GUJARAT ENGINEERING RESEARCH INSTITUTE

NARMADA, WATER RESOURCES, WATER SUPPLY &

KALPASAR DEPARTMENT

HYDROLOGY PROJECT
(PDS FINAL REPORT)

MONITORING WATER QUALITY FLUCTUATION IN THE RIVER SABARMATI

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6.	**PROJECT TITLE**	**:**	Monitoring Water Quality Fluctuation in River Sabarmati
7.	**PERIOD OF THE PROJECT**	**:**	3 Years

Abbreviations

AMC	Ahmedabad Municipal Corporation
ASP	Activated Sludge Process
BOD	Biochemical Oxygen Demand
CETP	Common Effluent Treatment Plant
CGWB	Central Ground Water Board
CMIE	Centre for Monitoring India's Economy
COD	Chemical Oxygen Demand
CPCB	Central Pollution Control Board
CWC	Central Water Commission
DO	Dissolved Oxygen
FC	Fecal Coliform
GoI	Government of India
GERI	Gujarat Engineering Research Institute
GIDC	Gujarat Industrial Development Corporation
GPCB	Gujarat Pollution Control Board
GSWSSB	Gujarat State Water Supply and Sewerage Board
HIS	Hydrology Information System
HP-II	Hydrology Project Phase-II
IMD	Indian Meteorological Department
IRMA	Institute for Rural Management, Anand
KM	Kilometre
LPCD	Litre per Capita per Day
MCM	Million Cubic Meter
MGD	Million Gallons per day
MLD	Million Litres per day
MoEF	Ministry of Environment and Forest
NRCD	National River Conservation Directorate
NRCP	National River Conservation Plan
PDS	Purpose Driven Study
SRFDCL	Sabarmati River Front Development Corporation Ltd.
SS	Suspended Solids
SSI	Small Scale Industries
STP	Sewerage Treatment Plant
UNICEF	United Nation Children Fund
WASMO	Water and Sanitation Management Organization

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Executive Summary

The Sabarmati basin extends over an area of 21,674 sq km. Located in Western India, the basin covers areas in the states of Rajasthan and Gujarat. It raises in the Aravalli hills. The total length of the river from the head to its outfall into the sea is 371 km. The principal tributaries of the river are the Sei, the Wakal, the Harnav, the Hathmati, and the Vatrak and the Meshwa. The river Sabarmati and its tributaries are all rain-fed. The rainfall being fairly low in the basin, its water wealth potential is one of the lowest in India. The total domestic sewage generation from Class-I Cities & Class-II towns in the basin is estimated at 1088 MLD out of which Ahmedabad alone contribute about 824 MLD. Ahmedabad Municipal Corporation has established the sewage treatment capacity of about 980 MLD out of which 670 is functional and 310 MLD is under construction. Contribution of industrial sources is estimated at 110 MLD, out which Narol Industrial area itself contribute about 75 MLD. The treatment capacity of about 25 MLD is created through CETPs and remaining industrial effluent is being treated by the individual industries. A 27 KM long pipeline of 90 MLD Capacity was installed to transport the Naroda industrial area effluent to Pirana, which in the downstream of Ahmedabad City. Thus, the river in the city limit of Ahmedabad is not receiving industrial effluent from this industrial area.

Ahmedabad Municipal Corporation took several initiatives to restore Sabarmati River. One of the most ambitious initiatives was Sabarmati River Front Development. This include reclamation of the banks of the Sabarmati, making the entire stretch of river publicly accessible, public Ghats for direct access to the water, interception of all the wastewater outfalls into trunk sewer lines along both the banks of the river and transport them to Vasana sewage treatment plant. This gave a great relief to the river from pollution. Under the same programme Narmada water is released into Sabarmati to augment its flow. In order to assess impacts of all these initiatives the present study was implemented under Hydrology Project and a Purpose Driven Study (PDS). Samples were collected from 11 locations all along the river right from Dharoi Dam to Galiyana. Monthly samples were collected and analyzed in GERI's Gandhinagar Laboratory.

The river Sabarmati u/s of Ahmedabad city to Sabarmati Ashram and from Sabarmati Ashram to Vautha have been identified as polluted stretches under the proposed NRAP. The detailed survey of these stretches have been carried out and they have indicated that immense urban and industrial growth combined with growing demand of irrigation water have taken their toll as observed by the deteriorating water quality recorded particularly from Ahmedabad city to Vautha.

The total length of the stretch from Ahmedabad city to Vautha is of 52 km and in the polluted river stretch; the main contributing outfalls are the Maninagar (mixed effluent) and river Khari (industrial).

The results with respect to COD indicated that there is no definite trend due to these initiatives. This is attributed to intermittent and indefinite quantity of water released from the Narmada Escape due to availability variation. Moreover, the entire sewage is still not effectively collected and transported to the downstream all the time. This results in fluctuating trend of water quality in the river.

An attempt was made to use secondary data for trend studies. CPCB water quality data of last 20 years with respect to BOD was analyzed to see the trend. It was observed that there is no definite trend. The trend is highly fluctuating. This further strengthens the statement that the release of water for dilution is not regular, continuous, fixed and the polluting sources also are not effectively contained.

Chapter-1

Introduction

1.1 Background

Water resources management is on top priority on government's agenda in India. For rational planning and implementation of water resources management, water related information is pre-requisite. Hydrology Project-I (HP-I) was taken up to develop Hydrological Information System (HIS) by creating facilities and standardized procedures for data collection, data compilation, processing and data storage for data use in 9 peninsular states of the country including Gujarat. HP-I was implemented during the period 1995 to 2003. Under Gujarat State Narmada, Water Resources, Water supply & Kalpsar Department 4 groundwater and 3 surface water labs were established. A network of water quality monitoring was established comprising of 2042 groundwater sampling sites and 154 surface water sampling sites. Activities accomplished during HP-I were the establishment and improvement of Data Collection Network; Data entry, validation and storage system; Computerized data banks.

As an extension to the HP-I, HP-II was conceived to include more agencies in the Project to establish facilities for hydrology information system (HIS) and further strengthen the HP activities in HP-I agencies. Gujarat has been monitoring water quality for about 8-10 years now and has developed a good competence, skill and expertise in sampling, analysis, data handling and storage. In order to optimally utilize the facilities and competence developed, it was thought appropriate to carry out studies on some water quality problems in the HP States as "Purpose Driven Study" (PDS). In Gujarat three PDSs were conceived on water quality as follows:

1. Sabarmati River Study

2. Vishwamitri River Study

3. Hot spot study

1.2 Sabarmati River Study

Objectives:

1. To update the water quality data
2. To observe the effect of dilution on surface water quality due to Narmada River water discharge through Narmada main Canal at locations along River Sabarmati.

3. To study the influence of Sabarmati River on groundwater in terms of concentration of pollutants.

1.3 Sabarmati River Basin

The Sabarmati River Basin lies on the west coast of India between latitudes 22° N to 25° N and longitudes 71° E to 73° 30’ E, and is spread across the States of Rajasthan and Gujarat as shown in Figure 1.1. Sabarmati River originates from Dhebar lake at an altitude of 782 m in the Aravalli Hills in Udaipur District of Rajasthan State, and flows for a length of 371 km in a south-west direction, of which 48 km lie in the Rajasthan State and 323 km lie in the Gujarat State. The river empties into the Gulf of Cambay in the Arabian Sea. The Sabarmati River is one of the biggest rivers of north Gujarat. It is also one of the major West flowing rivers of Gujarat. The Sabarmati basin has a maximum length of 300 km. and maximum width of 105 km. The total catchment area of the basin is 21,674 km^2, out of which, 4,124 km^2 lies in Rajasthan State and the remaining 18,550 km^2 lies in Gujarat State. Sabarmati River Basin extends in Rajasthan over parts of Udaipur, Sirohi, Pali and Dungarpur Districts. Geographically, the western part of the Basin is marked by hilly terrain belonging to the Aravalli chain. East of the hills lies a narrow alluvial plain with a gentle eastward slope. The basin area in also roughly mark the western boundary of Udaipur District, i.e. Mount Abu area, and flows in a south-westerly direction.

The basin area of Sabarmati is covering the States of Rajasthan, Madhya Pradesh and Gujarat. The important urban centres in Gujarat are Gandhinagar, Mehsana, Visnagar, Himatnagar, Ahmadabad, Kheda, Anand, Dholka, Kalol, Unjha, Viramgam.

1.4 Tributaries

The Sabarmati River has six important tributaries. The principal tributaries of the river are the Sei, the Wankal, the Harnav, the Hathmati, the Watrak and the Meshwa as shown in Figure below. The Wankal and Sei also rise in the Aravalli hill range west of Udaipur city and flow south-westwards in courses generally parallel to the Sabarmati River.

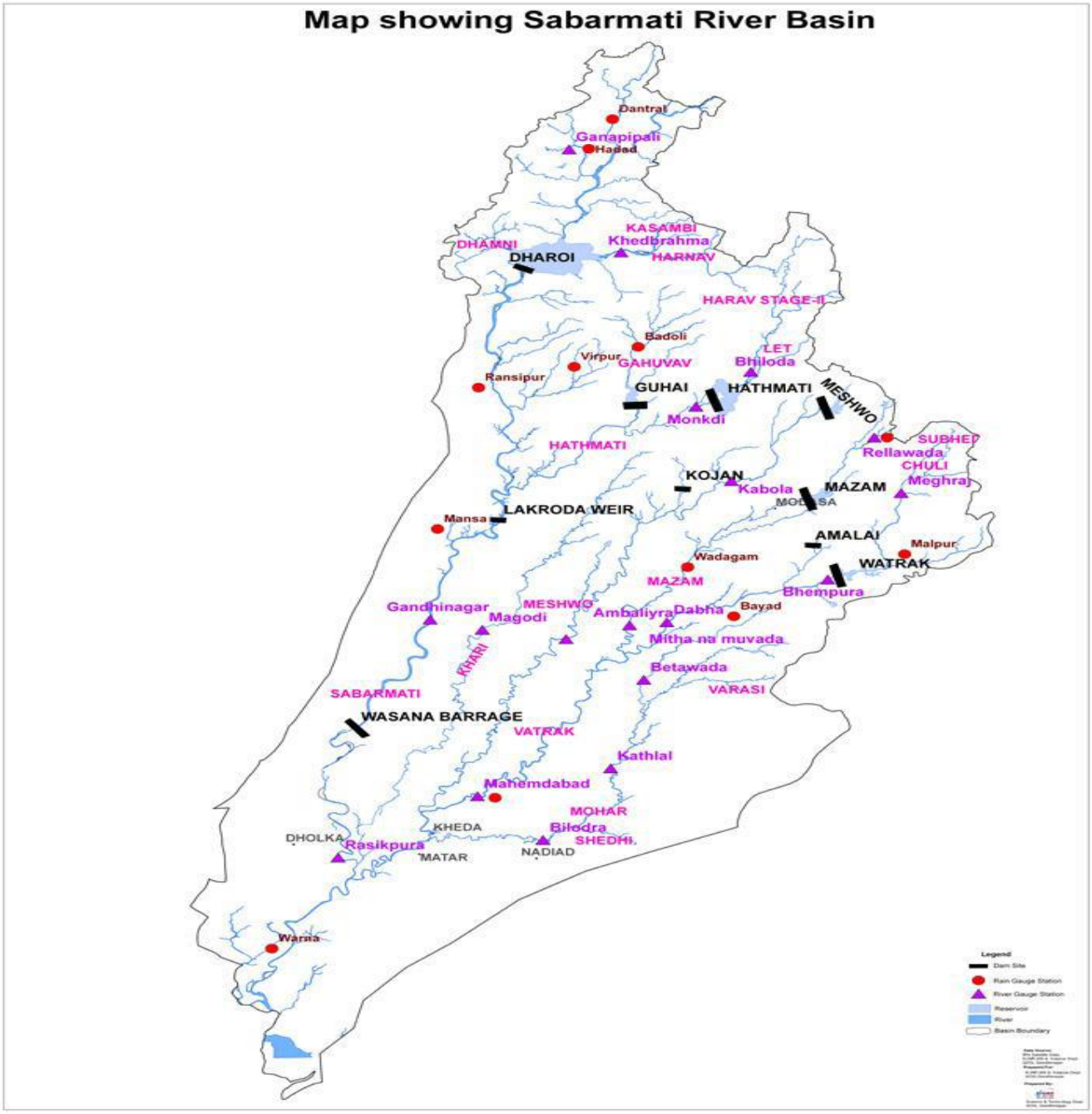

Figure 1.1: Sabarmati River Basin

1.5 Climate

The climate of Sabarmati River Basin is tropical monsoon climate. The average annual temperature varies between 25 and 27.5º C. The rainfall occurs almost entirely during the monsoon months. The average rainfall of the entire basin is 749 mm. The rate of evaporation is at its maximum during April to June due to a rise in temperature and increase in wind 10 speed.

The average annual evaporation losses in the basin are in the order of 1500-2000 mm. High co-efficient of variation of rainfall in the basin results to droughts in the basin. The rainfall variation in last 5 years at 4 IMD stations in the basin is shown in Figure below. The river is perennial in nature with three smaller sub-basins namely: Dharoi, Hathmati and Watrak. The average annual surface water resources of the basin in Gujarat have been estimated to be 3,256 million cubic meters (MCM), while the average recharge of the groundwater is estimated to be 2,570 MCM per year.

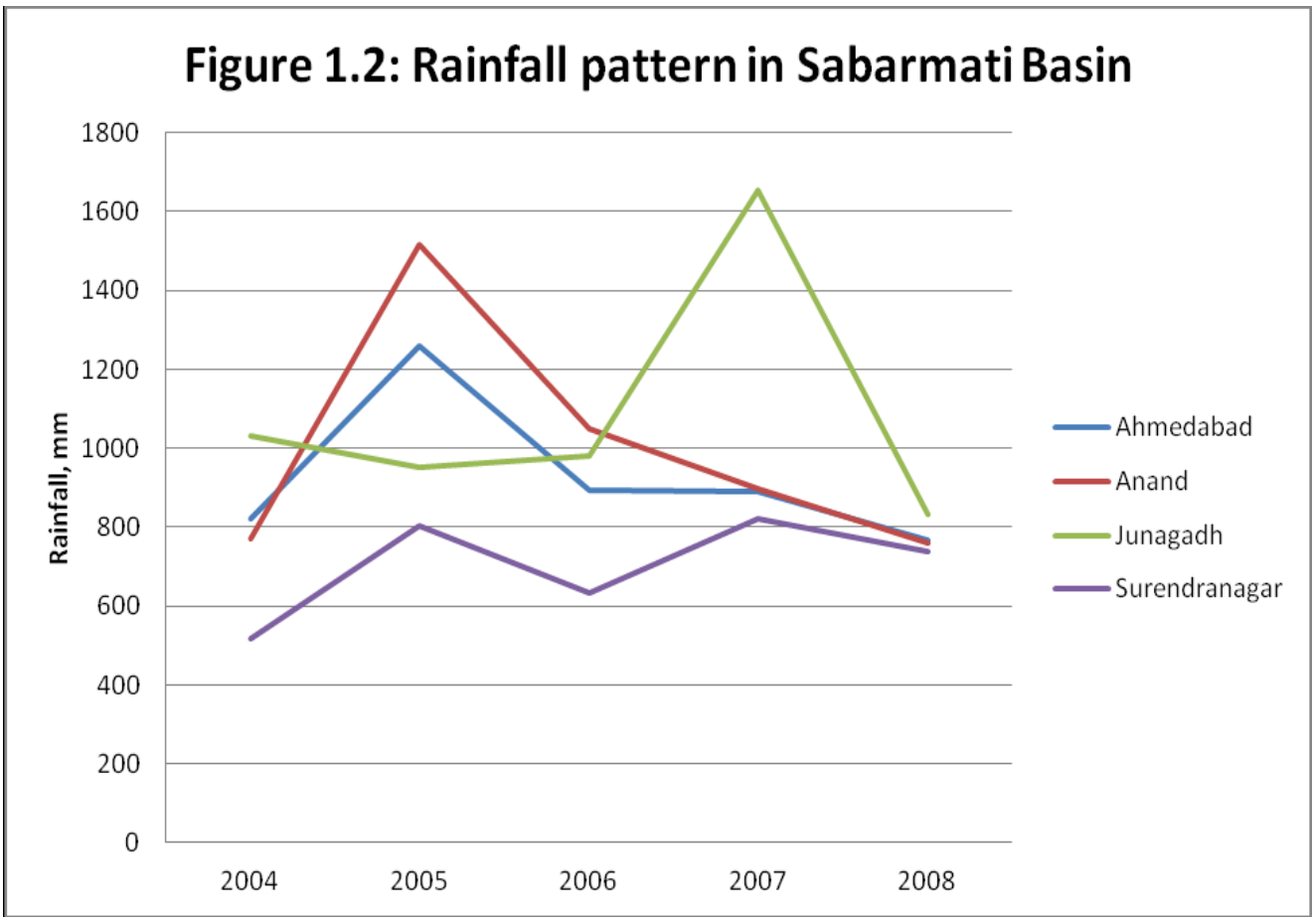

Figure 1.2: Rainfall pattern in Sabarmati River Basin

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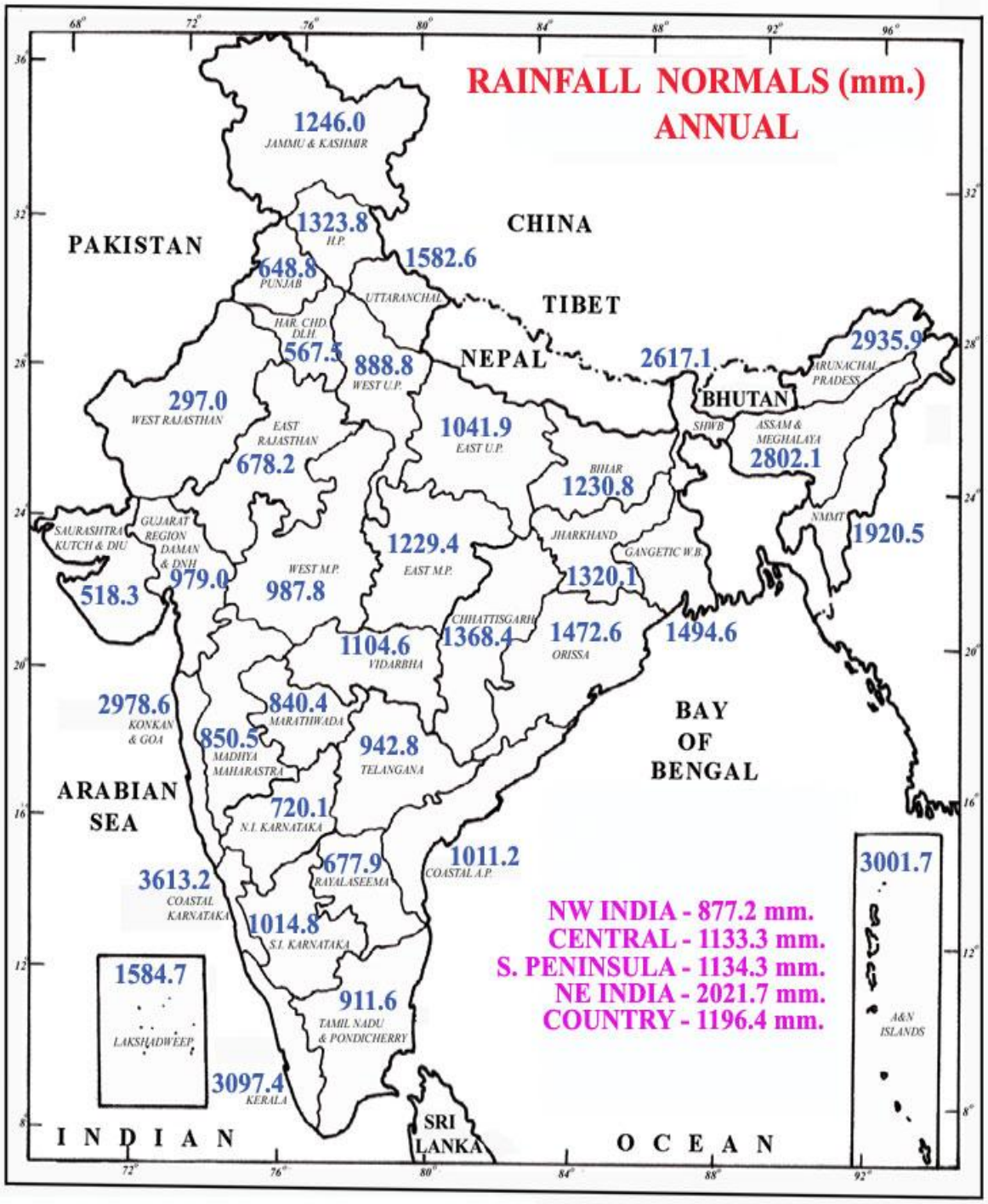
INDIA METEOROLOGICAL DEPARTMENT



1.6 Demography of Sabarmati Basin

In 2001, the basin's population was 11.75 million, of which 11.44 million in Gujarat. The per capita water availability in the basin is 324m3/person/year, which is the lowest in India. About 52 percent of the population in the basin is urban, all of which lives in Gujarat. Ahmedabad alone accounts for 74.2 percent of the basin's urban population and 35.7 percent of the basin's total population.

1.7 Economy of Sabarmati Basin

Agriculture accounts for 57 percent of the total geographic area of the basin. The cropping pattern shows a significant change over the years with commercial agriculture being predominantly practiced in areas close to the urban centers. Kharif and Rabi season are the main cultivation seasons; summer crop depends on the availability of irrigation facility in the area. About 19 percent of the land in the basin is not available for cultivation. This land is either naturally hostile to cultivation (barren, hilly, marshy, saline) or it has been developed (build up areas, roads, railways and other uses). Rest 24 percent is forest and pastures.

The region is witnessing industrial boom with water intensive industrial units coming up at rapid pace irrespective of the limited surface water supply. The basin supports a large diversity of industries comprising of both large and small scale textile industries followed by chemical industries, dairy and distilleries. In addition to these industries industrial estates developed by Gujarat Industrial Development Corporation (GIDC) have come in all urban centers in past two decades.

1.8 Water Use

1.8.1 Irrigation

Within the Gujarat portion of the basin, there are 11 major and medium irrigation projects, five diversion projects, and many minor projects. In addition to the irrigation projects, the basin characterizes significant inter-basin transfer through network of canals and reservoirs, which import water from the Narmada River and the Mahi River.

Several surface water projects are carried out in River Sabarmati. The existing surface water projects in Sabarmati River have facilitated the irrigation procedure to a great strength. There are only 47 minor irrigation projects in the Sabarmati River basin, along with some small irrigation systems, covering less than 20 ha, which are constructed and operated by Panchayat

Samities. Several surface water projects of River Sabarmati have facilitated irrigation in this basin. The ongoing water surface projects of the Sabarmati River include 15 minor irrigation projects with a total storage capacity of 15.4 Mm3, which are under construction in this Basin. An additional area of 3.2 kha will be irrigated on the completion of these projects. The upcoming water surface projects include 26 minor and three medium irrigation projects with one lift scheme. The total live storage capacity of this project is 180 Mm3, which have been proposed in this Basin. An additional area of about 19 kha will be irrigated after the completion of these schemes.

1.8.2 Domestic Use

In general, 85 percent of rural drinking water comes from groundwater; rest is supplied from basin's surface water. In the Sabarmati river basin's urban centers, the majority of current water demands are met through a combination of groundwater wells and surface water imports. About 85 percent of the basins' groundwater is used for irrigation, while 15 percent is used for industry and domestic purposes. Of 921 villages affected by poor groundwater quality in the basin, 58 percent are affected by fluoride, 23 percent by salinity, and 19 percent by nitrates.

1.9 Water Resources: Demand, Supply and Distribution

The water supply within Ahmedabad city limits is catered by Ahmedabad Municipal Corporation (AMC), which is dependent on both surface water and groundwater sources. The rural water requirements are mostly catered through a total of 404 regional water supply schemes, reaching to 4675 villages. Irrigation water for agriculture is supplied to the rural areas of the district mainly through the Fattewadi canal but this supply is always complemented with groundwater extraction from private and community bores present in the villages.

The water supply to Gandhinagar city is managed by the Gujarat State water Supply and Sewage Board (GSWSSB), Gandhinagar. The daily domestic water requirement of the city is 460 LPCD. This water requirement is jointly met by surface water and groundwater supplies but the dependence on groundwater in the area is very high, 76% of the water use is from bore-wells (1999). As regard to agriculture, the cropping intensity is 116% with groundwater being the only source of irrigation in the district.

1.10 Ground Water

With a groundwater development of 92.6% Ahmedabad district falls in the “dark” category as per the Central Groundwater Board (CGWB). The gross groundwater draft of the district is 701.7 MCM with gross annual withdrawal exceeding 90% of utilizable annual recharge (UNICEF/IRMA, 2000). Water quality is highly deteriorated. The groundwater drawn for domestic water supply to the urban residential area has high TDS level exceeding the permissible limit of 2000ppm in almost all areas (Moench et al 2003). Besides this out of 360 villages of the district, 359 are affected by fluoride, 34 with nitrate and 83 with salinity problem (WASMO, 2003)

Gandhinagar district falls in the over-exploited category as per the CGWB classification for groundwater development. The gross groundwater draft is 130.35 MCM/ year resulting in declining groundwater levels and it faces a water deficit of 41.09 MCM/year (CGWB 1997). The depleting water table also has an adverse effect on the water quality. Out of 168 villages in Gandhinagar district 132 villages are affected by fluoride, 32 with nitrate and 9 with the problem of salinity (WASMO, 2003)

The urban- rural mix that is evident in desakota areas result in unique stresses on ecosystem services. As the area has to support industries along with agriculture and domestic, the existent water resources of the area have to be shared with new user – industry. On the other hand, these industries are also contributing to large scale deterioration of the water quality in the area as they usually dispose their waste water in existing surface or ground water. Deterioration in water quality inflicts a chain of events adversely impacting the health of the entire ecosystem. A direct consequence of deterioration of water quality is land degradation, reducing its productivity. Urban influence and accessibility to technology further add on to the stress on the water resource in the area. Technologies like bore-wells and pumps are making, even the otherwise inaccessible water resource accessible to people thus, resulting in water mining in the region.

This water resource use scenario in the area of interest, clearly presents the enormous pressure that exists over the resource. As water becomes scarce and technology is growing the access to the resource has become a function of capital power, resulting in inequitable use of water. This has an important implication on the social system and is a potential source of conflicts between various resource users.

Besides these, another aspect which remains mostly untouched is the requirement of water by nature, the natural flow of water required for the sustenance of the ecosystem is often

compromised for meeting human water requirements. This practice has serious long term implications which might lead to total lapse of the ecosystem.

The Study was carried out by GERI. The study was carried out during 2009-2011.

1.11 Sources of Pollution

Sabarmati River is seriously affected by discharge of untreated and partially treated wastewater from domestic and industrial sources located all along its bank and banks of its tributaries. The river is one of the most polluted rivers in the country although it is the life line of the State of Gujarat. Intensive agricultural practices coupled with intensive withdrawal of water for cropping had left the river absolutely dry in most of the upper segment.

The river Sabarmati U/s of Ahmedabad city to Sabarmati Ashram and from Sabarmati Ashram to Vautha has been identified as polluted. The immense urban and industrial growth combined with growing demand of irrigation water has taken their toll as observed by the deteriorating water quality recorded particularly from Ahmedabad city to Vautha. The total length of the stretch from Ahmedabad city to Vautha is about 52 km, which is heavily polluted; the main contributing outfalls are the Maninagar (mixed effluent) and river Khari (industrial).

The quantity of wastewater generated from industrial and domestic sources is presented in figure below. As clear from figure, the industrial wastewater is about 12% of the wastewater is contributed from industrial sources, while about 88% is contributed from domestic sources. Apart from this a large amount of wastewater is contributed from non-point sources. The details of these sources are provided in the next section.

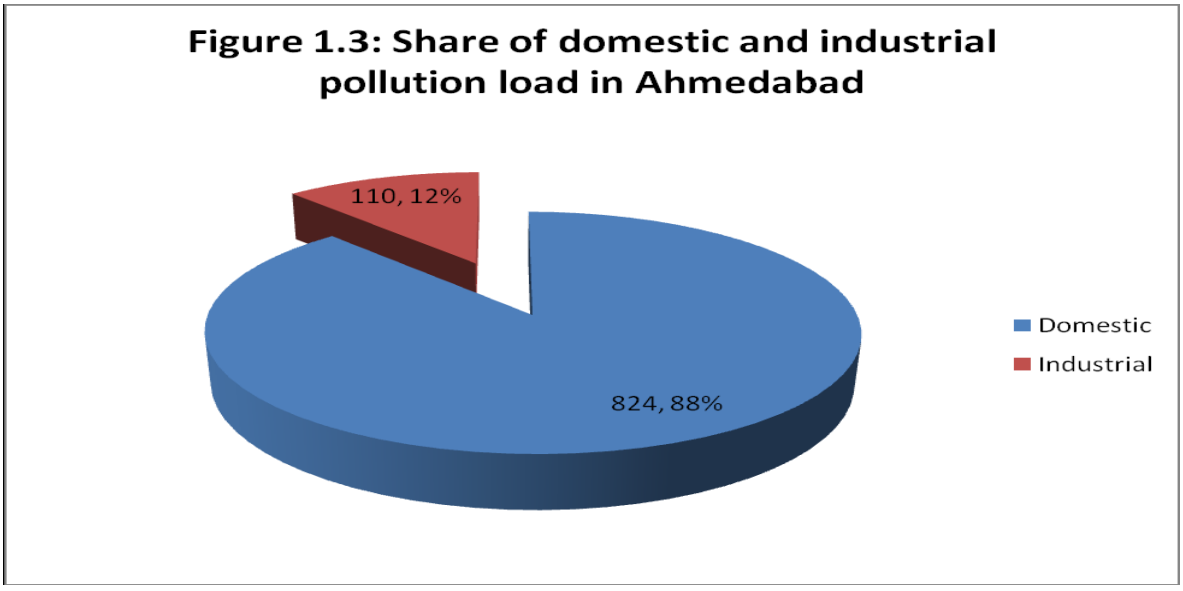


Figure 1.3Share of pollution load in Ahmedabad

1.11.1 Domestic Sewage

As reported by CPCB (CPCB 2009), there are 13 class-I cities and class-II towns in the basin. The wastewater and solid wastes generated from these urban centres are presented in the table below. As clear from table, Ahmedabad generates more than 80% of pollution loads in terms of sewage and municipal solid wastes. Ahmedabad Municipal Corporation has created sewage treatment capacity of about 980 MLD out of which 670 MLD capacities is operational and 310 MLD is under construction (GPCB, 2010). Thus, part of sewage still is not fully treated. It is also observed that the Ahmedabad city is not fully sewered and hence part of sewage flows in storm water drains ultimately leading to Sabarmati River. In a recent move to restore Sabarmati, Govt of Gujarat took several initiatives. These initiatives are explained in detail in the flowing paragraph.

Table 1.1: Pollution load generation from Class-I Cities & Class-II Towns of Sabarmati River Basin

Major towns/cities in Sabarmati Basin	Population, 2001	Projected Population, 2011	WW as per CPCB	MSW as per CPCB	Projected WW, 2011	Projected MSW, 2011
Naidiad	132799	225132	10	20	17.0	33.9
Gandhinagar	195891	208299	43.5	30	46.3	31.9
Junagarh	168686	320250	7.6	13	14.4	24.7
Ahmedabad	3515361	5570585	520	1683	824.0	2667.0
Surendranagar	156417	253620	41.4	7	67.1	11.4
Gandhidham	151693	248705	8.4	20	13.8	32.8
Anand	130462	286921	14.4	25	31.7	55.0
Dholka	53792	61569	3.6	9	4.1	10.3
Himatnagar	58267	66528	2.63	12	3.0	13.7
Kalol	24689	112126	10.8	15	49.0	68.1
Unjha	53868	61617	3.4	7	3.9	8.0
Viramgam	53095	61210	6.3	19	7.3	21.9
Visnagar	65826	73688	4.8	17	5.4	19.0
	4760846	**7550250**	**676.8**	**1877.0**	**1086.9**	**2997.6**

1.11.2 Industrial Wastes

Large numbers of industrial units are located in Ahmedabad. About 85% of the large and 87% of medium scale units of the basin is located in Ahmedabad. Besides this, thousands of small scale industries (SSI) are engaged in diversified products mostly concentrated in various industrial estates like Naroda, Odhav, Vatva and Chandola etc. All these industries are discharging their waste waters D/s of Sabarmati Ashram whereas M/s AECO, thermal power plant is discharging U/s of Sabarmati Ashram.

The lower part of the basin has become a haven for industries and GIDC has encouraged a new genre of small and medium industries many of them being engineering and chemical units generating significant water pollution. The textile industry continues to dominate the industrial scene in Ahmedabad. In the recent times about 100 km long 30 km wide Gandhinagar-Vadodara belt is a prosperous and fast developing urban industrial area.

As per the CMIE data, there are 314 working factories in Ahmedabad district, which employs 18219 persons (2000-01). Number of registered SSI units in the district is 6591 (2202-03). Similarly, Gandhinagar district have 203 working factories employing 12914 persons (2000-01). Number of registered SSI units in the district is 61185.

It is estimated that about 110 MLD of wastewater is generated from Ahmedabad industrial sources (GPCB Report, 2010). There are 9 Common Effluent treatment Plants having capacity of 25 MLD. The details of these treatment plants are provided in the next section.

1.11.3 Diffuse Pollution

The nature and magnitude of diffuse pollution in Sabarmati basin is diverse. Due to the prevailing situation in the basin, quantification of the diffuse pollution is extremely difficult. For the sake of understanding the nature and magnitude of diffuse pollution, a brief description on various sources and their nature is explained below. For a proper understanding of the nature and the magnitude of diffuse water-pollution under different circumstances, it would be necessary to consider some source-related characteristics, briefly discussed below for diffuse pollution from some more common sources.

-Pollution from Small Rural Villages:

Almost as a rule these would not have running water supply nor sewered sanitation. In many areas in the basin most people would use open field for defecation, with a few using pit-

latrines or septic-tanks. Much of the bathing and washing (clothes, utensils etc.) shall be in or near the water-body reducing abstraction and transport of water but causing in-situ diffuse pollution. Generation of liquid effluents would be minimal and all wastewater generated shall soak into the nearby land. One would be tempted to say that such habitats would cause no water pollution. And yet a careful materials-balance as also field experience would show significant quantities of various types of pollutants including salts, nutrients, organics and micro-organisms from such hamlets and rural areas reaching ground or surface water bodies through leachate and as washings in the storm run-offs.

-Wastewaters and Pollutants from Un-sewered Towns:

For improving standards of life, running water- supply has been established in most of the towns and even in some villages over the past three decades in the Sabarmati Basin. This has, in turn, led to flush- latrines and much large use of water in homes for bathing, washing of clothes utensils etc, generating significant amounts of wastewaters. Use of soaps and detergents and amounts of various food materials going to the sink have also grown with improved life standards. Unfortunately, sewerage or improved sanitation is not adequately addressed. Hence sewerage has lagged far behind water supply. A large part of the population in the basin either does not have any sewerage system or the sewerage system is inadequate, overloaded or defunct. All this resulted in large amount of wastewater uncollected leading to storm water drains and ultimately to the river. The bulk of pollution shall get retained on land to percolate, leach or get washed-off.

-Industrial Pollutants from Cottage/ Small Scale Industries:

Encouragement of cottage and small-scale industries through subsidies, market-preferences or other benefits has been an important component of economic development programmes of India particularly Gujarat in the past. These units, in general, neither have nor can afford appropriate sanitation and/ or pollutant disposal systems, and yet have not been hesitant in adopting highly polluting production technologies such as chrome-tanning of leather, use of azo-dyes in fabrics, use of cadmium in ornaments and silver-ware, electroplating with cyanide baths, production of dye-intermediates and other refractory and toxic chemicals etc. Their solid wastes and sludge's get scattered-around or dumped in unlined pits and effluents flow to streams through storm-drains or stagnate in depressions to percolate, leach or get washed-off during next rainy season. This is the story of many industrial areas & urban centers in the Sabarmati Basin resulting in generation of large quantity of diffuse pollution.

-Industrial Pollutants from Large Industries:

While industries might claim to have installed costly treatment and disposal plants, these also often cause leakages and wash-over from storage yards, waste dumping, ash-ponds, sludge-pits etc. And treated effluents, having at least some pollutants, are getting leached or washed to streams as diffuse pollution. While any number of examples could be cited, oily wastes present in the storm-water drains in the city of Ahmedabad, Gandhinagar, Anand, Kalol are enough to prove such contribution.

-Pollutants due to Leakages and Escaping due to Accidents during Transportation, Storage or Handling:

With increasing storage, handling and transport of various chemicals, including those highly toxic and/ or hazardous, the contribution of these has been growing. Accidents involving mineral oils, acids, chlorine, ammonia etc are very well known in the industrial areas around Ahmedabad.

-Effluents, Leachates and Wash-over from Cattle-farms and Animal Husbandry:

Cattle-farms in the Sabarmati basin rarely have adequate arrangements for collection, treatment and proper disposal of their solid and liquid wastes. Such wastes are properly collected and used in rural areas, but in most of the urban areas this kind of wastes are flushed into the drains leading to increased pollution load.

-Pollutants in Agricultural Drainage Waters:

Drainage waters from irrigated agricultural land are always high in salts, since they also have to carry the salts originally contained in the trans-evaporated fraction of the irrigation water. Intensive and ever- increasing usage of chemical fertilizers, pesticides, weedicides and other chemicals is adding a new facet to such pollution, though the problem in this respect may yet be at a lower stage than in developed countries.

-Deposition of Air- Pollutants:

Atmospheric pollutants may deposit directly on surface waters. Also the pollutants depositing on vegetation and soils may get leached or washed- over to water bodies.

1.12 Initiatives for Sabarmati River Restoration

Looking to the poor conditions of the Sabarmati River, Govt of Gujarat took several initiatives to restore this river. Some of the important initiatives are as follows:

1.12.1 River Front Development

One of the most ambitious and unique plan taken up by the Municipal Corporation of Ahmedabad during mid-nineties was Sabarmati River Front Development. The Sabarmati Riverfront Development Project is an environmental improvement, social uplift and urban rejuvenation project to restore Sabarmati River and renew Ahmedabad. The project is being implemented by the Sabarmati Riverfront Development Corporation Ltd. (SRFDCL), a company wholly owned by the Ahmedabad Municipal Corporation. Looking to the grim situation of water quality in the river Sabarmati, Govt of Gujarat took several initiatives to restore the river. The Ahmedabad Municipal Corporation conceived a project on Sabarmati Riverfront Development and established Sabarmati River Front Development Corporation Limited (SRFDCL) in May 1997 to implement it.

The important activities under Sabarmati River Front Development include innovative solutions to the challenges of managing a river in a rapidly growing urban metropolis. Solutions include laying interceptor sewer lines along the length of the river and building pumping stations to capture previously untreated sewage and preventing waste water disposal in the Sabarmati. The Riverfront Development reclaims the banks of the Sabarmati, making the entire stretch of river publicly accessible. The project provides more than ten kilometres of uninterrupted pedestrian promenade on each bank and public ghats for direct access to the water.

SRFDCL's intention to cash in on the new perennial status of the Sabarmati by keeping water in the course throughout the year in the 10.5 km city stretch also caused apprehensions. The river used to be seasonal, retaining water for two to three months. According to the environment impact assessment report, maintaining a water depth of 1 m at Subhash Bridge will require a continuous flow of 108 to 140 mld from October to June. Accordingly, surplus water in the Narmada main canal is being diverted to ensure this. This has resulted in improving water quality of the river to a large extent.

The project is expected to reclaim approximately 200 hectares of land from the riverbed. To reclaim the land, protect low lying developments from floods, and to prevent erosion of the river banks, retaining walls have been built on both sides of the river. Since Sabarmati is a seasonal river, water is channeled into the river from Narmada canal, which intersects the river upstream from Ahmedabad and is retained in the river using the Vasana Barrage which is located downstream. To prevent untreated sewage flowing into the river, two sewage interceptor lines

with new pumping stations have been constructed along both the reclaimed banks. These lines carry untreated sewage to the augmented sewage treatment plants south of Vasna Barrage. Slum dwellers living on the riverbed, and affected by the project, are being rehabilitated. The reclaimed land will make Ahmedabad's riverfront, a public asset. For better access to the riverfront and facilities built along it, a number of streets leading up to the river are being strengthened. Many more will be added so that people can easily walk up to the river. The project is expected to provide Ahmedabad with 11.5 km long pedestrian promenades at the water's edge along both the banks of the river. In addition to the promenade, many new parks and gardens are proposed to be built on the reclaimed land. Many new public facilities are proposed to be built on the reclaimed land: cultural centers, museums, sports facilities, trade fair grounds and open air markets. The project has won Prime Minister's National Award for Excellence in Urban Planning and Design in the year of 2003.

1.12.2 Sewage Treatment

As per the estimation Ahmedabad generates about 824 MLD of domestic wastewater. The existing sewage treatment capacity is about 670 MLD as per Gujarat PCB Report and an additional capacity of 310 MLD is being created. The details of these sewage treatment plants are provided in the table below.

Table 1.2: Capacity of Sewage Treatment Plants in Ahmedabad City

Sr .No.	Name of Sewage Treatment Plant	Capacity, MLD	Operational Status
1	Old Pirana STP near Behrampura	16	Operational
2	Old Vasna STP, Narol-Sarkhej Highway	126	Operational
3	New Pirana STP, Narol-Sarkhej Highway	182	Operational
4	New Vasna STP, Narol-Sarkhej Highway	76	Operational
5	East Zone AUDA STP at Vinzol	70	Under Construction?
6	West Zone AUDA STP at Gyaspur	240	Under Construction?
7	New Pirana STP Narol-Sarkhej Highway	180	Operational
Total:	**Seven**	**980**	

The performance of these treatment plants is regularly monitored by GPCB. The results indicated that the performance has gradually improved over last 3 years (GPCB, 2010).

1.12.3 Industrial Wastewater Treatment

There are about 9 industrial areas in Ahmedabad and about 1240 industries are located in these industrial areas. However, there are two large industrial areas generating significant amount of wastewater. The details of these industrial areas are provided in Table 4.The major industrial effluents are contributed from two large industrial areas i.e. Narol and Vatva. The quantity of industrial effluents generated from these industrial areas is presented in Table 1.3.

Table 1.3 Wastewater generated from large industrial areas in Ahmedabad

Sr.No.	Name of Industrial Area	Number of industries	Volume of wastewater generated, MLD
1	GSIDC Vatva Industrial Estate	682	18.2
2	GSIDC Narol Industrial Estate	224	75
Total:			**93.2**

Gujarat Pollution Control Board, which is responsible for regulating pollution in the State, took several measures to contain pollution of Sabarmati. All the large and medium industries were asked to put up effluent treatment plants and comply with the national standards. The small scale industries were asked to install common effluent treatment plant (CETP). Under these initiatives 9 CETPs were installed in the Sabarmati Basin. The details of these CETPs are provided in table below.

Table 1.5: Common Effluent Treatment Plants in Sabarmati Basin

Sr. No.	Name of Common Effluent Treatment Plant	Number of Members	Capacity, MLD
1	The Green Environ. Services Society Ltd, Vatva, Ahmedabad	518	16
2	Odhav Environ. Proj. Ltd, Odhav, Ahmedabad	60	1.2
3	Gujarat Vepari Maha Mandal Udhyog Vasahat Ltd, Odhav, Ahmedabad	357	1
4	Odhav Green Environ Projects Association, Odhav, Ahmedabad	3	1

5	Naroda Environment Projects Ltd, Naroda, Ahmedabad	242	3
6	Narol Dyestuff Environ Society, Narol, Ahmedabad	12	0.1
7	Sanad Eco Projects Ltd, Ahmedabad	16	0.2
8	Balva Eco Projects Ltd, Ahmedabad	12	1
9	Vinayak Jal Sudhikaran Cooperatives Ltd, Ahmedabad	20	1.5
		1240	**25**

1.12.4 Flow Augmentation through Narmada Water

Sabarmati River has been one of the most polluted rivers in the country due to highest biochemical oxygen demand (BOD) values observed in the country under National Water Quality Monitoring Programme of Central Pollution Control Board. It was on August 28, 2002, the river showed some hope of clean water, when Narmada water started to flowing in it. The merriment was made possible by the diversion of water to Sabarmati from the overflowing Narmada dam, 225 km away, a few days ago. The spectacle was reminiscent of a promise made by two water quality experts -Dr K.L. Rao and Captain Dastur-over three decades ago.

They had proposed to link India's major rivers, from the Brahmaputra, Ganga and Yamuna to the Krishna, Narmada and Godavari, through a network of canals. It was supposed to be their answer to the twin menace of droughts and floods, and would meet the country's economic needs through water conservation. Rao's project was called "Water Grid" while Dastur's "The Garland Canal System". Unfortunately, prohibitive costs of implementation rendered both the schemes unfeasible.

The release of water from Narmada to Sabarmati not only changed the quality of Sabarmati water but has drastically changed life of the people in the downstream. Just how Narmada has changed the scene is evident in the Fattewadi canal command area in Ahmedabad district.

All the above initiatives led to lots of improvement in Sabarmati River water quality. It was thought important to study the impacts of such initiatives and hence the present study was conceived.

The present study aimed at studying the impact of Narmada water release on water quality of Sabarmati River. The details of methodologies and findings are presented in the following sections.

Chapter 2

Methodology:

In order to fulfill the preset objective as mentioned in the previous chapter, the study was carefully designed to achieve the objectives. An inventory was carried out on the basin activities, including population, water use, urbanization, industrialization, wastewater generation, treatment and disposal, information on basin activities, industrialization, pollution load generation, treatment and disposal, solid waste generation, collection, treatment and disposal. Information was also collected on different initiatives taken by the Govt of Gujarat to restore the Sabarmati River. All important activities initiated are summarized in this report. Since this study was planned for limited duration it was thought appropriate to collect the information on water quality monitoring carried out by other agencies like CPCB/GPCB. The data generated during last 20 years were collected and summarized in this report. The monitoring programme was designed as explained below:

2.1 The Monitoring Programme:

- Objectives of the Study:
- It was a surveillance programme planned for Sabarmati River, which is heavily polluted in the vicinity of Ahmedabad city. The study was planned to get the better understanding on water quality fluctuations due to Narmada water released into the Sabarmati River.
- Monitoring network:

2.2 Sampling Locations:

Surface Water Locations

1. Dharoi Dam (Reservoir)
2. Sabarmati River at Sapteshwar
3. Sabarmati River at Derol
4. Sabarmati River at Sanpad
5. Sabarmati River at Lakroda
6. Sabarmati River at Chiloda
7. Sabarmati River at Narmada Escape
8. Sabarmati River at d/s Vasana Barrage

9. Sabarmati River at Bakrol
10. Sabarmati River at Vautha
11. Sabarmati River at Galiyana

2.3 Selection of Sampling Locations:

To fulfill the objectives and considering all important water use points (use of river water & surrounding ground water), natural and manmade operations (vegetation, farming, agriculture, cattle & industrial activities etc.), joining of river tributaries & effluent discharge point due to industrial development, locations of river gauging stations, locations of weirs and barrages across the river following eleven Surface Water locations are selected. So the sample can be a true representative of river water.

The sampling locations on the River Sabarmati were selected also on the basis of the need to fulfill the set objectives of the study based on potential of water quality impacts due to pollution and pollution load contributed by the drains and impact of Narmada water input.

Easily accessible sites with road connectivity were the main consideration for site selection. There are many disturbing influences in the river, especially cattle wading, melon farming, fishing, sand recovery etc. These can drastically influence the chemical processes and the water quality. It was tried to avoid such influences in the samples.

Considering all the above points and issues the number of sampling locations are justified as it can fulfill the objectives.

The sampling locations of the Sabarmati along with major outfalls of drains are depicted in Figure below.

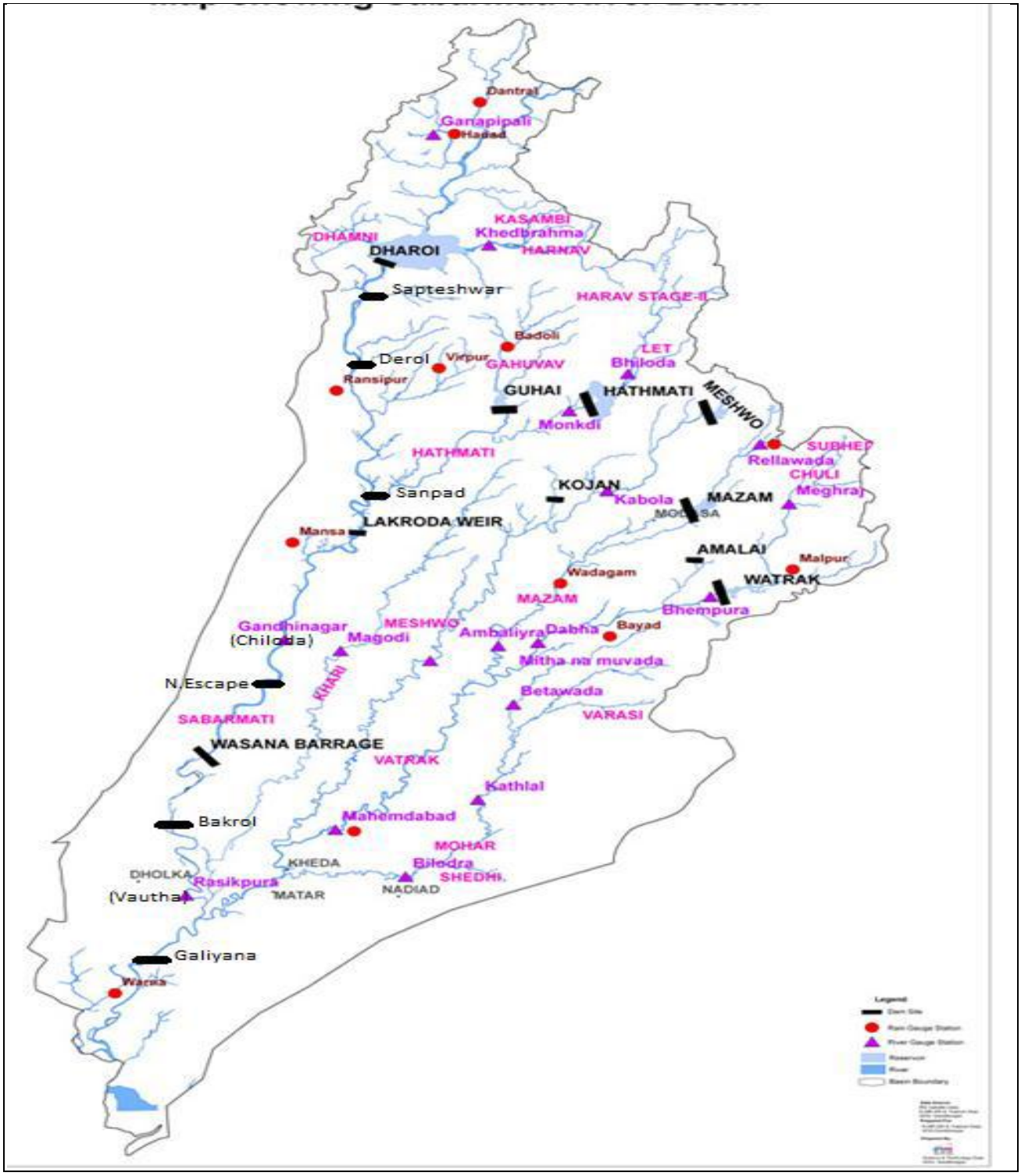


Figure 2.1 Map of Sabarmati Basin showing sampling locations

1. Dharoi Dam (Reservoir):

The Dharoi Dam is the most important structure of the Sabarmati basin. It is located on Sabarmati River near village Dharoi in Kheralu taluka of Mahsana district, 103 km from the source of the river. The latitude and longitude of the dam are 24° 00' N and 72° 52' E, respectively. Their purposes are water supply to the cities of Ahmedabad and Gandhinagar, Irrigation, flood control and power generation. The Catchment area of the river at the Dam site is 5,540 sq. km. The dam was completed in the year 1976. The dead storage and live storage capacity of the reservoir (revised) are 131.99 and 775.89 MCM, respectively. The dam is also one of the tourist spots in the state. The water is also used for irrigation. This location provides baseline water quality information for the study. The Sabarmati River is diverted at this point into the Canal for irrigation and drinking purpose leaving no water in the downstream to flow. Only some seepage flows beyond this barrage in the river. Hence a sampling location was selected in the reservoir itself.

2. Sabarmati River at Sapteshwar:

About 11 km. downstream of Dharoi Dam a Sapteshwar Mahadev Temple is located. The water flowing at this location is not the original flow of the river Sabarmati but is brought to the river through ground water accrual and tributaries contribution. Sampling at this location reflects the water quality before receiving the waste water discharges at Ahmedabad City. During monsoon period the river receives several tributaries and land wash through run-off. The impact of such contribution can be studied at this location.

3. Sabarmati River at Derol:

This station is located on Sabarmati River at about 16 km. downstream of Sapteshwar near Derol village. This location helps in assessing the impact of small tributaries. The water quality at this location reflects the impact of agricultural and rural activities including cattle run-off.

4. Sabarmati River at Sanpad:

This station is located on Sabarmati River at about 26 km. downstream of Derol village near Sanpad village. The water quality at this location reflects the impact of tributaries like Hathmati River joining after Derol village and rural activities including cattle and agricultural run-off.

5. Sabarmati River at Lakroda:

This station is located just 8 km. downstream of Sanpad near Lakroda village. A weir is constructed at this location for water storage for agriculture. The water quality of this location reflects the impact of rural activities including cattle and agriculture.

6. Sabarmati river at Chiloda:

This station is located at about 30 Km. downstream near Chiloda village on Sabarmati River. This station is important to know the water quality of Sabarmati River before Narmada water is released in it.

7. Sabarmati at Narmada Escape:

This station is located about 8 km. downstream of Chiloda village on Sabarmati River after Narmada Escape joins the river. This station helps in evaluating the impact of Narmada Water on river Sabarmati. This station also helps in assessing the water quality of the Sabarmati River before entering in the vicinity of Ahmedabad City.

8. Sabarmati at D/s of Vasana Barrage:

This station is located on Sabarmati River about 20 Km. downstream of Narmada Escape confluence. The water quality of this station will help in assessing the impact of waste water discharge in the vicinity of the Ahmedabad City.

9. Sabarmati at Bakrol:

This station is located on Sabarmati River at about 20 Km downstream of Vasana Barrage. The Water quality of this station will help in assessing the impact of all the outfalls after Vasana Barrage and also diversion of water of the river in Fattewadi Canal.

10.Sabarmati at Vautha:

This Station is located on Sabarmati River at about 20 Km downstream of Bakrol near village Vautha. The water quality of this station will help in assessing the impact of discharges from the sewage treatment plants and also the urban waste water generated in the downstream.

11.Sabarmati at Galiyana:

This station is located on Sabarmati River at about 50 Km. downstream of Vautha. The Water quality observations of this station will help in assessing the self purification capacity of the river during travel time from Vautha to Galiyana.

About 20 Km. after this location the river empties into the Gulf of Cambay near village Mitli covering a distance of about 220 Km. from Dharoi Dam. So the overall length of the river under study would be around 200 Km.

(DHAROI RESERVOIR)

Ground Water Locations:

Since Gujarat is a low rainfall zone large stretches of the river are dry almost the whole year round. Almost all open wells have gone dry or have been abandoned. The river remains mainly dry except for the few days of monsoon. During the monitoring programme it was observed that the river bed remained dry till Karai village where Narmada River water is being discharged through the escape. Water can be seen in Sabarmati River only after Narmada River water is discharged through the escape. Hence to study the influence of the River on ground water following nine bore-well locations on either side of the river and along the river stretch from Karai to Vautha Village are selected for collection of samples.

Karai, Nabhoi and Bhat locations are situated before the Narmada Water enter Ahmedabad City and water from these bore-wells is mainly used for irrigation purpose.

From Gayatri Temple location to Vasana Swaminarayan Temple location water is being used for drinking by all castes of society. It is being used for house hold work by rich and poor, by schools & colleges, by shopping mall owners, marriage halls and small scale industries etc.

The Vautha location bore-well in particular is affected mainly due to underground recharge process by polluted river water due to chemical, dyes and paper, pharmaceutical and steel industries in and around Ahmedabad City. The list of Ground Water location is given below:

Sr. No.	Name of Location
1	Karai Village (Near Left bank of the river near N. Escape)
2	Nabhoi (Near Right bank of the river near N. Escape)
3	Bhat Village
4	Gayatri Temple
5	Sabarmati Ashram
6	Near R.B.I. Ahmedabad
7	Bhavan's College
8	Swaminarayan Temple Vasana
9	At Vautha (Near surface water location)

2.4 Preparation for Sampling

At least one day before sampling, it was made sure that all the arrangements are made as per the check list. It was also made sure to know how to reach sampling site(s). Help of maps and landmarks was extensively taken before ensuring proper location. For each sampling location,

depending on the pre-decided sampling procedure the sampling check-list was prepared and accordingly the preparation was done. It was always safer to carry a few numbers in excess.

2.5 Sampling Procedure

The objective of sampling is to collect a portion of water from the water body small enough in volume to be conveniently transported and handled in the laboratory, while still accurately retaining its representatively. This implies that the relative proportions or concentrations of the components of interest should be the same in the samples when they are being analyzed, as they were originally in the river or drain. This requires that the sample will be handled and, if necessary, treated in such a way that no significant changes in composition occur that may hamper proper analysis. In other words, no addition (e.g. contamination), loss (e.g. adsorption to the wall of the sample bottle) or deterioration (e.g. physico-chemical or biological degradation or transformation) can be allowed.

2.6 Grab Samples

Grab river water samples were collected from the well mixed zone at all the river locations at an appropriate depth. Grab samples were also collected from the drain locations before their merger with river or canal. Details of sampling planned and samples actually collected are shown in the in table below:

Table: Table showing samples actually planned & No. Of samples collected

Sr. No.	Particulars	No. of Samples Planned	No. of Samples collected	Parameters tested
1.	Surface Water (River Water Samples)	132	110	Conductivity, pH, TDS/TS, Sodium, Potassium, Calcium, Magnesium, Carbonate, Bi-Carbonate, Chloride, Sulphate, Turbidity, DO, COD, BOD, Phosphate, Nitrates, Boron, Fluoride, Ammo. Nitrogen
2.	Ground Water (Bore-Well Water Samples)	108	108	

2.7 Field Measurements:

Some determinants are more likely to be affected by sampling and sample storage than others. In several cases the expected changes are so large, that it is impossible to store the sampled material for a correct analysis at a later moment. If possible, these parameters should be analyzed on the sampling site or, even better, in-situ. Most important parameters that should (and can) be analyzed in situ are the pH, dissolved oxygen, temperature, conductivity and sometimes turbidity. For several measurements special portable measuring devices are available. But considering the seasonal issues, it was decided to carry out all the testing parameters at the laboratory only, so as to attain the uniformity.

Sample for dissolved oxygen was collected in a pre-cleaned/sterilized BOD bottle and DO was fixed with Manganous Sulphate and sodium Azide solution on the spot for further analysis in the Laboratory.

2.8 Preservation and Transport of Samples to the Labs

With respect to preservation, samples are taken to perform analysis on two types of parameters: for some parameters such as, BOD, Nitrates, Ammonia the samples have to be cooled without adding any preservative. Thus Ice preservation is ideal. The samples for these parameters were immediately preserved in ice box. The samples for DO were preserved by fixing it with Manganous Sulphate and Sodium Azide. The samples for ammonia and COD were preserved by adding Sulphuric Acid as preservative.

However, the samples for analysis of parameters like BOD cannot be preserved for longer and need to reach the laboratory shortly after taking the sample. The need to transport the samples to the laboratory will govern the range of determinations which can be carried out for a particular sampling site. Travel time greater than 24 hours between the site and laboratory was avoided.

2.9 Analytical Methods

The samples were analysed in GERI, Gandhinagar & Vadodara laboratories. The samples were analysed following the Standard Methods (APHA, 2005). All precautions were taken to ensure the quality of data. The methods of analysis chosen are presented in Table below:

Table 2.1: Methodologies adopted in analysis of water samples

Sr. No.	Parameter	Analytical Method
1.	Conductivity	Conductometric method
2.	pH	Potentiometric/Electrometric method
3.	TDS	Gravimetric calculation method
4.	Sodium & Potassium	Flame photometric method
5.	Calcium & Magnesium	EDTA Titrimetric method
6.	Carbonate & Bi-carbonates	Volumetric Titration method
7.	Chlorine	Volumetric Titration ($AgNO_3$) method
8.	Sulphates & Nitrates	U.V/Vis Spectro-photometric method
9.	Turbidity	Nephelometric method
10.	DO	Winkler Azide Titrimetric method
11.	COD	Open Reflux method
12.	BOD	Bottle Incubation method
13.	Phosphate	Molybdate Colorimetric method
14.	Fluoride	Ion Meter method
15.	Boron	Curcumine Colorimetric method
16.	Ammonical Nitrogen	U.V/Vis Spectro-photometric method

DATA ANALYSIS OF SURFACE WATER

Sabarmati River

Location : Dharoi

Sr. No.	Month	General				Nutrient		Organic matter		Major Ions									Other Inorganic		Turbidity_NTU
		E.C. ms/cm	TSS mg/l	TDS mg/l	pH	NH_3-N mg/l	PO_4 mg/l	DO mg/l	COD mg/l	SO_4 mg/l	Na mg/l	CL mg/l	Ca mg/l	Mg mg/l	K mg/l	NO_3-N mg/l	CO_3 mg/l	HCO_3 mg/l	B mg/l	F mg/l	
1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22
1	Jan-09	435	26	252	8.2	0.02	0.05	6.5	7.5	15.2	30.9	42.6	12.0	21.9	2.5	0.63	3.0	122.0	0.09	0.03	15.0
2	Mar-09	568	30	330	8.4	0.03	0.07	7.0	9.0	20.7	29.1	42.6	20.0	17.0	2.1	1.29	9.0	97.6	0.18	0.16	12.0
3	May-09	545	18	310	8.1	0.03	0.02	6.8	8.5	10.1	3.9	7.1	12.0	17.0	0.5	0.90	12.0	61.0	0.11	0.15	10.5
4	Jul-09	478	18	280	7.4	0.02	0.07	7.9	8.0	10.3	38.3	56.8	16.0	21.9	3.3	0.26	6.0	122.0	0.07	0.12	13.0
5	Sep-09	398	18	224	8.5	0.01	0.07	7.2	4.5	5.7	18.5	35.5	24.0	24.3	2.6	0.40	0.0	168.0	0.07	0.00	10.0
6	Nov-09	370	18	211	7.7	0.01	0.56	6.7	4.5	4.8	11.1	21.3	32.0	7.3	0.7	0.40	0.0	101.0	0.05	0.13	11.0
7	Jan-10	363	25	204	8.4	0.00	0.74	6.5	7.0	12.1	22.5	35.5	16.0	26.7	5.8	0.40	0.0	146.4	0.05	0.19	5.5
8	Mar-10	424	16	242	8.4	0.02	0.03	8.8	9.5	3.3	26.5	42.6	20.0	14.6	3.5	0.58	0.0	100.7	0.07	0.18	6.5
9	May-10	414	16	240	8.1	0.02	0.02	6.8	7.0	16.7	22.9	35.5	12.0	14.6	3.6	0.85	0.0	82.4	0.13	0.16	7.0
10	Jul-10	334	14	194	7.8	0.00	0.26	7.0	0.0	2.1	18.1	28.4	24.0	12.2	3.4	0.62	0.0	115.9	0.09	0.11	14.0
11	Sep-10	394	19	222	7.3	0.01	0.62	13.5	6.5	14.6	17.9	28.4	20.0	12.2	0.8	0.28	3.0	73.2	0.05	0.12	12.0
12	Nov-10	414	19	232	7.5	0.02	0.22	7.2	6.5	14.3	23.8	35.5	16.0	21.9	2.7	1.02	3.0	122.0	0.07	0.20	10.0

Sabarmati River

Location : Sapteshwar

Sr. No.	Month	General				Nutrient		Organic matter		Major Ions									Other Inorganic		Turbidity_NTU
		E.C. ms/cm	TSS mg/l	TDS mg/l	pH	NH_3-N mg/l	PO_4 mg/l	DO mg/l	COD mg/l	SO_4 mg/l	Na mg/l	CL mg/l	Ca mg/l	Mg mg/l	K mg/l	NO_3-N mg/l	CO_3 mg/l	HCO_3 mg/l	B mg/l	F mg/l	
1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22
1	Jan-09	990	45	585	7.1	0.05	0.09	7.5	5.5	28.8	82.7	142.0	20.0	24.3	3.9	1.10	6.0	91.5	0.09	0.25	15.0
2	Mar-09	967	55	560	8.5	0.04	0.11	7.5	6.0	24.8	68.9	107.0	20.0	38.9	3.0	3.20	12.0	176.9	0.01	0.21	12.5
3	May-09	1080	40	635	8.3	0.07	0.04	6.0	7.5	19.5	113.0	178.0	24.0	48.6	1.2	2.00	24.0	198.3	0.06	0.29	11.0
4	Jul-09	436	13	245	7.4	0.00	0.00	8.0	5.0	10.5	30.5	42.6	16.0	17.0	4.5	5.70	6.0	97.6	0.05	0.03	23.0
5	Sep-09	742	28	426	8.2	0.05	0.08	6.5	6.5	14.4	48.9	71.0	28.0	24.3	3.4	0.20	0.0	180.0	0.09	0.14	10.5
6	Nov-09	866	35	503	7.7	0.05	0.20	7.5	6.5	13.7	67.3	92.3	24.0	31.6	0.8	0.00	0.0	180.0	0.07	0.39	12.0
7	Jan-10	787	34	465	8.3	0.03	0.89	7.2	6.5	9.9	113.1	163.3	12.0	34.0	3.0	2.10	0.0	170.8	0.09	0.43	6.0
8	Mar-10																				
9	May-10																				
10	Jul-10	514	23	304	8.1	0.00	0.62	7.4	6.0	1.7	27.0	42.6	32.0	14.6	3.3	3.60	0.0	134.2	0.11	0.45	6.0
11	Sep-10	786	29	456	7.9	0.03	0.12	10.6	7.0	26.9	50.4	71.0	20.0	34.0	0.7	2.80	12.0	155.6	0.13	0.22	7.0
12	Nov-10	825	28	470	7.6	0.04	0.00	7.4	7.0	28.1	69.8	120.7	16.0	46.2	1.7	2.50	3.0	183.0	0.11	0.34	10.5

Note: Blank row indicates no sample collection due to dead water.

Sabarmati River

Location : Derol

Sr. No.	Month	General				Nutrient		Organic matter		Major Ions									Other Inorganic		Turbidity_NTU
		E.C. ms/cm	TSS mg/l	TDS mg/l	pH	NH_3-N mg/l	PO_4 mg/l	DO mg/l	COD mg/l	SO_4 mg/l	Na mg/l	CL mg/l	Ca mg/l	Mg mg/l	K mg/l	NO_3-N mg/l	CO_3 mg/l	HCO_3 mg/l	B mg/l	F mg/l	
1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22
1	Jan-09	688	35	406	8.2	0.04	0.03	7.5	6.8	23.2	58.3	85.2	24.0	26.8	3.7	1.20	9.0	153.0	0.07	0.13	12.0
2	Mar-09	924	49	540	8.4	0.05	0.03	7.5	7.5	30.5	61.3	92.3	24.0	29.2	4.2	1.30	0.0	177.0	0.06	0.39	11.0
3	May-09																				
4	Jul-09	221	7	122	7.3	0.00	0.30	9.0	1.0	13.0	10.6	14.2	12.0	12.2	4.0	2.80	3.0	73.2	0.00	0.09	42.0
5	Sep-09	669	21	390	8.1	0.03	0.60	6.8	6.5	16.4	41.6	71.0	36.0	24.3	3.5	0.30	0.0	177.0	0.03	0.15	10.0
6	Nov-09	627	24	364	8.1	0.03	0.65	6.9	6.5	14.5	43.0	63.9	20.0	26.7	1.3	0.00	0.0	156.0	0.05	0.15	10.5
7	Jan-10																				
8	Mar-10																				
9	May-10																				
10	Jul-10	501	19	288	7.8	0.04	0.00	9.8	6.0	1.7	26.0	35.5	24.0	19.4	3.6	2.30	0.0	140.3	0.14	0.16	5.5
11	Sep-10	654	25	375	7.9	0.05	0.09	9.6	6.5	24.6	43.3	56.8	28.0	19.4	0.1	3.00	12.0	122.0	0.09	0.17	8.0
12	Nov-10																				

Note: Blank row indicates no sample collection due to dead water.

Sabarmati River

Location : Sanpad

Sr. No.	Month	General				Nutrient		Organic matter		Major Ions									Other Inorganic		Turbidity_NTU
		E.C. ms/cm	TSS mg/l	TDS mg/l	pH	NH_3-N mg/l	PO_4 mg/l	DO mg/l	COD mg/l	SO_4 mg/l	Na mg/l	CL mg/l	Ca mg/l	Mg mg/l	K mg/l	NO_3.N mg/l	CO_3 mg/l	HCO_3 mg/l	B mg/l	F mg/l	
	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22
1	Jan-09	756	36	446	7.8	0.06	0.54	8.0	7.5	29.5	39.2	63.7	16.0	29.2	2.3	14.97	9.0	107.0	0.07	0.12	10.0
2	Mar-09	869	45	515	8.4	0.08	0.59	7.0	8.0	33.8	39.6	56.8	44.0	29.2	2.0	9.85	15.0	183.0	0.06	0.23	10.0
3	May-09	819	25	480	7.5	0.07	0.55	6.5	7.5	22.9	37.9	71.0	20.0	31.6	3.4	0.41	9.0	134.0	0.06	0.11	11.0
4	Jul-09	275	9	152	7.7	0.00	0.00	8.5	1.0	27.6	27.3	35.5	12.0	12.2	4.2	0.00	6.0	54.9	0.03	0.14	80.0
5	Sep-09	662	20	382	8.3	0.03	0.23	6.7	5.8	18.0	43.9	63.9	32.0	17.0	3.6	0.00	0.0	159.0	0.00	0.17	10.0
6	Nov-09	759	29	448	7.9	0.04	0.89	6.2	6.2	16.6	33.8	56.8	48.0	36.5	0.6	0.94	0.0	256.0	0.08	0.14	10.0
7	Jan-10	610	29	354	8.3	0.05	0.79	7.6	6.5	27.8	37.2	56.8	20.0	29.2	3.0	3.45	0.0	131.2	0.07	0.15	6.0
8	Mar-10																				
9	May-10																				
10	Jul-10	320	12	182	7.6	0.00	0.04	6.4	1.0	4.5	7.6	14.2	24.0	12.5	6.2	7.33	0.0	109.8	0.09	0.15	34.0
11	Sep-10																				
12	Nov-10																				

Note: Blank row indicates no sample collection due to dead water.

Sabarmati River

Location : Lakroda

Sr. No.	Month	General				Nutrient		Organic matter		Major Ions									Other Inorganic		Turbidity_NTU
		E.C. ms/cm	TSS mg/l	TDS mg/l	pH	NH_3-N mg/l	PO_4 mg/l	DO mg/l	COD mg/l	SO_4 mg/l	Na mg/l	CL mg/l	Ca mg/l	Mg mg/l	K mg/l	NO_3.N mg/l	CO_3 mg/l	HCO_3 mg/l	B mg/l	F mg/l	
1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22
1	Jan-09	779	38	460	8.2	0.05	0.09	7.0	7.0	23.4	75.2	142.0	20.0	33.8	3.6	3.10	6.0	125.0	0.07	0.25	13.0
2	Mar-09	1140	58	685	8.5	0.07	0.91	7.0	8.5	25.7	94.0	135.0	24.0	31.6	7.7	0.90	12.0	183.0	0.07	0.21	10.0
3	May-09	1280	42	765	7.8	0.07	0.85	7.0	8.0	21.1	91.8	128.0	16.0	46.2	2.1	0.50	18.0	183.0	0.07	0.34	12.5
4	Jul-09	192	7	106	7.0	0.00	0.00	7.9	1.0	12.9	9.1	14.2	12.0	7.3	3.8	0.00	0.0	48.8	0.00	0.09	32.0
5	Sep-09	651	16	375	8.4	0.04	0.05	6.1	4.0	19.3	44.3	63.9	32.0	17.0	3.5	0.90	0.0	153.0	0.02	0.19	12.0
6	Nov-09	934	38	552	7.9	0.05	0.94	6.5	5.5	19.9	68.3	100.0	40.0	41.3	1.1	0.90	0.0	278.0	0.10	0.45	11.5
7	Jan-10	896	35	538	8.5	0.05	1.06	7.5	7.0	22.5	85.9	142.0	20.0	36.5	3.7	3.50	0.0	173.9	0.11	0.34	6.5
8	Mar-10	1530	65	900	8.3	0.07	0.00	6.5	9.0	25.1	110.5	170.4	12.0	38.9	3.5	1.50	0.0	183.0	0.13	0.24	6.5
9	May-10																				
10	Jul-10	474	17	266	8.4	0.02	0.82	8.6	1.0	11.3	19.2	28.4	32.0	14.6	2.5	4.70	0.0	131.2	0.08	0.39	9.0
11	Sep-10	836	31	494	8.0	0.05	0.13	7.8	6.0	30.6	59.3	92.3	36.0	26.7	6.0	6.90	12.0	158.6	0.17	0.77	7.4
12	Nov-10	1010	34	586	7.7	0.07	0.02	10.0	6.5	19.1	109.0	156.2	20.0	55.9	2.0	12.00	15.0	213.5	0.11	0.55	9.5

Note: Blank row indicates no sample collection due to dead water.

Sabarmati River

Location : Chiloda Bridge (Near Pethapur)

Sr. No.	Month	General				Nutrient		Organic matter		Major Ions									Other Inorganic		Turbidity_NTU
		E.C. ms/cm	TSS mg/l	TDS mg/l	pH	NH_3-N mg/l	PO_4 mg/l	DO mg/l	COD mg/l	SO_4 mg/l	Na mg/l	CL mg/l	Ca mg/l	Mg mg/l	K mg/l	NO_3-N mg/l	CO_3 mg/l	HCO_3 mg/l	B mg/l	F mg/l	
1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22
1	Jan-09																				
2	Mar-09																				
3	May-09																				
4	Jul-09																				
5	Sep-09	323	12	185	8.5	0.03	0.17	7.1	3.5	8.5	15.5	28.4	20.0	12.2	2.8	0.40	0.0	97.6	0.02	0.25	12.0
6	Nov-09																				
7	Jan-10																				
8	Mar-10																				
9	May-10																				
10	Jul-10	373	15	210	8.5	0.03	0.26	10.2	4.0	15.8	16.7	28.4	20.0	12.2	2.6	0.33	0.0	91.5	0.02	0.34	6.0
11	Sep-10																				
12	Nov-10																				

Note: Blank row indicates no sample collection due to dead water.

Sabarmati River

Location : Narmada Escape

Sr. No.	Month	General				Nutrient		Organic matter		Major Ions									Other Inorganic		Turbidity_NTU
		E.C. ms/cm	TSS mg/l	TDS mg/l	pH	NH_3-N mg/l	PO_4 mg/l	DO mg/l	COD mg/l	SO_4 mg/l	Na mg/l	CL mg/l	Ca mg/l	Mg mg/l	K mg/l	NO_3-N mg/l	CO_3 mg/l	HCO_3 mg/l	B mg/l	F mg/l	
1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22
1	Feb-09	298	18	172	8.2	0.35	0.11	8.5	3.5	3.5	9.0	14.2	24.0	19.4	1.3	3.50	0.0	153.0	0.13	0.05	10.0
2	Apr-09	340	18	196	8.1	0.85	0.15	9.5	5.0	3.7	8.8	14.2	24.0	14.6	1.5	0.00	9.0	110.0	0.11	0.11	11.0
3	Jun-09	346	14	192	7.7	0.50	0.23	8.0	5.0	4.8	8.5	14.2	12.0	12.2	1.8	5.00	6.0	61.0	0.15	0.09	10.0
4	Aug-09	322	14	184	7.7	0.00	0.17	7.8	4.0	5.8	10.7	14.2	20.0	17.0	1.7	0.00	3.0	122.0	0.11	0.00	13.0
5	Oct-09	332	15	186	8.3	0.33	0.10	6.8	4.5	2.2	7.8	14.2	12.0	14.6	1.5	0.43	0.0	97.6	0.12	0.00	12.5
6	Dec-09	245	9	138	8.2	0.27	0.07	7.5	1.0	15.7	7.6	14.2	24.0	14.6	1.7	0.25	0.0	107.0	0.00	0.16	10.0
7	Feb-10	284	14	160	7.9	0.00	0.04	6.7	1.0	5.6	8.4	14.2	16.0	19.4	2.6	1.80	0.0	119.0	0.09	0.12	10.5
8	Apr-10	285	12	160	8.3	0.00	0.04	8.2	1.0	4.3	8.9	14.2	12.0	9.7	2.5	0.10	0.0	73.2	0.10	0.00	7.0
9	Jun-10	318	18	185	8.4	0.00	0.16	8.2	2.5	2.5	10.0	14.2	16.0	12.2	1.5	0.80	3.0	82.4	0.14	0.31	5.5
10	Aug-10	283	13	156	8.4	0.00	0.27	8.8	1.0	3.6	4.4	7.1	12.0	19.4	2.3	0.20	0.0	106.8	0.00	0.21	5.0
11	Oct-10	352	14	194	8.5	0.21	0.11	8.6	3.5	4.4	12.4	21.3	12.0	7.3	2.2	6.60	0.0	48.8	0.09	0.19	11.0
12	Dec-10	616	25	345	8.4	0.00	0.15	9.4	5.0	15.5	11.5	21.3	28.0	7.3	73.3	3.50	15.0	140.3	0.16	0.16	8.5

Sabarmati River

Location : Vasana Barrage

Sr. No.	Month	General				Nutrient		Organic matter		Major Ions									Other Inorganic		Turbidity_NTU
		E.C. ms/cm	TSS mg/l	TDS mg/l	pH	NH_3-N mg/l	PO_4 mg/l	BOD/ DO mg/l	COD mg/l	SO_4 mg/l	Na mg/l	CL mg/l	Ca mg/l	Mg mg/l	K mg/l	NO_3.N mg/l	CO_3 mg/l	HCO_3 mg/l	B mg/l	F mg/l	
1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22
1	Feb-09	382	23	222	7.6	7.44	0.00	8.5	0.0	3.5	9.0	14.2	24.0	19.4	1.3	3.50	0.0	153.0	0.00	0.05	11.0
2	Apr-09	383	18	228	7.4	6.50	0.00	7.5	0.0	4.8	8.1	14.2	24.0	14.6	1.8	6.50	6.0	106.8	0.00	0.14	11.5
3	Jun-09	405	16	232	7.4	7.10	0.00	**6.5/**5.5	20.0	5.0	8.5	14.2	20.0	14.6	1.9	7.10	3.0	91.5	0.05	0.11	10.5
4	Aug-09	497	22	280	7.3	6.50	0.30	**8.0/**5.0	30.0	7.5	29.3	42.6	12.0	31.6	2.8	6.50	6.0	149.5	0.04	0.13	9.0
5	Oct-09	547	24	318	7.6	7.46	1.55	**10.0/**5.0	30.0	7.3	22.8	35.5	12.0	19.4	2.3	1.45	0.0	109.8	0.00	0.00	10.0
6	Dec-09	386	14	220	7.2	5.24	1.25	**6.6/**5.2	20.0	19.5	28.6	49.7	20.0	19.4	3.0	10.70	0.0	97.6	0.06	0.18	10.5
7	Feb-10	421	20	244	7.6	0.00	7.27	**5.6/**4.8	30.6	11.5	32.2	49.7	24.0	21.9	2.8	10.00	0.0	152.5	0.09	0.33	6.0
8	Apr-10	436	15	252	7.7	6.54	0.08	**5.6/**4.9	20.0	20.9	27.4	42.6	16.0	12.2	3.0	0.30	0.0	76.3	0.03	0.01	6.5
9	Jun-10	1030	65	578	7.5	0.29	1.10	**6.8/**5.7	20.0	54.5	121.5	170.4	24.0	24.3	7.0	6.90	0.0	122.0	0.02	0.34	6.0
10	Aug-10	725	29	410	7.5	4.28	2.02	**11.0/**4.7	30.0	47.8	43.4	63.9	24.0	21.9	4.2	4.20	0.0	109.8	0.12	0.43	10.0
11	Oct-10	665	24	370	7.3	0.52	0.33	**0.0/**6.0	10.2	21.1	41.8	71.0	16.0	12.2	4.2	18.00	0.0	61.0	0.11	0.39	9.5
12	Dec-10	1120	48	660	7.7	0.00	0.00	**8.2/**5.5	19.5	61.4	167.5	241.4	36.0	26.7	4.2	2.20	0.0	152.5	0.16	0.35	13.0

Sabarmati River

Location : Bakrol

Sr. No.	Month	General				Nutrient		Organic matter		Major Ions									Other Inorganic		Turbidity_NTU
		E.C. ms/cm	TSS mg/l	TDS mg/l	pH	NH_4-N mg/l	PO_4 mg/l	BOD/ DO mg/l	COD mg/l	SO_4 mg/l	Na mg/l	CL mg/l	Ca mg/l	Mg mg/l	K mg/l	NO_3-N mg/l	CO_3 mg/l	HCO_3 mg/l	B mg/l	F mg/l	
1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22
1	Feb-09	1040	40	625	7.1	9.41	0.00	25.0	55.0	52.6	96.0	142.0	48.0	34.0	6.6	41.00	12.0	183.0	0.00	0.09	11.5
2	Apr-09	2740	100	1650	7.2	17.24	0.50	30.0	80.0	106.0	180.0	256.0	56.0	34.0	21.0	36.00	12.0	153.0	0.12	1.05	11.5
3	Jun-09	3740	135	2210	7.3	28.76	3.26	35.0	120.0	186.0	419.0	568.0	40.0	60.8	27.5	85.80	0.0	110.0	0.18	1.40	12.5
4	Aug-09	3070	125	1840	7.1	25.35	3.12	21.0	70.0	78.9	113.0	156.0	16.0	53.5	7.0	48.20	12.0	165.0	0.20	1.39	8.0
5	Oct-09	4190	125	2555	6.9	36.85	0.41	50.0	120.0	168.0	366.0	504.0	20.0	46.2	22.0	9.07	0.0	168.0	0.18	0.09	9.0
6	Dec-09	2300	70	1400	8.0	10.53	0.39	25.0	80.0	145.0	400.0	518.0	40.0	24.3	41.0	3.75	0.0	214.0	0.09	0.26	9.0
7	Feb-10	1310	45	790	7.2	0.68	12.60	9.5	40.8	116.0	155.0	206.0	28.0	36.5	9.0	7.40	0.0	116.0	0.54	0.59	6.0
8	Apr-10	2820	165	1580	7.6	21.35	1.89	24.5	80.0	112.5	328.8	447.3	24.0	29.2	20.0	7.40	0.0	167.8	0.11	0.34	13.0
9	Jun-10	3820	145	2290	7.5	0.23	1.51	65.0	153.0	108.5	537.0	717.1	24.0	38.9	25.0	7.10	0.0	262.3	0.09	0.50	16.0
10	Aug-10	3720	165	2200	7.6	9.95	4.25	90.5	270.0	188.4	405.0	568.0	56.0	36.5	54.5	9.00	0.0	183.0	0.40	0.65	38.0
11	Oct-10	1780	82	1052	7.6	2.73	0.21	12.0	40.5	103.0	150.9	213.0	24.0	24.3	27.9	6.20	0.0	91.5	0.35	0.46	15.0
12	Dec-10	3880	140	2325	7.8	0.97	0.57	22.5	80.0	148.4	440.0	603.5	48.0	48.6	9.0	12.00	3.0	198.3	0.28	0.61	10.0

Sabarmati River

Location : Vautha

Sr. No.	Month	General				Nutrient		Organic matter		Major Ions									Other Inorganic		Turbidity_NTU
		E.C. ms/cm	TSS mg/l	TDS mg/l	pH	NH_3-N mg/l	PO_4 mg/l	BOD mg/l	COD mg/l	SO_4 mg/l	Na mg/l	CL mg/l	Ca mg/l	Mg mg/l	K mg/l	NO_3-N mg/l	CO_3 mg/l	HCO_3 mg/l	B mg/l	F mg/l	
1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22
1	Feb-09	918	45	542	7.3	10.42	1.25	30.0	85.0	53.6	90.1	128.0	40.0	31.6	5.8	23.00	9.0	171.0	0.15	0.77	12.5
2	Apr-09	3220	115	1930	7.0	19.33	3.70	50.0	130.0	143.0	230.0	320.0	64.0	41.3	18.0	32.00	15.0	156.0	0.11	1.09	12.0
3	Jun-09	3180	102	1870	7.9	18.56	3.50	20.0	75.5	110.0	356.0	497.0	24.0	36.5	25.5	60.80	21.0	91.5	0.17	1.20	11.5
4	Aug-09	6180	220	3700	7.3	42.50	9.50	28.0	90.0	213.0	205.0	298.0	24.0	102.0	10.0	68.30	12.0	238.0	0.29	1.47	7.0
5	Oct-09	4000	152	2350	7.7	33.35	8.50	15.5	60.0	142.0	386.0	504.0	16.0	55.9	1.8	10.70	0.0	214.0	0.18	0.82	14.5
6	Dec-09	1860	69	1115	7.6	12.95	3.20	12.0	40.0	85.5	289.0	419.0	44.0	29.2	28.0	8.81	0.0	192.0	0.08	0.26	13.0
7	Feb-10	861	35	508	7.4	1.75	2.25	9.5	40.8	72.9	110.0	149.0	24.0	29.2	7.7	6.20	0.0	134.0	0.59	0.38	11.5
8	Apr-10	1820	98	1010	7.8	12.68	0.97	11.5	40.0	72.6	190.8	284.0	40.0	14.6	12.8	6.20	0.0	106.8	0.07	0.25	10.0
9	Jun-10	3140	125	1855	7.9	9.03	1.47	15.0	52.5	84.6	351.5	511.2	24.0	34.0	21.1	17.00	0.0	152.5	0.11	0.51	7.0
10	Aug-10	3370	130	2025	8.1	6.35	2.81	60.5	200.0	110.5	399.0	568.0	28.0	43.2	51.5	16.00	0.0	170.8	0.20	0.59	33.0
11	Oct-10	1230	49	1235	7.6	1.36	0.27	10.5	30.0	78.6	98.0	127.8	24.0	21.9	12.5	47.00	0.0	73.2	0.22	0.29	13.0
12	Dec-10	3030	128	1785	8.0	8.53	1.50	12.5	40.0	62.3	298.0	411.8	40.0	51.0	5.0	2.80	12.0	213.5	0.22	0.78	9.0

Sabarmati River

Location : Galiyana

Sr. No.	Month	General				Nutrient		Organic matter		Major Ions									Other Inorganic		Turbidity_NTU
		E.C. ms/cm	TSS mg/l	TDS mg/l	pH	NH_3-N mg/l	PO_4 mg/l	BOD mg/l	COD mg/l	SO_4 mg/l	Na mg/l	CL mg/l	Ca mg/l	Mg mg/l	K mg/l	NO_3-N mg/l	CO_3 mg/l	HCO_3 mg/l	B mg/l	F mg/l	
1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22
1	Feb-09	1065	47	635	7.6	11.42	2.24	40.0	90.0	113.0	170.0	241.0	48.0	36.4	12.5	47.00	15.0	122.0	0.28	0.82	11.5
2	Apr-09	3150	130	1900	7.3	21.50	0.89	22.0	75.5	136.0	228.0	320.0	64.0	38.9	18.0	40.00	15.0	149.0	0.09	1.10	12.5
3	Jun-09	3430	110	2060	8.0	24.70	4.40	30.0	92.0	127.0	381.0	504.0	32.0	46.2	23.0	75.50	15.0	91.5	0.11	1.25	11.5
4	Aug-09	5180	175	3100	7.3	38.05	3.45	12.0	40.0	191.0	194.0	305.0	16.0	104.0	8.0	53.30	6.0	214.0	0.22	1.40	7.0
5	Oct-09	1910	90	1130	7.8	12.25	1.06	18.5	50.0	78.0	164.0	220.0	16.0	31.6	7.6	6.65	0.0	149.0	0.13	0.02	8.5
6	Dec-09	2540	125	1530	7.9	17.45	0.96	25.0	75.0	167.0	438.0	589.0	36.0	51.0	26.0	5.63	0.0	241.0	0.09	0.31	8.5
7	Feb-10	927	36	557	7.4	0.61	3.43	3.5	20.4	79.5	124.0	170.0	20.0	34.0	8.2	8.30	0.0	137.0	0.46	0.41	10.0
8	Apr-10	4170	212	2340	8.1	28.40	2.27	42.5	110.0	120.5	545.6	745.5	84.0	24.0	24.8	8.30	0.0	335.5	0.08	0.47	7.5
9	Jun-10	3260	96	1990	7.8	0.08	1.05	10.5	26.6	38.1	452.1	660.3	32.0	34.0	24.0	6.20	0.0	183.0	0.07	0.53	4.0
10	Aug-10	3270	103	1895	7.9	5.96	1.72	56.0	140.0	135.7	326.0	489.9	20.0	65.6	51.0	13.00	0.0	164.7	0.15	0.32	15.0
11	Oct-10	603	21	338	7.6	0.06	0.12	4.5	20.0	35.9	46.7	71.0	16.0	12.2	3.3	5.80	0.0	45.8	0.16	0.26	12.0
12	Dec-10	5940	175	3625	8.1	1.21	3.75	48.5	115.0	145.3	545.0	809.4	32.0	87.5	1.0	8.10	0.0	244.0	0.31	0.54	7.5

ABSTRACT

Annexure –1 (a)

			Dharoi			Sapteshwar			Derol			Sanpad			Lakroda		
Sr No.	Parameter	Unit	Max	Mini	Average	Max	Mini	Average	Max	Mini	Average	Max	Mini	Average	Max	Mini	Average
1	PH	Unit	8.5	7.3	8.0	8.5	7.1	7.9	8.4	7.3	8.0	8.4	7.5	7.9	8.5	7.0	8.1
2	Turbidity	NTU	15.0	5.0	10.5	23.0	6.0	11.4	42.0	5.5	14.1	80.0	6.0	21.4	32.0	6.5	11.8
3	TDS	mg/l	330.0	194.0	248.0	635.0	245.0	465.0	540.0	122.0	355.0	515.0	152.0	370.0	900.0	106.0	521.0
4	Chloride	mg/l	56.8	7.1	34.3	178.0	42.6	103.1	92.3	14.2	59.8	71.0	14.2	52.3	170.4	14.2	106.6
5	Sulphate	mg/l	20.7	2.1	10.9	28.8	1.7	17.8	30.5	1.7	17.7	33.8	4.5	22.6	30.6	11.3	21.0
6	Calcium	mg/l	32.0	12.0	19.1	32.0	12.0	21.2	36.0	12.0	24.0	48.0	12.0	27.0	40.0	12.0	24.0
7	Mg^{++}	mg/l	26.7	7.3	17.5	48.6	14.6	31.3	29.2	12.2	22.6	36.5	12.2	24.7	55.9	7.3	31.8
8	Na^{+}	mg/l	38.3	3.9	21.8	113.1	27.0	67.2	61.3	10.6	40.6	43.9	7.6	33.3	110.5	9.1	69.7
9	K^{+}	mg/l	5.8	0.5	2.7	4.5	0.8	2.6	4.2	0.1	2.9	6.2	0.6	3.2	7.7	1.1	3.6
10	DO	mg/l	13.5	6.5	8.0	10.6	6.0	7.6	9.8	6.8	8.2	8.5	6.2	7.1	10.0	6.1	7.4
11	COD	mg/l	9.5	0.0	6.3	7.5	5.0	6.4	7.5	10.0	5.8	8.0	1.0	5.4	9.0	1.0	5.8
12	NH_3-N	mg/l	0.0	0.0	0.0	0.1	0.0	0.0	0.1	0.0	0.0	0.1	0.0	0.0	0.1	0.0	0.1
13	PO_4	mg/l	0.7	0.0	0.3	0.9	0.0	0.2	0.7	0.0	0.2	0.9	0.0	0.0	1.1	0.0	0.4
14	NO_3	mg/l	1.3	0.3	0.7	5.7	0.0	2.3	3.0	0.0	1.6	15.0	0.0	4.6	12.0	0.0	3.2

N.B.: Enough samples could not be collected from Chiloda location for aforesaid values.

ABSTRACT

Annexure –1 (b)

Sr No.	Parameter	Unit	Narmada Escape			Vasana Barrage D/s			Bakrol			Vautha			Galiyana		
			Max	Mini	Average	Max	Mini	Average	Max	Mini	Average	Max	Mini	Average	Max	Mini	Average
1	PH	Unit	8.5	7.5	8.2	7.7	7.2	7.5	8.0	6.91	7.41	8.1	7.0	7.6	8.1	7.3	7.7
2	Turbidity	NTU	13.0	5.0	9.5	13.0	6.0	9.5	38.0	6.0	13.3	33.0	7.0	12.8	15.0	4.0	9.6
3	TDS	mg/l	345.0	138.0	189.0	660.0	220.0	335.0	2555.0	625.0	1710.0	3700.0	508.0	1660.0	3625.0	338.0	1758.0
4	Chloride	mg/l	21.3	7.1	14.2	241.4	14.2	67.5	717.1	142.0	408.2	568.0	127.8	351.5	809.4	71.0	427.1
5	Sulphate	mg/l	15.7	2.2	6.0	61.4	3.5	21.6	188.4	52.6	126.1	213.0	53.6	102.4	191.0	35.9	113.9
6	Calcium	mg/l	28.0	12.0	17.7	36.0	12.0	21.0	56.0	16.0	35.3	64.0	16.0	32.7	84.0	16.0	34.7
7	Mg^{++}	mg/l	19.4	7.3	14.0	31.6	12.2	19.8	60.8	24.3	38.9	102.0	14.6	40.9	104.0	12.2	47.1
8	Na^{+}	mg/l	12.4	4.4	9.0	167.5	8.1	45.0	537.0	96.0	299.2	399.0	90.1	250.3	545.6	46.7	301.2
9	K^{+}	mg/l	73.3	1.3	7.8	7.0	1.3	3.2	54.5	6.6	22.5	51.5	1.8	16.6	51.0	1.0	17.3
10	DO BOD	mg/l	9.5	6.7	8.2	11.0	0.0	7.0	90.5	9.5	34.2	60.5	9.5	22.9	56.0	3.5	26.1
11	COD	mg/l	5.0	1.0	3.1	30.6	0.0	17.6	270.0	40.5	99.1	200.0	30.0	73.7	140.0	20.0	71.2
12	NH_3-N	mg/l	0.9	0.0	0.2	7.5	0.0	4.3	36.9	0.2	13.7	42.5	1.4	14.7	38.5	0.1	13.5
13	PO_4	mg/l	0.3	0.0	0.1	7.3	0.0	1.2	12.6	0.0	2.4	9.5	0.3	3.2	4.4	0.1	2.1
14	NO_3-N	mg/l	6.6	0.0	1.9	18.0	0.3	6.5	85.8	3.8	22.7	68.3	2.8	24.9	75.5	5.6	23.2

DATA ANALYSIS OF GROUND WATER

Ground Water Results

Location : Karai

Sr. No.	Month	General				Nutrient		Organic matter		Major Ions									Other Inorganic		Turbidity_NTU
		E.C. ms/cm	TSS mg/l	TDS mg/l	pH	NH_3-N mg/l	PO_4 mg/l	DO mg/l	COD mg/l	SO_4 mg/l	Na mg/l	CL mg/l	Ca mg/l	Mg mg/l	K mg/l	NO_3-N mg/l	CO_3 mg/l	HCO_3 mg/l	B mg/l	F mg/l	
1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22
1	Nov-09	1000	50	590	8.0	0.0	0.65	3.5	12.0	23.5	119.0	156.0	36.0	19.4	0.3	0.10	6.0	174.0	0.19	0.99	5.0
2	Dec-09	625	30	370	8.1	0.01	0.35	3.0	13.3	43.0	119.0	185.0	16.0	17.0	0.5	0.00	0.0	94.6	0.11	0.92	9.5
3	Jan-10	711	30	423	7.9	0.01	0.51	3.3	12.8	4.3	150.0	213.0	12.0	9.7	0.3	0.40	0.0	101.0	0.00	0.99	12.5
4	Feb-10	847	39	505	7.7	0.01	0.55	3.8	14.2	49.8	146.0	213.0	20.0	17.0	0.9	0.95	0.0	70.2	0.24	0.89	3.5
5	Mar-10	825	35	486	8.3	0.0	0.49	3.8	14.0	45.5	128.5	184.6	24.0	14.6	1.2	0.21	6.0	76.3	0.00	0.50	4.0
6	Apr-10	818	40	475	7.9	0.0	0.41	3.6	13.8	5.6	105.0	142.0	20.0	17.0	3.4	0.80	15.0	122.0	0.00	0.20	5.0
7	May-10	1160	60	660	8.0	0.04	0.30	3.9	14.5	15.9	144.0	192.0	12.0	12.2	0.5	5.80	0.0	88.5	0.19	1.03	7.0
8	Jun-10	940	39	555	8.5	0.01	0.27	3.6	13.5	20.1	123.0	170.0	20.0	7.3	6.9	5.90	0.0	76.3	0.14	1.01	6.5
9	Jul-10	906	42	528	8.0	0.02	0.17	3.2	11.5	14.1	111.0	163.0	28.0	46.2	1.8	6.60	0.0	244.0	0.21	0.45	5.0
10	Aug-10	1040	42	624	8.0	0.0	0.28	3.7	13.9	16.6	239.0	355.0	16.0	19.4	2.1	6.00	9.0	91.5	0.21	1.24	5.1
11	Sep-10	1000	40	595	8.0	0.03	0.39	4.0	14.6	22.6	132.0	192.0	20.0	19.4	0.8	6.30	0.0	122.0	0.19	1.21	12.0
12	Oct-10	1000	51	595	8.2	0.0	0.55	4.0	14.0	19.9	151.0	213.0	32.0	19.4	2.4	6.70	12.0	13.2	0.15	1.78	7.0

Ground Water

Location : Nabhoi

Sr. No.	Month	General				Nutrient		Organic matter		Major Ions									Other Inorganic		Turbidity_NTU
		E.C. ms/cm	TSS mg/l	TDS mg/l	pH	NH_3-N mg/l	PO_4 mg/l	DO mg/l	COD mg/l	SO_4 mg/l	Na mg/l	CL mg/l	Ca mg/l	Mg mg/l	K mg/l	NO_3-N mg/l	CO_3 mg/l	HCO_3 mg/l	B mg/l	F mg/l	
1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22
1	Nov-09	990	52	580	8.2	0.05	0.84	5.5	9.5	21.3	119.0	156.0	36.0	17.0	0.2	0.20	9.0	183.0	0.15	1.27	5.0
2	Dec-09	776	37	459	8.4	0.04	0.46	5.5	10.0	32.0	136.0	185.0	12.0	17.0	0.4	0.20	0.0	109.8	0.09	1.45	10.0
3	Jan-10	688	22	419	8.2	0.07	0.67	6.0	9.2	5.5	127.0	178.0	12.0	12.2	0.3	0.10	0.0	97.6	0.00	1.27	11.0
4	Feb-10	794	31	475	8.1	0.00	0.55	6.0	9.0	42.5	158.0	227.0	12.0	14.6	0.4	3.40	0.0	70.2	0.18	0.63	5.0
5	Mar-10	903	48	515	8.4	0.05	0.89	5.0	9.8	29.5	132.0	170.0	12.0	14.6	0.4	2.10	0.0	109.8	0.00	0.08	5.5
6	Apr-10	904	49	515	8.2	0.05	0.00	5.2	10.1	45.5	124.0	178.0	16.0	21.9	1.8	1.90	6.0	82.4	0.00	0.09	5.0
7	May-10	1180	54	668	8.2	0.03	0.30	4.3	11.9	35.6	154.0	213.0	16.0	14.6	0.5	5.40	0.0	88.5	0.11	1.15	6.5
8	Jun-10	862	32	498	8.4	0.00	0.00	4.8	12.6	13.3	118.0	170.0	16.0	12.2	3.3	2.00	0.0	94.6	0.08	0.92	6.0
9	Jul-10	836	28	478	8.2	0.00	0.27	4.7	12.5	9.1	91.5	142.0	24.0	38.9	1.2	2.80	0.0	183.0	0.16	0.39	6.0
10	Aug-10	888	40	524	8.4	0.00	0.16	4.2	12.8	8.1	324.0	341.0	20.0	26.7	2.1	1.60	30.0	88.5	0.16	1.43	6.0
11	Sep-10	922	35	545	8.4	0.03	0.00	4.0	12.9	20.5	128.0	185.0	16.0	19.4	0.8	7.30	0.0	109.8	0.16	1.46	8.5
12	Oct-10	950	50	570	8.4	0.04	0.83	4.1	12.5	21.3	115.0	149.0	36.0	17.0	0.2	8.20	9.0	137.3	0.12	1.81	7.0

Ground Water

Location :Bhat

Sr. No.	Month	General				Nutrient		Organic matter		Major Ions									Other Inorganic		Turbidity_NTU
		E.C. ms/cm	TSS mg/l	TDS mg/l	pH	NH_3-N mg/l	PO_4 mg/l	DO mg/l	COD mg/l	SO_4 mg/l	Na mg/l	CL mg/l	Ca mg/l	Mg mg/l	K mg/l	NO_3.N mg/l	CO_3 mg/l	HCO_3 mg/l	B mg/l	F mg/l	
1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22
1	Nov-09	428	21	248	8.0	0.01	1.06	6.0	9.0	18.4	31.6	42.6	12.0	17.0	2.0	0.0	0.0	91.5	0.00	0.84	6.0
2	Dec-09	331	12	198	8.4	0.01	0.19	6.2	8.2	26.0	29.4	42.6	12.0	14.6	1.3	0.0	0.0	70.2	0.00	0.74	8.5
3	Jan-10	290	16	170	7.9	0.00	0.93	6.5	8.0	1.6	24	35.5	12.0	14.6	0.5	0.0	0.0	91.5	0.00	0.84	18
4	Feb-10	325	15	182	7.9	0.00	0.17	6.3	8.3	19.6	26.4	35.5	16.0	9.7	0.7	0.8	0.0	61.0	0.00	0.12	5.0
5	Mar-10	356	18	203	7.9	0.03	0.02	6.1	8.5	4.6	27.6	42.6	12.0	12.2	0.9	0.0	0.0	82.4	0.00	0.09	3.0
6	Apr-10	317	12	188	8.0	0.03	0.70	6.0	8.4	4.9	35.9	56.8	12.0	12.2	1.3	0.7	6.0	70.2	0.00	0.00	4.5
7	May-10	481	22	270	8.2	0.04	0.81	5.5	9.1	3.2	31	42.6	8.0	14.6	0.6	0.7	0.0	91.5	0.00	0.45	7.00
8	Jun-10	367	16	212	8.3	0.02	0.00	5.7	8.9	5.1	25	35.5	12.0	24.3	0.7	0.2	0.0	122.0	0.02	0.00	5.00
9	Jul-10	353	16	195	8.0	0.02	0.11	5.5	9.0	6.2	20	35.5	16.0	26.7	1.7	0.5	0.0	153.0	0.00	0.11	6.50
10	Aug-10	396	25	226	8.1	0.00	0.36	5.8	8.5	1.9	56.4	85.2	20.0	7.3	3.3	0.0	15.0	61.0	0.00	0.76	3.0
11	Sep-10	387	17	216	8.0	0.00	0.02	5.7	8.5	6.6	25.1	35.5	8.0	12.2	0.7	1.4	0.0	64.1	0.00	0.65	11.5
12	Oct-10	380	18	215	8.1	0.00	1.01	5.7	8.5	6.5	26	42.6	24.0	7.3	2.3	0.7	12.0	61.0	0.00	1.03	8.00

Ground Water

Location : Gayatri Mandir

Sr. No.	Month	General				Nutrient		Organic matter		Major Ions									Other Inorganic		Turbidity_NTU
		E.C. ms/cm	TSS mg/l	TDS mg/l	pH	NH_3-N mg/l	PO_4 mg/l	DO mg/l	COD mg/l	SO_4 mg/l	Na mg/l	CL mg/l	Ca mg/l	Mg mg/l	K mg/l	NO_3-N mg/l	CO_3 mg/l	HCO_3 mg/l	B mg/l	F mg/l	
1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22
1	Nov-09	1340	57	800	7.7	0.01	0.73	3.7	15.2	28.2	174.0	227.0	28.0	21.9	1.0	0.50	0.0	183.0	0.15	0.89	6.0
2	Dec-09	1020	41	610	7.9	0.01	0.92	3.9	14.5	95.8	156.0	213.0	20.0	21.9	0.9	0.40	0.0	73.2	0.24	0.76	11.0
3	Jan-10	1060	28	657	7.8	0.03	0.54	3.9	14.3	55.9	168.0	227.0	16.0	19.4	0.6	0.30	0.0	110.0	0.12	0.89	11.5
4	Feb-10	1300	37	795	7.7	0.00	0.70	3.5	15.6	129.0	185.0	256.0	20.0	38.9	0.8	9.20	0.0	107.0	0.28	0.99	3.5
5	Mar-10	1290	57	760	7.8	0.03	1.70	3.6	14.8	49.9	151.0	213.0	16.0	17.0	1.2	0.00	0.0	91.5	0.21	0.10	3.0
6	Apr-10	1390	85	765	7.9	0.04	0.89	3.3	14.9	61.9	151.0	213.0	24.0	21.9	2.0	3.20	12.0	91.5	0.18	0.09	6.5
7	May-10	1410	69	830	8.0	0.05	0.67	3.1	14.5	59.7	175.0	234.0	12.0	21.9	1.0	2.70	0.0	94.6	0.21	1.18	6.0
8	Jun-10	1340	88	745	8.4	0.00	0.04	3.2	15.0	55.6	144.0	213.0	16.0	34.0	0.9	1.30	0.0	128.0	0.22	1.17	5.50
9	Jul-10	1320	51	780	7.9	0.01	0.16	3.2	14.7	81.8	186.0	284.0	36.0	36.5	2.5	2.10	0.0	153.0	0.23	1.26	8.00
10	Aug-10	1510	45	922	8.2	0.00	0.40	3.0	15.4	46.6	238.0	355.0	24.0	21.9	3.3	3.10	6.0	94.6	0.23	0.92	5.0
11	Sep-10	1380	50	835	7.8	0.06	0.00	3.3	14.8	59.8	180.0	249.0	24.0	21.9	1.0	4.30	0.0	128.0	0.20	0.81	11.00
12	Oct-10	1370	75	820	8.0	0.00	0.71	3.3	14.8	58.5	168.0	249.0	36.0	19.4	2.6	3.40	24.0	64.1	0.17	1.25	8.00

Ground Water

Location : Gandhi Ashram

Sr. No.	Month	General				Nutrient		Organic matter		Major Ions									Other Inorganic		Turbidity_NTU
		E.C. ms/cm	TSS mg/l	TDS mg/l	pH	NH_3-N mg/l	PO_4 mg/l	DO mg/l	COD mg/l	SO_4 mg/l	Na mg/l	CL mg/l	Ca mg/l	Mg mg/l	K mg/l	NO_3-N mg/l	CO_3 mg/l	HCO_3 mg/l	B mg/l	F mg/l	
1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22
1	Nov-09	1780	100	1040	8.1	0.05	1.24	3.1	14.3	50.8	269.0	355.0	24.0	19.4	1.5	3.00	0.0	183.0	0.08	1.17	5.0
2	Dec-09	1640	54	995	8.2	0.09	1.17	3.5	14.5	150.0	291.0	383.0	32.0	21.9	2.5	2.90	0.0	101.0	0.19	1.02	10.5
3	Jan-10	1550	55	930	8.1	0.07	0.76	3.6	14.2	55.9	244.0	327.0	16.0	17.0	0.8	11.00	0.0	122.0	0.24	1.19	10.5
4	Feb-10	1700	45	1035	8.0	0.08	0.71	3.0	14.9	124.0	278.0	369.0	20.0	24.3	0.9	0.60	0.0	82.4	0.25	0.65	3.5
5	Mar-10	1850	56	1110	8.1	0.08	1.09	2.9	15.1	77.7	246.0	334.0	32.0	24.3	1.2	1.10	0.0	156.0	0.19	1.45	3.5
6	Apr-10	2310	126	1315	8.1	0.05	0.94	3.1	15.0	60.9	274.0	355.0	28.0	21.9	1.2	45.00	18.0	85.4	0.15	0.26	5.5
7	May-10	2640	152	1485	8.2	0.05	0.13	2.8	15.6	78.8	317.0	426.0	24.0	21.9	0.5	50.00	3.0	91.5	0.25	2.01	6.0
8	Jun-10	2220	105	1310	8.5	0.11	0.19	3.1	15.0	80.0	283.0	383.0	28.0	36.5	0.6	50.00	18.0	91.5	0.21	1.93	5.0
9	Jul-10	1770	89	1060	8.2	0.04	0.30	3.3	14.7	79.1	213.0	284.0	28.0	19.4	4.0	47.00	0.00	91.50	0.17	1.37	6.50
10	Aug-10	1940	82	1160	8.1	0.02	0.39	3.5	14.9	56.2	155.0	213.0	28.0	24.3	4.2	44.00	9.0	73.2	0.15	1.31	6.5
11	Sep-10	2210	90	1320	8.4	0.05	0.31	3.0	15.0	61.4	249.0	355.0	28.0	24.3	1.2	46.00	0.0	91.5	0.17	1.39	12.5
12	Oct-10	2390	65	1460	8.5	0.15	0.27	3.0	15.5	75.5	320.0	426.0	20.0	41.3	3.3	48.00	21.0	146.0	0.21	2.62	8.0

Ground Water

Location : Near R.B.I.

Sr. No.	Month	General				Nutrient		Organic matter		Major Ions									Other Inorganic		Turbidity_NTU
		E.C. ms/cm	TSS mg/l	TDS mg/l	pH	NH_3-N mg/l	PO_4 mg/l	DO mg/l	COD mg/l	SO_4 mg/l	Na mg/l	CL mg/l	Ca mg/l	Mg mg/l	K mg/l	NO_3-N mg/l	CO_3 mg/l	HCO_3 mg/l	B mg/l	F mg/l	
1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22
1	Nov-09	2030	85	1215	8.1	0.02	2.32	3.0	15.1	49.9	338	447	20	26.7	1.5	11.00	0.00	201.3	0.09	0.70	5.0
2	Dec-09	1360	62	805	7.7	0.02	1.03	3.6	12.9	94.5	264	355	28	17.0	5.0	11.00	0.00	109.8	0.14	0.55	9.5
3	Jan-10	1350	51	795	7.9	0.03	2.03	3.5	13.1	27.8	163	227	20	24.3	1.5	4.20	0.00	167.8	0.18	1.06	10.0
4	Feb-10	1360	39	815	7.7	0.04	0.53	3.5	13.0	96.7	263	355	20	21.9	0.9	0.40	0.00	103.7	0.14	0.54	4.0
5	Mar-10	1470	42	895	7.7	0.03	1.16	3.2	13.5	47.1	203	284	28	19.4	1.2	1.40	0.00	143.4	0.12	0.82	3.5
6	Apr-10	1600	75	930	8.0	0.00	0.95	2.9	14.4	41.6	203	284	24	21.9	0.9	29.0	15.00	73.2	0.11	0.14	6.0
7	May-10	1870	95	1066	8.1	0.01	0.06	3.0	14.9	45.7	203	263	20	17.0	0.5	34.0	0.00	106.8	0.15	0.82	6.0
8	Jun-10	1520	85	880	8.4	0.01	0.00	3.3	13.7	45.1	186	284	24	34.1	0.9	33.0	12.00	73.2	0.11	0.71	5.0
9	Jul-10	1500	72	890	8.1	0.00	0.19	3.1	13.5	48.9	161	213	32	21.9	2.0	33.0	0.00	122.0	0.15	1.05	6.5
10	Aug-10	1690	84	998	8.2	0.03	0.58	2.8	13.6	40.5	142	199	24	21.9	3.6	29.0	15.0	70.2	0.17	0.74	5.0
11	Sep-10	1660	78	980	8.5	0.01	0.00	3.0	13.5	49.0	185	263	24	21.9	0.9	30.0	0.00	88.5	0.16	0.74	11.5
12	Oct-10	1550	45	915	8.2	0.00	0.45	3.2	13.3	39.5	194	284	16	34.0	3.3	31.0	18.00	100.7	0.17	0.88	7.0

Ground Water

Location : Bhavan's College

Sr. No.	Month	General				Nutrient		Organic matter		Major Ions									Other Inorganic		Turbidity_NTU
		E.C. ms/cm	TSS mg/l	TDS mg/l	pH	NH_3-N mg/l	PO_4 mg/l	DO mg/l	COD mg/l	SO_4 mg/l	Na mg/l	CL mg/l	Ca mg/l	Mg mg/l	K mg/l	NO_3-N mg/l	CO_3 mg/l	HCO_3 mg/l	B mg/l	F mg/l	
1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22
1	Nov-09	1080	40	650	7.5	0.03	0.95	3.7	10.5	34.6	122.0	163.0	28.0	26.7	0.9	2.8	0.0	198.0	0.08	0.26	5.0
2	Dec-09	719	35	425	8.1	0.01	0.78	4.5	8.8	99.0	89.4	128.0	36.0	14.6	1.4	2.9	0.0	61.0	0.05	0.27	9.0
3	Jan-10	798	47	460	7.7	0.02	1.87	4.6	9.5	29.5	95.8	142.0	20.0	31.6	0.9	3.3	0.0	162.0	0.12	0.98	10.5
4	Feb-10	953	35	555	7.8	0.00	0.51	3.9	9.6	89.8	117.0	163.0	16.0	29.2	0.9	0.4	0.0	91.5	0.10	0.49	3.0
5	Mar-10	1070	37	640	7.6	0.04	1.00	3.7	10.1	36.1	110.0	170.0	20.0	21.9	1.6	1.0	0.0	107.0	0.09	0.35	3.0
6	Apr-10	1050	50	588	7.9	0.03	0.46	3.5	10.4	39.5	90.6	136.0	20.0	31.6	2.0	22.0	9.0	110.0	0.00	0.09	6.0
7	May-10	575	26	335	8.1	0.00	0.07	4.3	8.9	13.0	44.1	63.9	12.0	19.4	1.5	16.4	0.0	97.6	0.00	0.29	5.5
8	Jun-10	896	62	503	8.3	0.00	0.00	3.8	9.5	31.0	74.4	107.0	20.0	36.5	1.2	17.0	0.0	83.0	0.02	0.30	5.0
9	Jul-10	944	50	540	7.7	0.00	0.32	3.7	9.6	30.7	64.0	99.4	20.0	36.5	2.5	19.0	0.0	122.0	0.08	0.72	7.0
10	Aug-10	990	40	594	7.8	0.00	0.17	3.5	9.5	31.3	126.0	185.0	20.0	21.9	5.1	16.0	9.0	76.3	0.11	0.34	5.0
11	Sep-10	1410	76	815	8.3	0.04	0.03	3.4	11.7	45.9	126.0	185.0	20.0	21.9	1.2	37.0	0.0	61.0	0.13	0.32	11.0
12	Oct-10	1030	40	598	8.0	0.03	0.22	3.6	10.2	28.4	115.0	170.0	16.0	29.2	2.0	25.0	15.0	91.5	0.11	0.38	7.5

Ground Water

Location : Swaminarayan Temple, Vasana

Sr. No.	Month	General				Nutrient		Organic matter		Major Ions									Other Inorganic		Turbidity_NTU
		E.C. ms/cm	TSS mg/l	TDS mg/l	pH	NH_3-N mg/l	PO_4 mg/l	DO mg/l	COD mg/l	SO_4 mg/l	Na mg/l	CL mg/l	Ca mg/l	Mg mg/l	K mg/l	NO_3-N mg/l	CO_3 mg/l	HCO_3 mg/l	B mg/l	F mg/l	
1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22
1	Nov-09	2030	80	1210	7.3	0.13	0.57	2.9	14.4	36.2	226.0	312.0	16.0	21.9	1.5	7.00	0.0	153.0	0.10	0.30	5.0
2	Dec-09	1520	58	910	7.9	0.12	1.33	3.6	11.2	220.0	152.0	199.0	36.0	51.0	2.4	6.10	0.0	119.0	0.10	0.32	10.0
3	Jan-10	1330	40	811	8.2	0.00	1.08	3.9	12.5	79.6	151.0	213.0	16.0	65.6	2.3	11.00	0.0	275.0	0.16	1.05	12.5
4	Feb-10	1540	48	915	7.7	0.08	0.68	3.5	12.4	113.0	184.0	256.0	24.0	43.7	1.0	0.60	0.0	104.0	0.21	0.55	3.0
5	Mar-10	1690	30	1050	7.7	0.05	0.98	3.1	12.7	109.0	168.0	241.0	28.0	46.2	2.4	1.50	0.0	162.0	0.12	0.40	3.5
6	Apr-10	1910	95	1125	7.9	0.09	1.25	3.4	12.5	61.3	173.0	234.0	24.0	29.2	2.0	46.00	15.0	88.5	0.14	0.09	5.0
7	May-10	1870	99	1075	8.0	0.11	0.09	3.5	12.5	89.8	197.0	284.0	20.0	36.5	2.0	50.00	0.0	82.4	0.18	1.06	4.5
8	Jun-10	1720	92	995	8.2	0.07	0.08	4.2	11.9	65.9	111.0	163.0	24.0	41.3	1.5	50.00	0.0	122.0	0.14	1.09	3.0
9	Jul-10	1740	82	1035	7.9	0.00	0.18	4.0	11.8	92.1	189.0	249.0	20.0	58.3	9.5	50.00	0.0	244.0	0.18	1.41	7.0
10	Aug-10	1900	56	1160	7.8	0.00	0.16	3.8	12.2	66.8	205.0	284.0	28.0	26.7	7.2	48.00	15.0	79.3	0.19	0.47	3.0
11	Sep-10	1860	68	1122	7.9	0.04	0.35	3.7	12.3	57.5	139.0	213.0	28.0	24.3	1.8	47.00	0.0	67.1	0.19	0.49	10.0
12	Oct-10	1740	57	1045	7.9	0.05	0.48	3.9	12.2	58.9	161.0	213.0	16.0	55.9	2.4	47.00	9.0	210.0	0.15	0.60	8.0

Ground Water

Location : Vautha

Sr. No.	Month	General				Nutrient		Organic matter		Major Ions									Other Inorganic		Turbidity_NTU
		E.C. ms/cm	TSS mg/l	TDS mg/l	pH	NH_3-N mg/l	PO_4 mg/l	DO mg/l	COD mg/l	SO_4 mg/l	Na mg/l	CL mg/l	Ca mg/l	Mg mg/l	K mg/l	NO_3.N mg/l	CO_3 mg/l	HCO_3 mg/l	B mg/l	F mg/l	
1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22
1	Nov-09	2450	72	1495	7.4	0.19	1.80	3.3	12.8	58.5	245.0	327.0	32.0	34.0	6.0	10.00	0.0	229.0	0.10	1.21	7.5
2	Dec-09	2240	49	1385	7.6	0.16	1.55	3.3	12.5	25.0	335.0	440.0	36.0	55.9	4.1	14.00	0.0	183.0	0.29	0.97	11.5
3	Jan-10	3160	70	1950	7.6	0.24	2.29	2.9	13.9	466.0	500.0	646.0	24.0	99.6	30.0	4.10	0.0	198.0	0.29	1.45	11.5
4	Feb-10	3250	124	1920	8.2	0.25	1.25	2.7	14.5	445.0	494.0	710.0	36.0	104.0	36.0	19.00	0.0	153.0	0.29	1.45	7.0
5	Mar-10	3990	136	2390	7.5	0.29	2.67	1.9	16.6	311.0	530.0	731.0	40.0	134.0	3.2	20.00	0.0	378.0	0.21	0.84	3.5
6	Apr-10	3800	175	2250	8.0	0.23	1.40	2.2	15.8	212.0	562.0	731.0	36.0	58.3	2.0	50.00	18.0	183.0	0.45	1.87	5.5
7	May-10	3750	165	2100	8.1	0.31	0.10	2.5	15.2	203.0	520.0	710.0	28.0	53.5	2.5	16.00	3.0	159.0	0.50	0.88	9.5
8	Jun-10	3220	132	1950	8.2	0.14	0.20	2.8	14.5	122.0	275.0	355.0	12.0	48.6	2.7	11.00	0.0	195.0	0.13	1.11	5.0
9	Jul-10	3260	145	1980	8.0	0.09	0.26	2.7	14.4	136.0	298.0	398.0	12.0	55.6	5.5	13.00	0.0	195.0	0.36	0.95	7.0
10	Aug-10	3320	120	1998	8.3	0.18	0.78	2.7	14.5	124.0	309.0	426.0	32.0	31.6	9.9	12.00	18.0	101.0	0.41	0.93	7.0
11	Sep-10	3910	79	2424	7.6	0.22	0.64	2.1	16.5	91.8	533.0	738.0	28.0	36.5	3.0	3.10	0.0	183.0	0.45	0.97	11.5
12	Oct-10	4180	85	2590	7.5	0.34	0.57	1.6	17.7	155.0	504.0	710.0	48.0	117.0	6.0	20.00	18.0	305.0	0.31	1.19	9.5

ABSTRACT

			Karai			Nabhoi			Bhat			Gayatri Mandir			Gandhi Ashram		
Sr No.	**Parameter**	**Unit**	**Max**	**Mini**	**Average**	**Max**	**Mini**	**Average**	**Max**	**Mini**	**Average**	**Max**	**Mini**	**Average**	**Max**	**Mini**	**Average**
1	PH	Unit	8.5	7.7	8.1	8.4	8.1	8.3	8.4	7.9	8.1	8.4	7.7	7.9	8.5	8.0	8.2
2	Turbidity	NTU	12.5	3.5	7.0	11.0	5.0	6.8	18.0	3.0	7.2	11.5	3.0	7.1	12.5	3.5	6.9
3	TDS	mg/l	660.0	370.0	531.0	668.0	419.0	521.0	270.0	170.0	210.0	922.0	610.0	770.0	1485.0	930.0	1185.0
4	Chloride	mg/l	355.0	142.0	207.0	341.0	142.0	191.2	85.2	35.5	44.4	355.0	213.0	244.4	426.0	213.0	350.0
5	Sulphate	mg/l	49.8	4.3	22.3	45.5	5.5	23.7	26.0	1.6	8.7	129.0	28.2	65.2	150.0	50.8	79.2
6	Calcium	mg/l	36.0	12.0	21.5	36.0	12.0	19.0	24.0	8.0	13.7	36.0	12.0	22.7	32.0	16.0	25.7
7	Mg^{++}	mg/l	46.2	7.3	19.8	38.9	12.2	18.8	26.7	7.3	14.4	38.9	17.0	24.7	41.3	17.0	24.7
8	Na^{+}	mg/l	239.0	105.0	143.7	324.0	91.5	143.9	56.4	20.0	29.9	238.0	144.0	173.0	320.0	155.0	261.6
9	K^{+}	mg/l	6.9	0.3	2.0	3.3	0.2	1.0	3.3	0.5	1.3	3.3	0.6	1.5	4.2	0.5	1.8
10	DO	mg/l	4.0	3.0	3.6	6.0	4.0	4.9	6.5	5.5	5.9	3.9	3.0	3.4	3.6	2.8	3.2
11	COD	mg/l	14.6	11.5	13.4	12.9	9.0	11.1	9.1	8.0	8.6	15.6	14.3	14.9	15.6	14.2	14.9
12	NH_3-N	mg/l	0.0	0.0	0.0	0.1	0.0	0.0	0.0	0.0	0.0	0.1	0.0	0.0	0.2	0.0	0.1
13	PO_4	mg/l	0.65	0.17	0.41	0.9	0.0	0.4	0.1	0.0	0.0	1.7	0.0	0.6	1.2	0.1	0.6
14	NO_3	mg/l	6.7	0.0	3.3	8.2	0.1	2.9	1.4	0.0	0.4	9.2	0.0	2.5	50.0	0.6	29.1

ABSTRACT

			Near RBI			Bhavan's College			S.Narayan Temple			Vautha		
Sr No.	**Parameter**	**Unit**	**Max**	**Mini**	**Average**	**Max**	**Mini**	**Average**	**Max**	**Mini**	**Average**	**Max**	**Mini**	**Average**
1	PH	Unit	8.5	7.65	8	8.3	7.5	7.9	8.2	7.34	7.9	8.3	7.4	7.82
2	Turbidity	NTU	11.5	3.5	6.6	11.0	3.0	6.5	12.5	3.0	6.2	11.5	3.5	8.0
3	TDS	mg/l	1215.0	795.0	932.0	815.0	335.0	559.0	1210.0	811.0	1038.0	2590.0	1385.0	2036.0
4	Chloride	mg/l	447.0	199.0	288.2	185.0	63.9	142.7	312.0	163.0	238.4	738.0	327.0	576.8
5	Sulphate	mg/l	96.7	27.8	52.2	99.0	13.0	42.4	220.0	36.2	87.5	466.0	25.0	195.8
6	Calcium	mg/l	32.0	16.0	23.3	36.0	12.0	20.7	36.0	16.0	23.3	48.0	12.0	30.3
7	Mg^{++}	mg/l	34.1	17.0	23.5	36.5	14.6	26.8	65.6	21.9	41.7	134.0	31.6	69.1
8	Na^{+}	mg/l	338.0	142.0	208.8	126.0	44.1	97.9	226.0	111.0	171.3	562.0	245.0	425.4
9	K^{+}	mg/l	5.0	0.5	1.9	5.1	0.9	1.8	9.5	1.0	3.0	36.0	2.0	9.2
10	DO	mg/l	3.6	2.8	3.2	4.6	3.4	3.9	4.2	2.9	3.6	3.3	1.6	2.6
11	COD	mg/l	15.1	12.9	13.7	11.7	8.8	9.9	14.4	11.2	12.4	17.7	12.5	14.9
12	NH_3-N	mg/l	0.0	0.0	0.0	0.0	0.0	0.0	0.1	0.0	0.1	0.3	0.1	0.2
13	PO_4	mg/l	2.3	0.0	0.8	1.9	0.0	0.5	1.3	0.1	0.6	2.7	0.1	1.1
14	NO_3-N	mg/l	34.0	0.4	20.6	37.0	0.4	13.6	50.0	0.6	30.4	50.0	3.1	16.1

Chapter-3

3.1 Observations & Findings: (SW)

The fluctuation of physico-chemical parameters of water on bi-monthly basis at eleven different locations are depicted by Tabular form and graphical presentation (Annexure-I) and the average values of some of the important parameters are given in Annexure-1(a) &(b).

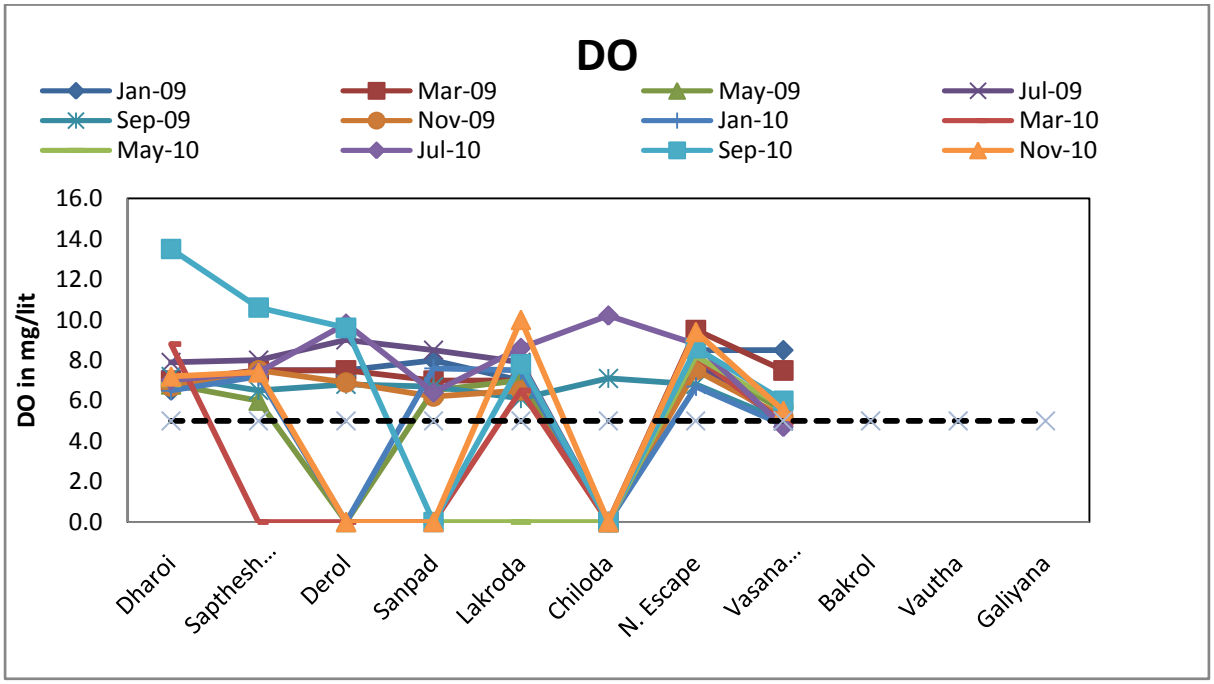
The study revealed that the temperature has direct effect on certain parameters due to chemical activities. Since the North Gujarat Region is a hot and semi -arid region the temperature of study sites ranged between 10°c in January to 45+°c in May. The temperature gradually increases from the month of March till the onset of monsoon season in July and gradually decreases from the rainy season to the post monsoon months. The rise in temperature could be due to shorter winter period less intense than summer.

(a) pH & DO:

The pH is the scale of intensity of acidity and alkalinity of water and measures the concentration of hydrogen ions. In the present study the mean values of pH at all the eleven sites of river ranged between 6.91- 8.5. This is in accordance with the prescribed limit of 6.5-8.5.

The DO and pH of the water showed a highly positive correlation in river water. Both the parameters are indicators of good quality water in first of the two phases, that is, up to first six locations. (First phase includes locations u/s to Narmada escape location & second phase includes locations d/s to Narmada escape location.) The quality of water was even better at the location where the Narmada River starts flowing in Sabarmati River bed through the escape and good up to the D/s of Vasana Barrage. At D/s of Vasana Barrage sometimes DO decreases moderately due to the beginning of discharge of urbanization waste. Dissolved oxygen (DO) is very crucial for the survival of aquatic organisms and it is also used to evaluate the degree of freshness of a river. DO in the river water showed marked variation at different sites. The DO value at river upstream ranged from 13.5 mg/l to 6.0 mg/l. The DO level fell sharply in downstream of the river after the Vasana Barrage Location with increase in COD. Hence, COD and BOD parameters needed to be measured after this location. Further in the downstream the persistence DO deficit indicated that the de-oxygenation rate due to biological decomposition of organic matter is higher than re-oxygenation from the atmosphere or probably due to the oxygen demanding industrial wastes

into the water body. DO value also decreases with increase in temperature which proves that at high temperature the dissolution of oxygen decreases in water. Thus, the DO values can be treated as the basic criteria required for water quality assessment.



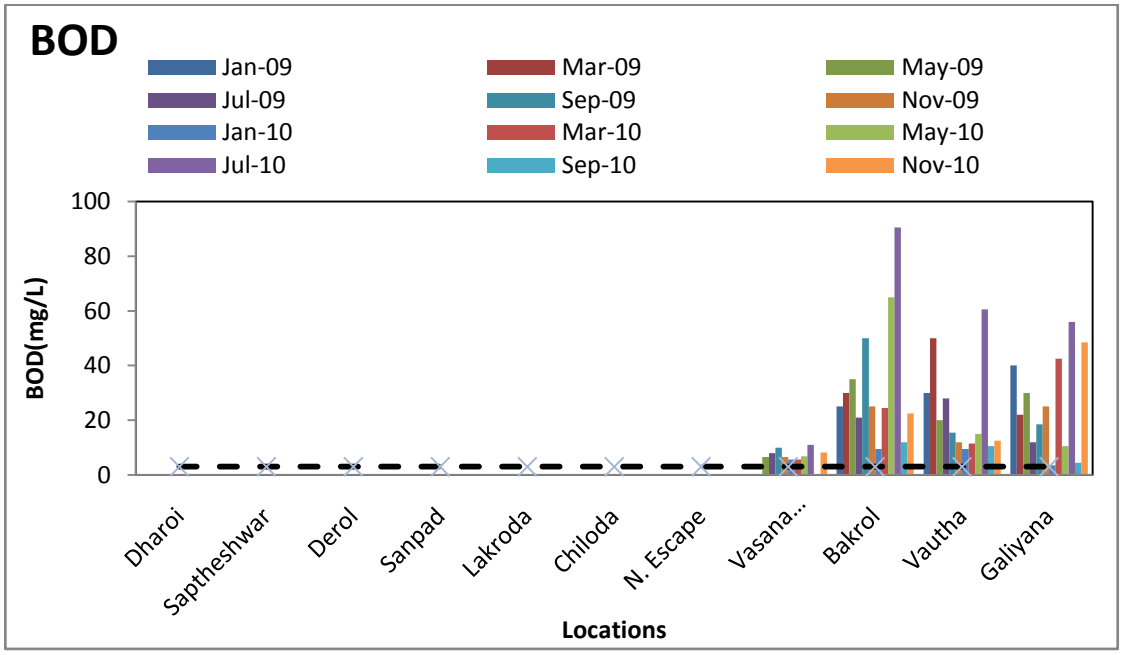
(b) BOD and COD:

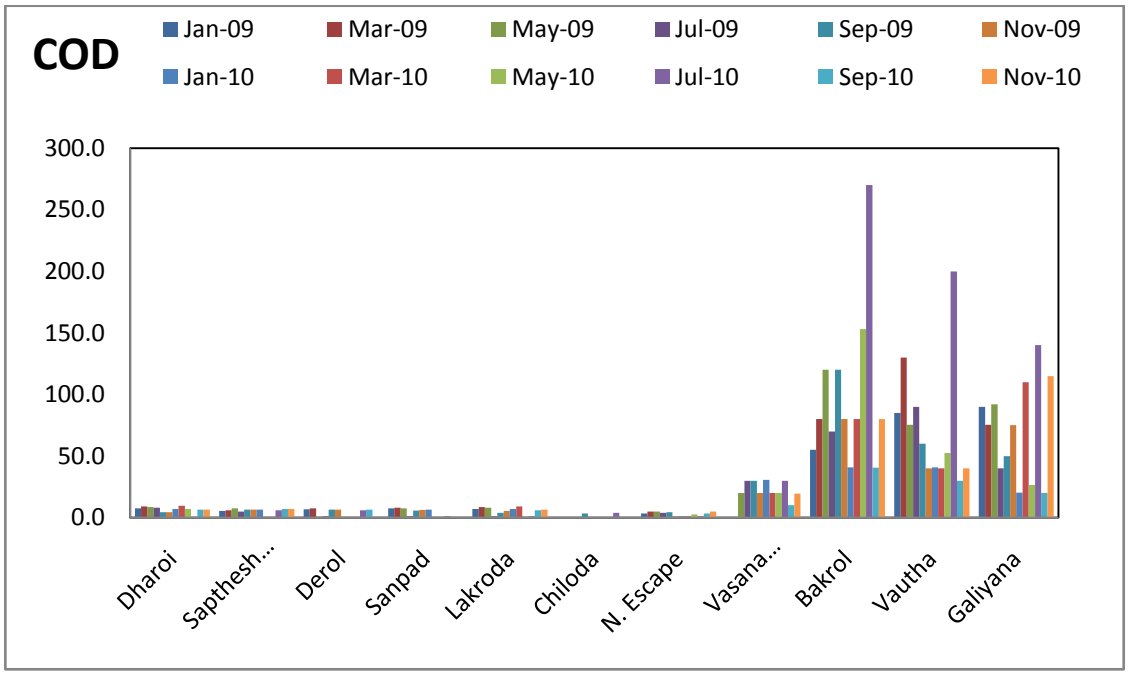
COD is a measure of oxygen equivalent to the organic matter content of the water susceptible to oxidation and thus it is an index of organic pollution in river water.

The COD values are very low in the fresh water region [i.e first of the two phases] and hence the BOD values are not required to be monitored as the DO values also indicate fresh and good quality of water. Normally BOD values are required only when the water is highly polluted or COD values are high due to any reason which may affect the aquatic life.

As the river passes from the Ahmedabad City the beginning of the effect of industrialization and urbanization can be seen at and after the Vasana Barrage location. The value of COD is above the normal and hence DO value is not required to be monitored at these locations.

High value of COD indicates less quantity of dissolved oxygen. The COD value in the second phase of the river (i.e. from Vasana Barrage to Galiyana) ranges from 0-270 mg/l depending upon the quantity of release of water from the Narmada Escape or effect of dilution due to monsoon.

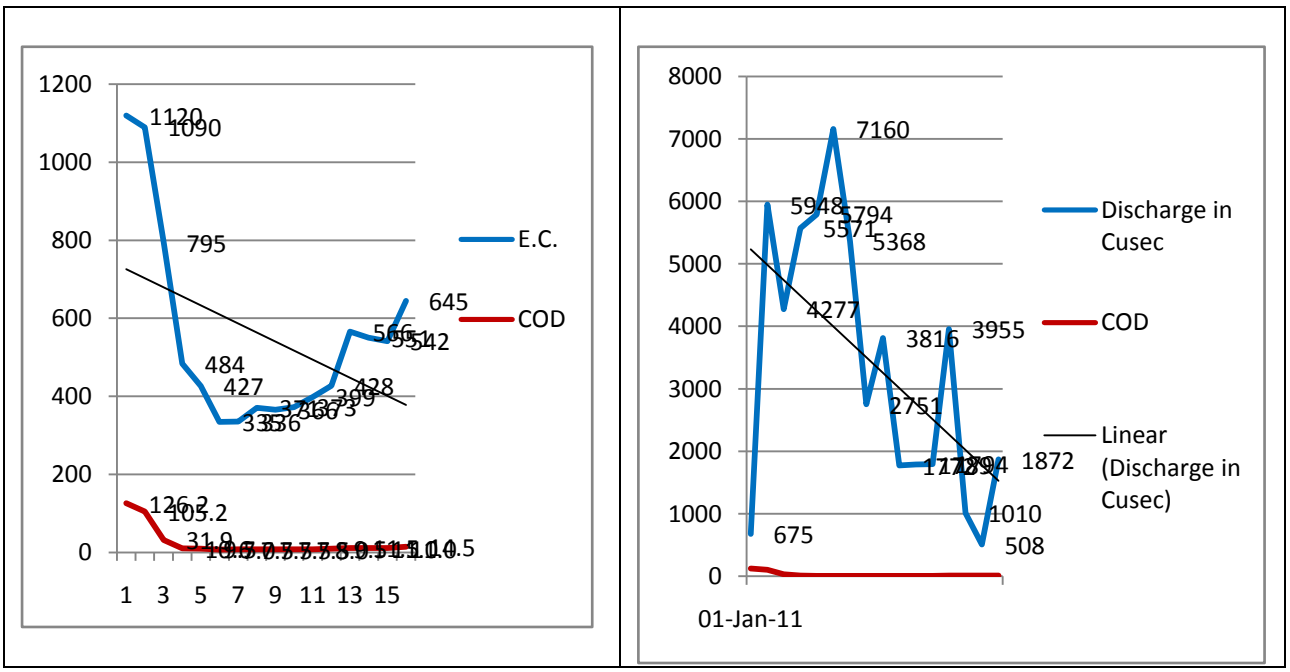




The one month monitoring data given below of COD & E.C. on alternate day basis in the month of January-2011 with respect to quantity of water released reveals that as the quantity of discharge of water from Narmada Escape increases, the value of E.C. and COD decreases and as the quantity of discharge reaches and maintained around 5500 Cusec per day, both the values of E.C. (TDS) and COD remains within the permissible limit. But again as the discharge is decreased,

the value of COD and E.C. (TDS) though look within the permissible limit for few days at the first instance, goes on increasing continuously. Hence, we may say that, discharge of approximately a minimum 5500 cusec of water per day from the Narmada Escape will be the suitable cut-off value to maintain a good quality of water for the domestic purposes.

DATA OF SAMPLES COLLECTED IN JANUARY-2011					
Sr. No.	Date	Discharge in Cusec	E.C.	COD	PH
1	1-Jan-11	675	1120	126.2	6.7
2	3-Jan-11	5948	1090	105.2	6.5
3	5-Jan-11	4277	795	31.9	7.32
4	7-Jan-11	5571	484	10.6	7.25
5	9-Jan-11	5794	427	9.5	7.06
6	11-Jan-11	7160	335	7.0	7.51
7	13-Jan-11	5368	336	7.5	7.38
8	15-Jan-11	2751	371	7.5	7.42
9	17-Jan-11	3816	366	7.5	7.41
10	19-Jan-11	1772	373	7.5	7.55
11	21-Jan-11	1789	399	8.0	7.3
12	23-Jan-11	1794	428	9.5	7.47
13	25-Jan-11	3955	566	11.5	7.32
14	27-Jan-11	1010	551	11.0	7.16
15	29-Jan-11	508	542	11.0	7.29
16	31-Jan-11	1872	645	14.5	7.42

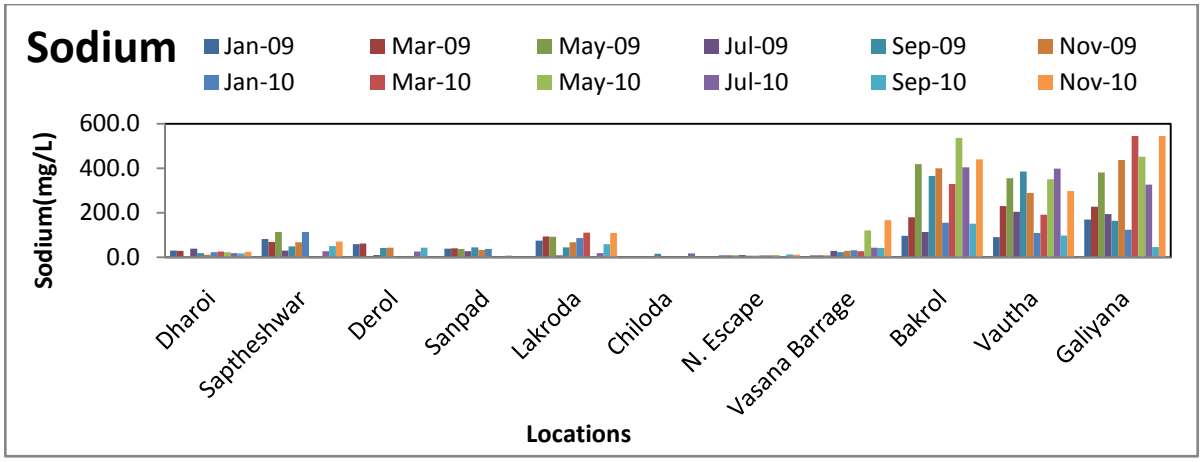


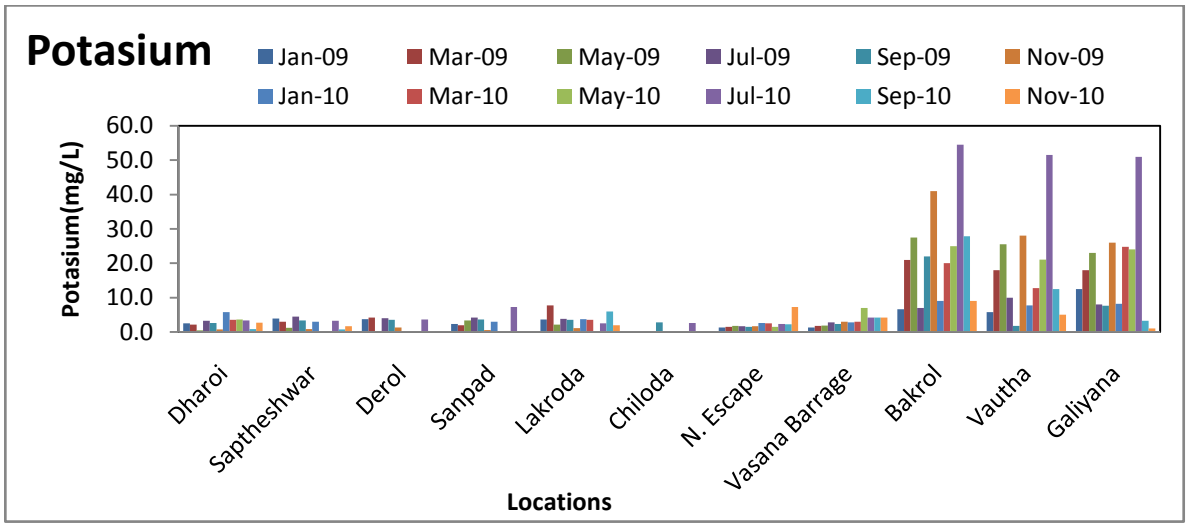
(c) <u>Sodium/Potassium/Calcium/Magnesium & TDS:</u>

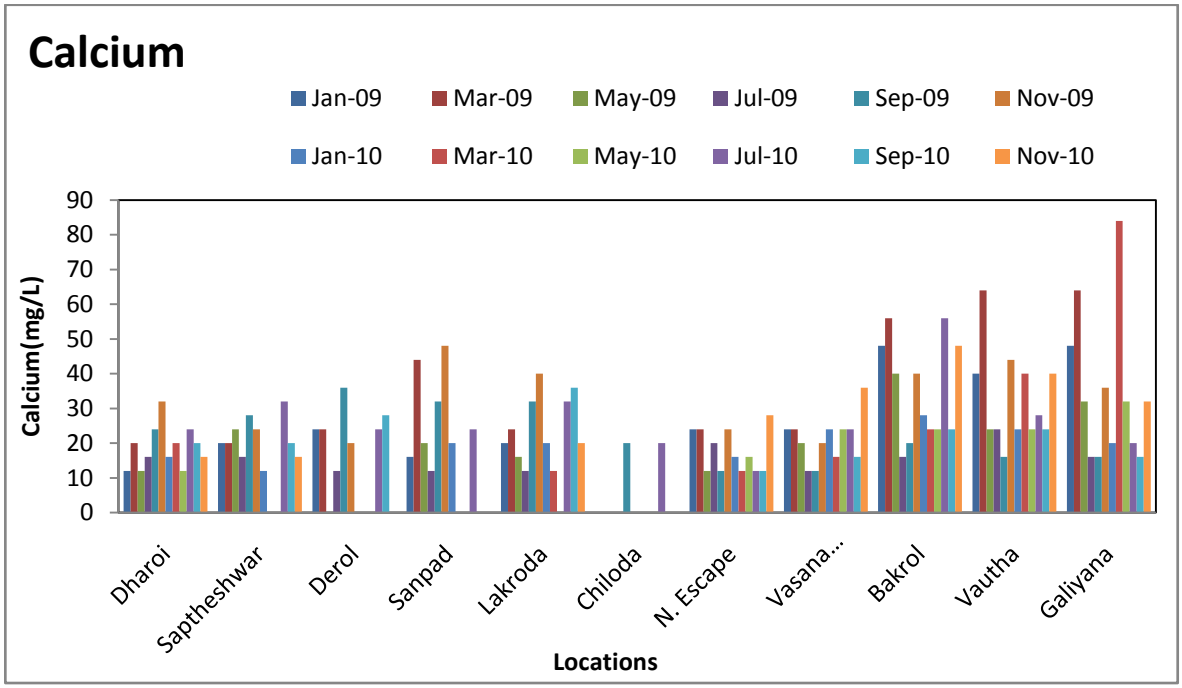
The Na/K values in the entire stretch of River Sabarmati depend mainly on the domestic and industrial activity. Since the river is mainly dry till the Narmada Escape location there is no domestic or industrial activity. Hence, in this stretch the quantity of Na/K is quite less but as the river enters Ahmedabad City domestic activity till Vasana Barrage location is very high hence in this stretch the Na/K value increases drastically. But in the d/s stretch of the river after Vasana Barrage the industrial waste adds to the flow making river water highly polluted. Moreover, in the d/s of the river the tidal effect also adds Na/K salts and hence the Na/K value here shoots up.

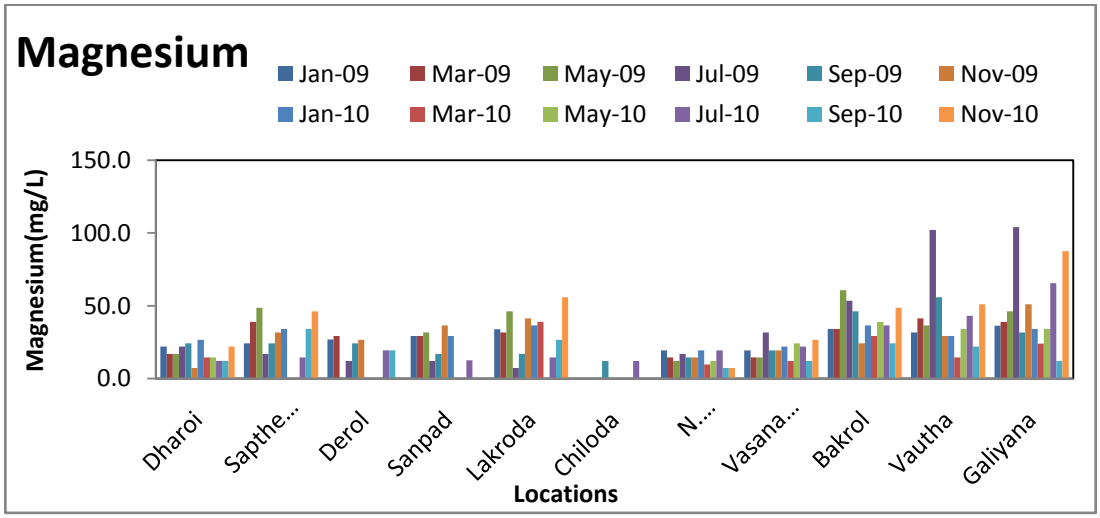
The TDS value is low or within the permissible limits in the fresh water zone that is up to Narmada Escape location and then onwards the TDS value increases as the industrialization and urbanization increases. In this study the primary source for high TDS level in river water may be due to pollution i.e. discharge from industries and sewage treatment plants particularly during dry season. Low values in urban and semi-urban zone might be due to dilution effect due to release of water from the Narmada escape or due to monsoon. The average value of TDS varies between 189.0 mg/l to 1758 mg/l in the entire stretch with 3700 mg/l. being the highest value at Vautha and minimum being 122 mg/l. at Derol.

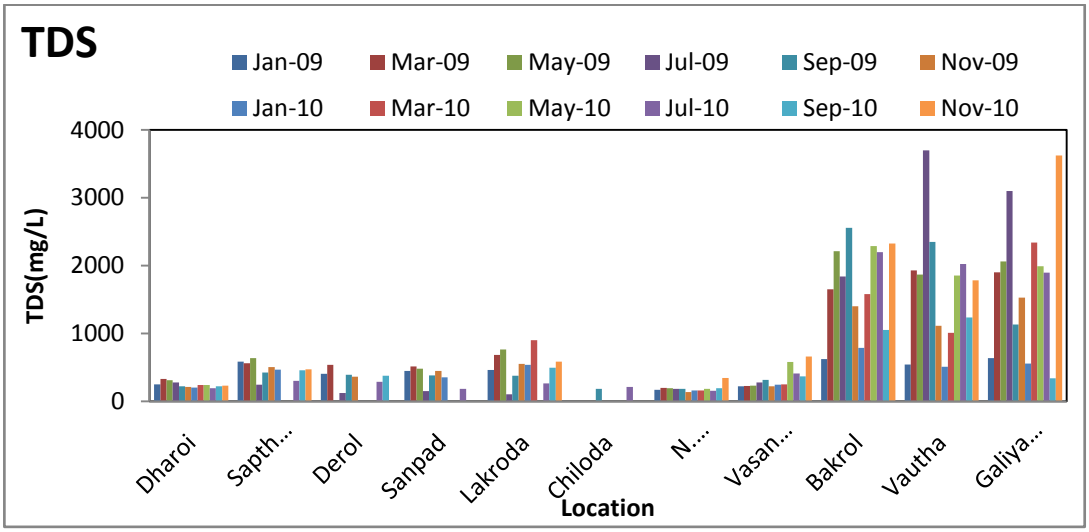
Total hardness is mainly imparted by the calcium and magnesium ions in most fresh waters, which apart from sulphate, chloride and nitrate are found in combination with carbonates and bicarbonates. In the present study Ca+Mg showed higher values in pre-monsoon season due to reduced inflow and evaporation followed by monsoon and post monsoon. The average values of Calcium and Magnesium in river water varied from 12.0 mg/l. in fresh water stretch to 84.0 mg/l. at Galiyana and 7.3 mg/l. in fresh water stretch to 104.0 mg/l. at Galiyana respectively. The hardness of water depends upon the dissolve salts present in the water. The present values in fresh water stretch could be attributed to no discharge of industrial effluent or no industrial activities in this zone containing high values of dissolved cations and anions. However, the average values of Calcium and Magnesium from D/s of Vasana Barrage onwards indicates discharge of industrial waste in very high quantity. Magnesium form salt with chlorides and mainly remains present as $MgCl_2$. It may also remain present with phosphates, sulphates and nitrates. When the Magnesium quantity is high the Calcium remains in the lower range.


Sodium
Jan-09
Mar-09
May-09
Jul-09
Sep-09
Nov-09
Jan-10
Mar-10
May-10
Jul-10
Sep-10
Nov-10
Sodium(mg/L)
600.0
400.0
200.0
0.0
Dharoi
Saptheshwar
Derol
Sanpad
Lakroda
Chiloda
N. Escape
Vasana Barrage
Bakrol
Vautha
Galiyana
Locations


Potasium
Jan-09
Mar-09
May-09
Jul-09
Sep-09
Nov-09
Jan-10
Mar-10
May-10
Jul-10
Sep-10
Nov-10
Potasium(mg/L)
60.0
50.0
40.0
30.0
20.0
10.0
0.0
Dharoi
Saptheshwar
Derol
Sanpad
Lakroda
Chiloda
N. Escape
Vasana Barrage
Bakrol
Vautha
Galiyana
Locations


Calcium
Jan-09
Mar-09
May-09
Jul-09
Sep-09
Nov-09
Jan-10
Mar-10
May-10
Jul-10
Sep-10
Nov-10
Calcium(mg/L)
90
80
70
60
50
40
30
20
10
0
Dharoi
Saptheshwar
Derol
Sanpad
Lakroda
Chiloda
N. Escape
Vasana...
Bakrol
Vautha
Galiyana
Locations



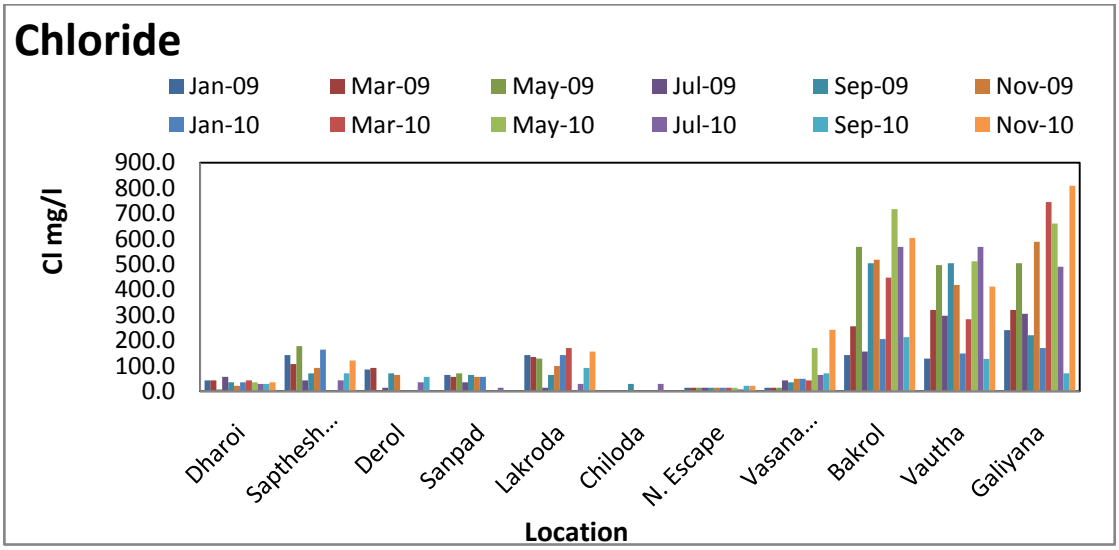


(d) <u>Chloride:</u>

Chloride occurs naturally in all types of water. High concentration of chloride is considered to be the indicator of pollution due to organic wastes of animal or industrial activities. A high value of chloride is troublesome in irrigation water and also harmful to aquatic life. The mean value of chloride varied between 7.1 to 809.0 mg/l in river water with maximum value of 809 mg/l. being at Galiyana location. The downstream locations after Vasana Barrage show extremely high value of Chloride.

High value of Chloride in summer months may be due to high temperature which enhances the evaporation process, reducing the volume of water thus resulting in the high

concentration of salts. Chloride also gets added to waters from the discharge of industrial effluents or gets contaminated with sewage.



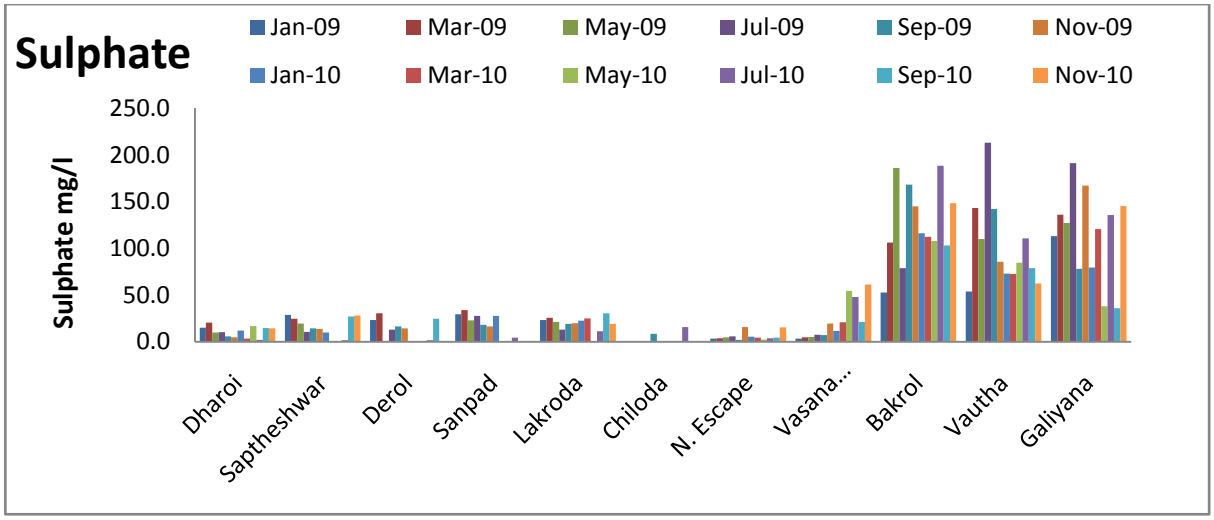
(e) <u>Sulphate, Phosphate and Nitrates:</u>

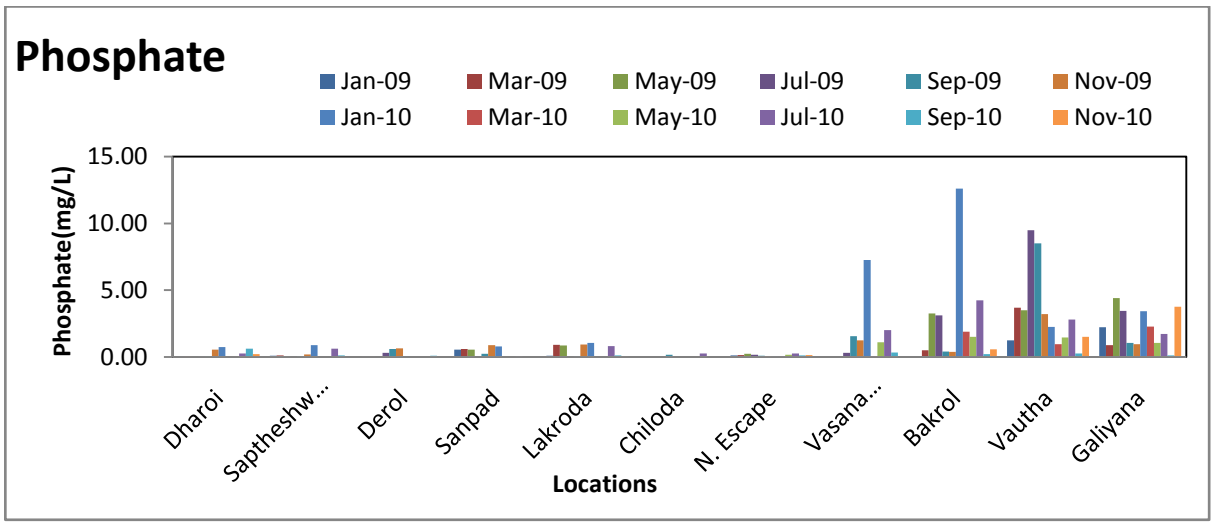
The mean concentration of sulphate was observed in the range of 6.0 to 126.1 mg/l. in the entire river stretch with minimum of 1.7 mg/l. being at Sapteshwar and Derol locations and 213 mg/l. being at Vautha location. The variation in the fresh water stretch depends on the rainfall and the evaporation process. Where as in polluted river stretch the variation depend on quantity of water released from the escape, monsoon, and discharge of polluted water by the industries and the dilution due to tidal effect near the sea.

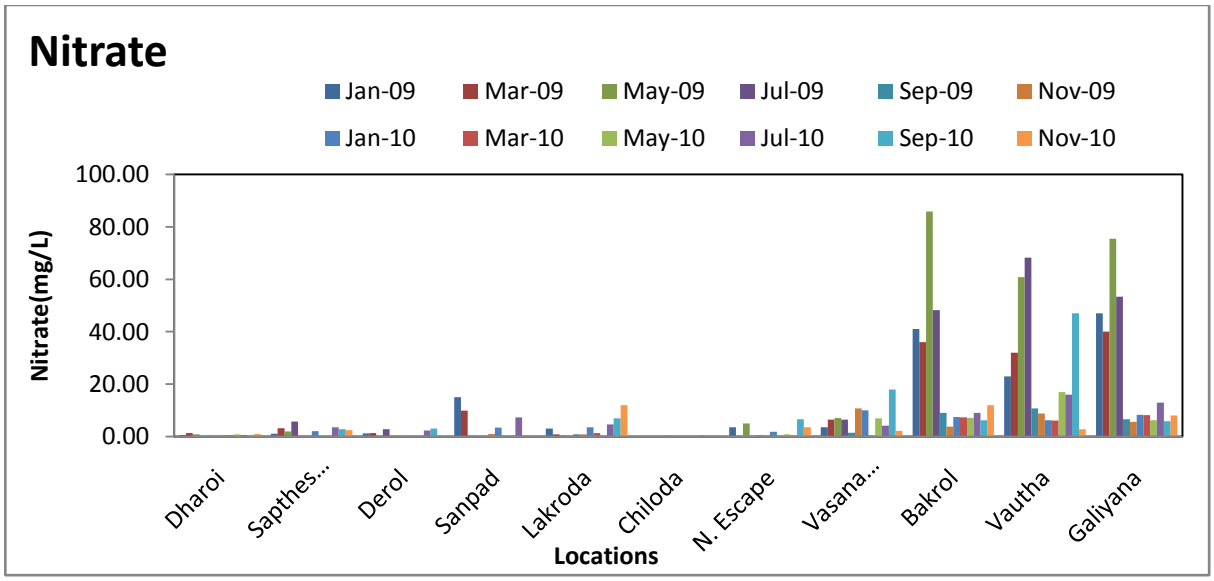
Phosphate is present in natural waters as soluble phosphates and organic phosphates. In river water the phosphate values ranged from 0 mg/l to 3.2 mg/l. with 9.5 mg/l. being at Vautha location. The high concentration of phosphate may be due to detergent contents in the water from urban areas.

The concentration of nitrate varied from 0.0 mg/l to 85.8 mg/l in the entire stretch of the river. i.e. from reservoir to Galiyana, covering the fresh water stretch and polluted industrial waste water stretch.

The highest nitrate value was measured at Bakrol location. Higher values of Nitrate may be because of surface runoff from farms as well as storm water runoff into the river.


Sulphate
Jan-09
Mar-09
May-09
Jul-09
Sep-09
Nov-09
Jan-10
Mar-10
May-10
Jul-10
Sep-10
Nov-10
Sulphate mg/l
250.0
200.0
150.0
100.0
50.0
0.0
Dharoi
Saptheshwar
Derol
Sanpad
Lakroda
Chiloda
N. Escape
Vasana...
Bakrol
Vautha
Galiyana


Phosphate
Jan-09
Mar-09
May-09
Jul-09
Sep-09
Nov-09
Jan-10
Mar-10
May-10
Jul-10
Sep-10
Nov-10
Phosphate(mg/L)
15.00
10.00
5.00
0.00
Dharoi
Saptheshw...
Derol
Sanpad
Lakroda
Chiloda
N. Escape
Vasana...
Bakrol
Vautha
Galiyana
Locations

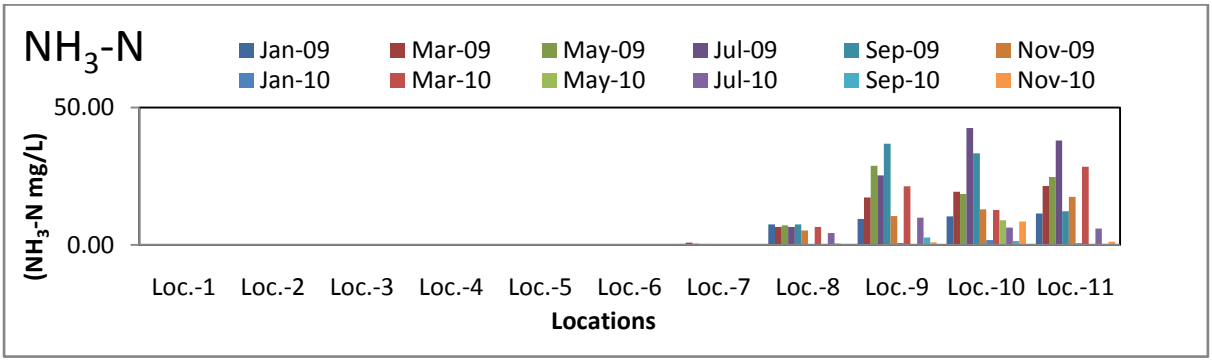

Nitrate
Jan-09
Mar-09
May-09
Jul-09
Sep-09
Nov-09
Jan-10
Mar-10
May-10
Jul-10
Sep-10
Nov-10
Nitrate(mg/L)
100.00
80.00
60.00
40.00
20.00
0.00
Dharoi
Sapthes...
Derol
Sanpad
Lakroda
Chiloda
N. Escape
Vasana...
Bakrol
Vautha
Galiyana
Locations

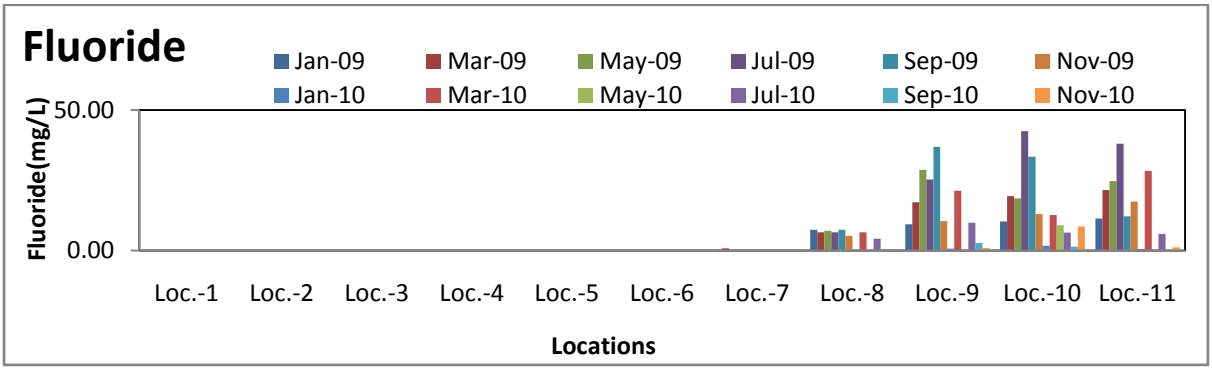
(f) Ammonical Nitrogen:

Ammonical nitrogen gives an indication of industrial effluent discharge. In the entire stretch the concentration of Ammonical Nitrogen was observed only after the Vasana Barrage Location. Many chemical, soap pharmaceutical and steel industries discharge the untreated water into the river. This increases the value of Ammonical Nitrogen. However, the value may decrease on releasing fresh water from Narmada Escape or due to rain or due to tidal effect in case of Galiyana and Vautha Locations. The average value of Ammonical Nitrogen in the entire river stretch ranged from 0 mg/l. in fresh water stretch to 14.7 mg/l. in polluted industrial waste water stretch, with maximum value being 42.5 mg/l. at Vautha location.

(g) Fluoride:

Fluoride is one of the important parameters for the monitoring point of view. But it was observed that fluoride is not a cause of worry so far as the surface water is concern. Of course, it was measured on a slightly higher side in the polluted stretch of Sabarmati River, i.e. only after Vasana Barrage location. The maximum value observed was 1.47 mg/l at Vautha. In fresh water stretch i.e. from Dharoi Dam to Vasana Barrage location it ranged between 0 mg/l to 0.43 mg/l. However this value is within the permissible limit of drinking water standards.



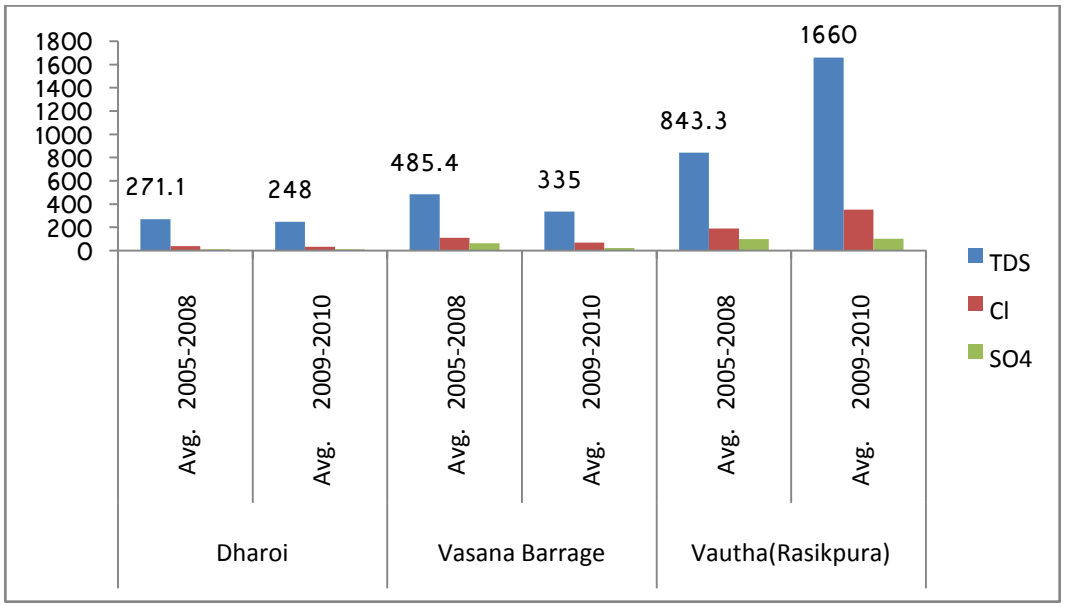


3.2 Data Comparison (SW)

It may be mentioned here that, though the water quality data prior to the beginning of water discharge from Narmada Escape (i.e. before 1998) could not be put on record, but the graphical comparison of 2005-2008 data (studied under HP-I & II) with 2009-10 PDS data and 2006 CWC data of Derol Bridge & Vautha location with 2009-10 PDS data of the same locations reflects the deterioration of river water quality. This means that even though Narmada River water is being often discharged in Sabarmati River there is deterioration in water quality. Hence release of a minimum quantity of 5500 cusec of water per day will help maintaining a reasonably good quality of water for domestic purposes. The graphical presentation of Derol & Vautha is also shown below.

Table below shows comparison of Avg. Value of the Parameters of samples collected by WRI during 2005-08 and by GERI during 2009-10 PDS study

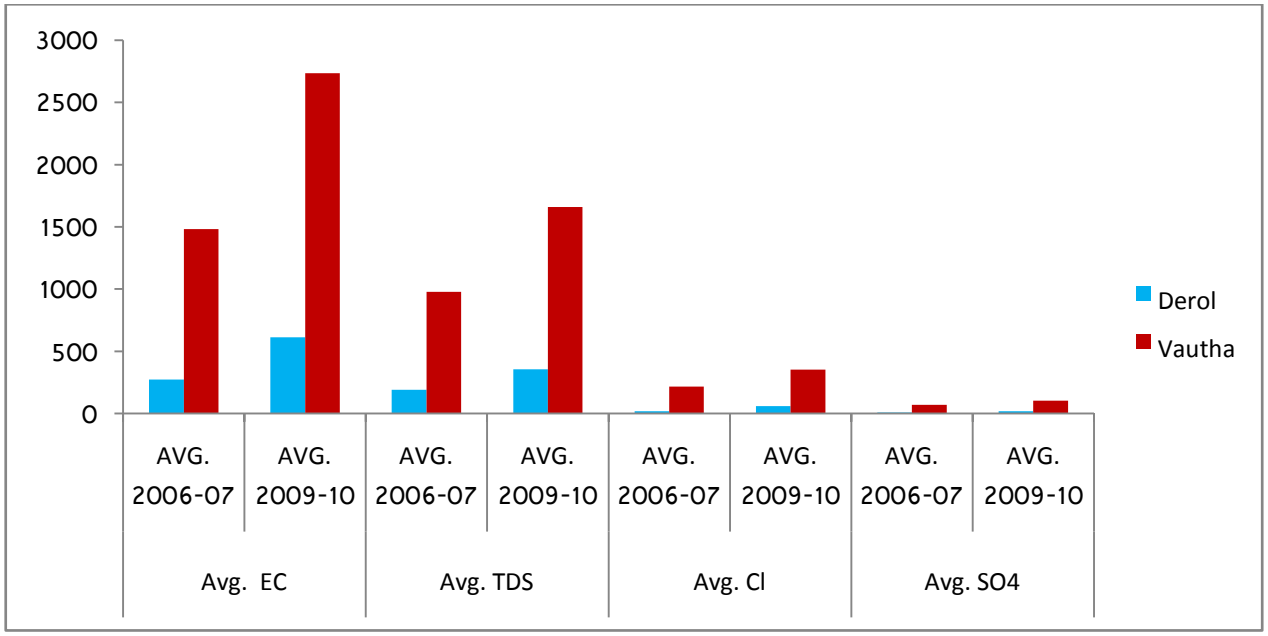
	Dharoi		Vasana Barrage		Vautha(Rasikpura)	
	Avg. 2005-2008	Avg. 2009-2010	Avg. 2005-2008	Avg. 2009-2010	Avg. 2005-2008	Avg. 2009-2010
TDS	271.1	248	485.4	335	843.3	1660
Cl	39.3	34	110.1	67.5	190	351.5
SO4	11.8	10.9	62.7	21.6	100.4	102.4



COMPARISION OF DATA SHOWS THE EXTENT OF DETERIORATION IN WATER QUALITY IN FOUR YEARS														
Sr. No.	Parameter	Unit	Derol Bridge						Vautha					
			2006-07*			2009-10			2006-07*			2009-10		
			Maxi.	Mini.	Avg.	Maxi.	Mini.	Avg.	Maxi.	Mini.	Avg.	Maxi.	Mini.	Avg.
1	E.C._GEN	µmhos/cm	418	129	274	924	221	612	2260	303	1481	6180	861	2734
2	pH_GEN	Unit	7.9	7.0	7.5	8.4	7.3	8.0	8.4	6.5	7.6	8.1	7.0	7.6
3	TDS	mg/l	260	120	190	540	122	355	1430	196	977	3700	508	1660
4	NH_3-N	mg/l	0.02	0.01	0.02	0.05	0.0	0.03	25.8	0.47	16.52	42.5	1.36	14.73
5	Total_P	mg/l	0.08	0.02	0.05	0.65	0.0	0.24	7.00	0.04	1.399	9.5	0.27	3.24
6	NO_3-N	mg/l	1.89	0.17	1.03	3.0	0.0	1.56	3.67	0.63	1.77	68.3	2.8	24.9
7	Na	mg/l	24.0	4.0	14.0	61.3	10.6	40.6	245.7	20.0	155.7	399	90.1	250.3
8	K	mg/l	1.0	1.0	1.0	4.2	0.1	2.9	14.0	1.3	9.7	51.5	1.8	16.6
9	Ca	mg/l	32.0	14.0	23.0	36.0	12.0	24.0	69.0	30.0	51.0	64.0	16.0	32.7
10	Mg	mg/l	6.8	5.8	6.3	29.2	12.2	22.6	20.4	8.8	17.4	102	14.6	40.9
11	Cl	mg/l	32.0	6.0	19.0	92.3	14.2	59.8	316.0	28.0	216.0	568	127.8	351.5
12	SO_4	mg/l	10.9	2.8	6.8	30.5	1.7	17.7	100.2	18.6	68.8	213	53.6	102.4
13	CO_3	mg/l	0.0	0.0	0.0	12.0	0.0	3.4	2.0	0.0	0.2	21.0	0.0	5.8
14	HCO_3	mg/l	127.0	61.0	94.0	177	73.2	143	259.0	105.0	184.0	238	73.2	159.4
15	F	mg/l	0.40	0.22	0.31	0.39	0.09	0.18	0.88	0.54	0.78	1.47	0.25	0.70
16	DO	mg/l	8.4	7.1	7.7	9.8	6.8	8.2	-	-	-	-	-	-
17	BOD	mg/l	-	-	-	-	-	-	17.0	2.6	9.4	60.5	9.5	22.9
18	Turbidity	NTU	1037	29	533	42	5.5	14.1	753	1	94.2	33.0	7.0	12.8

Graph Showing Deterioration in Water Quality from 2006-07 to 2009-10

Location	Avg. EC		Avg. TDS		Avg. Cl		Avg. SO_4	
	AVG. 2006-07	AVG. 2009-10	AVG. 2006-07	AVG. 2009-10	AVG. 2006-07	AVG. 2009-10	AVG. 2006-07	AVG. 2009-10
Derol	274	612	190	355	19	59.8	6.8	17.7
Vautha	1481	2734	977	1660	216	351.5	68.8	102.4



3.3 Observations & Findings: (GW)

In Sabarmati River basin most of the open wells are dry or abandoned. In most of the North Gujarat areas agricultural activities depend either on rain, canal irrigation or on tube-wells. In addition to scanty rain in North Gujarat Sabarmati River is mainly dry up to Narmada Escape location. Hence question of fluctuation in ground water quality due to river does no arise in these regions. However the effect of river water on ground water quality can be monitored from Narmada Escape location, as discharge of Narmada Water from the escape may bring some fluctuation on ground water viz. bore-wells/Tube-wells along the river side. Hence nine (9) bore-well locations along the river side were selected for the purpose.

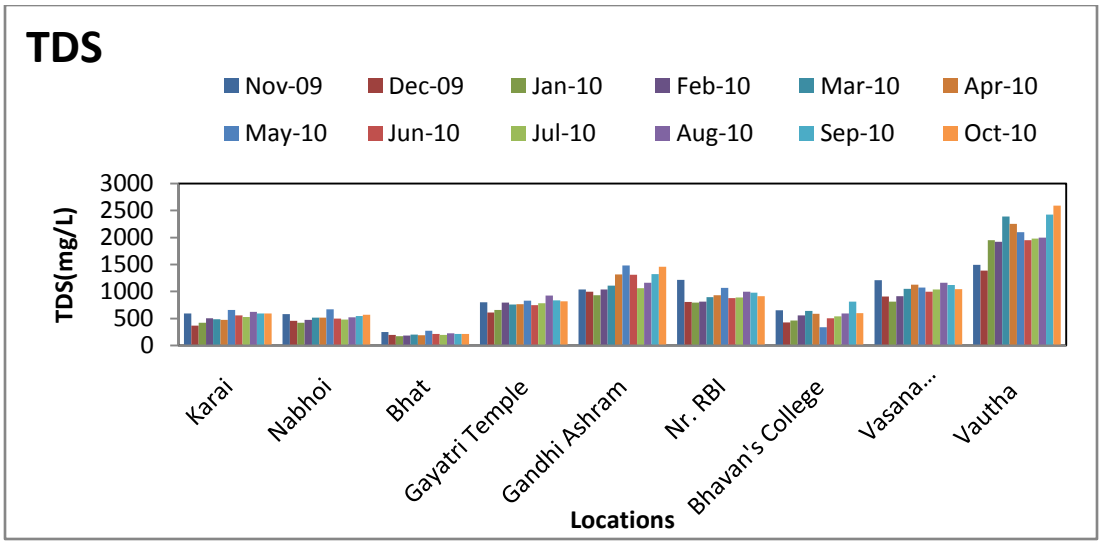
Most of the bore wells are being used for domestic purposes in the city area. The water of three bore-wells used for irrigation purpose is the locations at Nabhoi, Bhat and near Vautha. Hence the parameters like TDS, fluoride and nitrate are of great importance.

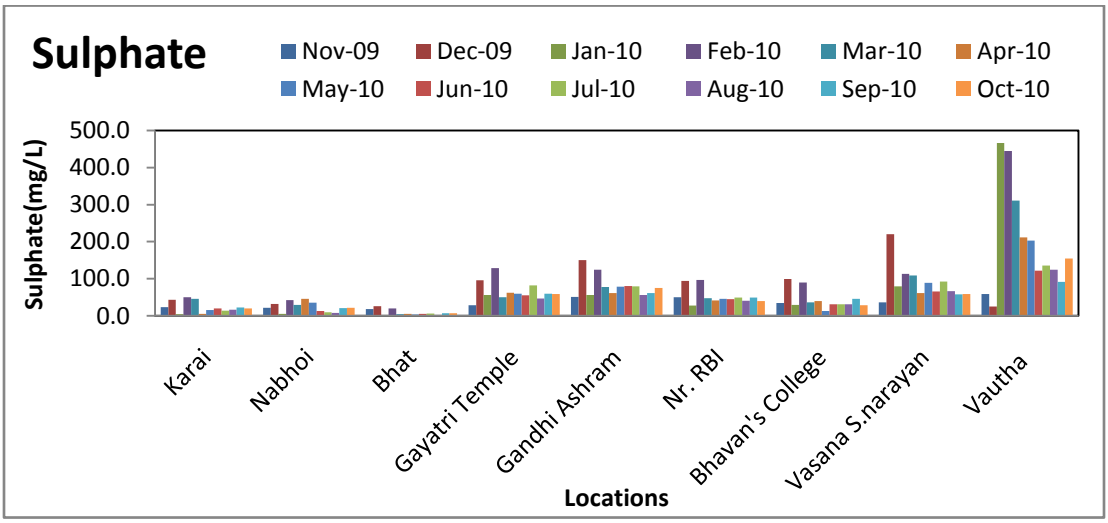
(a) TDS:

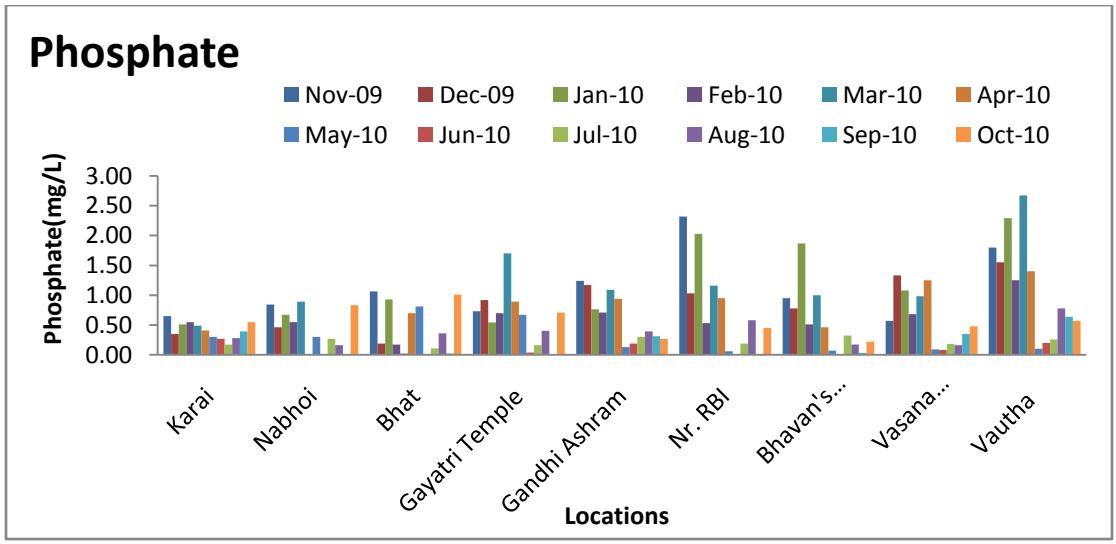
The first two locations namely, Karai and Nabhoi are in upstream just near the point on left and right banks of Sabarmati respectively from where the Narmada water is being discharged in Sabarmati River from the escape. Hence, here the Narmada river water has little impact on the quality of the ground water. The quality of the bore-wells here therefore remains stable throughout the year. The conductivity remains steady around 1000 µmhos/cm and the fluctuation in quality is negligible. However the quality of water is good.

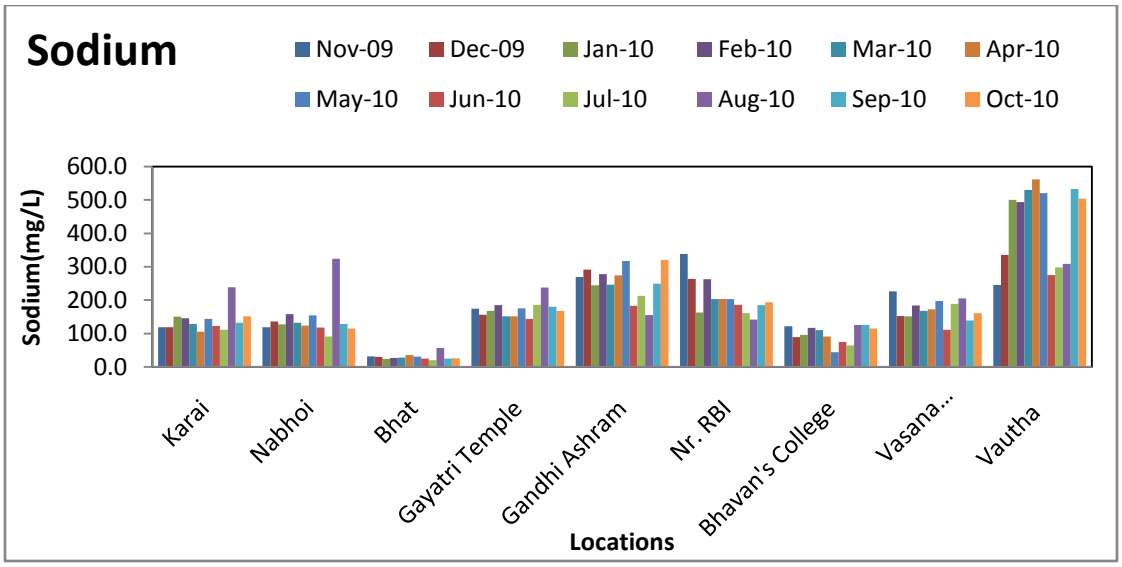
As the Narmada Water flows towards the city the underground water quality at Bhat improves to a great extent. Since this area is a semi urban area the ground water is mainly used for the irrigation purpose compared to the domestic purpose. The quality at this location is quite good even in the pre-monsoon season.

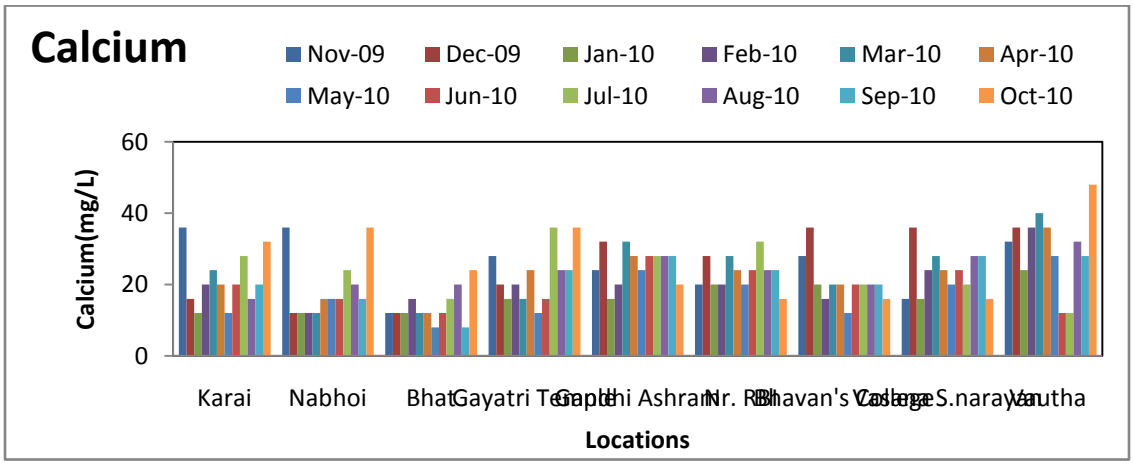
After this location the ground water is largely used for domestic purposes. Many high rise buildings are constructed along the river side having the bore-well facilities. The TDS value in the bore-well water in the city area indicates the depletion in ground water level. However, continuous release of Narmada water from the escape has helped in maintaining the ground water quality. The TDS value from Gayatri Temple to Swaminarayan Temple location varies from 559µmhos/cm to 1185µmhos/cm with other parameters are quite satisfactory including the fluoride. This is well within the prescribed limits of drinking water standards.

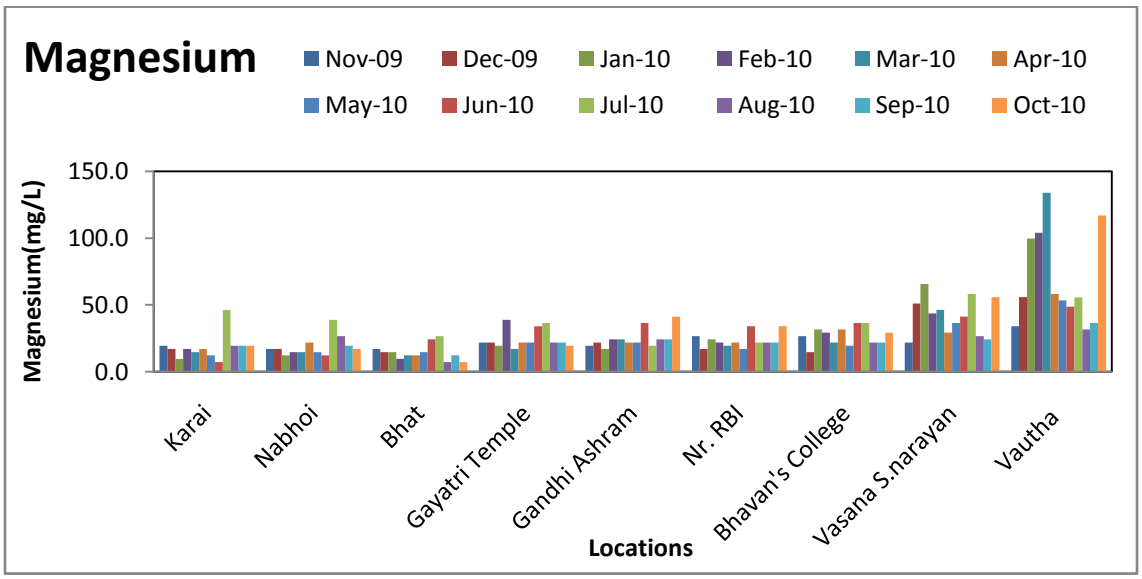

TDS
Nov-09
Dec-09
Jan-10
Feb-10
Mar-10
Apr-10
May-10
Jun-10
Jul-10
Aug-10
Sep-10
Oct-10
TDS(mg/L)
3000
2500
2000
1500
1000
500
0
Karai
Nabhoi
Bhat
Gayatri Temple
Gandhi Ashram
Nr. RBI
Bhavan's College
Vasana...
Vautha
Locations


Sulphate
Nov-09
Dec-09
Jan-10
Feb-10
Mar-10
Apr-10
May-10
Jun-10
Jul-10
Aug-10
Sep-10
Oct-10
Sulphate(mg/L)
500.0
400.0
300.0
200.0
100.0
0.0
Karai
Nabhoi
Bhat
Gayatri Temple
Gandhi Ashram
Nr. RBI
Bhavan's College
Vasana S.narayan
Vautha
Locations


Phosphate
Nov-09
Dec-09
Jan-10
Feb-10
Mar-10
Apr-10
May-10
Jun-10
Jul-10
Aug-10
Sep-10
Oct-10
Phosphate(mg/L)
3.00
2.50
2.00
1.50
1.00
0.50
0.00
Karai
Nabhoi
Bhat
Gayatri Temple
Gandhi Ashram
Nr. RBI
Bhavan's...
Vasana...
Vautha
Locations

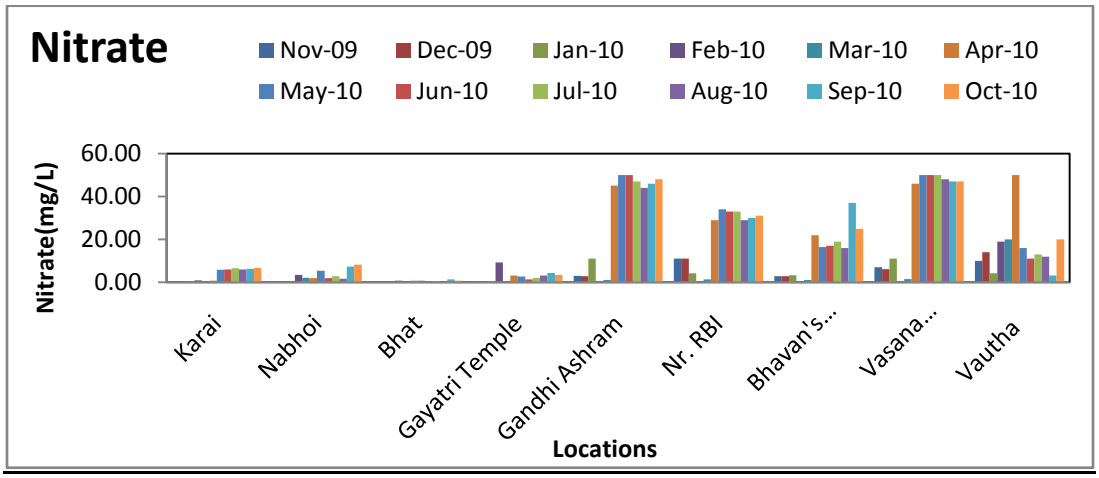

Sodium
Nov-09
Dec-09
Jan-10
Feb-10
Mar-10
Apr-10
May-10
Jun-10
Jul-10
Aug-10
Sep-10
Oct-10
Sodium(mg/L)
600.0
500.0
400.0
300.0
200.0
100.0
0.0
Karai
Nabhoi
Bhat
Gayatri Temple
Gandhi Ashram
Nr. RBI
Bhavan's College
Vasana...
Vautha
Locations


Calcium
Nov-09
Dec-09
Jan-10
Feb-10
Mar-10
Apr-10
May-10
Jun-10
Jul-10
Aug-10
Sep-10
Oct-10
Calcium(mg/L)
60
40
20
0
Karai
Nabhoi
Bhat
Gayatri Temple
Gandhi Ashram
Nr. RBI
Bhavan's College
Vautha
Locations


Magnesium
Nov-09
Dec-09
Jan-10
Feb-10
Mar-10
Apr-10
May-10
Jun-10
Jul-10
Aug-10
Sep-10
Oct-10
Magnesium(mg/L)
150.0
100.0
50.0
0.0
Karai
Nabhoi
Bhat
Gayatri Temple
Gandhi Ashram
Nr. RBI
Bhavan's College
Vasana S.narayan
Vautha
Locations

(b) Nitrate & Fluoride:

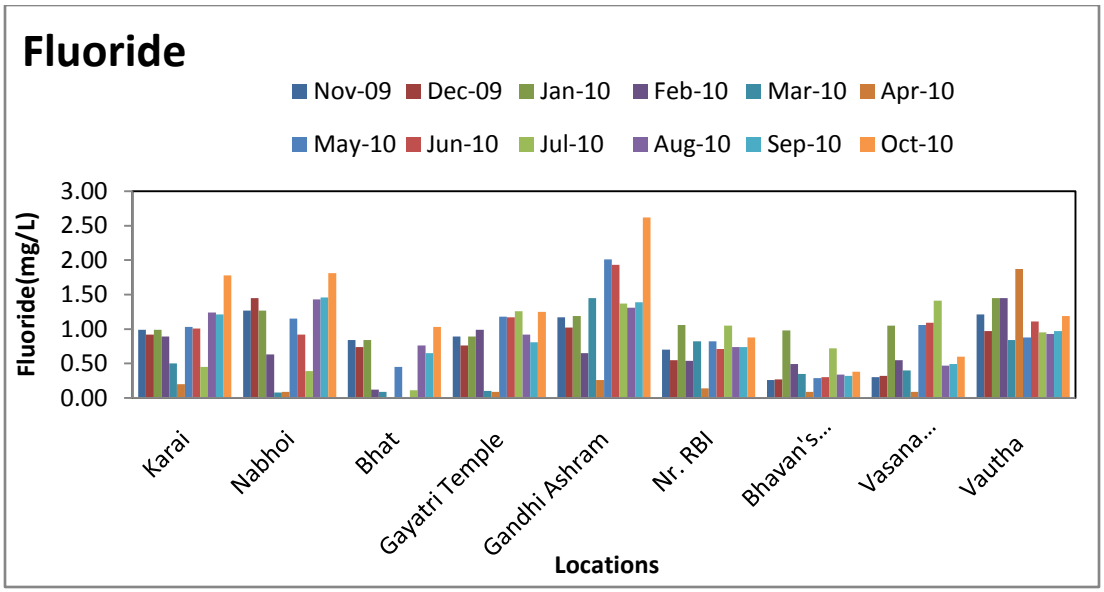
One important feature of the ground water observed at these locations is regarding the quantity of Nitrate parameter. It is observed that from November-2009 onwards, till the end of March-2010 the quantity of water discharged from the Narmada Escape was on an average over 60 MCM every month. And suddenly from April-10 to October-10 there was a sharp decrease in discharge quantity. As the discharge quantity decreases the quantity of Nitrate suddenly shoots up in majority of locations in the city area. This is also the case with the fluoride parameter at few locations.



The table below shows the quantity of water released from the Narmada Escape which can be compared with the observed Nitrate & Fluoride quantity at the location in the city area i.e. location No. 4 to 8.

Table Showing the Quantity of Water Released in Sabarmati River from Narmada Escape *	
Month & Year	**Quantity Of Water Released (in MCM)**
Nov-2009	42.307
Dec-2009	54.363
Jan-2010	82.692
Feb-2010	64.503
Mar-2010	52.396
Apr-2010	22.210
May-2010	31.777
Jun-2010	20.501
July-2010	15.338
Aug-2010	32.075
Sept-2010	64.520
Oct-2010	40.295

(* Data received from Narmada Nigam, Gandhinagar)

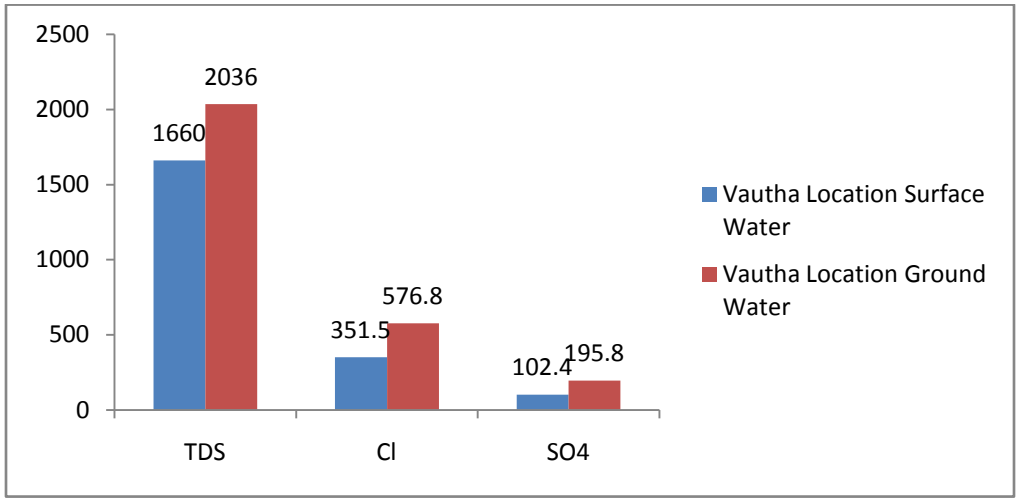


Vautha bore-well located on the bank of the river has direct impact of river which shows high value of TDS due to the recharge effect and penetration of polluted river water horizontally. The quality of bore-well water becomes worst from worse with the increase in pollution due to urbanization and industrialization. Table & graph below shows the effect of pollution in river on nearby bore-well.

3.4 Data Comparison (GW)

Ground Water and Surface Water of Vautha Location

	Vautha Location	
	Surface Water	**Ground Water**
TDS	1660	2036
Cl	351.5	576.8
SO_4	102.4	195.8



Chapter 4

Results and Discussions

The Sabarmati basin extends over an area of 21,674 sq km. Located in Western India, the basin covers areas in the States of Rajasthan and Gujarat. It raises in the Aravalli hills. The total length of the river from the head to its outfall into the sea is 371 km. The river Sabarmati and its tributaries are all rain-fed. The rainfall being fairly low in the basin, its water wealth potential is one of the two lowest in India. Intensive agricultural practices coupled with intensive withdrawal of water for cropping had left the river absolutely dry after it entered the Ahmedabad city limits. The river is in a very serious state and deserves urgent attention.

4.1 Water Quality of river Sabarmati:

The Sabarmati has total length 371 km traversing through two states i.e. Rajasthan and Gujarat. The main stream of river originates from the Aravalli Ranges of Udaipur District of Rajasthan. The river in the upper course of about 100 Km stretch remain dry for almost all round the season. The main tributaries of the Sabarmati River are Wakal river and the Sei Nadi, which also rise in the Aravalli hill range west of Udaipur city and flow south-westwards in courses generally parallel to the Sabarmati River. Owing to the construction of the Dam at Dharoi, Sabarmati River carries only dry weather flow without any assimilative capacity and starts stinking right at the beginning of the city as major storm water outlets discharges Sewage and Industrial waste waters. The Dharoi Dam water is mainly used for irrigation. The river can regain its flow only through ground water accrual and return flows from irrigation. However, during the last two decades the groundwater abstraction in the catchment areas has increased steeply resulting in lowering the water table. Thus the river hardly gets either return flows or groundwater accruals and remains dry for about 8-9 months in a year. The water quality of the river is highly dependent on the availability of freshwater in the river, which is greatly varied with time and space. Precipitation is confined to only three months in a year and varies greatly. Most of the water flows in the Sabarmati (nearly 80%) in monsoon period (July, August and

September) only. Whatever water flows in non-monsoon period (October to June) is extensively used for irrigation and drinking leaving very little or no water in the river to flow.

It is observed that about 70 km long stretch of the river is in bad shape, having water quality, most of the time, below desired level for "designated best use". In the dry season four distinct gradients of pollution load can be discerned in the river stretch between Dharoi Dam and Vautha. The stretch between Vasana Barrage and Vautha is the most heavily polluted one, carrying the massive input of wastewater from Ahmedabad. This input has sets off a progressive series of chemical and biological events in the downstream water. This stretch is characterized by high bacterial population, cloudy appearance high BOD and strong disagreeable odour - all indicating general depletion of oxygen. Masses of gaseous sludge rising from the bottom are often noticed floating near the surface of the water. During monsoon due to flood the sludge deposited in this stretch is flushed and stay in suspension causes rise in oxygen uptake in the downstream. Though there are number of bathing "Ghats along the river in Ahmedabad stretch, the quality of water is far below the bathing standards. Even in this short stretch, remarkable purification takes place due to high temperature and long retention time in this stretch. After a few kilometers the repeated additions of sewage are mainly noticeable by a higher state of Eutrophication leading to the formation of algal mats in the River. Excessive algal can cause problems associated with the oxygen balance in the water (day time super saturation and night time oxygen depletion). The water quality from DO, BOD, and bacterial point of view is not fit for designated best uses of this stretch. In the 60 km long stretch from Vasana Barrage to Vautha, the estuarine region is characterized by self-purification processes of the Ahmedabad effluents. The confluence with relatively clean Bay of Khambat is of great value in diluting the pollution load of Sabarmati River to reduce its effect on estuarine and marine eco-system. During the monsoon period due to huge mass of water flows in the river the barrages are opened leading to a more or less continuous system. The high load of untreated bio-degradable material (domestic sewage) leads several gradients in saprobic and eutrophic conditions; major part of the Sabarmati can hardly fulfill the designated uses.

4.2 Water Quality Segments

Based on flow conditions, water quality and ecological considerations, the Sabarmati River can be classified into four independent Segments. These are:

Segment I:

This segment is identified from the origin to Dharoi Dam. The major source of water in this segment is only run-off water. Due to excessive groundwater extraction in the catchment, this segment remains dry for about 8-9 months in a year and thus, the river ecosystem is adversely affected.

Segment II:

This segment (about 120 km) lies between Dharoi Dam and Vasana Barrage. The water of the river is completely diverted through Dharoi Dam and hence, this segment remains dry most of the time during the year except monsoon. The main source of water in this segment is ground water accrual. Few small tributaries also contribute water in this segment.

Segment III:

This 17 km segment of Sabarmati River is located in between Vasana Barrage and Vautha Bridge. This segment receives wastewater from large number of sewage drains of Ahmedabad city. This river segment terminates into Fattewadi Canal, which is used for irrigation in the downstream.

Segment IV:

This Segment of Sabarmati River is about 40km. long initiate immediately downstream to Vautha Barrage and extends up to confluence to Estuary. The source of water in this segment is ground water accrual. The small tributaries and waste water carrying drains of other settlements contributes in the downstream. The water of this segment is used for domestic purposes, bathing, irrigation and industrial use.

4.3 Important Water Quality Issues of Sabarmati River

The Central Pollution Control Board has been monitoring water quality of the river for the last over 30 years. It has also carried out a river basin study of Sabarmati River during 1985-86. The report of such study was published as river basin report in 1988. All these studies and

other studies carried out by CPCB, GPCB, CWC and other research institutes revealed that Organic and pathogenic pollution originated from discharge of domestic sewage is the major water quality issue for the Sabarmati. The micro-pollutants in terms of pesticides and heavy metals measured over several years revealed that either they are insignificant or occur in some patches of the river. The major water quality issues are as follows:

-Organic Pollution

River Sabarmati receives significantly high amount of organic matter, which is generally, originates from domestic sources. For bio-degradation, this organic waste requires oxygen, causing significant depletion of dissolved oxygen in the river water. The oxygen depletion not only affects biotic community of the river but also affects its self-purification capacity. This problem is critical in the river stretch from Vasana Barrage & Vautha Bridge. In Ahmedabad stretch, the load of organic matter is so high that it consumes the entire dissolved oxygen available in river water.

-High Nutrients Load:

The organic matter after bio-degradation release nutrients in the water. High nutrients concentration leads to Eutrophication, a condition characterized by significant diurnal variation in dissolved oxygen concentration and excessive algal growth.

-High Pathogens:

Continuous flow of sewage waste, dumping of garbage, industrial wastes, religious offerings and in stream uses of water like bathing, cattle wading etc. contribute significant load of pathogens in the river water making it unsuitable for drinking and bathing purposes.

4.4 Critical Segments

The water quality data of the river indicated that the Rajasthan Segment of the river is dry and does not support any aquatic ecosystem on perennial basis. The stretch between Dharoi Dam and Vasana Barrage also remain dry for considerable period in a year. Both these segments are critical from water quantity point of view. Due to non availability of water the aquatic life of the river and terrestrial life supported by the river flow for their water and food needs is seriously affected due no flow conditions in the river. The stretch between Vasana Barrage and Vautha Bridge is heavily polluted and cannot support freshwater aquatic life and

hence it is a most critical stretch in the river. Due to large extraction of water from the river and discharge of large amount of untreated and partially treated sewage into the river the stretch between Vasana Barrage and Estuary is heavily polluted. The stretch between Vasana Barrage and Vautha Bridge is most polluted stretch, carrying the massive input of wastewater from Ahmedabad. This input has sets off progressive series of chemical and biological events in the downstream water. This stretch is characterized by high bacterial population, cloudy appearance high BOD and strong disagreeable odour - all indicating general depletion of oxygen. Masses of gaseous sludge rising from the bottom are often noticed floating near the surface of the water. During monsoon due to flood the sludge deposited in this stretch is flushed and stay in suspension causing rise in oxygen uptake in the downstream. This often results in fish mortality during first flushing after onset of monsoon in the downstream.

4.5 Water Quality Trend of Sabarmati:

The water quality data acquired by GERI during last 3 years are compiled and presented in Figure 3.5 depicting river profile from origin to end in terms of critical pollutants i.e. DO, BOD, Total Coliform and Fecal Coliform. As clear from the figure 3.5, the water quality of the river showed similar trends throughout the 3 year period. The year 2010 was worst for the river in terms of water quality. This can be attributed to draught in the catchment of the river resulting in low flow conditions.

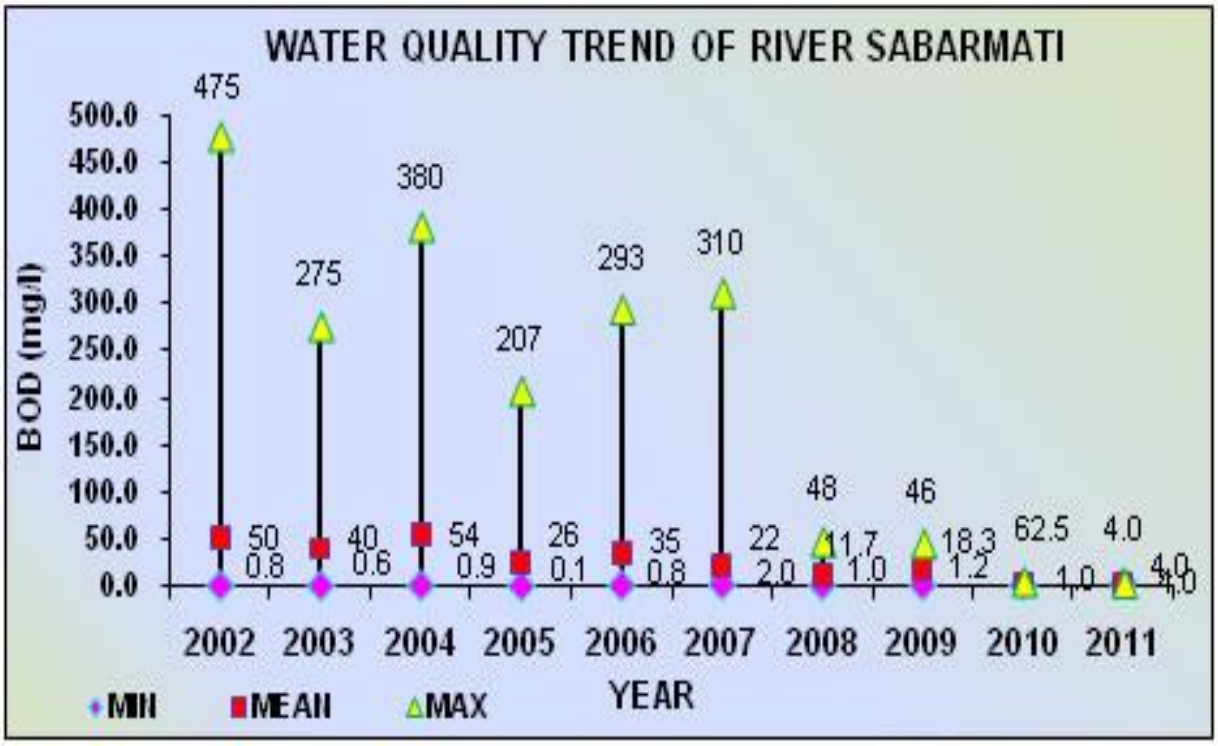
4.6 Water Quality Profile of Sabarmati

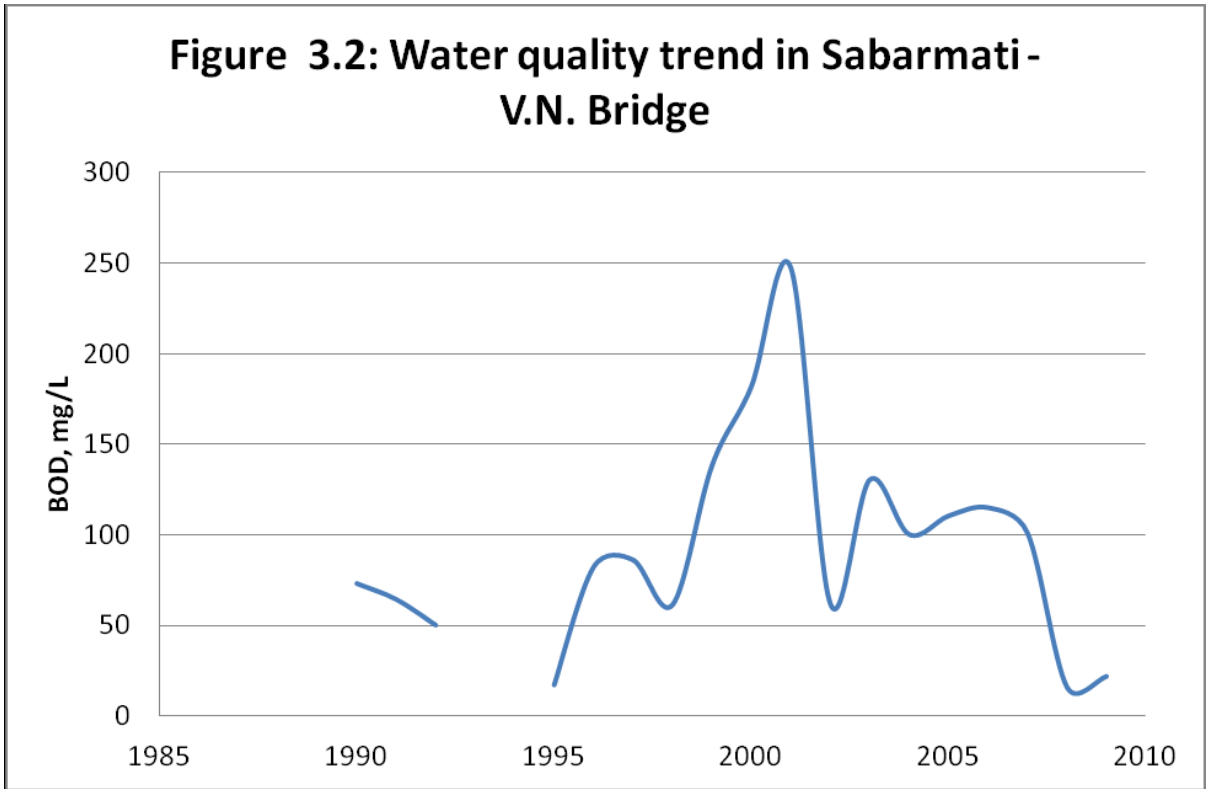
The water quality of River Sabarmati in terms of organic pollution and Coliform count had been satisfactory from origin till Vasana Barrage as evident from Fig. 1 to 5. Though, there was a gradual increase in BOD from origin to upstream Ahmedabad. However, the average BOD values have been well below the designated best use criteria in this stretch. The BOD level increased significantly after Vasana Barrage. This is mainly due to discharge of partially treated wastewater through several drains in Ahmedabad. The average BOD values were not confirming the desired water quality criteria till the estuarine region of the river. In Ahmedabad stretch of the river there are number of bathing "Ghats along the river, the quality of water is far below the bathing standards. Even in this short stretch, remarkable purification takes place

due to high temperature and long retention time. After a few kilometers the repeated additions of sewage are mainly noticeable by a higher state of eutrophication leading to the formation of algal mats in the River. Excessive algal can cause problems associated with the oxygen balance in the water (daytime super saturation and night time oxygen depletion). The water quality from DO, BOD, and bacterial point of view is not fit for designated best uses of this stretch. The 70 km long stretch from Vautha Barrage to estuarine region is characterized by self- purification processes. The confluence with Bay of Khambhat, the river is relatively clean.

During the monsoon period due to huge mass of water flows in the river the barrages are opened leading to a more or less continuous system. The high load of untreated biodegradable material (domestic sewage) leads several gradients in saprobic and eutrophic conditions; major part of the Sabarmati can hardly fulfill the designated uses.

Figurer: 3.1 (DATA PLOTTED BY CPCB)





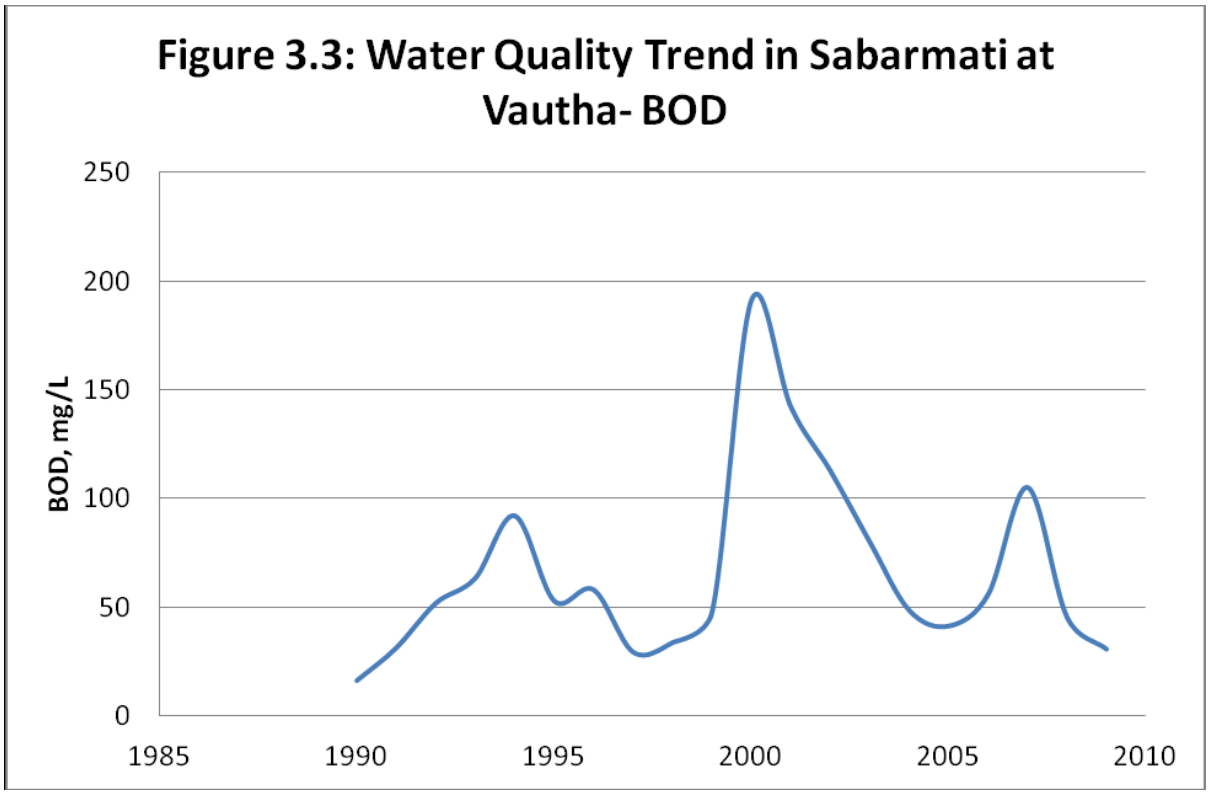


Figure 3.3: Water Quality Trend in Sabarmati at Vautha- BOD
BOD, mg/L
250
200
150
100
50
0
1985
1990
1995
2000
2005
2010

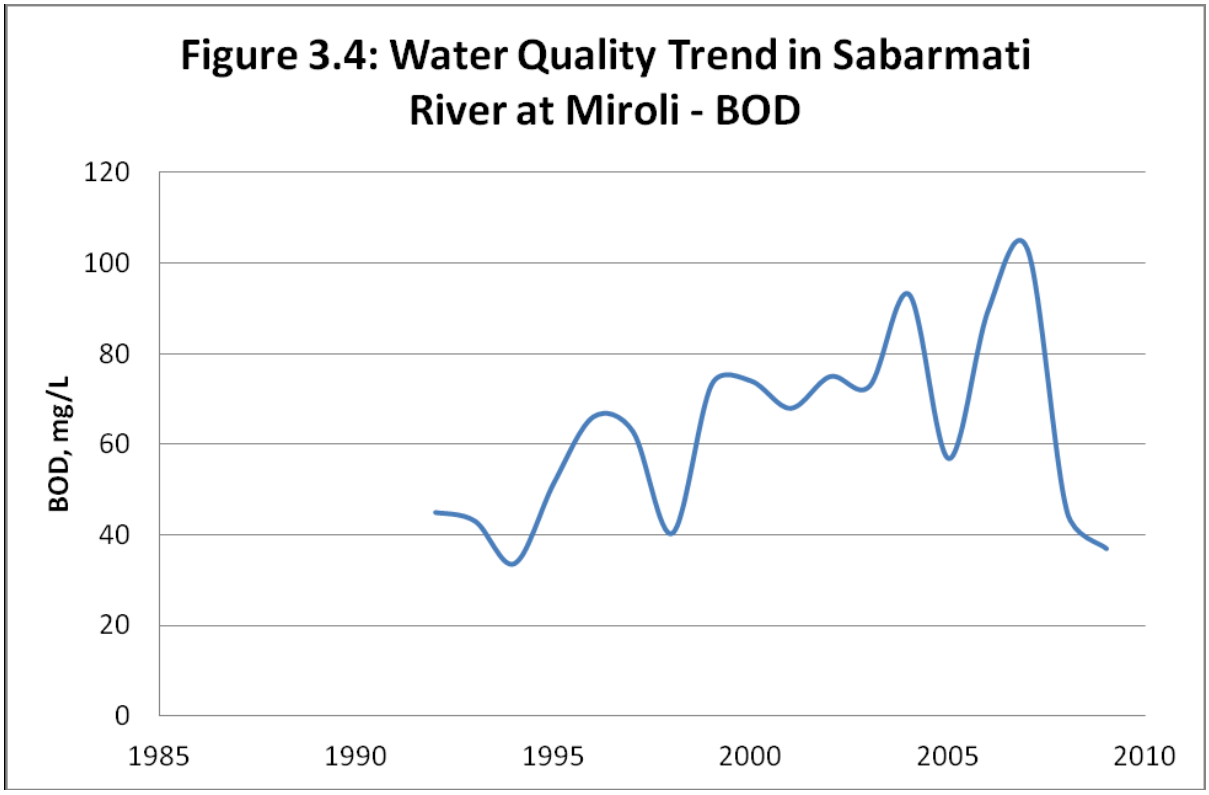
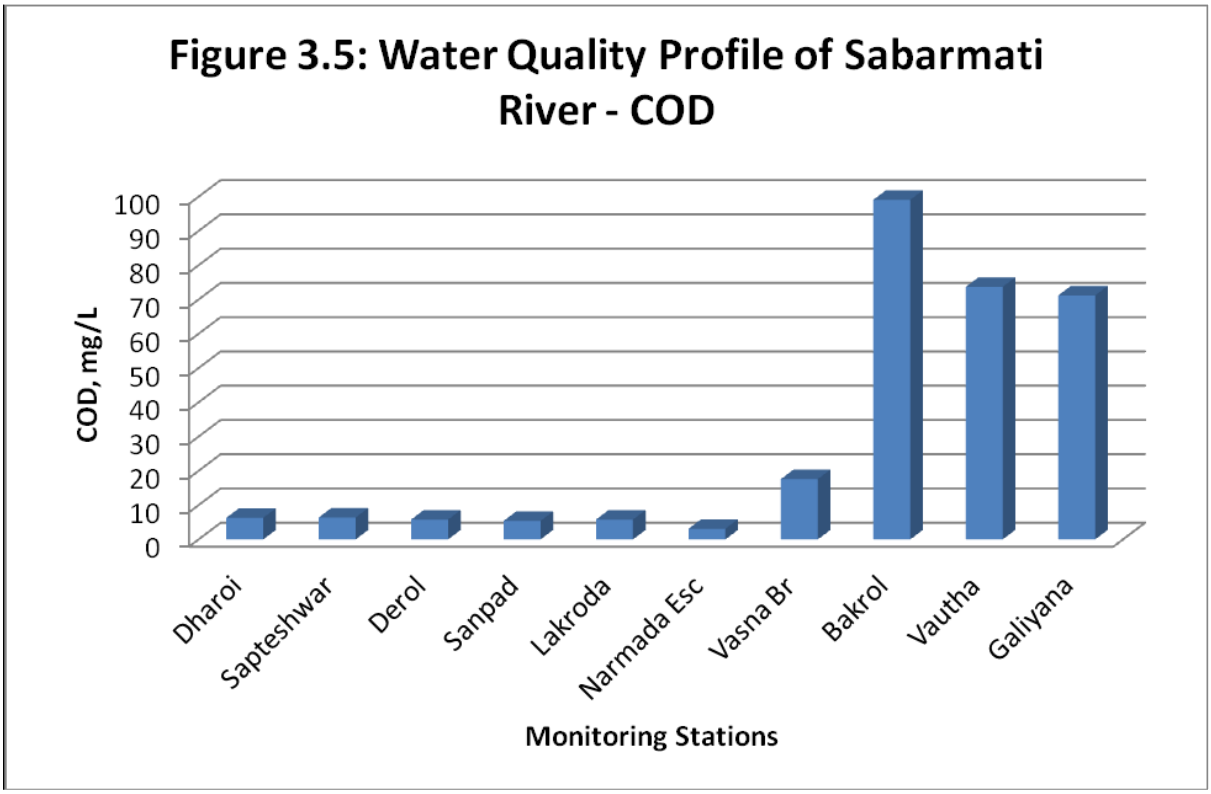


Figure 3.4: Water Quality Trend in Sabarmati River at Miroli - BOD
BOD, mg/L
120
100
80
60
40
20
0
1985
1990
1995
2000
2005
2010

(AS per data acquired by GERI)



Chapter 5

Conclusions:

The present monitoring of the study area gives the clear idea that starting from Dharoi Reservoir the river till the Narmada Escape location is not affected by any man made activities or industrial activities. Hence, the water quality is quite good. Of course, the dry phase and deterioration in water quality of the river is due to natural reasons like climate, temperature, rain and texture of the soils and also may be due to manmade reasons like excess withdrawal of ground water and deforestation.

The results of the present study also showed that the levels of nutrient parameters of water in downstream of river are very much higher than the corresponding levels at upstream which shows that the quality of Sabarmati River at Ahmadabad is being adversely affected by discharge of domestic, agricultural and industrial effluents as a result of extended urbanization. The value of COD becomes higher as the river approaches the Gulf of Cambay. But at Galiyana location few parameters show improvement sometimes due to dilution on account of tidal effect. The higher values of chloride, hardness, organic matter and other nutrients in the downstream of river give unpleasant smell and salty taste to water. The river gets more and more polluted as it traverses downstream in the main city area. The higher value of COD at study area crosses the water quality criteria by any standard. So it should be used only after proper primary treatment. Results of physico-chemical analysis at study area revealed high pollution load with highest values of total hardness, chloride and COD and negligible values of dissolved oxygen during the whole monitoring period. The discharge of partially treated or untreated effluent with high oxidizing matter in the river may be the principal source of pollution and needs to be treated completely before the river water is used for any human intended purposes.

In other words, Sabarmati River maintains reasonable good quality in the upstream of Ahmedabad and thus it satisfies the designated best use criteria most of the times except sometimes in summer season. Addition of huge amount of untreated domestic sewage in Ahmedabad and non-availability of dilution resulted in degradation of water quality in the

downstream stretch of the river. The river in its 70 Km stretch from Ahmedabad to Estuarine Region is not fit for its designated best use even in monsoon season when sufficient dilution is available. The pollution is predominantly organic in nature. Therefore, the depletion of oxygen is the major impact in the polluted stretch of the river which disturbed the river ecosystem to a large extent. The biodegradation of this organic pollution resulted in release of nutrients which in turn promotes the growth of algae and other aquatic plants in the river. This excessive growth of unwanted plants results in the situation of Eutrophication. Due to eutrophic conditions in this segment of the river, the dissolved oxygen during nights is depleted to a large extent resulting in adverse effect on fish and other aquatic life. Thus in this entire stretch of about 100 Km, the oxygen is the key factor which determines the health of the river and distribution of aquatic life in it.

The microbiological pollution is prevailing over the entire Sabarmati River due to contribution of human wastes. The Sabarmati River is used for almost all the uses identified under the designated best use classification by CPCB. Considering the holy nature, people from Ahmedabad city and other parts of Gujarat gather at several places along the river to take holy dip in the river on few auspicious occasions. The results of GERI monitoring indicate that the river is not meeting the designated best use criteria for outdoor bathing. At present there is no study to establish the health impact of taking bath in the river.

The results of micro-pollutant analysis in water and sediment indicate that some of these pollutants especially pesticides like DDT and BHC may be present in quite significant amount. Other micro-pollutants are generally found either below detection limit or in low concentrations. The micro-pollutants are generally discharged along-with huge amount of organic matter and thus they are adsorbed on the surface of organic particles and settle down in the sediment in the bottom of the drains and river bed. This deposited sludge is annually flushed during the floods in monsoon season. Thus, the river and drains are being annually cleaned and are not allowed to build up micro-pollutants in their beds year after year.

The addition of Narmada river water to the Sabarmati resulted in significant improvement in the water quality of the river. However, the improvement is not adequate to satisfy the desired water quality criteria set by CPCB. The water quality trend is also highly

fluctuating in nature indicating irregular variable quantity of water released from Narmada Escape. In order to satisfy the desired water quality criteria it is important to treat the waste water rigorously to achieve much lower level of pollution in the final effluent and release of more water on regular basis from the Narmada Escape.

Chapter 6

Recommendation & Remedies:

The water of the river Sabarmati from its point of origin till the end point that is Bay of Cambay is used for several purposes. From the point of origin to Narmada Escape location its water is mainly used for irrigation and agricultural purposes. And then up to Vasana Barrage location its water is widely used for domestic and industrial purposes. And again from d/s of Vasana Barrage its water is used for agricultural purpose. Hence considering the water use and pollution level at the d/s of Vasana Barrage following remedial measures are recommended for controlling the pollution of River Sabarmati.

(1) First of all, North Gujarat is a scanty rain region with erratic monsoon conditions and semi arid climate added with very high temperatures in summer. Hence, **rain water harvesting** in all possible ways must be given utmost priority. **Check dam** is one of the important methods in this region which should be given highest importance.

(2) Dharoi to Narmada Escape location is a fresh water stretch since there is no man made activities or industrial activities near or around the river. The reason may be the dryness of the river almost all round the year. Hence the water released from the dam is mostly used for the irrigation purposes. However, agriculture activities are also being carried out during the non-monsoon months by using ground water. But, under any circumstances **excess ground water should not be withdrawn** except for the irrigation purposes. This may help in lessening the infiltration of river water.

(3) **Latest irrigation techniques** should be used for agricultural activities **to achieve more crop production with minimum use of water**.

In city area, Sabarmati River does not have the flow of its own. Actually Narmada River water starts flowing in Sabarmati River bed from Narmada escape location. From Narmada Escape location to Vasana Barrage location the water released from the escape is mostly used by AMC for domestic purposes. It is also being

used for irrigation and industries. The primary cause of deterioration of surface water quality is municipal and domestic sewage, industrial wastes (organic & mineral waste) and solid and semi-solid refuse. In most cases the upstream users discharge untreated sewage & toxic chemicals in such quantities so that it becomes too costly to treat for use as a water supply. So it is significant that the waste product discharged by cities and industries be controlled at the point of initiation. But the demand of water for domestic and industrial use has increased to a great extent and moreover it is necessary also to use the river water for these purposes. Hence, following measures are recommended.

(i) Social awareness should be brought by educating people regarding minimizing the use of water and harvesting of water, keeping the river and surroundings clean by not throwing the waste in and around the river. Strict laws should be enforced for this purpose.

(ii) Strict laws should be framed out against immersing 'Offerings' and idols of 'GOD' into the river. As adopted in the states like Karnataka and Maharashtra, authorities may construct temporary 'pools' at different locations in the city area for immersing the idols into the pool.

(iii) Strict rules should be framed out for adopting the water harvesting techniques & should be made mandatory for shopping malls, marriage halls, town halls, theaters, apartments, hotels and temples.

(iv) As per observations a minimum of 5500 cusec of water per day needs to be released from the Narmada Escape to maintain the good quality of water for the domestic purposes.

(v) Projects like **'River Front development'** should be given top priority by the Government & municipal corporations.

(4) From Vasana Barrage onwards as the river flows towards Bakrol, Vautha and Galiyana majority of industries discharge the chemical waste into the river. Hence,

(i) Stringent effluent discharge standards for industries should be prescribed and industries should be allowed to dispose their effluents only after proper treatment.

(ii) More and more water treatment plants should be used.

(iii) In order to prevent polluted river water from affecting the surrounding Ground water, the sources of ground water along the river should be assessed regularly.

:News Report:

(Divyabhaskar News Paper- Dt. 14/10/2011)

વીતેલા દિવસોમાં થયેલા મૂર્તિ વિસર્જનને કારણે દિલ્હીમાં પીવાનું પાણી દૂષિત થવાનો ખતરો વધી ગયો છે. દિલ્હીમાં ખાસ કરીને વજીરાબાદ વિસ્તારમાં મૂર્તિ વિસર્જન થાય છે. ત્યાંથી જ દિલ્હી માટે પાણી પુરવઠો પૂરો પાડવામાં આવે છે. કેન્દ્રીય પ્રદૂષણ નિયંત્રણ બોર્ડના ચેરમેન એસ.પી. ગૌતમે જણાવ્યા મુજબ બોર્ડ યમુના અને અન્ય પીવાના પાણીના સ્ત્રોતોના નમૂના લઇ રહ્યા છે. ટૂંકસમયમાં જ તેના પરિણામો જાહેર કરવામાં આવશે. એક સ્વૈચ્છિક સંગઠન સાથે સંકળાયેલા રવિ અગ્રવાલનું કહેવું છે કે મોટી સંખ્યામાં મૂર્તિ વિસર્જન થતાં પાણીમાં આર્સેનિક, કૈડેમિયમ અને સીસાનું પ્રમાણ વધ્યું છે.

Translation of the aforesaid Gujarati News Report:

In the recent past in Delhi, due to the 'Visarjana' of the idols, the pollution in drinking water has reached the danger mark. In Delhi the 'Visarjana' of idols are made mainly in Vazirabad. The drinking water supply is provided to Delhi mainly from Vazirabad. As informed by the Chairman of Central Pollution Control Board Shri S.P. Gautam the board is collecting samples from Yamuna and other drinking water sources. The reports of the same are expected very shortly. As stated by Mr. Ravi Agrawal associated with one of the voluntary organizations, due to the idol 'Visarjana' in very large numbers the quantity of Arsenic, Cadmium and Lead content has increased in the water.

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