13.0

RESULTS AND DISCUSSIONS

13.0

RESULTS AND DISCUSSIONS

13.1 Sampling Locations

As seen in the preceeding chapters, the State is having varied climatic and goe-hydrolgocial conditions. The quality of water therefore varies from area to area and sometimes from season to season. Sample collection was therefore arranged in such a way so as to cover all regions of the State. This includes hilly areas of Saputara and Ahwa in Dangs, coastal lines of Saurashtra, Alluvial tracks of north and central Gujarat, desert region of Kutch, brackish zones of central and north Gujarat and industrial belts of south Gujarat.

Details of sampling points with type of source and their location on map of Gujarat are given in **Annexure - 13.1.** To cover the various type of sources like surface sources and shallow as well as deep sources, samples from following sources were collected.

- Open wells
- Hand pumps
- Dam reservoirs
- Canal fed ponds
- Infiltration galleries
- Radial collector wells(french well)
- Deep tube wells
- Blended water (Surface + Ground)
- Artisen well (free flowing water - This water is not used for drinking purpose).

The samples were collected during the years **1987-88 and 1988-89** which were the years of worst scarcity in the State as will be evident from the rainfall data given in the chapter No. 6 **on profile of Gujarat State.** This has revealed the picture of quality during the worst period which has scope for improvement in the good monsoon period due to recharge and also reduced drawal. The samples were collected during pre-monsoon and post monsoon period. For many of the sources, repeated samples were collected to check seasonal variations. Samples from some of the large regional water supply schemes were also collected to check the qualaity of water available to many villages covered under such schemes. Details of Regional schemes for which samples are collected are given in **Table-13.1.**

In addition to this, water samples from both rural and urban areas were collected. This included water samples from major cities like Ahmedabad, Vadodara,, Surat, Rajkot, Jamnagar and towns like Kalol, Mehsana, Bhuj, Amreli, Valsad, Godhara, Dabhoi, Idar. Himatnagar, etc.

13.2 Selection of Parameters

For deciding the potability of water, in all 23 physico-chemical parameters were selected and analysed. These parameters are such which decide the potability(drinking) and acceptability of water for other important domestic uses.

They include

- Organoleptic/physical parameters : colour, odour
- Aesthetic parameters: turbidity, silica
- Non metals: Chloride, Nitrate, Sulphate, Phosphate
- Metal: Zinc, Sodium, Iron
- Plant nutrients: Nitrate, Phosphate, Potassium, Boron
- Indicators of pollution: Chemical Oxygen Demand, pH, Turbidity, Alkalinity
- Scale formers: Hardness, Calcium, Magnesium, Sulphate
- Stain former: Iron
- Indicatrors of brackishness/salinity: Total Dissolved Solids, Chlorides
- Health effecting/toxic chemicals: Fluoride, Nitrate, Cyanide, Zinc, Magnesium, Sodium

Since the study was mainly confining to the quality of drinking water in the state, the parameters concerning to the quality of drinking water and that too mainly prescribed by national and international standard agencies are covered. The No **Source Criteria** of the State Government also stipulate that if the chemical quality of water is not acceptable in a public source than the users are to be provided water from alternative source. Hence emphasis was given to Physico-chemical parameters. Bacteriological quality could deteriorate at the users end also and can be improved by taking due care or resorting to simple treatment like chlorination and hence is not considered in the scope of this study. Moreover, the major dependence for drinking water supply in the State is on ground water. Ground waters are usually high in mineral content. The three important parameters which are causing concern about the acceptability and health effects are **salinity, fluoride and nitrate**. These parameters are individually discussed in separate chapters on occurrence of salinity, fluoride and nitrate and hence do not need further elaboration. Many adversities of weather like scanty and uneven rainfall as well as diversities of geo-hydrological formations like rocky terrain, hilly areas, coastal-line and effect of desert are aggravating the drinking water quality problems which are described in the preceding chapters and hence are not repeated here.

13.3 Approach of the State Government for water quality

The objective of the State Government by providing drinking water supply is to improve and **protect the health and welfare of the people**. For this reason, it is highly imperative that the quality of water supplied to the community is safe and adequate. The state authorities are therefore

exercising all precautions to see that the sources tapped are safe and accepted from quality point of view. For this, extensive geo-hydrological surveys and intensive water quality testing/ monitoring works are undertaken. The state has many welfare programmes under which safe water supplies to the communities are ensured, these programmes include -

- Minimum Needs (MNP)
- No Source
- Rejuvenation
- Tribal development
- Special component (for schedule castes)
- Desert area development
- Accelerated Rural Water Supply (ARWS) Govt. of India Support
- Salt workers in coastal areas.

Under these programmes, the quality and quantity of water supply to people especially in rural areas are ensured. The sources of doubtful quality are abandoned and safe and reliable sources are tapped. Due to this fact, the water quality in the sources which are in use and are covered under the study work are found mostly safe and within permissible limits. The State authorities have adopted latest BIS standards IS:10500/1991 for assessment of drinking water quality. Based on that, the parametric evaluation and interpretation of results obtained during the study is made as under :

13.4 Analytical Results

Analytical results of the parameters analysed for all the sources surveyed during the research study are tabulated in **Table No. 13.2**. These parameters were analysed as per the methods described in **Chapter No. 12**. The values of parameters are expressed in **mg/l** except for colour, odour, pH, conductivity and turbidity. Unit values for other parameters are expressed as;

Colour - Hazen Units(Platinum Cobalt Scale)
Conductivity - μ mhos/ cm^2
Odour - Thresold Order Unit (TOU)
pH - No Unit
Turbidity - Nephelometric Turbidity Unit (NTU)

13.5 Parametric Evaluation

The parametric evaluation of the Physico-chemical quality of drinking water is made here under. This evaluation is based on the samples drawn by the author for this research study. The samples were drawn from public water supply sources only. The evaluation is made taking BIS standards (IS: 10500/1991). as guidelines. The significance of all these parameters is shown in **Chapter No. 10** and the guideline standards for deciding the quality of water for drinking purpose are given at **Table No. 4.1** in **Chapter No. 4** and hence are not repeated here.

13.5.1 Alkalinity

Although alkalinity is not a very detrimental parameters, its significance is associated with taste, chemical reactions and presence of other dissolved materials. The value of alkalinity in surface sources is found to be very low. However in the ground water sources particularly from the deep strata, the values are observed to be high sometimes. For example, sources at Kalol(NG), Pij(Dist. Kheda), Kapurai village (Dist. Vadodara) are found to be on higher side. It could be said that generally the alkalinity in ground waters are moderately high and in few cases it is exceeding the permissible limits. Alkalinity values are generally high in Gujarat Waters, but are not posing any problems.

13.5.2 Boron

Boron is not very significant parameter. The prescribed limit is 1.0 mg/l which is relaxable upto 5.0 mg/l. Except a few sources, water in all other places is found to have Boron within permissible limit of 1.0 mg/l. However, at only few places like Kalol(NG), Vaghania (Dist.-Amreli), Pij(Dist.-Kheda) and Dholera (Dist.- Ahmedabad) it is found to be marginally higher than the permissible limit but within relaxable limit of 5.0 mg/l. Artisen well at Dholera shows higher values but is not in use for drinking purpose.

13.5.3 Calcium

Permissible limit for calcium is 75 mg/l which can be relaxed upto 200 mg/l. Calcium has no direct health significance but is the principal cation which contribute hardness. Most of the sources are having low calcium content, which indicates propotionately low hardness also. However a few sources like Mehsana city(N.G.), Dudheswar water works (Ahmedabad City), Banny scheme (Bhuj City), Shivlakha scheme (Dist.Kutch), Kapurai (Dist. Vadodara) and SZBT scheme at Ankleshwar (Dist. Bharuch) are having higher amount of calcium but not exceeding the relaxable limit of 200 mg/l.. Thus calcium is also not a problem in Gujarat Waters.

13.5.4 Chloride

Chloride is a parameter associated with salinity (expressed as Total Dissolved Solids). Looking to the peculiar geohydrological conditions of the State, and ingress of salinity, the incidence of high chloride is encountered at many places. We have seen in the chapter - 7 on **"Occurrence of Salinity in Gujarat"** that large number of areas/villages are falling under the effects of salinity which also is due to high amount of chloride.

In the study results, out of total 39 sources examined, 14 sources are having chloride higher than permissible value of 250 mg/l but not more than 1000 mg/l the upper limit for relaxation. These sources having higher values of chloride are in north Gujarat, coastal regions and some of the regional schemes. Dholera artisen well is having very high chloride value but is not used for drinking purpose.

13.5.5 COD (Chemical Oxygen Demand)

There are no guideline values for COD in drinking water quality Standards. However, this test was performed to check the presence of any industrial/organic pollution in public water sources. It is a quick test replacing 5 days BOD test. The results indicate that none of the source water contains any industrial or organic pollution. Of course, some of the surface sources are having marginally high COD values which are presumably due to humus material in water and not due to any pollution. Values in Milrampura - Valli (Dist. Kheda) Shetrunji Dam water (Dist:- Bhavnagar) and Banny Scheme water (Dist.: Kutch) are found slightly higher but are not alarming. In these sources no evidence of pollution is noticed and it is presumed that higher values are due to algae and other natural pollution. Marginally higher COD values in ground waters at Bhuj city, Banny Scheme at Khavada (Dist. Kutch) and Kapurai (Dist. Baroda) are unusual but certainly not of any outside pollution. Presumably they are due to some weed growth or handling contamination.

13.5.6 Colour

Appearance of colour in drinking water is not desirable as it will indicate the presence of some pollution. No one likes to drink water with any colour except in soft drinks. Fortunately none of the sample shows presence of colour establishing the fact that no industrial pollution reaches to the drinking water sources.

13.5.7 Cyanide

Cyanide is a highly toxic material which is suspected to come from industrial effluents. None of the sources have shown presence of cyanide in water proving that drinking water soruces in Gujarat are safe from Cyanide contamination.

13.5.8 Fluoride

Fluoride is very important parameter from health point of view and it is fully discussed in a separate Chapter No. 8 on **"Occurrence of Fluoride in Gujarat"**. Areas having high values are also pointed out in that chapter. However the study results have shown the actual status of the existing sources. Out of 39 samples collected, 6 samples are showing higher values of fluoride. But these values are only moderately high and not very high (Not more than 3.0 mg/l). Some of the scheme waters like Santalpur Regional Scheme, Shivlakha Scheme, Banny Scheme and Dhadhodar scheme have started showing increasing trend of fluoride,which is causing concern. However, the values have yet not exceeded more than 2.0 mg/l. But they need constant vigil and some corrective measures. As seen in Chapter No. 8 districts like Amreli, Bhavnagar, Mehsana, Sabarkantha, etc are showing higher values of fluoride.

13.5.9 Hardness

Hardness is an important parameter for taste and cooking as well as laundry(washing) purpose. Hardness is also associated with TDS and ground waters in Gujarat obviously contain high amount of hardness. In the study results only two sources are found to have high hardness i.e. more than relaxable limit of 600 mg/l. It is observed that these two sources which are having high amount of hardness are in Kutch area where they are coupled with high values of TDS. Obviously ground waters are having high values of hardness.

13.5.10 Iron (Fe)

Iron is not an important parameter from health point of view. It is also not a problem parameter in Gujarat. The permissible value is 0.3mg/l which can be relaxed upto 1.0 ,g/l. Except for two sample in the study results, the values of this parameter are well within the permissible limits. At Malegao village (Hand pump) in Dangs district and at Ajawa lake water (Dist. Baroda) the values are reported slightly higher than the relaxable limit of 1.0 mg/l but are not alarming. The high values at these two places are attributed to the hilly catchment area. The sample taken from surface water at Saputara (lake water) is not having high iron content indicating moderately high content only in surface water.

13.5.11 Magnesium

Bureau of Indian Standard has not prescribed any limit but Ministry of Rural Development in Government of India (Rajiv Gandhi National Drinking Water Mission) has prescribed the limit of 30 mg/l for Magnesium which is relaxable upto 150 mg/l. It has got laxative effect if coupled with high amount of sulphates.

Magnesium is observed to be high in deep ground waters. High values are reported at Sabarmati (Ingoli) scheme(Dist. Ahmedabad), Pij (Dist. Nadiad), Palej (Dist. Bharuch), and SZBT Scheme at Ankleshwar (Dist. Bharuch). Thus out of 39 samples only 6 samples are showing values beyond permissible limit of 30 mg/l but none beyond relaxable limit of 150 mg/l. It is therefore clear that magnesium is not a serious problem in drinking waters of Gujarat. However, high magnesium values are encountered particularly in Bharuch district.

13.5.12 Nitrate

Nitrate is an important parameter from health point of view. Its adverse effects are eleborately discussed in a separate chapter - 9 on **"Occurrence of Nitrate in Gujarat"**. As seen in that chapter the permissible limit for nitrate as per BIS standards is 45 mg/l (as NO_3) which could be relaxed upto 100 mg/l.

Out of 39 samples collected during the study work, only three samples are showing higher values of nitrate but are not exceeding the relaxable limit of 100 mg/l. Moreover these 3 sources having higher values are in north Gujarat region. Two in Sabarkantha District viz. Idar and Himatnagar, whereas the third source is that of Mehsana city supply.

As seen in the chapter - 9 the incidence of nitrate occurrence is high due to obvious factors listed in that chapter. Their presence in drinking water sources is not reported high due to care exercised while selecting the sources for public supply. However, high nitrate values are observed more in ground waters of Sabarkantha district in particular.

13.5.13 Odour

Occurrence of odour in water is expected either from decomposition of organic materials (Putriscible), or presence of industrial wastes particularly organic chemicals such as Phenol etc. None of the samples have shown presence of odour in water. This shows that the water sources are free from any organic pollution or other contamination.

13.5.14 pH

pH of water in the sources is not a problem although occassionally it shows higher values in surface water sources due to eutrophication and algal growth. Such incidences are reported during the study also. Notable are sources at Milrampura - Valli (Dist. Kheda) where the source is canal fed pond, Ukai dam water (Dist: Surat) and Narmada water at Kevadia colony(Dist. Bharuch) and water coming at Varachha head works (Surat city), where pH is reported tobe high in surface water sources. Some of the ground water sources unexpectedly show higher values of pH. They are Dudheswar water works (Ahmedabad city), handpump water at Malegao(Dist. Dangs)Tubewell water at Shihori Head works (Dist. Banaskantha) and Tap water at Valsad. Since most of the samples were drawn during summer, the eutrophication in the surface water is expected to be the cause for increase in the pH values for surface sources.

13.5.15 Phosphate

Phosphate is not an important parameter for drinking water and no standard values are prescribed by any agency except European community (5 mg/l). It is considered important for the eutrophication of surface water mainly due to nutrient value. It's higher values can indicate entry of fertilizers or synthetic detergents in water. But no such incidence is reported in Gujarat sources used for drinking purpose. All sources show values well below 0.1 mg/l.

13.5.16 Potassium

Potassium is also considered an important nutrient for eutrophication of surface water. it has no important health significance. It's values are found low except bore waters at Pij(Dist Nadiad) and Shivalakha scheme (Dist. Kutch) where excessive drawal of deep strata or saline water intrution may be responsible.

13.5.17 Silica

As such there is no prescribed standard for silica. It is also not harmful for health. It can be easily removed by plain sedimentation or storage. Occasionally silica is appearing in

Tubewell waters. Silica is detrimental for desalination plants and needs to be removed in pretreatments.

13.5.18 Sodium

Sodium is mainly associated with salinity (NaCl) and is expected high in ground waters from deep strata. Higher values are detrimental for heart and hence some agencies have fixed upper limit of 200 mg/l.

The water sources surveyed during study, normally do not show higher values. However some sources particularly those of deep ground water show increasing sodium content. Following sources have shown higher values -

Jangaral village - District Mehsana

Mehsana city - north Gujarat

Ingoli water supply - District Ahmedabad

Vaghania village - District Amreli

Kalol city - North Gujarat

Dudheshwar water supply - Ahmedabad city

SZBT Water supply - Ankleshwar Dist. Bharuch

Pij Water works - Dist. Kheda

Banny Water supply scheme - District Kutch

Shivlakha Water works scheme - Dist. Kutch

Majority of these sources show higher values due to salinity ingress in the sources.

13.5.19 Sulphate

Sulphate is not observed high except for two sources. The two sources having high sulphate out of which only one source (i.e. Sabarmati scheme (Ingoli), Dist. Ahmedabad) is exceeding the permissible limit of 400 mg/l. The another source is Banny Water Supply Scheme in Kutch district. Both these sources are from deep ground water strata where salinity is high. It is therefore asssumed that high sulphate is due to the ingress of salinity. Incidently in Sabarmati scheme magnesium is also marginally more,combination of which with sulphate is not desirable.

13.5.20 TDS (Conductivity)

Conductivity and TDS are inter-related and their values are usually high in ground water. They are primarily responsible for occurrence of salinity if their values are high. As such TDS/conductivity is detrimental for palatability and some other industrial uses but are not directly responsible for any health effect. These parameters are elaborately discussed in a separate chapter-7 on **"Occurrence of Salinity in Gujarat"** and hence are not repeated here.

Out of total 39 sources surveyed, only six sources(except artisen well at Dholera) are showing high values of TDS. They are Vaghania(Dist. Amreli), Sabarmati scheme - Ingoli(Dist. Ahmedabad), Pij (Dist. Kheda), Banni Scheme - Khavda (Dist. Kutch), Shivalakha Scheme - Rapar (Dist. Kutch) and Mehsana City. These sources are all deep tubewells and their higher values are attributed to over exploitation of ground water.

13.5.21 Turbidity

Turbidity is an important parameter from aesthetic point of view and is detrimental in treatment of water. Turbidity is high in surface sources. Ground waters are devoid of turbidity. Turbidity in five surface sources is found to be as under :

Source	District	Period	Value(NTU)
Shetrunji River	Bhavnagar	July 1987	415
-do-	-do-	Feb. 1988	30
Ajawa Lake	Vadodara	Aug.1987	348
Narmada River	Bharuch	Sept. 1987	360
Damanganga River	DNH	Nov. 1987	24
Kalubhar River	Amreli	March 1988	37

It will be seen that turbidity is higher in rivers during monsoon months only. Afterwords it comes down to average 30 to 40 units. This shows that during non-monsoon months it could be taken directly on to the filters without giving any coagulation in treatment plants. Surprisingly ground water sources for Sabarmati scheme(Dist. Ahmedabad) is showing high values of turbidity which may be presumably some on-line contamination on the long distance pipeline. (Sample was taken at Vataman Chokdi).

13.5.22 Zinc

Zinc also is not an important parameter. It also has no direct health implication. None of the sample in Gujarat is showing high values of zinc which may cause concern.

13.6 Overall assessment of water quality

Based on the results of the study and extensive survey made during the sample collection work and also the authors own experience of working in the field of water quality for nearly two decades, the following generalised view could be expressed for quality of drinking water in Gujarat.

13.6.1 Although there are large number of constraints in tapping acceptable quality of drinking water for public use at many places, the overall picture of existing drinking water quality in the State is found quite satisfactory. This is due to the fact that sufficient care is exercised by the State Authorities for selecting and maintaining the public water sources.

13.6.2 The public water supply is provided from both surface and ground water sources. Where no reliable source of acceptable water quality is available , the water is imported from other

potential areas. Details of comprehensive(regional)water supply schemes covering large number of villages in hardcore areas, are given in chapter-7.

13.6.3 The surface water quality is obviously superior over the ground water, particularly in respect of aesthetic and chemical aspects.

13.6.4 All surface water sources particularly from river or dam source are provided with necessary treatment to bring down the exceeding parameters like turbidity and bacterial contamination.

13.6.5 The turbidity of surface water is moderately high in river waters during monsoon period. During non-monsoon period it comes down as low as 20 to 30 NTU. Thus it is evident that during non-monsoon months the river/dam water could be directly taken on the filters by passing the coagulation and sedimentation treatment.

13.6.6 The surface water sources also show the presence of algae and other aquatic weeds. Algae is responsible for higher values of pH in water which is interfering with the treatment and also its use for potable purpose.

13.6.7 No evidence of any chemical or industrial pollution is reported during survey or detected during analysis. This is substantiated by absence of colour, odour and low values of COD parameter. Thanks to the meticulous selection of sources and their protection subsequently.

13.6.8 Trace elements like Iron, Cyanide and Zinc are also found either absent or at very low value indicating the safety of public water supplies from toxic or harmful elements.

13.6.9 Nitrates are found to be high at many places, sometimes excessively high in some pockets. Some parts of central Gujarat like Kheda district and north Gujarat like Sabarkantha and Banaskantha are showing very high values causing concern. This aspect is elaborately discussed in a separate chapter.

13.6.10 Other parameters which are known as "plant nutrients" such as Phosphate, Potassium and Boron are found to be at very low level and do not pose any threat to the quality of water.

13.6.11 Alkalinity of drinking waters in Gujarat is moderate or sometimes high but not very high. it is not a problem. Similarly pH of water is also mostly in the acceptable range except for a 6.10few surface water cases where it is moderately high due to algae growth and in some ground waters which are showing alkaline trend.

13.6.12 Hardness of waters particularly from ground waters is more or less within the acceptable range. Although at times it is slightly high in deep ground strata. Calcium and Magnesium are also not causing any problem. Although magnesium values are reported higher in Bharuch district which may be due to sea water intrusion as a result of over exploitation of ground water and back tide effect of Narmada river.

13.6.13 Fluoride poses serious problem in ground waters at many places and is seperately discussed in Chapter 8. However, fluoride problem is more in Mehsana, Amreli, Sabarkantha, Bhavnagar and Kheda districts.

13.6.14 Salinity/ Brackishness is also a serious problem in the State due to many factors. This aspect is also discussed seperately in Chapter No. 7. Salinity is more in coastal, desert and arid semi-arid areas of State. Over exploitation of ground waters has aggrevated this problem rendering many sources non potable. Saurashtra - Kutch and North Gujarat regions are confronting the serious challenge of salinity.

13.6.15 Some areas which are under potential canal irrigation, show deterioration in ground water quality particularly TDS. e.g. Kheda district is getting Mahi canal facilities where gorund water (at Pij) show deterioration in ground water quality.

13.7 Water quality problems in Gujarat

Water quality problems of the State of Gujarat are discussed elaborately in separate Chapters in this thesis. However viewing them at a glance, the main problems could be summarised as under.

13.7.1 Salinity/ Brackishness

13.7.2 Fluoride

13.7.3 Nitrate

These problems are cropped up to some extent due to some natural factors and to a large extent due to the human induced activities.

The water supply authorities are seized of these problems and are finding it most difficult to provide safe and protect supply to the ever increasing needs.

The natural and human induced factors responsible for such situation could be explained as under :

Natural factors :

- Inadequate and uneven rainfall at many places.
- Sea water intrusion in coastal regions.
- Mineral deposits and rocky terrains

Human induced factors

- Exploding population ever increasing the demand for water.
- Reckless exploitation of ground water.
- Unscientific and excessive use of water for irrigation.
- Access of industrial and domestic wastes to water sources.
- Increasing use of chemicals (Pesticides) and fertilizers in agricultural practices.

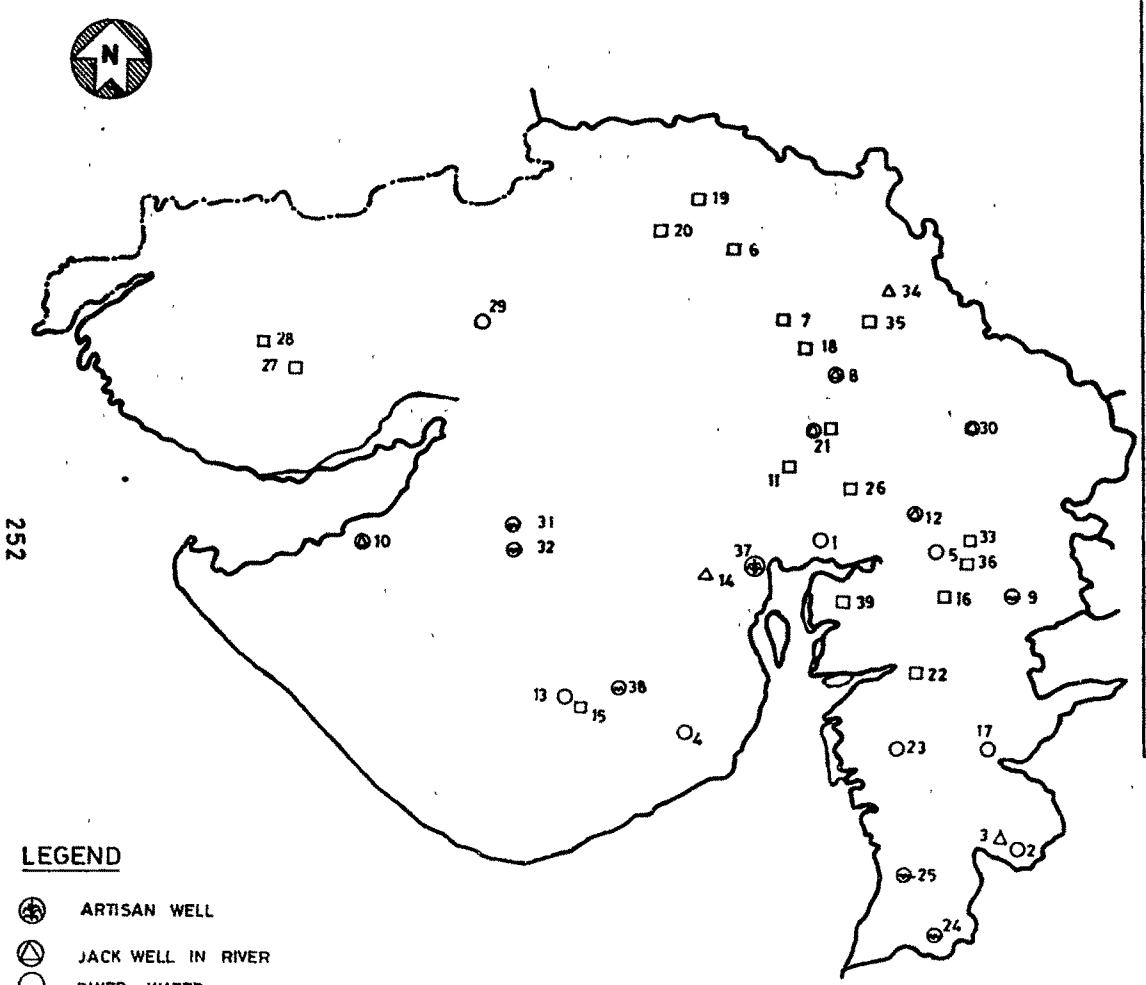
Industrial pollution

As is evident,Gujarat is the highly Industrialised State ranking first in the country which has got many problems of pollution of water resources due to discharge of Industrial effluents. Some of the incidences are narrated in Chapter - 10 "On Case Studies". However, a map showing areas which are affected by the discharge of such effluents is shown in **Annexure No. 13.3.**

Table-13.1 Details of Regional schemes for which samples are collected

Sr.No	Scheme	Head works location	Villages Covered
1	Santalpur Regional Water Supply Scheme	Shihori, Ta.Shihori, District Banaskantha	72
2	(Aad) Tharad Regional Water Supply schme	Akhol, Ta-Deesa, District Banaskantha	169
3	North Zone Bara Track Regional W/S. Scheme	Umara, Ta- Jambusar, District Bharuch	81
4	Central Zone Bara Track regional W/S. Scheme	Palej, Ta- and District Bharuch	99
5	South Zone Bara Track regional W/S. Scheme	Ankaleswar, Distrcit Bharuch	59
6	Milrampura Regional Water Supply Scheme	Valli, Ta-Khambhat, District Kheda	33
7	Banni Regional Water Supply Scheme	Khavda, Ta-Bhuj, Ditrict Kutch	45
8	Shivlakha Regional Water Supply Scheme	Shivlakha, Ta-Rapar, District Kutch	29
9	Kalubhar Regional Water Supply Scheme	Ranghola, Ta-Lathi, District Amreli	36
10	Sabarmati Water Supply (Ingoli) Scheme	Vataman, Ta-Dholka, District Ahmedabad	59
11	Gariadhar Regional Water Supply Scheme	Shetrunji Reservoir,Ta-Palitana,Dist. Bhavnagar	15
12	Dhadhodar Regional Water Supply Scheme	Barwala, Ta-Dhandhuka, District Ahmedabad	25

MAP OF GUJARAT SHOWING LOCATIONS OF SAMPLES COLLECTED



	STATION	TALUKA	DISTRICT
1	WALLI	KHAMBHAT	KHEDA
2	SAPUTARA	AHWA	DANGS
3	MALEGAO	AHWA	DANGS
4	SHETRUNJI H. W.	PALITANA	BHAVNAGAR
5	NIMETA H W.	VADODARA	VADODARA
6	JANGARAL	PATAN	MAHESANA
7	MAHESANA CITY	MAHESANA	MAHESANA
8	GANDHINAGAR CITY	GANDHINAGAR	GANDHINAGAR
9	KEVADIA COLONY	BHARUCH	BHARUCH
10	JAMNAGAR CITY	JAMNAGAR	JAMNAGAR
11	VATAMAN	DHOLKA	AHMEDABAD
12	BARODA CITY	BARODA	BARODA.
13	AMRELI CITY	AMRELI	AMRELI
14	BARWALA H. W.	DHANDHUKA	AHMEDABAD
15	VAGHANIA H. W.	LILIYA	AMRELI
16	PALEJ H. W.	BHARUCH	BHARUCH
17	UKAI DAM.	SONGADH	SURAT
18	KALOL CITY	KALOL	MAHESANA
19	AKHOL H.W.	DEESA	BANASKANTHA
20	SHIHORI H.W.	SHIHORI	BANASKANTHA
21	DUDHESHWAR H. W.	AHMEDABAD CITY	AHMEDABAD.
22	ANKLESHWAR H. W. (SZBT)	ANKLESHWAR	BHARUCH
23	VARACHHA H.W.	SURAT CITY	SURAT
24	DAMANGANGA RIVER	SILVASSA	DADARA-N'HAVELI
25	VALSAD CITY	VALSAD	VALSAD
26	PIJ TOWN	NADIAD	KHEDA
27	BHUJ CITY	BHUJ	KACHCHHA
28	BANNI H.W. (KHAVADA FATAK)	BHUJ	KACHCHHA
29	SHIVALAKHA H W (KUMBHARIA)	RAPAR	KACHCHHA
30	GODHRA CITY	GODHRA	PANCHMAHALS
31	RAJKOT CITY (NYARI ZONE)	RAJKOT	RAJKOT
32	RAJKOT CITY (AJI ZONE)	RAJKOT	RAJKOT
33	DABHOI CITY	DABHOI	VADODARA
34	IDAR TOWN	IDAR	SABARKANTHA
35	HIMATNAGAR CITY	HIMATNAGAR	SABARKANTHA
36	KAPURAI VILLAGE	DABHOI	VADODARA
37	DHOLERA ARTISEN WELL	DHANDHUKA	AHMEDABAD.
38	KALUBHAR H. W.	LATHI	AMRELI
39	UMRA H. W.	JAMBUSAR	BHARUCH

LEGEND

- ARTISAN WELL
- JACK WELL IN RIVER
- RIVER WATER
- SURFACE RESERVOIR / DAM
- DEEP WELL / TUBE WELL
- SHALLOW WELL

Annexure 13-1

Table 13·2 ANALYSIS RESULTS OF SAMPLES COLLECTED DURING STUDY WORK

Sample No.	1		2	3	4		5		6		7		8
Source	Raw water of pond at RWSS		Lake water at Saputara	Hand pump 120' Deep	Raw water from treatment plant site		Raw water		Tube-well water		Tube-well water		Mixed water of river & tube-wells
Location	Vill-Valli, Ta: Khambhat Dist: Kheda		Saputara Dist:-Dangs	Malegao Dist:-Dangs	Shetrunji Dam Dist:-Bhavnagar		Ajwa Lake Dist:-Baroda		Jangaral Ta:- Patan Dist:-Mehsana (N.G)		Mehsana City Dist:-Mehsana (N.G)		Gandhinagar (Capital)
Dt. of sample collection	19.7.87	24.3.88	7.8.87	7.8.87	31.7.87	23.2.88	22.8.87	18.5.89	28.8.87	6.3.88	28.8.87	6.3.88	4.9.87
Alkalinity ($CaCO_3$)	120	128	80	76	200	174	92	102	440	436	480	440	208
Boron (B)	0.045	0.12	0.015	0.135	0.33	0.27	0.06	--	0.6	0.81	0.82	0.79	0.21
Calcium (Ca^{+2})	8.8	24.8	16.8	12.6	27	26.4	14.4	16	38	22.08	102	49.9	37
Chloride (Cl)	38	24	16	46	110	70	20	76	432	464	574	510	60
COD	24	--	5.5	5	22	--	18	--	NIL	5.0	NIL	5.0	6
Colour	NIL	NIL	NIL	NIL	NIL	NIL	NIL	NIL	NIL	NIL	NIL	NIL	NIL
Conductivity	470	430	270	380	--	800	360	280	3300	3400	3900	3700	800
Cyanide	NIL	NIL	NIL	NIL	NIL	NIL	NIL	NIL	NIL	NIL	NIL	NIL	NIL
Fluoride $(F)^-$	0.62	0.48	0.16	0.16	1.12	0.38	1.12	0.74	1.04	0.97	0.62	0.52	0.92
Hardness$(CaCO_3)^-$	48	104	68	42	104	108	60	80	178	196	492	456	156
Iron $(Fe)^{+2}$	0.1	NIL	0.6	1.4	0.82	0.04	1.3	--	0.04	NIL	NIL	NIL	0.02
Magnesium(Mg)	6.24	10.8	6.24	1.44	9	10.08	5.8	10	20	--	56.6	--	15.4
Nitrate (NO_3^-)	4.4	NIL	2.2	6.7	17.7	NIL	5	44.3	33.2	30.7	65.4	52.9	1.6
Odour	NIL	NIL	NIL	NIL	NIL	NIL	NIL	NIL	NIL	NIL	NIL	NIL	NIL
pH	9.45	8.95	8.3	8.6	8.3	7.8	7.75	8.48	8.1	7.95	7.6	7.85	8.00
Phosphate$(PO_4^-)^3$	0.04	NIL	0.01	0.02	0.095	NIL	0 095	--	0.04	NIL	0.025	NIL	0.04
Potassium$(K)^+$	1	--	2	1.5	4	--	2	--	2	--	3	--	4
Silica $(SiO_2)^-$	20.4	34.5	27.5	36.5	18	18.0	4	--	36.5	36.5	46	48.0	27.5
Sodium $(Na)^+$	50	--	7	40	116	--	28	--	335	--	370	--	55
Sulphate $(SO_4)^{-2}$	7	NIL	10	18.5	63	8.0	38.4	17	88	73	87	131	36
TDS	178	--	88	150	410	--	116	154	1339	1448	1744	1601	323
Turbidity	3.5	25	2	3.5	415	30	348	--	--	4.0	--	0.4	--
Zinc$(Zn)^{+2}$	—	--	NIL	NIL	NIL	--	—	--	—	—	—	--	—
Remarks													

Sample No.	9		10	11		12		13	14		15	16		
Source	Narmada river water		Mixed water of dam reservoir & Tube-wells	Tube-well of ingoli W/S Scheme		French well in Mahi river		Tap water (Dhari Dam water)	ESR Water of Dhadhodar W/S Scheme		Bore Water	Head Works		
Location	Kevadia near Rajpipla Dist:-Bharuch		Jamnagar Dist:-Jamnagar	Ingoli Ta:-Dholka Dist:-Ahmedabad		Baroda		Amreli Dist:-Amreli	Barwala Dist: Ahmedabad		Vaghania, Ta:Liliya, Dist: Amreli	Palej, Dist: Bharuch		
Dt. of sample collection	8.9.87	29.2.88	11.9.87	12.9.87	19.3.88	12.9.87	4.5.89	6.10.87	6.10.87	23.2.88	6.10.87	15.10.87	22.3.88	7.4.88
Alkalinity ($CaCO_3$)	100	180	100	384	348	196	250	152	406	484	544	452	450	410
Boron (B)	0.06	0.06	0.12	0.985	0.79	0.15	--	0.15	0.395	0.54	1.46	0.55	0.515	--
Calcium (Ca^{+2})	29	26.4	27.2	62.4	7.4	27.2	26	42.4	9.6	12.8	36	64	61.6	59
Chloride (Cl)	20	14	24	636	586	40	48	54	58	110	396	454	440	454
COD	10	5.0	9	5	NIL	5	--	1	Nil	--	Nil	Nil	7.7	--
Colour	NIL	NIL	NIL	NIL	NIL	NIL	NIL	NIL	NIL	NIL	NIL	NIL	NIL	NIL
Conductivity	300	490	480	4700	4400	640	600	800	1350	2300	3700	3200	--	2800
Cyanide	NIL	NIL	NIL	NIL	NIL	NIL	NIL	NIL	NIL	NIL	NIL	NIL	NIL	NIL
Fluoride $(F)^-$	0.42	0.28	0.38	1.2	0.97	0.42	0.98	0.24	1.96	1.88	2.8	0.42	0.34	0.86
Hardness$(CaCO_3)^-$	88	146	92	396	406	144	148	160	48	82	168	576	578	554
Iron $(Fe)^{+2}$	0.1	NIL	NIL	0.02	NIL	NIL	--	NIL	NIL	0.04	NIL	NIL	NIL	--
Magnesium(Mg)	3.84	19.2	5.76	57.6	--	18.24	21	14	6	14.4	19	99.84	--	101
Nitrate (NO_3^-)	2.2	0.44	3.3	1.3	0.5	3.9	39.87	10	31	14.5	33.2	7.8	7.77	8.86
Odour	NIL	NIL	NIL	NIL	NIL	NIL	NIL	NIL	NIL	NIL	NIL	NIL	NIL	NIL
pH	7.7	8.45	7.1	7.85	8.25	7.9	8.20	7.7	8.65	8.25	8.25	7.75	--	8.03
Phosphate$(PO_4^-)^3$	0.04	0.054	0 025	0.04	--	0.025	--	Nil	0.03	0.09	0.0306	0.0612	--	--
Potassium$(K)^+$	2	--	2	3	--	2	--	2	1	--	1	3	--	--
Silica $(SiO_2)^-$	22.5	20.0	18.5	27.5	--	27.5	--	26	64	76.5	88	64	--	--
Sodium $(Na)^+$	11	--	34	590	--	42	--	40	225	--	600	256	--	--
Sulphate $(SO_4)^{-2}$	2	1.0	59	460	376	7	8	30	28.4	25.5	176	61.2	35	58
TDS	171	228	245	2256	2058	327	366	146	341	--	1636	1293	1297	1274
Turbidity	360	3.1	8	105	1.6	0.8	--	NIL	NIL	1	NIL	NIL	1.0	--
Zinc(Zn) $^{+2}$	--	--	--	--	NIL	--	--	--	--	--	--	0.32	--	--
Remarks														

Table 13.2 contd...

Sample No.	17		18	19		20		21	22		23	
Source	Ukai Dam		Tap Water - Tower Chock	Head Works		Tube wells on the bank of River Banas		Mixed water of Jack well in River Sabarmati	Sump water at Ankaleswar SZBT RWSS		Mixed water at tap in village varachha - Surat	
Location	Ukai Dam, Dist: Surat		Kalol, Ta: Kalol Dist: Mehsana (N.G.)	Akhol, Ta:Deesa Dist: Banas-kantha		Shihori, Dist: Banas-kantha		Dudheshwar Ahmedabad	Ankaleswar ESR, Dist: Bharuch		Municipal Head Works, Surat	
Dt. of sample collection	15.10.87	22.3.88	20.10.87	25.10.87	10.4.88	15.11.87	15.1.88	16.11.87	20.11.87	9.4.88	20.11.87	9.4.88
Alkalinity ($CaCO_3$)	114	132	598	232	170	270	264	340	330	332	282	292
Boron (B)	0.09	0.03	1.12	0.21	--	0.43	0.32	0.67	0.52	--	0.3	--
Calcium (Ca^{+2})	23.2	29.0	38.4	59.2	32	20	17.6	89.6	66.4	79	30.4	21
Chloride (Cl)	14	18	366	110	40	116	114	334	326	428	90	124
COD	10	2.2	NIL	NIL	--	NIL	5.0	NIL	NIL	--	NIL	--
Colour	NIL	NIL	NIL	NIL	NIL	NIL	NIL	NIL	NIL	NIL	NIL	NIL
Conductivity	360	--	3500	1200	--	1150	1150	2600	2800	--	1100	--
Cyanide	NIL	NIL	NIL	NIL	NIL	NIL	NIL	NIL	NIL	NIL	NIL	NIL
Fluoride $(F)^-$	0.28	0.24	1.84	0.92	0.34	1.8	1.66	1.0	0.675	0.5	0.72	0.5
Hardness($CaCO_3$)$^-$	96	126	210	230	204	96	100	260	410	476	182	154
Iron $(Fe)^{+2}$	NIL	NIL	0.1	NIL	--	NIL	0.01	0.027	NIL	--	NIL	--
Magnesium$(Mg)^{+2}$	9.12	--	27.36	20	--	11	--	15.8	58.56	--	25.44	--
Nitrate (NO_3^-)	NIL	2.22	63	22.2	0.5	6.65	3.77	16.05	3.544	2.2	3.566	5.25
Odour	NIL	NIL	NIL	NIL	NIL	NIL	NIL	NIL	NIL	NIL	NIL	NIL
pH	8.85	--	7.8	7.6	8.55	8.45	8.1	8.3	7.8	8.5	8.1	8.6
Phosphate(PO_4^-)^3	0.0306	--	NIL	0.046	--	0.027	0.06	0.126	0.023	--	0.1	--
Potassium$(K)^+$	2	--	1	3	--	1	1.0	4.5	4.5	--	2	--
Silica (SiO_2)$^-$	23.2	--	34.5	32	--	25.8	25	31.4	39	--	48.5	--
Sodium $(Na)^+$	20	--	460	93	--	182.5	200	265	222.5	--	100	--
Sulphate $(SO_4)^{-2}$	1.8	6.6	18.6	7.2	5.10	26.2	27	71.2	01.15	95	0.185	16.40
TDS	128	180	1476	484	251	518	528	1030	1109	1329	498	531
Turbidity	3.5	0.4	NIL	NIL	1.5	NIL	NIL	NIL	NIL	2	NIL	2.7
Zinc$(Zn)^{+2}$	NIL	--	NIL	NIL	--	NIL	--	NIL	--	--	--	--
Remarks		Not in use for Drinking purpose										

Table 13.2 contd.....

Sample No.	24	25		26		27	28	29	30	31	32
Source	Raw water of River Daman-Ganda-Nr. Naroli bridge at Silvassa	Tap water below ESR at Valsad in Kalyan-bag		ESR Water at Bore site (160' deep)		Tap water at water works B/H Banny G.H.	Tap water of Banny W/S Scheme (Bhuj) at Khavada Fatak	Mixed water of Shivalakha W/S Scheme	Mixed water from ESR at Godhara	Tap water from Rajkot Nyari zone supply	Tap water at Rajkot Aji Zone
Location	Silvassa (Dadra and N.H)	Municipal Supply Valsad		Pij, Ta: Nadiad Dist: Kheda		Bhuj City, Bhuj (Kutch)	Khavada Fatak Nr. Loria village Ta: Bhuj Dist:Kutch	Vi: Kumbharia Ta:Rapar Dist: Bhuj	Dist: Panchmahals	Rajkot City	Rajkot City
Dt. of sample collection	21.11.87	21.11.87	10.4.88	15.12.87	5.6.88	16.1.88	16.1.88	16.1.88	22.1.88	25.1.88	26.1.88
Alkalinity ($CaCO_3$)	90	42	170	684	628	202	206	238	186	148	134
Boron (B)	0.09	0.03	--	1.32	--	0.485	0.575	1.09	0.09	0.03	0.075
Calcium (Ca^{+2})	22.4	21.6	32	66	54	70.4	167.2	132	54.4	36.8	30.4
Chloride (Cl)	14	18	40	792	796	170	500	600	48	16	16
COD	9	NIL	--	NIL	NIL	22	52	9	9	9	9
Colour	NIL	NIL	NIL	NIL	NIL	NIL	NIL	NIL	NIL	NIL	NIL
Conductivity	320	360	--	5100	--	1390	3500	4100	760	480	490
Cyanide	NIL	NIL	NIL	NIL	NIL	NIL	NIL	NIL	NIL	NIL	NIL
Fluoride $(F)^-$	0.345	0.375	0.34	0.74	--	1.6	1.15	2.6	0.54	0.27	0.27
Hardness$(CaCO_3)^-$	84	86	204	518	528	310	716	760	202	138	120
Iron $(Fe)^{+2}$	0.24	0.02	--	0.02	0.04	NIL	NIL	NIL	NIL	0.06	NIL
Magnesium(Mg)	6.72	8.18	--	85	94	--	--	--	16.08	11.04	10.56
Nitrate (NO_3^-)	--	1.772	0.5	45.41	43.2	16.4	2.2	1.1	5.1	0.11	0.11
Odour	NIL	NIL	NIL	NIL	NIL	NIL	NIL	NIL	NIL	NIL	NIL
pH	8.0	7.5	8.55	7.9	--	7.65	7.75	8.1	7.8	7.65	7.65
Phosphate($PO_4^-)^3$	0.077	0.012	--	0.084	0.1224	0.06	0.03	0.12	0.12	0.03	0 06
Potassium$(K)^+$	1	1	--	11	1	4.0	14	24	7	1.5	2
Silica $(SiO_2)^-$	--	22.5	--	55	53	22.5	18	55	13.0	8.5	8.5
Sodium $(Na)^+$	7	9	--	690	750	126	355	395	48	32	38
Sulphate $(SO_4)^{-2}$	0.013	0.275	5.10	134	--	77	354	7.95	18	8	25
TDS	151	134	251	2366	2340	692	1820	2127	292	180	202
Turbidity	24	3	1.5	NIL	0.45	4.7	12	16	14	7	7
Zinc$(Zn)^{+2}$	--	--	--	--	--	--	--	--	--	--	--
Remarks											

Table 13-2 contd.....

Sample No.	33	34	35	36	37	38	39
Source	Tap water from Mun. Garden Nr. Rly. Crossing on Baroda Road Dabhoi	HP Water from a Pvt. House at Idar Town	Mixed water of TWs from ESR in Mun. Garden at Himatnagar Town	Public well water at Vi: Kapurai on Dabhoi Road	Artisen well at Dholera	Kalubhar Dam Intake Point	Mixed water of Umra HW
Location	Distt: Baroda	Dist: Sabar-kantha	Himatnagar	Ta & Dist: Baroda	P.O.:Dholera Ta: Dhandhuka		Jambusar Dist. Bharuch
Dt. of sample collection	29.2.88	31.1.88	31.1.88	29.2.88	19.3.88	19.3.88	13.5.89
Alkalinity($CaCO_3$)	352	152	238	518	130	132	--
Boron (B)	0.33	0.09	0.14	0.46	3.65	0.09	--
Calcium (Ca^{+2})	14.4	85.60	108.8	84.0	11.3	27.2	43
Chloride (Cl)	58	60	92	306	2590	12	370
COD	5.0	NIL	NIL	27.0	5	--	--
Colour	NIL	NIL	NIL	NIL	NIL	NIL	NIL
Conductivity	1170	920	1290	2500	9500	410	2700
Cyanide	NIL	NIL	NIL	NIL	NIL	NIL	NIL
Fluoride (F^{-})	0.67	2.32	0.48	0.53	0.20	0.2	1.12
Hardness($CaCO_3$)	92	270	356	574	418	108	310
Iron (Fe^{+2})	NIL	0.04	0.04	NIL	0.18	0.14	--
Magnesium(Mg)	13.44	13.2	20.04	87.36	--	9.6	50
Nitrate (NO_3^-)	4.4	84	99	2.2	NIL	NIL	8.86
Odour	NIL	NIL	NIL	NIL	NIL	NIL	NIL
pH	9.05	7.5	7.35	8.2	7.85	7.95	7.91
Phosphate(PO_4^-)^{3}	0.077	0.0612	0.0306	0.230	--	NIL	--
Potassium(K)$^{+}$	--	--	--	--	--	--	--
Silica (SiO_2)$^{-}$	36.5	--	--	41.0	--	13.5	--
Sodium (Na)$^{+}$	--	--	--	--	--	--	--
Sulphate $(SO_4)^{-2}$	15	--	--	27	8.5	0.75	54
TDS	520	515	726	1137	4848	--	1356
Turbidity	1.0	2	NIL	26	1.0	37	--
Zinc(Zn)$^{+2}$	--	--	--	--	NIL	--	--
Remarks							

Table 13.2 contd....