Hidden Consequences

The costs of industrial water pollution on people, planet and profit

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image A hidden pipe, only visible at low tide, discharges water from a textile factory into canals only 1 km from the Chao Phraya river in Bangkok, Thailand.

Contents

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Note to the reader

Throughout this report we refer to the terms 'Global North' and 'Global South' to describe two distinct groups of countries.

The term 'Global South' is used to describe developing and emerging countries, including those facing the challenges of often rapid industrial development or industrial restructuring, such as Russia. Most of the Global South is located in South and Central America, Asia and Africa. Within this report this term refers specifically to case studies located within a group of countries including China, Thailand, the Philippines and Russia.

The term 'Global North' is used for developed countries, predominantly located in North America and Europe, with high human development, according to the United Nations Human Development Index.* Most, but not all, of these countries are located in the northern hemisphere. Within this report this term refers specifically to case studies located within a group of countries including the USA, Switzerland, the Netherlands and Slovakia.

* United Nations Development Programme (UNDP). (2005). Human Development Report 2005. International cooperation at a crossroads. Aid, trade and security in an unequal world. Available at: http://hdr.undp.org/en/media/HDR05_complete.pdf

© LU GUANG / GREENPEACE

image In Gurao, China, the economy is centred around textile production. Greenpeace has documented the effects this has had on the community.

Executive Summary

Industrial pollution is a severe threat to water resources around the world, particularly in the Global South where the view prevails that pollution is the price to pay for progress. This view is usually associated with the ideas that dealing with pollution is too costly, that pollution prevention is too difficult and impractical, and that environmental and social effects can be dealt with in the future.

To make matters worse, there is also a general misconception that wastewater treatment plants can eventually deal with all water pollutants, whatever their toxicity.

This short-term view has resulted in the widespread dumping of undisclosed and often hazardous chemicals into water. However, when substances with persistent and/or bioaccumulative[1] properties remain undetected or ignored in the aquatic environment, long-lasting and irreversible environmental and health problems can result.

'Zero discharge'

The only way to address these hidden dangers in our water is through a preventative approach: Taking action to phase out the use and discharge of hazardous chemicals, rather than attempting to control the damage with end-of-pipe treatment methods. Accordingly, Greenpeace is calling for governments to adopt a political commitment to 'zero discharge'[2] of all hazardous chemicals within one generation, based on the precautionary principle and a preventative approach to chemicals management.

This commitment must be matched with an implementation plan containing short-term targets, a dynamic list of priority hazardous substances requiring immediate action[3], and a publicly available register of data about discharge emissions and losses of hazardous substances, such as a Pollutant Release and Transfer Register (PRTR)[4].

Our call for 'zero discharge' is built upon three decades of exposing and addressing the problem of hazardous chemicals. However, rapid industrialisation is now taking place in many parts of the Global South, with seemingly little regard for the painful lessons learnt in the Global North – where the pollution caused by hazardous substances has generated enormous economic, environmental and social costs.

Learning lessons from the Global North

Case studies from the Global North show the extent to which persistent and bioaccumulative substances have contaminated entire regions. They also show the immense difficulties – technical, economic and political – of cleaning up these hazardous chemicals after release, including the very high expense of restoration programmes and the impossibility of total decontamination.

Worse still, the largely unquantifiable costs to human health, the environment and to local economies are rarely considered or compensated. Many of these effects are irreversible, while the effects beyond the region concerned are impossible to calculate. For persistent and bioaccumulative substances these effects can be global, as they can be transported far beyond their source via ocean currents and atmospheric deposition, and they have even accumulated in the polar regions of the Earth.

In East Asia, Southeast Asia and other parts of the world where industrialisation is booming, there is a danger that expenditure on even basic environmental measures – let alone the avoidance of hazardous substances through substitution – could be seen as an unnecessary impediment to economic growth. The case studies from the Global North show that attempts to 'save money' by opting for the cheapest ways to use and dispose of hazardous chemicals in the short term can ultimately translate into extremely high costs and losses in the future. These costs then have to be borne by someone, and this is either the companies concerned or the taxpayer – often both.

Polluting in the pursuit of profit can prove to be an expensive strategy for industry in the long run. The Swiss chemical industry and General Electric in the US have both been held accountable for subsequent clean-up costs. However, pinning responsibility onto the polluter is not always straightforward, such as in the case of the Laborec River in Slovakia. If financial liability cannot be established, or if the polluter is no longer around, it is the state, and therefore the taxpayer, who is left with the clean-up bill.

In a large river basin, the polluters can be so numerous and widely spread that it is not possible to hold them liable for clean-up of the enormous pollution problems caused downstream, as is the case with the delta formed by the confluence of the Rhine, Meuse and Scheldt rivers in the Netherlands and Belgium. The Rhine-Meuse delta problem is not unique – the world has many heavily industrialised water basins. The Yangtze and the Pearl River Delta in China, the Great Lakes in the US and the Riachuelo River basin in Buenos Aires face similar difficulties, with high concentrations of persistent contaminants in the sediments of the rivers and their harbours.

The opportunity

If we fail to learn from the mistakes of the past, then we are doomed to repeat them. This is especially the case in those regions of the world where much chemical and manufacturing production has now relocated – namely Asia and the wider Global South. Policy makers in these regions have the opportunity to avoid making some of the same grave mistakes that were made in Global North, and 'leapfrog' over the conventional approach of waste and wastewater end-of-pipe treatment to focus on prevention first.[5] A precautionary approach would help protect their waters – and the livelihoods of all those who rely on those waters – both now and for future generations.

The message could not be clearer. Governments have a choice. Should they expose their citizens and the environment to hazardous toxic pollution, and condemn future generations to pay for the management of contaminated sediments, whose full and final costs are incalculable? Or should they instead commit to a 'Toxic-Free Future', and take precautionary action to support truly sustainable innovation and progressively eliminate the use and release of hazardous substances down to 'zero discharge'?

image A Greenpeace campaigner takes a water sample from a polluted river near Dadun Village, Xintang, Zengcheng, in China.

image Food is sold from a boat in a floating market in the Taling Chan canal in Bangkok.

01

01

Rescuing our iconic rivers

An opportunity to act, before it's too late

Rivers provide a lifeline for the communities through which they flow and for the cities that swell on their banks. They supply vital and life-sustaining resources, including drinking water, crop irrigation, and food. They also serve as a critical support system for industrial activity, providing water for many manufacturing or cooling processes.

It is this industrial activity that often has a hidden, darker side.

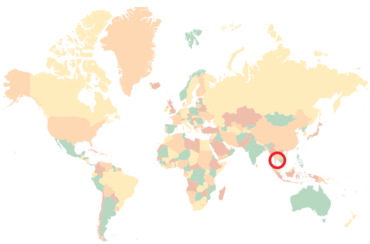
This section portrays four iconic rivers in the Global South, which are increasingly being destroyed by industrial activity and the use of hazardous substances. These rivers are the Chao Phraya in Thailand, the Neva in Russia, the Marilao River System in the Philippines and the Yangtze in China.

Hazardous industrial chemicals can be found in all of these rivers. Many of these substances are persistent and can gradually accumulate in sediments and in the food chain, impacting upon critical resources, such as water for agriculture and drinking water, and contaminating wildlife and entire ecosystems. This, in turn, can cause long-term, irreversible damage to people, the environment, and the wider economy. Worse still, this damage has the potential to spread far beyond the boundaries of the rivers themselves. For example, when these rivers discharge into seas and bays, the pollutants they carry are transported even further – affecting coastal and marine environments and resources.

The evidence of pollution by persistent hazardous substances contained within this section shows that industrial production around these rivers is taking place with little regard for the ecological and human health consequences. This is happening despite the fact that industries from the Global North have had to learn difficult lessons about the serious repercussions of short-term thinking (see Section 2) and that avoiding the use and discharge of hazardous substances is both possible and more cost-effective (see Section 3).

It is not too late to act. It is still possible to limit and prevent future damage to these – and many other rivers – but new rules and responsibilities are required. It is clear that the use of pollution control or wastewater treatment does not deal effectively with all hazardous substances, and only postpones the need for more effective measures. The problem has to be tackled at its source. This means that in order to eliminate and prevent discharges of hazardous chemicals into the environment, all their uses need to be phased out – throughout the chain of production. To be effective, this action needs to be based on knowledge, which in this case requires the quantities of hazardous substances used and discharged to be reported and monitored, with full availability of data to the public.

The time to act is now. As the following four case studies demonstrate, there is an urgent need to eliminate the use and discharge of hazardous substances by industry, to rescue these precious rivers and protect the livelihoods of all those who rely upon them.



Case Study: Thailand

The Chao Phraya River

The Chao Phraya is the most important river system in Thailand. Comprising four major, upstream tributaries, the river flows southwards through Bangkok before emptying into the Gulf of Thailand.[6] In 2009, the population of the Chao Phraya River basin was nearly 13 million people.[7]

Due to its profound cultural and historical significance, many revere the Chao Phraya as the 'heart' of Thailand, and the river basin is widely regarded as the most important food production area in the country.[8] In addition, much of the upstream river and associated wetlands are very rich in wildlife – the Chao Phraya and its tributaries boast over 300 species of fish[9], for example.

The river basin is also vital to the country's economy. Over 30,000 industrial facilities are located in the Chao Phraya basin[10], including pulp and paper, textile and dyeing, rubber and food production industries. However, the ongoing industrialisation competes with traditional uses such as fishing or water for agriculture, and also with the provision of safe drinking water to Thailand's biggest metropolis – Bangkok.[11]

The river currently suffers from growing pollution, and the water quality in its lower reach – where most of the industry is located[12] – has been classified as 'deteriorated', based on the Thai water quality index.[13] Yet despite significant quantities of hazardous chemicals being manufactured and in use[14], little is known about the releases or about the extent of pollution caused by hazardous substances from industrial sources. This is true not only for the Chao Phraya River, the groundwater, ecosystems and agricultural land in the basin, but also for other river basins in Thailand. The absence of good data gathering systems and data management problems[15] are partly to blame for this.

However, a number of specific studies in the Chao Phraya basin have provided clear evidence that certain effluents containing persistent, bioaccumulative and toxic chemicals, are being discharged by industry and are contaminating the river basin. For example, a study by Greenpeace in 2003 showed the presence of many toxic metals and organic pollutants in the sediments of canals and in effluents discharged into them at an industrial estate at Samut Prakarn.[16] Substances including copper, lead, nickel and zinc were found in the sediments of one canal at between 50 and 100 times the background levels. Phthalate esters and nonylphenols – both toxic substances – were also identified.

Industrial chemicals known as perfluorooctane sulfonate (PFOS) and perfluorooctonoic acid (PFOA) have also been measured in a 2009 study in water samples from the Chao Phraya River and in wastewater discharges from treatment plants at industrial estates.[17] One sampling point was near the mouth of the Chao Phraya at the Gulf of Thailand. Here, the calculated loads of these substances entering the Gulf via the Chao Phraya had the potential to enter the food chain, given the 'important food sources' in the Gulf. There was also indication of tap water contamination at some locations. Both chemicals have been shown to disrupt hormone systems and are now widely found in humans.[18]

Although the studies discussed above are not designed to provide a comprehensive overview of the situation, they nonetheless demonstrate industrial contamination of water and sediments in parts of the Chao Phraya and its interconnecting canals. There is no reason to presume that these are isolated or unusual instances, but more investigation is needed in order to form a clearer picture of the situation. The potential for accumulation of persistent chemicals in the environment and bioaccumulation in wildlife and humans can already be seen, even if the scale of the problem so far is not fully clear.

There is an urgent need to establish the extent of the problem and develop appropriate solutions – including the establishment of a priority substance list – with the aim of eventually eliminating all releases of hazardous substances. In this respect, a precautionary and sustainable approach to the management of hazardous substances is required, starting with more transparency and publicly accessible data.

Time is short. The fact that many of the hazardous substances identified in the Chao Phraya and in the sea water off the coast of Thailand[19] are banned in other more developed markets, or have been prioritised for elimination by the Stockholm Convention on Persistent Organic Pollutants, should be a wake-up call to the authorities to start addressing this problem now.

image A water treatment pond of a bleaching and dyeing factory near the Samrong Canal, in the lower part of the Chao Phraya River basin. The waste water released from this textile factory has many different colours from dyeing, and a chemical smell.

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'About 30 years ago, when I was a kid, there were only orchards in this area. People made sugar, and rowing boats came in and out to transport the sugar. I used to swim in the canal. My parents and neighbours fished in this canal. We caught fish and huge river prawns that are now very expensive. We could catch plenty of them. We didn't sell them but caught enough for our consumption.

'Around 1973, factories began springing up. At first there was only a corn syrup factory and that didn't really cause so much pollution. People around here began to sell their land to factory builders. Orchards disappeared and were replaced by more and more factories. When the garment bleach and dyeing factory came here, the water got worse.

'There are about five factories of this kind today, dumping their wastewater into both canals. They usually do that during the night. In the evening, I can see the water turns dark and the foul odour gets really strong at dawn. We have petitioned the provincial office, but it has fallen on deaf ears. The factories don't care about us and don't tell us anything, but what they do to my community is so severe.

'We should have the right to know what kind of substances the factories are using and how much pollution they release and how dangerous it is. I want someone to work on it. It should be the beginning of new things.'

Boonsong Nakarak – a resident of a community living by the Klong-Samrong canal and the Klong-Mahawong canal, which connect to the Chao Phraya River, Samut Prakarn province

© JOHN NOVIS / GREENPEACE

image In many areas from the upper reach to the middle reach of the Chao Phraya, water is extensively used for domestic consumption. However, it has been limited to only cleaning purposes as the water is no longer drinkable.


Chao Phraya

Case Study: Russia

The Neva River

The Russian Neva, the third largest river in Europe in terms of average discharge, supplies St Petersburg and its 5 million inhabitants with all its drinking water.[20] Despite this critical role, its waters remain largely unprotected from contamination with hazardous chemicals as a result of both formal and informal industrial activities.

St Petersburg and its surroundings are home to a large number of diverse industrial enterprises, including a substantial concentration of electric and electronic equipment manufacturers. While the final products are 'high tech', their production uses a wide range of hazardous chemicals, which generate large quantities of liquid wastes. In the St Petersburg area, these are either discharged directly into the Neva River or directed to one of three large common effluent treatment plants. The solid waste (sludge) from the treatment plants was, until recently, sent to landfill.[21] Here the sludge ended up in disposal pits where it could continue to produce liquid wastes, which have the potential to pollute surface waters, groundwater and soil.

One toxic waste landfill in the Neva watershed, Krasny Bor, receives not only wastewater sludge, but also industrial organic and inorganic hazardous waste from enterprises in Leningrad Oblast, including industrial solvents, PCB-containing equipment, and pesticides.[22] This landfill is the cause of substantial water contamination with a wide range of contaminants – including phenols and polychlorinated biphenyls (PCBs)[23] – and illustrates the failure of traditional methods of pollution control, as the pollutants simply get transferred from one medium to another.

In addition, there are many poorer urban areas where unofficial and unregulated 'recycling' of electronic waste takes place. A common practice is the open burning of cables, circuit boards and other components in order to recover traces of precious metals for resale. However, such activities may also release hazardous chemicals, including PCBs, brominated flame retardants (BFRs) and toxic heavy metals.[24,25,26,27] Their release further exposes humans and the environment to significant quantities of these substances and adds to the pollution in the Neva River basin.

An investigation by Greenpeace in 2010 showed the presence of a variety of toxic metals and persistent organic chemicals in some industrial effluents, in the sludge of certain wastewater treatment plants, in river sediments, and in soils where electronic waste 'recycling' had been carried out. The results demonstrated considerable contamination by industrial substances, including chemicals with persistent and bioaccumulative properties.[28]

Together, these factors highlight the urgent need for systematic assessment of industrial pollution of the Neva and the environs of St Petersburg. Although an official system for monitoring the water quality in the Neva basin is in place[29], only a relatively small range of persistent and potentially hazardous chemicals are routinely measured in the surface water by the state agency[30]. As a result, only limited information on persistent organic pollutants (POPs) or heavy metal contaminants in the Neva River and its sediments are available. Similarly, monitoring of industrial effluents, whether directly discharged into rivers or sent to treatment plants, is not comprehensive.[31] There is no disclosure of the data to the public[32] and there is little incentive for companies to substitute hazardous chemicals[33] or implement pre-treatment measures[34].

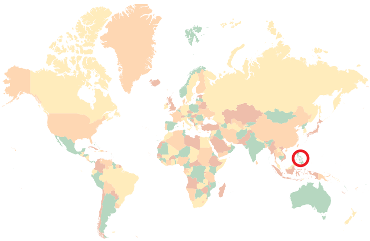
In order to address the problem of hazardous chemicals, it is therefore necessary to first identify the sources, range and quantities of hazardous chemicals being released into the river basin by industry, and to provide full public access to this data. As the situation in the Neva illustrates, pollution is caused by hazardous chemicals at both ends of a product's life cycle – in its manufacturing and its disposal. This demonstrates the urgent need for a chemical management strategy that is based on a political commitment to 'zero discharge' of all hazardous substances, including both those present in products, and those found in industrial releases.[35]

image The Slavyanka, a tributary of the Neva. The Neva remains largely unprotected from contamination with hazardous chemicals as a result of both formal and informal industrial activities.

© GEORGY TIMOFEEV/GREENPEACE

image The Krasnenkaya river, a tributary of the Neva.

Neva



Case Study: The Philippines

The Marilao River System

The extensive Marilao River System in the province of Bulacan, near Manila in the Philippines, now holds the dubious distinction of being labelled by the Blacksmith Institute as one of the world's dirtiest rivers.[36]

The report by the Institute points to the high levels of pollution being due to wastes received from various sources, including tanneries, gold and precious metals refineries, a legacy of lead-smelting waste, from numerous municipal dumpsites, and from small-scale lead recycling facilities along the river. A monitoring programme for the Marilao River System – set up in 2008 with the Asian Development Bank[37] – confirmed the contamination of the Marilao River System by heavy metals, with the levels of many exceeding the surface water standards[38] set by the Department of Environment (DENR-EMB)[39] at one or more monitoring stations. Furthermore, in a number of groundwater samples the levels of manganese, zinc, nickel and cadmium in groundwater exceeded the Philippines National Drinking Water Standard. At least one of the groundwater sources sampled was being used as drinking water by the local community.[40]

The monitoring programme report also documents river sediment samples with levels of metal contaminants – notably of copper, nickel, mercury and lead – that exceed the limits set under the US Washington State sediment standards.[41] This contamination is most likely a result of a long-term build up of these persistent metal pollutants over many years.[42]

Shellfish and freshwater fish from the Marilao River System, widely consumed by the population in the area and in metropolitan Manila, also displayed evidence of metal contamination, in some cases with levels in excess of established limits for human consumption.

The report observes a correlation between the monitored river contamination and the levels of heavy metal pollutants – manganese, zinc and nickel – that were found in fish. The report also warns that the heavy metals present in the edible fish and shellfish can, as a result of their consumption, potentially bioaccumulate in humans over the years, leading to the possibility of 'certain diseases and ailments'.[43]

The need for the rehabilitation of the Marilao, Meycauayan and Obando rivers has been recognised by authorities in the Philippines. In 2008, the DENR and the Provincial Government of Bulacan established the country's first Water Quality Management Area (WQMA)[44], including a draft 10-year action and implementation plan[45]. However, while this plan covers the clean-up of the existing contamination and wastewater treatment for ongoing discharges, it contains very few concrete measures to prevent future contamination by addressing the problem at source and eliminating the actual use of hazardous chemicals. As the plan stands at the moment, it is questionable whether it will be able to fully deliver on its goal of achieving complete control over the source of the pollution. However, it is clear that any effort undertaken to clean up the existing damage to the river system will entail massive costs for the provincial government.

Already, the consequences for the national economy have been demonstrated by the scale of the estimated clean-up costs[46] – which are prohibitive in a country such as the Philippines. Experience from the Global North (see Section 2) would also suggest that these costs are just the beginning. In this situation, the authorities are rightly focusing on controlling the sources of pollution, yet their proposed plan will not completely eliminate the use and discharge of hazardous chemicals, such as heavy metals.

There is an urgent need to implement plans for clean production and to eliminate discharges of hazardous chemicals into the river basin, with the priority on substituting the most hazardous substances with safer alternatives (see Section 3). The creation of a national Pollution Release and Transfer Register (PRTR), supported by UNITAR, would be a first step[47], followed by a more comprehensive list of priority substances to be tackled[48] and a robust strategy aiming to eliminate all releases of hazardous chemicals within one generation.

image A Greenpeace volunteer talks to a local resident beside Marilao River in Bulacan. The river has been identified by the DENR as one of the Philippines' 50 dead rivers due to heavy pollution.

© JOHN JAVELLANA/GREENPEACE

image Workers operate a machine that separates various layers of animal skin to be processed inside a tanning facility located in Meycauayan, Bulacan, north of Metro Manila.

Marilao

Case Study: China

The Yangtze River

Throughout China's long history, the Yangtze River basin has been a centre of cultural and industrial activity.[49] Today, it contributes around 40% of the nation's GDP[50], the equivalent of about $1.5 trillion US dollars[51].

Commercial activity has prospered; over a billion tons of cargo passed through Yangtze River ports in 2008[52], and these convenient national and international transport links and abundant water resources also offer vital advantages to industry. Industrial developments are particularly concentrated in the Yangtze River Delta region. Major industries there include raw chemicals and chemical products, chemical fibres, petroleum refining, coking and nuclear fuel processing, smelting and pressing of ferrous metals, transport, electric equipment and machinery, telecom, textiles, and computers and other electronics.[53]

The delta region alone accounts for around one-fifth of China's entire economy.[54] It includes 16 cities, among them Shanghai, whose 20 million people are dependent on the Yangtze for drinking water[55].

The river receives around 30 billion tons of wastewater every year (including domestic sewage), some of it untreated.[56,57] According to Müller et al (2008), the quantity of pollutants disposed of into the Yangtze may be 'one of the world's largest', albeit diluted by the enormous volume of water in the river.[58] Approximately 15% of the river failed to meet the standard for use as a drinking water source in 2008.[59]

While a great variety of chemicals are inevitably discharged by industry every day, perhaps the most insidious are the persistent and bioaccumulative substances. Despite the dilution factor mentioned above, these substances can be subsequently re-concentrated back to harmful levels in sediments and biota.

Inevitably, such chemicals will eventually become problematic if their discharge is continued. In an interview with Greenpeace, Dr. Beat Müller of the Swiss Federal Institute of Aquatic Science and Technology recalled that in Europe during the 1950s and 60s the attitude that 'dilution is the solution to pollution' had disastrous effects[60], as levels of persistent chemicals built up over time in sediments and wildlife. Existing data suggests that there is no room for complacency. A range of organic pollutants, including persistent substances, has already been found in the Yangtze.[61]

Combined with other pollutants, such as increasing quantities of nutrients from sewage and agriculture discharging into the estuary and East China Sea, it is considered that the loads of pollutants in the Yangtze could have a 'disastrous effect' on the estuarine and marine area.[62] Persistent substances that have the potential to accumulate in the food chain could have serious consequences for fisheries in this area.

In a 2010 study, Greenpeace looked at samples of popular edible fish – wild southern catfish and common carp – from locations near four major cities along the Yangtze. Alkylphenols (APs) – a group of persistent hazardous chemicals with hormone disrupting properties[63,64] – were recorded in the livers of all but one fish. The results support the bioaccumulation of APs in the fish species along the Yangtze and show that APs are widespread in fish along the Yangtze – with consequences for human exposure since the two species sampled are commonly eaten.[65]

Another persistent industrial chemical, perfluoroctane sulfonate (PFOS), was also detected in almost all the samples. The beginnings of long-term build-up of bioaccumulative and hazardous substances in the Yangtze River food chain seem very clear[66]; the widespread pollution by these and other hazardous chemicals released by industrial processes could undermine the health of the river and the sustainability of the region's economy.

In addition to the enormous quantities of wastewater discharged into the Yangtze River Basin on a daily basis, industrial accidents can also result in serious additional pollution. With thousands of chemical enterprises operating in the Yangtze River Basin, the danger of an accidental release of hazardous chemicals into waterways is present for as long as these substances remain in use.

Pollution incidents may have immediate and large-scale consequences for local communities, ecosystems and the economy – for example, if drinking water sources are affected. In one incident in the Yangtze River basin, water supplies to nearly 1 million people were suspended when malfunctioning equipment at a fertiliser plant caused serious river pollution.[67] In another region, a serious explosion at a chemical factory, which caused five deaths, released 100 tonnes of benzene and other chemicals, and lead to the temporary shutdown of tap water supplies for 3.5 million people.[68]

It should not be assumed that the Yangtze River has an unlimited capacity to absorb and dilute industrial pollution. There is grave concern for the Yangtze River, because of the sheer scale of the industrial development that is taking place and because of the huge number of people whose livelihoods depend upon its waters. Contamination by hazardous chemicals is already measurable despite the volume of the river, and is also threatening the East China Sea. A plan that leads to 'zero discharge' of hazardous substances needs to be urgently implemented in order to avoid the potentially enormous costs of remediation, and before China's rapid economic growth pushes the Yangtze beyond its ecological limits.

'Many chemical and industrial enterprises are built along rivers so that they can dump the waste into water easily. Excessive use of fertilisers and pesticides also pollute underground water. The contaminated water has directly affected soil, crops and food.'[69]

Chen Zhizhou, a health expert with the Cancer Research Institute affiliated to the Chinese Academy of Medical Sciences

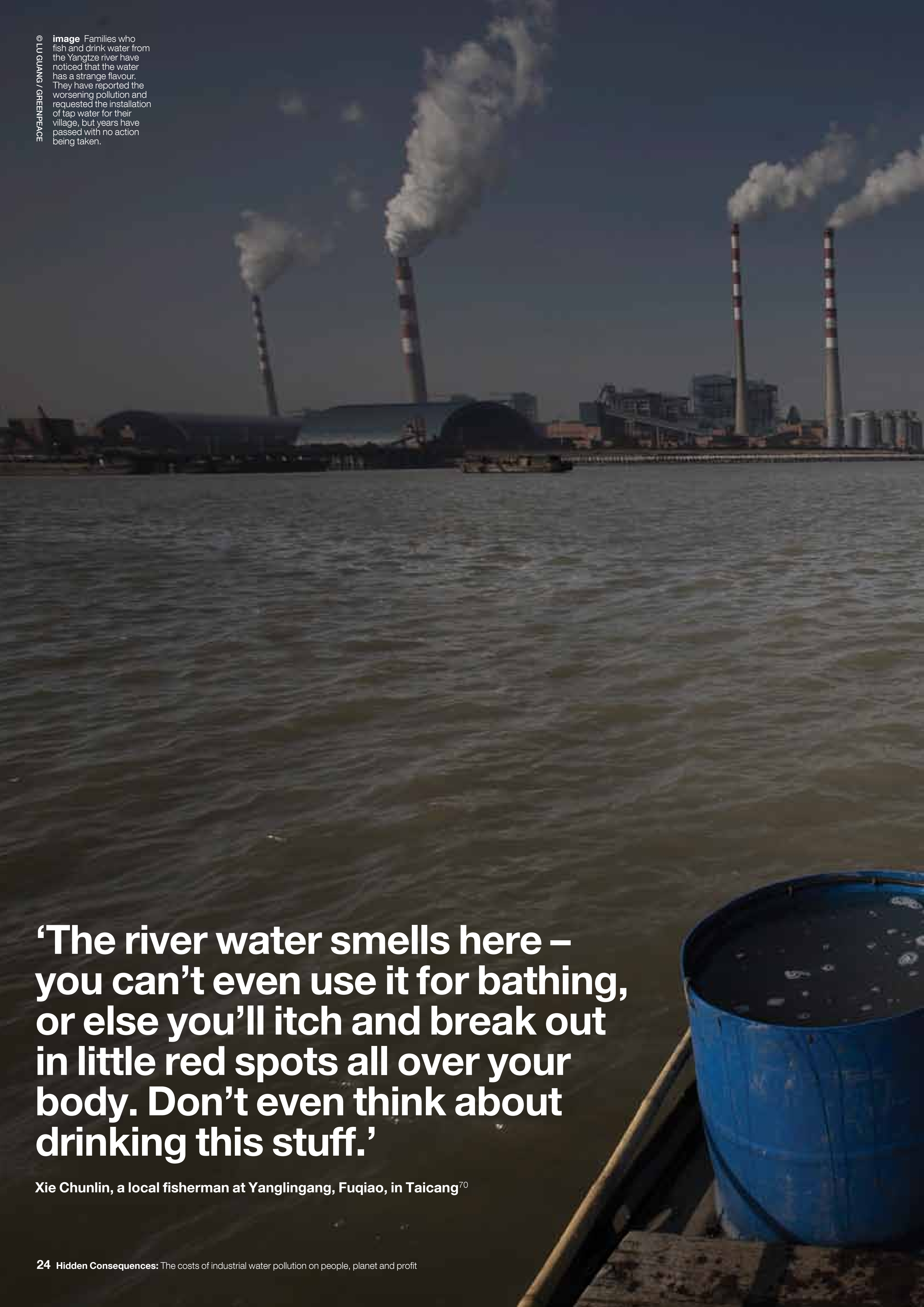


image Families who fish and drink water from the Yangtze river have noticed that the water has a strange flavour. They have reported the worsening pollution and requested the installation of tap water for their village, but years have passed with no action being taken.

‘The river water smells here – you can’t even use it for bathing, or else you’ll itch and break out in little red spots all over your body. Don’t even think about drinking this stuff.’

Xie Chunlin, a local fisherman at Yanglingang, Fuqiao, in Taicang[70]

Yangtze

image The arched roof of the clean-up hall at Bonfol, in Switzerland.

02

Learning from our past mistakes

Prevention is better than cure

The old adage 'prevention is better than cure' could not ring more true than in the case of industrial water pollution by hazardous chemicals. Once discharged into our water, many of these chemicals have the potential to persist over a long period of time, to accumulate through the food chain, to disrupt the human hormonal system and to inflict toxic effects on people, wildlife and the wider environment. The enormous environmental, social and economic costs of water contamination by hazardous chemicals experienced by countries in the Global North, and the short-term thinking that lay at the root of these costs, should serve as a stark warning to policy makers in the Global South.

In the past, governments have either been ill-informed about the serious threats that hazardous substances pose to aquatic ecosystems, or they simply decided to ignore the evidence. As a result, for decades authorities have granted licences to manufacturers, who were then allowed to pollute in the pursuit of profit. Often, this pollution has been in the form of the discharge of hazardous effluents and the dumping of hazardous chemicals in, or near to, bodies of water.

Consequently, many regions are now being forced to confront the realities of cleaning up the mess. This comes at many times the cost of what the industries concerned originally 'saved' by taking the 'cheap', short-term option. Recovering the financial costs from those responsible for the pollution is seldom an easy process, and it is often not possible at all. The other irreversible effects of pollution – such as those upon human health, wildlife and other economic activities in the area – are almost never fully compensated.

This section profiles four cases in Europe and the US where authorities have struggled to solve the problem of historic industrial water pollution. Two of these cases have been contributed by technical experts with an in-depth knowledge of the case concerned. These stories have taken decades to unfold, and in all cases are still ongoing – providing enduring testimony to the complex, if not impossible, nature of removing hazardous chemicals from water, sediments and the wider environment.

Box 1 Four cases of contamination – Four reasons to do things differently from now on

1 The case of the ‘Swiss Toxic Dumps’ is an example of the cumulative costs of clean-up operations as a result of short-sighted dumping of hazardous wastes in landfill sites – in this case by the chemical and pharmaceutical industries in Switzerland. A hub of industrial manufacturing activities, the Basel region has been subjected to decades of groundwater pollution. The culprits – among them Novartis, Roche, Syngenta and Ciba (now BASF) – are now confronted with their ‘past sins’ and the negative impact upon their reputations resulting from the intense debates in public and in court. They are also being forced to spend a lot of time, money and human resources to deal with the problem, with hundreds of millions of euros having already been shelled out on investigative reports and rehabilitation work.

2 The Hudson River in New York State in the US was, for decades, used as a disposal route for wastewaters from General Electric. These wastewaters contained the now banned polychlorinated biphenyls (PCBs), which together with other chemicals contaminated many kilometres of the river and the surrounding environment and wildlife. Although the direct discharges were halted around 30 years ago, the river and its surroundings remain seriously polluted. Drawing up and starting to implement restoration plans has been long and complicated. While work on the river itself has recently started, it will prove to be a long and very expensive process that will neither fully address the scale of the problem nor the legacy of the pollution.

3 The case of the ‘Polluted Sediments in the Dutch Delta’ further demonstrates the great difficulties we face in trying to effectively remove hazardous chemicals from a river system once they have been released. The case also shows how further problems with hazardous waste can be created as a result of the clean-up process itself, which in turn generates even more costs. While the polluted sediments are part of the legacy from the industrial expansion that followed the Second World War, it is the Dutch taxpayer who is forced to foot the bill today. This huge financial burden, caused as a result of industrial apathy, is financing the removal of heavy metals and organic chemical pollutants discharged into the rivers Rhine, Scheldt and Meuse – rivers that to this day remain critical sources of drinking water for millions of people.

4 Finally, the case of Chemko Strážske and the Laborec River in Slovakia shows the severe consequences of neglecting the impacts of persistent hazardous contamination. Like the Hudson River in the US, the Laborec River has been contaminated by the release of the now banned polychlorinated biphenyls (PCBs). The chemicals contaminated many kilometres of the river and the surrounding environment, including wildlife in the vicinity and the local population. Yet despite the promise of international help, and recognition that the area is one of the most polluted in Europe, progress in dealing with the pollution has stalled. As a result, the local population continues to be exposed to the hazardous chemicals – in spite of the significant health impacts that have been observed.

image General Electrics' Hudson Falls plant, USA

Case Study: The 'Swiss Toxic Dumps'

The cost of cleaning up Swiss landfill sites

By Martin Forter

Dr. Martin Forter, geographer and expert on the chemical industry, has studied – and critiqued – the Swiss chemical and pharmaceutical industry for many years as an independent researcher. He has published two books on the subject and has close contacts in the sector. Much of the information drawn on in this case-study is from internal documents formerly belonging to the companies that he has investigated and made available to the public in articles, books, newspapers and websites. *www.martinforter.ch*

Summary

Until the mid 1990s, the Swiss chemical industry chose to dump its chemical waste in landfill sites at the lowest possible price. This cheap but inappropriate disposal is now coming back to haunt companies through extremely high clean-up costs in the region of hundreds of millions of euros.

The Swiss town and agglomeration of Basel, on the borders of Germany and France, forms the heart of the country's chemical and pharmaceutical industry. The global businesses of Novartis, Syngenta, Ciba (now BASF), Clariant and Roche have their headquarters in this area.

Since the middle of the 19th century, the predecessors of Novartis et al. have based their production sites nearby. Initially, they mainly produced dyes, before moving on to the production of textile additives, plastics, agrochemical and pharmaceutical products.

image: Historical dumping of waste at the Bonfol landfill site.

Today, while the pharmaceutical industry still dominates the region, the era of mass production of chemicals in the Basel region is largely over. In the last 10 to 15 years, many chemical firms have moved their production to locations outside of Europe, particularly to Asian countries.

For several decades during the 20th century, the companies simply dumped their chemical wastes into landfill sites such as unsecured old gravel pits, with grave consequences for drinking water sources. However, in recent years, these chemical and pharmaceutical giants have been forced to re-excavate their chemical wastes. This has been due to a combination of increased public pressure – spearheaded by groups such as Greenpeace – and a tightening of Swiss law[71].

400,000 tons of chemical waste dumped 'cheaply'

Switzerland is often perceived as a small, tidy and clean country – but 50,000 contaminated sites spoil that neat image. Official government figures speak of 5 bn Swiss francs (€3.8 bn) to clean up these 'sins of the past'. The old dumpsites of the Swiss chemical industry feature among the worst-contaminated sites; they are also the most expensive to clean up.[72]

Between 1945 and 1996, companies from the Basel chemical industry disposed of around 400,000 tons of chemical waste, sometimes illegally, in at least 25 locations around Basel (in Switzerland, Germany and France) and in other parts of Switzerland. These locations included disused gravel pits or quarries.[73]

Today, this waste is polluting the groundwater, endangering and – in some cases – polluting the drinking water supplies of several hundred thousand people, particularly in the Basel region.[74] According to internal documents, this danger was recognised and acknowledged by parts of the chemical industry back in the 1950s, but monetary concerns took precedence over health and safety and the dumping of toxic chemical waste continued till the 1990s.[75] Government representatives have since stated that it should not have been acceptable for the government of the Canton of Basel-Country to authorise such dumping in the first place, particularly as other means of disposal were available to the chemical industry. At the time, these alternatives were generally believed to provide safer means of disposal, but were rejected on 'financial grounds'.[76]

Early attempts to shroud responsibility

During the 1950s, the companies responsible considered ways to conceal their role in groundwater pollution at the landfill sites. An example of this was documented in an internal company report from 1955, in reference to the Feldreben dumpsite at Muttenz, in the Canton of Basel-Country. This site is situated next to drinking water that supplies over 200,000 people. The report advised that, given the fact that several chemical firms used the same site at the same time, it would be 'practically impossible to establish' which of the companies would be responsible for any future pollution.[77]

In 1957, a predictable problem occurred: A bore hole between a chemical waste site in Feldreben and the drinking water wells spouted an orange brew smelling of phenol. At this point, the government of Basel-Country decreed a ban on the dumping of chemical waste in landfills, in order to protect the drinking water in the canton.[78]

Despite this ban, the chemical industry continued to deposit its toxic waste in close proximity to drinking water springs in the region. It moved away from the Swiss part of Basel, onto German and French soil and into other parts of Switzerland – as far as necessary, and only as a result of increasing public and political pressure.

In Germany, competitors began investing in different disposal techniques for chemical waste during this period.[79] The German chemical firm Bayer and chemical producer BASF each operated their own hazardous waste incinerators – Bayer from 1957 in Leverkusen and BASF from 1960 in Ludwigshafen. At the time, incineration was seen in Germany as safer and less polluting than direct landfill deposits.[80] This was despite the fact that it subsequently became known that incineration of hazardous wastes – especially chlorinated wastes, and under the conditions employed at that time – posed other hazards to human health and the environment.[81] As for the Swiss dumpsites, to fully 'clean up' the legacy of incineration would also have been very difficult – if not impossible.

In Switzerland, it was not until 1996, due to the tightening of Swiss legislation, that the Basel chemical industries stopped the direct dumping of chemical waste.[82]

Box 2 The financial burden of toxic legacies – How 'cheap' disposal at the time will cost the industry at least 800 m Swiss francs today

Up until 2010, the Swiss chemical and pharmaceutical industry (Novartis, Roche, Ciba (now BASF), Syngenta and others) has spent 800 m Swiss francs[83] (about €600 m) dealing with its previous environmental misdeeds. An estimated 1.5 to 2 bn Swiss francs (€1 to 1.5 bn) will be required in addition by the industry in the coming years, in order to clean up the chemical waste dumps as far as technically possible.[84]

The hidden consequences of the dumping of hazardous waste into landfills have cost the industry dearly. Having chosen the cheapest option at the time, companies are now paying a big price for cleaning up their 'sins of the past' – using inappropriate disposal methods has turned into a financial boomerang.

If the full costs of pollution, including those related to environmental damage, are consistently passed back to the polluter, it may drive home the message that long-term sustainable thinking and pollution *prevention* are more profitable than the short-term pursuit of the seemingly cheapest options – which often come at the expense of the environment.

It should also be considered that, however great the efforts now being made to address the problem, it is unlikely that the impacts and the costs resulting from the use and release of hazardous chemicals in the past will ever be entirely redressed. This case should therefore act as a warning to policy makers to further eliminate all uses of hazardous chemicals and their discharges, emissions and releases into the environment. 'Clean Production' is the only solution.

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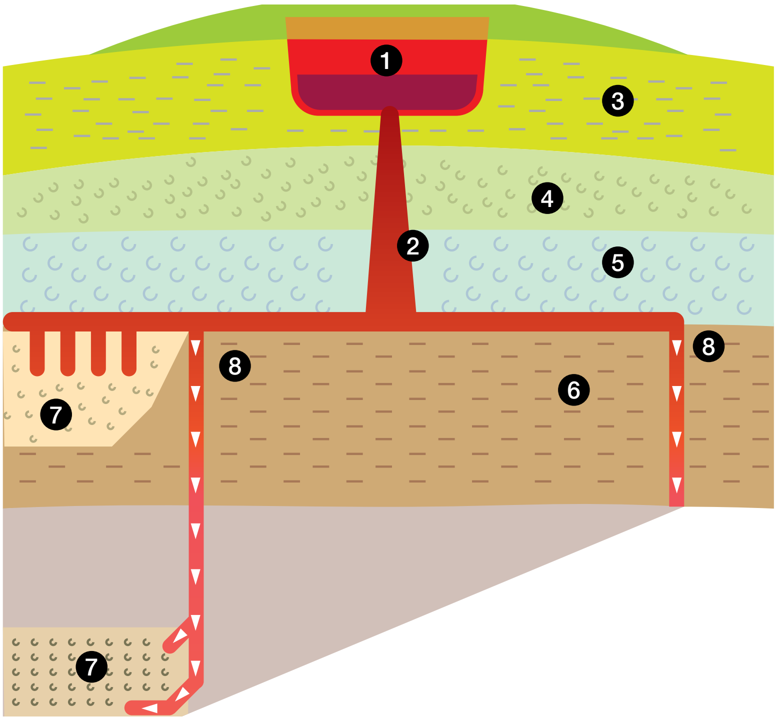
Bonfol Landfill: Today's costs amount to 3,000 Swiss francs per tonne

The case of one particular landfill serves as a useful illustration of the problems created. In Bonfol, in the Canton of Jura, Switzerland, directly along the state border with France, the companies of the Basel chemical industry – a consortium now consisting of Novartis, Roche, Syngenta, Ciba (BASF), Clariant and others – disposed 114,000 tonnes of chemical waste between 1961 and 1976.[85] Once filled, they covered the site with earth and then planted trees. However, the slowly leaking pit filled up with water, overflowed, and threatened to slide partially – or in its entirety – towards France. In the 1980s and 1990s, the industry tried to seal off the dumps in the region. However, as in the majority of such cases, this containment attempt failed.

Figure 1:
Possible emission path for hazardous chemicals at a typical waste dump (example taken from Bonfol, Switzerland) (*simplified, reproduction Greenpeace*)



Dumpsite

1) Mixed chemical waste

2) Dissolved hazardous chemicals

3) Natural clay layer

4) Rubble layer

5) Groundwater level

6) Argillaceous layer

7) Sandy layer, through which chemicals can travel

8) Geological ruptures, allowing chemicals to travel through the argillaceous layer

image: Construction of the clean-up hall at Bonfol

In 2000, Greenpeace Switzerland occupied the landfill site for two months and proved that the dump was heavily polluting the ground water and endangering sources of drinking water.[86] The cantonal government of Jura also demanded the complete clearance of the dump, with the support of the Swiss national Environment Agency.[87] Following the occupation, and under legal pressure from the cantonal government, the industry agreed to a total clean-up and rehabilitation of the dump in June 2000.

An 8-year dispute ensued among industry, authorities, environmental organisations and trade unions, as to how to excavate the 114,000 tonnes of mostly highly toxic chemical waste from the dump in a clean, safe and efficient way. This ended in court in 2008, with a settlement that allowed the environmental organisations to achieve most of their urgent demands, and which went beyond the requirements of a technically overwhelmed and financially threatened local government.[88]

Today, an enormous excavation hall measuring 150m x 120m is situated on top of the landfill as excavations begin.[89] The hall has a sophisticated air ventilation and pollutant treatment system to prevent releases from the site during operations. Arching steel girders hold the enormous roof from above, as it is not possible to place pillars within the perimeter of the dump to statically support the roof.

It is estimated that the clean-up operation will cost around 350 m Swiss francs (€270 m).[90] In the past, tipping one tonne of chemical waste into the Bonfol site cost the equivalent of 190 Swiss francs. Today, its excavation and subsequent treatment is costing around 3,000 Swiss francs per tonne.[91]

Le Letten Landfill: Today's costs amount to 7,500 Swiss francs for each tonne

A similar incident took place at Le Letten, in France, at another much smaller landfill site of about 3,900 tonnes of chemical waste[92], used by the same Swiss industries between 1957 and 1960.[93] Here, the total clean-up cost amounted to approximately 25 m Swiss francs, roughly 7,500 Swiss francs per tonne, as opposed to 33 Swiss francs per tonne (adjusted for inflation) for the original dumping.[94] Again, from an economic perspective, this case demonstrates that the dumping of waste and pollution into landfill sites does not pay in the long term.

images: Water sampling at Hardwasser AG, undertaken by Greenpeace Switzerland, in 2006

Hirschacker dump: Partial clean-up is not a solution

The Hirschacker dump in Grenzach, on the German bank of the Rhine, contains between 3,000 and 100,000 tonnes of chemical waste – according to industry estimates – and is situated right next to the source of drinking water for this German municipality. A 1978 investigation reported a 'colossally large' array of substances at the landfill site.[95] Yet, as a result of selecting a limited range of chemicals in the monitoring of the site later on – presumably to keep down costs – the clean-up has been limited to excavations at just two 'hot-spots' containing halogenated volatile organic compounds, such as tri- and tetrachloroethylene, within the larger landfill site.

Although three independent reports from 2007 state that the problem at the Hirschacker dump has not been solved by the partial 'hot-spot' excavations[96], the pharmaceutical company responsible – Roche – and the controlling authorities have not changed the design and scope of the remediation work. A particular problem was the insufficient classification of the excavated material. Due to the lack of comprehensive monitoring data, thousands of tonnes of excavated and contaminated materials were declared to be suitable for re-dumping. Subsequently, with the approval of the Lörrach District Office, these materials were again disposed of in the neighbouring German state of Rheinland-Pfalz and other locations. Consequently, it is still unknown which hazardous substances, and in what quantities, were re-dumped[97], resulting in the risk that new contaminated sites were created.

Worse still, at the original Hirschacker site, it has been witnessed that half-rotten barrels and other chemical waste residues, clearly visible on the edges and below the excavated 'hot-spots', were covered with soil again – probably with the aim of avoiding a bigger clean-up and in order not to exceed the approved budget for this partial clean-up.[98]

The costs for this partial clean-up so far have amounted to approximately €15 m, far more than the originally budgeted €4.8 m.[99] In addition, the polluted groundwater will need to be pumped and treated for at least another 20 years, which is not accounted for in the €15 m already spent.[100]

Box 3 **Playing Dirty:** Hazardous chemicals in dumpsites and drinking water

Approximately 5,000 to 7,000 different chemical substances from the Swiss chemical and pharmaceutical industry are believed to be present in the landfill sites in the region of Basel (Switzerland, France and Germany), according to a historical investigation.[101]

In individual waste samples from within the dumps, up to 600 substances have been detected[102], in the ground water next to these dumps up to 300 harmful substances have been found[103], and in the drinking water in the vicinity up to 40 harmful substances have been discovered[104]. The large quantities of different chemicals and the mixture of substances found are hardly manageable.

These chemicals include hazardous substances, such as chlorinated organic compounds with carcinogenic properties, for example 2-naphthylamine and hexachlorethane[105], the toxic hexachlorobutadiene, and other chemicals such as tetrachlorobutadiene – whose toxic effects are largely unknown. The chemicals found were typical for the chemical production of the time when the dumping in the region occurred. Methanesulfonanilide, for example, found in the drinking water at the Feldreben chemical waste dump near Basel, is an intermediate product for the fungicide Norsulfan, produced at the time by JR Geigy Ltd (now Novartis and Syngenta).

In order to keep this vast array of harmful substances at their dump sites concealed – and so avoid, or at least delay, the potential clean-up – the industry has been applying inappropriate methods for years. For example, no effort has been made to determine the full extent of pollution caused by its chemical waste dumps, and instead a restrictive ‘individual target substance analysis’ methodology has often been used. At the aforementioned dump of Le Letten, in France, this methodology entailed only looking for the presence of a small number of targeted substances within ground water samples. Where these substances were not found, the companies declared that the ground water was ‘clean’, despite not knowing whether other substances were present.[106]

Aware that individual substance analysis only results in the discovery of those substances that are being looked for explicitly, Greenpeace turned to a more comprehensive method of analysis. Using GC/MS screening, the organisation’s experts looked to detect as wide a spectrum of harmful substances as possible, including those that were not being expressly sought. Using this method, Greenpeace found 26 chemicals in the same ground water – including toxic, mutagenic and carcinogenic substances such as anilines and aromatic compounds.[107]

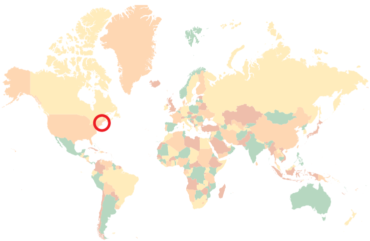
For far too long, the real extent of the pollution was unclear due to complacency by both the industry and the authorities, who applied selective monitoring methods. Environmental and consumer groups needed to call persistently for the complete elimination of chemical waste from the dumps and for the treatment of the drinking water that had become contaminated as a result of inappropriate disposal practices. They demanded that this be paid for by the producer, in accordance with the ‘polluter pays principle’.[108]

At first, the government of the Canton of Basel-Country rebuffed the call for the drinking water to be treated in the region of Basel, saying that the toxic load had always been clearly below the applicable limits.[109] However, at the end of 2007, as more and more pollutants became known which threatened the margins of safety, the government decreed that the drinking water must be treated and the hazardous chemicals removed from the drinking water supply.[110]

image: In March 2008, Greenpeace climbers hung banners on the chimneys of a CIBA building calling on the chemical industry to pay for the clean-up of their chemical waste sites in the area around Basel.

Greenpeace's conclusion on the case of the 'Swiss Toxic Dumps'

The case of the 'Swiss Toxic Dumps' illustrates what can be achieved when enough public pressure is brought to bear on politicians and industry, with regard to the industry's toxic legacy. Although severe damage has been done to the environment, there is a chance that at least some of it will be remediated, using the best available technologies. This clearly comes with a high price tag, which in this case is being paid by the companies responsible. However, the effort involved to make this happen, and the scale of the challenges that had to be overcome, must not be underestimated.



Case Study: PCB contamination of the Hudson River in the US

The 'Swiss Toxic Dumps' case is not an isolated incident with regard to the length of time required to try and clean up the damage caused due to the release of hazardous chemicals. A similar story can also be found in the US.

The Hudson River, in New York State, is one of the world's major polychlorinated biphenyl (PCB) pollution 'hot spots'. A huge stretch of the Hudson, classified as an American Heritage River[111], received wastewaters contaminated with PCBs for many years. The river is now the focus of a large-scale clean-up operation.

The Hudson has many unique and sensitive habitats – it is home to 200 species of fish, for example[112] – and is important recreationally and commercially. However, despite these factors, the clean-up of the river sediments only began in 2009. The process has involved many years of investigations, reviews and court actions, and pressure from numerous public bodies, stakeholder groups, environmental NGOs and tens of thousands of individuals.[113]

The source of the contamination is beyond dispute. The General Electric Company (GE) had two production plants at Fort Edwards and Hudson Falls, manufacturing electrical capacitors on the banks of the Hudson, 300 km upstream of New York City.

From the late 1940s until 1977, when the use of PCBs was halted, it is estimated that GE discharged – legally – up to 600 tonnes of PCBs into the river.[114] A large proportion of the chemicals (possibly between 200 to 300 tonnes) remain in the sediments of the Hudson.[115] PCBs from the GE sites are now found along the entire length of the river, up to the point where the Hudson discharges into New York Harbour.[116]

Although the GE plants are no longer in operation, serious contamination of soil, groundwater and bedrock underneath the production plants means that, even today, about 100 grams of PCBs are leaking into the river from contaminated ground on a daily basis.[117] This in itself is serious enough for the sites to be currently undergoing remediation work – requiring blasting and tunnelling into the bedrock to intercept the seeping PCBs.[118]

Inevitably, the long-term exposure has caused widespread contamination of the wildlife along the Hudson. Monitoring has been under way since 1969. At one point, fish were found with levels of PCBs of over 1,000 mg/kg[119], far above the 0.05 mg/kg that would allow unrestricted fish consumption[120]. As a result, fishing and recreation on the Hudson have been severely limited and closed in many areas. Women of childbearing age and children under 15 are specifically advised not to eat fish from the Hudson, and strict limits on fish consumption have been imposed on the rest of the population.[121]

The pollution has spread well beyond the river's banks. Terrestrial species in the vicinity of the river, such as earthworms, shrews[122] and bats[123], became contaminated as PCBs passed through the food chain. Predators higher up the food chain, such as owls, falcons and eagles, are then also exposed to the risk of contamination.[124]

Box 4 Polychlorinated biphenyls (PCBs)

Figure 2. Chemical structure of the 3,3',4,4'-Tetrachlorobiphenyl (PCB 77 congener) molecule.

PCBs are a group of synthetic chlorinated organic chemicals comprising over 209 individual compounds (called congeners), each consisting of two linked benzene rings with chlorine atoms in different positions (see Figure 2). PCBs have been used in a wide variety of applications, including transformer oils, capacitors, hydraulic fluids, plasticisers, printing inks[125], carbonless copy papers and some personal applications such as 'kiss-proof' lipsticks.[126] They are highly stable and resistant to degradation, and bind strongly to soils and sediments.

Restrictions on the use of PCBs, including in EU countries, began in the 1970s, when their ability to accumulate in the environment and to cause harmful effects became apparent.[127] PCB production ended in Japan in 1972[128], after a serious outbreak of disease caused by contaminated rice oil in 1968[129]. The production of PCBs was banned in the US in 1979.[130]

At least one third of the PCBs that have been produced are now estimated to have entered the environment.[131] The other two-thirds remain in old electrical equipment and in waste dumps, from which they continue to leak into the environment, including when obsolete equipment is dismantled, recycled and/or disposed of. PCBs can also be produced during the combustion of chlorinated organic materials, including polyvinyl chloride (PVC).[132]

Once released into the environment, regardless of the source, PCBs are highly persistent. Their properties mean that PCBs can be transported around the globe and affect communities and ecosystems far from their site of production or use.[133] Airborne PCBs can be deposited in colder regions; for example, elevated levels of PCBs are found in polar bears[134]. Furthermore, PCBs can bioaccumulate and, in aquatic organisms and fish, levels can reach many thousands of times higher than the levels in the surrounding water.[135,136]

For the general population today, food is undoubtedly the primary route of exposure to PCBs[137], although dermal exposure may be dominant among those directly handling PCBs or PCB-contaminated materials[138].

PCBs exhibit a wide range of toxic effects in animals, including immune-suppression, liver damage, tumour promotion, neurotoxicity, behavioural changes and damage to both male and female reproductive systems.[139,140,141]

PCBs may also affect many endocrine systems.[142] Although it is difficult to assess their impact on animal populations in the wild – not least because they are exposed to complex mixtures of chemical contaminants – some immunological and reproductive disorders in marine mammals have nevertheless been linked to elevated levels of persistent organochlorines, in particular the PCBs.[143]

The control of PCBs is addressed under many international legal instruments relating to environmental pollution (*inter alia*, the Barcelona, Helsinki, Basel, Bamako, Rotterdam, OSPAR and Long-Range Transboundary Air Pollution Conventions, and the International Joint Commission on the Great Lakes). In addition, PCBs are subject to a global production ban under the 2001 Stockholm Convention on Persistent Organic Pollutants – a treaty that also requires proper controls on the destruction of stockpiles and the handling of wastes.

Deliberations and delays on cleaning up

The river and contaminated plants are now a US Environmental Protection Agency (EPA) Superfund site, one of over 1,200 abandoned hazardous waste sites in the US targeted for clean-up.[144]

However, deliberations regarding the clean-up operation have gone on for over 30 years. In 1984, the EPA initially declared that 'No Action' was needed with respect to the river sediments, while taking action on some other aspects of the case. The justification for this 'No Action' decision was that, according to the agency, a 'technologically feasible, cost-effective remedial response to the PCB-contamination in the riverbed that would be reliable and would effectively mitigate and minimise damage to public health, welfare and the environment is not presently available'.[145] However, a reassessment led to a decision in 2002 to remove a large volume of sediments from a 60 km stretch that was the most severely contaminated. Despite several attempts by GE to limit responsibility and financial liabilities, such as filing a lawsuit in 2001 challenging Superfund provisions[146], the EPA reached an agreement in 2005 that GE should be held responsible for the necessary dredging[147].

This dredging to remove contaminated sediments began in 2009. The first phase of a 6-year project has focused on cleaning just a 9 km stretch of the Upper Hudson River, but it should also improve the stretches downstream by reducing the pool of PCBs that can move there.[148] The programme has involved a huge sampling survey, consideration of the best timing and dredging technology, a dewatering facility to separate sludges from water, water treatment facilities to remove PCBs from the water, disposal of the contaminated sludges (at a landfill in Texas), habitat restoration and public information initiatives.[149]

Nevertheless, the mobilisation of sediments and PCBs that occurs during the dredging process also results in the transfer of PCBs downstream. Dredging was halted a number of times when downstream concentrations of PCBs rose above target levels. Considerable testing took place both during and after dredging in order to monitor the impact of the remediation works downstream and improve procedures for the next phase.

Capping of sediments – as opposed to removal – has also been controversial. GE had been trying to extend the amount of capping that it could undertake[150], but it has now been agreed that the second phase will incorporate more rigorous dredging[151].

Even though Phase 1 of the operation is a relatively modest part of the overall job – only 10% of the targeted sediments were addressed – the scale of this task is noteworthy. Some 500 people were employed and the area of the river tackled amounted to around 20 hectares. Initially, an even larger area was to have been addressed, but contamination more widespread than originally estimated forced a scale-back of the plans.[152]

Although the overall cost of remediation is not known, GE claims that it has already spent over $800 m US dollars[153] and anticipates that costs could amount to $1.4 bn[154]. The work amounts to a mammoth effort, and the river will certainly become much cleaner upon completion. The PCBs, however, will live on in a landfill site in Texas. There, they present the possibility of another clean-up cost, handed down for future generations to pay.

The consequences of contamination time bombs

The clean-up and environmentally acceptable destruction of PCBs and other hazardous chemicals is a matter of great concern that urgently needs addressing. Given the extensive amount of information about the global cycling of PCBs[155], polluted sites such as the Hudson River and the Laborec River (described later in this section), are a concern not only for the local populations living near the affected areas, but also for the global community at large. The PCB problem reaches far beyond the worst affected hotspots. As a result of widespread use in the past, PCBs can now be found in some of the most remote places of the planet.[156]

The case of the Hudson River is just one example of many, involving only a single company. Yet the scale of remediation work and the costs involved – be they financial, social or environmental – are enormous. The following case of the 'Polluted sediments in the Dutch Delta' further demonstrates the great difficulties we face in trying to effectively remove hazardous chemicals from a river system once they have been released, and the impossibility of total decontamination.

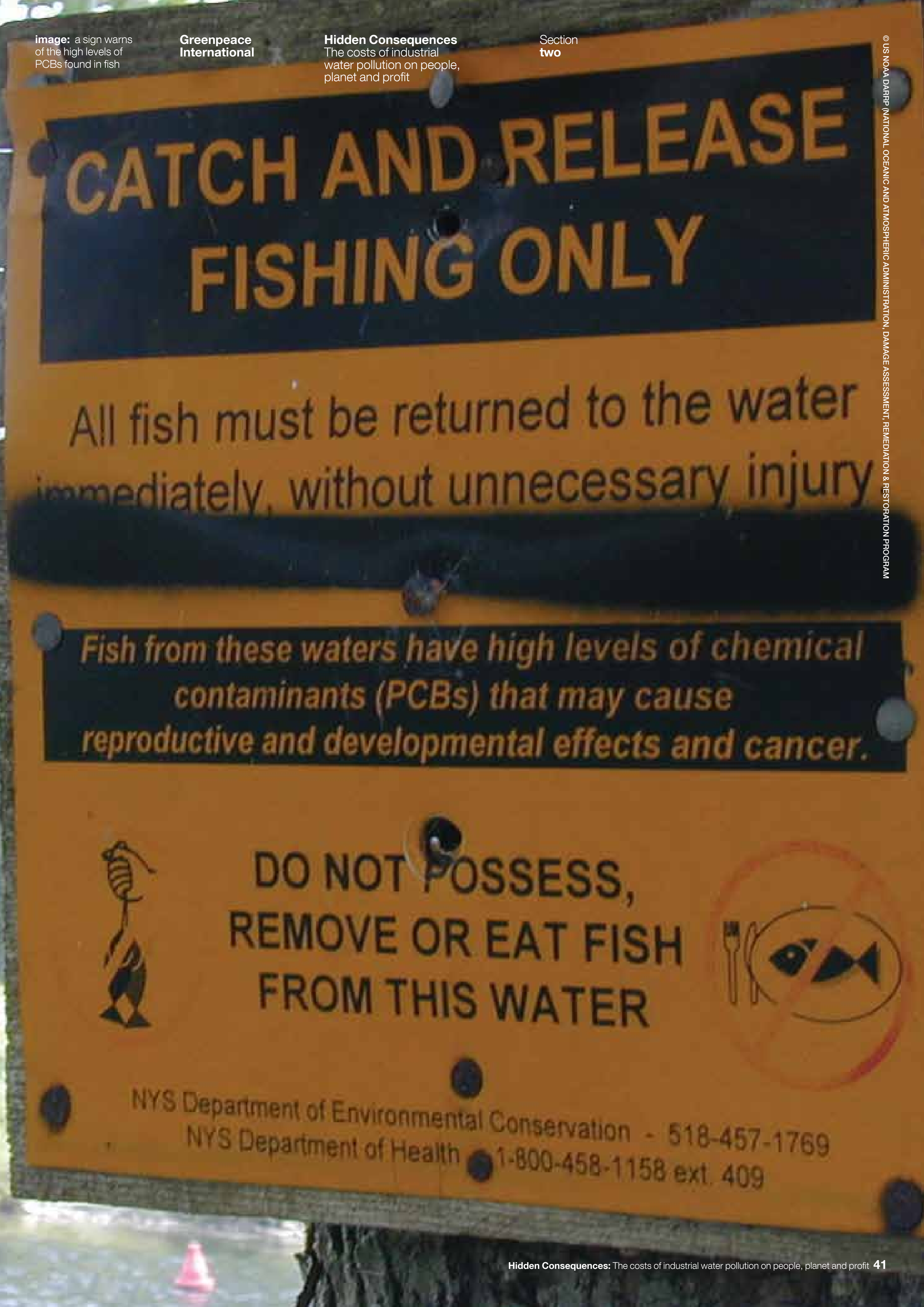


image: a sign warns of the high levels of PCBs found in fish

Case Study: Polluted sediments in the Dutch Delta

Cost analysis of efforts to clean up sediments contaminated with hazardous chemicals

By Aldert van der Kooij

The author is a principal consultant at DHV, a leading international consultancy and engineering firm, providing services and innovative solutions in environment and sustainability, general buildings, manufacturing and industrial process, urban and regional development and water.

Much of Aldert van der Kooij's work has dealt with water and sediment quality, including designing strategies and solutions for the rehabilitation of contaminated waterways. He holds several technology patents relevant to his subject. In 2003 the Dutch engineering association awarded him 'Engineer of the Year'.

The Netherlands is a victim of its geographical location when it comes to water pollution. The contamination of sediments in the Delta region is caused mainly by heavy metals and organic chemical pollutants like polychlorinated biphenyls (PCBs), pesticides, polycyclic aromatic hydrocarbons and mineral oil. The Netherlands, with its location at the downstream end of some major Western European rivers, is particularly vulnerable to sediment pollution by these contaminants. Indeed, as sediments in upstream parts of the river Rhine and its tributaries are still contaminated, they continue to be a serious threat for future dredging maintenance and create costs for Rotterdam and other ports.[157]

The history of accumulating pollution in sediments

The Dutch Delta was created as a result of the flow of the rivers Rhine (Dutch: Rijn), Meuse (Maas) and Scheldt (Schelde). The rivers act as natural transporters of sediments[158], which settle out when broader and calmer waters are reached, particularly in downstream sections. The Dutch Delta receives an estimated 8 million tonnes of sediment via the rivers and about 25 million tonnes via the sea every year.

This creates an extremely fertile delta region. It naturally attracted a large population and became home to some of the busiest harbours and industries of the world around cities like Antwerp in Belgium, and Amsterdam and Rotterdam in the Netherlands, all of which are extremely important economically.

Maintenance dredging is naturally crucial to the harbours and ports of the region to maintain the navigability of its waterways and general water management. Nowadays, about 50 million m^3 of sediment a year are dredged from the waterways.[159]

The post-World War Two boom and western industrialisation brought many new industries along the rivers, including chemical, petrochemical and ore-processing units. The wastewater discharges from these industries contributed to poor surface water quality and contaminated river systems. In addition, the use of pesticides in agriculture, municipal wastewater discharges and an increase in traffic and other sources of air emissions contributed to diffuse inputs into the rivers and other bodies of water. The result was a mixture of chemicals, leading to water pollution that originated from industrial, agricultural and municipal sources. The more soluble chemicals largely stayed in the water and were transported towards the North Sea. Others settled out in sediments, where they remained adsorbed to organic matter and clay particles. Some types of chemicals do degrade easily – persistent inorganic and organic chemicals do not. The latter – including heavy metals and PCBs – form a persistent threat to aquatic life, surface water and ground water.

As the Rhine and Meuse were – and still are – sources of drinking water for millions of people, the Clean Surface Water Act in 1969 forced polluters in the Netherlands to treat wastewaters. Large investments in municipal and industrial wastewater treatment plants led to an improvement in the quality of the surface waters. However, contamination of river sediments and pollution from upstream sources beyond the Netherlands still posed a big problem. In 1985, a fire at the Sandoz chemical company in Switzerland triggered an international plan. The International Rhine Committee – comprising all countries in the Rhine tributary: Switzerland, France Germany, Luxembourg and the Netherlands – joined hands to improve water quality. Similar cooperation started with reference to the rivers Scheldt and Meuse in the 1990s.

However, the problem of polluted sediments at the bottom of the rivers, harbours and canals remained unsolved. Investigations beginning in the 1980s confirmed that the Dutch Delta was highly contaminated with pollutants such as heavy metals, PCBs and polycyclic aromatic hydrocarbons.[160,161]

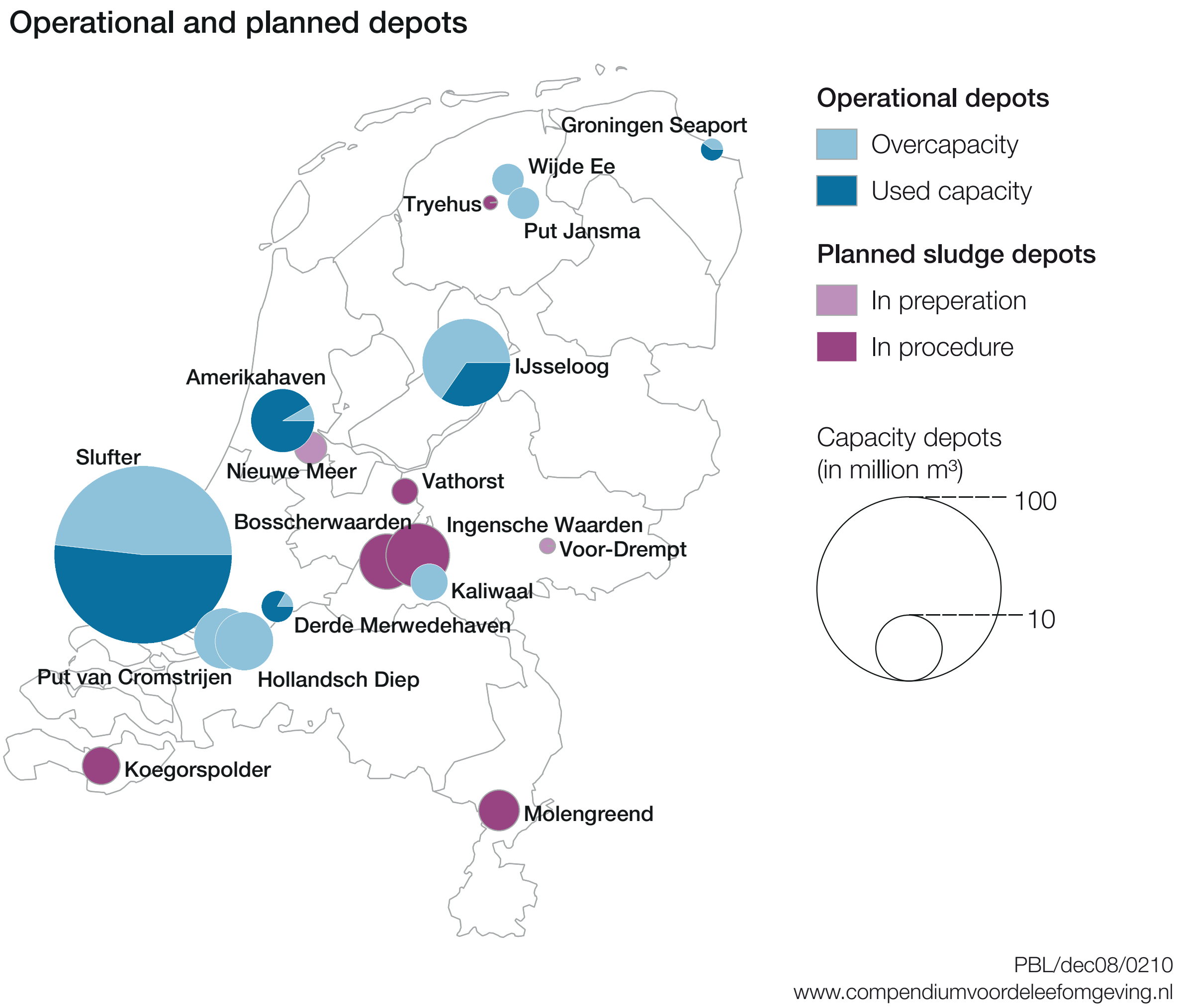
Dutch legislation[162] prohibited the dumping of contaminated dredged material into the North Sea, but dumping had been common practice in the past, as it was expected that the material from the Rotterdam harbour area was not polluted. Now the knowledge that much of the sediment was contaminated with hazardous chemicals has forced a new approach. Dumping into the North Sea is currently only allowed if the dredged material respects the relevant standard.[163]

Technical treatment: Storage and processing

The Dutch government embarked on a two-pronged strategy to deal with the issue of contaminated sediments. It built large depots for the storage of contaminated dredged material – from the end of the 1980s up to 2007 – while simultaneously researching to develop methods to process these contaminated sediments into materials that would be applicable and safe for use in the building industry.

With estimates of the amount of contaminated sediments to be dealt with varying between 29 million m^3 to 231 million m^3, the Dutch Ministry of Transport, Public Works and Water Management and the city of Rotterdam built a depot in 1987 with a capacity of 150 million m^3 to store contaminated material from the Rotterdam harbour area. The volume of this Slufter depot was calculated to be large enough to store dredged materials until roughly 2003. Later, other depots were built, resulting in a total storage capacity of about 225 million m^3.[164,165]

Figure 3: Depots for contaminated dredged material in the Netherlands.[166]



PBL Netherlands Environmental Assessment Agency, from original source: RWS/AKWA-DWW (2003, 2008).

Many calculations were carried out on the risks of the migration of pollutants from sediments and their uptake into organisms. Although the binding of pollutants to sediments may be strong, there is always a small desorption, causing fluxes to the groundwater and surface water. The results of the calculations showed that there would always be some pollution of the groundwater in the very long term, albeit at relatively low concentrations that do not exceed the current Dutch standards.[167]

Research, meanwhile, began focusing on how to process contaminated sediments into reusable materials – like sand, clay, gravel, basalt and bricks – that could meet relevant Dutch building product standards. Many pilot projects were executed, in order to demonstrate the practical applicability of the treatment process as well as the final product.[168,169,170] A variety of techniques have been developed. While some usable products can be obtained, the processes to achieve acceptable levels of decontamination are – compared with storage – costly, intensive and time-consuming, and require special precautions in use.[171]

Four techniques are described below:

1. Dewatering, ripening and land-farming

Dredged material is turned into soil (sand, clay and/or peat soil) by removing water. The dewatering is carried out mechanically or via drainage ditches. The material is then ripened in contact with air, allowing many organic materials to degrade through biological activity. However, heavy metals and persistent organic compounds (such as PCBs and DDT) are not broken down during this process. To be used, materials from this process would need to meet Dutch product standards (for example for use in the recovery of industrial sites and road building). If not, they must be regarded as inapplicable waste materials.

The ripening process is rather time-consuming. Under normal circumstances, the ripening of a one-metre layer of dredged material could take up to two years. In addition to this, the buying or renting of land also involves major costs.

2. Sand separation

This is a common technique used in the region, as the law requires sand to be separated out if the dredged material is more than 60% sand. As contaminants adsorb primarily into the fine and organic fractions, the sand fraction is less contaminated and can be used as a raw material. Conversely, the contaminants are concentrated in the residues, which then require further processing or storage.

3. Chemical immobilisation

Contaminated substances are fixed with hardened substances, by mixing dewatered dredged material with a binding substance, usually cement, to create building material for roads that can act as a very stable foundation layer. Tests show that metals immobilised in this way[172] are to a great extent ‘fixed’, meaning that the potential for long-term environmental releases of hazardous heavy metal substances is greatly reduced[173], compared to the disposal via landfill of untreated dredged sediments. Life cycle analysis shows a similar level of environmental improvement as with sand separation.[174]

4. Thermal immobilisation

The aim is to change the structure and the chemical properties of the material at high temperatures, and to produce building materials such as gravel, bricks and basalt. Metals are immobilised, and organic pollutants (such as polychlorinated hydrocarbons and mineral oils) are virtually destroyed by the high temperature combustion process. However, as the destruction may not be complete – and new hazardous substances such as chlorinated dioxins may also be generated – a cleaning system for off-gasses is still required, and this can generate potentially hazardous wastes, that require disposal. In spite of several pilot projects, thermal immobilisation is not an operational technology at the scale that would be required to make the process economically viable. The need for long-term contracts has also proved to be a barrier.

It should also be mentioned that none of the above technologies – despite their high costs – is able to achieve the complete prevention of future cycling and releases of the contaminants and hazardous substances back into the environment, via the waste fraction.

The financial burden of processing contaminated sludge

Dredging and processing dredged material is an expensive proposition as a whole. Before any dredging work starts, a detailed site investigation and survey is required.[175] In uncontaminated areas the costs of site investigation range between €0.1 and €0.3 per m^3 of sediment to be removed, but in contaminated areas this cost can rise up to €1 per m^3.

The differences in costs of dredging uncontaminated and contaminated areas are also significant. In the Netherlands, the costs of removal for contaminated sediments may be up to between 3 and 15 times higher per cubic metre than the cost of removing uncontaminated sediments.[176]

The cost of the depot must also be taken into account. The building costs for the large depots in the Netherlands have been estimated at approximately €160 m[177], equating to a minimum of €2 per m^3, with this figure not including the inevitable maintenance and operation costs that depots entail. Additional costs are also charged for operation, maintenance and monitoring releases of pollutants. The costs of storing contaminated dredging spoil in large depots such as IJsseloog, Slufter and Hollands Diep vary at around €10 per m^3 sediment. Private depots, mostly former sand and clay extraction pits along the rivers, are more expensive still, at around €20 per m^3 sediment.

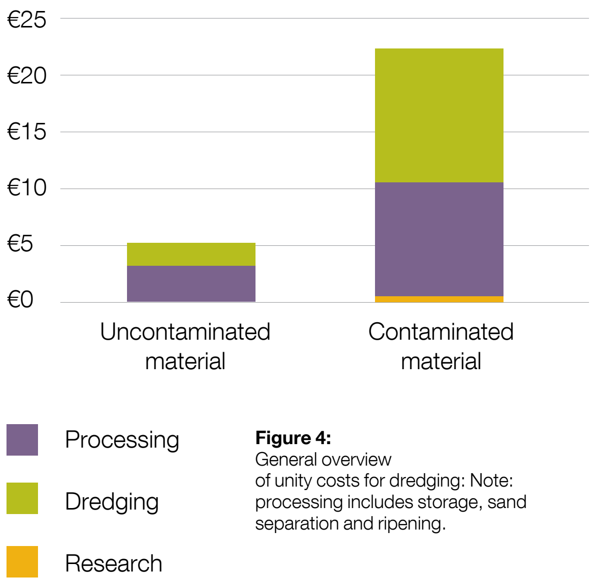


Figure 4:
General overview of unity costs for dredging: Note: processing includes storage, sand separation and ripening.

The cost involved in the processing of sediments can vary widely, depending on the volumes to be processed and the possibility of using any derived materials.[178] However, at present, the ripening or storage of contaminated dredging material in allocated depots, combined with sand extraction, is the only feasible solution. The cost of more complex processing, such as chemical or thermal treatment, is too high for the Dutch economy (at two to three times the cost of dewatering or sand extraction). Storage is generally a cheaper option, and changing legislation and priorities are currently decreasing the incentive to invest in advanced technologies.

A rough estimate shows that, on average, between 1987 and 2009, about 6.8 million m^3/year of contaminated sediments in the Netherlands were dredged, with a total volume of approximately 160 to 165 million m^3. As the additional costs[179] of dredging and processing contaminated sediments are on average €17 per m^3 higher than those for uncontaminated sediments, the economic damage can be estimated to be €2.8 bn for the period (approximately €120 m a year on average).

On the whole, this money is spent simply moving the contaminated sediments and associated hazardous substances into storage. More complex thermal or chemical treatment would add roughly €1.3 to €2.9 bn to the total costs, as unit costs vary between €25 and €35 per m^3 sediment. This additional treatment would result in materials with higher added values than stored materials in depots, but would still not completely solve the problem of potential future cycling or releases of contaminants. However, simply leaving contaminated sediments where they are would cause even greater economic damage – especially to shipping trade, water management and ecosystems – and have negative repercussions on fishing, land value for building, and tourism.[180]

Lessons

Sediments reflect the history of a water body, even if the current water quality improves. Wastewater treatment and the elimination of persistent hazardous substances are not only necessary for cleaner water, but are also necessary to prevent the additional pollution of sediments.

For many years, the Netherlands has looked for standards to judge the degree of pollution. Lots of research has been done, resulting in changing standards and their implementation, which have, in turn, also been influenced by political decisions. Indeed, this has been a process whereby scientists propose standards based on ecological, human and financial risks, where engineers propose solutions, and where politicians decide how much money can be spent to solve the problems.

Nowadays, the concern has shifted towards a more information-rich, risk-assessment-based approach. This is partly due to the high costs associated with the management of sediments – namely the incremental costs of cleaning up less contaminated areas (as 'hot spots' have already been dredged at great cost) – and partly due to the implementation of the EU's Water Framework Directive (WFD) – which has requirements regarding water basin planning, the 'whole systems approach'[181] and the use of environmental quality standards. These factors have meant that the Dutch government is increasingly focusing on 'managing' (in other words 'monitoring') contaminated areas, and on conducting risk-assessments within the context of a regional systems approach.

This systems approach results in the identification of new risks (like the threat posed to the ecosystem by mobilisation of contaminated sediments during extreme floods), but it also means that the remediation and cleaning of sediments currently takes a lower priority. Monitoring of both chemical and biological parameters has become much more important than taking the more simple approach of removing all the contaminated sediments, as a result of the increasing costs of dredging beyond the 'hot spots'.

After decades of exposure to persistent and hazardous substances, and with financial issues at stake, the water and sediment quality of the Dutch Delta is likely to be compromised for a very long time. More and more, it appears that dealing with risks, dealing with uncertainty, and risk communication have become increasingly important issues. Social, more interactive learning on this issue is also set to become more prominent, in the form of participatory processes, stakeholder involvement, and shifting from a mindset of 'learning to manage' to 'managing to learn'.

Greenpeace comments and conclusions on the Dutch Delta polluted sediments case

The Dutch Delta region provides a useful lesson on the management and costs of processing contaminated sediments, caused by decades of chemical waste 'disposal' upstream, which in this case originated from rivers passing through multiple European countries. At one time these rivers were so grossly polluted – with both municipal sewage and industrial wastes – that almost no fish could be found in the water, while the pollution posed real risks for human health.[182] In fact, by the 1970s, the Rhine had become so polluted that the river was often referred to as a 'dead river'.

While industry has clearly contributed to the pollution – especially pollution from hazardous chemicals – the considerable financial burden of restoration has been passed on to the Dutch government. This is because contamination cannot be traced back directly to the original, individual polluters. However, the narrative of Aldert van der Kooij (DHV) makes this huge expenditure of public money transparent for the Dutch public, and sends out a clear warning to policy makers around the world about the true costs of releasing hazardous chemicals into our shared water supplies.

In recent decades, the surface water quality has improved due to stronger European legislation and the transition of industry towards the reduction and elimination of discharges of some of the most hazardous chemicals. However, ambiguities created by the EU's Water Framework Law and its risk-based approach to environmental contamination (so-called environmental quality standards), may cause some distractions from the objective of eliminating all releases of the most hazardous chemicals into the aquatic environment.[183]

image:
The Rhine-Meuse-Scheldt delta is a river delta in the Netherlands and Belgium formed by the confluence of the Rhine, the Meuse and the Scheldt rivers. The economic importance of the Rhine-Meuse-Scheldt delta is enormous, since the three rivers are important navigable waterways.

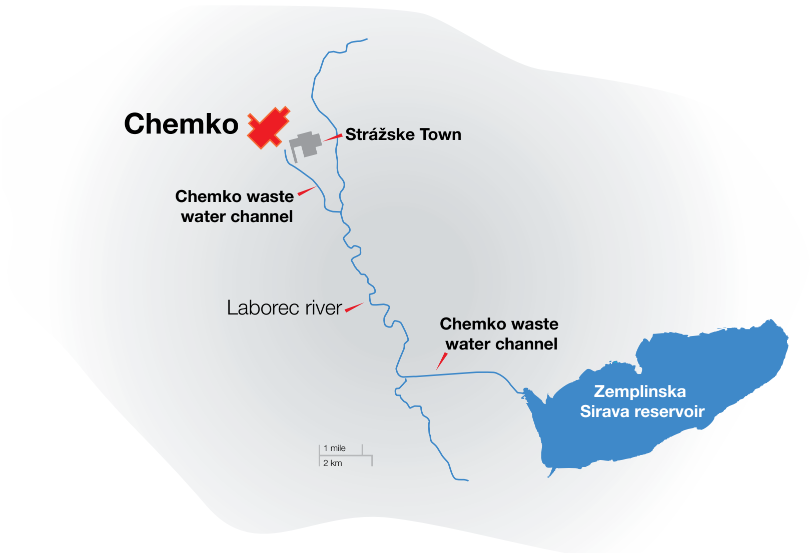
Although somewhat reduced, the burden of the contaminated sediments nevertheless remains. This is due to historic pollution and the ongoing discharges of persistent organic and inorganic pollutants transferred from upstream sediments.[184] In this respect, the Dutch Delta case illustrates clearly that dredging does not fully solve the problem. For the most part, it simply moves contaminated dredged material into large storage sites, effectively shifting the problem from one place to another, and all at a very high expense.

Estimating the full cost of such pollution is a virtually impossible task. Subtle toxic impacts on humans and wildlife, which could affect health, reproduction and/or behaviour, may be unknown, and the potential impacts caused due to mixtures of pollutants are rarely considered. The risks of long-living persistent substances may also be difficult or impossible to gauge in the long term.

So, what is the real price of the pollution and who has to pay? As this case demonstrates, often – due to a lack of causal evidence and the number of facilities involved – it is hard to make the upstream polluters liable for the hidden consequences of the pollution that they *de facto* caused. Ultimately, it is the taxpayers who then have to bear the burden of the costs that industry has successfully managed to externalise. All the while, hazardous chemicals continue to accumulate downstream with the flow of the river, and sadly it is only the 'polluter pays principle' that is watered down.

The problem of getting the polluter to pay – even when it is just one company – is brought sharply into focus in the following story.

Case Study: Chemko Strážske's persistent PCBs in the Laborec River in Slovakia



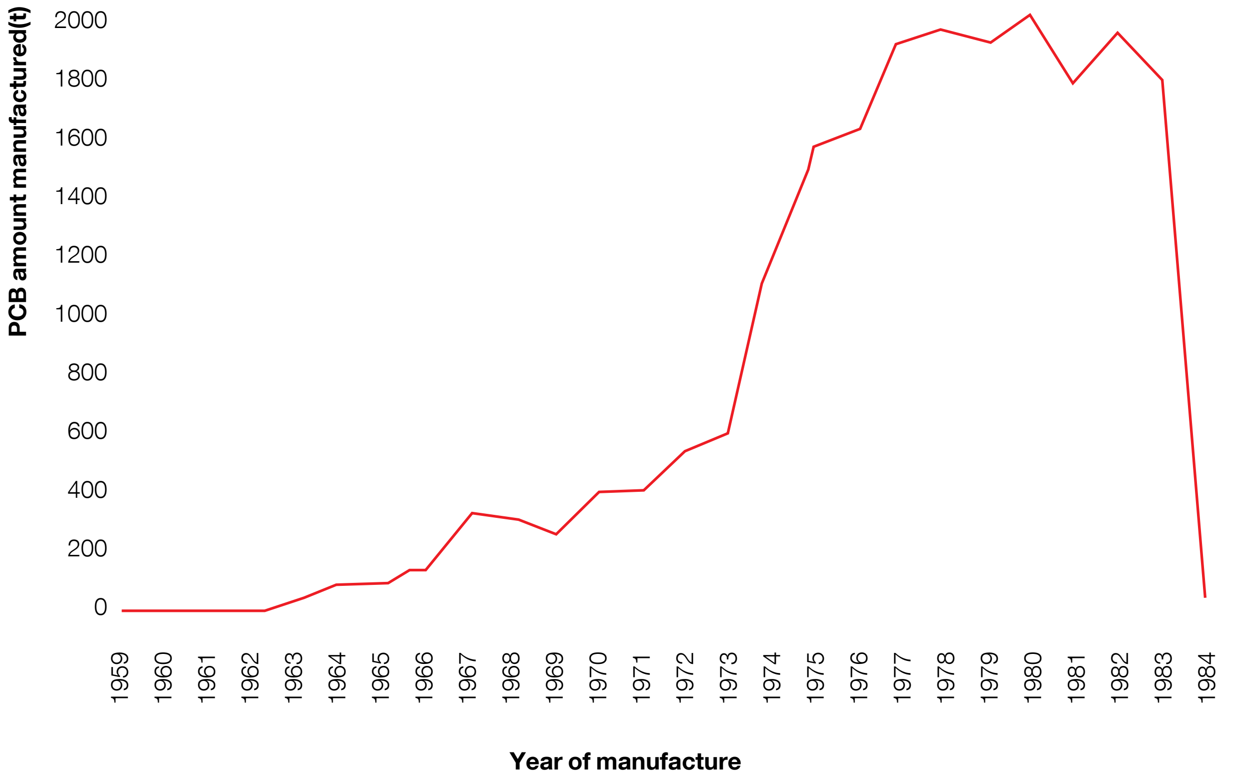
The Chemko plant at Strážske, situated in the Michalovce district, eastern Slovakia, together with its subsidiaries, was one of the most important chemical companies in Central Europe.[185] Founded in 1952 as a 'national enterprise', it primarily produced explosives and by-products for military and civilian purposes.[186] Nearly 21,500 tonnes of PCBs were produced between 1959 and 1984[187], about half of which were exported. This equated to approximately 1.5% of the world's PCB production up until 1984[188], when production was finally shut down[189]. Chemko is now in liquidation, but several hundred tonnes of PCBs remain in the buildings[190], awaiting destruction. In the meantime, the results of past production by Chemko Strážske continue to cause serious contamination of the environment.

The dangers of poor waste management

Under the former planned economy system, poor waste management – combined with ignorance and complacency about the consequences – resulted in widespread contamination of highly toxic and persistent PCBs.[191] In 1980, suspicions were raised about the health consequences and water pollution at Strážske. One alarm signal was the high incidence of a particular kidney defect being reported in the Michalovce district. This led to an investigation that pointed to PCB contamination as the main cause. Drinking water inlets were closed and new drinking water sources had to be found.[192]

During its processing operations, the factory had been discharging vast quantities of PCBs, resulting in serious ramifications for the entire region. Investigations have shown that the waste channel, surface waters and the sediments in the river and the downstream reservoir were – and still are – contaminated. Between 1997 and 1998, over a decade after the factory officially closed, extremely high levels of PCBs – up to 5g/kg – were measured in the wastewater channel.[193] This channel leads to the Laborec River, which in turn enters the Zemplínska Šírava reservoir, a huge lake created by diverting part of the Laborec. At one time, the reservoir – a major recreation area in eastern Slovakia – had over a million visitors every year, but these numbers have since fallen dramatically.[194] It is estimated that several tonnes of PCBs remain in the sediments of the reservoir itself, contaminating approximately 40,000 tonnes of sediment.[195] In addition to this, the river and reservoir are part of the Danube basin, meaning that the site is also of international significance, given that the waters move downstream through other countries.[196]

Figure 5: Amounts of PCB formulations manufactured by Chemko Strážske, 1959-84.[197]



The pollution is widespread

A waste dump at Chemko Strážske also shows high levels of PCB contamination, and the municipal landfill for Michalovce may similarly be contaminated by waste from the factory – contributing to ambient air and soil contamination in the district.[198]

The consequences also extend beyond the natural environment – with fish, wildlife and humans all having accumulated PCBs in their bodies. Fish from the area, for example, contained PCB levels about 100 times higher than those caught in an upstream, upwind district. Game animals from local forests have also shown elevated levels of PCBs.[199]

Humans are similarly contaminated, with high levels of PCBs having been found in the breast milk of women in the area, which can be passed on to the next generation by nursing mothers.[200] Residents who eat locally-reared food, such as eggs and chicken, for example, have also been found to have higher blood serum levels of PCBs.[201]

Peoples' lives have been directly impacted

While many people still live and farm in the area[202], studies have found that it is one of the areas most polluted with PCBs in the world. It has also been noted that residents in the Michalovce region have some of the highest PCBs levels ever monitored.[203]

Studies in the area have found numerous adverse health impacts linked to the PCB levels, such as enlarged thyroid glands[204], enamel defects of permanent teeth in children[205], (sub-clinical) hearing effects[206], impaired mental health development[207], smaller thymus volume in newborns (suggesting impaired immunologic development)[208], and neuro-behavioural impairment[209].

Professor Trnovec, an expert from Slovak Medical University in Bratislava, who has been studying the consequences of environmental exposure to PCBs, stresses: 'The knowledge that we obtained clearly shows that PCBs significantly harm human health and Slovakia is one of the areas with the highest exposure to PCBs in the world. Those responsible for the health of the Slovak population do not share this view, but that is not scientifically based.'[210]

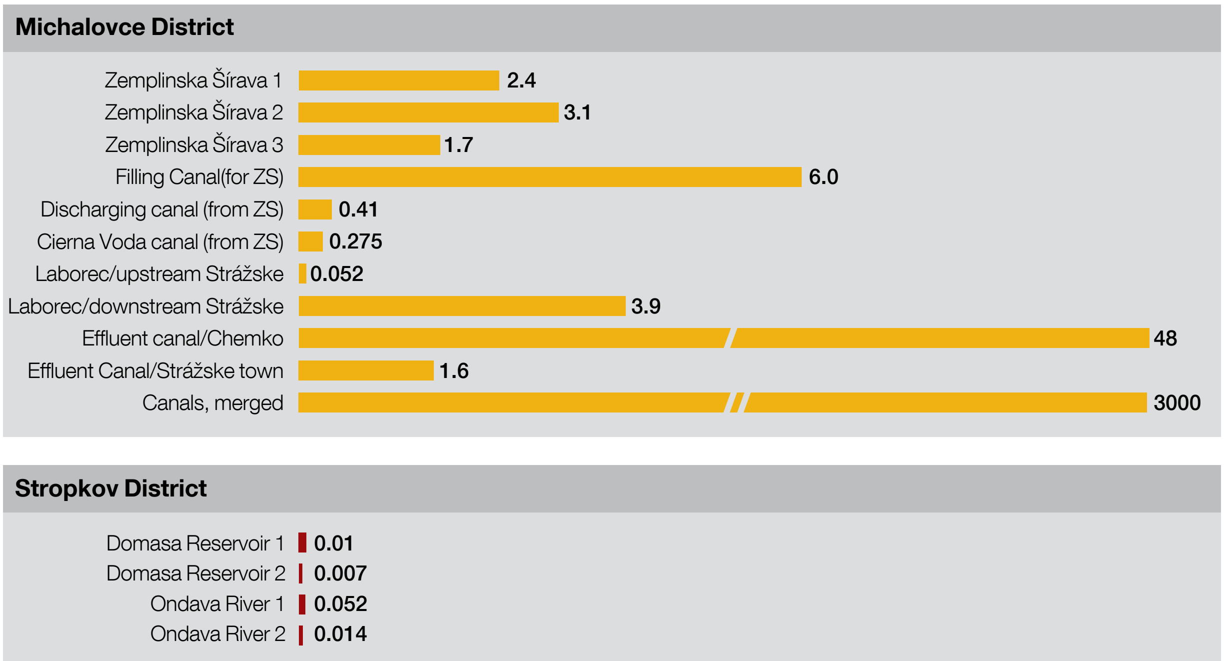


Figure 6: PCB levels (the sum of all congeners) in bottom sediment samples taken from some water courses in the districts of Michalovce and Stropkov.[211]

PCB Concentration 1ug/g dry matter

Remediation and a critical case study of non-incineration technology

Given the health risks associated with some of the highest levels of contamination ever measured in the world[212], and with international legislation requiring destruction of stockpiles of chemicals such as PCBs, it would seem obvious that the area should be a priority for clean-up.

Three NGOs operating in Slovakia – Open Circle, Friends of the Earth and Greenpeace – created an informal group to increase public awareness for the issue. In July 2002, Greenpeace organised a protest in Strážske against continued pollution from the Chemko site. Various public meetings and public hearings were also organised throughout 2002.

By 2005, with Slovakia now a member of the EU, plans were drawn up by the government in conjunction with the UN Development Programme and the Global Environment Facility (UNDP/GEF) to embark on a significant clean-up programme.

This programme was designed to have multiple outcomes: decreased human and wildlife exposure to PCBs, remediation of the area and a reduction in environmental pollution (including that of downstream international areas), and the revitalisation of the economic potential of the area including the Zemplínska Šírava reservoir.

A further significant aim was to demonstrate the effectiveness of non-combustion technology for the destruction of the PCBs and contaminated material (see Box 5). Incineration – which was commonly used to destroy chemicals such as PCBs – has a controversial history due to the harmful dioxins it releases into the environment. UNDP/GEF felt that the Slovak project could provide a critical case study on the use of non-incineration technology that, if successful, could be enforced in other parts of the world to deal with persistent organic pollutants (POPs).

Box 5 Destruction of PCBs

Persistent organic pollutants (POPs) such as PCBs are difficult to destroy and have commonly been managed by storage or burial in landfills and/or burning in combustion systems, such as dedicated incinerators, industrial boilers or cement kilns.

Both methods have their downsides. While storage can never provide a complete or long-term solution and risks further environmental contamination, combustion is very controversial and often provokes public opposition. In practice, destruction by incineration is far from efficient and the process can create further by-products, such as dioxins and furans, which are very toxic and are of major concern from a health and environmental perspective.[213]

Alternative approaches, based on non-combustion techniques and involving various chemical methods, have therefore been sought. Plans have been developed for dealing with the Chemko Strážske site, in which UNDP/GEF has recognised that innovative non-combustion methods could be 'far superior' to incineration – with greater efficiency, better waste control, safer working conditions and the ability to handle wider variations in materials.[214]

In Slovakia, both the government and the public supported the use of non-combustion techniques to destroy PCBs. UNDP/GEF therefore supported a project to demonstrate technology that – assuming it was successfully implemented – could be transferred to other countries around the world.

This project offered Slovakia the chance to deal not only with the terrible inheritance of the Chemko Strážske site, but to also contribute to improving POPs destruction programmes around the world.

GEF offered $10 m US dollars for a $20 m project. The Slovak Republic, in conjunction with private partnerships, including Chemko ($6 m), was to contribute the remainder. A Memorandum of Cooperation was signed between representatives of the project and the Mayor of Strážske, the Ministry of Environment and Chemko.[215] A steering committee was set up, holding its first meeting in April 2006.

In January 2007, a contract was drawn up with the Canadian company, Kinetrics, to initiate the PCB destruction technology. However, the project never got under way as a result of arguments over its economic feasibility.

Slow and painful progress

Initially, issues were raised by the Slovak side over the exact quantities of PCBs and waste inventoried in the country, which would affect the economics of the project. Some PCB destruction was ongoing during this time at a controversial Slovak incinerator and some PCBs were being exported, so the quantities needing treatment were being reduced.[216]

Then, despite recognising that the project was in the public spotlight and under international pressure, Chemko declared that it believed that the co-operation and competence of the parties involved was 'not clear and unified'.[217] The company asked the Ministry of Environment to support the project financially. But the Ministry's contribution was to be 'in kind', as laid out by the UNDP/GEF project document.

To make matters worse, there was also a considerable lack of trust in the affected communities. According to the mayor of Strážske, at least some residents feared that hazardous waste from around the world would be sent to Michalovce for destruction after the end of the project.[218] It was proposed that the destruction units be relocated to a site some distance from Chemko Strážske. However, this would require transporting the PCBs, which was seen as intrinsically undesirable by the UNDP[219] – presumably because of the risk of further releases in handling and transportation.

Meanwhile, at an extraordinary general meeting in 2009, Chemko announced its liquidation.[220] Even if the project does now go ahead, it is highly unlikely that Chemko will make any contribution towards it.

Delays only increase the contamination

It is now a quarter of a century since PCB production ended at the plant. Despite extremely high levels of pollution in the region, obvious health impacts and considerable international attention, the Laborec River and the surrounding area remain grossly contaminated. The delay in clean-up means that contamination of the environment continues – with local, regional and global consequences. Meanwhile, the PCBs remaining in the Chemko facilities pose a very real risk of further contamination.[221]

In its implementation plan (2006)[222], the Ministry of Environment recognised that remediation of Chemko Strážske and its surroundings was 'the most important task from the population health burden point of view'. Accordingly, it is imperative that urgent action is taken to regain the momentum to deal with the legacy of Chemko Strážske's operations.

Unfortunately, the Chemko site is not an isolated case. Rather, it is just one on a long list of PCB 'hot spots' around the world.[223] As the cases of the Hudson River and the Laborec River show, efforts to clean up existing contaminated sites and water systems are ongoing and far from resolved.

Perhaps the most serious hidden consequence of PCB contamination is that a very large proportion – some estimate as much as two-thirds[224] – of all the PCBs ever produced have yet to be destroyed. They are to be found in equipment, dumps and landfills across the globe, still waiting to cause serious contamination problems when their containment fails due to corrosion or breakage.

Only one conclusion can be drawn: The costly repercussions from the use of PCBs must not be repeated with other persistent hazardous chemicals.

image: Greenpeace highlighted the problems of contamination around the Chemko facility in 2002.

image: Fishing nets gummed up with discharged paper pulp. This fishing village on the Yangtze River is surrounded by power plants, paper-making factories and chemical plants. The water that flows beneath the fishing boats is polluted by the wastewater discharged from the factories.

Learning lessons from the Global North

The case studies contained within this section show the extent to which persistent and bioaccumulative substances have contaminated entire regions. They also show the immense difficulties – technical, economic and political – of cleaning up these hazardous chemicals after release, including the very high expense of restoration programmes and the impossibility of total decontamination.

Worse still, the largely unquantifiable costs to human health, the environment and to local economies are rarely considered or compensated. Many of these effects are irreversible, while the effects beyond the region concerned are impossible to calculate. For persistent and bioaccumulative substances these effects can be global, as many of them can be transported far beyond their source via ocean currents and atmospheric deposition, and have even accumulated in the polar regions of the Earth.

In East Asia, Southeast Asia and other parts of the world where industrialisation is booming, there is a danger that expenditure on even basic environmental measures – let alone the avoidance of hazardous substances through substitution – could be seen as an unnecessary impediment to economic growth. The case studies from the Global North show that attempts to 'save money' by opting for the cheapest ways to use and dispose of hazardous chemicals in the short term, can ultimately translate into extremely high costs and losses in the future. These costs then have to be borne by someone, and this is either the companies concerned or the taxpayer – often both.

Polluting in the pursuit of profit can prove to be an expensive strategy for industry in the long run. The Swiss chemical industry and General Electric in the US have both been held accountable for subsequent clean-up costs. However, pinning responsibility onto the polluter is not always straightforward, such as in the case of the Laborec River in Slovakia. If financial liability cannot be established, or if the polluter is no longer around, it is the state, and therefore the taxpayer, that is left with the clean-up bill.

In a large river basin, the polluters can be so numerous and widely spread that it is not possible to hold them liable for clean-up of the enormous pollution problems caused downstream, as is the case with the delta formed by the confluence of the Rhine, Meuse and Scheldt rivers in the Netherlands and Belgium. The Rhine-Meuse delta problem is not unique – the world has many heavily industrialised water basins. The Yangtze and the Pearl River Delta in China, the Great Lakes in the United States and the Riachuelo River basin in Buenos Aires face similar difficulties, with high concentrations of persistent contaminants in the sediments of the rivers and their harbours.

03

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03

A ‘Toxic-Free Future’ – Providing a blueprint towards ‘zero discharge’ of hazardous chemicals

Early environmental laws to control pollution relied on a combination of treating wastes to break down and/or remove contaminants, and subsequent dilution to less harmful levels that – it was assumed – natural systems could assimilate. While these approaches had some merit in relation to biodegradable pollutants, they were not able to deal effectively with more persistent chemical wastes. This is particularly true for those chemicals with the propensity to concentrate in the tissues of plants and animals, and, in some cases, accumulate through the food chain.

When applied to wastes containing heavy metals or persistent organic pollutants (POPs), attempts to control pollution through ‘end-of-pipe’ treat, dilute and disperse approaches have been very costly, and have proven to be impossible at times. This is demonstrated by the long and expensive clean-up stories of the Hudson River and the Rhine Delta[225], and the potential costs that the clean-up of the Filipino Marilao River System could cause.

Twenty years ago, in recognition of these limitations, chemical management policy began to focus on more preventative approaches. These included prevention or ‘reduction at source’ legislation and toxics-use reduction planning. Today, the focus is on chemical substitution and green chemistry research.

Preventing pollution and substituting hazardous chemicals with safer alternatives can bring multiple benefits. For instance, it reduces waste – especially hazardous waste – and the cost of its disposal; it makes the workplace safer; and it delivers substantial economic benefits with regard to manufacturing costs. These financial benefits are the result of an increased understanding of inefficiencies, and a focus on innovation in products and the production process.

In order to avoid repeating the long search for a more effective chemicals policy, and thereby prevent irreversible and costly damage to rivers and waters, governments must put policies in place and engage companies to implement a set of important framework principles for the sound management of chemicals. This is particularly true in emerging and developing economies, which can ill afford to pay the clean-up costs that will inevitably result from acting otherwise.

Framework principles for the sound management of chemicals

1. It is important to know and disclose all chemicals in use and to prioritise action on the most hazardous. To achieve this, and to establish a clear roadmap, governments must establish a list of locally relevant priority chemicals. This list must be based on their intrinsic hazardous properties as chemicals – in line with the approaches and processes used to establish existing priority substances lists under international and regional policies.[226] Governments should begin by eliminating the most threatening chemicals and evolve over time towards the elimination of all releases of hazardous chemicals ('zero discharge').

'Zero discharge' is inclusive of releases to all environmental media, ensuring that there is not simply a displacement from one place or media to another. 'Zero discharge' of hazardous chemicals into the environment also recognises the difficulty of establishing 'safe' levels of emissions of hazardous chemicals. It has thus been the focus of the most comprehensive regional initiatives, such as the Great Lakes Water Quality Agreement in the US and the European Water Framework Directive.

Reflecting the lessons learnt on the value of precaution, regulatory mechanisms should address the source of the hazardous chemical rather than try to establish what levels of exposure are 'safe' and then try to 'manage' pollution down to those levels in the environment. The focus should be on eliminating the use of toxics and the activities that generate them, without waiting for harm to occur or be a proven certainty.

2. It is important to focus on prevention, clean production[227] and the prioritisation of the substitution principle[228], so that inherently hazardous chemicals are continually designed out of production processes and products. Green chemistry promotes the design and use of inherently non-hazardous chemistry. This focus on inherently non-hazardous chemicals, rather than exposure control, must be the clear policy goal with regard to all hazardous chemicals. Green chemicals innovation in the marketplace relies on the ability of companies to develop knowledge about safer products, and the need to avoid the costs and liabilities associated with hazardous chemicals in their production facilities, and in the chemicals' lifecycles.

3. Targets are important. International conventions, such as OSPAR for the North East Atlantic, or the Stockholm Convention on Persistent Organic Pollutants, call for the elimination of highly hazardous chemical emissions into the environment within one generation. This target not only seeks to ensure the protection of the environment and future generations, it also allows progress towards the goal to be tracked. It also recognises that merely trying to mitigate exposure is impossible, given the multiple sources of chemical exposure. As with business development plans, chemicals policy must have a clear roadmap and metrics for success. For instance, policy tools – such as the Toxics Use Reduction Act in the US state of Massachusetts – have succeeded by setting a clear intermediate goal.

4. It is important to establish a good framework to encourage and ensure the compliance of companies, and foster their ability to innovate and transition to the use of non-hazardous chemicals. The framework should enforce the ‘principle of producer responsibility’, placing the responsibility to prevent ecological harm in the hands of those who can make the most effective changes. The REACH[229] approach of ‘no data, no market’ provides a good example. Harnessing the watchdog capacities of wider society is another important building block for accelerating change, commonly referred to as the ‘right to know’. To this end, it is imperative that governments establish the obligation for chemical users to disclose all of their uses and releases.

These policies and others should be coupled with bans or appropriate restrictions on the use of chemicals that cause substantial harm and need not be used, and fees for chemical use. These fees would both fund the necessary support programmes, and act as a disincentive to use toxics and as a reward for cessation of use.

Other transition tools, such as enforceable requirements for examining alternatives, e.g. toxics-use reduction plans, audits[230] or alternatives assessments, should be complemented with direct assistance. This direct assistance can take the form of: education, training, research, databases of alternative non-hazardous chemicals, technology demonstrations and subsidies for innovation and technology upgrades.

Small and medium-sized companies need technical support, clear regulatory policy and financial incentives to constantly improve their chemicals performance. Some international support for education and training exists – be it UNITAR’s work to promote Pollution Release and Transfer Registers, or cleaner production centres’ advice and support for small and medium-sized enterprises (SMEs) – but more is needed. Good examples of such support exist. For instance, the technical assistance provided in the United States under initiatives such as the US EPA P2 programme, and the Massachusetts Toxics Use Reduction Act (MTURA), described further in Boxes 6 and 7.

Box 6 The Massachusetts Toxics Use Reduction Act (MTURA): A strong pollution source reduction programme

The Massachusetts Toxics Use Reduction Act consists of:

- An ambitious intermediate reduction target for the state of Massachusetts: 50% reduction in the generation of hazardous chemical wastes over 10 years.
- Extensive right-to-know reporting, including public disclosure of chemical use and release by industrial facilities.
- Obligatory toxics-use reduction plans, based on the principle that the manufacturer choosing to use toxic chemicals has the responsibility to attempt to reduce that use and the associated risks through mandatory planning.
- Concerted technical assistance, professional education and research, based on the principle that such 'transitional tools' facilitate a shared commitment between firms and government, to assure better-tailored regulations and more successful adoption of safer alternatives.
- Use of third-party certification, based on the principle that government cannot efficiently oversee all parties, and must also delegate the means of ensuring responsible action (which in turn enables the diffusion of needed expertise).
- Fees for toxics use, based on the principle that those who impose the risks of toxics use on society should bear the cost of the programme developed to reduce those risks (thereby providing an incentive to stop using toxic chemicals).
- A flexible planning requirement, based on two principles:

(1) That government cannot effectively prescribe exactly what changes need to be made for each process or product,

(2) That businesses will elect to implement source reduction options that they identify through planning, when they make sense.

Combining pollution prevention with cost efficiencies

The most extensive data analysis[231] of company and chemical categories covered by the MTURA law from 1990 to 2004, showed that (adjusting for a 17% increase in production over this time), the companies reduced their toxic chemical use by 41% and their by-products (emissions) by 65%.

In 1997, the programme commissioned an independent evaluation by Abt Associates of Cambridge, Massachusetts, which found that companies saved more than MTURA cost them. Total costs amounted to $76 m US dollars[232], while savings equalled $90 m[233].

No company was forced to make any particular changes, only to consider them through mandatory planning. Plans had to be certified by toxics-use-reduction planners at the Toxics Use Reduction Institute (TURI). However, once companies realised the cost savings possible due to the opportunities for toxics-use reduction, most of them implemented the plans.[234]

Prevention planning, and adopting a preventative approach, also prompts innovation. This innovation arises out of the careful examination of what is being used, and what could be used, to accomplish a task, and by constant consideration of ways to improve how things are done.[235]

Auxiliary benefits

When total chemical use is reduced, it is likely that toxic accidents, contamination, exposures, and the loss of resources – as well as the impacts on health and the environment – are also reduced significantly. Companies that eliminate toxics use eliminate storage costs, the concerns of neighbours and local emergency responders, the need to prepare for accidental releases, as well as the potential of costly litigation. Litigation is a growing 'economic risk' companies are facing globally.[236] Companies that reduce toxics input to their processes also reduce the need to authorise transport of hazardous materials, and thus the responsibility for spills.

Box 7 Pollution prevention pays – for the wider economy

'Prevention at source' policies have benefits – at both the individual company level and at the level of a region or state – not only in terms of protecting the environment, but also in terms of innovation and economic competitiveness.

North Carolina, the first state in the US to establish a cleaner production programme (the 'Pollution Prevention Pays' programme), provides an example of the benefits of the 'prevention at source' approach. The state's approach to tackling alkylphenol surfactant pollution is an example of how conventional pollution controls failed to solve the problem, and instead risked placing an increased financial burden on the sector. In contrast, substitution and redesigning how things were made proved to be successful strategies, which allowed more than 100 companies to stay in operation for more than a decade.

The value of this is difficult to estimate. In 1992, the North Carolina textile industry represented about 16% of total manufacturing in the state, compared to a national average of 2%. Hundreds of thousands of jobs were at stake.[237] A substantial portion of this industry involved wet processing, potentially using toxic surfactants. Sam Moore, formerly of Burlington Research Incorporated, the primary consulting firm working with the state on the project, later wrote that the effort 'demonstrated that there could be measurable improvements in aquatic toxicity and POTW[238] treatment efficiency, driven by the goal of increased industrial productivity and reduction of aquatic toxicity by industry. This kept stakeholders out of costly litigation, while improving environmental quality'.[239]

The state of North Carolina's 'Pollution Prevention Pays' programme was based on this 'win-win' concept, in which both society and the regulated entities benefited from reducing pollution at the source of the problem – reducing their toxic inputs and using materials more efficiently.[240] Since that time, the programme has provided benefits to the state far exceeding its costs. One recent programme, the Environmental Stewardship Initiative, saved more than $23 m US dollars in just over two years, while preventing 2,579 tons (2,340 tonnes) of air emissions, water emissions and hazardous waste. Comparatively, the cumulative cost of the programme during those years amounted to less than half a million US dollars.[241]

According to Gary Hunt[242], who has provided pollution prevention assistance out of the Division of Environmental Assistance and Outreach, North Carolina Department of Environment and Natural Resources, for 25 years:

'Over the last 25 years, the programme has helped thousands of businesses and industries reduce their operating costs and improve their competitive advantage, through the implementation of pollution prevention techniques and technologies. However, it has taken many years for policymakers and the general public to really see that it is possible to advance environmental protection through means that benefit the economy. I believe that the North Carolina experience has shown quite clearly that it is also possible not just to avoid costs, but to stimulate new technology, modernisation, upgrading and the kind of development that allows a state to keep up with global competition.

'The growing green economy in North Carolina is an example of how the public and private sectors can work together to foster a better economy and cleaner environment for all of NC citizens … More investment in clean technology will mean more jobs, yet a smaller impact on the environment. It's a hard concept for people to grasp – it seems counterintuitive. People have grown up with the assumption that protecting the environment costs money, and it's hard to see that there actually is a way to protect the environment and not just save, but make money. Pollution Prevention does Pay!' [243]

A better route to prosperity for governments

In short, the preventative approach forces regulated entities to rethink and redesign their products, which leads to better knowledge and understanding, and often results in permanent solutions that have many ancillary benefits.[244] Waste, including hazardous chemical releases, is after all an indicator of operating inefficiency.[245]

In addition to the need to tackle pollution to protect the environment and people's health, strong chemical management systems can also provide clues as to how operations and products should be redesigned – enabling processes to become more efficient as problems are proactively prevented. Countries that are developing programmes for chemical management have an opportunity to 'leapfrog' over the conventional approach of waste and wastewater end-of-pipe treatment, and focus on prevention first.[246]

Adopting clean production policies will cause industries to not only become cleaner and more resource-efficient, but also enable them to participate in the rapidly growing markets for safer and eco-labelled goods. Examples include clothing with no harmful chemicals; low-VOC carpets, furnishings and paints; and children's toys without lead paint or phthalates. As people all over the world are waking up to the need for environmental responsibility, there is a rapidly growing demand for responsible manufacturing[247] and clean products[248] that do not destroy the natural world.

Not only consumers but also investors are following the trend for more responsible production. The socially responsible and green investment market has grown exponentially over the past 20 years and now makes up over 11% of all assets under professional management in the US[249], and 10% in the EU[250].

Even lenders now favour processes that do not use toxic chemicals such as nonylphenol ethoxylates. The guidelines of the International Finance Corporation, for use by World Bank members, recommend that 'potentially hazardous surfactants should be replaced with biodegradable/bioeliminable compounds that do not generate potentially toxic metabolites'.[251]

The message is clear

Countries in Asia and other regions developing their chemicals policy simply cannot afford to make the same mistakes that led to countries in the Global North spending billions of euros and dollars cleaning up the damage they inflicted upon their rivers, reservoirs and deltas. As the examples contained within this report demonstrate[252], prevention not only saves society money, but it can also reduce companies' costs. Encouragingly, the market potential for the development of innovative green chemistry and clean processes is growing internationally, both due to pressure from the substitution requirements of REACH and the substance restrictions of EU laws, and due to a growing demand for responsible manufacturing and clean products.

Emerging economies have an enormous opportunity to learn from the experiences of the Global North and other industrialised countries. Acting in a precautionary way, preventing pollution, aiming for 'zero discharge', eliminating toxics and promoting clean production and green chemistry are not only more effective strategies for protecting human health and the environment, they also offer opportunities for companies. Forward-thinking companies can not only strengthen their market competitiveness and increase their capacity to innovate but ultimately, they can save themselves significant sums of money.

To this end, Greenpeace is calling for governments to adopt:

1) A political commitment to 'zero discharge'[253] of all hazardous chemicals within one generation[254], based on the precautionary principle and a preventative approach to chemicals management. This commitment must have the substitution principle at its core, and include producer responsibility[255] in order to drive innovation and toxics-use elimination.

2) An implementation plan to:

- establish a dynamic priority hazardous chemical list, for immediate action[256];
- establish intermediate targets to meet the generation goal above; and
- establish a publicly available register of data about discharge, emissions and losses of hazardous chemicals.

3) Measures to ensure infrastructure and policies are in place to support implementation, including:

- identifying priority chemical restrictions;
- policies and regulations that require mandatory audits and planning;
- the provision of technical help and appropriate financial incentives; and
- research and support for innovation in green chemistry.

For more details on why Greenpeace is supporting these principles and policies please see our accompanying Questions and Answer document – available at: http://www.greenpeace.org/q-and-a-for-a-toxic-free-future.pdf

1 'Bioaccumulative' means the ability to accumulate in the food chain.

2 'Discharge' means all discharges, emissions and losses. In other words, all pathways of releases.

3 Based on the basic intrinsic properties of hazardousness – persistence; bioaccumulation; toxicity (including carcinogenicity, mutagenicity and toxicity to reproduction (CMR); endocrine disruption; and equivalent concern.

4 PRTRs are inventories of pollution from industry and other sources providing government, industry, and the public with information on releases and transfers of hazardous chemicals to air, water and land.

5 Evans JE & Hamner WB (2003) suggest the leapfrog approach in 'Cleaner Production at the Asian Development Bank', Journal of Cleaner Production, 11:6: 639-649, 2003. This states that the bank 'believes that CP (Cleaner Production) can save the Asian region billions of dollars in environmental infrastructure costs', and that the conventional command and control approach has not significantly succeeded in reducing pollution in most developing countries due to 'lack of political will, financial resources and legal capacity to enforce standards, and the mistaken belief that environmental protection was an obstacle to economic development'.

6 USGS Delta Research and Global Observation Network. (2011). Chao Phraya River. At: http://deltas.usgs.gov/rivers.aspx?river=chaophraya [accessed 22 January 2011]

7 Ministry of Interior (2009). Annual Report: Important Statistics. At: http://www.moi.go.th/pls/portal/docs/PAGE/MOI_NEW/MOI_INDEX/%CB%B9%E9%D2%E1%C3%A1/%CA%B6%D4%B5%D4%A2%E9%CD%C1%D9%C5%CA%D3%A4%D1%AD/YEAR2551.PDF [accessed 22 January 2011]

8 Greenpeace Southeast Asia (2009), analysing Department of Land Development: Land Use Survey data, 1999-2002. Dr. Arisara Charoenpanyanet, AIT researcher, Greenpeace.

9 Fishbase. At: http://www.fishbase.org/trophiceco/FishEcoList.php?ve_code=161 [accessed 24 January 2011]

10 Department of Industrial Works (2010). Statistical database. At: http://www.diw.go.th/diw/query.asp [accessed 22 January 2011]

11 Environmental Quality Management and Control Division, Department of the Permanent Secretary for the Bangkok Metropolitan Administration (2003). Bangkok State of Environment report 2003. At: http://www.rrcap.unep.org/pub/soe/bkk_2004_chpt03.pdf [accessed 13 April 2011]

12 Pollution Control Department (2011). At: http://www.pcd.go.th/info_serv/water_Chaopraya50.cfm [accessed 22 January 2011]

13 Pollution Control Department (2011). At: http://www.pcd.go.th/info_serv/reg_std_water05.html#s1 [accessed 22 January 2011]

14 Pollution Control Department (2008). Annual Report: State of Pollution in Thailand. At: http://www.pcd.go.th/public/Publications/print_report.cfm?task=pcdreport2551 [accessed 24 January 2011]

15 For example, the UNESCO report notes inconsistencies in collected data and data management problems. UNESCO World Water Assessment Programme (2007). Chao Phraya River Basin, Thailand. At: http://www.unesco.org/water/wwap/case_studies/chao_phraya/chao_phraya.pdf [accessed 22 January 2011]

16 Brigden K, Labunska I & Stringer R (2003). Bangpoo Industrial Estate, Samut Prakarn, Thailand: An investigation of environmental pollutants. Greenpeace Research Laboratories. Technical Note 03/2003. At: http://www.greenpeace.to/publications/Bangpoo2003.pdf [accessed 8 December 2010]

17 Kunacheva C, Boontanon SK, Fujii S, Tanaka S, Musirat C, Artsalee C & Wongwattana T (2009). Contamination of perfluorinated compounds (PFCs) in Chao Phraya River and Bangpakong River, Thailand. Water Science & Technology 60:975-82. At: http://www.iwaponline.com/wst/06004/wst060040975.htm [accessed 24 January 2011]

18 United Nations Environment Programme (2006). Risk profile on perfluorooctane sulfonate. UNEP/POPS/POPRC.2/17/Add.5. At: http://chm.pops.int/Portals/0/download.aspx?d=UNEP-POPS-POPRC.2-17-Add.5.English.pdf [accessed 4 February 2011]

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20 Labunska I, Brigden K, Santillo D, Kiselev A & Johnston P (2010). Russian Refuse2: an update on PBDEs and other contaminants detected in St-Petersburg area, Russia. Greenpeace Research Laboratories Technical Note 04/2010. At: http://www.greenpeace.to/publications/russian-refuse-2-english%5B1%5D.pdf [accessed 10 January 2011]

21 More recently, the sludges generated are being sent for incineration – where they contribute to air pollution. Flue gases from sludge incinerators transport hazardous substance large distances within the Baltic region (statement supported by 'Northern Aeration Station. St. Petersburg. Sludge burning. Construction material. Requires approval part. EIA. Part 10. 373 pp. St. Petersburg 2005', where approximate emission data from the stack were published).

22 HELCOM (2010). BALTHAZAR project 2009-2010: Reducing risks of hazardous wastes in Russia. http://www.helcom.fi/stc/files/Publications/OtherPublications/hazardous_full_english.pdf [accessed 3 February 2011]

23 Environmental control service for the Russian Federation, north-west branch (Rosprirodnadzor po SZFO), letter to St. Petersburg division of Greenpeace Russia, 6 August 2010.

24 Luo Y, Luo X-J, Lin Z, Chen S-J, Liu J, Mai B-X & Yang Z-Y (2009). Polybrominated diphenyl ethers in road and farmland soils from an e-waste recycling region in Southern China: Concentrations, source profiles, and potential dispersion and deposition. Sci. Total Env. 407, 1105-1113.

25 Ibid.

26 Leung AOW, Luksemburg WJ, Wong AS & Wong AH (2007). Spatial Distribution of Polybrominated Diphenyl Ethers and Polychlorinated Dibenzo-p-dioxins and Dibenzofurans in Soil and Combusted Residue at Guiyu, an Electronic Waste Recycling Site in Southeast China. Environ. Sci. Technol. 41, 2730-2737

27 Wang D, Cai Z, Jiang G, Leung A, Wong MH & Wong WK (2005). Determination of polybrominated diphenyl ethers in soil and sediment from an electronic waste recycling facility. Chemosphere. 60, 810–816

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29 RD 52.24.643-2002 (normative act emitted by state agency). Method of complex evaluation of surface water contamination by hydrochemical parameters. Annex B (mandatory). Issued and approved by the State Hydrometeorological service for the Russian Federation on 3 December 2002. This act specifies the mandatory monitored list of substances for the integrated complex surface water quality index.

30 Only five substances of the 15 substances required by Annex B of the RD 52.24.643-2002 are potentially persistent hazardous chemicals. There is a list of non-mandatory chemicals for monitoring, including some persistent and/or hazardous chemicals, for example mercury, cadmium, lead, arsenic, borium, fluorine, aluminum, formaldehyde, anilin, methylmercaptan, sulphides, chlorinated and fluorinated pesticides. However these non-mandatory chemicals are not monitored regularly (or at least data on these substances are not included in the latest National State of the Environment report of (Report from The Federal Service for Hydrometeorology and Environmental monitoring for the Russian Federation, Review of State of the Environment of the Russian Federation in 2008, Moscow, 2009. UDK 551.550.42) nor exist in other reports to our knowledge).

31 Presentation given by Ms. Irina Alexeeva, Vodokanal St. Petersburg at XI Baltic Sea Day International Environmental Forum, St. Petersburg, 22 – 24 March 2010 as part of the COHIBA PROJECT (see http://www.cohiba-project.net/publications/en_GB/publications/), a meeting with involvement of Russian stakeholders. Describes the methods for identification of sources of hazardous substance in waste streams and discharges. However, this presentation was a one-off exercise. Greenpeace has reason to believe that it came only in response to Greenpeace pressure on the local authorities to provide data.

32 For example, the data in the presentation refered to in the preceeding footnote is not available in the public domain. No data from other wastewater treatment plants is available.

33 See Question 4 in separate Q&A document, available at: http://www.greenpeace.org/q-and-a-for-a-toxic-free-future.pdf

34 Saint-Petersburg.ru (2010). 'Vodokanal of St. Petersburg does not want to stay alone with polluters', 7 December 2010. At: http://saint-petersburg.ru/m/241547 [Accessed 27 Jan 2011]. This article quotes the CEO of Vodokanal, Mr. Felix Karmazinov, saying: 'Municipal water treatment facilities can`t treat industrial wastewaters, but this is due to the shortcomings in the legal relationship between treating and discharging businesses. But we are powerless to challenge the polluters. We are taking them to the Arbitrary court but they are laughing and saying: "Prove it."' (Greenpeace translation).

35 For example, many major electronics manufacturers have phased out the use of brominated flame retardants and PVC in their products. See http://www.greenpeace.org/international/en/campaigns/toxics/

36 Blacksmith Institute (2007). The World's Worst Polluted Places – The Top Ten (of The Dirty Thirty). Blacksmith Institute, New York, September 2007. At: http://www.blacksmithinstitute.org/wwpp2007/finalReport2007.pdf [accessed 31 January 2011]. Note: The Blacksmith Institute establishes the list of pollution hot spots by accepting nominations from around the world and assessing the severity of their impacts on health with the support of a Technical Advisory Board (TAB). The hot spots are scored using a set of criteria that includes types of pollutants found, pathways and potential exposure of people, but it recognises that the classification of the sites still remain heavily dependent on the experience and professional judgement of TAB members.

37 Asian Development Bank (2009). Pilot and Demonstration Activity: Philippines. Reduction of Mercury and Heavy Metals Contamination Resulting From Artisanal Gold Refining in Meycauayan, Bulacan River System: Final Report. At: http://www.adb.org/water/pda/PDFs/phi-200801-Final.pdf [accessed 31 January 2011]. The monitoring stations measured heavy metal pollutants in water and sediments at over 40 sampling stations on the river system (with fewer for groundwater) and compared them to national and US Washington State standards.

38 The EMB limit for surface water for 'Class C' (fisheries, boating and industrial purposes) was exceeded in one or more sampling stations for eight heavy metals - arsenic, cadmium, chromium, copper, lead, mercury, manganese and nickel.

39 Department of Environment and Natural Resources-Environmental Management Bureau.

40 Asian Development Bank (2009). Pilot and Demonstration Activity: Philippines. Reduction of Mercury and Heavy Metals Contamination Resulting From Artisanal Gold Refining in Meycauayan, Bulacan River System: Final Report. At: http://www.adb.org/water/pda/PDFs/phi-200801-Final.pdf [accessed 31 January 2011]

41 Though not specified, it is assumed that the US Washington State standard was used in the Asian Development Bank Report, in the absence of an applicable Philippines standard for contaminants in sediment. It should be recognised that the US Washington State standard is not legally applicable in the Philippines.

42 The Asian Development Bank Report from May 2009 does not clarify the natural background levels for this river basin, which may not be known. However, these rivers have had been subject to industrial discharges for more than 100 years. For example, the fireworks industry has been present in the river system since the 1850s (see: http://environment.peza.gov.ph/getfile.php?fileid=74) and the jewellery industry that handles heavy metals such as mercury has been present in the river system since the 1930s (see: http://bulacan.gov.ph/business/jewelry.php).

43 Asian Development Bank (2009). Pilot and Demonstration Activity: Philippines. Reduction of Mercury and Heavy Metals Contamination Resulting From Artisanal Gold Refining in Meycauayan, Bulacan River System. Final Report. At: http://www.adb.org/water/pda/PDFs/phi-200801-Final.pdf [accessed 31 January 2011]

44 As laid down in Department of Environment and Natural Resources Administrative Order No. 7, Series of 2008, dated 14 May 2008. Subject: Designation of the Marilao-Meycauayan-Obando River System Water Quality Management Area and Creation of Its Governing Board.

45 DENR-EMB (2010). Draft Ten-Year WQMA Implementation Plan for Marilao-Meycauyan-Obando River System 2010-2020. A hard copy of this has been shared with Greenpeace Southeast Asia by DENR-EMB Region 3, Q3 2010.

46 'Our initial estimate with the Blacksmith Institute was around 2.2 billion Philippine pesos [approximately $50 m US dollars] just for dredging activities,' said Engr. Exuperio Lipayon, Chief of the Pollution Control Division for EMB Region III, while recognising that this initial figure does not even take into account the treatment and disposal of the dredged material.

47 Unitar (2011). Pollutant Release and Transfer Registers. At: http://www.unitar.org/cwm/prtr [accessed 17 February 2011]

48 The Philippines already possesses a list of priority 48 hazardous substances, promulgated as part of the DENR Administrative Order No. 2005-27, issued 19 December 2005. However, this list should be eventually extended and regularly updated.

49 Yang G, Weng L & Li L (2007). Yangtze Conservation and Development Report 2007. Wuhan: Changjiang Press.

50 Yang G, Ma C & Chang S (2009). Yangtze Conservation and Development Report. Wuhan: Changjiang Press.

51 Yang, G, Weng, L & Li L (2007). Yangtze Conservation and Development Report 2007. Wuhan: Changjiang Press.

52 Yangtze Conservation and Development Report (2009). Executive Summary. At: assets.wnf.nl/downloads/english_brief_of_yangtze_report_2009.doc [accessed 4 February 2011]

53 Li and Fung Research Centre (2006). Industrial Clusters in Yangtze River Delta (YRD). At: http://www.idsgroup.com/profile/pdf/industry_series/LFIndustrial3.pdf [accessed 4 February 2011]

54 Ibid. See data for 2005.

55 China Daily (2006). 'Yangtze river 'cancerous' with pollution'. At: http://www.chinadaily.com.cn/china/2006-05/30/content_604228.htm [accessed 4 February 2011]

56 Ministry of Environmental Protection, People's Republic of China (2010). Clean-up Bid for Yangtze Set to Begin. See http://www.chinadaily.com.cn/usa/2010-09/01/content_11239709.htm [accessed 7 February 2011]

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59 Ministry of Environmental Protection, People's Republic of China (2008). Report On the State of the Environment In China 2008: Water Environment. At: http://english.mep.gov.cn/standards_reports/soe/soe2008/201002/t20100224_186070.htm [accessed 7 February 2011]

60 Dr. Beat Müller in an interview conducted by Greenpeace Southeast Asia , 19 November 2010.

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62 Müller B, Berg M, Yao ZP, Zhang XF, Wang D & Pfluger A (2008). How Polluted is the Yangtze River? Water Quality Downstream from the Three Gorges Dam. Science of the Total Environment. 402: 232-47.

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65 Brigden K, Allsop M & Santillo D (2010). Swimming in Chemicals: Perfluorinated chemicals, alkylphenols and metals in fish from the upper, middle and lower sections of the Yangtze River, China. Greenpeace Research Laboratories. Amsterdam: Greenpeace International. At: http://www.greenpeace.to/publications/swimming-in-chemicals.pdf

66 Ibid.

67 Legal Daily (2005). 'Verdict of trial on pollution of Tuo River has been passed.' 12 September 2005. At: http://legal.people.com.cn/GB/42735/3686828.html [accessed 4 February 2011]

68 Xie J (2009). Addressing China's Water Scarcity. The International Bank for Reconstruction and Development/The World Bank. ISBN: 978-0-8213-7645-4.

69 China Daily (2007). 'Pollution makes cancer the top killer.' At: http://www.chinadaily.com.cn/china/2007-05/21/content_876476.htm [accessed 31 January 2011]

70 Xie Chunlin in an interview conducted by Greenpeace Southeast Asia on 10 July 2010. at Yanglingang, Fuqiao, Taicang, Jiangsu province.

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225 It is estimated that the company General Electric will pay $1.4 bn US dollars for cleaning up the Hudson. The costs of dredging and processing contaminated sediments in the Rhine Delta since 1997 is estimated at about €2.8 bn (see Section 2).

226 For example, the Convention for the protection of the marine environment of the NE Atlantic (OSPAR) and the EU chemicals management Regulation (REACH).

227 It is important to make a distinction between Cleaner Production and Clean Production. Clean production is any practice that eliminates at source the use or formation of hazardous substances through the use of non-hazardous chemicals in production processes, or through product or process redesign, and thereby prevents releases of hazardous substances into the environment by all routes – directly or indirectly. Cleaner production includes conserving raw materials and energy; eliminating toxic raw materials; and reducing the quantity and toxicity of all emissions and wastes before they leave a process (UNEP Cleaner Production Program - http://www.unido.org/index.php?id=o5152). In other words, Clean Production requires elimination and Cleaner Production requires only reductions.

228 The substitution principle requires finding solutions through non-hazardous alternatives and not simply through transforming one hazard into another hazard, or by substituting a hazard with another slightly less hazardous but still problematic chemical

229 REACH is the European Community Regulation on chemicals and their safe use (EC 1907/2006). It deals with the Registration, Evaluation, Authorisation and Restriction of Chemical substances. The law entered into force on 1 June 2007. The aim of REACH is to improve the protection of human health and the environment through the better and earlier identification of the intrinsic properties of chemical substances, and to make the `burden of proof´ (of a chemical´s safety) the responsibility of the chemical producer and not the authorities. At the same time, REACH aims to enhance innovation and competitiveness of the EU chemicals industry. See http://ec.europa.eu/environment/chemicals/reach/reach_intro.htm [accessed 18 February 2011]

230 For example as mandated by the Massachusetts Toxics Use Reduction Act (MTURA).

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232 Note that $27 m US dollars of this is investment by the companies in voluntarily improving their own operations. These would not even be counted as costs in some analyses, but as benefits. Rick Reibstein, OTA, personal communication.

233 Toxics Use Reduction Institute (1997). Evaluating Progress: A Report on the Findings of the Massachusetts Toxics Use Reduction Program Evaluation, March 1997; www.turi.org/content/content/view/full/998. For an academic perspective on TURA, see: O'Rourke L (2004). Mandatory Planning for Environmental Innovation: Evaluating Regulatory Mechanisms for Toxics Use Reduction. Journal of Environmental Planning and Management. Vol. 47, No. 2: 181–200.

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235 See, for example, Opportunities for Innovation: Pollution Prevention Edited by David E. Edgerly. National Institute of Standards and Technology Gaithersburg, MD 20899. Prepared for US Department of Commerce National Institute of Standards and Technology Gaithersburg, MD : 20899NIST GCR 93-659, August 1994. http://www.p2pays.org/ref/02/01123/01123.pdf

236 See, for example, how standing is now being granted in China to environmental protection organisations to sue for environmental damage. Shanxi province has passed a law to encourage public participation in environmental protection. http://www.greenlaw.org.cn/enblog/?tag=environmental-litigation [accessed 18 October 2010]

237 Conway P et al (2003). The North Carolina Textiles Project: An Initial Report, U. NC at Chapel Hill. At: http://www.unc.edu/~pconway/Textiles/nctp_tatm_rev.pdf

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240 NC Department of Environmental Management (1982). Incorporating the Pollution Prevention Pays Concept - A Plan of Action. Raleigh, NC.

241 NC Division of Pollution Prevention and Environmental Assistance, Environmental Stewardship Initiative Legislative Report, 2008.

242 Gary Hunt has served as director of the division for most of that time, and has also advised EPA and the National Pollution Prevention Roundtable on pollution prevention practice and policy.

243 Phone interview with Gary Hunt, October 2010.

244 For example, 'Case Studies of Strategic Benefits Realized by Selected Participants in the Toxics Use Reduction Program', (Meninger, Wirtanen, Kelly, Diener, UMass Boston, 1995), found that companies examining their toxic materials inputs not only reduced toxics use but also achieved 'enhanced product quality, new product development, reduced and competitive pricing, increased customer responsiveness, reduced time to market, and increased share of market'.

245 Personal communication from Richard Reibstein, Massachusetts Office of Technical Assistance.

246 JE Evans and WB Hamner suggest the leapfrog approach in 'Cleaner Production at the Asian Development Bank', Journal of Cleaner Production, 11:6: 639-649, 2003, which states that the bank 'believes that CP (Cleaner Production) can save the Asian region billions of dollars in environmental infrastructure costs', and that the conventional command and control approach has not significantly succeeded in reducing pollution in most developing countries due to 'lack of political will, financial resources and legal capacity to enforce standards, and the mistaken belief that environmental protection was an obstacle to economic development'.

247 For examples of initiatives that seek to green whole sector lifecycles such as the NICE fashion Initiative (Nordic Initiative Clean & Ethical Fashion), see http://www.nicefashion.org/en/about/ and http://www.nicefashion.org/en/resources/Chemicaltool.html. For product environmental CV initiatives such as the new open source eco-index launched by some big clothing brands, see http://www.ecotextile.com/index.php?option=com_content&view=article&id=10864:worlds-clothing-brands-to-launch-eco-label-for-consumers&catid=10:fashion-retail&Itemid=32. These are just examples of many such initiatives and do not correspond to a Greenpeace endorsement of these tools and initiatives.

248 Ecolabel Index, which tracks eco-labels, now includes 329 eco-labels in 207 countries. The International Finance Corporation of the World Bank Group now applies environmental sustainability standards 'to all investment projects to minimise their impact on the environment and on affected communities'. See http://www.ifc.org/ifcext/sustainability.nsf/Content/EnvSocStandards, and http://www.sciencedaily.com/releases/2008/01/080121100554.htm

249 2003 report on Socially Responsible Investing Trends in the United States, Social Investment Forum, October 2003. See www.socialinvest.org/resources/research/documents/2003TrendsReport.pdf [accessed 17 December 2010]

250 2010 European SRI Study, Eurosif, 2010. See http://www.eurosif.org/research/eurosif-sri-study/2010 [accessed 17 December 2010]

251 Textile Manufacturing Environmental Health and Safety Guidelines (2007). International Finance Cooperation - World Bank Group, April 2007. At: http://www.ifc.org/ifcext/sustainability.nsf/Content/EHSGuidelines

252 MTURA has reduced toxic chemical use in the state of Massachusetts by several hundred million pounds (100 million pounds = 45,000 tonnes) and saved companies more than the cost of its requirements. The latest results from the US EPA P2 programme indicate that prevention has been very cost-effective, saving a total of approximately $6.4 billion US dollars between 2004 and 2006 (see examples of MTURA and the North Carolina Pollution Prevention Pays in boxes 6 and 7.)

253 'Discharge' means all discharges, emissions and losses. In other words, all pathways of releases.

254 Typically, one generation is understood to be 20 to 25 years.

255 For example, 'no data, no market' provisions.

256 Based on the eight basic intrinsic properties of hazardousness – persistence; bioaccumulation; toxicity; carcinogenic, mutagenic and reprotoxic; endocrine disruption; and equivalent concern.

image: A winter swimmer cuts through the waters underneath the bridge spanning the Yangtze River in Wuhan City, China.

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Greenpeace is an independent global
campaigning organisation that acts
to change attitudes and behaviour,
to protect and conserve the environment
and to promote peace.

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