Water Quality and Health Status in Kollam Municipality

M. K. P. Roy

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1. Introduction

Several studies have indicated that household environment and quality of potable water play a significant role in the health status of the people of Kerala. Well water in several parts of Kerala is reported to be highly contaminated. Doubts have been cast even on the purity of piped water. Out-breaks of a series of water-borne diseases were reported from thickly populated areas of Kollam district in recent years, especially during rainy seasons. It is in this context that the present investigation is made into the environmental conditions, quality of potable water and socio-economic conditions and health status of the population in the Kollam Municipality.

Objectives

The major objectives of the present study are the following:

(i) investigation into the factors related to the poor quality of drinking water in Kollam Municipality area; and
(ii) assessment of the impact of poor water quality on the health status of the local population and the incidence of water-borne contagious diseases in the area.

Review of studies

The Report of Fifth Five-Year Plan (1974-'79) of Government of Kerala (GOK, 1974) revealed that 99 percent of the *panchayats* in Kerala faced drinking water scarcity of varying duration and intensity. Soman (1981) observed that one-half to two-thirds of the households in Kerala had no protected water supply and sanitary latrines. Panikar and Soman (1984) studied the health status of Kerala and observed that diseases of gastro-intestinal system contribute to the largest proportion of diseases.

Another study conducted by KSSP (1987) in Kuttanad, Kerala revealed that diseases like

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diarrhoea, dysentery, typhoid, worm infestations, and infectious hepatitis (jaundice) accounted for 50 percent of illnesses. It was further observed that in half the area of Kuttanad, which had piped water supply, cases of water-borne diseases were significantly lower.

Aravindan (1989) documented that in Kerala, in spite of its high literacy and widespread health services, the diarrhoeal mortality rate was high and pointed out that Kollam district was one among the four districts with the highest rates of diarrhoeal mortality in the state. Abhayambika, et al, (1989) who investigated the epidemiological factors of diarrhoeal diseases in rural Kerala, observed that poor housing, lack of protected water supply and inadequate toilet facilities were the major risk factors in the three southern districts of Kerala.

A study on the bacterial quality of water in selected wells in Kerala jointly conducted by Kerala Water Authority and Kerala Pollution Control Board (KWA, 1991) showed that water in none of the open wells investigated was safe for drinking. This was a startling observation because more than 50 percent of the population of Kerala used dug-well water for drinking. The study also indicated the need for a detailed investigation for finding out the factors related to the deterioration of water quality in the state.

Kannan *et al* (1991) conducted a study in all the fourteen districts of Kerala on the health status of rural households and reported that acute morbidity declines as the social and economic status of households rises due to fall in the incidence of infectious diseases. The study further pointed out that the incidence of diarrhoea cases was more among persons using public wells and public taps.

A study carried out by Soman *et al* (1991) in two localities of Thiruvananthapuram city showed that there was up to six times greater risk for many disease groups in the more environmentally deprived area. It was also observed that only 3.5 percent of the households had safe drinking water in the environmentally deprived area compared to 53 percent for the rest of the study area, the corresponding figures for toilet facilities being 25.9 percent and 62.2 percent respectively.

Jalasandesh (1994) reported that Kerala is identified as the only place in the world with such large numbers of open dug-wells. Further, it revealed that the density of dug-wells in coastal areas of Kerala is about 250 km^2, 150 km^2 in the midlands and 25 km^2 in the highlands and that there are totally three million wells in Kerala. Owing to poor environmental conditions and unhygienic behavioural practices the wells get frequently contaminated; the incidence of water-borne diseases gets thereby aggravated.

Studies by Radhakrishnan *et al* (1996) on the bacteriological quality of water in the coastal village of Pulluvila (Kerala) showed that all the samples of dug-well water in the area were coliform positive. The MPN values ranged from 41 to 1200/100ml. It was further recorded that 20 wells out of 35 were located within a distance of 10 m from septic tank and 90 percent of the people in the area defecated in open places.

A study conducted by Panicker *et al* (2000) in Kottayam municipality on the bacteriological

quality of various drinking water sources, indicated that almost all dug-well water samples had faecal coliform count much above the WHO standard. But chlorinated tap water samples from Kottayam municipal area showed total absence of coliform organisms.

Komath *et al* (2000) observed the impact of solid waste disposal on ground-water quality in Kozhikode, Kerala. Results of the study confirmed that open dumping of solid waste led to contamination of ground water sources within the vicinity of dumping sites.

Pillai and Ouseph (2000) observed that more than half the Kerala population utilises dug-wells as the sole source of drinking water. They also stated that outbreaks of water-borne diseases were due to consumption of contaminated water from poorly protected wells. Temperature and rain were found to have a decisive role in the pathogen count. Further it was seen that 0.2 –0.3 ppm free chlorine was found to be the optimum for disinfection of the open dug-wells for 3 to 4 days.

Calvert and Andersson (2000) observed that sanitation is very poor in the fishing villages along the cost of Kerala. Over 80 percent of the households have no latrines and at least 50 percent obtained water from communal wells. Open-air defecation, which is the norm in the area combined with poor hygiene and proximity of communal wells to pit-latrines, resulted in the contamination of most wells with coliform bacteria. The authors pointed out “people did not know that virtually all the wells in the villages were seriously contaminated with faecal coliforms”.

The present study was carried out in two phases. The first phase consists of a detailed analysis of physico-chemical and bacteriological characteristics of various water sources in the area including domestic dug-wells, public dug-wells, tube-wells (KWA), municipal piped water supply (KWA), small public and private tap-water supplies and pond-water. The second phase of the study comprises the investigation into the reasons for the poor water quality and its possible impact upon the health status of the people in the area through a household survey.

The results of the study would help understand the actual position of fresh water sources, the nature and quality of water made available, the causes and implications of water quality upon the health profile of the population in the study area. On the basis of the findings, a few suggestions are also made to improve the quality of water used for drinking and domestic purposes in the study area.

2. Socio-economic Status of Households

Survey area

The survey was conducted in Kollam municipality of the State of Kerala, which has an area of 18.48 sq.km and 36 wards. The total population of the Municipality according to the 1991 Census was 139,717. Out of these, 19 wards were selected for household survey (Fig.1) based mainly on geographical and environmental characteristics. Geographically the study area is divisible into three zones: a marine zone, a brackish water zone and a fresh water zone. The Lakshadweep sea bordered the north-western region of Kollam municipality (marine zone), the *Ashtamudi kayal* bordered the eastern part (brackish water zone) and the southern region of the study area constituted the fresh water zone.

The municipal wards selected for the household survey were those in which the 18 water sampling stations were located. The main objective of the household survey was to analyse the impact of socio-economic and sanitary conditions on the quality of water used for drinking and domestic purposes and to find out the relationship between the water quality and the health status of the people in the area, particularly water-borne morbidity.

Methodology

A household survey questionnaire was prepared after discussions with experts from the Achutha Menon the Centre for Public Health Studies of SCTIMST, Thiruvananthapuram and the Centre for Development Studies (CDS), Thiruvananthapuram. The random sampling method was adopted for the selection of households (National Family Health Survey-India, 1992-1993 and Demographic Health Survey (DHS)-Macro International, 1997). A total of 800 households from 19 wards of Kollam municipal area were randomly selected for the survey.

Data collection

The data were collected by trained interviewers. The help of epidemiological and environmental experts was sought in giving comprehensive training to interviewers for collecting accurate and reliable data. The data entry was carried out in Dbase III + and the data analysis was done in FoxPro programme.

Survey design

The survey was designed on a status-based approach, which consisted of collection of data on socio-economic status, sanitary status, and health status of the residents of the area. In addition, the questionnaire was designed to obtain data on various drinking water sources along with their accessibility, availability and potability.

Social status

The data collected on the social characteristics of the sample population comprised size and composition of the family, education and employment, age group and sex.

Economic status

The indicators for economic status of the area consisted of monthly expenditure, expenditure on housing quality reckoned in terms of roof, wall, and floor and floor area, occupation of the head of the household and assets and consumer durables. Since it was difficult to obtain the actual monthly income of each household, data on monthly expenditure were considered for status identification. Most of the households, irrespective of rich and poor had less than 10 cents of land. So the floor area of each household was considered more relevant than the total land area in terms of economic status. Occupation of the head of the household and possession of household items such as water purifier, refrigerator, cooking range, washing machine, water cooler/air cooler, water heater, water storage tank, air conditioner, telephone, computer, and vehicles (two wheelers, three wheelers and four wheelers) were also considered for socio-economic classification.

Thus based on these indicators, the people living in the municipal area were classified into five socio-economic groups: very poor, somewhat poor, middle class, above middle class and rich. The first two groups fell in the category "Below Poverty line" (BPL). For socio-economic classification of households, the weights assigned were 0.35 for monthly expenditure, 0.25 for education, 0.15 for housing (roof 0.05, floor 0.05 and wall 0.05), 0.10 for floor area, 0.05 for occupation, 0.05 for household items and 0.05 for movable assets and consumer durables. Weights for monthly expenditure, education and housing conditions were those adopted by earlier studies (KSSP, 1991). For the remaining indicators such as occupation, household items and moving properties, weights were assigned after discussions with groups of 30 persons, and according to the weights assigned to the various characteristics as indicated earlier.

Results and Discussion

Social status

Household/family particulars

Male population

It was observed that 25 percent of the male population belonged to the age group <14 years; 60% belonged to the working age group 15-59 years and the rest 15 percent belonged to the age group above 60 years.

Female population

The age-wise distribution of females was almost entirely similar to that of males. It was seen that 24 percent of female population belonged to <14 years group; 60 percent to the age group 15-59 whereas 16 percent belonged to above 60 years. It indicated that the populations of both the sexes were equally represented.

Education

Educational qualification of the head of the family

The heads of the sample households were relatively well-educated, illiterates among them being less than one-eighth. Among the literates (88 percent), 18 percent had primary education and 27 percent had secondary education. SSLC holders were 24 percent and those who completed pre-degree course were 6 percent. However, seven percent of the family heads had degrees and three percent had post-graduate qualification. Diploma holders were one percent whereas MBBS/Engineering degree holders were two percent.

Educational qualification of the spouse

Illiterates constituted only 9 percent among the spouses of the heads of households; among them those with primary education came to 8 percent; those with secondary education were 31 percent whereas SSLC holders were 27 percent. Further, 9 percent of spouses had education up to the pre-degree level and 4 percent had degree qualification. Only 1 percent of spouses were postgraduates or persons with professional qualification like MBBS/Engineering degree. In the matter of education, not much difference is observed between the spouses.

Educational qualification of children

All children in the age group 0-14, except those below the school-going age of 5 years attended school.

Job of the head of the family

It was found that 12 percent of the heads were government employees while 6 percent were working as doctors/engineers; 16 percent were found to be engaged in business; 37 percent as skilled labourers; 17 percent as manual workers; 9 percent without job as retired employees; 2 percent working in private firms and 1 percent as politicians.

Job of spouses

It was noticed that 21 percent of the spouses were working as government employees while 9 percent as doctors/engineers. The business group comprised 18 percent and the skilled labour group 17 percent. The percentage of manual labour was recorded as 19 percent whereas that of retired employees as 10 percent. Further it was noticed that 6 percent of spouses were working in private firms.

Job of children

Nine percent of children belonged to the group of Government employees; 5 percent belonged to those of professionals like doctors, engineers and the like; 13 percent to business groups and 50 percent to skilled labourers. Further, 18 percent of children in the study area belonged to the manual labourer group and 5 percent to the group of workers in private firms.

Figure 2.1 Male population - Kollam Municipal area

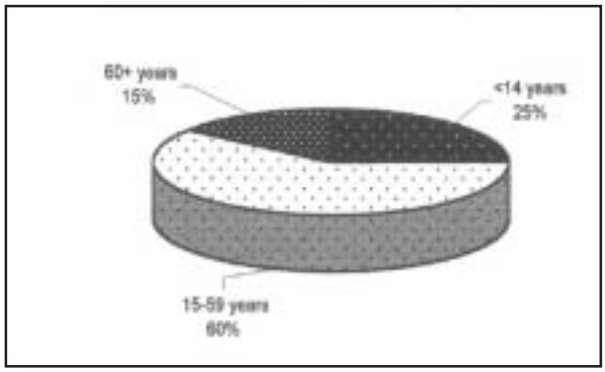


Figure 2.2 Female population - Kollam Municipal area

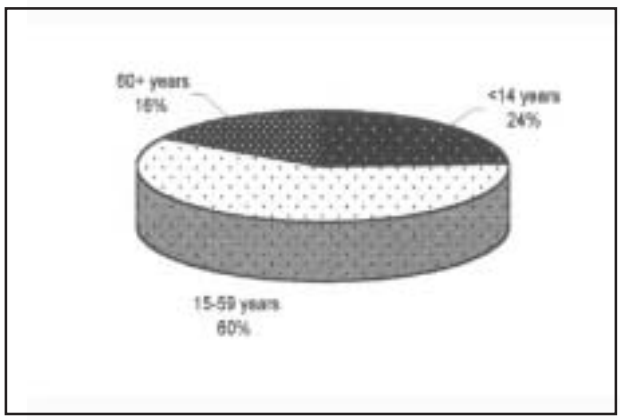


Figure 2.3 Head of the family - Educational qualification

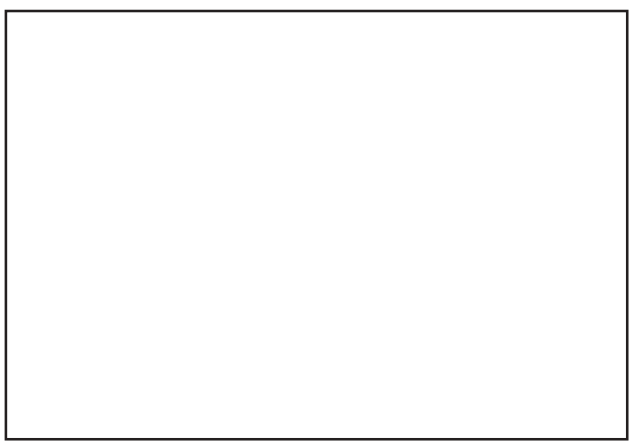


Figure 2.4 Spouse - Qualification

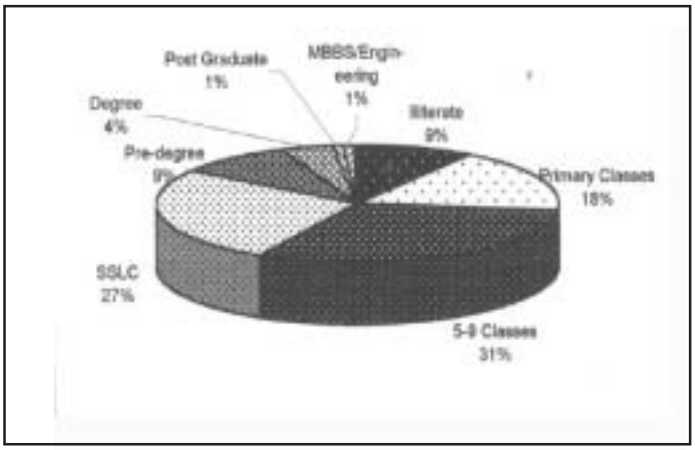


Figure 2.5 Children - Education

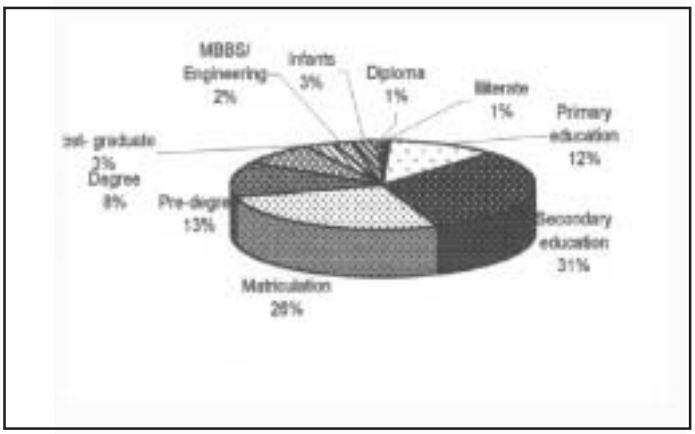


Figure 2.6 Head of the family - Job

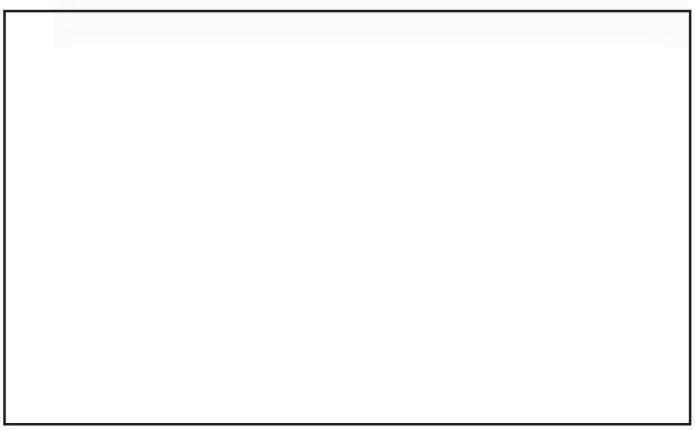


Figure 2.7 Spouse - Job

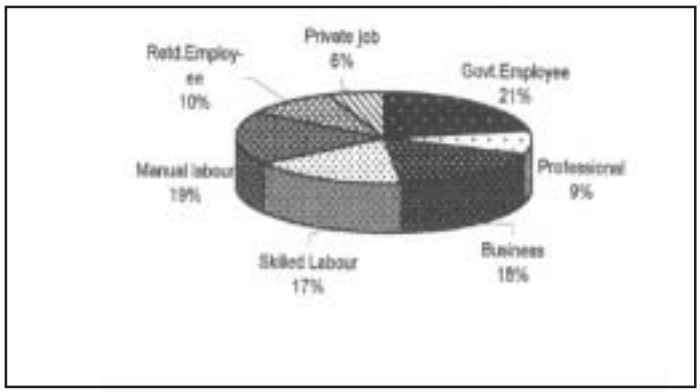


Figure 2.8 Children - Job

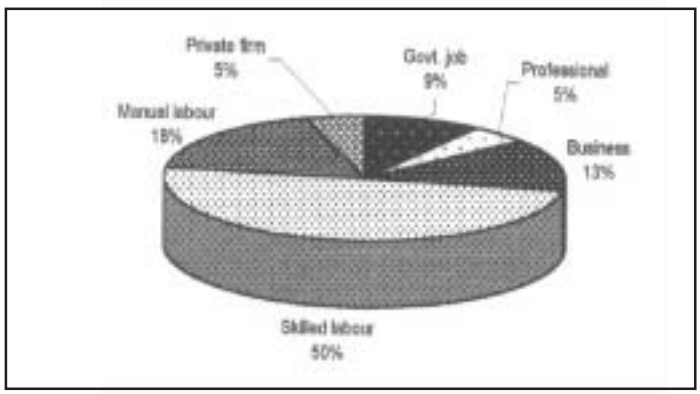
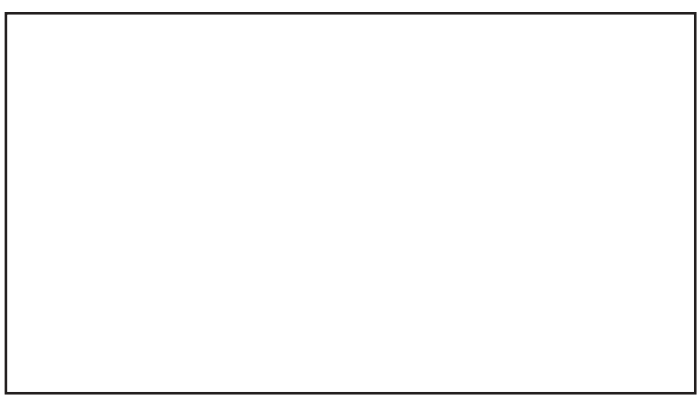


Figure 2.9 Land holding



Economic status

Land holding

Eighty-six percent of households (686 out of 800 households) possessed land area up to 10 cents each while only 2 percent of households were recorded as landless; 11 percent possessed 11-50 cents, whereas only 1 percent was noticed with land area of 51-250 cents. Only 3 households possessed more than 251 cents.

Monthly expenditure

Since it was difficult to collect data on the actual income of families, the expenditure of the households was taken into account as an index of their economic status. People with a monthly expenditure Rs <750 were estimated to be 2 percent. In Rs 751-1500 category, there were 7 percent. The next group, which consisted of 35 percent, spent Rs 1501-3000. In Rs 3001-7000 group, recorded with the highest percentage of 43 percent. Thirteen per cent of households registered with the monthly expenditure of Rs 7000>. The five groups based on their monthly expenditure were called very poor, somewhat poor, middle class, above middle class and rich. Based on monthly expenditure, most of the people in the study area were under either middle class or above middle class.

House details

Roof of the house

It was recorded that 8 percent of houses were with grass/thatch roof; 17 percent with sheet; 40 percent with tiles; 7 percent with a combination of tiles and concrete whereas 28 percent with concrete roof. It was significant to notice that roofs of the majority of the households were made up of tiles of traditional Kerala style.

Wall of the house

It was observed that 9 percent of the walls of the sample households were with grass/ *panambu*; 9 percent with wood or sheet; 4 percent with non-plastered wall of bricks and stone and 78 percent with plastered wall of bricks and stone.

Floor of the house

Only 2 percent of floors were with mud or cow dung whereas cement floor was recorded with 81 percent; a combination of cement and mosaic was found with 4 percent; mosaic floor alone with 11 percent and with marble and granite floor with 2 percent. It was significant to notice that although 8-9 percent of the houses were with grass/thatch roofs and walls with grass/*panambu*, only 2 percent were with cow dung floors. It showed that even poor people of the area preferred cement flooring.

Figure 2.10 Monthly expenditure

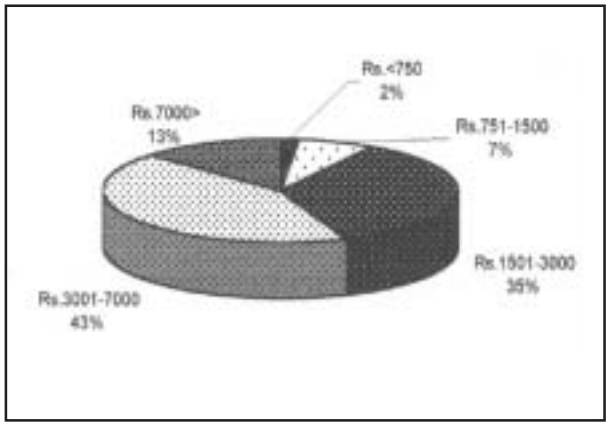


Figure 2.11 Wall of the house

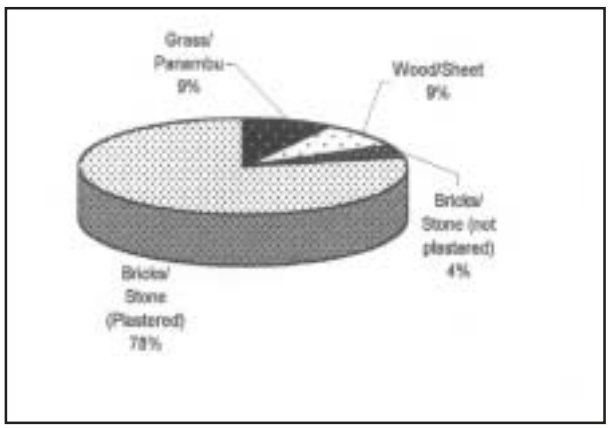


Figure 2.12 Floor

Figure 2.13 Number of floors

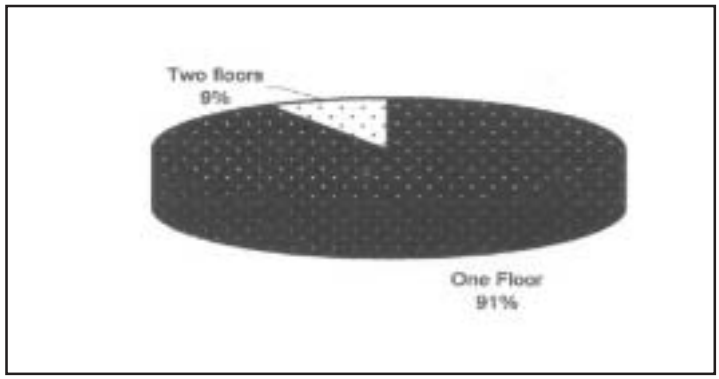


Figure 2.14 Floor area (sq.ft)

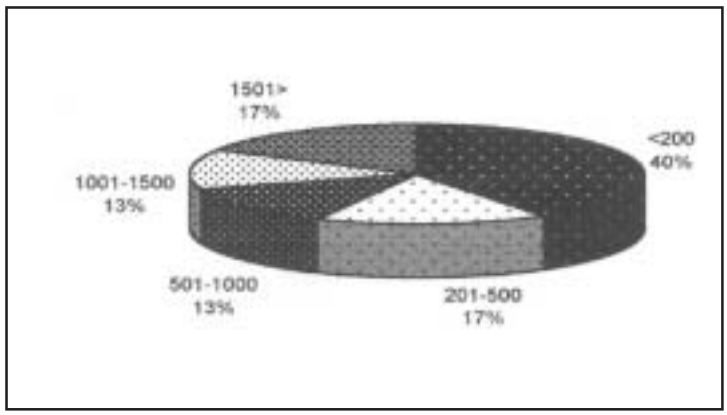


Figure 2.15 Moving properties

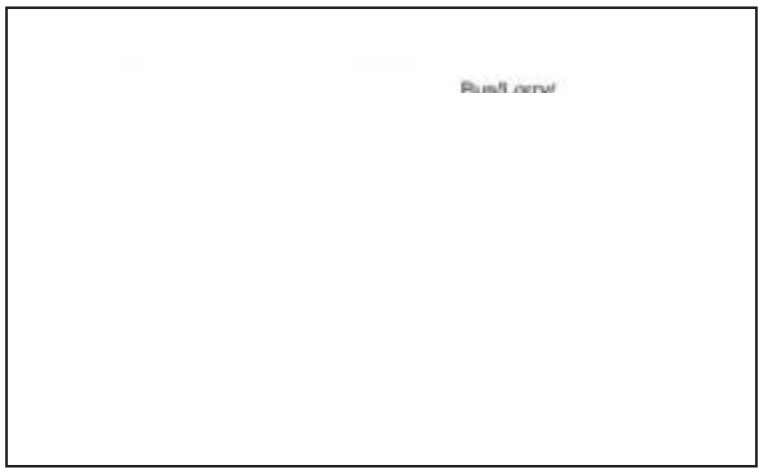


Figure 2.16 Household items

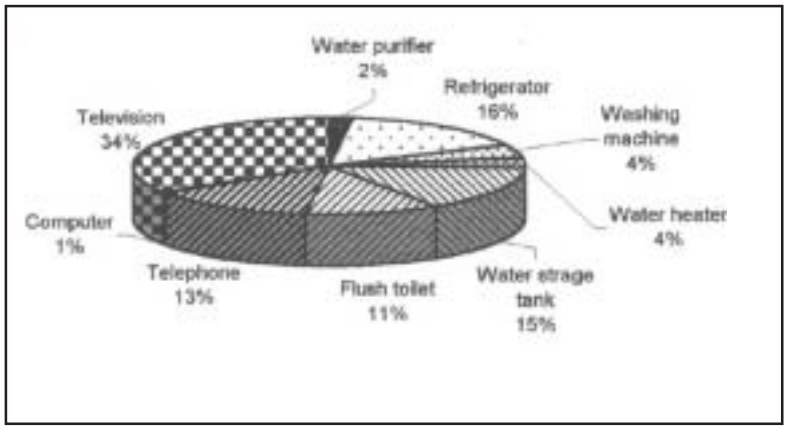


Figure 2.17 Socio-economic classification of households of Kollam municipality

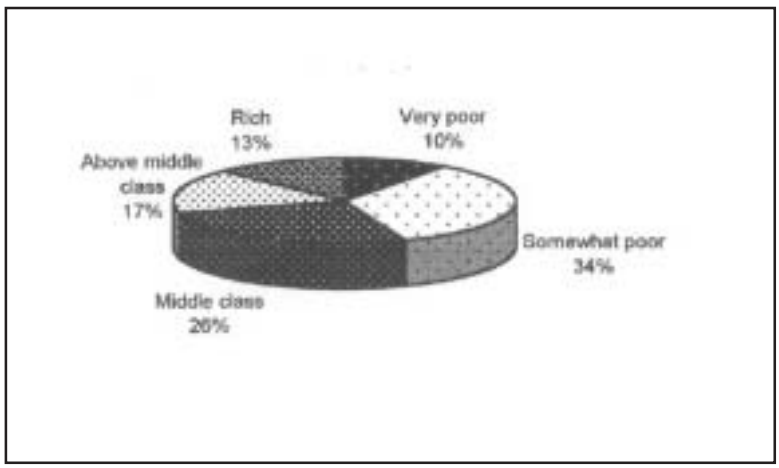
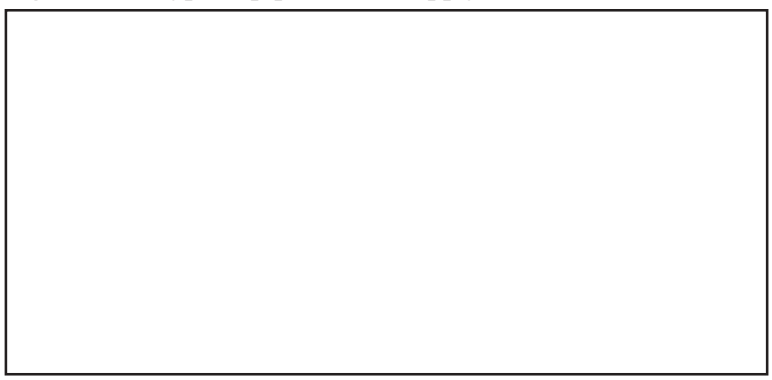


Figure 2.18 Type of piped water supply



Number of floors

It may be seen that 91 percent of households had only one floor; 9 percent had two floors.

Floor area

Forty percent of houses were with less than 200 sq.ft. floor area while 17 percent had floor area of 201-500 sq.ft.; in 13 percent of the households, it was in the range of 501-1000 sq.ft. and another 13 percent had 1001-1500 sq.ft. Further it was estimated that 17 percent of houses were with floor area of > 1500 sq.ft.

Household belongings

Moving properties

It was recorded that 62 percent of the households possessed bicycle/pull cart/country canoe(*nadan vallom*) while 24 percent possessed motor cycle/scooter; 3 percent had auto rickshaw/motor vallom; 1 percent had mini lorry/car/jeep/mini bus used as taxi and 10 percent with private car/jeep and other heavy vehicles.

Household items

It was noticed that 2 percent of households possessed water purifiers; 16 percent refrigerator; 4 percent washing machine and water heater; and 34 percent television. Telephone was used by 13 percent and computer by 1 percent of the population. Further, 15 percent possessed water storage tank and 11 percent owned flush toilet.

Table1 2.1 Socio-economic status of households of Kollam municipality, based on indicators for which weights were assigned

(SES = Socio-economic status; NHH = No. of households)

Socio-economic status (SES)	Expenditure NHH	%	Education NHH	%	Job NHH	%	Household items NHH	%
SES 1		1.6%		11.8%		22.1%		23.4%
SES 2		7.0%		17.5%		13.4%		7.9%
SES 3		35.4%		27.8%		37.8%		6.8%
SES 4		43.0%		29.5%		9.6%		7.6%
SES 5	104	13.0%	108	13.5%	137	17.1%	142	17.8%
Total	800	100%	800	100%	800	100%	507	63.4%

Table 2.2 Socio-economic status of households of Kollam municipality: Number and percentage of households

Socio-economic status of households	Number of households	Percentage of each group
SES 1 (Very poor)	81	10.1%
SES 2 (Somewhat poor)	273	34.1%
SES 3 (Middle class)	210	26.3%
SES 4 (Above middle class)	135	16.9%
SES 5 (Rich)	101	12.6%
Total	800	100%

3. Quality of Drinking Water: Physio-chemical and bacteriological characteristics

Method of analysis

The quality of drinking water was analysed in terms of colour, hydrogen ion concentration, turbidity, total alkinity, total dissolved solids, chloride, total hardness, fluoride, iron, coliforms and residual chlorine.

(i) Colour: Colour of water sample was determined by Platinum-cobalt method (APHA, 1985) in which visual comparison with known colour standards was made. Colour standards and reagents were prepared as per details mentioned in APHA (1985). It was based on the calculation that one colour unit of the standard is equivalent to the colour produced by 1mg/ l of platinum.

(ii) Hydrogen ion concentration (pH): pH is the measure of the relative acidity or alkalinity and it represents the negative logarithm of the concentration of free hydrogen ions in a solution. Scale of pH ranges from 0 to 14 with 7 as neutral; below and above this range; it is acidic or alkaline respectively.

In this method, pH of water was measured by electrometric method (APHA, 1985).

(iii) Turbidity: Turbidity of water is an expression of optical property in which the light is scattered by the particles present in the water. It includes clay, silt, organic and inorganic matter, soluble coloured organic compounds, phytoplankton and other microscopic organisms. The scattering of the light is proportional to the turbidity. Turbidity was determined by Nephelometric method. The turbidity suspension was prepared as per standard procedure (APHA, 1985)

(iv) Total Alkalinity: Alkalinity of water is a measure of its capacity to neutralise acids. It is due to the salts of carbonate, bicarbonate, borate, silicate and phosphate together with the hydroxyl ions in free state. In natural waters, the major portion of the alkalinity is caused by hydroxide, carbonate and bicarbonate that may be ranked in order of their association with high pH values. Titrimetric method was used for the determination of total alkalinity.

(v) Total Dissolved Solids (TDS): Total dissolved solids (TDS) in water are the residues left after evaporation of the filtered sample. It was determined by the evaporation method of filtered sample followed by gravimetric analysis.

(vi) Chloride: Chloride was estimated by Mohr's titration method. In this method, chloride is titrated with silver nitrate in the presence of potassium chromate to form a very slightly soluble white precipitate of AgCl. The brick-red silver chromate was formed at the end point owing to the reaction of a slight excess of silver nitrate with potassium chromate. Reagents were prepared as per Adoni (1985).

(vii) Total hardness: Hardness of water is mainly due to the calcium and magnesium ions present in it. It is imparted by the calcium and magnesium ions, which are in combination with bicarbonates and carbonates apart from sulphates, chlorides and nitrates. Total hardness was estimated by EDTA Titrimetric method (APHA, 1985).

Reagents were prepared as per APHA (1985)

(viii) Fluoride : Excess fluoride ions in water supplies are known to damage teeth, skeleton and other organs of the human body. High concentration of fluoride causes dental fluorosis. BIS mentions the permissible upper limit as 1mg/l. Fluoride was determined by SPADNS method (APHA, 1985)

(ix) Iron : Phenonthroline method was used to determine the concentration of iron (APHA, 1985). Iron occurs in natural waters both in oxidised (ferric) and reduced (ferrous) states. All the iron is converted into ferrous state by boiling with hydrochloric acid and hydroxylamine. The reduced iron chelates with 1,10-phenonthroline at pH 3.2 to 3.3 to form a complex of orange-red colour. Intensity of this colour is proportional to the concentration of iron.

(x) Coliforms

Multiple-tube fermentation technique: Multiple tube fermentation technique is widely in use due to its applicability to almost all kinds of waters. The technique involves inoculating the sample in a suitable liquid medium. After the expiry of the incubation period, the tubes are examined for gas production by the coliform organisms. This presumptive test is followed by confirmatory test for the positive tubes. (APHA, 1985).

(xi) Residual chlorine: The chlorination of water supplies serves primarily to destroy or deactivate disease-producing micro-organisms. Presence of excess chlorine intensifies the taste and odour of water. Though chlorine is widely used as water disinfectant, it can also produce chlorinated organic by-products in water. Orthotolidine test was used to estimate the residual chlorine in water (PHED, 1984).

Sampling stations

The list of selected sampling stations is given in Table 1.

a. Domestic dug-wells

(i) Well No. 1 (Ward No.8 – Pattathanam West): This well is located in a thickly populated (railway colony) area. More than 10 families of this area used this well for drinking and domestic purposes. It is provided with a platform and protective wall. Soil type of the well is sandy. Waterlogging is found all around the well. The well is located in the fresh-water zone.

(ii) Well No.2 (Ward No. 7 – Asramam South): On this well in the Kollam municipal area several families and commercial establishments of that area depend for drinking water

purposes. The well is built with a platform along with a protective wall. A latrine is located within 2 m from the well. This domestic dug-well is located in the fresh water zone.

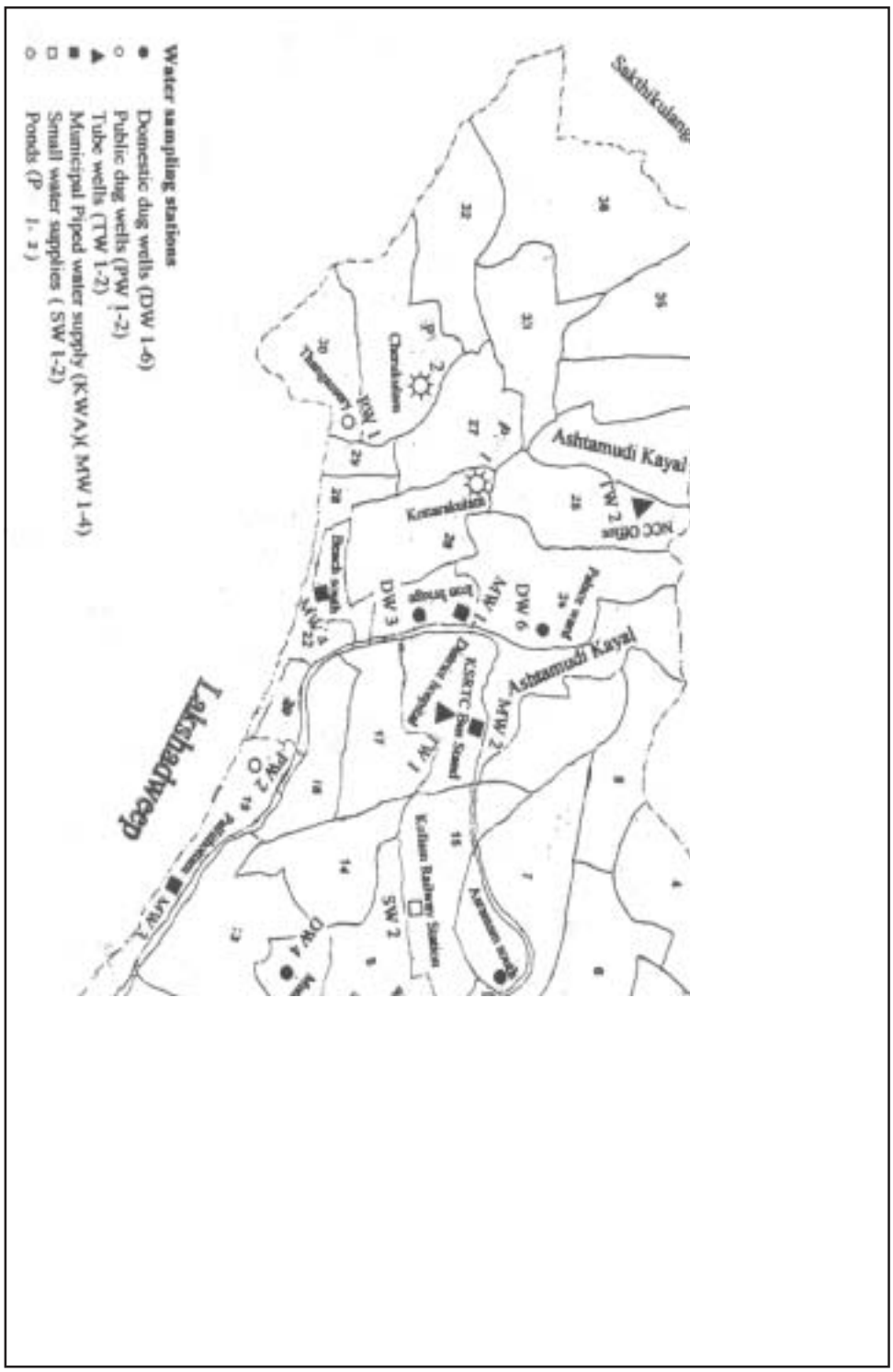
Table 1 List of Selected Sampling Stations

Well No.	I Domestic Dug-wells
1	Pattathanam West (Ward No.8)
2	Asramam South (Ward No.7)
3	Kottakkom (Ward No.23)
4	Mundakkal Middle (Ward No.12)
5	Pattathanam East (Ward No.9)
6	Palace Ward (Ward No.24)
	II Public Dug-wells
1	Pallithottam Church Well (Ward No.19)
2	Thangassery Library Well (Ward No.30)
	III Tube Wells
1	Vadakkumbhagom - District Hospital) (Ward No.16)
2	Thevally – NCC Office (Ward No.25)
	IV Municipal Tap-water Supply (KWA)
1	Pallithottam (Ward No.20)
2	Vady (Ward No.21)
3	Kottakkakom, Iron Bridge (Ward No.23)
4	Vadakkumbhagom (Ward No.16)
	V Small Water Supplies
1	Cantonment North, Kollam Central Rly Station (Ward No.15)
2	Pattathanam West, FMN College (Ward No.8)
	V Ponds
1	Kottarakkulam, Cutchery Ward (Ward No.26)
2	Cherukulam, Punthole South (Ward No.31)

(iii) Well No.3 (Ward No.23-Kottakkakom): This well is located about 50 meters away from the Kollam *thodu* (T-S canal). Though it is a privately-owned well several families in the locality and shops and establishments use its water for drinking and domestic purposes. The water level was almost that of the canal. The well is built with protective wall outside and rings inside. The well is located in the brackish water zone.

(iv) Well No.4 (Ward No. 12-Mundakkal Middle): This privately-owned well is surrounded by visible pollution sources such as latrine, domestic animal waste and other solid wastes. There is no protective wall for the well. More than five families use this water source for drinking and other domestic purposes. This well is located in the fresh water zone of Kollam municipal area.

Figure 3.1 Kollam municipal area



(v) Well No.5 (Ward No. 9-Pattathanam East): This is a privately-owned well; it is provided with all protective measures like elevated platform, protective wall (specially constructed aprons), rings within the well and net covering with net. The well is located in a residential area and the households in the vicinity around belonged to the upper socio-economic stratum. The well is located in the fresh water zone.

(vi) Well No. 6 (Ward No.24- Palace Ward): The well is located in the brackish water zone. It is provided with protective wall and net covering. It is owned by a household belonging to the middle-income group.

b. Public dug-wells

(i) Well No. 1 (Ward No.19-Church well, Pallithottam): This well belonging to the Latin Catholic Church and located in the coastal area of Pallithottam (in the marine zone) is used by the local fishermen community. This well is provided with platform and a protective wall. About 50 local fishermen families use this well for drinking, bathing and other domestic purposes. Since piped municipal water is available only during mornings and evenings, this well is the only sure source of water for drinking and other domestic purposes throughout the day.

(ii) Well No. 2 (Ward No. 30-Library well, Thangassery): This public dug-well is located in the coastal village of Thangassery on the side of the Arabian Sea (marine zone). The well is popularly known as the *library well* of Bonovista. It is very large and is covered with an iron net. More than 50 families, mostly belonging to low-income groups, use water of this well for drinking and other domestic purposes.

c. Tube-wells

(i) Well No. 1 (Ward No. 16- Vadakkumbhagam, District hospital, Kollam): Kollam district hospital obtains water from this tube-well. A large open storage tank is built in the hospital compound for storing the water from this tube-well for distribution. This tube-well is one of the eight tube wells in the municipal area managed by Kerala Water Authority (KWA). This tube-well is located in the fresh water zone.

(ii) Well No.2 (Ward No. 25- Thevally, NCC Office, Kollam): This well is located on the banks of the Ashtamudi *kayal* (brackish water zone) and managed by Kerala Water Authority (KWA). This is the only source of piped water supply in this region. Consumers of this source of supply are mainly people working in Government offices like the NCC Office and the SP Office, Kollam.

d. Municipal tap-water supply (KWA)

(i) Public tap No.1 (Ward No. 20- Beach East, Pallithottam): This public tap is located in the coastal area of Pallithottam where there is a dense population of the fishermen community. Long queues for collection of drinking water is a common sight at this point during mornings and evenings because water in the dug-wells in this area is mostly brackish due to nearness to the Arabian Sea.

(ii) Municipal public tap No.2 (Ward No. 21- Beach South, Vady): This tap located in Vady, a coastal village of Kollam. Hundreds of people from the fishermen community depend on this water point since it is the only source of water for drinking in this area.

(iii) Municipal public tap No.3 (Ward No. 23- Kottakkakom, Iron Bridge) : This tap is located on the bank of Kollam *thodu* (T-S canal) in the brackish water zone. The area is thickly populated and most of the people are associated with the coir industry.

(iv) Municipal public tap No.4 (Ward No.16- Vadakkumbhagam, KSRTC-Bus stand): This water point is located in the Canteen of the Kollam Transport Bus Stand (KSRTC). Hundreds of passengers use this water for drinking.

e. Small tap-water supplies

(i) Small tap-water supply No.1 (Ward No. 15, Cantonment North, Kollam Central Railway Station): This sampling station is the drinking water point of Kollam Central Railway Station. Everyday hundreds of passengers make use this water for drinking. Water for this Station is obtained from a large dug-well located nearby the Railway Station and the well is poorly protected of this well is poor. There is no protective wall and the surrounding areas are not clean. This well is located in the fresh water zone of Kollam municipality.

(ii) Small tap-water supply No.2 (Ward No. 8, Pattathanam West, Fatima Mata National College, Kollam): The water in this tap is obtained from the municipal water supply (KWA) and a nearby well. College students use this water for drinking, especially after taking lunch. The college is located in the fresh water zone.

f. Ponds

(i) Pond No.1 (Ward No. 26, *Cutchery* Ward, Kottarakkulam): It is a pond located at the heart of the town since ancient times. Scenic beauty of this pond has been renowned. It remains in a deteriorating condition. There was hue and cry from all walks of life to protect this perennial water body. This pond is located in the fresh water zone.

(ii) Pond No.2 (Ward No.31, Punnathala South, Cherukulam): Cherukulam is a medium-sized pond with an area of more than 5 acres. The municipality has built a retaining wall to prevent soil erosion and protect this water-body. The people of this area use this water-body mainly for bathing.

Results and Discussion

Colour (Hazen Units)

Colour of water from domestic dug-wells

In well No.(i) (Pattathanam West) the colour of water ranged from 05 to 20 HU whereas in well No.(ii) (Asramam South) it varied from 05 to 20 HU. 10 HU was the lowest value and

55 HU was the highest value of colour recorded in well No.(iii) (Kottakkakom). In well No.(iv) (Mundakkal Middle) the maximum was noticed in July 1997 (40 HU) and the minimum in June 1997 (05 HU). In well No. (v) (Pattathanam East) the colour of water varied from 25 to 35 HU. The above results of colour were compared with the standards prescribed by Bureau of Indian Standards (BIS) and WHO. BIS (1991) has prescribed a value of 5 Hazen Units as the desirable limit of colour for drinking water. Thus we find that water from these 6 domestic dug wells was highly unsuitable for drinking.

Colour of water from public dug-wells

In dug-well No. (i) (Church well, Pallithottam) the maximum value (90 HU) for colour was observed in February 1998 and the minimum (15 HU) in June 1997. The colour from public dug well No. (ii) (Library well, Thangassery) varied between 15 and 70 HU. From the results it was noticed that water of public dug wells was highly unsuitable for drinking purpose as per standards prescribed by BIS and WHO.

Colour of water from tube wells

In tube well No.(i) (District Hospital, Kollam) the maximum value of colour (25 HU) was observed in September 1997 and minimum in July 1997 (05 HU). In tube well No. (ii) (NCC Office, Kollam) the highest value was recorded in September 1997 (25 HU) and lowest in June 1997 (05 HU). The data also revealed that the water from Tube Wells was objectionable for drinking as per the guidelines prescribed by Bureau of Indian Standards (BIS).

Colour of water from municipal tap-water supply (KWA)

For Station (i) (Pallithottam) the maximum and minimum colour obtained was 25 and 10 HU respectively. The colour of water varied between 10 and 30 HU in station (ii) (Vady). In station (iii) (Iron Bridge) the colour of water varied from 10 to 25 HU. A range from 10 to 25 HU was observed for station (ii) (KSRTC-Bus Stand). As per specification (BIS) it was observed that drinking water of the municipal water supply (KWA) of Kollam was not suitable for drinking.

Colour of tap-water from small water supplies (public and private)

In Station (i) (drinking water supply, Kollam Railway Station) the peak colour was recorded in August 1997 (30 HU) and the lowest value (05 HU) during July 1997 and February 1998. Kollam Railway drinking water supply is an important one since the consumers are mainly the Railway passengers. As per the standards prescribed by BIS and WHO, it was objectionable for drinking purpose. In Station (ii) (FMN College, Kollam) the range of colour obtained during the period of investigation was from 20 to 25 HU.

Colour of pond water

In Pond No. (i) (Kottarakulam) the colour of water ranged between 80 and 100 HU whereas in pond No. (ii) (Cherukulam) it ranged from 80 to 100 HU. The mean monthly value of

colour varied from 82.5±3.54 to 100.0±0.0 HU. It may be noted that water from both ponds was highly unsuitable for drinking and other domestic purposes as per standard norms prescribed by BIS and WHO.

2. pH

pH of domestic dug-well water

In well No. (i) (Railway colony) pH ranged from 6.2 to 7.0 whereas in well No. (ii) (Asramam south) the range of pH was from 6.5 to 6.9. A range of 6.5 to 7.6 was observed in well No. (iii) (Kottakkom). In well No. (iv) (Mundakkal Middle) the range was between 5.5 and 7.0 while in well No. (v) (Pattathanam East) the minimum value was 6.5 and the maximum 7.0. Among the domestic dug-wells, the highest fluctuation in pH was noticed in well No. (vi) (Palace Ward) where the lowest value was 6.5 and the highest 7.7. As per Bureau of Indian Standards (BIS), pH of water of the selected wells was within the permissible limit (6.5-8.5) and therefore, safe for drinking.

pH of public dug-well water

In dug-well No. (I) (Church well, Pallithottam) pH varied between 6.6 and 7.5. The highest fluctuation of pH was noticed in public dug well No. (ii) (Library well, Thangassery), where the lowest value was 5.5 and the highest value 8.2. As per BIS, it was found that the range of pH was within the safe limit for drinking.

pH of tube well water

In tube well No. (i) (District Hospital, Kollam), the pH range was from 6.8 to 7.7. A range of 7.3 to 7.7 was observed in tube well No. (ii) (NCC Office, Kollam). The results revealed that the pH of water from both tube wells recorded safe for drinking as per standards prescribed by (BIS).

pH of tap-water from Kollam municipal water supply (KWA)

In station (i) (Pallithottam) the pH value was between 6.5 and 7.7. In station (ii) (Vady) the lowest value of 6.5 and the peak value of 7.9 were observed. In station (iii) (Iron Bridge) pH range was from 6.5 to 7.9 whereas in station (iv) (KSRTC-Bus Stand, Kollam) a minimum value of 6.5 and maximum level of pH 7.6 were recorded. It was noticed that pH values of tap water from Kollam municipal water supply were safe for drinking as per BIS.

pH of tap-water from small water supplies

In station No. (i) (Kollam Central Railway Station) the range was between 6.0 and 6.9. In station (ii) (FMN College, Kollam) the pH varied from 6.5 to 7.0. The monthly mean value ranged from 6.25±0.35 to 6.9±0.14. The study revealed that the pH of water from the 2 small tap water supplies was within the safety limit for drinking as per (BIS).

pH of pond water

In pond No. (i) (Kottarakulam) the range of pH was from 7.4 to 11.0. In pond No. (ii) (Cherukulam) the pH range was between 7.6 and 11.0. As per the standards prescribed by BIS, water from both ponds was highly alkaline and objectionable for both drinking and domestic purposes.

Turbidity (NTU)

Turbidity of domestic dug-well water

In dug-well No.1 (Pattathanam West) the range of turbidity was from 0 to 0.8 NTU whereas in well No.2 (Asramam South) the turbidity variation was between 0 and 2.4 NTU. In dug well No.3 (Kottakkakom) the lowest value obtained was 0.4 and highest 14.4 NTU. The lowest value was 0 while the highest value 3.6 NTU in dug well No. (iv) (Mundakkal Middle). The range of turbidity in well No. (v) (Pattathanam West) was between 0 and 1.6 NTU. The highest fluctuation in turbidity was noted in well No.6 (Olayil) where the range was from 2.4 to 29.6 NTU. The Bureau of Indian Standards (BIS) prescribed a value of 5 NTU as desirable limit for drinking water. In well No.3 (Iron Bridge) and well No. (vi) (Palace Ward), the turbidity values were exceedingly high as per the standards. Therefore, water from these two wells was not safe for drinking purpose in respect of turbidity.

Turbidity of public dug-well water

In well No. (i) (Church well, Pallithottam) the range of turbidity was from 0.8 to 40 NTU while in well No. (ii) (Library well, Thangassery) it ranged between 0 and 27.2 NTU during the period of study. The study revealed that the turbidity values of both public dug wells had exceeded the desirable limit during non-rainy season as per BIS.

Turbidity of tube well water

In tube well No. (i) (District Hospital, Kollam), the turbidity value ranged from 0.4 to 4.4 NTU whereas in tube well No. (ii) (NCC Office, Kollam) it varied between 0.4 and 5.6 NTU. The results revealed that the turbidity of water from both tube wells was within desirable limit as per standards and therefore, safe for drinking.

Turbidity of tap-water from municipal water supply (KWA)

Turbidity varied from 0.8 to 4.4 NTU in station (i) (Pallithottam) while in station (ii) (Vaddy) the range was from 1.6 to 4.2 NTU. In station (iii) (Iron Bridge) the turbidity value varied from 0.8 to 3.6 NTU whereas in station (iv) (KSRTC-Bus Stand, Kollam) the lowest value was recorded as 1.2 and the highest as 3.2 NTU. Results of turbidity from Kollam municipal water supply revealed that the water was safe for drinking with respect to turbidity.

Turbidity of tap-water from small water supplies

In station (ii) (FMN College, Kollam) the turbidity range was from 0.8 to 2.8 NTU. In station (i) (drinking water supply of Kollam Central Railway Station), turbidity ranged between 0 and 3.2 NTU during the period of observation. As per the standards prescribed by BIS, it was noticed that the range of turbidity in both Stations was within limit and so safe for drinking.

Turbidity of pond water

In pond No. (i) (Kottarakulam) the turbidity range was from 16.4 to 39.2 NTU whereas in pond No. (ii) (Cherukulam) the range was from 10.4 to 27.6 NTU. Based on standards (BIS), it was noted that water from both ponds was highly turbid and not safe for drinking or domestic purpose.

Total alkalinity (mg/l)

Total alkalinity of Domestic Dug-Well Water

In dug-well No. (i) (Pattathanam West) the total alkalinity ranged from 85.0 to 115.0 mg/l whereas in well No. (ii) (Asramam South) it ranged from 35.0 to 100.0 mg/l. Total alkalinity fluctuated from 115.0 to 245.0 mg/l in well No. (iii) (Kottakkam). A variation of alkalinity from 40.0 to 145.0 mg/l was recorded in well No. (iv) (Mundakkal Middle). In well No. (iv) (Pattathanam East) the lowest alkalinity value was 100.0 mg/l whereas the highest was 170.0 mg/l. The fluctuation of alkalinity in well No. (vi) (Olayil) was from 90.0 to 225 mg/l. Alkalinity of domestic dug-well No.3 (Iron bridge) and well No.6 (Olayil) observed above the desirable limit as prescribed by BIS.

Total alkalinity of public dug-well water

In public dug-well No. (i) (Church well, Pallithottam) the range was from 120 to 175 mg/l whereas in well No. (ii) (Library well, Thangasserry) the Total alkalinity ranged between 110 and 215 mg/l. Alkalinity values of public dug-well No.2 (Library well, Thangassery) were recorded as high and exceeded the desirable limit of 200 mg/l (BIS)

Total alkalinity of tube well water

In tube well No. (i) (District Hospital, Kollam) the range was from 85.0 to 170.0 mg/l whereas 180.0 to 215.0 mg/l was the range in tube well No. (ii) (NCC Office, Kollam). In tube well No. (ii) (NCC Office, Thevally, Kollam), the values of total alkalinity observed above the desirable limit as per standards (BIS).

Total alkalinity of tap-water from municipal water supply (KWA)

The range was between 15.0 to 30.0 mg/l in station (i) (Pallithottam) while that of Station (ii) (Vady) was from 15.0 mg/ to 25.0 mg/l. In station (iii) (Iron Bridge) the range of alkalinity

was from 15.0 to 20.0 mg/l whereas in station (iv) (KSRTC Bus Stand, Kollam) the lowest value was 15.0 mg/l and the highest was 35.0 mg/l. The data indicated that alkalinity values of different sampling stations of Kollam municipal tap water supply were within the desirable limit of standards, as per BIS.

Total alkalinity of tap-water from small water supplies (public and private)

A range of 50.0 to 75.0 mg/l of total alkalinity was documented in station (i) (drinking water supply of Kollam Central Railway Station). In station (ii) (FMN College, Kollam) the total alkalinity ranged from 25.0 to 40.0 mg/l during the period of observation. Alkalinity of both stations recorded within the desirable limit of BIS.

Total alkalinity of pond water

In pond No. (i) (Kottarakulam) the total alkalinity ranged from 65.0 to 115.o mg/l while in pond No. (ii) (Cherukulam) the range was between 45.0 and 145.0 mg/l.

Alkalinity values were recorded within the limit as per BIS.

Total Dissolved Solids (TDS-mg/l)

Total Dissolved Solids of domestic dug-well Water

In dug-well No. (i) (Pattathanam West) a range of 120 to 560 mg/l was observed during the period of investigation. TDS varied from 80 to 680 mg/l in dug-well No. (ii) (Asramam South) whereas in well No. (iii) (Kottakkakom) the fluctuation was from 40 to 1880 mg/l. The lowest and highest values of TDS were found to be 120 mg/l and 1080 mg/l respectively in well No. (iv) (Mundakkal Middle). In well No. (v) (Pattathanam East) TDS varied from 360 to 800 mg/l during the course of observation. It was also noted that 160 to 720 mg/l was the range of TDS in well No. (vi) (Palace Ward). The results revealed that TDS of drinking water from domestic dug-wells exceeded the acceptable limit as prescribed by BIS.

Total Dissolved Solids of public dug-well water

In well No. (i) (Church well, Pallithottam) TDS ranged from 280 to 1440 mg/l whereas in well No. (ii) (Library well, Thangassery) the range of TDS was from 320 to 680 mg/l. As per the standards prescribed by BIS, it was noticed that drinking water from both public dug wells was not safe for drinking purpose.

Total Dissolved Solids of tube well water

In tube well No. (i) (District Hospital, Kollam) the range of TDS varied from 200 to 360 mg/l while in tube well No. (ii) (NCC Office, Kollam) the values varied between 80 and 720 mg/l. It revealed that in tube well No.2 (NCC Office, Kollam) the TDS range exceeded the permissible limit for drinking water as per BIS.

Total Dissolved Solids of tap water from municipal water supply (KWA)

In station (i) (Pallithottam) the range of TDS was between 80 and 240 mg/l. However, 40 to 400 mg/l was the range of TDS in station (ii) (Vady). In station (iii) (Iron Bridge) the TDS varied from 40 to 200 mg/l while in station (iv) (KSRTC Bus Stand, Kollam) the range was from 40 to 240 mg/l. It was found that TDS of all sampling Stations of Municipal Water Supply (KWA) were within the limit as per BIS.

Total Dissolved Solids of tap water from small water supplies

In station (i) (drinking water supply of Kollam Railway Station) and in station (ii) (FMN College, Kollam) the TDS ranged from 80 to 480 mg/l. As per standards, TDS of water from both stations was within permissible limit.

Total Dissolved Solids of pond water

In pond No. (i) (Kottarakulam) the TDS ranged from 120 to 480 mg/l while in pond No. (ii) (Cherukulam) the range was between 80 and 480 mg/l. The study revealed that TDS of pond water was within prescribed limits (BIS). during the period of study

Chloride (mg/l)

Chloride of domestic dug-well water

Chloride values ranged from 21.3 to 48.1 mg/l in well No. (i), whereas in well No. (ii) the fluctuation was noticed between 15.6 and 76.7 mg/l. In well No. (iii) the lowest value was observed as 28.4 mg/l while the highest as 243mg/l. Chloride varied from 12.3 to 66.5 mg/l in well No. (iv) and from12.7 to 59.6 mg/l in well No. (v). A range of 9.9 to 123 mg/l of chloride was observed in well No. (vi) during the period of investigation. The Bureau of Indian Standards (BIS) prescribed 250 mg/l of chloride as desirable limit for drinking water supplies. Limit beyond this affected the taste, corrosion and palatability of drinking water. It was noticed that chloride in all 6 domestic dug-wells was within this limit.

Chloride of public dug-well water

Range of chloride in public well No. (i) was recorded from 34.1 to 117 mg/l and in well No. (ii), from 35.5 to 64.9 mg/l. It was observed that chloride of both wells recorded within the limit as per BIS.

Chloride of tube well water

In tube well No.(i) the lowest value was observed as 8.5 mg/l whereas the highest as 26.5 mg/l. The range of chloride in tube well (ii) was from 7.1 to 52.1 mg/l. As per the guideline of BIS it was noticed that chloride in both tube wells was within the limits.

Chloride of tap-water from municipal water supply (KWA)

The range of chloride in station (i) varied from 5.6 to 21.3 mg/l. The fluctuation of chloride content in station (ii) was from 4.8 to 21.3 mg/l. In station (iii), chloride values ranged from 4.8 to 24.2 mg/l while in station (iv) the lowest value was documented as 5.6 mg/l and the highest as 21.3 mg/l. From the results, it was observed that the mean value during non-rainy season was a little higher than rainy season. This was in contrast to the values obtained from dug wells. The value of chloride in treated water like municipal water supply was comparatively less than other sources of drinking water.

Chloride of tap water from small water supplies

While in station (i) chloride fluctuated from 29.8 to 44.0 mg/l. In station (i), it was varying form 16.8 to 55.4 mg/l. Chloride values of both stations recorded within the desirable limit of BIS.

Chloride of pond water

In pond No. (i) the range was from 16.0 to 41.2 mg/l whereas the range in pond No. (ii) was from 16.8 to 44.0 mg/l. It was significant to note that the pond water contained more chloride during non-rainy season than rainy season unlike the case of dug wells and tube wells.

Total hardness

Total hardness of domestic dug-wells

The range of hardness varied from 122 to 154 mg/l in well No. (i) while in well No. (ii) the fluctuation was from 42 to 210 mg/l. The highest range of fluctuation was recorded in well No. (iii), where it was from 182 to 722 mg/l. In well No. (iv) the lowest value was documented as 74 mg/l whereas the highest as 370 mg/l. The range of total hardness in well No. (v) varied between 132 and 166 mg/l. It was notable that in well No. (iii) and (iv), the range of total hardness was above the desirable limit of 300 mg/l as per the BIS and hence not safe for drinking.

Total hardness of public dug-well water

In well No. (I) range was from 146 to 290 mg/l whereas in well No. (ii) the fluctuation was from 126 to 198 mg/l. It was noticed that the total hardness of water from both public dug wells was within the limit as per standards (BIS).

Total hardness of tube well water

In tube well No. (i) the range of hardness was from 62.0 to 112.0 mg/l while in tube well No. (ii) the fluctuation was between 144.0 and 160.0 mg/l. From the results, it was noticed that the total hardness of water from both tube wells was within the desirable limit as per the standards prescribed by BIS.

Total hardness of tap-water from municipal water supply (KWA)

A range from 14 to 22 mg/l was recorded in Station (i) and the variation was between 14 and 22 mg/l in Station (ii). In station (iii), the range was between 16 and 26 mg/l while in station (iv) the fluctuation was from 16 to 36mg/l. It was noticeable that the total hardness was less in municipal tap water supply (KWA) than other water sources.

Total hardness of tap-water from small water supplies

In station (i) (Kollam Railway Station) the lowest value was recorded as 82.0 mg/l and the highest as 126.0 mg/l. whereas in station (ii) the range was from 36.0 to 76.0 mg/l As per the standards prescribed by BIS, it was noticed that values of total hardness of 2 small water supplies were within the limit.

Total hardness of pond water

In pond No.(i) the range of hardness varied from 42 to 80 mg/l whereas in pond No.(ii) the fluctuation was from 50 to 82 mg/l. As per the guidelines prescribed by BIS, it was noticed that total hardness of both ponds was within the desirable limit.

Fluoride (mg/l)

Fluoride of domestic dug-well water

In well No. (i) the range of fluoride in drinking water varied between 0.22 and .75 mg/l whereas in well No. (ii) it varied from 0.22 to 0.81 mg/l. The lowest value of fluoride in well No. (iii) was observed as 0.51 mg/l while the highest as 0.90 mg/l. A range of 0.20 to 0.73mg/l was recorded in well No. (iv). The highest fluctuation of fluoride of 0.23 to 0.91 mg/l was found in well No. (v). In well No. (vi) the lowest value of fluoride was found to be 0.22 mg/l and the highest to be 0.75 mg/l. As per Standards (BIS), it was found that values of fluoride in all domestic dug-wells were below the permissible limit.

Fluoride of public dug-well water

The fluoride in well No. (i) was varying from 0.34 to 0.86 mg/l whereas in well No. (ii) the fluctuation was between 0.15 and 0.77 mg/l during the period of study. The fluoride concentration of both dug-wells was below the desirable limit as per BIS.

Fluoride of tube well water

In tube well No. (i) the range was between 0.52 and 0.90 mg/l whereas in well No. (ii) it varied from 0.51 to 1.30 mg/l. Fluoride content of both tube wells was found to be below the desirable limit as per standards (BIS).

Fluoride of tap-water from municipal water supply (KWA)

In station (i) the minimum value was recorded as 0.22 mg/l and the maximum as 0.65 mg/l.

The range of fluoride in station (ii) was from 0.21 to 0.67 mg/l. The fluctuation of fluoride in station (iii) was from 0.20 to 0.67 mg/l while in station (iv) the variation was between 0.20 and 0.65 mg/l. As per standards (BIS) it was observed that fluoride in municipal water supply was below the desirable limit for drinking

Fluoride of tap-water from small water supplies

While in station (i) the range was between 0.22 and 0.77 mg/l. In station (ii) the fluoride was varying from 0.22 to 0.73 mg/l. The study revealed that the fluoride content in (iii) small water supplies (public and private) was below the desirable limit as per standards (BIS).

Fluoride of pond water

In pond No.1 the fluoride varied from 0.10 to 0.53 mg/l while in pond No. (ii) the fluctuation was between 0.12 and 0.61 mg/l. It was also found that the pond water contained lowest amount of fluoride when compared to tap water or dug Well water.It was significant that fluoride concentration from all sources of potable water of Kollam municipal area was below the desirable limit as per standards (BIS). As per Indian Standards (BIS) all drinking water sources should maintain 1 mg/l of fluoride. Below this level of fluoride in drinking water may cause dental caries.

Iron (mg/l)

Iron of domestic dug-well water

A range of 0.04 to 0.81 mg/l of iron was recorded from well No. (i) while in well No. (ii) the fluctuation was between 0.05 and 0.25 mg/l. The lowest and highest values in well No. (iii) were found to be 0.05 and 0.44 respectively during the period of study. In well No. (iv) the iron concentration varied from 0.07 to 0.25 mg/l whereas 0.11 to 0.25 was the range of iron in well No. (v) Fluctuation of iron in well No. (vi) was from 0.11 to 0.35 mg/l. BIS prescribed an upper limit of 0.3 mg/l of iron for drinking water. It was noticeable that iron content of the water from domestic dug-well No. (i), (iii) and (vi) was beyond this upper limit and thus not suitable for drinking purpose.

Iron of public dug-well water

In well No. (i) the fluctuation of iron was from 0.11 to 0.38 mg/l whereas in well No. (ii) it was between 0.09 and 0.52 mg/l. As per standards, water from both public dug-wells was not suitable for drinking purpose due to high concentration of iron.

Iron of tube well water

The highest fluctuation of iron was recorded in tube well No. (i) (District Hospital, Kollam) which ranged from 0.09 to 0.73 mg/l. In tube well No. (ii) (NCC Office, Kollam) the range was between 0.10 and 0.34 mg/l. As per standards (BIS) the iron concentration of both tube wells exceeded the upper safe limit and found to be not for drinking.

Iron of tap-water from municipal water supply (KWA)

The lowest value of iron in station (i) was recorded as 0.12 mg/l and the highest as 0.34 mg/l during the period of study. In station (ii) the amount of iron varied from 0.11 to 0.35 mg/l. In station (iii) the concentration ranged from 0.13 to 0.52 mg/l whereas in station (v) the variation was between 0.12 and 0.38 mg/l. From the results it was noticed that water from all sampling stations of Kollam municipal water supply (Kerala Water Authority) was not suitable for drinking purpose as per standards prescribed for iron (BIS).

Iron of tap-water from small water supplies

While in station (i) (Kollam Central Railway Station) the fluctuation of iron was between 0 and 0.30 mg/l. In station (ii) (FMN College, Kollam) the range of iron was from 0.16 to 0.35 mg/l Based on standards (BIS) it was noticed that iron content of water from station 1 (FMN College, Kollam) was not safe for drinking.

Iron of pond water

In pond (i) (Kottarakulam) the range of iron was from 0.37 to 0.74 mg/l whereas in pond (ii) (Cherukulam) the fluctuation was between 0.20 and 0.69 mg/l. It was obvious that water from both ponds contaminated with iron and not suitable for drinking or domestic purposes. From the results it was observed that almost all water sources including domestic dug-wells (well No. (i), (iii) and (vi)), public dug wells, tube wells, municipal tap water supply, small tap water supply (FMN College) and pond water recorded high concentrations of iron and not safe for drinking and other domestic purposes as per standards (BIS).

Coliforms

Coliforms of Domestic Dug-Well Water

In well No. (i) the number of total coliforms varied from 350 to 10420 coliforms/100 ml of water while the faecal coliforms ranged between 50 and 5200 coliforms/100 ml of water. The variation of total coliforms in well No. (ii) was from 160 to 5000 coliforms/100 ml of water whereas that of faecal coliforms was from 35 to 720 coliforms/100 ml. In well No. (iii) the lowest value of total coliforms was 620 and the highest 5000 coliforms/100 ml during the period of study while the faecal coliforms varied from 50 to 250 coliforms/100. The greatest fluctuation of total coliforms was recorded as 950 to 16800 coliforms/100 ml from well No. (iv). The faecal coliform range in well No. (iv) was 190 to 4200 coliforms/100 ml of water. The range of total coliforms in well No. (v) was 1200 to 8600 coliforms/100 ml of water while that of faecal coliforms was from 130 to 360 coliforms/100 ml. In well No. (vi) the fluctuation of total coliforms ranged from 720 to 8500 coliforms/100 ml whereas the faecal coliforms it was from 90 to 340 coliforms/100 ml. Based on BIS, it was evident that drinking water from all domestic dug-wells of Kollam municipal was highly contaminated with total and faecal coliforms and not suitable for drinking purpose.

Coliforms of public dug-well water

In well No. (i) the total coliform count ranged from 1700 to 9200 coliforms/100 ml of water whereas the faecal count varied from 180 to 2500 coliforms/100 ml of water. In well No. (ii) the total coliform organisms varied from 1800 to 12500 coliforms/100 ml of water while the faecal count ranged from 180 to 720 coliforms/100 ml. It was obvious that water from both the public dug-wells was highly contaminated with total and faecal coliform organisms and thus not safe for drinking purpose as per standards (BIS).

Coliforms of tube well water

In tube well No. (i) (District Hospital, Kollam) the total coliform count varied from 90 to 12500 coliforms/100 ml of water whereas the faecal coliform range was from 12 to 250 coliforms/100 ml. In tube well No. (ii) the total count ranged from 90 to 720 coliforms/100 ml and that of faecal count from 20 to 90 coliforms/100 ml. It revealed that both tube wells were highly contaminated with coliform organisms.

Coliforms of tap-water from municipal water supply (KWA)

In station (i) the range of total coliforms was between 0 and 320 while that of faecal coliforms ranged from 0 to 90 coliforms/100 ml of water. In station (ii) the fluctuation of total coliform count ranged from 0 to 1650 and that of faecal coliform varied from 0 to 120 per 100 ml. In station (iii) the total coliform count ranged from 0 to 360 per 100 ml of water whereas the faecal coliforms varied from 0 to 90 per 100 ml. In station (iv) the total count was from 0 to 1200 coliforms/100 ml and that of faecal coliform was from 0 to 180 per 100 ml. It was noticeable that water from all tap water sampling Stations of Kollam municipal water supply was highly contaminated with total and faecal coliform organisms as per standards (BIS).

Coliforms of small tap-water supplies

In station (i) the fluctuation was between 75 and 5000 coliforms/100 ml. whereas that of faecal coliform was from 20 to 720 per 100 ml of water. In station (ii) the number of total coliforms varied from 950 to 8200 per 100 ml of water while the faecal coliform ranged from 150 to 3500 per 100 ml. From the results it was observed that water from the 2 small water supplies was not safe for drinking purpose.

Coliforms of pond water

In Pond No. (i) the range of total coliform was from 2500 to 16800 per100 ml of water while 240 to 5200 was found to be the range of faecal coliforms. In pond No. (ii) the variation of total coliform count was from 5000 to 36000 coliforms/100 ml of water whereas the faecal coliforms ranged between 2500 and 19000 coliforms/100 ml of water. The results showed that all sources of drinking water including dug-wells, tube wells, municipal tap water, pond water were highly contaminated with total and faecal coliforms.

Residual Chlorine

Residual chlorine of municipal tap-water supply (KWA)

In Pallithottam Station (i) the variation was from 0 to 4.0 mg/l while in Station (ii) (Vady) it was from 0 to 3.5 mg/l. Whereas in Station (iii) (Iron Bridge), the amount of residual chlorine was between 0 and 3.0 mg/l. In Station (iv) (KSRTC-Bus stand) it was from 0 to 3.0 mg/l. The mean of rainy season was found to be 2.22±0.68 mg/l and that of non-rainy season was 0.67±0.67 mg/l. The annual mean value of all stations was recorded to be 1.45±0.55 mg/l. As per standards (BIS), the desirable limit of residual free chlorine in drinking water supplies should be 0.2 mg/l and if there is viral infestation there should be a booster dose of 0.5 mg/l. Besides that 3.0mg/l or more of residual chlorine in drinking water is toxic to human body. From the results, it was noted that application of chlorine in the municipal water supply (KWA) of Kollam was irregular and unscientific. This led to a situation of municipal drinking water contamination due to the presence of coliform organisms, particularly during non-rainy season when residual chlorine was totally absent in certain stations. Further it was found that municipal water supply (KWA) was the only source of drinking water in the municipality with the application of chlorine as a disinfectant.

4. Health and Sanitary Status of Households

Sanitary status

Indicators of sanitary status included facility for defecation, type of latrines, medium used for anal cleaning, altitude of latrine and water sources, distance between latrine and water source, present condition of latrine, leakage of latrine during rainy season, frequency of cleaning and information on agencies helping latrine construction. Detailed information was collected on all these items as well as on water logging, mosquito menace, possible source of drinking water contamination, protection of water sources, provision of drainage system and means of domestic solid waste disposal, distance between animal waste and water sources, and disposal of child faeces.

Health status

Information on the health status of the people in the study area was collected through questions on consumer's opinions on the safety of their drinking water. Whether drinking water was used after boiling or not was looked into. Various methods adopted by the people for purification of drinking water were documented. It was also ascertained whether water quality was tested before drinking. Consumers' suggestions on the improvement of water supply in the region were also recorded. Water-borne and water-related diseases that occurred during weeks prior to the date of the survey were recorded .

It was assumed that episodes of water-borne diseases like diarrhoea may not be remembered by the respondents, if the incidence of disease had occurred more than two weeks prior to the date of the survey. Diseases were classified into two main groups as water-borne and water- related based on international classification. Systems of treatment resorted by the households, such as Allopathy and Homeopathy were recorded. Institutions of treatment, which the households approached such as Government hospital and Private hospital, were noted down. Immunisation steps taken as a preventive measure against various kinds of diseases including water borne diseases were also recorded.

Water sources and uses

Amount of water consumption for drinking and cooking

It was estimated that 8 percent of the households used 25 litres/day whereas 34 percent consumed 26-50 litres/day; 29 percent consumed 51-75 litres/day; 20 percent used 76-100 litres/day; and 9 percent consumed 101to 250 litres/day.

Amount of water consumption for washing and bathing

It was noted that one percent of households consumed up to 100 litres/day whereas 33 percent of households consumed 101 to 500 litres/day; 58 percent 501 to 1000 litres/day; 7 percent consumed 1001 to 1500 litres/day; and 1 percent consumed 1501 to 2000 litres/day

for washing and bathing. Therefore, it was estimated that the average consumption of water for drinking and domestic purposes of Kollam municipal area was 192 litres/capita/person.

Continuous/Intermittent type of municipal water supply

It was observed that 89 percent responded that municipal water supply was intermittent; only 11 percent responded that water supply was continuous. Frequent breaks in water supply may cause serious effects on the health of people because of the negative pressure they produce on the distribution system. In certain areas of Kollam municipality it was noted that both the drainage canal and the drinking water pipeline run parallel. Therefore, there are chances for contamination of drinking water through leakages, if there is negative pressure. Further people may resort to other water sources that may not be safe during the period of non-availability of municipal water supply.

Municipal drinking water with worms and other organisms

The report of occurrence of worms, larvae and other organisms in municipal water supply of Kollam (KWA) showed that 48 percent households found various types of organisms including worms larvae in their drinking water while 52 percent of households had no such experiences. This was a significant observation from the health point of view.

Scarcity of drinking water in the municipal area

It was observed that 37 percent of households experienced scarcity of drinking water while others did not. It was noted earlier that 30 percent of households experienced dry up of dug-wells during summer.

Sanitary status

Defecation (excretion) practice and type of latrine used

It was found that 66 percent of households used sanitary latrine; 25 percent used non-sanitary latrine; and 9 percent defecated in open-air. Open air defecation and non-sanitary latrines appeared to be the main sources of contamination of drinking water, particularly in dug-wells.

Altitude of latrine and dug-well

It may be observed that 45 percent of latrines are situated higher in altitudes than those dug-wells. Latrines located at higher altitudes may pave the way for leaching into the nearby wells leading to faecal contamination

Distance between water source and latrine

Twenty-four percentage of latrines were situated at a distance of less than 10 ft. from water sources; 38 percent of latrines were located at a distance of 11 to 20 ft.; 23 percent at a distance of 21 to 30 ft.; and 15 percent at a distance of 31 ft >. This might cause contamination of dug-wells.

Present state of latrine

It was found that 35 percent latrines in the study area were in good condition whereas 41 percent were moderately good and 24 percent poor.

Leakage of the latrines during rainy season

It was recorded that 24 percent of latrines in the study area became leaky during rainy season. This could lead to contamination of the surroundings of people.

Frequency of cleaning of latrines

It was understood that 6 percent of latrines were cleaned daily; 57 percent of latrines were cleaned weekly; 36 percent were cleaned monthly and 1 percent was not cleaned regularly. This overall unhygienic nature in the municipality might be accentuating the situation of high water-borne morbidity.

Latrines built with the help of aid agencies

It was recorded that 13 percent of latrines in the municipal area were built with the help of municipal and private agencies while the rest were constructed by the parties concerned themselves. Among aid agencies, 67 percent of the latrines were constructed by the Kollam municipality whereas the rest by non- governmental voluntary organisations such as FCDP (Fishermen Community Development Programme) (29 percent); QSSS (Quilon Social Service Society) and LCC (Latin Catholic Church) (2 percent).

Water logging around houses

Forty-eight percentage of households succumbed to water-logging during rainy season while 52 percent of households faced no such problems. Water-logging may pave the way for infestation by water-borne and water-related diseases.

Mosquito menace

More than 99 percent of households complained of mosquito menace while 0.1 percent of households reported no mosquito menace. Mosquito menace indicated water stagnation and consequences thereof.

Protection of dug-wells

Nearly 13 percent of wells were found to be protected with proper covering; 25 percent were provided with protective platforms; 32 percent were provided with net-cover and 30 percent were unprotected.

Provision of drainage system

It was observed that 29 percent of households enjoyed the provision of municipal drainage facilities while the rest were deprived of that provision. Lack of sufficient

drainage facilities might produce water contamination and associated water-borne and water-related diseases.

Disposal of domestic solid waste

It was found that 14 percent of households dumped domestic solid wastes in collection tanks/areas of the municipality; 15 percent resorted to burning; 71 percent responded that they had no facility for the disposal of their domestic solid wastes. Accumulation of solid wastes in their surroundings might lead to water pollution.

Disposal of child faeces

It was observed that 56 percent of households simply threw away child faeces while the rest deposited faeces safely in septic tanks. Such careless discard of faeces might lead to contamination of drinking water.

Possession of domestic animals

Out of 800 households, only 96 households owned domestic animals. Among domestic animals, 23 percent were cattle; 76 percent pet animals and 1 percent others.

Distance between cattle waste dumping site and water source

Data on distance between cattle-waste dumping site and water-source revealed that 24 percent were in the 10 ft. category; 24 percent in the 15 ft. category; 28 percent in 20 ft. category; 6 percent in 25 ft. category and 18 percent in 50 ft. category.

Health status

Use of boiled drinking water

Twenty-nine percentage of households used boiled water for drinking whereas 71 % used raw water for drinking. This was a significant observation in view of the reported recurrence of diarrhoea and other contagious diseases in the municipal area.

Methods adopted by people for disinfecting the drinking water

Twenty-nine percentage of households used bleaching powder, potassium permanganate, cloth filtration (or water filtration) equipment for purification whereas the rest consumed water without purification. Further it was noticed that out of those households using various types of disinfection methods, 52 percent used bleaching powder; 27 percent used potassium permanganate; 18 percent adopted filtration with cloth and 3 percent used Water filters (equipment).

Do people test their drinking water

It was noticed that 99 percent of households in Kollam municipal area never tested the potability of their drinkingwater. The people of Kollam municipality seem be either little

bothered of the safety of drinking water or have little accessibility to testing its quality.

Consumers' suggestions on the improvement of drinking water supplies

The consumers put forward various suggestions on the improvement of drinking water supplies during the interview. It may be noted that 39 percent suggested that proper treatment of drinking water would help to improve the piped water supplies; 21 percent of respondents suggested that replacement of the old pipe line could improve the present drinking water supply systems in the municipal area; 12 percent suggested proper drainage system and clean environment; 9 percent recommended construction of more bore-wells; 8 percent suggested regular monitoring of water quality and scientific application of chlorine in water supplies; 6 percent pointed out that an awareness programme on well-water disinfection would help improve the quality of drinking water and 5 percent suggested additional pipeline as a solution.

Occurrence of water-borne diseases

Of the various diseases, 33 percent of water-borne diseases in the area were diarrhoea; 30 percent gastroenteritis; 16 percent ascariasis; 8 percent typhoid; 7 percent enterobiasis; 2 percent cholera; 2 percent polio and 1percent amoebic dysentery. Further it was noted that diarrhoeal disease was predominant in the municipal area particularly among the lower socio-economic status groups; this may be due to the high level of bacterial contamination of all sources of water available in the area (vide previous section: bacteriological quality of water).

Occurrence of water-related diseases

It was observed that 36 percent of water-related diseases registered were conjunctivitis; 25 percent allergy; 24 percent malaria and 15 percent skin ulcers. Dangerous water-related diseases like malaria appeared to be prevalent in Kollam municipal area. Water-logging, mosquito menace and overall environmental degradation may have profound impact upon the high water-borne morbidity in the study area

Method of treatment

It was found that 94 percent of households depended on allopathy; 5 percent on homeopathy, and 1 percent on ayurveda.

Dependence of Government/Private hospitals for treatment

Seventy percent of households in Kollam municipal area sought medical care from private hospitals while 30 percent depended on government hospitals.

Immunisation of children between 1 and 2 years

It was documented that 95 percent of children in the municipal area had been subjected to full immunisation while the rest 5 percent to partial immunisation. It was significant to note

that every child in the study area was immunised. This indicated that people were fully aware of the need for child immunisation programme for guarding against the adverse environmental conditions. It was observed that 10.1 percent of households was recorded as very poor; 34.1 percent as somewhat poor; 26.3 percent as middle class; 16.9 percent as above middle class and 12.6 percent registered to be rich based on various indicators. The first two groups were considered to belong to the below poverty line (BPL) with a share of 44.2 percent of population. Further it was noticeable that the percentage of the very poor and the rich categories were recorded to be low.

Figure 4.1 Scarcity of drinking water

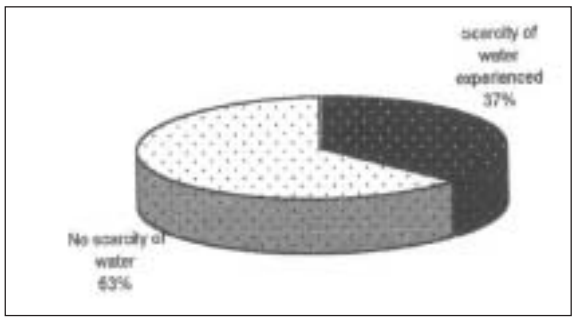


Figure 4.2 Water-borne diseases of Kollam municipal area

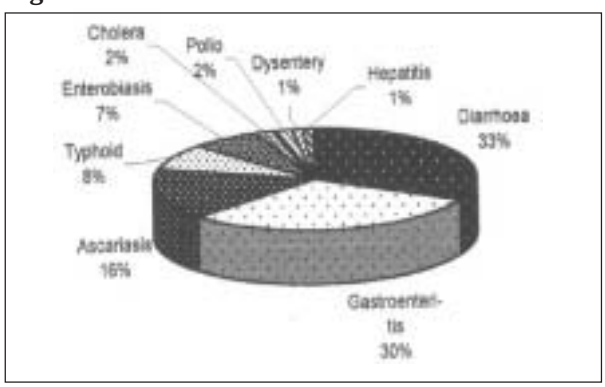
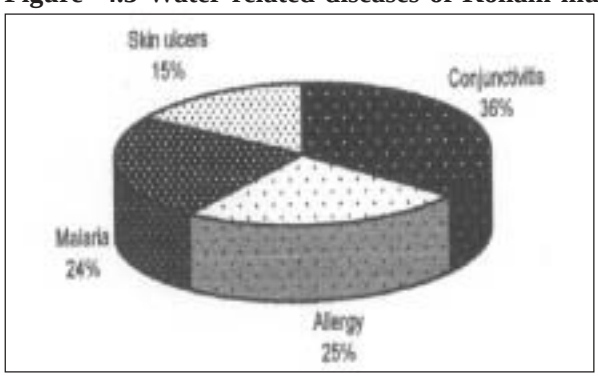


Figure 4.3 Water-related diseases of Kollam municipal area



5. Socio-economic and Health Status

Incidence of water borne diseases: Diarrhoea

It may be seen that 17.8 to 60.4 percent of households had histories of diarrhoeal disease. However, a higher percentage of diarrhoeal incidence occurred in households of lower socio-economic status. In other words, a declining trend of incidence of diarrhoeal disease was observed with increase in socio-economic status. The evidence further indicated that deterioration of various environmental factors including drinking water quality has higher impact on people belonging to lower socio-economic status.

Incidence of water-borne disease: Gastroenteritis

It was recorded that 12.8 to 51.8 percent of households had incidence of gastroenteritis. Lower socio-economic status groups of people had higher incidence of gastrointestinal disease than higher status groups. This may be due to the deprived environmental characteristics as well as poor drinking water quality of the latter.

Incidence of water-borne disease: ascariasis

It was observed that 7.9 to 28.3 percent of households had incidence of ascariasis. Lower socio-economic groups had higher percentage of ascariasis than higher socio-economic groups. Poor environmental factors accelerate the incidence of water-borne diseases like ascariasis.

Incidence of water-borne disease: Typhoid

It was seen that 4.9 to 13.5 percent of households had incidence of typhoid. Further, the incidence was higher among lower socio-economic groups (very poor and somewhat poor). This was due to the fact that deterioration of environment including contaminated water caused more water-borne diseases like typhoid.

Incidence of water-borne disease: Enterobiasis

About 1.9 to 12.3 percent of households had the incidence of enterobiasis. The incidence of enterobiasis was more among households of lower socio-economic status. This might have been due to the deprived environment of the lower socio-economic groups of people in the study area.

Incidence of water-borne disease: Cholera

It was found that 0 to 7.4 percent of households had incidence of cholera. It was further noted that the incidence of cholera was found only among the lower socio-economic groups. This might have been due to poor environmental factors as well as poor quality of drinking water.

Incidence of water-borne disease: Polio

It was noticed that 0.7 to 2.5 percent of households had the incidence of polio. The higher percentage of polio infections was found among lower socio-economic groups, may be also due to the impact of poor environmental factors.

Incidence of water-borne disease: Amoebic dysentery

It was recorded that 0 to 2.5 percent of households had the incidence of amoebic dysentery. Only households of lower socio-economic status had experienced amoebic dysentery whereas higher status (status 4 and 5) had no such problem. This might have been due to the deteriorated environment of people living below poverty line (BPL).

Incidence of water-borne disease: Infectious hepatitis

It was noted that 0 to 2.4 percent of households had incidence of infectious hepatitis. It is again households in the lower socio-economic status that had high incidence of hepatitis. This was due to the deprived environmental conditions including poor quality of drinking water available to the lower socio-economic groups.

Incidence of water-related disease: Conjunctivitis

It was observed that 6.9 to 31.1 percent of households had conjunctivitis. The incidence of conjunctivitis was higher in the lower socio-economic groups owing to their poor environmental characteristics.

Incidence of water-related disease: Allergy

Of the sample households, 6.9 to 23.4 percent had different kinds of allergic complaints. It was the lower socio-economic groups, which had higher incidence of allergy than higher socio-economic groups. The deteriorated environmental factors including contaminated water had greater damaging effect on the poor than on the well-to-do.

Incidence of water-related disease: Malaria

About 5.9 to 23.4 percent of households had bouts of malaria. Higher malarial incidence occurred among housedholds of the lower socio-economic status due to the deprived environment including widespread mosquito menace.

Incidence of water-related disease: Skin ulcers

The majority of households belonging to the lower socio-economic groups had higher incidence of skin ulcers. It was noted that 4.9 to 14.8 percent of households had been affected with skin ulcers. The lower socio-economic groups living under deprived environment were the prime victims of skin ulcers.

Method of treatment: Allopathy

It may be noted that 85.7 to 96.7 percent of households depended upon allopathy. It was the lower socio-economic groups which had to undergo frequent medical treatment.

Method of treatment: Ayurveda

Only less than three percent of the households depended on ayurvedic method of treatment for their ailments. Poor people were found to avoid ayurvedic method of treatment may be due to the fact that ayurvedic treatment was relatively expensive.

Method of treatment: Homoeo

The percentage of households from lower socio-economic status which depended on homeopathic method of treatment was even lower.

Agency of treatment: Government hospital

The proportion of households in the municipal area of Kollam which depended on government hospitals varied between 2.9 and 38.7 percent. A higher percentage of households from lower socio-economic status depended on government hospitals because treatment in government hospitals was less expensive than in private hospitals.

Agency of treatment: Private hospital

It was found that 62.7 to 97.1 percent of households depended on private hospitals. It was people from higher socio-economic status who depended more on private hospitals. The socio-economic status of people in the study area had profound impact upon the selection of the agency of treatment.

Immunisation of children: Fully immunised

It was seen that 87.2 to 100 percent of households had taken full immunisation of their children. This indicated that the degree of awareness of the people about the need for prevention of diseases.

Immunisation of children: Partially immunised

Only 2.5 to 11.1 percent of the households reported partial immunisation of children.

Table 5.1 Relationship between Socio-economic status (SES) and Sanitary status of households

Decimal No. of Questionnaire	Parameters	SE
5.1	*Defecation:*	
	Open air	30.
	Septic tank	28.
	Pit latrine	32.
	Public latrine	8.6
5.1.1	*Type of latrine:*	
	Sanitary latrine	28.
	Non sanitary latrine	40.
5.2	High altitude: latrine with water source	47.
5.2.1	*Distance between water source and latrine*	
	0-10 ft. distance	27.
	11-20 ft. distance	45.
	21-30 ft. distance	13.
	31 ft.> distance	13.

Table 5.1 contd. Relationship between Socio-economic status (SES) and Health status of households

Decimal No. of Questionnaire	Parameters	SES 1
5.2.2	*Present state of latrine:*	
	Good	3.6%
	Moderate	39.3%
	Poor	57.1%
5.2.3	Leakage of latrine during rainy season	53.6%
5.2.4	*Frequency of cleaning of latrine*:	
	Daily	…
	Weekly	34.5%
	Monthly	58.2%
	Not at all	7.3%
5.2.5	Latrine built with the aid of an agency	25.5%

Table 5.1 contd. Relationship between Socio-economic status (SES) and Health status of households

Decimal No. of Questionnaire	Parameters	SES
5.3	Water logging environment	65.8%
5.4	Mosquito menace	100%
5.6	Provision of a drainage system	25.0%
5.7	*Domestic solid wastes disposal:* Dumping Burning No facility	 6.3% 2.5% 91.0%
5.7.1	*Disposal of child faeces*: Simply throw In septic tank	 81.8% 18.2%

Table 5.2 Relationship between Socio-economic status (SES) and Health status of households

Decimal No. of Questionnaire	Parameters	
		S
6.1	*Consumer's opinion on drinking water*: Safe for drinking Not safe for drinking	
6.2	*Use of boiled drinking water:* Drinking water being boiled before use Drinking water not being boiled before use	3 6
6.2.1	Add something to increase the taste of water	2
6.4	Have tested drinking water	
6.6.1	*Water borne diseases*: Diarrhoea Gastroenteritis Ascariasis	6 5 2

Table 5.2 contd. Relationship between Socio-economic status (SES) and Health status of households

Decimal No. of Questionnaire	Parameters	SES 1
	Typhoid	9.8%
	Enterobiasis	12.3
	Cholera	7.4%
	Polio	2.5%
	Amoebic dysentery	1.2%
	Infectious hepatitis (Jaundice)	2.4%
6.6.2	*Water related diseases*	
	Conjunctivitis	31.0%
	Allergy	23.4%
	Malaria	23.4%
	Skin ulcers	14.8%

Table 5.2 contd. Relationship between Socio-economic status (SES) and Health status of households

Decimal No. of Questionnaire	Parameters	SES 1
6.6.4	*Method of treatment*	
	Allopathy	
	Ayurveda	96.7%
	Homeo	…
		3.3%
6.6.5	*Agency of treatment*	
	Government hospital	37.3%
	Private hospital	62.7%
6.7	*Immunisation*	
	Fully immunised	88.9%
	Partially immunised	11.1%

6. Conclusion

Results of the study indicated that all water sources including dug-wells, tube wells (KWA), municipal tap water supply (KWA), small public and private tap water supplies, and pond water were highly contaminated and not safe for drinking as per Bureau of Indian Standards (BIS).

It was further observed that serious lapses in drinking water disinfection and treatment along with intermittent supply, non-sanitary latrines, open defecation, water-logging environment, poor drainage facilities and unscrupulous dumping of domestic wastes resulted in the deterioration of water quality in the study area. The study also revealed that poor quality of drinking water was recorded as the major risk factor for the large-scale water-borne morbidity in the area.

Recommendations for improvement of water quality/quantity/distribution

(i) Sustainable management of both solid and liquid waste

(ii) Provision of adequate drainage facilities with utmost care and routine.

(iii) Protection and prevention of water-borne diseases by adequate measurers in co-ordination with both governmental and non-governmental participation

(iv) Water literacy in order to keep drinking water safe.

(v) Environmental sanitation with good hygiene practices at household level.

(vi) Cultivation of the habit of drinking boiled water.

(vii) Protection and disinfection of all open dug-wells. Dug-well water should be considered a good source of drinking water and adequate steps should be taken for the prevention of contamination of well water from household environment.

(viii) Maintenance of adequate distance of the pipeline from drainage canals and latrine sources. Water sources should be kept at a minimum distance of 15 metres away from latrines and animal waste dumping sites.

(ix) Water source protection in order to keep water clean and safe for drinking.

(x) Periodic and routine monitoring of the quality of tap water and other sources of drinking water. There should be a network of water-quality-monitoring laboratories both in rural and urban areas.

(xi) Avoidance of open-air defecation and elimination of non-sanitary latrines.

(xii) Protection of dug-wells with cement platform, protected wall, and net for adequate covering.

(xiii) Regular chlorination in dug-wells using chlorine, bleaching powder, and chlorine tablets.

(xiv) Regular treatment of water and testing of water samples periodically.

(xv) Scientific application and monitoring of chlorine.

(xvi) Training of technical staff for attedning pipeline breakage.

(xvii) Ensuring continuous supply of water in the municipal piped-water system.

(xviii) Strengthening of water quality research and finding out of the possible health implications of water quality parameters like trihalomethanes (THMs) due to hyperchlorination and increased organic matter.

(xix) Strict legislation against occurrence of high percentage of coliform organisms in drinking water sources.

(xx) Eradication of the mosquito menace with adequate steps taken to treat stagnant water bodies.

(xxi) Establishment of a "water quality surveillance system" with the co-ordination of various governmental and non-governmental organisations in order to improve the quality of drinking water. This will definitely improve the quality of life of the people in the area.

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