Environmental Quality and Health in Nattakom *Panchayat*

N. Valsalakumar

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N. Valsalakumar*

1. Introduction

Environment influences the health of people. Over-population leads to indiscriminate exploitation of resources and to environmental deterioration. Environmental problems have therefore received serious attention in recent years. At a global level, environmental issues are the topic of hot debate. Summits on environmental issues have chalked out plans of action to restore environmental quality. The earth summit held at Rio de Janeiro from 3 to 14 June, 1992 was the largest international conference even in the history of international relations; the fact that 178 nations and more than 20,000 participants attended it clearly indicates the growing awareness of and the common concern for the constantly increasing degradation of the global environment. Population growth leads to rising demand on resources and increasing human intervention in Nature. The interventions cause unforeseen changes in the environment. The intricate system of Nature becomes evident only when an alteration is caused to any one of the components, which trigger off adverse impacts on the biological system. If we admit the fact that the present generation has borrowed the environment from future generations and that we are liable to return it to them without damage, we have to be careful and cautious about our activities. In a far-reaching judgement the Supreme Court declared that access to pollution-free water and air is a fundamental right of citizens. Environment-monitoring programmes would help us understand the magnitude of the problems involved and plan the activities for ensuring upkeep of a healthy environment.

Water and air are the two major environmental components most affected by human activities. Ground water and surface water sources are used for a variety of purposes. Maintenance of water quality at acceptable levels is an essential requirement for successful use of the water resources. Being a dynamic system, pollutants getting into water bodies spread to wider areas. It is a cumulative insidious process difficult of correction once pollutant concentrations have reached problem proportions. In view of this fact, water quality monitoring becomes essential for identifying problems and formulating measures to minimise deterioration of water quality.

Air-borne respirable particulate matter (RPM) causes respiratory disorders. The main resources of RPM are factories and automobiles. Quantification of RPM is highly necessary in the light of higher incidence of respiratory disorders becoming increasingly common for devising strategies. It will help to evolve strategies to curb air pollution.

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2. Review of Research and Background

Several agencies have conducted studies on the water quality and related issues of Kuttanad in general. Kerala Sasthra Sahitya Parishat (KSSP) had conducted a study in 1978 on the problems induced by developmental activities in Kuttanad. The highlights of the study are the following:

(i) Permanent bunds are needed around polders instead of temporary bunds;
(ii) Effective weed control by mechanical or biological control is necessary;
(iii) Proper water supply schemes have to be implemented; and
(iv) Awareness programmes should be conducted for farmers on the negative impacts of fertilisers and pesticides.

The Indo-Dutch mission conducted the Kuttanad Water Balance Study the final report of which was published in 1989. The purpose of the study was to identify water management and hydraulic engineering measures required to eliminate or mitigate the water and related problems of Kuttanad such as the following:

(i) Lack of fresh water and saline water intrusion during summer;
(ii) Flooding during rainy season;
(iii) Conflict between the agriculture and the fishery sector; and
(iv) Environmental pollution.

Sabu, Prema, and Chacko (1993) studied the lateral variations of water chemistry induced by Thanneermukkom barrage constructed along the Meenachil River basin. The saline intrusion was detected up to 6.5km upstream. Unni and Nair (1995) studied the environmental issues in Vembanad estuary caused by salinity and flood control structures. The highlights of the study are mentioned below:

(i) Shrinkage of the lake due to human encroachment;
(ii) Eutrophication of the lake;
(iii) Decline in fishery wealth; and
(iv) Accumulation of pesticides in water and soil.

However, no studies exist on the environmental pollution problem, which specifically focuses on the Nattakom *panchayat* with emphasis on health and environmental quality.

In this project we have undertaken a preliminary study on water and air quality of Nattakom *panchayat* in relation to morbidity pattern.

Industrial background

Two major industries and 671 small-scale industries (SSI) are functioning in the *panchayat*. About 40 rubber crepe mills are located in the area, perhaps the only *panchayat* in Kottayam district to have such a high number of crepe mills. Travancore Cements Ltd. (TCL) and

Travancore Electro-chemicals Industries Ltd. (TECIL) are the two major industries (TECIL was under lockout during the entire period of the study).

Population

As per census 1991 the total population of the *panchayat* was 44915 inhabiting approximately 12000 houses. The sex ratio was 1146 females per 1000 males.

Water supply schemes

There are two water supply schemes in Nattakom *panchayat*. The major scheme is the one which was implemented with the assistance from World Bank and run by the Kerala Water Authority. The capacity of the storage tank of this scheme is 12,86000L. More than 2000 house connections have been provided through this network. However, the availability of water to the public is restricted to once or twice in a week, that too for only a limited number of hours. The *panchayat* operates the second water supply scheme. The distribution is only through public taps.

The idea for this project came from certain observations made in the panchayat such as the following:

(i) Sporadic epidemics occur in Nattakom *panchayat*, which take a toll of human lives; the epidemics are, in general, water-borne in nature.
(ii) Respiratory disorders are found frequently among people of certain localities of the *panchayat*.
(iii) A scientific study on the magnitude of air pollution from the Travancore Cements Ltd. is demanded in the *panchayat*'s *Vikasana Rekha* (Development Report).

These observations point *prima-facie* towards lack of environmental cleanliness in the *panchayat*. An environmental quality assessment has not taken place in the *panchayat*. Moreover, environmental issues are likely to aggravate in the future; an evaluation of the present situation is therefore highly necessary. The present study is a preliminary attempt in this direction, aimed at generating baseline data.

3. Area, Objectives, and Methodology

Location of area

Nattakom *panchayat* is situated in the southwest part of Kottayam district in Kerala State bound between E.longitude 76 ^{0} 30' - 76 ^{0} 32 ‘30’’ and 9^{0}30' - 9^{0} 35’N (according to Geographical Survey of India Toposheet No. 58 C/10). The area studied comes to about 25 km^{2} (Fig. 3.1).

Kottayam town is located 1 km north of the north end of the *panchayat*. Owing to proximity to Kottayam municipal town the *panchayat* falls under the impact of various developmental programmes.

Topography, climate, and crops

The study area lies in the low land region and is characterised mostly by a flat topography. Nearly 50 percent of the total area comprises wetlands, used for rice cultivation. Marshy lands are also present.

The area receives Southeast and Northwest monsoon rains. The temperature ranges from 25 to 31^{0}C. Coconut and rice are the major crops. In some part of the *panchayat* rubber is also cultivated.

Objectives

The major objectives of the study are the following:

(i) assessment of the morbidity pattern and water quality of the *panchayat*, and (ii) quantification of air-borne respirable particulate matter (RPM).

Methodology

Morbidity pattern

For studying morbidity pattern, secondary data from Nattakom Primary Health Centre and local hospitals were collected. A survey was also conducted at selected stations to collect data on minor health problems, which are not reported to the hospitals as well as to collect data on socio-economic status of the people.

Water quality assessment

Based on secondary data collected, water quality assessment to obtain primary data was done on 17 water samples collected from different stations (Fig. 3.2). The sampling stations were fixed on the basis of:

Figure 3.1 Location Map

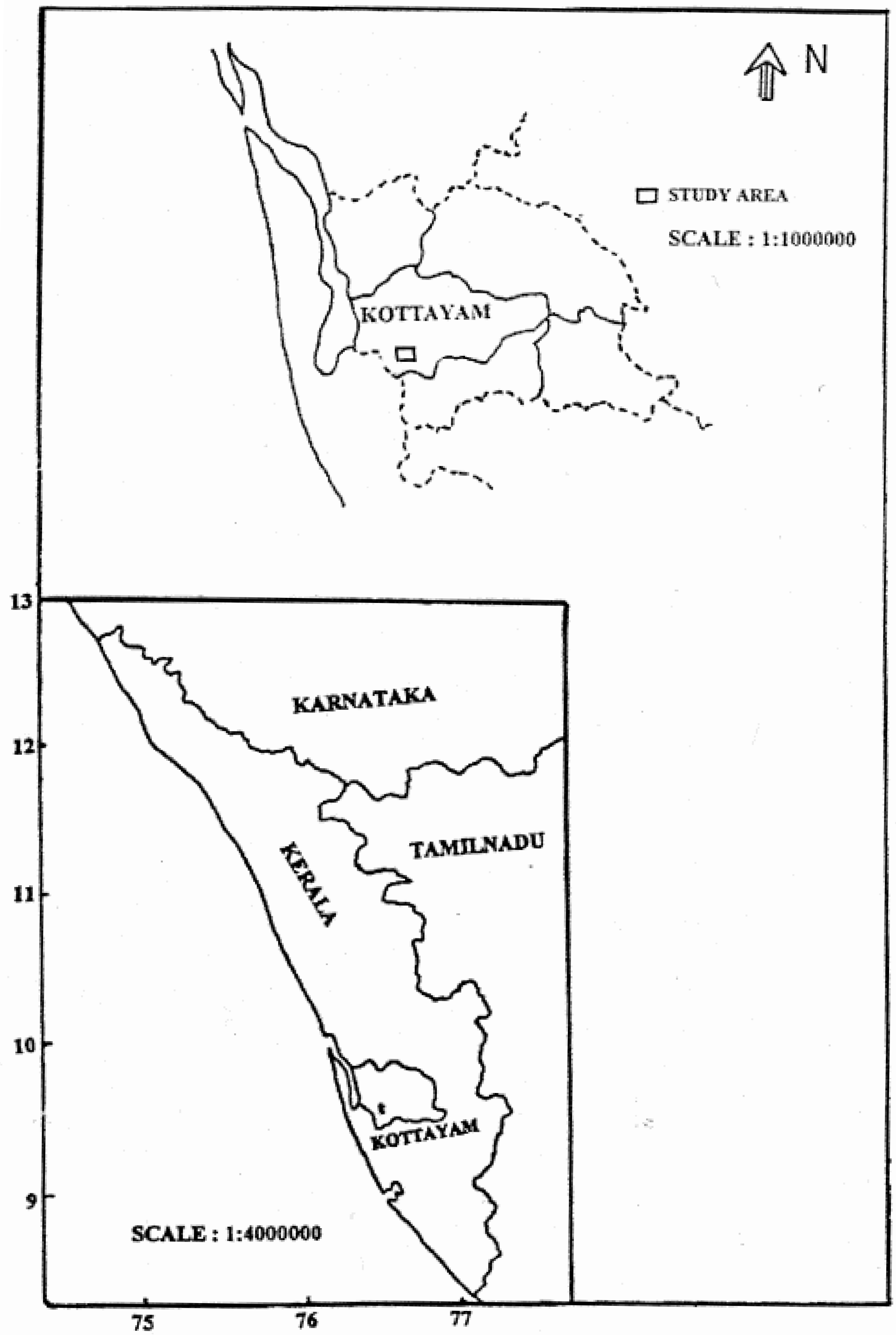
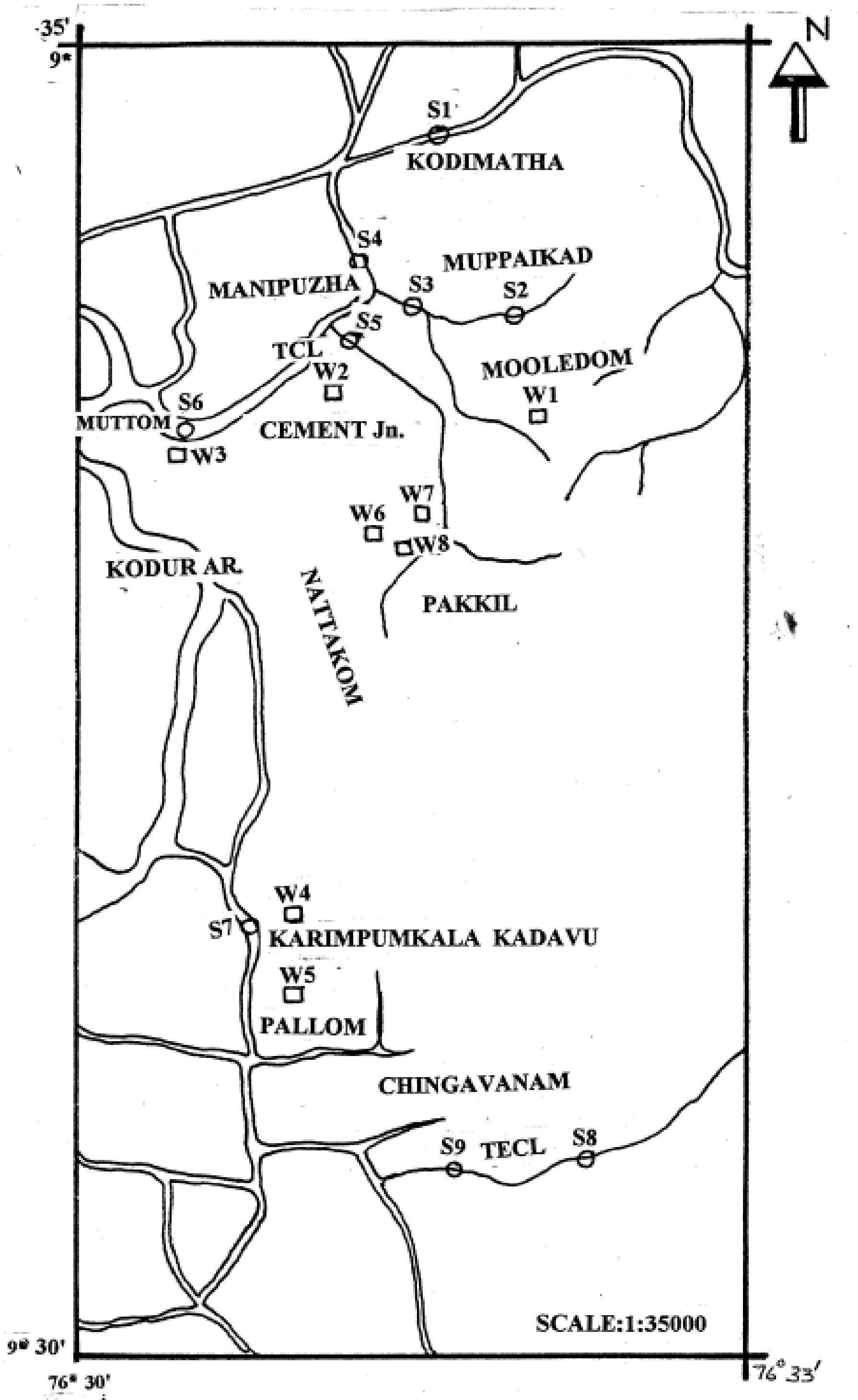


Figure 3.2 Map Showing Sampling Stations



(i) Extent of public use of the water source;

(ii) Locations having frequent incidences of water-borne epidemics;

(iii) Possible chances of pollution; and

(iv) Geological considerations.

The sample code and name of the sampling stations are given in Annexure I.

The water samples were analysed for physico-chemical and biological characteristics. The physico-chemical characteristics were studied for all the water samples. Bacteriological studies for detecting faecal contamination were done on eight water samples, which included five well samples and three stream samples.

The samples were processed and analysed for p^H, Electrical conductivity (EC), Total Dissolved solids (TDS), Total hardness (TH), Calcium (Ca), Magnesium (Mg), and Sodium (Na), Potassium (K), Chloride (Cl), Sulphate (SO_4), Phosphate (PO_4), Nitrate (NO_3), and Iron (Fe). The estimation of faecal coliforms and E. coli was done using MPN method. Methods of analysis of various parameters followed in the present study are given in (Table 3.1). Supplementary data relating to water quality and allied issues were collected by PRA technique. Field visits were conducted for the purpose.

Quantification of RPM

Quantification of RPM in the air was carried out with High Volume Sampler (HVS). The station selected for the study was Government College, Kottayam campus and adjoining places. The rationale behind the selection of Government College campus as the station for RPM studies was the following:

(i) The suspected air-polluting source, namely, Travancore Cements Ltd., is located close to the station. The people of the area have higher incidence of respiratory disorders than people in the rest of the study area.

(ii) A number of educational institutions are located in the area surrounding the station. The students and staff of these institutions are also possible victims of respiratory ailments, if the air they inhale is polluted.

The high volume sampler was operated at regular intervals for air sampling. Standard procedures were adopted for HVS Sampling (Section 6).

Table 3.1 Methods of analysis

WATER

A. Physico-chemical Parameters

Parameters	Method
Hydrogen ion concentration (p^H)	Electrometry
Conductivity	Conductometry
Total Dissolved Solids	Coductometry
Total Hardness	EDTA titration
Calcium	EDTA titration
Magnesium	EDTA titration
Sodium	Flame photometry
Potassium	Flame photometry
Chloride	Argentometry
Sulphate	Spectrophotometry
Phosphate	Spectrophotometry
Nitrate	Spectrophotometry
Iron	Spectrophotometry

B. Microbiological parameters

Parameters	Method
1.Total coliforms	Multiple tube fermentation. Confirmation medium BGLB. Count according to MPN. Incubation at 37^0C for 48 hrs.
2. Faecal coliforms	MPN count using EC broth medium- incubation at $44.5+0.5_0$*C.
3. E.coli	Test for indole production in peptone water using Kovac's reagent.

Air

Respirable particulate matter (RPM)	-	HVS -sampling & Gravimetry

4. Results and Discussion

Morbidity profile

Disease results from a complex interaction between man, an agent and the environment. The study of disease is really the study of man and the environment. Preventable diseases originating in the environment in which they live affect hundreds and millions of people. For man, the external environment includes all of man's external surroundings such as air, water, food, and housing.

For the purpose of the present study, data on morbidity pattern of Nattakom *panchayat* were collected mainly from Nattakom PHC. Special importance was given to those diseases, which are water and air-related.

Water-borne diseases

Human health may be affected by ingestion of contaminated water either directly or through food or by use of contaminated water for purposes of personal hygiene and recreation. Diseases caused by use of water were taken into account and analysed. The diseases included in the study as water-related diseases were

(i)Gastroenteritis

(ii)Amoebiasis

(iii)Ill-defined intestinal diseases

(iv)Filariasis

(v)Ancylostomiasis

(vi)Skin and subcutaneous diseases

The prevalence of these diseases for the past five years is given in Table 4.1.

Air-borne diseases

The immediate environment of man comprises air on which depends all forms of life. Air polluted by dust, smoke, toxic gases, and chemical vapours causes health problems and even death. The health aspects of air pollution are both immediate and delayed. The delayed effects most commonly linked with air pollution are Chronic Bronchitis, Lungs Cancer, Bronchial Asthma, Emphysema, and respiratory allergies. The major air-related diseases prevalent in Nattakom *panchayat* are given in Table 4.2.

The diseases included in the present study were -Pulmonary TB, Bronchitis and Bronchiolitis, Chronic bronchitis, unspecified emphysema, and asthma.

Table 4.1 Water-related Diseases and Number of Cases

Name/ Category of disease	No. of cases				
	1996-'97	1997-'98	1998-'99	1999-2000	2000-'01
Amoebiasis	260	236	328	212	252
Gastroenteritis	*	260	296	262	296
Ill-defined intestinal diseases	816	316	611	306	322
Filariasis	0	2	2	0	4
Ancylostomiasis	330	329	473	382	324
Skin & Subcutaneous diseases	240	1480	1640	583	1687
Total water-related diseases	1646	2623	3350	1695	2885
Other diseases	7604	10997	13661	9178	12702
Total no. of cases	9250	13620	15356	10874	15587

*Data not available; (Source: Nattakom PHC)

Table 4.2 Air-related Diseases and the Number of Cases

Name / Category of Disease	No. of cases				
	1996-'97	1997-'98	1998-'99	1999-2000	2000-'01
Pulmonary T.B	8	2	2	4	2
Chronic Bronchitis, unspecified Emphysema, Asthma	1530	840	593	296	957
Bronchitis & Bronchiolitis	1862	827	916	1026	942
Total air-related diseases	3400	1669	1511	1326	1901
Other diseases	5850	11951	13845	9548	13686
Total cases	9250	13620	15356	10874	15587

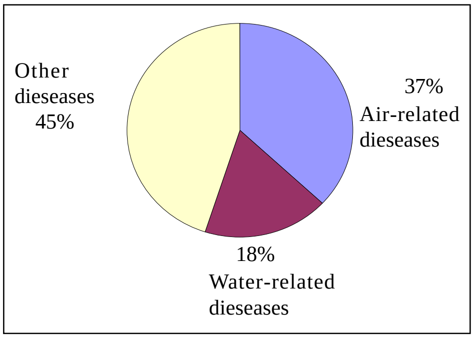
Source: Nattakom PHC

From year 1996-'97 to 2000-2001 a total of 64687 cases were reported at Nattakom Primary Health Centre. The total number of water-borne or water-related cases was 12199 (18 percent) and the total air-related diseases 9827 (15 percent). Hence water and air quality deterioration contributed to about 33 percent of the total morbidity in the Nattakom *panchayat* (Fig 4.1).

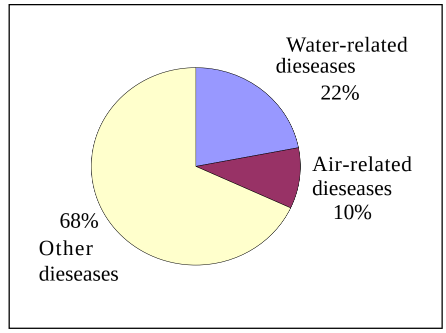
Outbreak of Leptospirosis in 2000 March took the lives of two persons and 35 patients were admitted to hospital from Nattakom *panchayat*. According to the records of the Health Department, regarding the cholera outbreak in Kottayam district in January 2000, out of 91 cases admitted to different hospitals 5 were from Nattakom *panchayat*.

Figure 4.1

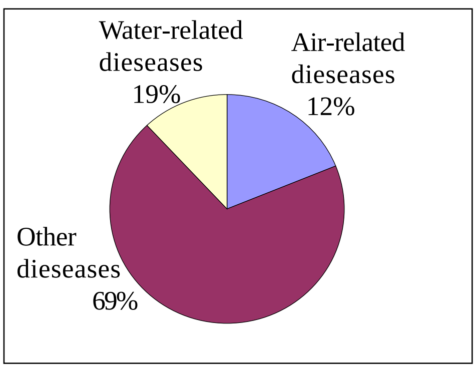
Percentage of Water and air -borne dieseases 1996-97



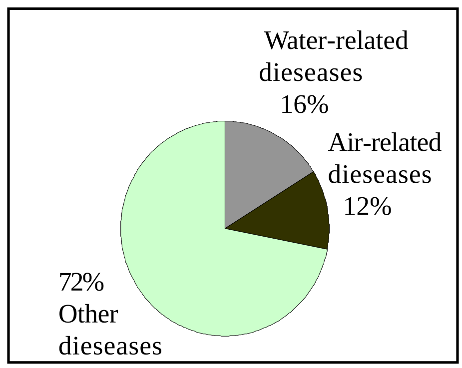
Percentage of Water and air - borne dieseases 1997-98



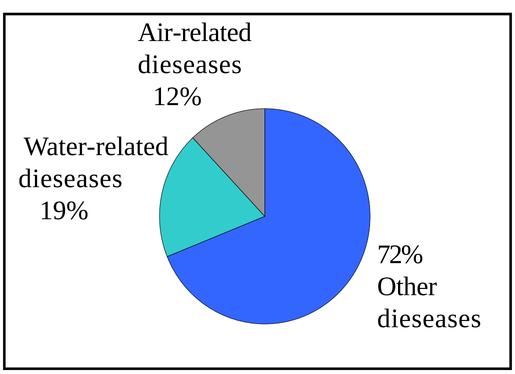
Percentage of Water and air - borne dieseases 1998-99



Percentage of Water and air - borne dieseases 1999-00



Percentage of Water and air - borne dieseases 2000-01



5. Water Quality and Bacteriological Studies

The quality analysis of representative water samples from Nattakom *panchayat* was carried out. The various physico-chemical and biological characteristics of water samples of both well and stream were studied (Table 5.1). The physical, chemical, and biological parameters are compared with the limits set up by Bureau of Indian Standards (BIS) for drinking water (Annexure II). While the well water samples were analysed strictly for drinking water quality, the stream water samples were analysed for estimating chemical and bacterial contamination which would affect the water quality for purposes other than drinking such as bathing and cleaning. Causes of eutrophication of streams were also analysed.

Physico-chemical quality

The physico-chemical characteristics of water investigated include
p^H,
Electrical Conductivity (EC),
Total Dissolved Solids (TDS),
Total Hardness (TH),
Calcium (Ca),
Magnesium (Mg),
Chloride (Cl),
Phosphate (PO_4),
Sodium (Na),
Potassium (K),
Sulphate (SO_4),
Nitrate (NO_3), and
Iron (Fe).

The results of analyses are given in Tables 5.1, 5.2, and 5.3.

p^H

It is the measure of hydrogen ion concentration. The p^H of natural water lies between 4.5 and 8.5. The p^H value depends on carbon dioxide/bicarbonate/carbonate equilibrium. It is also affected by the presence of humic substances, which change the carbonate equilibrium due to the bioactivity of plants. BIS specifies a p^H range 6.5 to 8.5 for drinking water. A lower p^H value (below 4) produces sour taste and high value (above 8.5) a bitter taste. Very high p^H induces the formation of trihalomethanes, which are carcinogenic to human beings. High p^H also reduces the germicidal potential of chlorine.

Table 5.1 Physico-chemical quality of water samples: Pre-Monsoon

Sample code	pH	EC Micro Siemens /cm	TDS ppm	TH (as CaCO3) mg/L	Ca mg/L	Mg mg/L	Cl mg/L	PO4 micro mol/ L	Na mg/L	K mg/L	SO4 mg/L	NO3 mg/L	Fe mg/L
W1	5.6	101	53.69	17.86	4.05	1.85	21.29	3.73	8	3	55	T	
W2	5.4	108.9	54.26	20.41	4.05	2.46	21.28	5.74	10	1	T	T	
W3	5.6	389.6	194.2	86.75	13.16	12.9	92.17	8.22	25	1	30	T	
W4	6.7	579.8	288.8	153.1	40.49	12.28	56.73	4.18	30	12	84	T	T
W5	5.4	114.3	57	20.41	5.06	1.84	21.28	0.6	10	2	T	T	
W6	6.2	226	109.9	40.83	11.13	3.07	35.46	2.66	13	2	T	T	T
W7	6.6	157.1	78.46	20.41	7.07	0.61	24.82	1.11	10	5	T	T	8
W8	6.6	192.6	93.97	45.93	10.12	4.91	10.64	21.645	10	4	T	T	
S1	6.7	606	303.3	86.75	19.23	9.21	127.64	0.67	18	11	65	T	
S2	6.7	305.3	150.6	51.03	10.12	6.14	60.28	0.72	28	6	T	T	
S3	6.8	808.6	404.6	102.06	21.26	11.66	180.22	2.33	190	12	350	T	
S4	6.5	828.4	418.7	107.17	20.25	13.51	187.91	2.02	200	11	570	T	
S5	6.5	765.7	383	91.86	17.21	11.66	166.64	1.75	173	11	180	T	
S6	6.4	901.5	451	96.96	14.73	14.17	209.19	0.9	180	11	450	T	
S7	6	1048	519.5	99.5	14.17	15.35	251.74	0.55	260	13	73	T	
S8	6.4	167.1	97.84	51.03	14.18	3.07	21.27	2.94	95	7	58	T	
S9	6.2	175.7	87.85	35.72	9.11	3.07	28.36	1.03	15	4	T	T	

Table 5.2 Physico-chemical quality of water samples: Monsoon

Sample code	pH	EC Micro Siemens/ cm	TDS ppm	TH (as CaCO3) mg/L	Ca mg/L	Mg mg/L	Cl mg/L	PO4 micro mol/ L	Na mg/L	K mg/L	SO4 mg/L	NO3 mg/L	Fe mg/L
W1	5.6	93.18	47.86	15.3	T	15.3	24.2	T				3	0.1
W2	5.6	105.8	53.18	12.4	T	12.4	16.1	T				3	0.1
W3	6.1	241.4	122.7	57.6	T	57.6	47.2	T				2	0.1
W4	6.7	609.3	309	198.4	150.3	48	47.3	T				5	0.2
W5	5.3	107.6	53.52	17.5	9	8.4	8.1	T				3	0.2
W6	4.5	201.2	100.9	14.7	T	14	24.2	T				5	0.5
W7	4.4	172.5	86.49	18.6	1.7	16.9	20.4	T				7	0.5
W8	6.4	186.6	92.7	42.9	13.6	29.4	T	T				T	3.5
S1	7.1	97.92	48.89	13.39	2.4	1.8	T	T			T	7.5	
S2	7.1	148.3	74.41	41.26	11.5	3.05	32	T			T	6	
S3	6.4	69.15	32.87	13.6	2.5	1.81	T	T			T	4	
S4	8.4	48.75	31.75	10.2	3.1	0.86	T	T			T	4.5	
S5	6.6	50.23	25.3	11.3	2.5	0.96	T	T			T	6.4	
S6	6.4	105.2	52.46	21.5	10.12	0.73	10	T			T	7	
S7	6.6	199.5	99.75	24	1.8	4.95	T	T			T	5.7	
S8	5.8	84.29	41.81	17	3.17	2.41	T	T			T	4.8	
S9	6.2	67.49	34.03	16.4	4.08	1.5	16	T			T	6.8	

Table 5.3 Physico-chemical quality of water samples: Post Monsoon

Sample code	pH	EC Micro Siemens/ cm	TDS ppm	TH (as CaCO3) mg/L	Ca mg/L	Mg mg/L	Cl mg/L	PO4 micro mol/ L	Na mg/L	K mg/L	SO4 mg/L	NO3 mg/L	Fe mg/L
W1	6.8	90.2	45.98	9.2	1.4	T	18	T	7.8	3	T	0.002	
W2	7.4	113.3	56.82	20.2	3.5	2.8	28	T	11.5	1	T	0.001	
W3	6.6	190.7	99.15	44	6.7	6.8	57	T	13.5	T	T	0.002	
W4	6.4	530.7	279.9	261.76	52.1	32	50	T	28.5	13.5	T	0.01	
W5	5.1	275.5	132.2	18.5	3.3	2.6	T	T	8.3	5	T	0.002	
W6	5.1	193.2	92.1	24.5	1.5	5	T	T	10.2	4	T	0.002	
W7	4.5	165.7	83.15	22.78	3.7	3.3	35	T	11.8	7.3	T	0.01	0.6
W8	6.7	84.7	86.2	55.04	18.5	2.15	T	T	8	4	T		2.5
S1	6.8	86.84	42.92	35	8.5	3.4	16.5	T	6.5	T	T	0.004	
S2	6.6	113.9	57.61	39.2	10.6	3.1	21.15	T	4.5	T	T	0.002	
S3	7.4	105.3	52.6	19.19	2.9	2.9	17.15	T	8.8	2.3	T	0.002	
S4	7	105.3	54.81	18.18	2.1	3.3	T	T	8.8	2.5	T	0.002	
S5	6.7	101.4	50.17	18.25	2.9	2.8	T	T	8.3	2.3	T	0.002	
S6	6.9	127.4	63.77	19.54	4.2	2.2	12.4	T	9	2.5	T	0.004	
S7	6	207.4	101.1	26	7.1	2	18	T	15.5	2.3	T	0.002	
S8	6.6	82.19	40.04	11.61	1.2	2.1	T	T	6.8	2.3	T	0.002	
S9	5.5	64.24	34.04	11.5	0.8	2.3	T	T	6	2	T	0.002	

In Nattakom *panchayat* studies on p^H of well water samples indicate that the values are within the permissible limits of BIS specification. The p^H measurement showed that the water in all the wells studied has p^H less than 7 (slightly acidic) during all the seasons.

The post monsoon p^H of W2 was slightly above 7 (Fig.5.1). The stream samples also showed the same tendency for p^H. Station No. S4 showed high p^H (above 8) during monsoon (Fig.5.2).

Figure 5.1 Histogram pH(well)

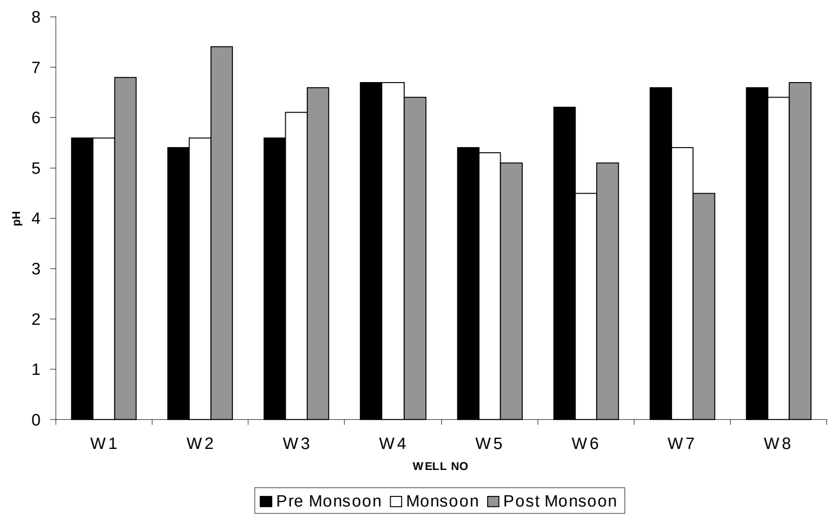
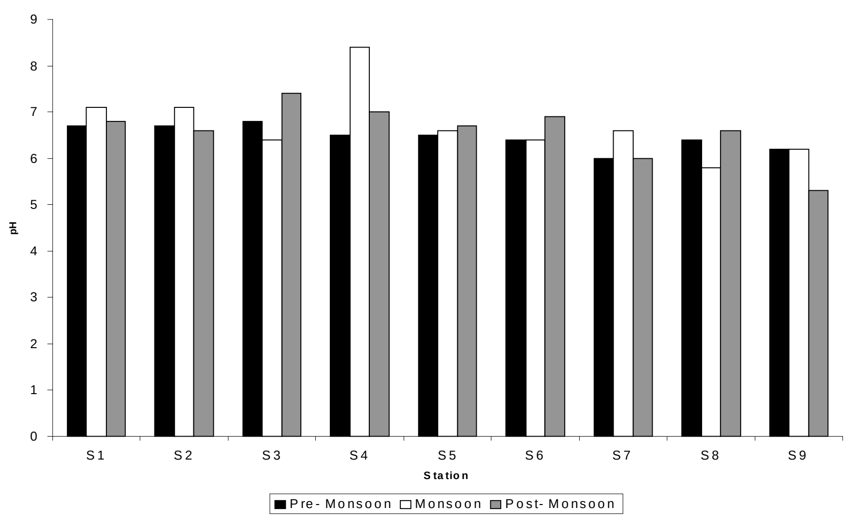


Figure 5.2 Histogram pH (Stream)

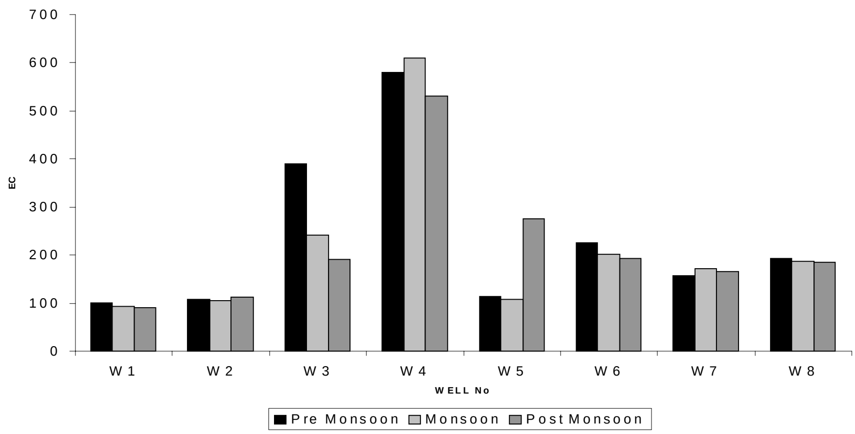


Electrical conductivity (EC)

EC measurements estimate the ionic concentration. Most of the inorganic salts, acids, and bases when dissolved in water make it a good conductor of electricity. Changes in EC signal changes in mineral composition of water, intrusion of saline water and pollution from industrial water. EC of potable water is between 50-500 Micro Siemens/Cm.

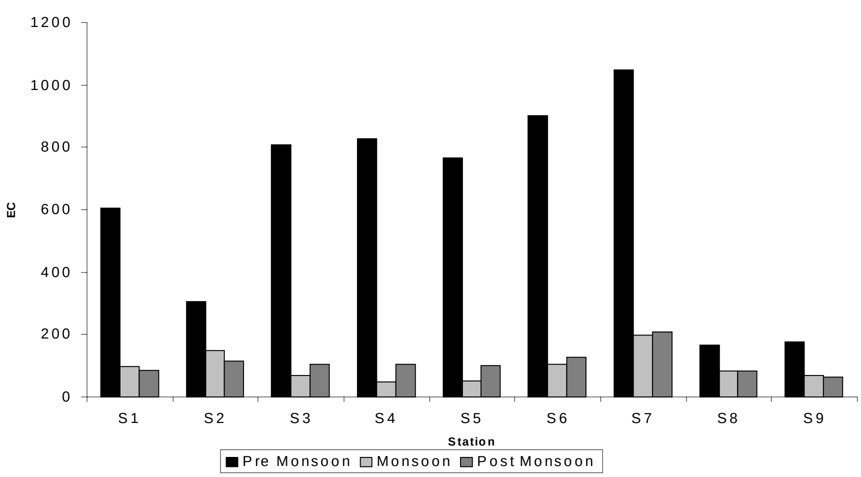
EC of water samples of wells of the study area were in the range of 90.22 - 609.3. Micro Siemens/Cm. W1, W2, W6, W7, and W8 showed almost constant EC during the whole period of the study. W3 was characterised by progressive decline of EC from pre-monsoon to post-monsoon. W4 had the highest EC for all seasons, which range from 530.7 to 609.3 Micro Siemens/cm. W5 had higher EC during post-monsoon (Fig.5.3).

Figure 5.3 Histogram EC (well)



Measurements of EC of stream samples showed high values for pre-monsoon sampling ranging from 167 to1043 Micro Siemens/cm. Monsoon and post-monsoon samples had EC below 200 Micro Siemens/cm except S7 where the post-monsoon EC was 207.4 Micro Siemens/cm (Fig.5.4).

Figure 5.4 Histogram EC (Stream)

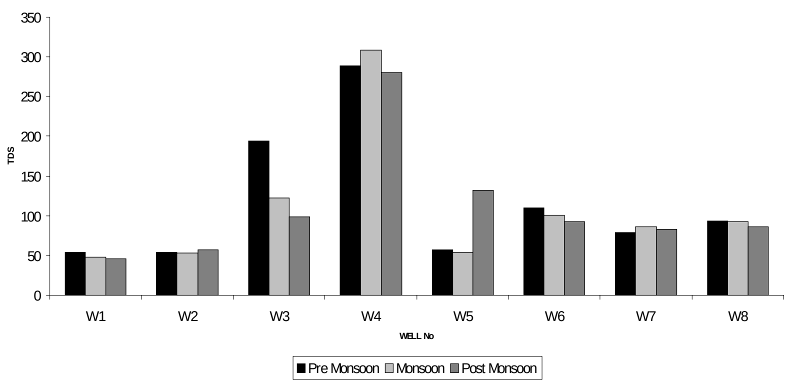


Samples S1, S3, S4, S5, S6, and S7 were taken from different locations of Kodur stream starting from north (Kodimatha) to south (Karimpinkala *kadavu*). Progressive increase in EC was observed from north to south. At S7 the maximum values for EC were recorded. S7 is a confluence of three streams where the water is almost stagnant and becomes enriched with ionic concentration.

Total dissolved solids (TDS)

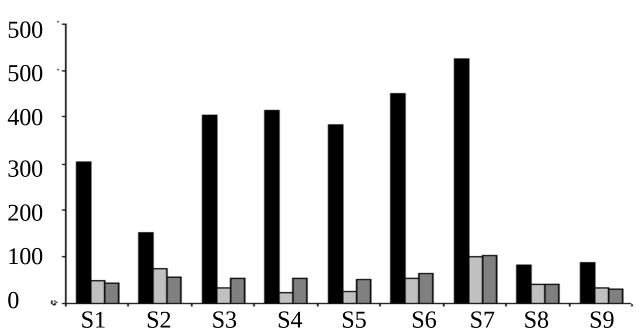
A large number of salts are found dissolved in water. The common ions are bicarbonates, carbonates, chlorides, sulphates, phosphates, calcium, magnesium, sodium, potassium, and iron. A high content of dissolved solids elevates the density of water, reduces the solubility of gases, and utility of water for drinking and other purposes. Measurements of TDS showed a close linear relationship with EC. The same pattern of relationship was found for well and stream samples (Fig.5.5).

Figure 5.5 Histogram-TDS (well)



Based on TDS estimates, the least mineralised wells were W1 and W2 and the most mineralised was W4, still within the limits of BIS specification (500 PPM). The streams had high TDS during pre-monsoon. Monsoon and post-monsoon samples showed more or less uniform TDS of less than 100 PPM (Fig.5.6).

Figure. 5.6 Histogram TDS (Stream)

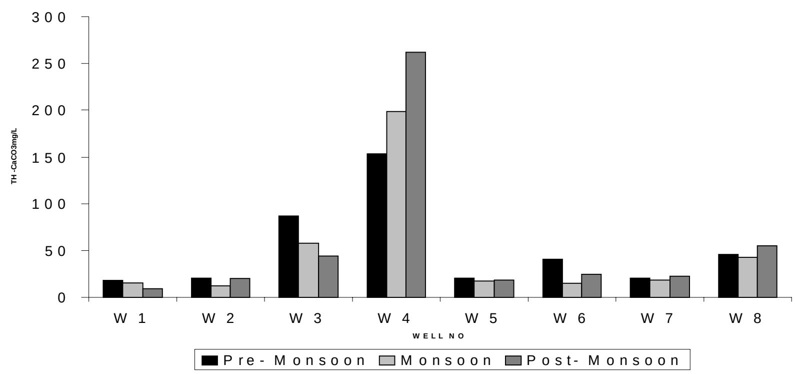


Total Hardness (TH)

Hardness results from the presence of divalent metallic cations of which Ca and Mg are the most abundant in fresh water. Hardness may also occur due to a variable mixture of cations and anions. Because of their adverse action with soap hard water is unsuitable for household cleaning purposes. Hard water is useful for growth of children due to the presence of Ca. Incidence of cardiovascular diseases is high among people using soft water, though the exact reason is not fully understood.

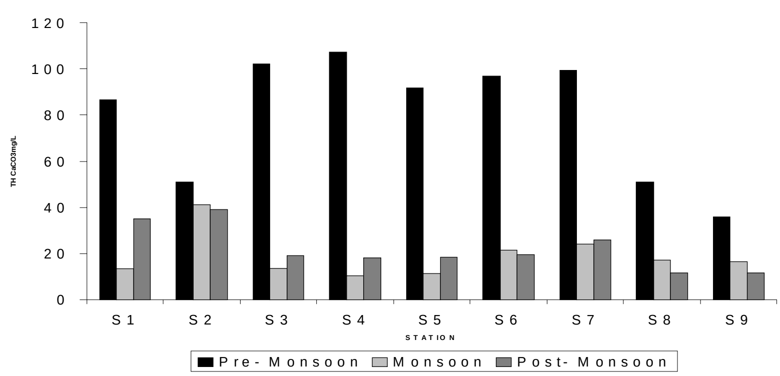
The TH in well samples of the study is given in Fig.5.7. As per hardness classification of water (Sawyer and McCarty, 1967) with hardness expressed in mg/litre as Ca CO_3 fall under four categories viz. Soft (0-75), moderately hard (75-150), hard (150-300), and very hard (above 300). According to this classification W4 had hard water. All the other wells had soft water.

Figure. 5.7 Histogram-TDS (well)



W3 showed, however, moderately hard water in pre-monsoon. The stream samples S1, S3, S4, S5, S6, and S7 showed moderately hard water during pre-monsoon. Monsoon and post-monsoon samples from the same stations showed soft water characteristics. S2, S8, and S9 had soft water in all the seasons (Fig.5.8).

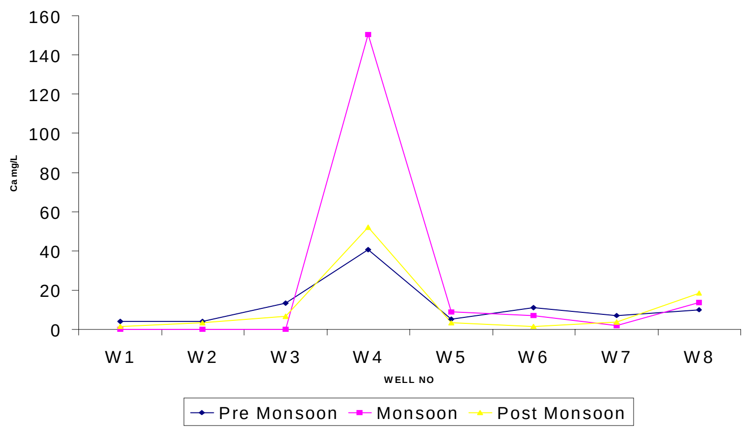
Figure. 5.8 Histogram-TH (Stream)



Calcium (Ca)

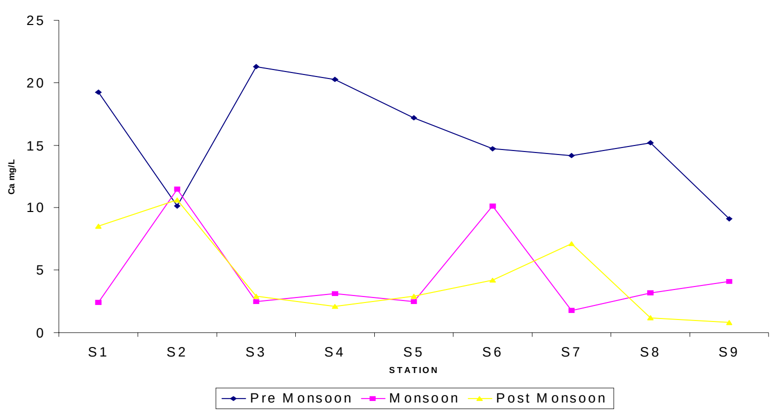
The major natural sources of Ca are gypsum, pyroxenes, calcite, dolomite, and clay minerals. Generally the Ca content of natural waters is less than 100 PPM. Deficiency of Ca causes rickets and defective teeth; it may cause kidney or bladder stones when Ca is in excess. Concentration of Ca in well samples during the study period is given in the Fig.5.9.

Figure. 5.9. Graph-Ca Conecentration (well)



All the wells under investigation showed Ca concentration within permissible limits. W4 showed, however, Ca concentration beyond permissible limit during monsoon indicating that there is recharge from the stream (S7). Calcareous soil with high deposit of lime shells may be the source of high Ca content at this location. The pre-monsoon sampling from W4 showed low concentration of Ca, suggesting a water flow from the well to the stream. The Ca concentrations of stream samples were in the range 0.8 and 21.2 mg/L. The maximum concentration of Ca in streams was observed during pre-monsoon. S2 is a sampling site without remarkable seasonal variation in Ca concentration (Fig. 5.10).

Figure. 5.10. Graph-Ca Conecentration (stream)

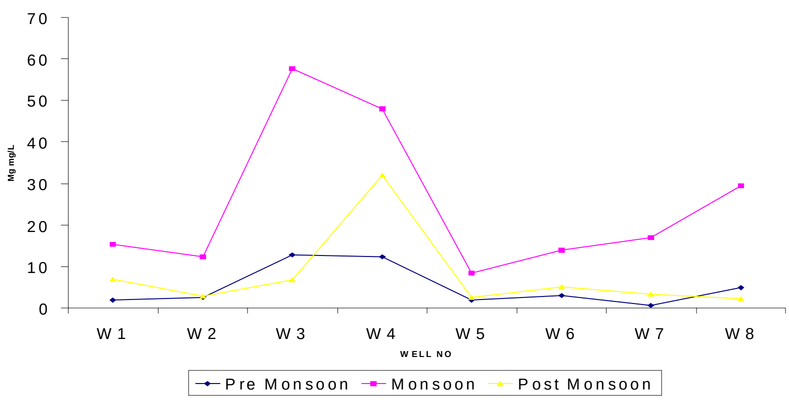


Magnesium (Mg)

The source of Mg in natural waters is the chemical weathering of rocks and chemical fertilisers. The amount of Mg ranges from zero to several hundred milligrams per litre. Concentration of Mg above 150 mg/L, if present with SO4 may cause gastro-intestinal problems and diarrhoea.

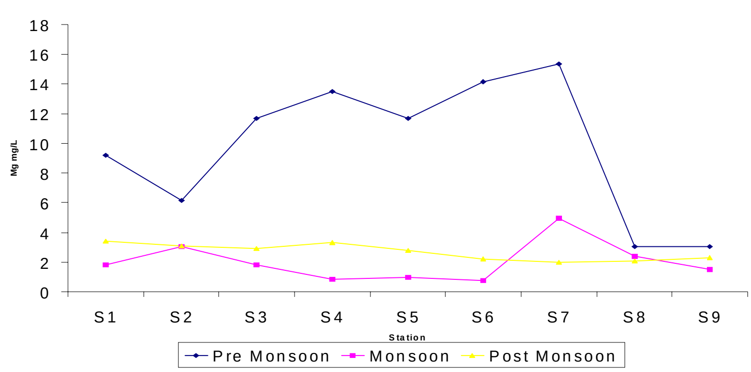
The concentration of Mg in all the well samples was below 60 mg/L during all the seasons. The maximum concentration of Mg was noticed in monsoon samples in all the wells (Fig.5.11), suggesting enrichment through water recharge. The possible source of Mg in the wells W1 and W3 may be the fertiliser applied to land crops. In other wells the rocky substratum might have contributed to the Mg content.

Figure. 5.11. Graph-mg Conecentration (well)



The stream samples registered comparatively low concentration of Mg when compared to wells. In contrast to well samples, streams showed maximum values for Mg during pre-monsoon (Fig.5.12). Decaying plant materials may contribute to high concentration of Mg during pre-monsoon in streams. The reason for low Mg content of streams may be the rapid absorption and assimilation of the element by the water plants.

Figure. 5.12 Graph-mg Conecentration (Stream)



Chloride (Cl)

Cl is a major constituent in water. The amount of Cl ranges from a few mg/L as in rainwater to a few gm/L as in saline ground waters. An increase in Cl content in natural water may be caused by pollution by sewage or geological factors. Seawater intrusion leads to increased Cl content in ground and surface water of coastal regions.

The desirable limit of Cl in drinking water is 250 mg/L. High Cl in drinking water may be injurious to people suffering from heart and kidney diseases. The Cl content in the study area was found to be well with in the permissible levels. Well sample W3 showed the maximum Cl content among the well samples during pre-monsoon (92.186 mg/L). This may be due to saline water intrusion from the nearby stream (S6). Stream sample S7 showed maximum Cl concentration (251.738 mg/L). Cl content of stream waters was high during pre-monsoon, resulting from stagnation. There is a general tendency for dilution during monsoon and post-monsoon seasons, which is evident in well samples as well as stream samples. The variations in Cl concentration are given in the Fig.5.13 (well) and Fig. 5.14 (stream).

Figure 5.13 Graph-mg Conecentration (Stream)

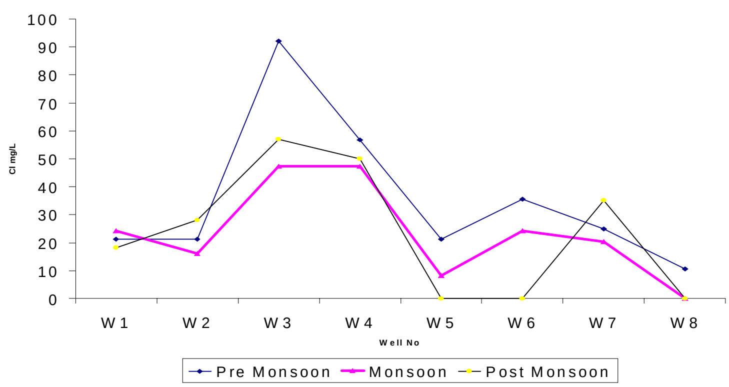
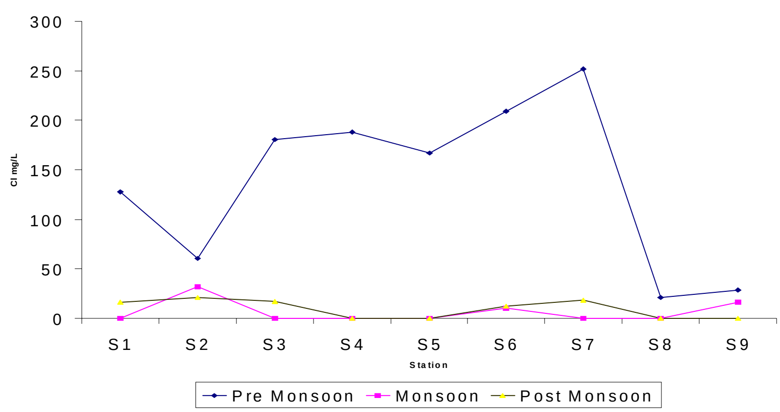


Figure 5.14 Graph-Ci Conecentration (Stream)



Phosphate (PO_4)

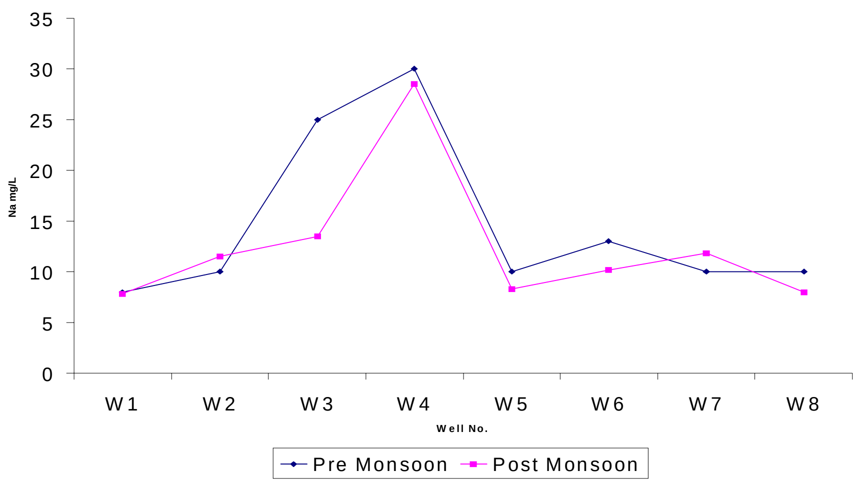
PO_4 is often the limiting nutrient for growth of plants in water. Available PO_4 is a decisive factor of eutrophication of water bodies. Plants can absorb PO_4 even if it is present in very minor quantities.The amount of PO_4 was found very low in all the samples. The pre-monsoon samples showed measurable quantities of PO_4 and are presented as micro mol/L (Tables 5.1, 5.2, 5.3).

Sodium (Na)

It is a major component of potable water. The amount of Na is subject to variation. In areas of saline intrusion the sodium content will be high in ground waters. Excessive consumption of Na may lead to hypertension.

The Na concentration in well water samples from the study area ranged from 7.8 to 30 mg/L (Fig.5.15). Majority of the wells showed comparatively low Na concentration during pre-monsoon and post-monsoon. W2 and W7, however, showed low values for Na during pre-monsoon and slightly higher values for post-monsoon.

Figure 5.15 Graph-Na Conecentration (well)



The stream samples showed maximum Na concentration during pre-monsoon. The value ranged from 15 to 260 mg/L. The post-monsoon samples showed very low Na concentration ranging from 4.5 to 15.5 mg/L, may be due to excessive dilution by rain (Fig. 5.16).

Potassium (K)

Estimates of K in water samples of the study area showed relatively low concentrations in both well and stream samples. The range of concentration in wells was from trace amounts to 13.5 mg/L and that of streams was from trace amounts to 13 mg/L (Fig.5.17).

Figure 5.16 Graph- Na Conecentration (Stream)

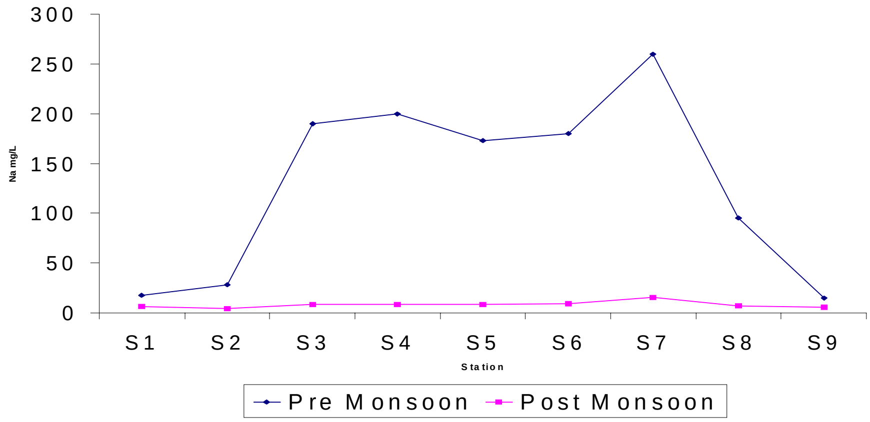
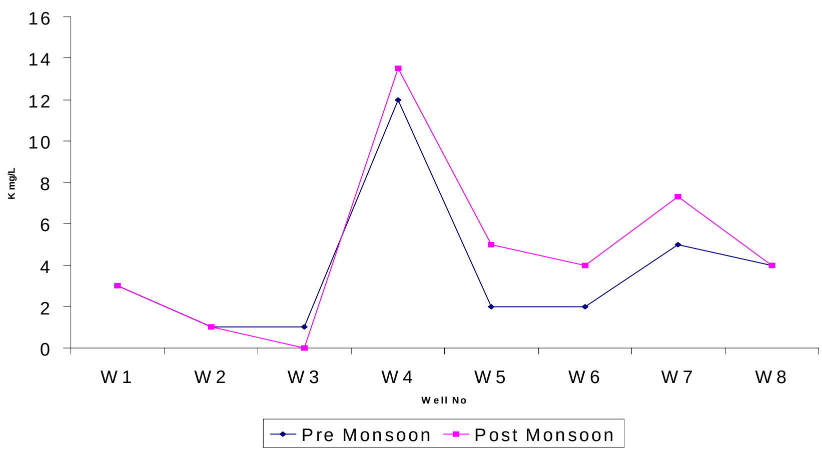


Figure 5.17 Graph- K Conecentration (well)



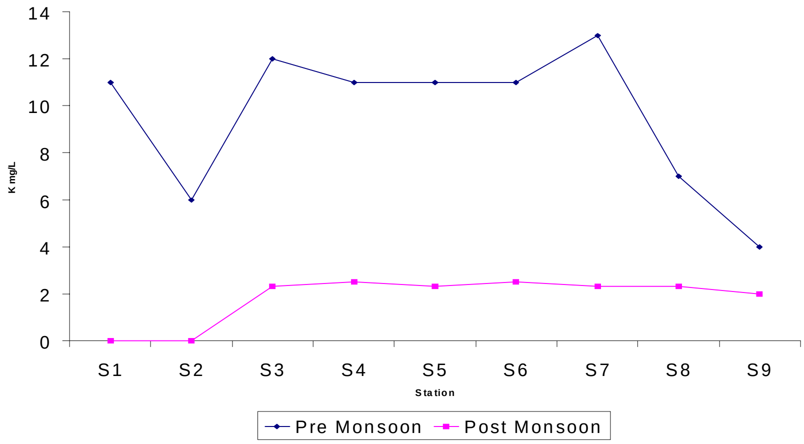
There was no significant variation in K concentration during pre-monsoon and post-monsoon periods in the majority of samples. However, stream samples showed a slight tendency for decline during post-monsoon, probably due to heavy dilution during monsoon (Fig. 5.18).

Sulphate (SO_4)

SO_4 occurs in natural waters in a wide range of concentrations. The BIS guideline is 200 mg/L as the desirable limit; it may be extended up to 400 mg/L, provided Mg does not exceed 30 mg/L. Consumption of water containing high SO_4 concentration (above 200 mg/L) may lead to diarrhoea, especially in new consumers.

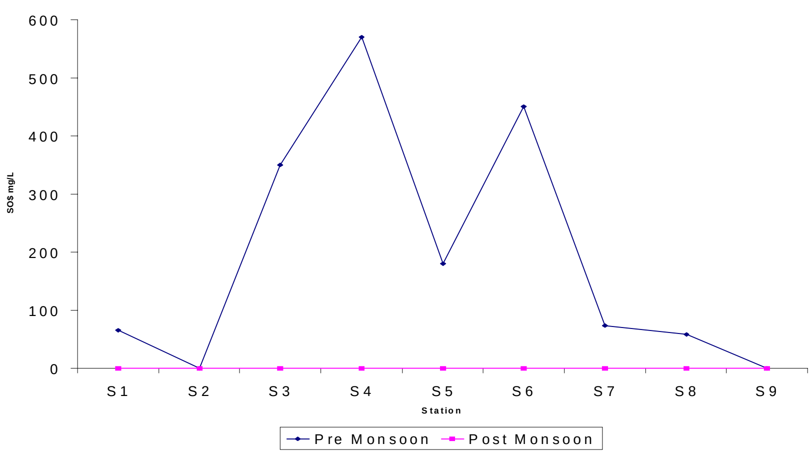
The SO_4 concentrations were within the permissible limit in all the wells of the study area (Tables 5.1, 5.2, 5.3).

Figure 5.18 Graph- K Conecentration (Stream)



However, the stream samples S3, S4, and S6 showed high SO_4 content during pre-monsoon. As high SO_4 concentrations were detected in stream samples down stream of rubber industries locations and chemical fertiliser godown, they could be the source of SO_4 in water. Bacterial oxidation of elemental Sulphur is also possible in calm waters leading to high sulphate content. Since SO_4 could not be detected in quantities comparable to pre-monsoon samples during other seasons, from the same locations, it is evident that stagnation of water has resulted in the augmentation of SO_4 (Fig.5.19).

Figure 5.19 Graph- So4 Concentration (Stream)



Nitrate (NO_3)

The source of NO_3 in natural water is nitrogen fertilisers, animal, and human excreta. Methaemoglobanemia is a known health disorder in infants due to high NO_3 content in drinking water. The guideline value for NO_3 in drinking water is 45 mg/L. The nitrate concentrations in the various sampling sites are given in the Table 5.1, 5.2, and 5.3.

The pre-monsoon samples, both well and stream, showed only traces of nitrate. The monsoon well samples showed nitrate concentration ranging from trace to 5 mg/L. The post-monsoon samples also had only very low nitrate content **(Fig.3).**

The monsoon stream samples showed nitrate concentration ranging from 4 to 7.5 mg/L followed by trace quantities during post-monsoon. The general tendency of water bodies in the study area with respect to NO_3 content is for an increase during monsoon, preceded and followed by low NO_3 concentrations. The increase in the NO_3 content during monsoon may be due to flushing of land by rainwater.

Iron (Fe)

Though analysis of water samples for the detection and quantification of Fe was done on all the water samples during pre-monsoon, the element could not be detected in quantifiable amounts except in W7 and W8. W7 had a Fe content 0.5 mg/L and0.4 mg/L in monsoon and post-monsoon periods. W8 is a bore well in the study area, which showed Fe concentration of 8, 3.5, and 2.5 mg/L during pre-monsoon, monsoon, and post-monsoon respectively. Both W7 and W8 are located in the same sampling area (Pathinanchil colony) that showed Fe content in remarkable amount. It might have been the contribution of laterite rocks in the deeper layers of the soil in the case of the open well or by iron pipes in the case of the bore well (Tables 5.1, 5.2, and 5.3).

B. Bacteriological Studies

The main purpose of bacteriological examination of the water samples of the study area was to detect recent and therefore potential danger of faecal pollution. Contamination of drinking water by human or animal excreta or sewage is dangerous if, among the contributing population, there are cases or carriers of infections of water-borne enteric diseases. However, it may not be possible to detect the pathogens in a water sample if they are present only in small numbers. It is also possible that the pathogens gain entrance into water sporadically as in the case of cholera, leptospirosis, etc. In such instances, chances are that they are missed in a sample taken for analysis. Since the laboratory examination of water for pathogens is beset with such disadvantages, techniques have been developed for detection of bacterial species of known excretal origin, particularly the coliform group of bacteria. These techniques are accepted worldwide. In the present study the bacteriological examination of water was carried out for the following:

(i) Total coliform count in water characterised by their ability to ferment lactose in culture at 37^0 C with production of acid and gas within 48 hours.

(ii) Faecal coliforms which have the ability to ferment lactose at 44.5^0 C, described as thermo-tolerant coliforms which include Escherichia coli (E.coli).

(iii) Detection of E.coli based on indole production in peptone water using Kovac's reagent.

The estimation of bacterial count was done with MPN Table (Annexure III).

The sampling and analyses were carried out on water samples collected from specific locations during pre-monsoon, monsoon, and post-monsoon periods.

Results of bacteriological examination of water samples

Bacteriological examination of well water samples during pre-monsoon showed relatively low count of coliforms (relative to BIS for drinking water). However, the stream samples especially S1 and S2 showed higher coliform count. There is strong evidence of faecal contamination at these stations.

The pre-monsoon samples showed coliform MPN index ranging from 7 to ^{3}1400 in well samples and 460 to ^{3} 1400 in stream samples.

The monsoon sampling showed high coliform MPN index in all the well samples except W4. W1 had the highest E.coli MPN. The streams recorded MPN index 1100 and above.

Post-monsoon sampling revealed very high coliform MPN index in all the water samples except W3. In relation to BIS specification for drinking water the wells studied have degraded water quality. All the stream sampling stations had very high coliform MPN index. E. Coli MPN index was also high for these stations indicating heavy faecal contamination (Table 5.4).

Location-specific analysis

A. Well samples

Sample code **W1** is a well, located 100m south of Mooledom railway cross. Bacteriological studies on the water sample revealed low bacterial contamination during pre-monsoon and progressively high contamination during monsoon and post-monsoon. The source of contamination is therefore through groundwater recharge. Since the well is located at down gradient, septic tanks, railway tracks, and open cow dung disposal area on the upper gradient might have contributed to the bacterial contamination.

W2 is the public well near *Shishu Vihar* at Nattakom. E.coli MPN indexes for pre-monsoon and monsoons were remarkably low. But the post-monsoon analysis showed faecal coliforms MPN ^{3}1400 and E.coli MPN 150. The post-monsoon recharge from adjoining granite quarry pond may be the source of contamination. The pond is in an abandoned stage and it accumulates sewage and discharge from country latrines. During summer, when the water level in the pond is below the level of the well, there is little possibility for recharge from the pond and hence the bacterial contamination is low. The water level in the pond rises following monsoon and recharges the well.

W3 is the well at Muttom. Though this is a private well it caters to the water requirement of a wider area. Being located near the side of stream, people from distant localities reach the well in country boats to collect water. About 40 country boats used to collect the water from this well on daily basis. Though coliform MPN index is 1100 for both pre-monsoon and monsoon, post-monsoon count is within the limit of BIS.

W4 is the well at Karimpinkala *Kadavu*, near the water-level-gauging station. Water chemistry of this well has a significant correlation with that of S7 (stream station at Karimpinkala *Kadavu*). This correlation suggests stream water infiltration into the well. Coliform count becomes significant during pre-, and post-monsoon periods.

W5, an open pond, is the source of water for water supply scheme run by the *panchayat*. The pond was formerly owned by the Pallom palace and was taken over by Nattakom *panchayat* in 1972. The *panchayat* water supply scheme has 40 public stand posts and no house connections. The pond is perennial and can satisfy the water requirement of a large section of the people of the *panchayat*. Though a compound wall protects the pond, water quality maintenance is poor. The pond premises are often used for cattle grazing which may be one of the reasons for the bacterial contamination. The pre-monsoon MPN index for the well is ³ 1400 and that of monsoon is 1100. E.coli was not detected during pre-monsoon and monsoon periods. But during post-monsoon, though coliform index became relatively low there was an increase in the faecal coliforms. The route of bacteria into the pond water may be through recharge.

W7 is a well located at the east end of Pathinanchil Colony near Pakkil. Many families of the colony use the well water. Bacteriological studies indicated that the coliform MPN index is within the permissible limit during pre-monsoon. Though the coliform MPN index was 1100 for monsoon the low faecal coliform count and non-detection of E.coli suggest better water quality in terms of bacterial count. The post-monsoon studies indicated high MPN index for coliform, faecal coliform, and E.coli. This is an indication of recent microbial contamination either due to human or animal excreta. A cattle shed was found improperly located near the well, which may be a source of contamination. Since the well is located at down gradient, contamination is also possible through underground recharge from up gradient.

The results of bacteriological analysis of water samples are given in the Table.5.4.

B. Stream Samples

All the stream samples analysed for bacterial contamination revealed the alarming state of the streams. Irrespective of the seasons, all the sampling stations showed high rate of faecal contamination. Open defecation is the most probable cause of bacterial contamination of streams. The high MPN index for post-monsoon sampling suggests infiltration from land. Bacterial contamination is a serious problem as the stream water is used for various household purposes other than drinking. Since the water bodies are inter-connected, migration of microbes becomes easy.

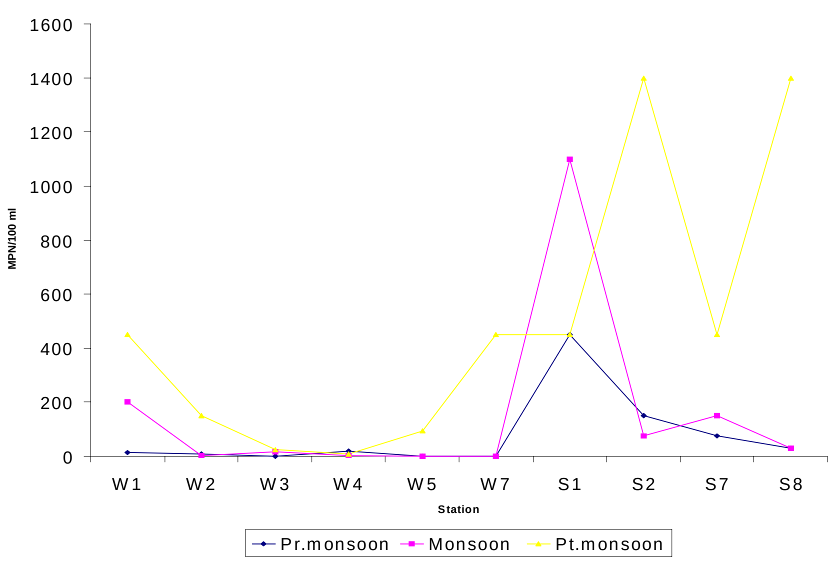
Seasonal variation in E.coli MPN at various sampling sites is given in Fig. 5.20.

The BIS standard of water for bathing specifies the maximum permissible limit for coliform bacteria as 500/100 ml and faecal coliform count as 300/100ml. Since the streams of Nattakom *panchayat* surpass these limits in all the seasons, the stream water is not fit even for bathing.

Table 5.4 Bacteriological characteristics of water samples from Nattakom *Panchayat*

Sample code	Pre -Monsoon			Monsoon			Post- Monsoon		
	Total Coliforms MPN / 100 ml	Fecal coliforms MPN/100 ml	E. coli MPN/ 100 ml	Total Coliforms MPN / 100 ml	Faecal coliforms MPN/100 ml	E. coli MPN/10 0 ml	Total Coliforms MPN / 100 ml	Faecal coliforms MPN/100 ml	E. c MPN/1 ml
W1	160	40	14	≥1400	1100	200	≥1400	≥1400	450
W2	1100	25	9	1100	1100	4	≥1400	≥1400	150
W3	1100	9	0	1100	150	15	45	45	25
W4	450	150	20	20	4	4	1100	95	7
W5	≥1400	65	0	1100	15	0	450	95	95
W7	7	3	0	1100	15	0	≥1400	1100	450
S1	≥1400	1100	450	1100	1100	1100	≥1400	≥1400	450
S2	460	240	150	≥1400	160	75	≥1400	≥1400	≥1400
S7	≥1400	1100	75	1100	150	150	≥1400	1100	450
S8	1100	30	30	≥1400	150	30	≥1400	≥1400	≥1400

Figure 5.20. Graph- E coil



Causes of water quality deterioration in streams

The data collected by applying PRA technique throw light on the major causes of water quality deterioration in streams. Though stream water is not used for drinking, it is extensively used for various household purposes and bathing. Hence stream water quality has remarkable impact on the health of the people. The following are the major causes of water quality deterioration identified and their impacts.

(i) Non-cultivation of paddy fields

Nattakom *panchayat* has 18 *padasekharams* with about 1007 hectares of area suitable for rice cultivation. Until the 1980s the entire area had remained under cultivation. But two of the *padasekharams* namely Muppaikkad (127.10 hectares) and Kakkur chempenveli (51.20 hectares) are not under cultivation for the past 3 to 15 years. As per the records of *Krishi Bhavan*, Nattakom, the total area of non-cultivation is 178.3 hectares, which is 18 percent of the total cultivatable wetlands. The ecology of the area changed drastically subsequent to stoppage of cultivation practices. Paddy fields have luxuriant growth of grasses among which rats breed. The streams through the paddy fields had been in use for irrigation and hence kept clean when they used to be cultivated. But now the streams have thick weed growth in them (Hyacinth and Salvinia). The decay of weeds creates fowl smell and provides breeding place for mosquitoes. As the weed growth is thick, penetration of light is rather impossible. Microbes like bacteria thrive in the underneath water for long periods. All these contribute substantially to water pollution. It is noteworthy that the outbreak of leptospirosis in March 2000 was in Muppaikkad in Nattakom *panchayat*. There were reports of leptospirosis in 1997 from the same location. The affected persons had close association with the water in the streams.

(ii) Effluents from rubber crepe mills

There exist 40 rubber crepe mills in the *panchayat*. The majority of them are located near streams. The effluents from the mills are directly flown into the streams. They contain organic and inorganic compounds and rubber particles. No proper treatment of the effluent prior to discharge is done by many of the crepe mills. When the stream water becomes stagnant consequent on the closure of Thannermukkom barrage the concentration of the effluents increases and attains intolerable levels. The stream water becomes fowl-smelling and dark coloured. People taking bath in the streams experience eye irritation and itching, especially during summer. A major cause of eutrophication of inland canals of the *panchayat* is the effluents from the rubber crepe mills.

(iii) Open defecation

Open defecation is the major cause of bacterial contamination of stream water. Stations S1 and S2 experience high degree of faecal contamination. At station S1 (Kodimatha) there are 34 families forming a colony. None of the families has latrine facilities; they resort to open defecation on the streamsides, causing high-level bacterial contamination of water. At station S2 (Muppaikkad) the uncultivated stretch of field and the bunds are the sites of defecation. In many places of the *panchayat*, country-type latrines have direct outlets into the streams.

(iv)Effect of Thanneermukkom barrage

The intensity of water-quality-deterioration is further augmented by the closure of Thanneermukkom barrage. The *puncha* lands of Kuttanad were cultivated only in alternate years till 1940. This type of cropping had the advantage of increased fertility of the land due to its submergence for long periods. With the prospect of raising a second crop in view, a permanent solution was thought of and implemented in the form of a salt-water barrage in 1974. The original suggestion was to close the barrier on the 15th December and to open it on 15th March every year. But owing to shift in the cultivation schedule it has become impossible to adhere to the schedule of barrage operation as had been originally envisaged. Late opening of the barrage, generally towards the middle or end of April, became necessary. As a result inland waters contain fresh water almost throughout the year. Stoppage of salt-water intrusion has, however, resulted in unforeseen ecological imbalances in the entire area.

(v) Eutrophication and weed problem

Accumulation of residues of enormous quantity of organic matter during the closure of the barrage has led to the eutrophication of Vembanad Lake and adjoining canals. Explosive growth of algae and aquatic weeds poses problems for primary aquatic productivity, fisheries, and inland water transport, and provides congenial breeding grounds for mosquitoes and other vectors of contagious diseases.

The role of the barrage in the prolific growth of water hyacinth has been proved. This weed is adapted to a salinity of less than 20ppt only and will be destroyed within a few days when the threshold limit is exceeded. Under natural conditions, as salinity intrudes during summer, this weed gets destroyed. The closure of the barrage in summer season converts the water body into a fresh water lake thereby preventing the natural destruction of water hyacinth.

(vi) Health hazards

During the period when the barrage remains closed large quantities of pollutants from domestic and urban sewage, and agrochemical and industrial effluents are accumulated in water and sediments. In the absence of a proper water supply scheme, not only people of the major part of the *panchayat* but also the entire Kuttanad have become dependent on this highly polluted water for all household purposes resulting in the upsurge of water-borne diseases like filariasis, schistosomiasis, cholera, typhoid, jaundice, gastroenteritis, leptospirosis, dysentery, and meningitis. Since most of the areas of the *panchayat* are interconnected by waterways, pollution, and consequent health hazards spread quite rapidly.

(vii) Some new menaces

Prevention of salt-water intrusion by the barrage has resulted in the emergence of new menaces. For example, the blood-sucking leech population is growing fast in the inland fresh waters. The leeches, which cannot survive in saline water, proliferate in stagnant fresh waters. The wound caused by the leech-bite may serve as the port of entry for pathogenic microbes like Leptospires. Cattle feeding in grassy field also succumb to leech attack.

Farmers from Perinilam and Gravu *padasekharams* of Nattakom *panchayat* reported that tortoise is emerging as a new pest for rice cultivation. Tortoises destroy rice at different stages of its development. The tortoise population has increased in recent years, taking advantage of the prevention of salt-water intrusion.

6. Quantification of Air-Borne Respirable Particulate Matter (Rpm)

Deterioration of air quality, a process that began after the industrial revolution, assumed alarming proportions in developed countries over the past half-a-century. The situation in developing countries is not better either. A well-designed, continuously functioning network of air quality monitoring stations providing data on the ambient air quality in urban centres has been found essential to organise effective air pollution control programmes. In India, NEERI initiated a programme for this purpose in 1978. Kochi has an air-monitoring station in Kerala under this scheme. Data on Suspended Particulate Matter (SPM) showed maximum pollution in the industrial zone followed by commercial and residential zones (NEERI, 1980).

Suspended particulate matter (SPM) is a composite group of substances, liquid or solid, dispersed in the atmosphere. The most significant factor of SPM is the respirable size that is larger than 0.1 micron and smaller than 10 microns. Particles in this range remain suspended in the air while particles larger than 10 microns settle down.

The human body has its mechanism for removal of the particulate matter from the body. The hairs and mucous lining of the nose trap larger particles of size10 microns or above entering the respiratory system. Particles of less than five microns may reach the lower respiratory passages and lodge in the tiny air sacs. Accumulated particulate matter together with oxides of sulphur may cause upper respiratory tract infections, and cardiac disorders, bronchitis, asthma, pneumonia, emphysema, conjunctivitis, and skin diseases. Carbonaceous particles could also be carcinogenic.

The toxic effect of RPM on humans is in one or more of the following ways:

(i) The particulates may be toxic because of their inherent chemical or physical characteristics;

(ii) The particles may interfere with the mechanisms of the respiratory tract; and

(iii) The particles may act as carrier of adsorbed toxic chemical or microbe.

Ambient air quality standards as per KSPCB specification are given in Annexure IV.

Cement manufacturing industries have contributed substantially to the air pollution problem as point source of emission. Fallout of cement factory emission is determined by several factors such as variation in manufacturing process, efficiency of emission control devices, and meteorological and topographical conditions. In India, several researchers (Agrawal M and N Khanam, 1989; Parthasarathy, et al, 1975; Singh S.N, 1979) have reported high dust fall rates from cement industries.

The exit gases of cement kiln consist of nitrogen, carbon dioxide, water vapour and small amounts of sulphur dioxide, nitrogen oxides, carbon monoxide, and hydrogen sulphide.

Materials and method

The present study was carried out at the outskirts of Travancore Cements Limited (TCL), Nattakom, Kottayam.

TCL started functioning in 1947 as a private company. The initial product was grey cement. During 1959 the company shifted to production of white Portland cement using the pioneer technology and machinery of F. L. Smith and Co. Denmark. At present it is a public sector venture.

Technically, cement manufacturing at TCL is done through the wet process. Lime shells, silica sand, clay, and gypsum are the raw materials used. Cleaned lime shells, sand and clay are mixed in definite proportions and crushed and ground with water to form a slurry. The raw mixture is then burnt at a high temperature in rotary kiln to form clinker. The clinker thus obtained is ground to a fine powder with addition of gypsum to give white cement. The fuel used in kiln is furnace oil (LSHS). The annual production of TCL is 30,000 metric tons.

The processing of raw materials by crushing, milling, grinding, and heating generates considerable amount of dust. The grained dust from the heating furnace is dispersed into the atmosphere. Large amounts of particulate matter are also produced during packing. The sources of dust generation and the quantum of normal dust generation in cement plants are shown in the Table 6.1.

Table 6.1 Dust generations in cement industry

Source	Normal dustgeneration range qm/ Nm$^{3)}$
Crusher	5 -15
Rawmill	
-gravity discharge	20-50
- -air swept	300 -500
Coal mill -gravity discharge	20 -80
-drying and grinding	100 -120
Kiln - dry	50 -120
-semi dry	10 -20
-wet	30 -50
Cement mill	150 -250
Packing plant	20 -40
Material handling operations	10-30

Source: Cement Data Book, Duda

The sites selected for study of Respirable Particulate Matter (RPM) were the campus of the Government College, Kottayam (GCK) and the adjoining places within a radius of 750 m from TCL. The sampling stations were in the outskirts of the cement factory where the wind direction was mostly in E and SE directions. Hence the sampling stations were within the major wind directions. The elevation of the study area ranges from 25 to 30 m above sea level.

The air sampling for RPM was carried out from September 2000 to March 2001. The sampling was done by using High Volume Sampler (HVS Make 'netel' model-NPM -HVS with RPM option), kept at 1.5m above ground level. GF/A (Whatman) filter paper was used for trapping particulate matter in the ambient air. The filter paper was conditioned before and after sampling. Initial airflow rate was adjusted to 1 m^3/min and the sampling duration for each sampling was 24 hrs. The information is presented as 24 hr mean concentration expressed as mg/m^3. The sampling was done at an interval of 10 days (Since the factory was not operating on certain days of sampling the data obtained on those days represent RPM standard for 'non-factory' days). The following formulae were used to calculate RPM;

(i). Volume of air sampled (V) = $$\frac{(Q1+Q2)}{2} \times t$$

(ii). RPM = $$\frac{(W2-W1)}{V} \times 10^6 mg/m^3$$

Where,

Q1 = Initial rate of air flow
Q2 = Final rate of air flow
t =Total time in minutes
W1 = Weight of the filter paper before sampling
W2 = Weight of the filter paper after sampling

(iii). Results and Discussion

The RPM concentration of the ambient air during the period of study is given in the Table 6.2.

Table 6.2 RPM concentration in ambient air: Sampling site - G C K

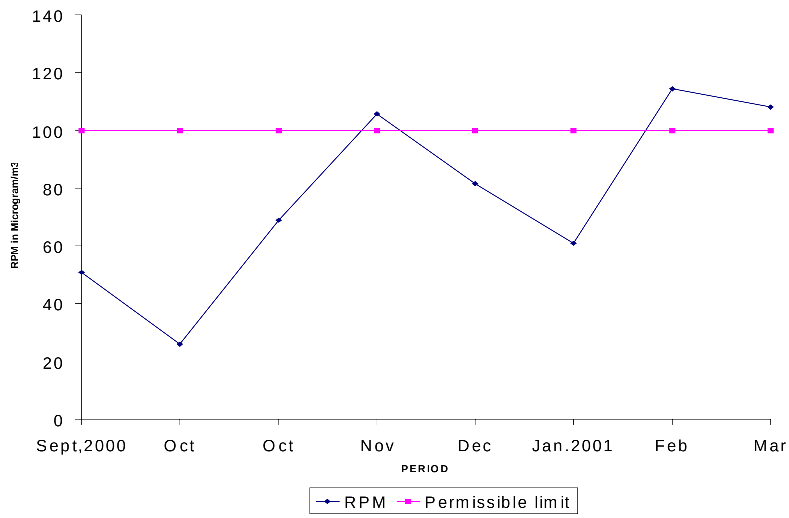
Period of study	No. of sampling	RPM max.mg/m^3	RPM (AM) mg/m^3
September,2000	1*	--	50.79
October	1*	--	26
"	2	72.9	68.95
November	3	159.13	105.71
December	2	84.1	81.5
January 2001	1*	--	61.02
February	2	114.8	114.52
March	1	--	108.18·

*Sampling on 'non factory day'

AM - Arithmetic mean

The average RPM for November 2000, February and March 2001 exceed the limit set by KSPCB for residential, rural, and other areas. On 'non-factory' days the RPM concentration is within the range 26-61 m g/m^3.

Figure .6.1 Graph RPM



The results clearly indicate that TCL is a major contributor of RPM in ambient air in the study area. Various factors like weather conditions, wind direction, and topography of the location influence the results of sampling. Significant negative correlation (r = -0.5) was obtained between rainfall and RPM.

The particulate matter caught in the filter shows predominance of carbon as indicated by the black colour, the source of which may be the plume from kiln stack where furnace oil is used as fuel. White particulate matter retained by the filter includes white cement dust, silica particles and calcium carbonate. The average particulate matter emission from the kilns of wet process technology in India amounts to 0.1 percent of cement produced (Madhoolika & Najma, 1997). The total amount of dust emission from TCL can be therefore estimated as 30 tons per year.

The kiln stack of TCL has 39.2 m height and 2.19 m diameter. The base of the stack is at an elevation approximately 20 m above the MSL; thus the emission is at a height of about 59.2 m above MSL. The elevation of the study area is in the range 25-30 m above MSL. Hence the clearance height of the stack is only about 29 m above the ground level of the study area. When considering the topography of the area and annual turn over of the factory the present stack height seems insufficient to disperse the emission at a level that would favour maximum scattering of particulate matter. Also, tall stacks release pollutants above the nocturnal inversion thus preventing much of the fumigation problems. Hence the insufficient stack height restricts pollutant dispersion by accumulating more emission around source.

It is also understood that no measures are adopted for curbing the dust emission from the kiln stack. Dust bags are used, however, in the packing section where cement dust is the major emission. The factory functions round the clock in three shifts. Hence emission is a continuous process. In addition to local people, about 2400 students studying in different educational institutions of the locality and their staff are also exposed to the pollutants every day. Continuous exposure to RPM-contaminated air may lead to pneumoconiosis. Inhaling particulate carbon would lead to anthroposis, which manifests as chronic bronchitis. Table 4.2 gives the number of cases of respiratory and allergic disorders during 1996-‘97 to 2000-‘01, according to the records of Nattakom PHC.

The study on RPM in the air around TCL gives the following results:

(i) TCL is a source of air pollution in the area.

(ii) Particulate emission includes Carbon, Silica, and Cement.

(iii) On certain days of sampling the RPM was found to be very high

(iv) Variations in recorded RPM may be due to fluctuations in the local weather conditions like wind direction, wind speed and humidity,

(v) Stack height seems insufficient and hence restricts dispersion of pollutants,

(vi) Particulate emission could be effectively controlled if dust control measures are adopted.

(vii) Detailed studies over a longer period are required to assess spatial and temporal variations in concentrations of particulate matter around the factory.

7. Conclusions and Suggestions

The preliminary studies on the environmental quality and health in Nattakom *panchayat* throw light on the following facts:

(i) Thirty-three percent of the health problems in the *panchayat* are due to poor water and air quality,

(ii) Socially and economically weaker sections of the population are the most affected groups of environmental deterioration,

(iii) Lack of proper sanitation and indiscriminate dumping of waste are the major causes of water quality deterioration in streams,

(iv) Major physico-chemical characteristics of well water from various parts of the *panchayat* are within the permissible limits for drinking water,

(v) Possibilities of microbial contamination of well waters are high, especially during post-monsoon periods,

(vi) Change in land use patterns is among the causes of decline of environmental quality,

(vii) Industrial firms, both major and minor, have significant role in polluting air and water,

(viii) The public water supply network is not effectively functioning in all parts of the *panchayat*. Hence people are bound to depend on the much polluted stream water for various purposes,

(ix) Air pollution due to RPM is significant around TCL.

Suggestions

(i) Priority should be given to public sanitation programmes,

(ii) As microbial contamination is high in water bodies, especially during post-monsoon, people should be warned about the potential danger of using untreated water for domestic purposes,

(iii) Restoration of cultivation should be encouraged in wetlands which are left uncultivated,

(iv) The merits and demerits of Thanneermukkom barrage should be evaluated and policies revised, if necessary,

(v) Possibilities for minor water supply schemes may be investigated and if found feasible, implemented with the help of beneficiaries,

(vi) Steps may be taken for periodical cleaning of the water source of public supply systems like wells and ponds,

(vii) The policy of industries, "to pollute the common man without paying for the damage they inflict", should be questioned and all efforts made to reduce environmental pollution,

(viii) Creation of public awareness on the necessity of a clean environment is highly necessary. Only through such awareness creation, would people abstain from activities leading to environmental deterioration.

Annexure-I

Sample code and name of stations

Sample Code	Nature of water source	Name of Station
W1	Well	Mooledom
W2	Well	Sisuvihar
W3	Well	Muttom
W4	Well	Karimpumkalakadavu
W5	Well	*Panchayat* pond
W6	Well	Pathinanchil Colony(W)
W7	Well	Pathinanchil Colony (E)
W8	Well	Bore well
S1	Stream	Kodimatha
S2	Stream	Muppaikkad
S3	Stream	Manipuzha (E)
S4	Stream	Manipuzha (W)
S5	Stream	Kannankara(W)
S6	Stream	Muttom
S7	Stream	Karimpumkalakadavu
S8	Stream	TECIL (W)
S9	Stream	TECIL (E)

Annexure-II

Indian Standard- Drinking water specification (IS 1991)

Sl. No.	Substance or Characteristics	Requirement/ Desirable limit
1	Colour, Hazen units, Max	5
2	Odour	Un-objectionable
3	Taste	Agreeable
4	pH value	6.5 to 8.5
5	Total Hardness (as CaCO3)mg/L, max	300
6	Iron (as Fe), mg/L, max	0.3
7	Chloride, mg/L, max	250
8	Calcium (as Ca) mg/L, max	75
9	Sulphate, mg/L, max	200
10	Nitrate (as NO3) mg/L, max	45
11	Flouride, mg/L, max	1.0
12	Magnesium, mg/L, max	30
13	Coliform, MPN/ 100 ml	50

Annexure- III

3 Tube- MPN values for Coliforms in water

Number of positive tubes observed in each dilution			
10 ml of thesample	1 ml of the sample	1 ml of the 1st dilution	MPN value/ 100Ml.
0	0	0	0
0	0	1	3
0	1	0	3
0	1	1	6
0	2	0	6
1	0	0	4
1	0	1	7
1	0	2	11
1	1	0	7
1	1	1	11
1	2	0	11
1	2	1	15
1	3	0	16
2	0	0	9
2	0	1	14
2	0	2	20
2	1	0	15
2	1	1	20
2	1	2	30
2	2	0	20
2	2	1	30
2	2	2	35
2	2	3	40
2	3	0	30
2	3	1	35
2	3	2	40
3	0	0	25
3	0	1	40
3	0	2	65
3	1	0	45
3	1	1	75
3	1	2	115
3	1	3	160
3	2	0	95
3	2	1	150
3	2	2	200
3	2	3	300
3	3	0	250
3	3	1	450
3	3	2	1100
3	3	3	1400+

Annexure-IV

Ambient air quality standard for RAM (KSPCB)

Area Category	Time weighted average	Concentration μ g/m^3
A. Industral	Annual Av.	120
	24 hours	150
B. Residential, rural & other areas	Annual Av.	60
	24 hours	100
C. Sensitive area	Annual Av.	50
	24 hours	75

Source: Kerala State Pollution Control Board - Standards & Guidelines

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