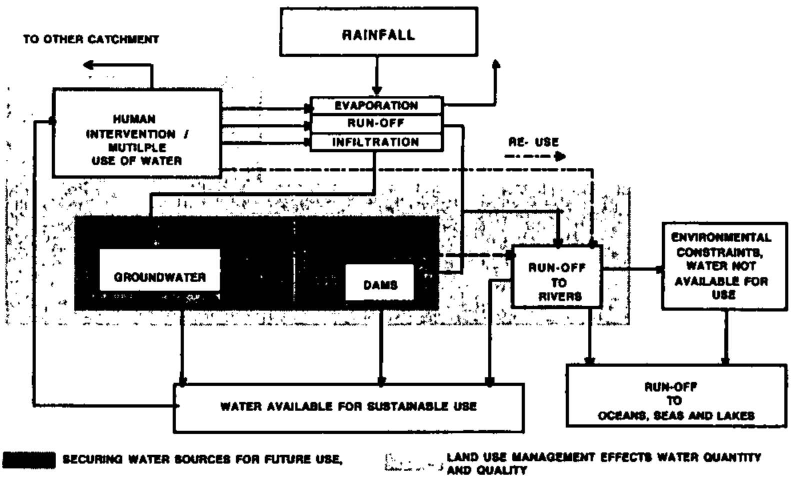


FIGURE 4 - SIMPLIFIED SCHEMATIC - LAND USE, WATER MANAGEMENT, ENVIRONMENTAL CONSTRAINTS AND AVAILABILITY OF WATER FOR SUSTAINABLE USE

6. PRIORITIES FOR GENERAL STRATEGIES

With regard to strategies for management of land and water resources countries can be broadly classified into:

i) countries or regions which experience a fast growing population and are or will be in the future poor in available water resources

ii) countries or regions which experience a growing population where availability of water resources has been diminished by human intervention

iii) countries or regions for which water resources assessment has not been conducted and water resources may limit future development

iv) countries rich in water resources for which strategies may be developed at a slower rate but in which urgency is related to selected regions.

7. DARWIN CASE STUDY

The Darwin case study is a good example of the approach presented in this paper.

The Northern Territory Government sponsored a public seminar in November 1986 (DT&W, 1986) which addressed broad scale issues for future development of the Darwin Region. Based on population Census, population of Darwin Region in June 1991 was 78500. The existing potable water sources for the Darwin Region have a total safe yield of 49,500 ML/year (this includes Darwin River Dam 36,500 Ml/year, McMinns borefield 5,500 ML/year and Manton Dam 7,300 ML/year). Water consumption was in the range 35,350 ML/year and 33,950 ML/year in 1992/93 and 1993/94 respectively.

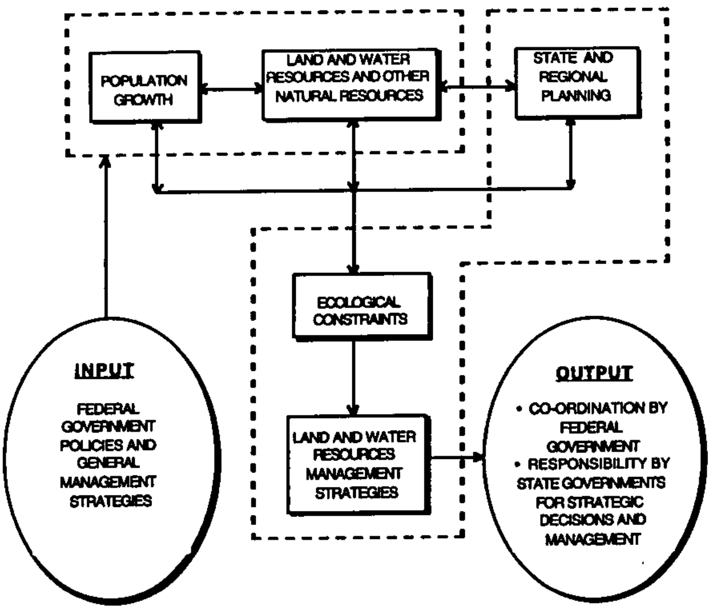


FIGURE 5 - INSTITUTIONAL ARRANGAMENTS FOR INTEGRATED LAND AND WATER MANAGEMENT

Potential major water sources include the following:

i) groundwater

• Howard East Borefied	16,400	ML/year
• Lambells Borefield	13,900	"

ii) surface waters

• Marrakai	440,000	ML/year
• Mount Bennet	200,000	"
• Warrai	120,000	"
• Batchelor	57,600	"
• Acacia Gap	32,000	"
• Tumbling Waters	32,000	"
• Manton Dam Transfer	15,000	"

The Northern Territory Government has decided on development of urban areas which can accommodate population in the order of 270,000 - 330,000. Development potential of the region was identified, scenarios for development considered and future water sources for population of approximately of 1,000,000 were identified.

Batchelor, Warrai and Tumbling Waters dams have the potential to be developed with closed catchments. Acacia Gap, Batchelor and Tumbling Waters dams have been abandoned on the basis of economic, social and land use constraints. An environmental impact study of the proposed regional development is still be completed.

Currently, relevant land for the selected sources is being reserved, or acquired. For location of existing and future water sources refer to Figure 6.

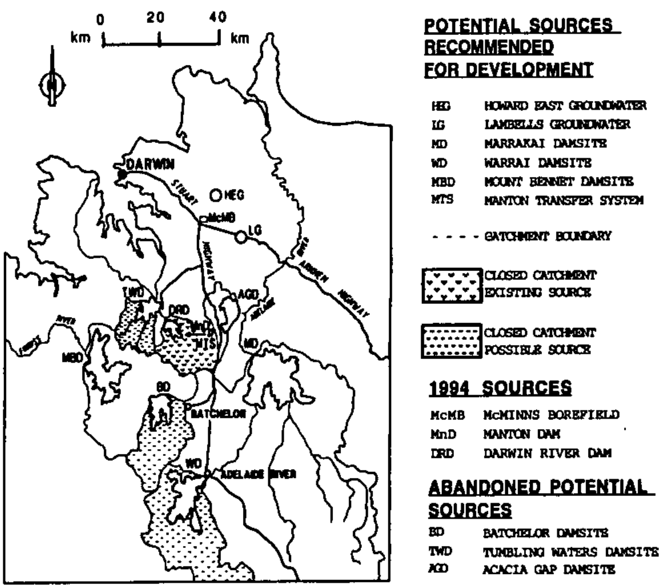


Figure 6 - WATER SOURCES IN THE DARWIN REGION

8. CONCLUSIONS

A. The transition to sustainability can be achieved by integrated resources management. This transition includes definition of development potentials, development scenarios and land and water resources management.

B. Developed and developing countries experience different population growth rates and different available water resources and, as a consequence, require different strategies for water resources management and may have different priorities. The point when stationary population of a country is reached should then be the the point at which development of water resources changes to water resources management.

C. More effort should be directed to further development of models which will lead to the definition of stationary population of a country. However, the definition of stationary population cannot resolve distribution of population between regions of a country. Such distribution should be based on the definition of development potential of regions and possible development scenarios.

If a concept of planning horizons is adopted, and then integrated with development potential and development scenarios, management strategies for land and water resources can be developed on a more rational basis.

D. The adoption of higher standards of living by developing countries will significantly influence land and water resources management strategies. Development of appropriate planning standards is, therefore, essential. Such planning standards should be related to evaporation rates, green areas which require watering and domestic plumbing facilities.

E. Development potentials of states or regions can be established only through the use of integrated multidisciplinary input, including definition of development potential and corresponding land use management strategies. A federal body should co-ordinate state activities, and utilise appropriate data for development of general policies. A state co-ordinating body should develop and implement national and state strategies.

F. Developing countries are in a worse position than developed countries. Developing countries, generally, lack the expertise required for development of strong land and water resources management strategies and policies, funds for assessment of water resources, as well as funds for better housing, employment and the improvement of living standards.

Better understanding of the development process, as presented above, should assist these countries in development of their own strategies. It is, therefore, proposed that further research in this direction should be supported. This research should provide the base for:

- Periodical revision of available data and improvement of accuracy for testing existing assumptions
- Finalisation of an appropriate methodology, including preparation of a manual of practice, as bases for development of national land and water management strategies in order to secure resources for future populations
- Preparation of a development manual in order to facilitate the adoption of water consumption rates which relate to standard of living and climatic conditions in urban areas
- Organisation of practical workshops/seminars to facilitate understanding and refinements of the proposed methodology.

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A BOTTOM-UP APPROACH TO INTEGRATING LAND AND WATER MANAGEMENT

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1. Introduction

It was here in Sweden in 1972 that the concept of sustainability became part of the international environmental vocabulary. Australia, like many other countries, chose to proceed and develop national policies on Ecologically Sustainable Development. A reasonable national consensus was achieved for two main reasons. Firstly, the symptoms of land and water degradation were becoming obvious to all in Australia. The main focussing event was a major dust storm that almost blacked out the city of Melbourne in mid afternoon. Graphic newspaper pictures of this event are still published from time to time. Secondly, the concept of sustainability was sufficiently ambiguous to attract wide ranging support without any clear specifications as to what it meant.

A subsequent event that maintained a feeling of national guilt was the development of a toxic algal bloom along 1000 km of the Darling River. This bloom led to international media coverage which did not sit well with the strategy of marketing Australian agriculture as "clean and green". The bloom led to stock deaths, wildlife deaths and a major effort to get emergency water treatment to towns and farms that were dependent on the river for water supply. This event finally convinced the bulk of the Australian public that we were not managing the country in a sustainable manner, and that things would have to change.

2. Failures of Integration

2.1 Integration of Government Activities

Australia is a Federal system of six States and two Territories. The State Governments have responsibility for managing natural resources such as land and water and the environment in general. The National Government has the bulk of the taxing powers and hence the funds. It also has international obligations under the various international environmental treaties and agreements. Co-ordination between State and Federal levels is largely done through Ministerial Councils where State and Federal Ministers reach agreement on various issues. The level of agreement is generally at the lowest common denominator, and this mechanism has generally not given us creative forward looking solutions to our land and water problems. State boundaries continue to be a problem to ecosystem level management. One optimistic element is the Murray-Darling Basin Commission where relevant State and Federal Ministers agree on sharing of water resources and the capital and operating costs involved with managing water across this large basin.

2.2 Integration between Functional Agencies

Australian States generally have separate agencies responsible for agriculture, forestry, water resources, nature conservation, environmental regulation and at times separate planning systems. Many of these functions also are supported by Federal agencies and from time to time there are tensions about the roles of each level of Government. Rural land use planning is very weak in Australia.

There are tensions between these various agencies and the interests they reflect, and integration has generally been poor. The narrow sectorial interests tend to discount externalities such as downstream degradation and any impacts that will not be apparent for some time.

2.3 Integration between Disciplines

Agencies tend to be dominated by expertise from a single discipline such as agriculture, ecology or engineering and this has reinforced agency functional boundaries. There have been tensions between the various disciplinary groups and communication has been poor at times.

The water industry has been dominated in the last 80 years by the engineering profession. This "can do" orientation has built a significant infrastructure which has had an important impact on the health and well being of Australians. To many the "building" phase is largely over, and the orientation of the water industry has moved on to managing the resource. The importance of economists and economic paradigms has increased since the sixties, and now several water agencies are led by people with an economic training.

Yet the water industry is about managing an ecological system. Governments have expressed concern that the existing water industry has not given us sustainable management of land and water.

2.4 Integration between Knowledge Providers and Knowledge Users

Tensions also exist between the research community and the managers of resources. In Australia the research agenda in the 30 years since the second world war was set largely by the research community. In the late seventies dissatisfaction with this process emerged since the country was failing to build an industry base on its scientific discoveries. Governments decided this could be remedied by having industry groups set the research agenda. A variety of structures were put in place to bring this about. The Australian research agenda changed dramatically with a marked drop in basic research and much applied activity. This has not led to the hoped for economic impacts either, and many of the research agendas set by these bodies are focussed firmly on problems of the past rather than opportunities for the future. The Government has now developed a new model of Collaborative research where industry and researchers work together to set agendas and carry out the research work. The 51 Cooperative Research Centres are the cornerstone of this policy and are and exciting development whose effectiveness will be able to be assessed in about 5 years time.

3 Organisational Turbulence

Decision making about natural resources appears to have reached a crisis point in many countries. Few people are satisfied that we are making good decisions that will lead to sustainable management of the resource and/or be acceptable to the main interest groups. There is widespread distrust in the professionals involved and the structures we have developed.

In the USA President Clinton has described the forestry-environment conflict as having reached Gridlock where those who do not like a decision can find some basis for a legal challenge. In ministerial systems such as Australia the problem seems to be the reverse. Rapid decisions, without adequate examination of the issues are announced, implemented and regretted. Generally a narrow range of mindsets are involved with the decisions, and various interests feel excluded or marginalised. In Australia the restructuring of the water industry involves decisions which have the hallmark of inadequate analysis and doctrinaire views of the world replacing wisdom and leadership.

A number of symptoms of institutional malaise are now apparent internationally (Renewable Natural Resources Foundation (1992):

an inability to identify and manage cumulative impacts,
limitations on what management agencies can do,
the bureaucratic nature of agencies,
limited understanding of issues on the part of decision-makers,
the narrow focus of professional organisations,
the lack of institutional rewards for professionals involving themselves in community conflict resolution,
harassment of scientists/professionals for voicing unpopular opinions,
the perception of land as a simply an economic commodity,
failure to internalise the environmental costs of using a resource (the costs are borne by others),
poor judgements about the costs and benefits of using a resource,
increasing polarisation and distrust.

This discussion leads one to the view that our organisational arrangements for managing natural resources in any integrated way have failed. Our professional training, professional organisations and agency structures have all evolved in simpler times. The pressures on resources were less and we had only simplistic understandings of the cause-effect relationships in ecosystems. It is little wonder they are not coping with the challenges of the nineties and beyond.

4. The Landcare Movement

Australia is seeing an exciting new approach to natural resource management that may be the key to resolving many of the difficulties outlined above.

4.1 Origins

The origin of development can be seen in the salinity program established by the Victorian State Government in the early eighties. Community groups were supported by technical experts from relevant agencies. Local groups were required to develop a plan within a limited time frame (usually two years) in accordance with published guidelines (Stone, 1992). Such plans were a prerequisite for Government funding of various remediation measures. This is an interesting mix of top down processes whereby State Government established a strategic framework and provided expertise and incentives to allow local groups to be empowered to tackle their problems in a "bottom up" approach.

These local groups were only seen as advisory, and the agency representatives had opportunities to comment on the effectiveness of the plans. However the power imbalance was redressed by the committees having a promise of direct access to the Minister. This ensured agency staff took the whole process seriously.

4.2 The Political Pressures

These early approaches to developing a "bottom up" system were seen as successful, and indeed they are still operating. The Federal Government got involved following pressure from the farming community, the conservation movement and from international pressures on a variety of Conservation issues. The critical factor however was a surprising and unlikely alliance between the National Farmers' Federation and the Australian Conservation Foundation. In the face of such an alliance the Federal Government provided funding to support the "Decade of Landcare" from 1990. The total commitment was some $360 million over the decade with some $15 million a year available to community landcare groups to carry out local works. However this commitment has escalated following the success of the program. More than $300 million has been committed ion the first three years and it is now expected that this will be maintained at $100 million per year.

4.3 The Landcare Movement

Landcare involves local communities banding together to solve problems with the support and assistance of the various agencies. A landcare group can be defined as a voluntary organisation of local community members dedicated to combating land degradation, protecting wildlife and managing the land in a responsible way. It involves neighbors working together to tackle a common problem of concern. It recognises that water, rabbits and other degrading factors do not recognise farm boundaries and that "no man is an island". Landcare groups are significant in that they draw upon common and preexisting social values and networks, and yet empower the individual to action (Cock, 1992). They allow the development and articulation of a new land management ethic, but also provide a framework through which government support and expertise can be made available in a cost-effective manner compared to previous extension models.

4.4 Extent of Landcare

There are now more than 2000 local, voluntary landcare groups in Australia. Nationally this represents some 30% of broad acre farmers and 19% of the dairy industry, although there are significant regional variations in membership (Mues, et al 1994). Over 90% of farmers nationally are aware of the landcare movement. Those involved with landcare tend to be younger, those with a farm plan, with a perceived land degradation problem, be active in restoration on farm and at a community level, be larger and with a somewhat higher rate of return on capital than non members. The most common land degradation problem reported was water erosion, with other concerns being woody weeds, soil acidity and salinity (Mues, et al 1994). Curtis et al (1994) report that landcare groups hold meetings to discuss issues and priorities, conduct field days and farm walks to discuss issues and solutions, conduct tree planting, construct salinity and erosion control structures, coordinate pest animal and weed control activities, erect fencing to limit stock access to streams, establish wildlife corridors, initiate whole farm and catchment planning processes, involve other community groups in activities and in community education, organise conferences, write newsletters and make submissions to Government.

Landcare is a partnership linking the expertise and funding of Governments with the knowledge, skills and concerns of local people. This has been a quite remarkable development. The possible impact on land prices, and the risk to the farmers reputations as a "good farmer" may well have inhibited the open sharing of community problems essential to the development of Landcare (Stone, 1992). This has led to an energising of local communities to do something about the problems in difficult economic times. Landcare has also provided a beneficial linkage between Federal, State and Local Governments in Australia.

This emerging "bottom up" approach gives the potential to achieve an integrated approach which has not been achieved in Australia with a range of top down agency co-ordinating efforts.

4.5 Higher Level Community Groups

There have been a number of approaches to trying to link landcare groups into larger units that can assist with integrating the very local approaches of landcare. In one State, New South Wales, Total Catchment Management has been developed to operate at a large catchment scales. Landcare is thought to work most effectively with less than 100 farmers participating. The Total Catchment Committees in NSW are generally appointed by the agencies and some might argue are an attempt by the agencies to capture the process. Nevertheless, they do provide a forum for local landcare groups to interact and have an input into policy development.

In the State of Victoria the Government required the development of Regional Landcare Plans. Curtis et al (1994) regard this as a bold experiment in linking integrated or catchment based planning with community participation in a way not experienced in Australia in earlier work.

There is an underlying tension of scale operating here. The ability to harness local energy is dependent on concerns shared by all members. This has been the power of Landcare, which builds on existing social networks (Wilkinson & Barr, 1993). Yet integrated resource management requires a consideration of a wide variety of factors, including upstream-downstream tradeoffs. Some would argue that the appropriate allocation of resources should be on severity and impact of a problem, not on the ability of a local group to articulate their case for help.

5. Improvements in Integration

5.1 Integration of Land and Water Management

There has been considerable discussion in Australia about the connection between land management and water quality, and most people now understand the connections. When rain runs off land it transports sediment and a variety of other contaminants like nutrients to the receiving waters. An aquatic ecosystem is therefore tightly coupled with its catchment. A degraded water body often points to a degraded catchment. Perhaps the best indicator of sustainable agriculture is the quality of water draining the catchment.

Land management strategies under active consideration include the retention of buffer strips along waterways, restriction of stock access to streambanks, encouragement of basic soil conservation measures involving vegetative cover and the development of artificial wetlands as nutrient and sediment traps along drainage lines.

In 1992 the Federal Government developed new legislation to integrate its programs addressing soil, water and vegetation (Natural Resources Management (Financial Assistance) Act 1992).

5.2 Integrating Ecologic and Economic Realities

We need to develop an Australian agriculture which is both ecologically and economically sustainable. Many would argue that the present situation is not sustainable on either count. Governments have committed substantial funds to improving the management of land, and for restructuring agriculture.

The farmer who lives on the land is the ultimate integrator between economic and ecologic realities, and generally has a concern for the long term well being of his land asset. However the farmer may well be caught in an economic situation where the funds are just not available to carry out the works that are required. Governments have been caught by the success of Landcare, and need to allocate additional funds if they are to maintain the energy and enthusiasm they have created. In some situations State agencies appear to have taken advantage of the new Federal funds by withdrawing their own support for rural land management.

5.3 Integration of Disciplinary Technical Expertise

The Landcare movement appears to have led to better integration of technical expertise from the various disciplines and agencies that supply information to the rural community. Extensive publicity in the rural press to the benefits of a more integrated approach has helped.

Integration is best achieved by those closest to the problem with a responsibility to manage the land. Technical information circulates through the landcare groups and peer pressure becomes important. The community takes on ownership of the problem rather than blaming Government. The groups become "learning communities" that develop an improved understanding of the causes and consequences of the problem, as well as sharing in experimentation and demonstrating possible solutions.

Governments have supported this development with the provision of funding once a Landcare plan is developed and through the provision of local Landcare Facilitators to help the process. They are also the major suppliers of technical information and analyse proposed works and present results back to the Landcare groups in what is much more of a partnership approach than the previous "top-down" approaches. There is also a National Landcare Facilitator and each State has a State Co-ordinator.

5.4 Social Integration

The gathering of small community groups to address a problem of common concern has often involved non-farmers in a community. This has helped build a sense of community in a period when economic pressures are continuing to put great stress on rural communities. There is even better integration within the family, since wives and older children play a significant role in landcare groups. This has helped diminish the older patriarchal model and the model of sharing community decisions is likely to spread to a sharing of family decisions.

In 1993 the Federal Government provided funding for City Landcare, which has not only directed attention to water quality problems in urban areas, but helped develop a better understanding of land management hence strengthening urban-rural understandings.

6. Challenges for the Landcare Model

6.1 Funding

The very success of the landcare model is a problem for Government. The number of landcare groups, and their local aspirations demand a level of funding greater than initially envisaged and additional funding has been provided. However if the growth of landcare continues additional funding will be needed. Local involvement will quickly fade to disillusionment if funds are not available. There are tensions already whether funds should be allocated on a small scale to many different groups or whether they should be focussed to particular problem catchments. There are some concerns that many of the costs of landcare are borne by landholders and benefits accrue to the community, and it is argued that the wider community should be providing more funds.

The National Landcare Advisory Committee (NLAC) was established by the Federal Government in July 1993 to specifically advise on priorities and strategies for natural resource management in Australia.

6.2 Getting Science and Technical Information to the Users

The landcare movement has largely replaced the old top down agricultural extension models which are now seen by many as costly and ineffective in that they only seemed effective with a small proportion of farmers. The landcare model uses a whole variety of local pressures to take people along, and these pressures from neighbours can not be ignored in the way an agency extension officer could be ignored. The key to this is to make sure we have mechanisms to provide technical information to these leaders and let them choose to demonstrate and push particular approaches. The agency staff are knowledge providers, not defacto managers of the land. They have to have time to build trust with key local influencers.

The knowledge providers from research have to re-examine how new findings can be got out to the farming community. No longer can agricultural experimental stations be relied upon to test and demonstrate new approaches. These demonstrations will be done with lead farmers. There remains a challenge of getting highly technical information presented in a form that it can used effectively by community groups.

6.3 Whole Catchment Thinking vs Disintegration

The underlying tension between focussed local communities pushing for resources to be spent on a particular problem, and the need to manage land and water on an integrated catchment basis remains a problem. In the State of Victoria catchment management and water resources management is being regionalised so that local communities may have more say in key management decisions. It is not yet clear how boundary issues between largely autonomous regional bodies will be integrated and how State and National interests will be handled.

The challenge here relate to a likely preferences in the landcare model for short term immediate problems over longer term underlying problems. NLAC has encouraged Ministers to recognise that long term solutions are necessary for land degradation problems.

6.4 Leadership and Energy

There has been speculation that the momentum of landcare may falter as the initial leaders lose energy and suffer what is described as "burnout". Local leadership is critical to landcare and the energy of groups will rise and fall partly as a function of leadership. Leadership training is however being provided and there is no reason to believe that succession of leadership of these groups cannot be effectively managed.

7. Summary & Conclusions

Landcare has demonstrated the power of community groups to provide an integrated approach to a problem and get solutions adopted. This has involved genuine public ownership of a problem and real public based decision making - not just an opportunity to participate or be involved with some one elses decision making,

There is a growing recognition that production and conservation interests must work in partnership to solve the land degradation and social problems of rural Australia. We must get to a situation of economic and environmental sustainability. This recognition has even led to better collaboration across agency boundaries.

Emerging "bottom up" decision making models provide new opportunities and new challenges in the management of natural resources. The opportunity is to better integrate the disciplinary inputs from various agencies to focus on problems seen as important by the local community. The opportunity is to develop solutions that have some possibility for being implemented because of the community ownership.

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INTEGRATED LAND AND WASTE MANAGEMENT TOWARDS ENHANCEMENT OF RESERVOIR NUTRIENT LEVELS — A SUCCESSFUL CASE STUDY IN SINGAPORE

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INTRODUCTION

The alleviation of water quality in impounding reservoirs has been the bane of investigators for quite some time. In 1968, Vollenweider came up with his monumental piece of work on the relationship between external nutrient inputs and state of eutrophication of reservoirs in Europe. Subsequently, the concept of curbing nutrient input loads into waterbodies has been employed with great success (Laurent et al 1970, Edmundson 1972) or with limited success (Emery et al 1973, Larsen et al 1979). In land-scarce Singapore having an area of 621 km^2, the pressing need for water from domestic sources has always been of primary concern. Thus the Kranji-Pandan Scheme was conceived and implemented in 1972 and for the first time land areas, wherein there was some form of industrial and farming activity, were being utilised as water catchment. The main objectives of this paper are:

(a) to describe the organization and methodology involved in the extensive pollution survey conducted to assess the sources of pollution,
(b) to analyse field data, identify the major pollution load contributors and the locations in which they occur,
(c) to describe measures taken and relevant legislation promulgated with respect to major sources of pollution and
(d) to monitor water quality in the streams and the reservoir in the Kranji catchment and also in relation to resettlement of pig farmers.

WATER SUPPLY IN SINGAPORE

Situation in 1972. As a young republic, rapid industrialization and urban housing were two areas that drastically affected the water demand. In fact the total water demand had increased by more than 50% during the previous decade (Appan, 1992). Before 1969, only catchments that had no water pollution-contributing activities were being utilised as they were protected by law (Nature Reserves Act 1951). But increasing water demands, the need to internalize an essential commodity like water and the scarcity of land due to its competing demands, led to the completion of the Seletar Scheme in 1969. In this scheme, the concept of using for the first time, *part* of the runoff from eight catchments in which there was some farming activity was introduced. Stringent measures were taken to ensure that there was some control over the pollution caused by pig farming. Following this project, the Kranji-Pandan Scheme was completed wherein the *whole* catchment area was not protected by the existing law. That meant that the catchment area could continue to be used for other existing activities.

The Kranji-Pandan Scheme. The Kranji-Pandan Scheme (see Figure 1 for schematic diagram and location plan) extends over a catchment area of 112 km^2 and lies in the western half of Singapore. The project involved the damming of the estuary of Sungei Kranji and forming the Kranji Reservoir (capacity 18.15×10^6 m^3) with facilities for supplementary pumping from Jurong Lake and the Pandan Reservoir. All the waters are directed to the Choa Chu Kang Waterworks wherein the raw water is subjected to conventional treatment and is finally disinfected with ozone. The average yield from the scheme was computed to be 297×10^3 m^3/d with a major contribution from Kranji catchment of about 165×10^3 m^3/d. Hence, special emphasis was placed on the pollution survey results and proposed line of action in the Kranji catchment.

METHODOLOGY OF POLLUTION SURVEY OF THE KRANJI CATCHMENT

Liaison with different departments. The responsibility for the planning and execution of the pollution survey was that of the Water Department of the Public Utilities Board, Singapore. Several government and quasi-government departments had to be contacted to obtain relevant information and to gain access to documents. The Survey Department was the national authority for providing the most recent field drawings which provided some details of streams, ponds, major types of land use, locations of buildings including farms, ponds, roads etc. The Primary Production Department gave full support with regard to farming animals like pigs, poultry and other animals and the Sewerage Department provided operational details of the then existing human-waste disposal systems like latrines, septic tanks, small sewage treatment plants etc. Statistics on farming structures and data on cost of resettlement were provided by the Resettlement Department. With representatives from these various departments embracing the ministries of national development and the environment, an anti-pollution coordinating committee was formed to assist in the interaction and cooperation necessary for the pollution survey of the catchments. This committee was initiated and chaired by the Water Department.

Pollution survey of land areas. Before proceeding with any fieldwork, it was necessary to obtain proper location maps encompassing the vast area so that the watercourses and morphological characteristics of the catchment were better understood. These maps were acquired from the Survey Department and it was necessary to obtain further information on the exact location of the pollution sources on land and to make a note of the magnitude or quanta. For this purpose, each of the detailed maps (1:2500 scale) was divided into grids, subgrids and micrLogrids.

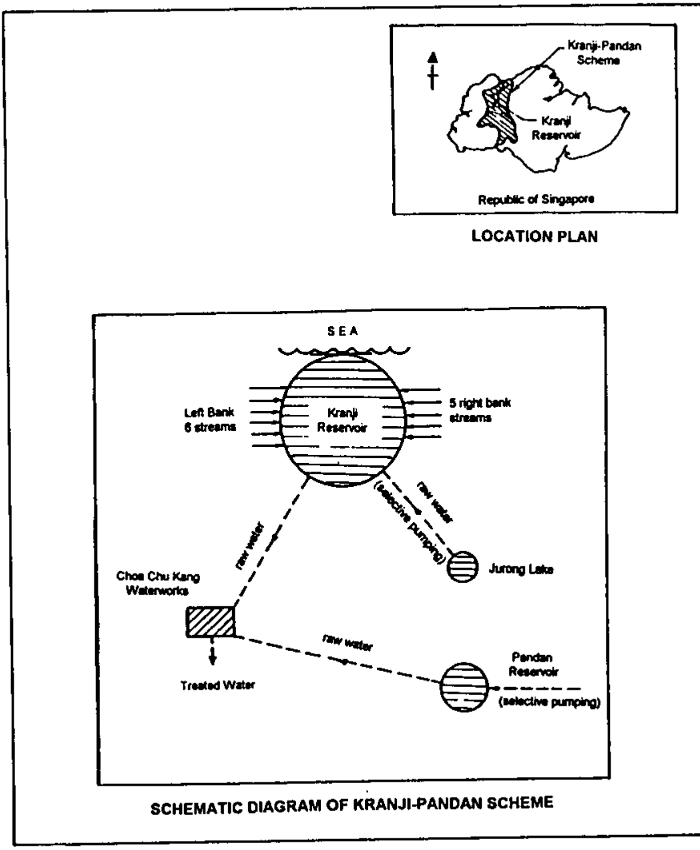


Figure 1 : Kranji-Pandan Scheme: Schematic Diagram & Location Plan

Each grid encompassed a rectangular area of 500 acres (202 ha) and, for ease of field operations, a grid was further subdivided into 200 microgrids (20 microgrids x 10 microgrids). Each microgrid, having an area of 2.5 acres (or app. 1 ha), was the smallest area that had to be dealt with and to incorporate existing field data.

It was possible for these field surveys to be carried out by semi-skilled staff as field orientation was neither difficult nor time-consuming. Within each of the microgrids the types, number and location of the pollution-contributing agents were identified and the information logged on standardised formats.

Water sampling and testing. This aspect of the work had to be carried out meticulously as the effect of pollution on catchment areas can best be appraised by the quality of runoff in streams and the water within the reservoir. Sampling locations were selected based on their accessibility, degree of representation of subcatchments, facilities for taking flow measurements and the influence of the backwater curves. The sampling locations within the Kranji catchment and the reservoir and also the sampling subcatchments are shown in Figure 2.

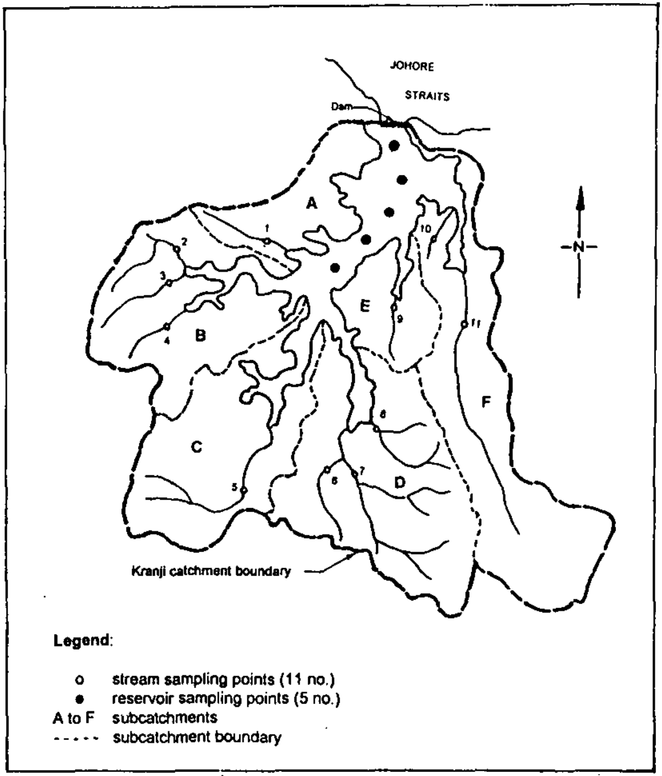


Figure 2 : Kranji Catchment - Streams & Reservoir Sampling Points

In the case of feeder streams 11 sampling points, lying on both sides of the Kranji Reservoir, were selected. Samples were collected and flow measurements made on a weekly basis. Monthly reservoir samples were collected at the top, bottom and middle at each of the selected 5 locations.

The samples were subjected to physico-chemical and microbiological tests to determine parameters such as temperature, colour, pH, turbidity, silica, phosphate, dissolved oxygen, BOD, COD, ammonia N, nitrite N, nitrate N, organic N and also Total Coli and E Coli counts.

POLLUTION SURVEY DATA - CLASSIFICATION, MODE OF WASTE GENERATION AND DISTRIBUTION

Based on the field surveys carried out between December 1971 and January 1973, the major sources of pollution contributors were identified and reported (Appan, 1973). A concise summary of these results is presented in Table 1.

Table 1 : Summary of data in Kranji Catchment *

Houses		Septic Tanks**	Pig farming		Industries	
No:	Population		Farmers	Pigs	No	Employees
9828	78705	65	3325	184369	184	8087

Note: * data collected during 1971 to 1973
** including small sewage treatment plants

The enumerated houses and population included the farm dwellings and the pig farmers respectively. The employees in industries mainly lived outside the catchment and commuted to and fro.

Classification: Based on the analyses of the information accumulated, pollution contributors were classified in the following order:

Pig wastes
Human wastes
Industrial wastes

Pig wastes: The main domesticated animal the farmers reared were pigs followed by poultry and ducks. Pigs were bred according to seasonal demands and, accordingly, there was always a wide fluctuation in the numbers being bred. Pigs were fed in their pens and no special area was provided for the collection of wastes. Pig waste was produced copiously and intermittently and to keep the pigs "cool", water was used extensively by the indigenous farmer. In most cases, the pig waste was directly discharged into the nearby watercourses.

The distribution of pigs is shown clearly in Figure 3 where the intensities of the pigs have been computed on a grid-by-grid basis. There is a predominance of highest intensities (45 to 100 pigs/ha) around the mouths of the watercourses confirming that pig-farming is distributed mainly in areas where there is abundant water.

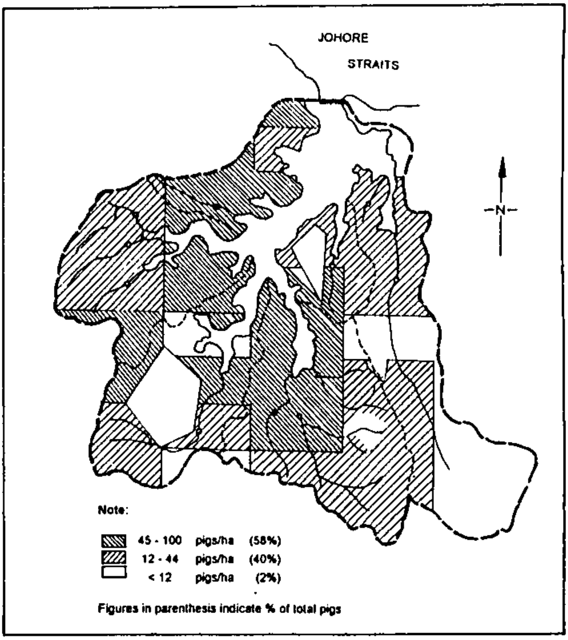


Figure 3 : Intensities of Pigs - Kranji Catchment

Poultry and Ducks: Poultry, though found in reasonable numbers, was not considered to be pollutive as the waste which was in great demand was removed in solid form. The duck-farmers were small in number and they were encouraged to convert to dry duck-farming.

Human Wastes: At the time of the completion of the survey in 1973, there was no sewerage system in the Kranji catchment. The population was only served by septic tanks and small sewage treatment plants that accounted for about 50% of the population. The partially-treated waste was being discharged into the nearby watercourses.

Industrial wastes: Only 39 of the 184 industries generated liquid wastes that were discharging into watercourses. The rest of the industries only generated solid waste. The effluent quality from industries was sampled and tested and compared with the allowable effluent quality standards as stipulated in the then existing regulations (Environmental Public Health Regulations, 1971).

Pesticides, herbicides etc.: From information obtained from the Primary Production Department, it was ascertained that only minimal quantities were used in the small vegetable-farms and horticultural activities. In general, highly toxic and persistent pesticides were not allowed to be imported for local use.

Water quality in Kranji streams: All the 11 streams were sampled weekly and the quality was monitored on a monthly basis by determining the flow-weighted concentrations each parameter. The annual concentrations of PO_4 and Total N (or TN) are presented in Table 2 (Annual Report, 1974). TN is the sum of ammonia, nitrite, nitrate and organic concentrations.

Table 2 : Water Quality in Kranji Catchment Streams

Sampling points	PO_4 mg/L*	TN mg/L*
1	4.0	49.8
2	3.7	32.8
3	0.8	13.3
4	3.6	26.1
5	2.7	20.3
6	3.5	30.5
7	2.1	15.3
8	3.3	27.0
9	1.8	14.5
10	1.0	10.0
11	1.0	11.0

Note: * Annual flow-weighted mean

The high range of PO_4 (0.8 to 3.7 mg/L) and TN (10.0 to 49.8 mg/L) reflected the extremely poor quality of runoff in the whole catchment.

Water quality in Kranji Reservoir. The annual water qualities used are based on monthly samples collected in the different locations at various depths and weighted to represent a mixed model. The range of PO_4 and TN values are shown in Table 3 (Appan, 1978) and compared with the water quality in MacRitchie Reservoir which has its catchment protected by law.

Table 3 : Water Quality in Kranji & MacRitchie Reservoirs

Reservoir	Weighted mean monthly values		Type of Catchment
	PO_4 (mg/L)	TN (mg/L)	
Kranji	0.33 to 1.22	11.0 to 19.0	Unprotected
MacRitchie	0.03 to 0.07	1.0 to 8.1	Protected

In the case of the Kranji reservoir, there was prolific growth of aquatic plants, different species of fish and microorganisms including algae. Comparatively, the MacRitchie reservoir had a very high standard of raw water quality and it can be considered to be in a trophic state in which it is free of algal and other nuisances. Hence, the safe trophic level in terms of PO_4 for a waterbody in the Singapore context was considered to be 0.07 mg/L.

ANALYSIS OF INPUT INTO KRANJI RESERVOIR

Input Budget. Regular stream sampling and gauging gave an idea of the pollution load being carried by each of the stream's subcatchment areas. To breakdown the various contributions from each of the pollution-contributing sources, unit pollution loads from both pigs and humans had to be determined. Hence, a proper literature survey was carried out and also the equivalent pollution load values for pigs appraised (Appan, 1978). Alternatively, the literature survey values can be used initially in a sampling catchment having a known number of pollution sources and a more exhaustive and an accurate computer solution obtained for unit pollution loads (Appan and Chin, 1979).

Having determined the unit pollution loads for humans and computed equivalent pollution loads for pigs, the rest of the input sources like erosion, rainfall etc. were measured on site or estimated (Loehr 1974, Weibel 1969). In the case of industrial inputs, the actual loads were calculated based on the effluent samples analysed and the flow measurements made. The input budgets for the 1973/74 hydrologic year, based on the above principles, were computed for PO_4 and TN and are presented in Tables 4 and 5 respectively.

Table 4 : Input Budget - PO_4 (Kranji Reservoir)

Sub catchment	Waste loads (in metric tons/annum)					Sub-total
	Pigs	Humans	Industries	Erosion	Rainfall	
1	53.11	1.64	0.00	0.27	0.30	55.32 (8.8%)
2	43.26	3.08	0.01	0.57	0.65	47.57 (7.5%)
3	83.38	10.20	0.92	0.63	0.72	95.85 (15.2%)
4	336.68	36.12	0.00	0.83	0.95	374.58 (59.4%)
5	21.47	3.09	2.08	0.17	0.19	27.00 (4.3%)
6	8.04	20.05	0.00	0.86	0.99	29.94 (4.8%)
TOTAL INPUT	545.94 (86.6%)	74.18 (11.8%)	3.01 (0.5%)	3.33 (0.5%)	3.80 (0.5%)	630.26 (100%) (100%)

Note: Figures in parenthesis represent % of total input.

Table 5 : Input Budget - TN (Kranji Reservoir)

Sub catchment	Waste loads (in metric tons/annum)					Sub-total
	Pigs	Humans	Industries	Erosion	Rainfall	
1	155.19	6.26	28.00	22.29	4.41	216.15 (5.3%)
2	189.84	17.72	23.00	47.33	9.40	287.29 (7.1%)
3	290.62	46.51	5.00	52.90	10.47	405.50 (9.9%)
4	827.77	116.16	212.00	69.61	13.78	1239.32 (30.5%)
5	79.52	14.94	0.00	13.92	2.76	111.14 (2.7%)
6	10.02	32.66	1681.00	72.60	14.29	1810.57 (44.5%)
TOTAL INPUT	1552.96 (38.1%)	234.25 (5.8%)	1949.00 (47.9%)	278.65 (6.8%)	55.11 (1.4%)	4069.97 (100%) (100%)

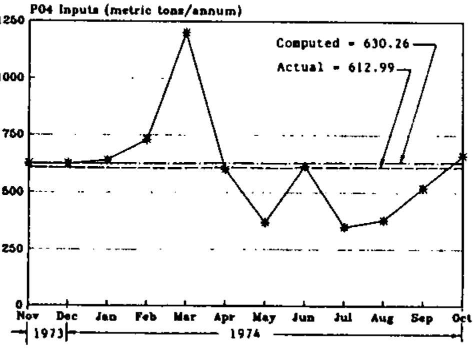
Note: Figures in parenthesis represent % of total input.

It can be noted that the highest PO_4 load of 59.4% emanates from subcatchment 4 which also has substantially high N load of 30.5%. Besides, in the Kranji catchment, the highest PO_4 input of 86.6% comes from the pig farming sector. This is very significant as PO_4 very often is identified to be the most critical parameter in terms of controlling eutrophication in waterbodies.

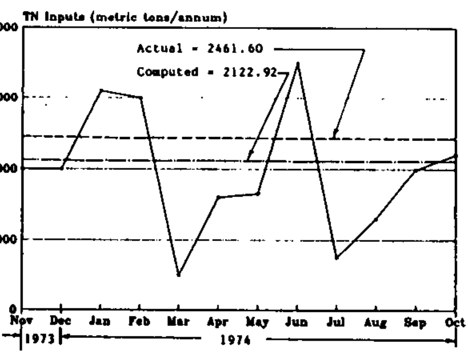
Computed vs Actual Inputs. The actual inputs into the Kranji Reservoir were determined by using the analytical values of the stream samples and also the flow measurements. These values were calculated on a weekly basis and the monthly values have been compared with the computed values as shown in Figure 4a (for PO_4) and Figure 4b (for TN). The close proximity of the computed and actual values of inputs, particularly with respect to PO_4, indicates that the selected unit pollution loads were sufficiently representative.

ANTI-POLLUTION MEASURES INCLUDING LEGISLATION

Following the publication of the results of the pollution survey (Appan, 1973), it was realised that there was an urgent need to adopt a positive policy to curb the ingress of very high nutrient loads into the reservoir which was in an advanced state of eutrophication. Action had to be taken at a brisk rate if the water quality within the streams and the reservoir was to improve. From the data presented and the analyses of the input, it was obvious that there was an immediate need to alleviate the high pollution loads from the pig farms and, to a lesser extent, from the human and industrial sources. Some of the major measures that were taken that had both direct and indirect impacts on the curbing of waste loads are as follows:



(a) PO_4 - Actual vs Computed Inputs



(b) TN - Actual vs Computed Inputs

Figure 4 : Actual vs Computed Inputs - Kranji Reservoir

Restriction of pig farming. The existing modus operandi of pig farming, as described earlier, had to be modified or totally changed to curb the high PO_4 loads that were being directly discharged into the watercourses. This could have involved a prolonged period of education, training and even subsidy for the pig farmers. The policy within the catchment was to cease pig rearing within the catchment; small pig-farmers were encouraged to concentrate on non-pollutive type of activity and, big pig-farmers were to be resettled outside the catchment in areas being utilised as or had potential for water resources development. This resettlement programme commenced in 1973 and by 1979 there were no more pigs within the Kranji catchment (see Figure 5).

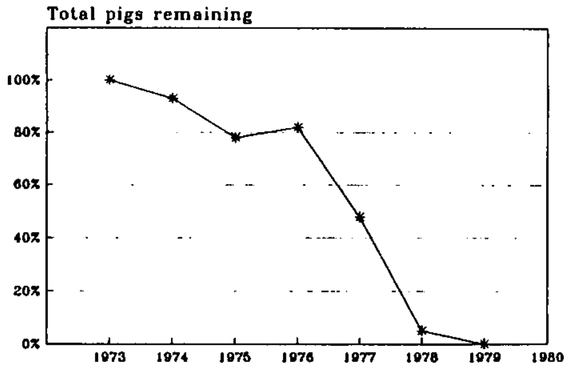


Figure 5 : Rate of Resettlement of Pig-Farmers

In the subsequent years, there was the realization that pig farming could be disastrous to runoff quality in all water catchments. This led to the promulgation of law on the prohibition of pig rearing in all water catchments in Singapore (Cattle Restricted Area Notification, 1977).

Effluent quality in controlled and uncontrolled watercourses. From 1971, the quality of allowable industrial effluents that could be discharged into a watercourse was dictated by the Environmental Public Health Regulations. Though ideally no activity should have been encouraged within a water catchment, the competing and pressing demands for land use in Singapore led to the promulgation of new set of regulations (Trade Effluent Regulations, 1976). According to this set of regulations, two sets of discharge standards were set. They were for two types of watercourses viz, "controlled" watercourses (which were being used for abstraction of potable water from partly-protected catchments) and "uncontrolled" watercourses (lying in unprotected catchments in which there was no form of water resources development). Consequently, industries within the partly-protected catchments were obliged to improve or upgrade their wastewater treatment systems.

Sewerage system within catchment. The input budgets (see Tables 5 and 6) established that human waste in the Kranji catchment accounted for 11.8% of PO_4 and 5.8% of TN loads. As part of the national development plan and also the need for the development of a sewerage a scheme within the catchment, the rate of laying of sewers was accelerated throughout the republic. Though in 1973, only about 75% of the population was accounted for in terms of the existing sewerage system, by accelerated developments and improvements coupled with the construction of additional sewage treatment plants, over 90% of the population in Singapore was served with modern sewerage and sewage treatment facilities by 1981 (Vickridge, 1992). This included the commissioning and operation in 1980 of the Kranji Sewage

Treatment Plant that lies outside the catchment boundary but caters primarily for the human and some of the industrial wastes within the catchment.

Physical control measures within the reservoir. To establish some temporary biological control the abundant hyacinth in the Kranji reservoir was harvested on a regular basis. The cultivation of big head carps which feed solely on planktonic organisms has acted as a natural filter and thus helped to remove some nutrients in the reservoir (Yang, 1989). These measures to a certain extent, have been instrumental in maintaining some local control on the appearance of the reservoir and have assisted in minimising nuisance effects in the treatment of raw water.

MONITORING OF WATER QUALITY IN RELATION TO RESETTLEMENT OF PIG FARMERS

The most effective way of measuring the success of antipollution measures taken within a catchment is to measure the quality of the runoff in the feeder streams and to monitor the water quality in the reservoir. The nutrient parameters measured in the Kranji were PO_4 and TN for the period commencing from 1974 to 1993. The rate of decrease of pigs during the same period of time will also explain the improvement in water quality.

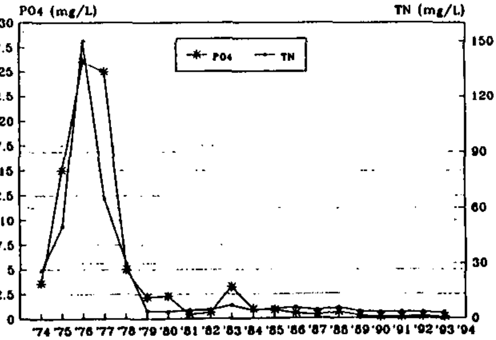
Water quality in Kranji streams. In Figures 6a and 6b are shown the results of two typical streams having large pollution loads in terms of PO_4 and TN. The progressive improvement of the quality can be seen over a period of time, particularly in relation to the resettlement rate.

Water quality in Kranji Reservoir. The weighted mean concentrations, on an annual basis, are shown in Figure 7. The variability in the data and the persistence of some high PO_4 values after the cessation of pig farming in 1979 could be attributed to the release of PO_4 from benthic deposits due to the prevalence of anaerobic conditions in the bed level of the impoundment. (Appan, 1993)

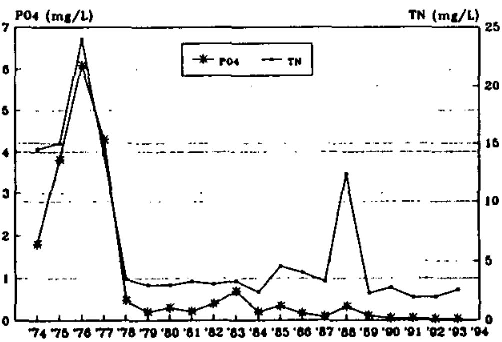
Rate of resettlement of pig farmers. During the exercise on resettlement of big pig farmers and the programme on encouraging small pig-farmers to take to other forms of farming, a routine count of the number of pigs remaining was carried out on a monthly basis. The resettlement rate is hence synonymous with the retention of pigs in the catchment (see Figure 5).

ANTI-POLLUTION COSTS

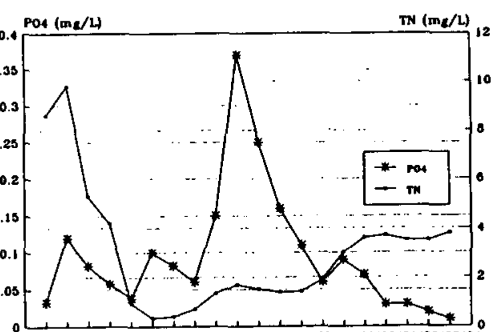
The major costs were directed towards curbing waste loads in the pig-farming, human and industrial sectors. The pollution due to human and industrial waste discharges, which amounted to only 12.3% of the PO_4 load, was largely accounted for by the sewerage system within the catchment. This sewerage system was part of the national development scheme to improve the waste disposal facilities in the Republic.



(a) Kranji Streams - Sampling Point 4



(b) Kranji Streams - Sampling Point 9



(c) Kranji Reservoir

Figure 6 : Water Quality in Kranji Streams & Reservoir

Hence, it can be argued that the antipollution measures direct involved for the success of the scheme should be mainly the expenditure incurred for the resettlement of the pig-farmers. This cost was calculated to be S$34.21 m. (Appan, 1978)

CONCLUSIONS

From the case study of the Kranji-Pandan Scheme in Singapore, it can be surmised that by harnessing the energies of different departments, both government and quasi-government, the major issue of the copious pig-farming waste was solved by resettling the farmers. Besides, a catchment area that covers almost 18% of the total land area in Singapore acquired, at an accelerated rate, an appropriate sewerage scheme. Consequently, almost all human and industrial wastes have ceased to be a problem.

The cumulative effect of all the antipollution measures taken was the drastic improvement in quality of water, both in the streams and within the reservoir. The Kranji reservoir, as it exists now, is a clean mass of water that exhibited in 1993 a PO_4 level of 0.01 mg/L and a TN content of 3.80 mg/L

Thus, it has been exemplified from this case study that by adopting a rational approach towards a massive water pollution problem, the multi-purpose use of land including its use for water resources development is very feasible. And, most important of all, it has been proven to be a working proposition in a developing country.

ACKNOWLEDGEMENTS

The survey and associated study were carried out during the period 1972 to 1980 when the author was Head, Pollution Survey Unit, Water Department, Public Utilities Board, Singapore. The data was also used extensively by the author for a successful PhD programme in which the input budgets and cost data were computed. Grateful acknowledgment is made to Mr Ong Ho Sim, Director, Water Department for granting the release of raw data on the field pollution survey of the Kranji-Pandan catchments and for arranging to check the veracity of water quality data in the Kranji reservoir and streams during the period 1974 to 1993.

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THE NATIONAL RIVERS AUTHORITY AND ITS APPROACH TO CATCHMENT MANAGEMENT PLANNING - RIVER TORRIDGE CASE STUDY

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A. INTRODUCTION

The National Rivers Authority (NRA) is responsible for protecting and improving the water environment in England and Wales. It has a wide range of responsibilities including pollution control, water quality, water resources, flood defence, fisheries, conservation, recreation and navigation.

Since its formation in 1989 the NRA has been working towards the integration of its responsibilities, based on specific river catchments. The development of catchment management plans is now central to its policy and their production for all controlled waters in England and Wales is now well advanced. The plans are subject to confirmation following wide consultation with interested bodies and are seen as an "agreed strategy to realise the environmental potential of a specific river catchment within economic and political constraints", whilst recognising the need for sustainable development and balancing the needs of the water environment against the needs of others. It is not possible to manage the water environment without considerable regard to the associated land.

Catchment Management Planning

The production process for catchment management plans (CMPs) within the NRA is identified on Appendix 1. There are two main stages, the Consultation Report identifies and discusses the uses of the catchment. Information is presented in the form of a map and supporting text (Appendix 2). These illustrate the information held by the NRA and others related to the use and possible impacts on the water environment for that use. Where appropriate, objectives and target standards are identified in terms of water quality, water quantity or physical features required to maintain that use of the river.

By constructing a series of objectives for a particular location, related perhaps to several uses such as drinking water abstraction, fisheries and sewage disposal, an overall objective can be determined for a river stretch and ultimately the rest of the catchment. It follows that it is the most stringent `use - related target' which must be achieved. In many areas and for several uses targets have yet to be developed.

By matching current status of the catchment against the objectives and targets, areas of shortfall, or issues, which need to be addressed can be identified. Apart from confirming that the basis for management of a specific river catchment is correct it is the identification and discussion of these issues and the promotion of options for their solution, that forms the most significant part of the Consultation Report.

A tabulated summary of issues and options concludes the report and encourages consultees to raise additional issues not identified in the plan; to comment on the issues and options identified and confirm or suggest alternative options for resolving these issues.

At this stage there must be proper consultation and care is taken not to restrict options for action even though many may be beyond the NRAs remit or resources and will involve organisations or individuals other than the NRA. This assists in the promotion and production of a "vision" for the catchment.

The Final Plan is then produced following the three month consultation period and this will form the basis for the NRA's actions within the catchment. It will also provide a public document which will encourage the involvement of others. Indeed the development of Catchment Action Plan Groups drawn from those who respond to the Consultation Reports is now well underway. An annual report and feedback will be given to each Catchment Action Group.

The Final Plan links resourcing to resolve an issue with priority action for the first time in the process and sets the constraints to realising the environmental potential of the catchment (Appendix 3). It is important to recognise and identify the true costs and limits to achievement as this enables more accurate targeting of blockages whether it is money, time or just someone elses job!

Throughout the CMP process it is vital to involve the public, industry, agriculture, conservation interests and crucially the planning authorities. The NRA is a consultee to local district and county planning authorities and with the onset of plan-led development in England and Wales, the input of CMPs will assist the planners in reaching decisions in favour of sustainable development in the local water environment

I now turn to a specific case study on the River Torridge but first an introduction to the Management Plan and an overview of the catchment :-

B RIVER TORRIDGE CATCHMENT MANAGEMENT PLAN

The River Torridge Catchment Management Plan Consultation Report was published on 24 June 1993. One hundred and twenty four reports were distributed together with hundreds of leaflets. In total thirty one consultation responses were received. A meeting with consultees held on 23 September 1993 confirmed the lack of detail concerning ecology, conservation, recreation and amenity uses and further work delayed the production of the Final Plan until August 1994.

C OVERVIEW OF TORRIDGE CATCHMENT

The River Torridge drains a large part of north west Devon and covers an area of 838km2. The main river rises at 200 in AOD (above ordnance datum). The River Okement, the major tributary rises on the granite massif of Dartmoor at 600m AOD. The landscape is characterised by steep sided valleys with extensive wooded slopes. These valleys contrast with the high culm farmland on either side. In summer the Atlantic climate is warm and moderately dry. Winters are typically wet and mild. However over the past fifteen years there have been six significant droughts (1975, 1976, 1984, 1989, 1990 and 1991).

The majority of the River Torridge catchment is underlain by rocks with generally low permeability and primary porosity. Water is abstracted from both surface and groundwater sources for public and private potable supply, industrial use, agricultural production, fish farming and for recreational/amenity use.

Much of the catchment is rural in nature with some 33,000 population in winter rising to 44,000 in summer during the peak of the holiday season. Land use is predominantly agricultural, dairying, sheep and beef farming. There is some quarrying for stone and ball clay and light industry associated with urban areas.

Discharges of effluent vary from sewage treatment works, fish farms and trade discharges, which are regulated by means of consents to discharge issued by the NRA and predecessor bodies and monitored by the NRA. There are eleven waste disposal sites receiving domestic, industrial inert and toxic materials which are regulated by Devon County Council.

The river Torridge is a major salmon, sea trout and brown trout fishery and contains many areas of regional, national and international importance to wildlife. Amongst the most significant is the remaining area of Culm grassland where half of the Devon resource lies in the Torridge catchment.

The catchment supports one of the best populations of otters in England. Immortalised by Henry Williamson's novel "Tarka the Otter" publicised in 1927 the Torridge now hosts a tourist attraction in the form of the "Tarka Trail" with the integration of rail, road, cycle and walking tracks adding a new opportunity for access into the countryside. Other recreational activities include angling, swimming and canoeing.

In order to demonstrate the practical management of land in reducing impact on the water environment I will use the agricultural experience of the Torridge Catchment referring specifically to the farm inspection campaign. With point source discharges control can be focused but with diffuse discharges, such as those found from farming control is more difficult.

D RIVER TORRIDGE CASE STUDY

i) Introduction

Over the last decade in particular, concern has been expressed about the apparent decline of the environmental quality of the Torridge. Intensive grassland cultivation assisted by land drainage and an increase in the use of fertilisers, coupled with higher stock numbers and a switch from hay to silage production caused organic pollution of the river. Between 1952 and 1982 dairy cattle numbers increased by 160%. The current total of 83,900 cattle has the potential to create a water pollution loading equivalent to 589,000 people. Farm pollution can be very polluting in comparison to other sources of pollution. In terms of Biochemical Oxygen Demand one gallon of silage liquor can be 200 times stronger than crude domestic sewage.

During the late 1970s and early 1980s proposals were made to reverse the deterioration, but these had limited success. Major fish mortalities were recorded in the upper catchment. In 1983 two separate incidents resulted in the loss of over 50,000 fish.

Action was required to address the land use activities causing the environmental damage to the river and in 1984 South West Water Authority, with support from the National Farmers Union and the Country Landowners Association launched the farm inspection campaign under the slogan "Pollution - Together We Can Beat It". A series of visits was undertaken to each farm in the catchment with the theme of information, education and persuasion.

ii) Farm Inspection Campaign

The farm inspection campaign was operated on a pilot scale in 1983 and formally launched in 1984 to combat farm pollution in the River Torridge Catchment.

Trained staff visited each farm, starting at the top of the catchment and working downstream to identify with the farmer whether his farm was polluting, or at risk of polluting and completed a data sheet. This FIRST VISIT was an important relationship building exercise and increased the farmers awareness of his farm pollution problems. Each farm was categorised : RED for polluting and immediate attention was needed; GREEN for high risk of polluting and in need of attention; and BLUE satisfactory.

Farmers were then recommended to seek professional help on the detailed design work needed from the Agricultural Development Advisory Service (ADAS). Authority staff agreed a time limit for the completion of any remedial work with the farmer.

A SECOND VISIT was then made to check completion of the work. If after a THIRD VISIT work was still unsatisfactory formal action, including prosecution was undertaken.

By 1989 the campaign on the Torridge had been completed, some 1610 visits had been made to 990 farms and a considerable database of farm pollution problems had been collected.

Of the farms first visited 23% were RED, reducing to 13% on the second visit and 2% on the third visit. Some 20% of farms were classified GREEN on the first visit, reducing to 16% on the second visit and 6% on the third visit. BLUE farms were not revisited and rarely became green or red as they were "well farmed".

Since 1989 a task-force has operated in the catchment to maintain the improvements was but at a much reduced level of resource and incorporating inspections of all potential pollution sources in a short stretch of catchment.

iii) Cost of the Farm Inspection Campaign

As with all pilot studies which evolve over many years detailed costs cannot be given but an estimate has been made in terms of input by the Authority and input by the farming community.

It is estimated that at £50 per visit the campaign cost between £80,000 to £100,000 and resulted in a total expenditure on farms over ten years in excess of £5 million pounds. Some 40% of the latter expenditure is due to government grants under the Agricultural Improvement Scheme and its successor the Farm and Conservation Grant Scheme.

Clearly a costly exercise but resulting in significant environmental improvements as outlined below :-

iv) Environmental Improvements in the River Torridge Catchment

Water Quality - The majority of the catchment was assigned a National Water Council (NWC) River Quality Objective of Class 1B in 1978 to protect uses for potable supply and salmonid fishery, whilst recognising that due to influences such as land use the waters were unlikely to achieve an RQO of Class 1A.

Water quality has been monitored annually since the middle 70s and there has been an improvement along the main River Torridge. 38% (5 out of 13) of sites complied with standards in 1985, whereas during 1992 there was compliance at 77% of sites (10 out of 13). In contrast there has been deterioration in water quality in the River Waldon in recent years despite an improvement in 1986.

The river sampling programme is based on monthly spot samples and cannot in isolation identify intermittent discharges or episodic quality changes associated with rainfall events. For this reason other indicators such as fish stocks and biota are used to support management decisions.

Farm Pollution - The inspection campaign identified the major sources of pollution from farms (see Appendix 4). As the farm inspection programme has been completed there has been a reduction from a total of 93 reported farm pollution incidents during 1991 to 44 incidents in 1992 and 29 in 1993. This has been achieved against a rising trend of reporting pollution and environmental awareness generally. It is particularly encouraging to note the drop in serious incidents.

This trend is in some part due to the farm inspection campaign. However, the strategy has been most effective where regulation, guidance and financial support are targeted together.

Most recently the Control of Pollution (Silage, Slurry and Agricultural Fuel Oil) Regulations 1991 have been introduced and are enforced by the NRA. These Regulations set minimum structural standards for the making and storage of silage, collection and storage of slurry and storage of fuel oil on farms. It was recognised that whilst improving the design and construction of storage compounds the minimum standards, such as 4 months design storage, might lead to an increased volume stored throughout a catchment and increased risk of pollution should the structure, or management of the structure fail. Farmers are required to demonstrate to the NRA that they can operate their farms with less than 4 months storage without increasing the risk of pollution. This has lead directly to the development of the farm waste management plan.

Piloted again in the Torridge Catchment, MAFF with ADAS have now developed a self-help farm waste management plan (Appendix 5). Details of how to match field capacity with disposal and utilisation of waste, without causing pollution of surface and underground waters are contained in the MAFF booklet - Code of Good Agricultural Practice for Protection of Water, currently undergoing revision. The principle is to identify high, medium and low risk areas on the farm for pollution prevention.

The farm waste management plan is therefore a practical solution to planning use of land for waste disposal to protect against water pollution. The concept is already being extended to pesticides disposal and identification of risk throughout the farming activity. It is also based on individual farm units, is prepared by the farmer and is therefore more likely to be used.

Salmon Fishery - The salmon fishery of the River Torridge had been declining for many years. This is shown by the decline in rod catches and surveys of juvenile fish populations in Appendix 6. Causes were poor water quality, pollution incidents and progressive degradation of habitat. It has been conjectured that over-exploitation at sea, disease and poaching, together with local netting and angling also contributed to the decline.

The precise mechanisms of the impact of farm pollution on salmonid fisheries in the Torridge is the subject of a research and development project to be published shortly.

Since 1981 a number of statutory and voluntary measures have been introduced to reduce over exploitation by licensed nets and anglers. Habitat improvements have been carried out with help and part funding from the Local Torridge Riparian Owners and Fishermens Association. An illustration again of the need to work with the local community to effect real change.

Recent fish population surveys have revealed an increase in the numbers of salmon fry in areas with intensive farming. This improvement in juvenile salmon is in part due to the farm campaign but also the rehabilitation and reduced exploitation. In addition control of acidic quarry discharges on the River Okement has contributed positively to the fishery improvements.

The rod catch, a notoriously volatile indicator of fishery health, has also increased from less than 40 per season in the late 80s to more than 350 in 1993.

There is now more optimism and economic activity associated with the salmon fishery, which between 1984 to 1988 (poor years) was estimated to be worth more than £1 million.

E CONCLUSIONS

1) The objectives of the farm inspection campaign of the River Torridge were to confirm the scale of agricultural pollution and convince farmers to stop pollution and minimise the risk of pollution. The campaign was designed to control the more obvious point source discharges but not the diffuse pollution which is more difficult to detect.

2) Now that the gross pollution is becoming controlled there is a rising trend in diffuse sources. Appropriate measures were identified, before the introduction of the Regulations for storage and promoted under the concept of farm waste management planning. This approach is well on the way to being adopted as best practice throughout the industry with more than 30 plans produced in the Torridge and more than 1,000 throughout the UK.

3) Talking to farmers face to face, persuading and guiding them, has proven to be the most effective means of promoting long term remedial action. In spite of extensive publicity campaigns and prosecutions farm pollution continued unabated until a personal approach, supported by incentive financing was

introduced. Whilst the cost has been high in the pilot, the regulatory input is now considered to be much lower to achieve the same environmental gains.

4) The farm inspection campaign provided considerable data and information which has helped to guide and refine the approach and convince others of the scale of problems that result from agricultural activities and land-use practices. The level of awareness of the need for vigilance, sound management, waste minimisation and safe disposal is now better understood and practised by the farming community.

5) The River Torridge Catchment Management Plan has again sought the views of local people and their representatives and identified nineteen issues for resolution in the Final Action Plan. In building on existing relationships and establishing new ones the NRA will pursue the following objectives :-

- to increase understanding of the effects of rural land use on water quality, fisheries and the river ecosystem enabling the development and promotion of practical solutions to the problems identified.

- to ensure that the impacts of discharges and abstractions do not conflict with the needs of the river ecosystem and fishery.

- to continue the improvement of the fishery.

- to develop an environmentally sensitive flood defence and land drainage strategy.

6) The NRA is convinced that in order to promote proper management of the water environment there is a need to consider land use management and to influence those who manage land. In order to identify the issues, promote debate and to pursue solutions to the conflicts of use which arise with the management of water and land, all those with a contribution must be heard. Our concept of river basin or river catchment management, based on sound science and common sense is a contribution to the debate on integrated management options. The NRA's CMP programme will give decision makers and planners the help they need to identify the consequences of their actions and 160 plans will be completed to cover all catchments in England and Wales by the end of 1998.

REFERENCES

1. NRA Water Quality Series No. 6 DAVIES et al. - 'The Influence of Agriculture on the Quality of Natural Waters in England and Wales.

2. NRA (SW) River Torridge Catchment Management Plan - Consultation Report - May 1993.

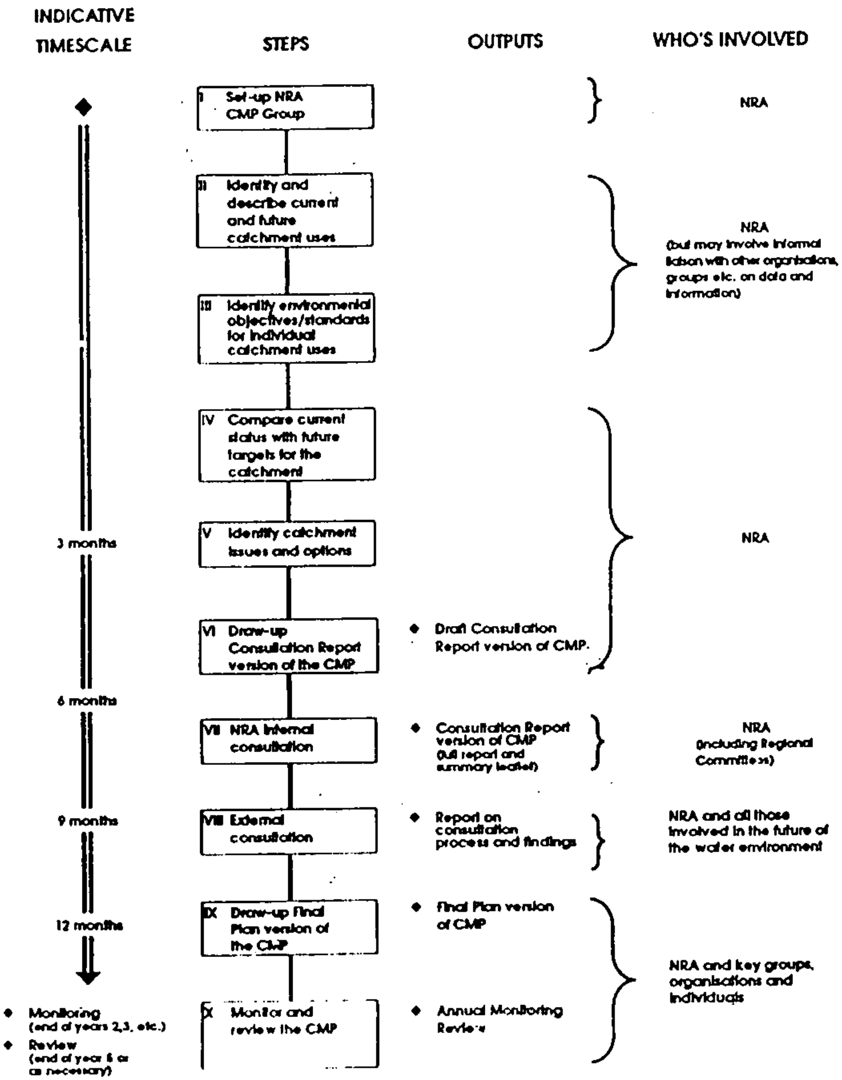
3. NRA (SW) River Torridge Catchment Management Plan - Final Report August 1994.

4. NRA (SW) Benefit of the Farm Inspection Campaign in the River Torridge - Dr R Smith et al.

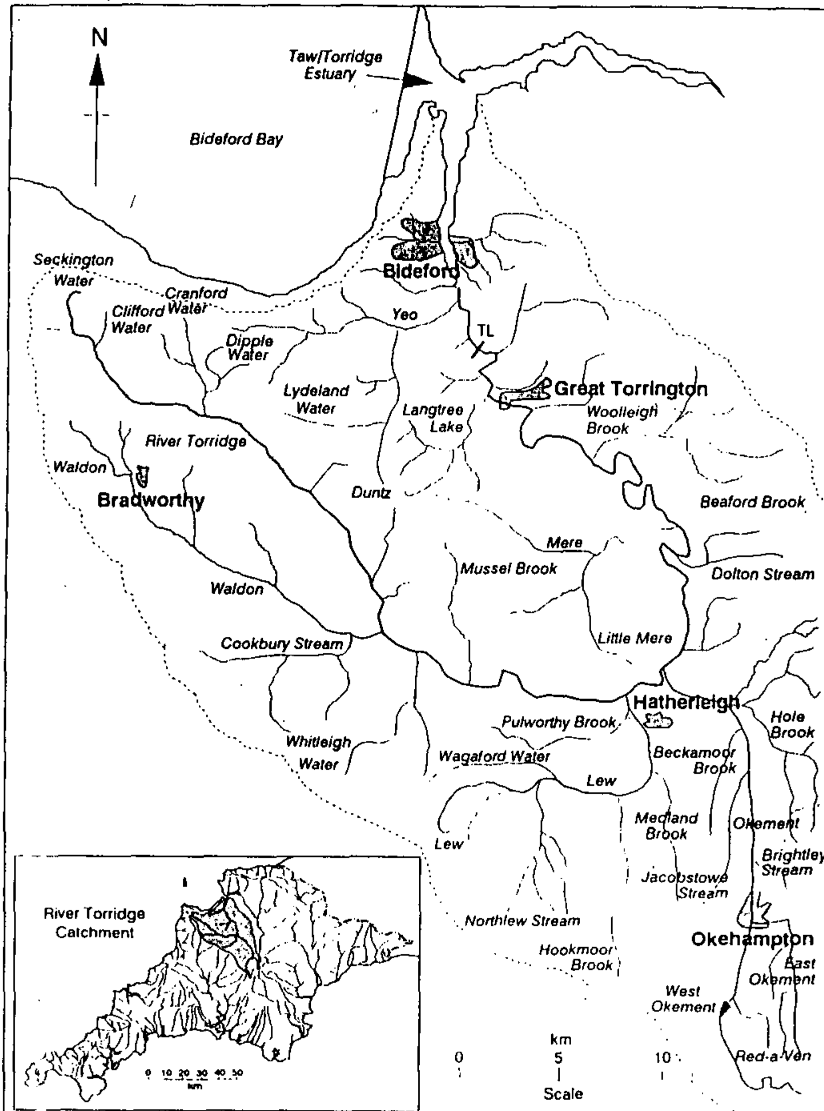
5. MAFF - Code of Good Agricultural Practice for the Protection of Water.

3. THE CMP PROCESS

THE CMP PROCESS

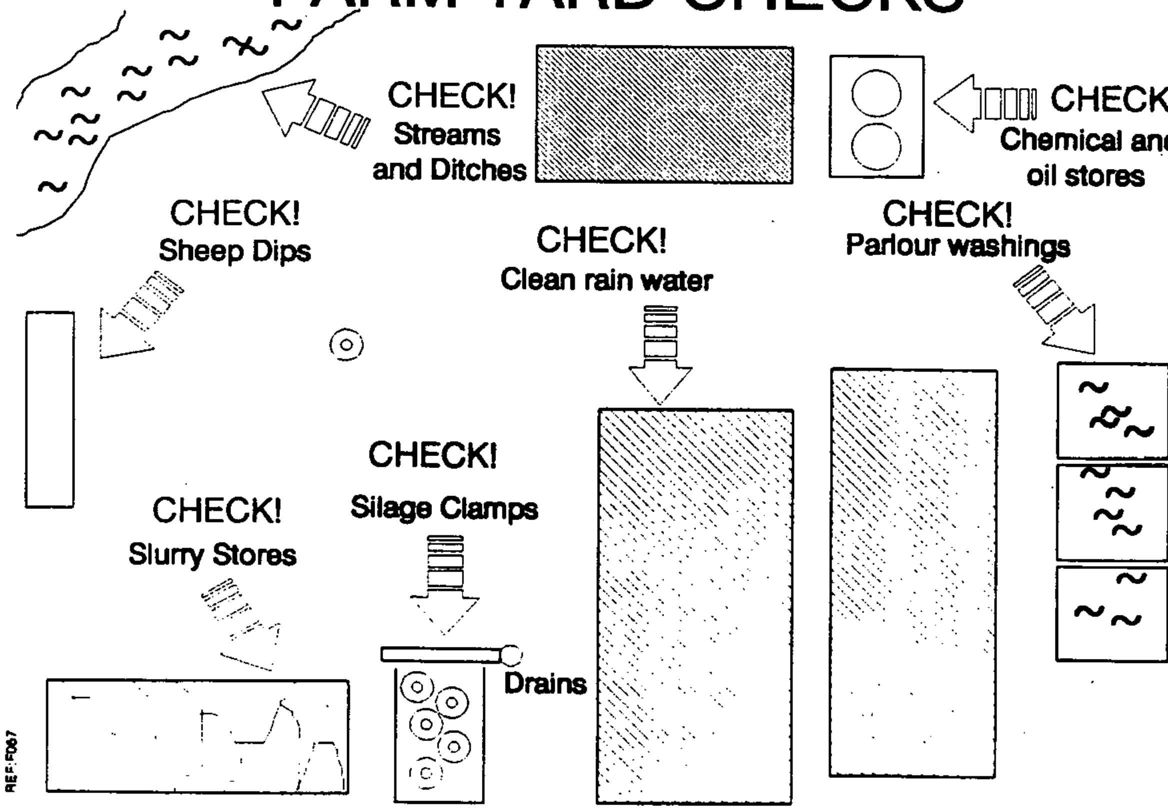


The River Torridge Catchment



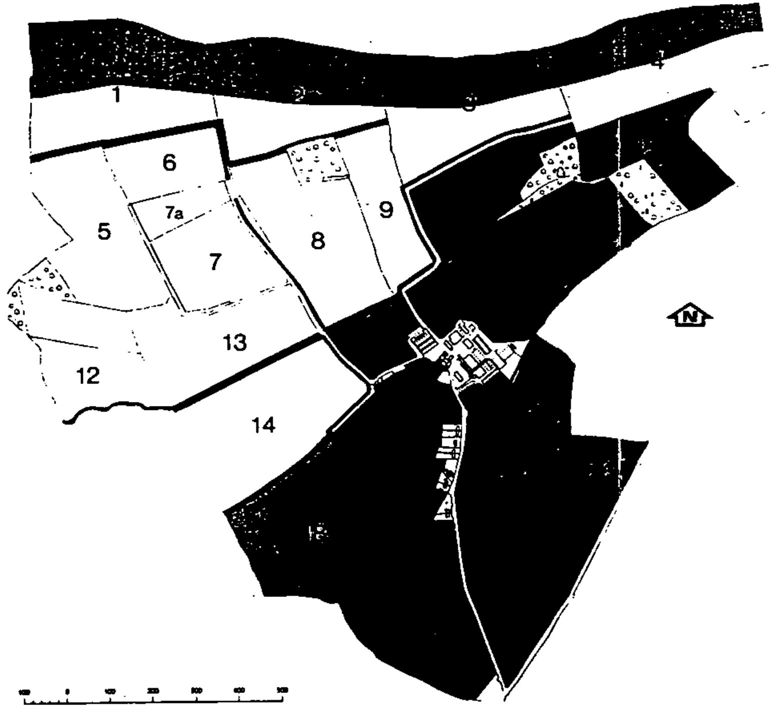
NO.	ISSUES	ACTIONS	RESPONSIBILITY		COST TO NRA	FINANCIAL YEARS					FUTURE
			LEAD	OTHER		1994	1995	1996	1997	1998	
1.	Improved Farm Waste Management Practices	Review Farm Visit Programme									
		• Identify target areas.	NRA		£200 p.a.	*	*	*	*	*	
		• Undertake farm visit programme.	NRA		£6000 p.a.	*	*	*	*	*	
		• Enforce farm waste legislation and secure improvements.	NRA	Landowners	£6000 p.a. Cost to Landowners	*	*	*	*	*	
		• Recommend suitable procedure to report on the work and environmental benefit achieved.	NRA		£1000		*				
		- Implement this procedure.	NRA		Not known		*				
		• Continue to liaise with the planning authorities to ensure that they are aware of NRA concerns and priorities with respect to all agricultural developments.	NRA	LPA		*	*	*	*	*	

FARM YARD CHECKS



APPENDIX 5

EXAMPLE FARM WASTE MANAGEMENT PLAN



Job title:

HOME FARM

Storage and Application of Slurry and Dirty Water

Pollution Risk Classification

Non spreading areas

Very high risk

High risk

Lower risk

Irrigated area

Irrigation pipeline

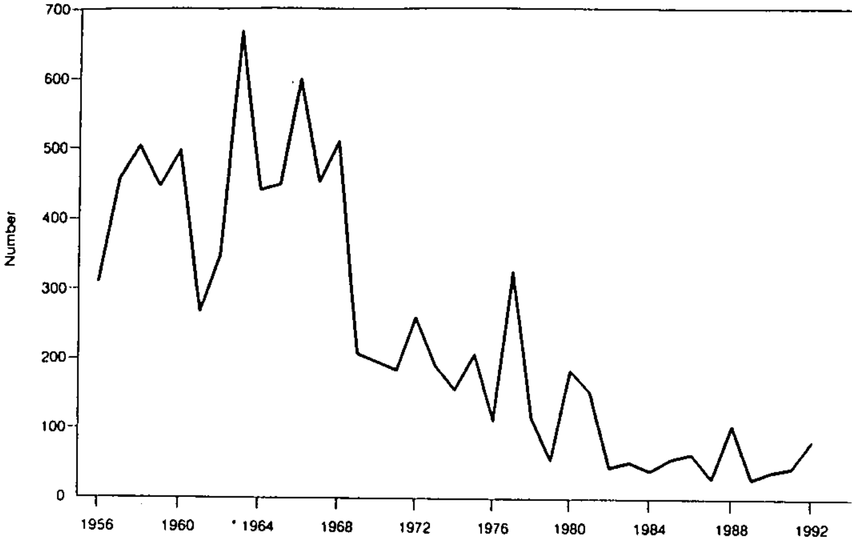
Borehole

Date: July 1991

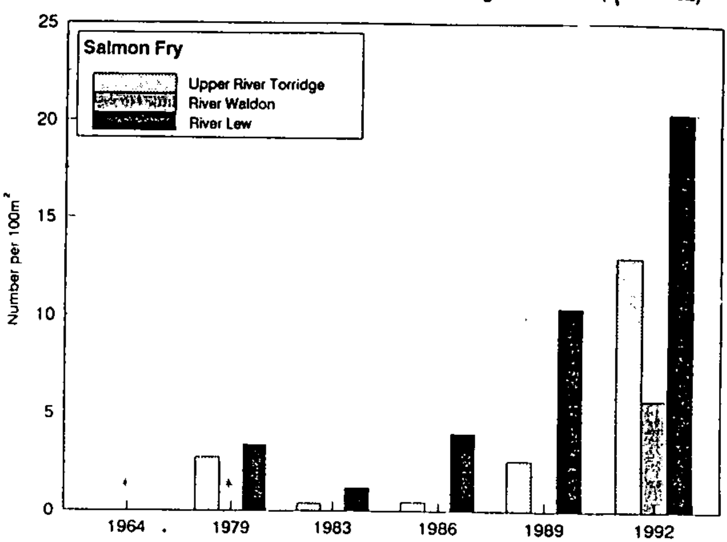
A D A S

DESIGN SERVICES

The annual rod catch of salmon from the River Torridge



Average juvenile salmon densities in the River Torridge catchment (1964-1992)



THE GLOBAL WATERSHED NETWORK: TOWARDS AN EDUCATIONAL FRAMEWORK FOR WATERSHED MONITORING

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We humans are majors players in global change. We contribute to it daily whether we realize this or not.

Water is essential to life. Yet understanding our connection to the movement of water through the earth system is little understood by most of us.

One of the most powerful ways to understand is to " DO IT".

Building on the successes of numerous water quality monitoring projects worldwide, the Global Watershed Network broadens the perspective to include a more comprehensive approach to understanding, through monitoring, the dynamic components of watershed ecosystems and our roles and responsibilities as the major player in this and all other ecosystems.

The 1991 report of the Earth Systems Sciences Committee of the NASA Advisory Council stated:

> "We, the peoples of the world have become collective participants in global change, contributing in barely perceptible but significant ways to the evolution of this special speck in the universe. In our effort to achieve a higher standard of living for an expanding population, we are spreading advanced technology to every region of the earth and are making increased demands on natural resources. These actions have begun to alter the atmosphere, oceans, lands,and life forms of our planet in ways that have no precedent in human history. Responsibility therefore dictates that we seek to understand more fully our role upon the Earth and the consequences of global change for humanity. Through the research approach of earth systems science, we can help ensure that the gifts of the Earth will be preserved and passed on to future generations."

The Vice President of the United States, Albert Gore, in his book **Earth In The Balance**, envisions:

"... a program involving as many countries as possible that will use schoolteachers and their students to monitor the entire earth..."

This program initiates a much needed research approach, and provides a model methodology for educational outcomes in a wide variety of disciplines.

The goals of the Global Watershed Network are:

1.) Provide an educational opportunity for teachers and their students in grades 7-12 to understand and value watershed ecosystems .
2.) Obtain accurate, consistent, and reliable data on all aspects of a watershed through monitoring some or all of these variables; climatic and hydrologic variables, biogeochemical factors, biodiversity, erosion, acid deposition, land use, water and air quality.
3) Utilize remotelty sensed satellite and aerial imagery, and data generated by this imagery, to assist in understanding global change both within a watershed as well as apply the data to other areas.
4) Add to and enhance communications via computer networks by providing links to satellites monitoring global phenomena as well as provide direct communication between students worldwide.
5.) Provide continous scientific, technological, and educational expertise and support to the educators involved.

The Global Watershed Network will include a more comprehensive approach to understanding, through monitoring, the dynamic components of an ecosystem. This approach draws on disciplines in the natural and social sciences such as biology, chemistry, and geography. The research and analysis of remotely sensed image data combined with student ground-based measurements and computer modeling provide a powerful way to gain a better understanding of the Earth as an integrated system.

In addition, as the participants gain knowledge, skills, and understanding about the dynamics of watershed ecosystems and the impacts humans exert; they gain expertise in making informed decisions and taking responsible actions on behalf of their watershed.

The pilot program will initially involve twenty countries, of which ten are developed countries and ten developing countries. This will facilitate pairing "sister" countries. A team of three selected by their country, or the sponsoring agency within the country, will be invited to participate in an intensive week long training session to be held at United Nations Headquarters in New York City.

The participating teams from each country will be responsible for implementing the program within their countries. Equipment and technical and educational support will be provided by Aspen Global Change Institute through funding from UNEP.

The variables, procedures, etc. are listed on the chart, " Watershed Ecosystem Monitoring Factors for the Global Watershed Network". Water quality monitoring will be the first variable implemented. Once this monitoring procedure is well established, other variables will be added subject to specific needs within the participating countries and availbility of funds to implement the procedures.

Aspen Global Change Institute
Watershed Ecosystem Monitoring Factors
For
The Global Watershed Network

Variables	Procedures	Agencies Wanting Data	CONNECT Standards -*	Data Bases
Water Quality	RCWNN Procedures, EPA Standard Methods	EPA, CDOW, Health, Water Districts, GRID	R&W 1-4 Sci 1-6 Math 1-6 Geog 1-6	Internet, Colo. Water Watch Network, BBS
Water Quantity	RCWNN Procedures, EPA Standard Methods	EPA, Agri., CDOW, GRID	R&W 1-4 Sci 1-6 Math 1-6 Geog 1-6	Internet, River Gauging Stations, Satellite Feeds
Air Quality- VIS, NO2, SO2, Particulates, etc.	Air Poll. Test Kits, HighVol. Sampler, Radon Kits	NASA, NOAA, Health Local Gov't.	R&W 1-5 Sci 1-6 Math 1-3,5,6 Geog 1-6	Internet, EOS, GEMS, etc.
Biodiversity - i.e. forest/veg health, indicator species, endangered species, pop. surveys, aquatic organisms, songbirds, etc.	Transects, surveys, GAP, MAAP, GIS, RCWNN Procedures	USFS CDOW USFWS EPA Partners in FL. Prog.	R&W 1-5 SCI 1-6 Math 1-3,5,6 Geog 1-6	Landsat, SPOT, EOS, SIR-C/X-SAR
Climate - temp., wind, cloud, precip. etc.	observations, records, Weather Station	NASA NOAA GRID	R&W 1-5 SCI 1-6 Math 3,4,6 Geog 1-6	EOS, etc.
Geology	observations, samples, site visits	U.S.G.S.	R&W 1-5 Sci 1-6 Math 3,5,6 Geog 1-4	Landsat & SPOT
Soil- moisture, ph, types	Munsell Soil Color Charts. Soil Test Kits	Soil Cons. Ser. NASA	R&W1-5 Sci 1-6 Math 3,5,6 Geog 1-6	EOS, etc.
Maps & Remote Imagery	Trace watersheds, False color uses, land use, ecosystem health	USGS, NOAA, NASA, GRID	R&W 1-5 Sci 5 Math 2,6 Geog 1-6 Hist 1,2,4	EOS, Landsat, SPOT
Sociology	Acting on Action ** Investigating Your Env. Workbook***	USGCRP, CIESIN	R&W 1-6 Sci 3,6 Math 1-3,5,6 Geog 1-6 Hist 1-6	CIESIN, Earth BBS

* 1ST Draft, *Model Standards for Reading, Writing, Mathematics, Science, History, and Geography.* Colorado Department of Education, 1994.
** Acting on Action, steps for taking responsible action. Bill Hammond, 1991.
*** Investigating and Evaluating Environmental Issues and Skill Development Modules. H. Hungerford, Ben Peyton, et al, 1985.

Compiled by Carol Bylsma, Director of Education, Aspen Global Change Institute, March, 1994. For more information: 303 925-7376 or E-Mail cbylsma@agci.org

PEOPLE AND THE ENVIRONMENT: SUSTAINABLE DEVELOPMENT OF THIRD-WORLD URBAN AREAS

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1. INTRODUCTION

In common with other developing countries, South Africa is experiencing a massive influx of people into urban and metropolitan areas. This has led to the mushrooming of shanty towns, as squatters move onto vacant land near cities, and also to the rapid development of high-density formal townships, in an effort to cope with the demands of people for land, housing and basic services near to potential employment. However these newly and rapidly established urban areas often become environmental disaster areas, not only for the people who live in them, but also in terms of their pollution impact on neighbouring areas.

Aspects of particular environmental concern include polluted urban runoff (high nutrient and faecal bacterial loads and litter), damage to soils and vegetation, uncontrolled dumping of domestic waste and night soil, and air pollution caused by the burning of wood and coal as fuels.

Any effective 're-planning' strategies aimed at preventing such potential disasters, must consider and include fundamental socio-economic aspects. These include high levels of unemployment and poverty amongst township residents, low levels of service provision, inadequate or totally absent refuse removal, lack of sewerage and water reticulation and the general inability, caused by lack of appropriate skills within the community, to utilise available resources for the upliftment of their living standards.

Innovative strategies are needed to integrate socio-economic, environmental and technical issues in order to ensure sustainable management of intensive urban land use. This paper describes the attempt made to introduce innovative concepts in urban planning, integrated environmental management and integrated land use management to the Chatty River catchment area in the Eastern Cape Region of South Africa (Figure 1).

This approach strongly supports the optimal use of available natural resources in, or adjacent to, urban areas as part of a community upliftment initiative. Among the potential benefits of this approach are stimulation of the local subsistence economy, improved environmental conditions in the urban area and significant decrease in soil and water pollution.

2. STUDY AREA

The study area in this paper is a shanty town called 'Soweto-on-Sea', located in the greater Port Elizabeth Municipal area (Figure 1) and contained within the lower reaches of the Chatty River. This river flows into the Swartkops Estuary, an extremely popular recreational area used for fishing, sailing, canoeing and windsurfing, which represents an irreplaceable asset for the local tourism industry.

Soweto-on-Sea is home to 80 000 poverty-stricken, unemployed people who are living in about 15 000 shacks; the existing roads are gravel and not maintained; stormwater can hardly drain away and, when it does, carries waste, pollutants and refuse with obvious downstream consequences. Furthermore, refuse is never collected; only 200 potable water taps are in use, to serve the whole of that community; no reticulated waterborne sewerage system exists - with only a 'bucket' toilet system in operation, served by a municipal collection which happens, at best, weekly.

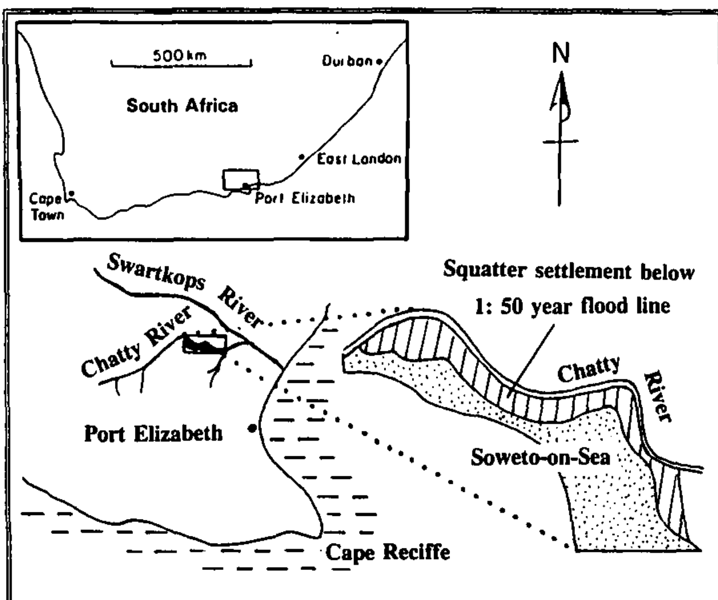

Figure 1: Locality of Soweto-on-Sea and area below 1:50 year flood line

Because of the rapid general influx of people into the greater Port Elizabeth metropolitan area, the birth and rapid growth of Soweto-On-Sea has happened without any pre-designed logical planning and according to a 'first come - first served, land-grab' strategy.

There is little freshwater freely available as water supplied by the Municipality is expensive and water in the Chatty River is saline.

The situation is further aggravated by the fact that, up to now, some 3 000 shacks have been erected below the 1:50 year floodline of the Chatty River : which could affect over 16 000 people.

The local authority structures are not prepared to take responsibility of up-grading Soweto-on-Sea as the land on which it is located was never zoned for residential use.

This poverty-stricken and under-serviced community could well become one of South Africa's largest and most pathetic disaster stories if timeous community-driven and government-supported intervention is not undertaken.

3. OBJECTIVES OF THE STUDY

The major objectives of the study were as follows:

3.1 Discourage new squatting in the floodplain, below the 1:50 year flood line. Firstly, because of dangers, but also because of municipal laws preventing zoning of land for residential use, or provision of water and sewerage, below this flood line.

3.2 Reduce pollutant loads to the estuary. This was a need of downstream users, and a broad environmental aspect identified by local and regional bodies. The major nutrient and faecal loads to the Swartkops estuary are contributed by the Chatty sub-catchment both in dry and wet weather (MacKay 1994).

3.3 Improve the urban environment for the people living within it.

3.4 Maintain and improve the natural environment. Although this was not seen as an important aspect by the Soweto-on-Sea community it was part of long-term objectives for the Swartkops River Integrated Catchment Management Plan.

3.5 Create tangible benefits for the catchment 'users' i.e. Soweto-on-Sea residents. These benefits could be social or economic. Whatever benefits arose the value of land under alternative land use had to be greater than its value for the present land use e.g. squatting.

4. APPROACH FOLLOWED

4.1 Community participation in decision making

Based on practical experience, and in line with the philosophy of the new democratic Government of National Unity of South Africa, the strategy of intervention based on full community participation at all stages of decision making, seems to be the best guarantee of success in trying to resolve the conflicts associated with integrated environmental issues.

The promotion of a well-organised process of community participation and the introduction of the concept of 'empowerment' in taking decisions on issues which would ultimately have a profound impact over their lives was the basis of communication in this study.

Different components such as land use, water quality, human settlements, quality of the environment etc. can be brought together to create a long term sustainable environment only through committed, free, community participation at all levels, from project conceptualization to community 'ownership'.

4.2 Development Trust formed

In order to address the urgent issues of services, health, relocation of the families that presently live below the 1:50 year floodline and the reduction of pollution from Soweto-on-Sea, a 'Development Trust' was formed. This Trust was composed of community representatives from a broad spectrum of organizations (local political representatives, business bodies and community groups). The Trust's first task was to obtain funding from aid agencies to support the process of phased general upliftment of services in the area and the progressive but rapid relocation of those families which are in danger, to preselected and fully supported areas outside the floodplain.

4.3 Available resources identified and quantified

The approach adopted also included the identification and quantification of the present land use issues. People are the most important resource as they are enthusiastic and committed. People who were unemployed were also used as labour in the clean-up of the floodline area and building of the relocated houses.

5. CONFLICT BETWEEN PRESENT LAND USE AND WATER QUALITY: OPTIONS NEGOTIATED

People presently squatting on un-serviced land below the 1:50 year flood line will inevitably have to be moved to serviced sites provided on higher ground in an area called Missionvale. However, one of the Trust's priorities is to ensure that where land has been vacated during execution of the project, no further squatting would occur in future.

At the moment, the commonly accepted and greatest value of the floodplain to the community is as an informal residential area : its proximity to job opportunities, educational and recreation facilities, makes it a prime settling site for destitute people. For surrounding communities therefore, the flood plain has a high perceived value for squatting, and when sites are vacated for any reasons, new squatters quickly settle there.

To avoid this, it is necessary to develop a new strategy whereby people are offered alternative uses for such precious land, which have a higher perceived value than as purely squatting areas. Any alternatives discussed with the community must clearly be seen to possess the potential to uplift and improve, in a short time, the quality of life in the neighbourhood. People's perceptions of the value of the land can only be changed by an offer of alternatives perceived as of equal or higher value.

5.1 Community proposals

The people of Soweto-on-Sea were asked to generate ideas for use of the floodplain land. They came up with a long list which was evaluated by the Technical Committee (appointed by the Development Trust). Some of the proposed ideas were not suitable e.g. cemeteries, scrapyards etc. The Technical Committee came up with a suitable mix of sustainable land use with tangible benefits.

5.2 Proposed alternative land uses

The strategy devised, through the process of consultation and empowerment described above, to prevent a new 'invasion' of settlers in the vacated land residing within the flood plain of the Chatty River, contemplates a combination of alternative land uses including stock grazing, recreational parks, sports fields, vegetable allotments, wetlands and even schools elevated artificially above the 50 year floodline.

The following list of alternative land usages were put forward, after review of all alternatives, by the Technical Committee : -

- **Grazing**

Many domestic animals (cattle, donkeys, pigs and goats) presently wander in the streets of Soweto-on-Sea, posing a health risk to local residents and a serious danger of collision for the vehicles on the adjacent municipal road system. If suitable grass cover could be established, these animals could be relocated to controlled grazing in the floodplain.

In order to ensure that adequate grass cover is sustained, and to manage the number of stock in the area, it is proposed that the land in the floodplain become a commonage, administered by the Soweto-on-Sea community, who would charge local herdsman a monthly grazing fee per head of stock and use the money for the upkeep of fences, grass etc.

- **Recreation**

The Chatty River is in a very poor condition at present. Natural riparian vegetation has largely been destroyed, the river banks are unstable, and the river is polluted with litter, rubble and raw sewage.

It is proposed to construct several sports fields in Soweto-on-Sea, combined with recreational areas, along the banks of the river, to be used by local people. The programme of development of such recreational areas will incorporate the stabilisation and beautification of the areas along the Chatty River banks.

- **Wetlands**

Reeds and riverine vegetation will be established in the river bed to intercept pollution and treat wastewater, that could be used for irrigation of the proposed sports fields, while allowing flood waters to pass through safely.

- **Vegetable lots**

Vegetables grown in allocated lots will allow subsistence or small scale enterprises for a local market.

5.3 Benefits of suitable land use options

The developments proposed above will greatly improve the environment of Soweto-on-Sea and will provide opportunities for upliftment in an area where unemployment is high and quality of life poor. The quality of runoff water would also be improved, to the benefit of downstream users.

Alternative land uses proposed, discussed and agreed upon,will be introduced, discouraging a new influx of squatters into the floodplain and preventing therefore a repetition of such a situation of extreme danger.

A vegetated 'buffer strip' will be established between urban areas and the Chatty River, which should significantly reduce pollutant loads presently washed off the Chatty catchment into the river, and thence into the Swartkops estuary.

6. USING A 3D VISUALIZATION TECHNIQUE APPROACH TO COMMUNICATE AND RESOLVE THE CONFLICT BETWEEN INTEGRATED LAND AND WATER MANAGEMENT

One of the main difficulties always encountered during attempts at establishing a line of communication and understanding between planners and the community affected by such planning, is the problem of cultural, technical and educational barriers .

It is often extremely difficult to establish a 'bridge of understanding' with people who do not speak the same language, have no formal education and who live in poverty. This communication is made more difficult when attempting to communicate complex spatial concepts related to integrated environmental planning, such as in the Soweto-on-Sea project.

In order to break down such barriers and in line with the new policy encouraged by the new South African Government, of maximum community participation, involvement and empowerment, a new communication technique was developed by the CSIR: '3D Visualisation Technology' (3DVT).

6.1 Description of the technology

The technique involves the creation of computer-generated 3D visual representations of any scale and degree of complexity, through a combination of computer modelling, graphics, scanned photographs and image processing.

The impact of any planning proposals for the built and natural environment can now be represented and assessed through the use of 'real' photos of actual sites, scanned into the computer for subsequent processing.

Different elements of different photos (trees, cars, people, shacks etc.) can be imported and 'fused in' together with computer-generated 3D elements (houses, schools etc.), allowing the artificial 'assemblage' of a realistic 'what-if' picture.

Image processing of the final images allows modifications to the characteristics of any element (such as colours, materials, lighting, reflections etc.) permitting therefore a viewer to 'see' alternative solutions to a problem and to make choices more easily.

Animations can also be created to simulate, for example, progressive environmental changes to a territory, the rising of a river water level, progressive erosion of river banks, illegal occupation of land over time by a squatter community and so on (Figures 2 and 3).

The final products can be projected for the community on a large screen; interaction is also possible at this stage and images can be further modified based on input from the community.

Hard-copy photos, transparencies, slides and video tapes (with audio in any indigenous language) can also be created and left with the community as required.

This technology has a definite advantage as a planning and communication tool, because of its capability in bridging the gap between first-world ideas and planning processes and third-world needs and aspirations. The fact that the majority of people in South Africa have a low level of technical understanding and the rising importance of community participation in any decision making process, makes 3DVT a factor of great importance in the New South Africa: this technology is in fact able to simply represent and communicate complex spacial concepts to the man in the street.

In conclusion, this technology is a communication and planning tool as it empowers any community and its representatives, decision makers and politicians, to make more appropriate choices, and helps planners to verify the correctness of their assumptions. It is a creative and educational tool as one is able to visualise the future and communicate complex spatial concepts to uneducated, non-technical people. It is an environmental and economical tool since it can assist in environmental studies related to urbanisation and industrial intervention strategies, and is capable of converting the planned investment propositions into simple, readily understandable graphic format.

Figure 2: Floodplain at present

Figure 3: Floodplain modified by 3DVT showing a potential flood

6.2 The application of 3DVT to the Chatty River project

Progress on the Soweto-on-Sea project was delayed by three years because of misunderstandings and lack of trust caused mainly by lack of comprehension by the local community of the 'sophisticated' proposals related to the integrated management of the Chatty River and to the relocation of the population currently residing below the flood line.

The 3DVT communication presentation was prepared in approximately one month and a presentation was given to a group of nearly one hundred officially appointed community representatives. Images were projected on to a large screen at a suitable community chosen venue. An interpreter was on hand to facilitate communication.

The presentation was 'two-way' in that the people were encouraged to ask questions, to interrupt and to discuss every image projected. Examples of some of the images projected can be see in Figures 2 and 3.

The entire presentation, including discussions and planning for the future, took three hours.

The major feeling expressed by the people there present was one of immense satisfaction: for the first time in three years, the community could 'see' what a floodline meant, could see the river floodwater rise amongst the shacks and could understand the grave danger they were living in. They could also understand, through visualisation, what concepts such as 'urban agriculture', 'wetlands', 'controlled grazing' etc. meant.

Such an understanding enabled the community to make decisions about the optimal management of their immediate environment. This contributed to a sense of ownership in the project and improved chances for long term success.

7. LESSONS FOR THE FUTURE

The unconventional but successful execution of this project clearly indicates the need for innovative thinking in the field of integrated catchment and environmental management.

Environmental specialists, urban planners, environmental managers, quality control specialists and others in the field, must understand the pressing need for their 'coming down' to a common level of understanding, where co-participation in such complex processes can benefit the entire ecosystem and the community directly involved through an effective process of 'empowerment'.

The sense of 'ownership' so established is the best guarantee for the creation of a sustainable environment for generations to come.

8. CONCLUSIONS

Any sustainable development must satisfy social, economic and environmental requirements. This will result in true empowerment and social upliftment.

The opportunities to educate people are tremendous. This project showed that supposedly uneducated people could quickly grasp technical concepts if they were presented properly through the use of 3DVT. This enabled the community to participate in planning in a constructive manner. The proposals suited the local situation since they were developed by local people.

The concepts described (urban agriculture) and the techniques (public participation and 3DVT) utilised in this case study, are applicable to many Third-World urban communities.

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AN INTEGRATED FLOOD AND STORMWATER MITIGATION AND ENVIRONMENTAL MANAGEMENT IN ANAMBRA STATE, NIGERIA

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ABSTRACT

Anambra State, Nigeria lies within the rainforest belt of West Africa charcaterised by heavy torrential rainfall during rainy season usually in form of rainstorms. The average annual rainfall is 2000 mm, concentrated within the months of April to September. The State is densely-populated, with an average of 590/km². The rainstorms cause extensive overland flow and heavy floods discharge. The floods, usually uncontrolled, flow with high velocities causing serious damages to lives and property in rural communities and densely-populated urban centres such as Onitsha (476.000) one of the largest commercial centres in West Africa, Awka /122,000) and Nnewi, the industrial centre of the state. Drowning of humans and livestock; washing away of roads, dams, houses; destruction of farmlands, crops and other farm products; silting up of streams, rivers, lakes and other surface water bodies; land deterioration through sheet erosion and gullying are commonplace in rural areas. In urban areas, collapse of buildings and other structures, washing out of road pavements, dislocation of water supply pipes, power and telecommunication cables are common. The gravity and intensities of these destructions vary from place to place and from year to year. The rapidity and intensities of flood flows and discharge, and the consequent damages are enhanced by the nature of the ground-surface slopes, nature of underlying rocks, poor engineering construction and drainage practices, excessive urban and rural growth, poor agricultural techniques and other inappropriate land use methods. Many houses have corrugated iron sheets as roofs, and cemented compounds that generate heavy floods into the roads that form flood channels since, in many cases, well-designed and built channels/canals are nonexistent. The severity of the damages is mitigated by employing some measures to check flood flow, reduce flow velocities and minimize sheet, rill, channel and gully erosion. A new techniques involving multipurpose and multiobjective concrete channelization, terracing, damming, home wells or reservoirs, and agroforestation have been employed in an integrated manner within a set of related flow paths, erosion spots/channels and/or gullies in a catchment area. This new model is Subcatchment Erosion Control Model (SCEM).

1.0 Introduction

Anambra State is located in the western margin of southeastern Nigeria, bound by latitudes 5° 40' and 6° 45' N and longitudes 6° 35' and 7° 30' E (Fig. 1). The state is found within the tropical rainforest belt of West Africa. This belt is characterised by heavy torrential rainfall, uniformly high temperature and high relative humidity. Heavy flooding and stormwater episodes characterise the belt especially during the rainy seasons. These result in large scale soil erosion, gullying and landslides that have attained endemic proportions in most parts of southeastern Nigeria.

The flooding stormwaters and their concomittant soil erosion, gullying and landslides have generated enormous environmental stress and hazards in Anambra State. These hazards which assume disastrous consequences include loss or utilities such as roads, water distribution pipes, electricity distribution poles, collapse of culverts, gutters, drainage systems, bridges; collapse of buildings, private and government projects; community facilities such as hospitals, schools, churches; loss of human and animal lives; destruction of agricultural lands, forest covers, shrines and plantations, destruction of hydrological and hydrogeological systems such as lakes, streams, wetlands, rivers, shallow groundwater and then eventual pollution. In the most severely-affected areas, villages and homes have had to be relocated and this has generated serious socio-political stresses on the people and the authorities affected. Uncertainty, social stress, political bickerings and economic losses and distractions have continued to characterize the lives of the governments and people of Anambra State who yearn for sustainable curative and preventive measures.

Several techniques and control schemes have been employed to check these problems. It is, however, important to note that over 90% of the techniques have been applied to control or contain erosion and gullying with little or no attention paid to floods that partly cause these.

Many of the control measures include construction of weirs, bunds, check dams, embankments, drainage systems, channelization, terracing, mulching, backfilling, catchpits, etc. Other measures are agroforestation, cover cropping, employing new methods of planting crops and trees, etc. These techniques have achieved some levels of success in checking or eliminating the initiation or growth of erosion spots and gully systems, but have sometimes aggravated the growth.

New integrated methods of control that are more efficient are the Subcatchment Erosion Control Model (SCEM) which includes Okawadike Lake (Okwalake) System. These methods employ an integrated multitechnique approach to control flood flow and

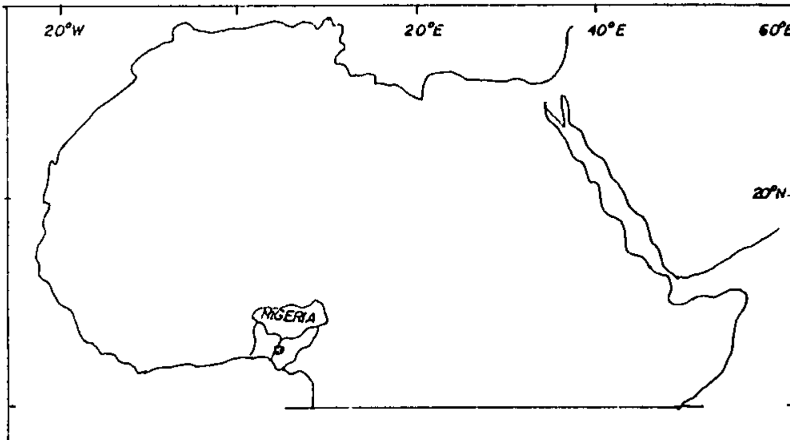


Fig. 1: MAP OF NORTHERN PART OF AFRICA SHOWING NIGERIA AND ANAMBRA STATE (▣)

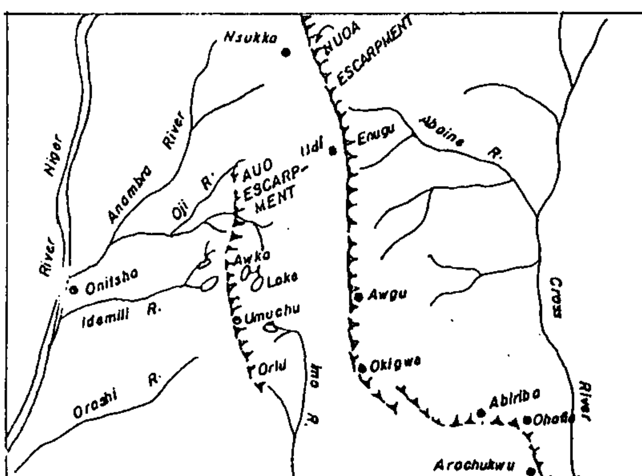


FIG. 2: THE ESCARPMENTS OF SOUTHEASTERN NIGERIA. (From Egboka & Orajaka, 1988)

eliminate erosion in defined catchment or subcatchment areas. These methods ensure the recognition of specific characteristics of each catchment or subcatchment area as a requirement to designing and developing the integral components of the multiple technique.

The multitechnique SCEM is most useful for flood mitigation and control, prevention of erosion and landslides as well as provide enough mechanisms for reclaiming devastated land and surfaces. They establish nuclei for the development of new protective macroenvironments against floods and erosion and exploitable hydrogeologic systems of man-made lakes (Okwalakes).

2.0 Climate and vegetation

Anambra State is characterised by an equatorial tropical rainforest climate, comprising rainy or wet season and dry season.

The rainy season lasts between the months of April and October. During this period, intense rainfall usually through thunderstorms occur,except in the month of August when there is significant but short drop in rainfall called "the August break". The period is characterised by high temperatures and high relative humidity. The temperature is high all through the year with maximum and minimum of 32°C and 28°C respectively (Egboka ed., 1993). The average rainfall is 2000 mm. The rainfall, mostly torrential downpours are concentrated over short periods and collect as large volumes of runoffs, causing high degree of flooding in both rural and urban areas. The floods cause high river discharges of between 2,694 m^3/sec and 23,550 m^3/sec (FMAWRRD, 1993). The intense rainfall and wetness initiate deep weathering of rocks, intense leaching of soils and extensive solid erosion including sheet washing, rill, channel and gully formations and landslides.

The dry season lasts from the month of November to March. It is characterised by chilly and dry harmattan winds. The main features of dry season are excessive evaporation, low relative humidity, low rainfall and general dryness. During the period, vegetation cover dry up and deciduous trees shed their leaves. Farm produce are harvested and sometimes sundried.

The vegetation cover in most parts of the state used to comprise tall trees amidst thick undergrowth. Most of these have been lost to deforestation. These trees have huge luxuriant foliage consisting mostly of broad leaves which build continuous but often graded canopy. The trees in the remaining forests are intertwined by climbers and epiphytes to produce complex tangles. The common trees are oil palms, raffia palms, iroko, etc. Raffia palms are more abundant in swampy areas.

The tropical rainforest vegetation is gradually disappearing in various parts of the state to give way to bushes and scrubland rich in dwarf trees and grasses. These are called derived savannah vegetation. The disappearance of the tropical rainforest is due to high rate of human activities including deforestation.

Derived savannah vegetation has significantly replaced tropical rainforests in Oko, Nanka, Neni, Alor, Oraukwu and Nri areas of the state. Within these areas of derived savannah are isolated patches or remnants of the rainforest preserved as shrines in Awka, Anaocha and Nijkoka areas.

3.0 Geomorphic features and surface water hydrology

The most prominent geomorphic feature in the state is the Awka-Umuchu-Orlu (AUO) escarpment/cuesta. This extends from the northwest corner of the state to the southeast margin and beyond into the Njaba River valley (Fig.2). It has a gully-indented-east-facing scarp slope and a dip slope which rolls gently westwards into the flood plains of the river Niger. The dip slope contains the major Nri-Oraukwu-Nnobi gully complex. This extends from Nri southwestwards to Alor, near the Idemili River. The development of this complex has caused Nri town to stand on a mock horst bound by two extensive depressions; the Enugu-ukwu-Nimo-Nri depression and the Agulu Lake depression. The former contains a line of lakes, including the Ulasi Lake, and extends from the north-western section. The two depressions run southward towards Oraukwu along the Idemili River which flows in a NE - SW pattern and empties into the River Niger at Obosi.

The gully indented scarp slope has the most developed gully complex in the West African subregion, the Agulu-Nanka-Oko gully complex. This comprises several gully networks at various stages of development. The scarp slope is further incised at different points by east trending streams and rivers. The Awka-Umuchu-Orlu escarpment forms the main drainage divide with west trending streams and rivers on the dip slope and east trending ones on the scarp slope (Fig.2).

4.0 Soils and land use

The soils in the state are dominantly loose, friable and sandy.Compact, wet and plastic clayey soils are also important. These soils are mostly lateritic and commonly derived from weathering of the underlying geologic units or transported from nearby sources. Some of the soils are cemented and indurated to form various thicknesses of ironstone bands or cappings. These are often mottled or have colours that range from greenish grey, reddish brown to brownish or yellowish brown. Their thicknesses vary from a few centimetres to more than 20 m.

Thick, loose or partly cemented soils are predominant on the AUO escarpment. These are often exposed along gully walls, stream channels; road cuts and other excavations. In the southeastern and western parts of the state, the soils are mainly dark grey, wet and plastic clay-rich soils. These are mostly expansive and cause numerous engineering problems such as buckling of roads, collapse of bridges, drainage systems and other structures constructed on them. In some places, these soils become loamy or humic and support the growth of thick rainforest vegetation. The soils are acidic and have pH values between 5.0 and 5.8.

These soils are used for various purposes in the state. The total land area of the state is 4,690 km^2. Out of the total area, 620 km^2 is under Tropical Rain Forest cover, 30 km^2 is woodland while only 50 km^2 occur as grassland. About 1,150 km^2 of the total land area of the state or nearly 25% of the area is under use for agricultural purposes including crop lands, irrigated areas, forestry and livestock farming and fisheries (Table 1). More than 60% of the land is being used for other purposes such as residential housing estates, urban development, industrial estates, wetlands, bareland, water schemes, etc. A National Water Resources Inventory Survey (NWRIS) recently conducted indicates that about 55% of the land in the state are bareland and these are very susceptible to flooding and erosion (FMWRRD, 1993).

There is a high population of 2.77 million inhabitants projected to reach 3.25 million and 4.64 million in the years 2000 and 2020 AD, at a growth rate of 1.8. The present population density of 590 persons/km^2 indicates that the stress on the unstable land is very high and with increasing human activities arising from rapid urbanization, this trend will further increase. The most direct consequences of the above is a higher degree of potential environmental hazard due to flooding and erosion in the already stressed lands.

Table 1. Land utilisation in Anambra State, Nigeria

	Type of use	Land area (km^2)	Percentage of total area
A.	Forest land; including tropical rainforest and wood lands.	650	13.86
B.	Grassland including; scrubland and derived savannah	50	1.07

ORAUKWU I AND INOBI

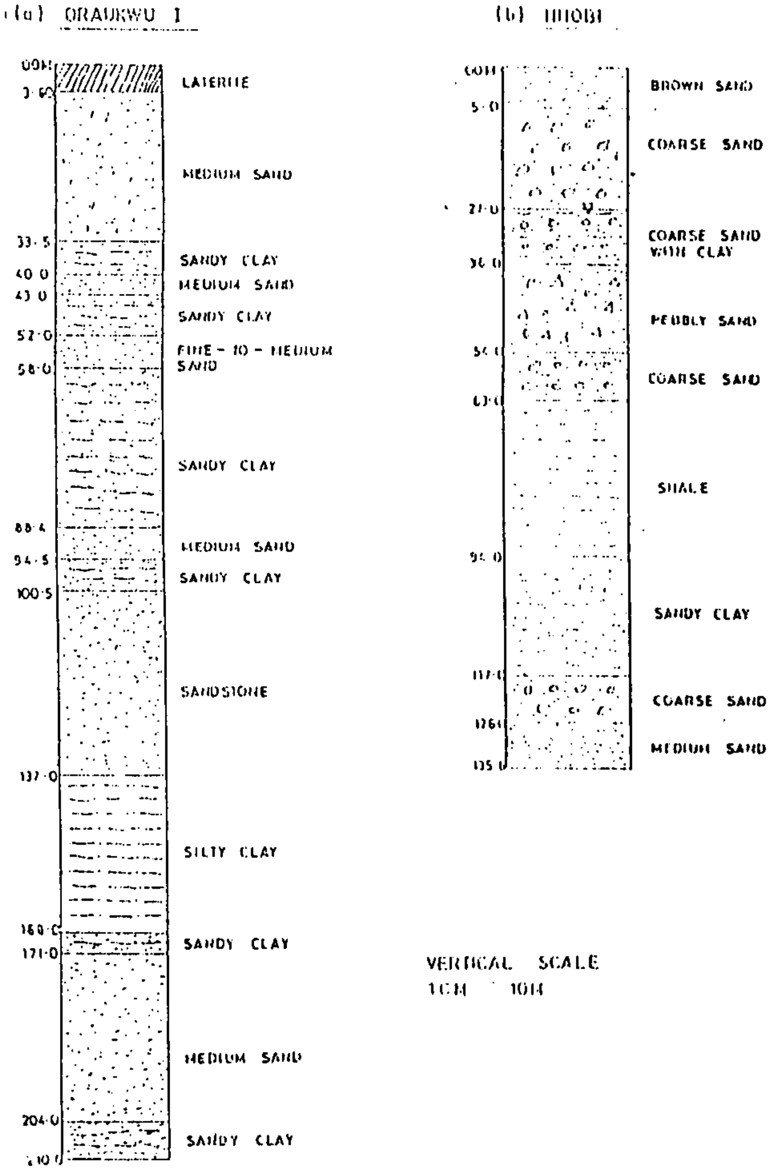


Fig. 4. Typical lithologic sections of some of the erosion prone areas of the state.

C.	Agriculture including crop farming, plantations, irrigation, forestry, fisheries traditional farming and livestock	1,150	24.52
D.	Other uses including, urban development, water schemes, wetlands, barelands industrial developments, etc.	2,840	60.55
	Total	4,690	100.00

Adapted from Federal Ministry of Agriculture Water Resources and Rural Development (FMARRD) Interim Report on National Water Resources Master Plan (1993).

5.0 Geology and hydrogeology

Anambra State occupies a greater part of the central and western sections of the Anambra River Basin. The basin formation is traceable to Santonian tectonism resulting in the subsidence of the Anambra platform and the folding as well as uplifting of the Abakaliki-Benue trough (Nwajide, 1986; and Nwajide and Hogue, 1978). The basin became a major dispositional zone filled with clastic sediments during the Eocene and later. There is no evidence of magmatism in the basin and crystalline rocks have not been found in it (Fig. 4).

The main lithologic units in the basin include, the Imo Shale, the Nanka Sands/Nsugbe Formation, Ogwashi-Asaba Formation, Benin Formation and Alluvial deposits along the flood plains of the River Niger and its tributaries. The Shales comprise bluish grey, fossiliferous shales that are sometimes locally sandy. Sandstones are mostly white, fine to medium grained and loose. The geology of this area has been well described by: Reyment, 1965; Adegoke, 1979; and Nwajide, 1980, 1986 etc.

Two major hydrogeological elements occur in Anambra State. These are: (a) NW - SE trending groundwater mounds or highs which occur in series along the central part of the state and (b) groundwater lows in the northeastern and southwestern flanks of the mounds (Fig. 5). The series of groundwater mounds provide a groundwater divide separating the northeast lows from the southwest groundwater lows. This divide approximately corresponds to the topographic and hydrological divide provided by the Awka-Umuchu-Orlu escarpment (Fig. 2).

The aquifer members/units are found in the Nanka Sands, Ebenebe Sandstone and the Nsugbe Formation. These are good and thick, more than 400 m in places. They are exploited by boreholes and hand dug wells in Anaocha, Aguata, Njikoka, Anambra and Oyi local government areas. The aquifers of the Nanka Sands and the Ebenebe Sandstone facies are heavily exploited in parts of Awka, Aguata (North and South), and Oyi local governments of the state. In Idemili, Onitsha, Ogbaru, Nnewi and Ihiala areas, the prolific Benin formation aquifers are used for both rural and urban water supplies. It has very high yield, and the mean specific capacity of 7.5. The Formation is very thick, reaching up to 2000 m and more in some parts. Studies indicate the static water levels range between 10 and 45 m in depth. Sandy members such as those of Ebenebe Sandstone of the Imo Shale provide groundwaters in some parts of Ebenebe, Achalla and Owerre-Ezukala areas. Their efficiency is usually very low and they are local in occurrence, mostly as lenses.

The combination of hydrological and hydrogeological patterns developed in parts of the state as responses to the main topographic divides would provide excellent guides to flood and erosion control programmes using the SCEM and/or the OLS schemes. These shall serve as surface water and groundwater sources of supplies. Giant connected deep boreholes shall tap the groundwater and reduce the water mounds and levels and hence, reduce the hydraulic gradients on gully faces. These shall equally reduce the porewater pressures, effluent seepages/discharges and hence, reduce gully incidences and landslides. Equally, the Okwalakes shall serve as stilling basins and avenues for artificial groundwater recharge from stored floodwater that has been prevented from reaching existing gullies such that they cannot expand or deepen further before reclamation.

6.0 Floods and stormwater

The intense torrential rainfall usually concentrated over short periods in tropical areas cause severe flooding and stormwater flows in many parts of the state. Earlier works have shown that only 5% of the total annual rainfall is used to water crops naturally, 25% recharges the aquifers, while the rest 70% is wasted through run-offs into streams, rivers and closed-or open-depressions, as well as through evaporation, evapotranspiration, floods and stormwater flows that are responsible for the chronic gully erosion problems (Egboka and Anike, 1993). The runoffs into streams and rivers cause variations in their discharge and flooding of areas adjoining them. The River Niger and its tributaries which traverse the length and breadth of the state drain greater part of Anambra State. The discharges of the River Niger is up to 23,550 m^3/sec. during the rainy season and about 289 m^3/sec in the dry season.

Stormwater flow, although generated by torrential downpours in the tropics, are enhanced by existence of poorly-constructed narrow flood channels, drains that are rough and poorly-built, natural and artificial channel ways that are blocked at different points by indiscriminate discharge of solid wastes. These are commonplace in urban centres such as Onitsha, Awka, (the state capital), Nnewi and Ihiala. Ekwulobia, Obosi and Nkpor areas are also affected. These areas are experiencing increased human activities and improper disposal of wastes along natural and artificial flood routes. These centres experience large and frequent stormwater and rapid high velocity floods with concomittant severe environmental hazards including loss of stored agricultural products, merchandise, loss of roads, bridges, culverts, buildings, churches, schools, lives of human and animals in the short term. In the long term, they cause loss of agricultural lands through soil erosion, gullying and landslides, silting up of natural water sources such as springs, streams, rivers, lakes, fish ponds, wetland, agricultural lands, etc. These as well ultimately pollute the environments, and cause a disruption of biological ecosystems.

Flooding more than stormwater flows, sometimes have some positive effects. Floods as a result of their relative low velocity of flow and greater residence time in the catchment area, provide sources of aquifer recharge in Fadama lands (Adams and Hollies, 1988). Both flooding and stormwater flows have the capacities to dispose wastes but the unguided disposal may only provide limited relief. The materials discharged may cause more pollution or contamination in downstream areas.

7.0 Erosion and landslides

Abundant evidence of soil and gully erosion, and landslides are commonplace in different parts of Anambra State. The state has one of the largest developed gully erosion complexes in the West African subregion - the Agulu-Nanka-Oko gully complex. Other numerous complexes which cover more than 70% of the state include the Oko-Ekwulobia-Aguluezechukwu, Oraukwu-Alar-Nnobi, Nnobi-Nnewi-Ozubulu, Enugu-Ukwu-Nri, Agukwu-Adazi, Ekwulumili-Ezinifite-Unubi, Achina-Akpo-Aguluezechukwu, Ojoto-Obosi-Oba, etc. gully complexes. These are extensive and interconnected, comprising both mature and incipient gully fronts and spots. The gully complexes comprise sheet wash, rill, channel and gully erosion. Their causes and modes of development are shown in Tables 2. These have been well-discussed in Egboka and Anike (1993), Egboka ed. (1993) Egboka and Nwankwor (1985), Okogbue (1987), Nwajide and Hoque (1978), Nwajide (1992 and 1994), Egboka and Orajaka (1988) and Imouokhome (1994). The above studies show intimate inter-relationships between surface water hydrology especially flood rate and intensity, groundwater movement and nature of underground rocks as well as geomorphic features, degree of vegetation and human/anthropogenic activities.

Table 2

Genetic Classification of Gullies and Their Modes or Origin and Advancement (Ezechi and Okagbue, 1989).

Gully Type	Modes and Conditions of Formation	Common Modes of advancement
1. Base Level (Type 1) Gully	Groundwater flow, critical and quick	Common Modes of advancement.
2. Scarp (Type 2) Gully	Runoff and slope changes	Slope undermining, sliding, slumping and toppling.
3. Fracture (Type 3) Gully	Runoff and shrinkage fracture.	Collapsing, and Block failure
4. Incidental (Type 4) Gully	Runoff concentration, and vulnerable soil exposure by man (engihanic agents), deforestation, etc.	Commonly sliding and slumping; and failures and landslides.

8.0 Mitigation/control of flood and stormwater problems

Various methods/techniques including engineering, agro-forestry, agricultural and sociological mechanisms have been employed to check or ultimately control flood and stormwater hazards. Some methods have achieved limited successes and others have aggravated the problems. Newer and more efficient and integrated mechanisms that achieve better results have been developed. They are the Subcatchment Erosion Control Model (SCEM) and the Okwadike Lake (Okwalake) System (OLS).

Table 3 gives a summary of the different techniques of flooding and erosion control and their applicability. One of the main characteristics of earlier techniques is that they have been employed singly most of the time. This has limited their effectiveness as their individual advantages and shortcomings have not been systematically complimented by other methods. The importance of integrated approach has been emphasized recently. Imouokhome (1994) noted that each flood protection measure should be technically connected or integrated with the whole drainage scheme for the urban, rural and highway areas. This is the philosophy of SCEM, methods and emphasize the integration of both control, reclamation and stabilization techniques. Infrastructure developed in these schemes have multiple application in controlling, reclaiming community services including roads, agriculture, water supplies, etc.

The Subcatchment Erosion Control Model (SCEM)

The Subcatchment Erosion Control Model (SCEM) recognises the site-specific nature of gullies and proposes the subcatchment management strategy for control programmes. This involves a systematic application of a combination of varied-scale control programmes that are site-specific. These include simple, inexpensive, sociological and physical measures, coupled with engineering construction, agroforestry measures and selected community-based or government-enforced cognate policies. The simplicity of the model, its composite nature, cost-effectiveness and adaptability enhance its application and competitiveness particularly in developing economies. These make the SCEM scheme advantageous over the old fashioned, expensive and ineffective single, isolated gully spot/site or largescale control measures (Fig. 3).

The Okwalake System (OLS) involves the development of various-sized artificial lakes - Okwalakes - along defined flood routes and at predetermined distances i gully fronts. These lakes serve to impound floods and stormwater generated in various parts of a catchment area reduce their flow velocities and store their water for later use. They are similar to the tameikes of Japan. These stored flood waters can be, as in Fig. 3 (b), subsequently used for water supply to various parts of the catchment area for purposes of irrigation, aquifer recharge, possible rural water schemes especially in dry season, as well as water supply for industries.

9.0 Summary and recommendation

Climatic conditions, geomorphic factors, nature of underlying rocks, hydrologic and hydrogeologic conditions, as well as land use and management are critical factors to flood volumes, flow rates, storm actions and environmental hazards caused by floods in the state. The heavy torrential rainfall characteristic of the tropical rainforest climate of the state generate large volumes of fast flowing floods in urban, suburban and rural areas. These floods often flow through poorly engineered, narrow channels, furrows and natural flood routes indiscriminately blocked in some parts by industrial and/or domestic solid/liquid wastes, buildings and other engineering structure. These cause flood flows to become rapid, turbulent and stormy, wreaking disastrous environmental havocs in densely-populated communities adjacent to these flood routes. Integrated methods, involving various experts and expertise in the fields of environmental

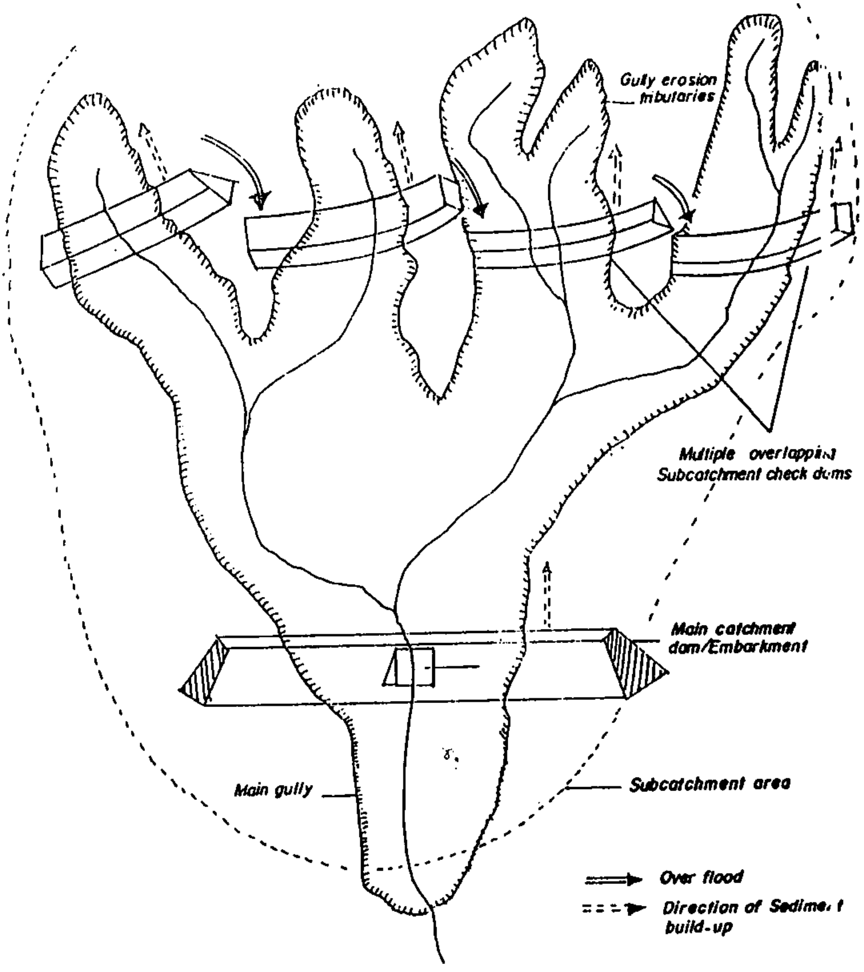
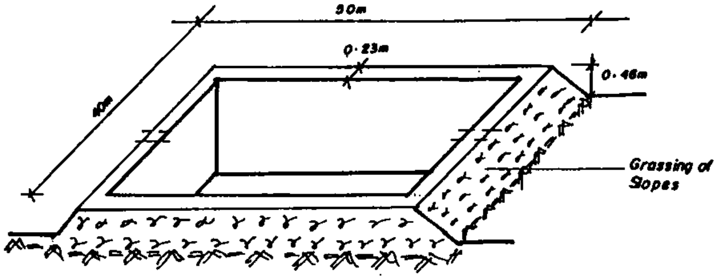


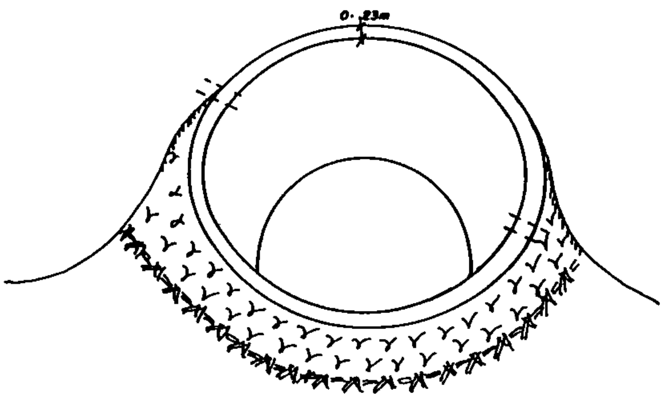
Fig. 3 *Combined Catchment and subcatchment check dams to control advancing main erosion channel and its fingers (tributaries). A subcatchment management technique (SCEM). (successful in most places)*



Depth = 2·5— 4m (a) Rectangular

Fig. 3 (b)

SOME CONFIGURATIONS OF OKWALAKES



Depth =?2·5 — 4m
Radius =?25·23m (b) Circular

sciences, engineering and technology are required to control these problems. Engineering, agroforestry and sociological measures, applied at definite phases of the control model are preferred to isolated less effective methods that are haphazard and ineffective. The integrated approach can be achieved by setting up a central Flood/Erosion Control Fund and Environmental Hazard Research Centre in the state. These two institutions would work in concert to develop appropriate models, define the programmes of control and look for funds to execute the control projects.

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TABLE 3. SOME CONVENTIONAL FLOOD/EROSION CONTROL MEASURES AND THEIR APPLICABILITY

CONTROL MEASURE	MAJOR CHARACTERISTICS	APPLICABILITY
1. Catchpits, Ditches, and bumps	Have circular, square, rectangular etc shapes and could be lined or unlined. Constructed along road sides, in homes, and require intermittent clearing periodically. Easy and cheap to make.	Useful in preventing runoff and uncontrolled overland flows. Collect and store flood waters.
2. Weirs: Fascine, Hedge, Stake, Stake and stone weirs	Convenient and low cost. Easily constructed with available materials. Require proper surveillance during rainy season where erosion occurs easily. Can be combined with sand bags.	Effective in preventing expansion of gullies at early stage, and conservation of soil.
3. Sand bag works	Consist of bags containing seeds and water retaining additives pinned with anchors. Bags are placed at interval of 50 cm, and put on slopes densely. Easy to construct.	Important in reducing rate of flow of floods and protecting slopes. Prevents expansion of gullies.
4. Gabion works and Wire Sousage	Very flexible and easily constructed on site. their designs can be easily changed to suite the ever changing shapes of erosion feature. Use natural and artificially planted grass to limit damage on ecosystems.	Useful in checking gullies created by spring discharge.

5. Check Dams	Constructed on medium scale gullies in Nigeria. Design and construction must consider hydrodynamics, geology and groundwater conditions of area to be protected.	Effective in control of floods and stormwater flows.
6. Drainage systems: channels, culverts, gutters, pipes, mole drains, etc.	Installed on the surface and ground gullies to prevent runoff flow into gullies and rainfall penetration into the ground. Placed in upper part of gullies. Combined with pavement and cover grass to be more efficient.	Efficient in protecting occurrence and expansion of gully erosion.
7. Agronomic works: Revegetation, regrassing or replanting	Cheaper than physical or technical measures. Better where ground slopes are low/gentle enough to be stable. Tolerance to drought, heat acidity, soil sterility and water logging is required for plants to grow effectively.	Effective in environmental protection and soil conservation.
8. Cognate measures; legislation, bye-laws, education, etc.	People, government establishment of institutions to execute and enforce policies, laws, etc. Mass education or specialized training, use of informal and formal techniques, use of media of communication eg. radio, television, newspapers, handbills, seminars, etc.	Useful in changing peoples negative attitudes to causes of environmental degradation. Increase environmental awareness.

Main conclusions

In the poster session 23 posters were exhibited, three on Educational Renewal, one on The Greening of Industry, three on The Agricultural Conflicts, six on Integrated Approach to Land and Water, one on Financing Options and finally nine on Hazardous Waste Management.

The pollution of scarce and vulnerable water resources caused by human activities were highlighted in several posters. The problems caused by the rapid and uncontrolled growth of cities is one of the main causes for groundwater pollution in the developing world.

Several solutions were presented both how to increase common knowledge of the role of water and how to decrease the flux of harmful compounds to potable or potentially potable water.

The local governing bodies generally both have the will and sufficient knowledge to tackle the problems, the problems are however of such a magnitude that they cannot be solved by the local authorities or even governments alone.

Large sums are needed for investments in infrastructure. In the meantime education is the most important tool to deal with the escalating problems caused by growing cities and agricultural practices that impoverish arable land and the environment.

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Akinaga, Kunji	Binnie & Partners Cons Eng
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Biswas, Asit	Middel East Water Comm
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Jones, Gerald	WRC plc
Norton, Chris	Anglian Water Services
Oatridge, James William	Severnt Trent Plc
Stanley, William	
Whitehead, Paul	Institute of Hydrology
Woodcock, Paul	Anglian Water Services

UNITED STATES

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Clark, Mary	San Diego State University
Dickerman, John	Global Water
Dombeck, Glenn	Montgomery Watson
Engelbrecht, Richard	University of Illinois
Gerwert, Philip	General Motors Corp
Matthews, Geoffrey	World Bank
Maxey, Margaret	The University of Texas
Moss, Marshall	Bayeswater/IAHS
Najlis, Pierre	UN/DIESA
Ringskog, Klas	World Bank
Raoul, Joseph	US Army Corps of Engineer
Sigford, Ann	Integrated Lab Systems
Sorber, Charles	The University of Texas
Stapp, William	The University of Michigan
Stottman, Walter	World Bank

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ZAMBIA

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Sakala, Wilson K	Met Dep

ZIMBABWE

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