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Original Research Paper

Assessment of Spatial and Temporal Variation in Physico-Chemical Properties of Water in River Sabarmati and Kharicut Canal at Ahmedabad, Gujarat

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ABSTRACT

The Sabarmati river is life-line of Ahmedabad city, as a source of irrigation and drinking water, and as a sink for urban and industrial wastewaters. Ahmedabad is known as a commercial and political capital of Gujarat with highest number of textile mills which poses a major problem of safe disposal of industrial and sewage effluents from different sources. River water quality at Ahmedabad has become a matter of concern due to continuous changing environment and increasing social and industrial activities that influence the water quality directly or indirectly. The present study was conducted to assess the water quality of Sabarmati river and Kharikat canal at Ahmedabad, Gujarat. An assessment of various physico-chemical characteristics of water such as pH, temperature, DO, hardness, acidity, alkalinity, phosphate, sulphate, nitrate, total dissolved solids and COD was carried out from July 2009 to April 2010 at three sites of River Sabarmati and two sites of Kharicut canal to know the pollution status. The correlation matrix among various physico-chemical parameters was also prepared. The study revealed the high pollution load at both the study areas with high values of COD and lower values of DO, which makes these unfit for any human intended purpose.

INTRODUCTION

Rivers are important freshwater resource for humans. However, since old times, rivers have also been used for cleaning and disposal purpose. Huge loads of wastes from industries, domestic, sewage and agricultural practices find their way into rivers, resulting in large scale deterioration of water quality (Khaiwal et al. 2003). The increased demand for water as a consequence of population growth, agriculture and industrial development has usurped environmentalists to determine the chemical, physical and biological characteristics of natural water resources (Sawant & Telave 2009). Increase in urbanization and industrialization has posed a major problem of safe disposal of sewage and industrial effluents in different parts of country. The discharge of industrial effluents has led inevitably, to alterations in the quality and ecology of receiving water bodies and this brings new challenges to both water resource managers and aquatic ecologists (Abida Begum & Harikrishna 2008).

Ahmedabad is located on the banks of the River Sabarmati in the northern part of Gujarat and the western part of India. It is located at 23.03°N-72.58°E spanning an area of 310 km². The average elevation is 53 meters from the mean sea level and is the centre for industrial, institutional and political activities of the Gujarat state, India. It is reviewed from the earlier reports that Sabarmati water is getting polluted due to rapid urbanization and industrialization. GPCB & MINARS (Monitoring of Indian National Aquatic Resources System) have studied the water quality of River Sabarmati and Khari during 2007-08 and reported the high values of different pollutants. The industrial belt of Ahmedabad is mainly situated in eastern part of the city, which includes different industrial estates like Nikol, Odav, Ramol, Vastral, Naroda and Vatva. Vatva is the oldest and largest industrial estate of the state having many small scale as well as large scale industrial units such as industries related to plastics, engineering, machinery and components, chemicals, paints, pharmaceuticals, foundries, textile, etc. Kharicut canal is situated in the eastern part of Ahmedabad city. The Kharicut canal was essentially built for supporting irrigation facilities for villages like Nikol, Odhav, Ramol, Vatva, etc. It is an extension from the river Khari and tributary of the river Sabarmati. Due to enhanced urbanization and industrialization, the disposal of industrial effluent into the Kharicut canal poses serious risk to the humans, animals and aquatic biota. Shah et al. (2008) carried out a study on water quality of Kharicut canal passing through Vatva area of Ahmedabad city.

The present study on water quality evaluation of the river Sabarmati was carried out along its course in Ahmedabad city in relation to Kharicut canal to evaluate the pollution status and variation in physico-chemical characteristics at five different sites.

MATERIALS AND METHODS

Study area: The Sabarmati river is one of the four main rivers, which traverse the alluvial plains of Gujarat. It arises in the Aravalli hills at a north latitude of 24°40’ and east longitude of 73°20’ in the Rajasthan State at an elevation of 762 meters above mean sea level. After traversing a course of about 48 km in Rajasthan, the river enters the Gujarat State and outfalls into the Gulf of Cambay in the Arabian Sea. Approximately 20-22 km stretch of River Sabarmati flows from north to south in the centre of the city and is a major source of water for every sector for the city.

The location of the sampling sites is given in Table 1. Five sites at the two study areas have been selected for the present study. Site 1 viz., Indira Bridge is an upstream; and Site 2 viz., Gandhi Bridge and Site 3 viz., Sardar Patel Bridge represent the mid and downstream and of the river respectively. Currently, the work on Sabarmati River Front Development Project is in progress at these two sites. Two sites of Kharicut canal at Vatva, one near Trikampura Chokdi and other is in Vatva GIDC phase-IV, receive Industrial effluents and sewage water from different industrial units of Vatva GIDC and residential areas of Vatva.

Sampling: The water samples for physico-chemical analysis were collected at monthly interval from July 2009 to April 2010. The sampling was done in morning hours and the surface water samples were collected in precleaned two litre polythene bottles with necessary precautions (Maiti 2001). The parameters such as pH, temperature, free CO_2 and dissolved oxygen were determined in the field. The concentration of DO was measured by azide-modification Winkler method. For analysis of chemical oxygen demand (COD), the pH of the water was lowered to 2.0 by adding H_2SO_4 and brought to the laboratory for further analysis. The other physico-chemical parameters such as total alkalinity, acidity, total hardness, calcium hardness, chloride, phosphate, sulphate, nitrate and COD were measured in the laboratory as per the standard methods of APHA (1987), Trivedy & Goel (1986) and Maiti (2001).

RESULTS AND DISCUSSION

The spatial and temporal variations of physico-chemical characteristics on monthly basis at five sites are depicted in Fig. 2 (Fig 2.1 to 2.14) and the average values along with standard deviation are summarized in Table 2. The temperature of water bodies ranges from 18°C to 33°C and was highest at S-5 in the month of October and the lowest at S-1 in January (Fig. 2.2). Temperature is basically important for its effect on certain chemical and biological activities in organisms in aquatic media. The pH in the present study showed mean values between 7.07±0.419 and 9.10±0.77. The least value was recorded to be 6.50 in the month of September at S-3, while the maximum value of 9.52 in the month of January at S-5 (Fig. 2.1). The range of desirable pH of water prescribed for drinking purpose by WHO is 6.5-8.5, whereas the canal water was found to be alkaline. Similar observations were recorded by Shah et al. (2008). DO in the river water showed marked variation at different sites. The DO value at river upstream ranged from 4.998 mg/L to 7.742 mg/L in the months of July and January respectively. The DO level fell sharply in downstream of the river i.e., at S-2 and S-3 with average values of 4.07 ± 0.652 and 2.29 ± 0.90mg/L, whereas S-4 and S-5 showed the lowest value of DO that were recorded to be 0.47±0.49 and 0.147±0.17 respectively (Fig. 2.3). The release of oxygen demanding industrial wastes into the water body attributes to the lower values of DO (Joseph & Tessy 2010). Free carbon dioxide in the water accumulates due to microbial activity and respiration of organisms. In the present study the average value of free CO_2 concentration ranged between 4.75 and 9.5mg/L in river water (Fig. 2.14), whereas at the two sites of Kharicut canal it could not be analysed due to highly coloured water. The values of alkalinity varied from 110-190.66 mg/L at S-1, 104-187.33 mg/L at S- 2, 123.33- 206 mg/L at S-3, 132.6-551.33 mg/L at S-4 and 175.33-861.33 mg/L at S-5 (Fig. 2.5). The alkalinity of water samples at five sites were mainly due to bicarbonate and not due to carbonate and hydroxide ions as in all the water samples the phenolphthalein alkalinity was zero. Similar results were observed by Thillai Arasu et al. (2007). The hardness of water depends upon the dissolved salts present in water (Prasad & Patil 2008). In most freshwaters, total hardness is mainly imparted by the calcium and magnesium ions, which apart from sulphate, chloride and nitrate are found in combination with carbonates and bicarbonates. In the present study the average values of total hardness varied from 114.06±25.14 to 460.73±271.32 mg/L at the five sampling sites. The range of total hardness in water prescribed by BIS is 300-600

Table 1: Geographical location of sampling sites.

Sr. No.	Site Name	Location
1	Indira Bridge (S-1)	23°5’26’ N 72°37’47’E
2	Gandhi Bridge (S-2)	23°2’24’N 72°34’24’E
3	Sardar Patel Bridge (S-3)	23°0’40’N 72°34’27’E
4	Kharicut canal (Trikampura chokdi) (S-4)	22°59’7’N 72°37’44’E
5	Kharicut canal (Vatva GIDC phase-IV) (S-5)	22°58’11’N 72°39’11’E

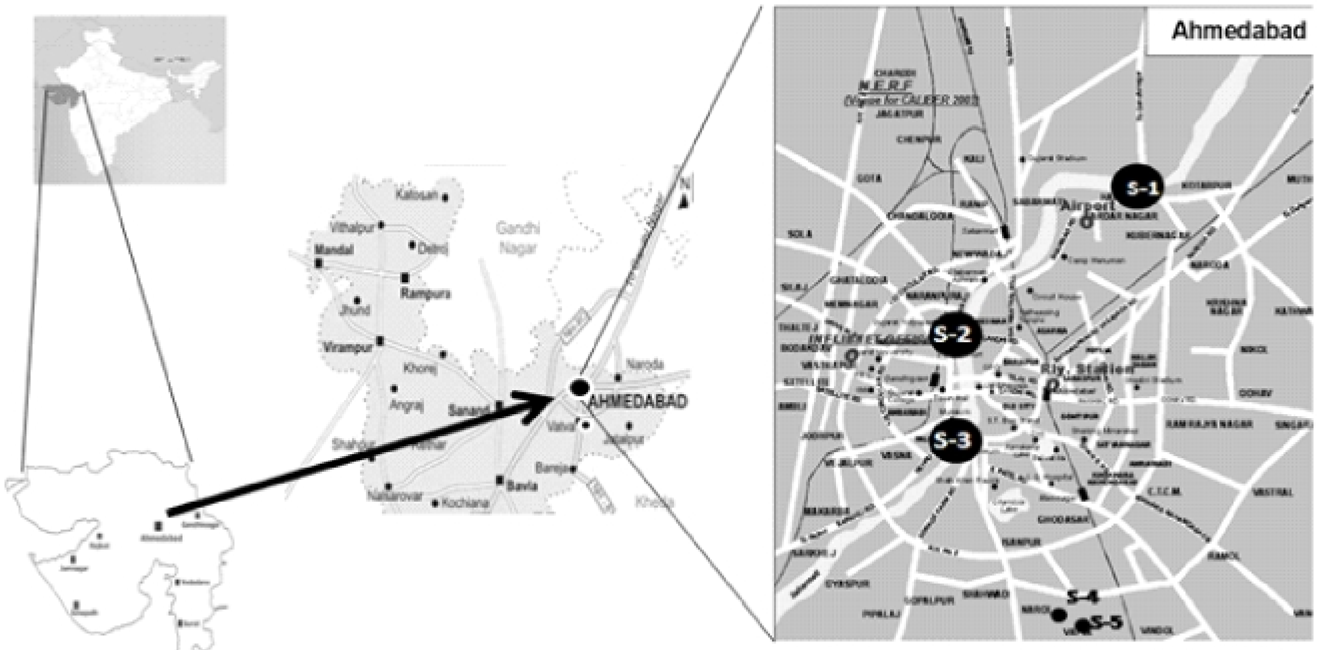

Fig. 1: Location of study area.

mg/L. The values of TDS were found to be the highest in July (840 to 426.66 mg/L) at all the three sites of river and were minimum in January (40 to 133.33 mg/L) (Fig. 2.10). These values are within the range of drinking water standards given by WHO and BIS (500mg/L). Site 4 and 5 showed high values of TDS viz., 1155.33 and 3331.1 mg/L due to discharge of industrial effluents into the canal. The mean value of chloride varied between 17.56 ± 8.52 and 25.88 ± 11.34 mg/L in river water with maximum value of 42.65 mg/L in July and lowest value of 5.99 mg/L in January at S-3 (Fig. 2.6). Whereas canal water showed extremely high values of chloride at S-4 and S-5 which were 168±88.93 and 1743.95±1684.14 mg/L respectively. Thillai (2007) also observed chloride concentration ranging between 9.67 mg/L and 62.33 mg/L in Tamirabarabarani river of south India. High values of chloride in summer months may be associated with high temperature which enhances the evaporation reducing the volume of water, thus, resulting in the high concentration of salts and chloride also get added to waters from the discharge of industrial effluents or contamination with sewage (Kumar et al. 2006 & Suthar et al. 2008). Concentration of sulphate was in the range of 1.16±0.619 mg/L to 8.38±6.85 mg/L and very high value of sulphate was recorded at S-5 in the month of September that is 21.33 mg/L (Fig. 2.12). The values are within the standard limits given by WHO and BIS (200 mg/L for drinking water). Sulphate enters the water body through weathering of sulphides, direct dissolution of salts or industrial pollutants containing sulphur oxide. Sulphate in excess may cause cathartic effect on human beings (Lokhande 2008). Phosphate and nitrate are the two nutrients which promote primary productivity in water body. The monthly fluctuation in phosphate and nitrate are depicted in Fig. 2.11 and Fig. 2.13 respectively. Phosphate content in the water varied spatially and ranged from 0.290-2.67 mg/L at S-1, 0.40-2.55 mg/L at S-2, 0.39-2.88 mg/L at S-3, 0.60-5.41 at S-4 and 0.97-5.71 at S-5. Agricultural runoff as well as wastewater containing detergents tend to increase phosphorus pollution in the present study. The concentration of nitrate ranged between 0.18±0.11 mg/L and 2.77±2.30 mg/L and was within the permissible limit of drinking water standards of WHO (10mg/L) and BIS (45 mg/L max.). The increasing levels of phosphate and nitrates entering rivers have been largely responsible for eutrophication. Eutrophication in river systems can also be caused by the construction of reservoir and locks both of which produce a marked decrease in flow velocities within river (Chapman 1996). The COD is a measure of oxygen equivalent to the organic matter content of the water susceptible to oxidation and, thus, is an index of organic pollution in river (Khaiwal Ravindra et al. 2003). In the present study value of COD was highest 1533.33 mg/L at S-5 in September, and lowest of 13.33 mg/L at S-1 in January. The discharge of highly oxidized chemicals from different industrial units at Vatva is the main reason of high value of COD.

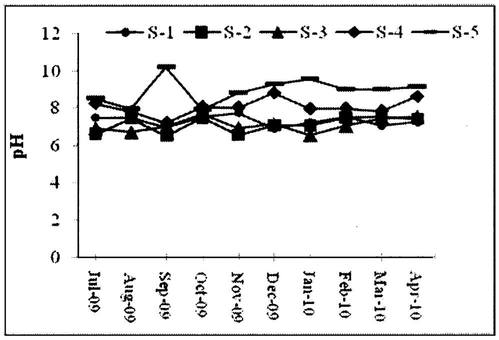

Fig. 2.1: Monthly variation in pH at five sites.

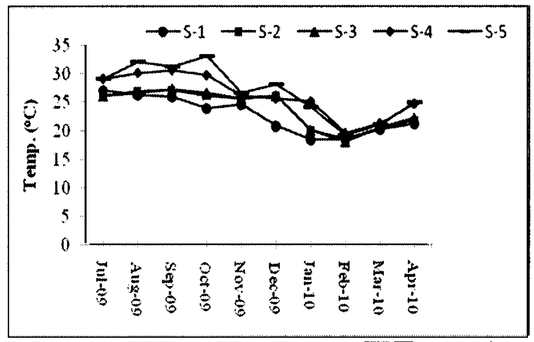

Fig.2.2: Monthly variation in Temperature at five sites.

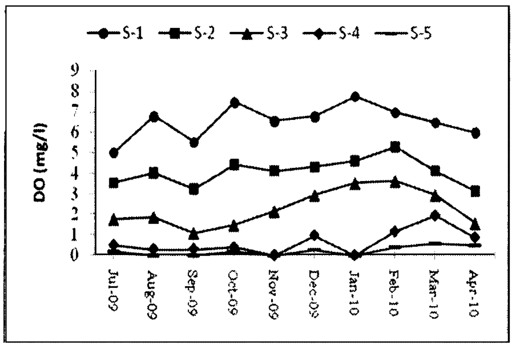

Fig. 2.3: Monthly variation in DO at five sites.

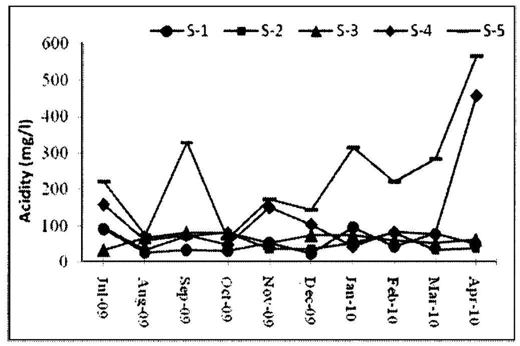

Fig. 2.4: Monthly variation in acidity at five sites.

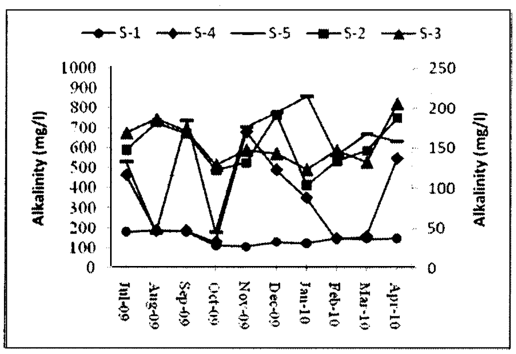

Fig. 2.5 Monthly variation in Alk. at five sites.

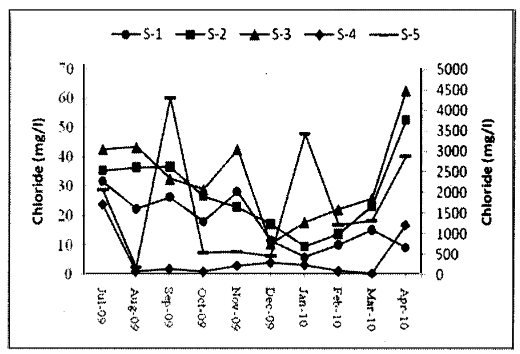

Fig. 2.6: Monthly variation in Cl at five sites.

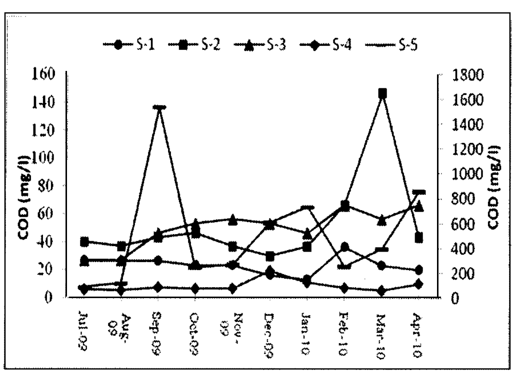

Fig. 2.7 Monthly variation in COD at five sites.

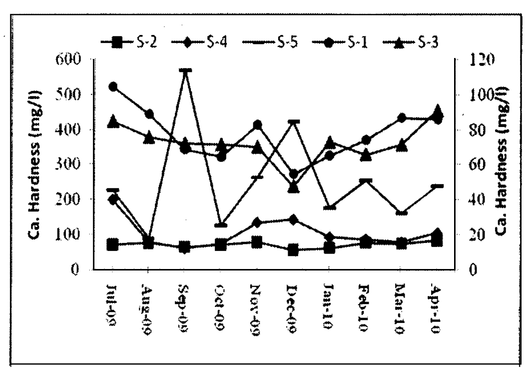

Fig. 2.8 Monthly variation in CH at five sites.

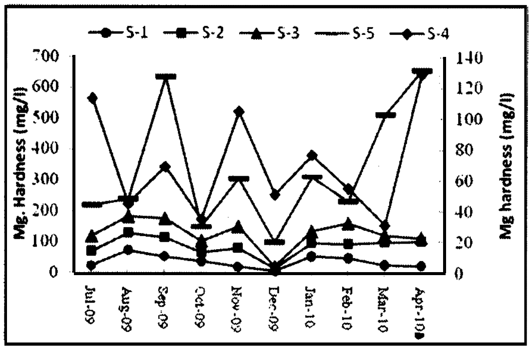

Fig. 2.9 Monthly variation in MH at five sites

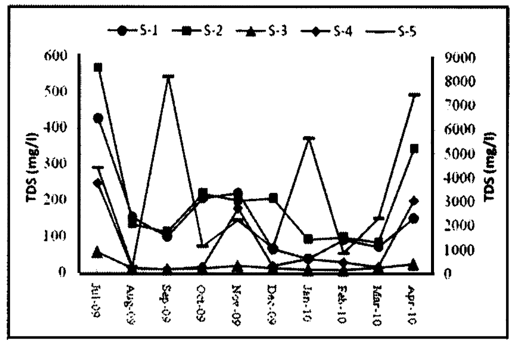

Fig. 2.10 Monthly variation in TDS at five sites

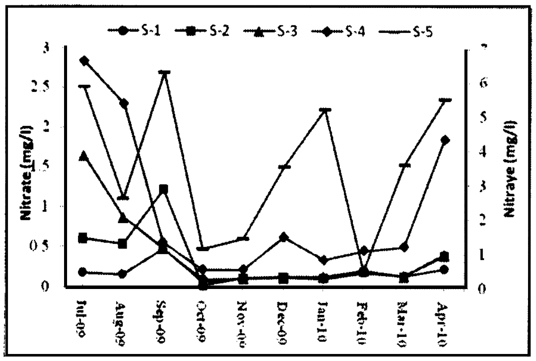

Fig.2.11 Monthly variation in NO_3 at five sites.

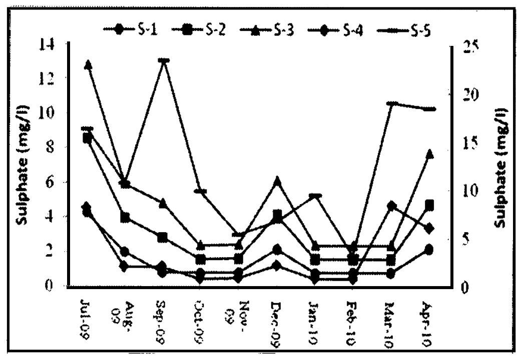

Fig. 2.12 Monthly variation in SO_4 at five sites.

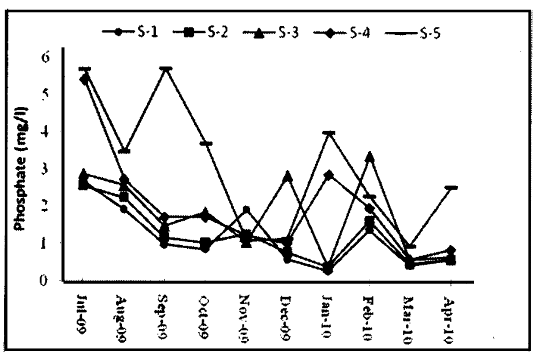

Fig. 2.13: Monthly variation in PO_4 at five site.

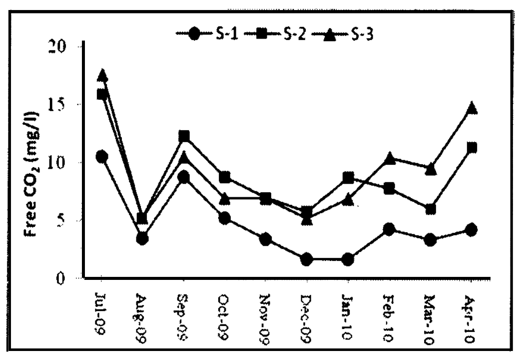

Fig. 2.14: Monthly variation in Free CO_2 at five sites.

Fig. 2 (2.1-2.14): Monthly variation in physico-chemical characteristics at five sampling sites.

Earlier reports of GPCB (2007-08) also observed values of COD ranging between 8 and 20 mg/L at Sabarmati and 30 and 400 mg/L at Khari. The values of COD at all sampling stations exceeded the standard limits of drinking water given by WHO which is 10 mg/L.

The correlation matrix among various physico-chemical parameters at selected sites are given in Tables 3, 4 and 5. The DO and pH of the water showed a highly positive correlation in river water (r = 0.90748). Both the parameters are indicators of good quality water indicating various favourable conditions for high primary and secondary production. DO and temperature (r = -0.91626) are negatively correlated with each other, which proves that at high temperature the dissolution of oxygen decreases in water. Canal water also exhibits negative correlation between DO and temperature with r = -0.6791 and r = -0.51935. In river water calcium hardness bears a negative correlation with number of parameters such as chloride, phosphate, TDS, nitrate and sulphate. This indicates the presence of calcium in the water in less soluble forms, more likely in the form of carbonate, which

Table 2: Average values of physico-chemical characteristics at five sampling sites with standard deviation. Values are in mg/L except for pH and temperature.

S. No.	Parameter	S-1 Mean ± S.D.	S-2 Mean ± S.D.	S-3 Mean ± S.D.	S-4 Mean ± S.D.	S-5 Mean ± S.D.
1	pH	7.31 ± 0.28	7.10 ± 0.416	7.1 ± 0.57	8.05 ± 0.43	8.918 ± 0.69
2	DO	6.51 ± 0.839	4.07 ± 0.652	2.29 ± 0.90	0.64 ± 0.60	0.215 ± 0.22
3	Temperature	22.66 ± 3.229	23.8 ± 3.244	23.83 ± 3.34	26.09 ± 3.75	26.88 ± 4.64
4	Free CO_2	4.752 ± 2.85	8.94 ± 3.34	9.5 ± 4.102	-	-
5	Alkalinity	149.33 ± 29.39	151.26 ± 29.58	155.4 ± 26.75	336.06 ± 199.40	583.4 ± 235.08
6	Acidity	52.833 ± 27.0	56.0 ± 23.74	63.66 ± 15.21	124.66 ± 123.7	239.0 ± 147.36
7	Total Hardness	114.06 ± 25.14	121.66 ± 27.73	113.33 ± 26.78	175.53 ± 68.369	460.73 ± 271.329
7	Ca-Hardness	77.56 ± 14.81	71.12 ± 8.58	72.24 ± 11.42	105.07 ± 42.84	253.4 ± 143.54
8	Mg-Hardness	36.37 ± 20.11	50.47 ± 20.84	41.09 ± 22.96	70.46 ± 34.117	207.33 ± 184.26
9	Chloride	17.92 ± 8.85	27.62 ± 9.61	33.02 ± 15.25	401.642 ± 88.93	1688.37 ± 1421
10	PO_4	1.174 ± 0.78	1.22 ± 0.729	1.77 ± 1.09	2.02 ± 1.40	3.06 ± 1.76
11	SO_4	1.54 ± 1.13	1.68 ± 1.38	1.73 ± 1.20	3.212 ± 2.55	9.011± 5.28
12	NO_3	0.18 ± 0.11	0.34 ± 0.36	0.41 ± 0.49	0.992 ± 0.93	3.554 ± 2.11
13	COD	23.69 ± 6.35	52.66 ± 34.85	50.16 ± 13.52	98.499 ± 47.63	509.92 ± 444.12
14	TDS	153.33 ± 113.13	206 ± 152.33	268.0 ± 216.8	1155.33 ± 140	3331.1 ± 2885.55

Table 3: Correlation matrix of various water quality parameters (three sites of Sabarmati river).

	pH	DO	Temp.	Alkalinity	Acidity	CH	MH	Cl	PO_4	SO_4	NO_3	COD	TDS
pH	1												
DO	0.86012	1											
Temp.	-0.99251	-0.7913802	1										
Alk.	-0.42419	0.09706554	0.531622	1									
Acidity	-0.78276	-0.9907102	0.700894	-0.2315116	1								
CH	0.80921	0.99570653	-0.73139	0.18877787	-0.9990447	1							
MH	-0.75827	-0.9847519	0.672964	-0.2687289	0.9992612	-0.99663	1						
Cl	-0.93139	-0.9867936	0.879953	0.06543435	0.9555984	-0.96756	0.943567	1					
PO_4	-0.49908	-0.8712929	0.389508	-0.5730186	0.9299376	-0.91298	0.943383	0.780291	1				
SO_4	-0.74074	-0.2944549	0.817247	0.92257129	0.1617587	-0.20473	0.123713	0.445368	-0.21245	1			
NO_3	-0.58854	-0.0938185	0.682874	0.98178159	-0.0424431	-0.00126	-0.08081	0.253848	-0.40686	0.979076	1		
COD	-0.89959	-0.9965314	0.839508	-0.0139045	0.9759572	-0.98455	0.966859	0.996851	0.827431	0.372962	0.176343	1	
TDS	-0.8048	-0.9949868	0.726276	-0.1961135	0.9993435	-0.99997	0.997213	0.965647	0.916005	0.197406	-0.00622	0.983213	1

Table 4: Correlation matrix of various water quality parameters at site-4 (Kharicut canal , Trikampura chokdi)

S-4	pH	DO	Temp.	Alkalinity	Acidity	CH	MH	Chloride	PO_4	SO_4	NO_3	COD	TDS
pH	1												
DO	0.20789	1											
Temp.	-0.25112	-0.6791	1										
Alkal	0.583215	-0.29588	0.006943	1									
Acidity	0.51997	0.113065	-0.12724	0.586586	1								
CH	0.587365	-0.11163	0.072693	0.703604	0.272272	1							
MH	0.303893	-0.35457	0.086077	0.782508	0.757986	0.572788	1						
Chloride	0.4631	-0.059	0.160786	0.523473	0.657322	0.741008	0.781092	1					
PO_4	-0.06781	-0.40375	0.395879	0.013512	-0.17586	0.543588	0.284525	0.562639	1				
SO_4	0.399242	-0.02561	0.260917	0.426384	0.646423	0.668937	0.706206	0.973609	0.547923	1			
NO_3	0.043989	-0.21548	0.477734	0.043856	0.001139	0.523854	0.217459	0.562423	0.816024	0.651132	1		
COD	0.636883	0.071476	-0.19876	0.361199	0.104905	0.230086	-0.00534	-0.0259	-0.27433	-0.044	-0.24182	1	
TDS	0.404138	-0.20676	0.071068	0.759345	0.690136	0.746858	0.910091	0.861282	0.392369	0.776128	0.36201	-0.15615	1

Table 5: Correlation matrix of various water quality parameters at site 5 (Kharicut canal , Vatva GIDC phase-IV).

S-5	pH	DO	Temp.	Alkalinity	Acidity	CH	MH	Chloride	PO_4	SO_4	NO_3	COD	TDS
pH	1												
DO	-0.01601	1											
Temp.	-0.31862	-0.59604	1										
Alkalinity	0.857109	0.076965	-0.51935	1									
Acidity	0.599914	0.389223	-0.4306	0.539676	1								
CH	0.783533	-0.13937	0.108732	0.565427	0.247211	1							
MH	0.59967	0.349112	-0.21144	0.427449	0.86155	0.360329	1						
Chloride	0.764808	-0.1206	-0.08775	0.532278	0.73627	0.474889	0.673482	1					
PO_4	0.103204	-0.4868	0.513529	-0.187	0.064037	0.175067	0.028727	0.588311	1				
SO_4	0.408814	-0.51391	0.608751	0.000464	0.25793	0.533164	0.401569	0.685599	0.763693	1			
NO_3	0.437757	-0.60018	0.424103	0.313002	0.042845	0.485525	0.002145	0.58349	0.754387	0.649373	1		
COD	0.860646	-0.1162	0.075722	0.547663	0.587997	0.761595	0.712411	0.797709	0.284229	0.73215	0.43812	1	
TDS	0.686653	-0.08477	0.016731	0.502203	0.817473	0.469095	0.777376	0.943506	0.514204	0.700745	0.515622	0.784724	1

DO - Dissolved oxygen; CH- Calcium hardness; MH - Magnesium hardness; COD - Chemical Oxygen Demand; TDS - Total Dissolved Solids

is also indicated by high values of hardness in water samples (Khaiwal Ravindra et al. 2003). Chloride exhibits significantly positive correlation with phosphate, sulphate and nitrate. There is strong correlation of chloride with TDS and COD (r = 0.978053 & r = 0.90535), the results of the study also indicated the similar relation. At S-5 also, there is positive correlation between TDS and chloride (r = 0.943506) and TDS and COD (r = 0.784724). The COD and DO exhibit negative correlation with each other with r = - 0.87201 at the three sites of river. At S-4 sulphate bears strong correlation with chloride and TDS (r = 0.973609 & r = 0.861282). A positive correlation between sulphate and chloride suggests that they are from similar sources (Abdul-Razak et al. 2009). At S-5 TDS is positively correlated with number of parameters like acidity, chloride, sulphate and COD. Thus, a single parameter of TDS can give reasonably good indication of a number of related parameters. Dissolved oxygen showed a significantly negative correlation with almost all the parameters at all sites. Thus, DO can serve as a single useful index of water quality as with increase in the value of most of these parameters there is decreases of the DO concentration.

CONCLUSION

The present study has provided information about the variation in water characteristics of River Sabarmati and Kharicut canal at Ahmedabad. The quality of water deteriorates in the downstream with high values of COD at all the sites and lower values of DO. The high values are mainly due to contamination with sewage water. So the water of the river can be used only after primary treatment. The results of physico-chemical analyses at Kharicut canal revealed high pollution load which exceeds the prescribed limits of WHO and BIS. The industrial effluent discharge was the main reason and found to be the point source of pollution, so the water of canal needs to be treated properly before its use for any human intended purpose.

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