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RESEARCH ARTICLE

WATER QUALITY INDICES IN CHIPLUN TOWN

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ABSTRACT

Chiplun is a rapidly developing town having average annual rainfall of about 3500 mm, with Vashishthi River as the only primary source of water. Because of a typical valley and hilly geographical location, the town is facing the problem of improper and inadequate drainage, leading to contamination of drinking water resources. Hence, eleven spots (A to K) in Chiplun town were selected for monthly collection of water samples during February 2003 to January 2004. The physico-chemical parameters *viz*. pH, Turbidity, Electrical conductivity, TDS, Total Hardness, BOD, COD, Total Alkalinity, Nitrate and Calcium were estimated by standard methods and used for calculation of Water Quality Indices. The water quality index (WQI) at spot 'C' was 50.2458 while at all the remaining spots it was between 30.2064 and 49.0535. Hence the status of water at all the spots was good except spot 'C', where water quality was poor.

INTRODUCTION

Water is the most important environmental factor essential for well being of the living world, especially for human population. Due to increasing population, mode of water utilization practices has been changed. In many parts of Indian subcontinent, groundwater as well as surface water has been used extensively for drinking, agriculture, industries, livestocks, etc; though the quality criteria of water are different. Sometimes these waters are not suitable for drinking and other purposes because of contaminations (Kulkarni, 1990). Wrong agricultural practices also deteriorate the quality of water by percolation of contaminates through subsoil and bedrock, and reaches the ground water table (Pondhe, *et al*, 1992). Chiplun is a small town in Ratnagiri district, situated along National Highway No. 66, surrounded by Western hilly ranges of Sahyadri and has population more than 65000. It is a fast developing town due to rapid industrialization, Konkan Railway, etc. However, less attention has been paid on the water system. The average rainfall in Chiplun is about 3500 mm/year. The river Vashisthi is the only source of water, which is utilized for water supply by Chiplun Municipal Corporation. The Corporation has setup two water lifting and treatment units, where, filtration and chlorination of water is carried out before it is supplied to the town.

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Due to high percentage of low-income group population, and their inability to meet the water charges, most of their houses are not connected to Municipal water supply. However, Municipal Corporation has dug 29 wells and 39 bore wells to meet the needs of these people. The quantity of daily water supply by Municipal Corporation is not sufficient; therefore, major population utilizes dug wells and bore wells as their secondary source of water without any treatment. Because of typical geographical location of this town, highly porous soil strata and improper and inadequate Municipal drainage system, there are greater chances of percolation of domestic waste and contamination of secondary sources of water.

As a result, people frequently and periodically suffer from epidemic diseases like diarrhea, jaundice, influenza, typhoid, etc. Extensive work on surface water pollution (Khan and Hussain, 1976; Ghosh and George, 1989; Pandey *et al,* 1993) and groundwater pollution (Ugam Kumari and Dilip Pathak, 1993; Pondhe *et al*, 1997; Dhembre and Pondhe, 1997, 1998a, 1998b; Mishra and Patel, 2001) has been done in India. However, reports on water quality in Konkan region of Maharashtra are lacking (Kamble *et al*, 2001), hence attempt was made to monitor the water quality by analyzing ten different physic-chemical parameters during February 2003 to January 2004. Water classification system is based on the purpose for which water is required. In the present study, water samples were analyzed on the basis of potability. The water quality parameters were used to determine water quality

index (WQI); and the relationship between water quality rating and water quality values are tabulated.

Study Area

The study area is located in the survey of India topographic sheet number 47G- Mahabaleshwar (scale 1:2,50,000 - SOI) and it is located at Latitude 17° 13' N and Longitude 73° 30' E. As the study area falls in sub-arid humid zone, it receives high rainfall during monsoon. The nature of soil is highly porous and therefore its water holding capacity is very low, hence it allows rapid percolation of water.

MATERIALS AND METHODS

For collection of water samples, eleven spots (A to K) were selected (Table No. 3). Out of them, five were dug wells (spot A, B, E, G and H), four were bore wells (spot C, D, F and I), one was river (spot K) and one was tap water (spot J). The water samples were collected from these spots in the first week of each month in clean dry polythene containers of two-liter capacity. Physico-chemical parameters *viz.* pH, Turbidity, Electrical conductivity, Total Dissolved Solids (TDS), Total Hardness (as $CaCO_3$), Biochemical Oxygen Demand (BOD), Chemical Oxygen Demand (COD), Total Alkalinity (TAL as $CaCO_3$), Nitrate and Calcium were analyzed by employing standard methods (APHA, 1985). The water quality index (WQI) was determined by using Deiniger and Maciunas method (1971) as given by (Mishra and Patel, 2001).

RESULTS

Annual average values of 12 reading of all the parameters were used for calculating water quality indices. The values of pH fluctuated between 6.53 at spot G and 7.63 at spot K (Table 1). The values of turbidity fluctuated between 0.961 NTU at spot B and 3.139 NTU at spot E. The Electrical Conductivity values fluctuated between 86.833 S/cm at spot K and 673.193 S/cm at spot C. The Total Dissolved Solids (TDS) fluctuated between 39.917 ppm at spot K and 987.5 ppm at spot B. The values of Hardness in terms of calcium carbonate fluctuated between 35.500 ppm at spot K and 317.860 ppm at spot C. The values of Total Alkalinity fluctuated between 35.277 ppm at spot J and 140.043 ppm at spot E. The values of BOD fluctuated between 1.387 ppm at spot K and 3.400 ppm at spot E. The values of COD ranged from 25.257 ppm at spot K to 43.193 ppm at spot F. The values of Nitrate ranged from 0.013 ppm at spot E to 0.121 ppm at spot F. The values of Calcium ranged from 3.597 ppm at spot K to 48.514 ppm at spot C (Table No. 1). The water quality indices for spots A through K have been calculated and presented in Table Number 2a to 2k.

Details of water quality index are as given below.

Calculation of Water Quality Index (WQI)

Water Quality Index (WQI) is defined as the composite influence of different water quality parameter in the quality of water.

Table 1. Average values of Physico-chemical parameters of water samples in Chiplun during February 2003 to January 2004

Parameter/ Spot	A	B	C	D	E	F	G	H	I	J	K
pH	6.62	7.25	7.26	7.60	6.98	6.65	6.53	6.66	6.77	7.15	7.63
Turbidity (NTU)	1.148	0.961	1.799	1.972	3.139	2.074	1.777	2.093	1.308	1.588	1.943
E. C. (S/cm)	198.277	139.727	673.193	163.777	183.110	155.667	172.057	140.277	119.057	92.390	86.833
TDS (ppm)	213.443	987.500	564.777	200.00	238.083	174.750	189.723	161.557	146.860	40.193	39.917
Hardness (ppm)	101.890	117.833	317.860	116.833	152.777	123.140	120.777	117.390	96.000	44.443	35.500
Total Alkalinity (ppm)	82.627	98.667	97.667	126.417	140.043	97.223	93.640	106.443	92.557	35.277	37.783
BOD (ppm)	3.283	3.097	3.133	2.830	3.400	2.780	1.690	2.173	2.880	1.507	1.387
COD (ppm)	29.823	36.290	39.327	41.300	41.717	43.193	33.043	31.300	28.817	26.950	25.257
Nitrate (ppm)	0.047	0.034	0.031	0.036	0.013	0.121	0.031	0.054	0.049	0.042	0.040
Calcium (ppm)	14.736	6.625	48.514	9.819	22.181	10.722	21.414	11.653	6.153	3.889	3.597

Table 2a. Water quality indices for Spot 'A' and 'B'

Parameter	S_n	$W_n = K/S_n$	Spot A				Spot B			
			V_n	$q_n = (V_n/S_n)\ 100$	Log q_n	$W_n \log q_n$	V_n	$q_n = (V_n/S_n)\ 100$	Logq_n	$W_n \log q_n$
BOD	1	0.5691	3.283	328.30	2.5163	1.4319	3.097	309.70	2.4909	1.4175
pH	8.5	0.0669	6.62	-25.33	1.4037	0.0940	7.25	16.67	1.2218	0.0818
TDS	500	0.0011	213.443	42.69	1.6303	0.0019	987.50	197.50	2.2956	0.0026
Hardness	300	0.0019	101.89	33.96	1.5310	0.0029	117.83	39.28	1.5941	0.0030
Alkalinity	120	0.0047	82.627	68.86	1.8379	0.0087	98.667	82.22	1.9150	0.0091
E. C.	300	0.0019	198.277	66.09	1.8202	0.0035	139.73	46.58	1.6682	0.0032
Turbidity	5	0.1138	1.148	22.96	1.3610	0.1549	0.961	19.22	1.2838	0.1461
COD	100	0.0057	29.823	29.82	1.4746	0.0084	36.290	36.29	1.5598	0.0089
Nitrate	20	0.0285	0.047	0.24	-0.6289	-0.0179	0.034	0.17	-0.7696	-0.0219
Calcium	200	0.0028	14.736	7.37	0.8673	0.0025	6.625	3.31	0.5202	0.0015
					$\sum(W_n \log q_n) = 1.6906703$				$\sum(W_n \log q_n) = 1.6517$	
					WQI = 49.0535				**WQI = 44.8436**	

WQI = antilog $[\sum(W_n \log q_n)]$
K = Proportionality constant = 0.56906;
q_n = Quality rating for the n^{th} parameter;
V_n = Observed value; I_n for pH = Ideal value for pH = 7;
I_n for DO = Ideal value for DO = 14.6;
W_n = Unit weight for the n^{th} parameter;
S_n = HDL (Highest Desirable Level);
q_n (pH) = 100 $[(V_n - I_n) / (S_n - I_n)]$
I_n (Ideal value) for all remaining parameters = 00;
Standard values for pH, TDS, Total Hardness (as $CaCO_3$) and Total Alkalinity are as per ICMR;
Turbidity, Nitrate and COD as per BIS; and Conductivity, BOD and Calcium as per WHO.

Table 2b. Water quality indices for Spot 'C' and 'D'

Parameter	S_n	$W_n = K/S_n$	Spot C				Spot D			
			V_n	$q_n = (V_n/S_n)\ 100$	Log q_n	$W_n \log q_n$	V_n	$q_n = (V_n/S_n)\ 100$	$\log q_n$	$W_n \log q_n$
BOD	1	0.5691	3.133	313.30	2.4961	1.4204	2.83	283.00	2.4518	1.3952
pH	8.5	0.0669	7.26	17.33	1.4037	0.0940	7.6	40.00	1.6021	0.1073
TDS	500	0.0011	564.777	112.96	2.0529	0.0023	200.000	40.00	1.6021	0.0018
Hardness	300	0.0019	317.860	105.95	2.0251	0.0038	116.833	38.94	1.5904	0.0030
Alkalinity	120	0.0047	97.667	81.39	1.9106	0.0091	126.417	105.35	2.0226	0.0096
E. C.	300	0.0019	673.193	224.40	2.3510	0.0045	163.777	54.59	1.7371	0.0033
Turbidity	5	0.1138	1.799	35.98	1.5561	0.1771	1.972	39.44	1.5959	0.1816
COD	100	0.0057	39.327	39.33	1.5947	0.0091	41.300	41.30	1.6160	0.0092
Nitrate	20	0.0285	0.031	0.16	-0.8097	-0.0230	0.036	0.18	-0.7447	-0.0212
Calcium	200	0.0028	48.514	24.26	1.3848	0.0039	9.819	4.91	0.6910	0.0020
					$\sum(W_n \log q_n) = 1.7011$				$\sum(W_n \log q_n) = 1.6918$	
					WQI = 50.2458				**WQI = 49.1813**	

Table 2c. Water quality indices for Spot 'E' and 'F'

Parameter	S_n	$W_n = K/S_n$	Spot E				Spot F			
			V_n	$q_n = (V_n/S_n)\ 100$	Log q_n	$W_n \log q_n$	V_n	$q_n = (V_n/S_n)\ 100$	$\log q_n$	$W_n \log q_n$
BOD	1	0.5691	3.4	340.00	2.5315	1.4406	2.780	278.00	2.4440	1.3908
pH	8.5	0.0669	6.98	1.33	-1.3333	-0.0893	6.65	23.33	1.3679	0.0916
TDS	500	0.0011	238.083	47.62	1.6778	0.0019	174.750	34.95	1.5434	0.0018
Hardness	300	0.0019	152.777	50.93	1.7069	0.0032	123.140	41.05	1.6133	0.0031
Alkalinity	120	0.0047	140.043	116.70	2.0671	0.0098	97.223	81.02	1.9086	0.0091
E. C.	300	0.0019	183.110	61.04	1.7856	0.0034	155.667	51.89	1.7151	0.0033
Turbidity	5	0.1138	3.139	62.78	1.7978	0.2046	2.074	41.48	1.6178	0.1841
COD	100	0.0057	41.717	41.72	1.6203	0.0092	43.193	43.19	1.6354	0.0093
Nitrate	20	0.0285	0.013	0.07	-1.1871	-0.0338	0.121	0.61	-0.2182	-0.0062
Calcium	200	0.0028	22.181	11.09	1.0450	0.0030	10.722	5.36	0.7292	0.0021
					$\sum(W_n \log q_n) = 1.5527$				$\sum(W_n \log q_n) = 1.6888$	
					WQI = 35.6999				**WQI = 48.8427**	

Table 2d. Water quality indices for Spot 'G' and 'H'

Parameter	S_n	$W_n = K/S_n$	Spot G				Spot H			
			V_n	$q_n = (V_n/S_n)\ 100$	Log q_n	$W_n \log q_n$	V_n	$q_n = (V_n/S_n)\ 100$	$\log q_n$	$W_n \log q_n$
BOD	1	0.5691	1.69	169.00	2.2279	1.2678	2.173	217.30	2.3371	1.3299
pH	8.5	0.0669	6.53	31.33	1.4960	0.1002	6.66	22.67	1.3555	0.0907
TDS	500	0.0011	189.723	37.94	1.5791	0.0018	161.557	32.31	1.5094	0.0017
Hardness	300	0.0019	120.777	40.26	1.6049	0.0030	117.390	39.13	1.5925	0.0030
Alkalinity	120	0.0047	93.64	78.03	1.8923	0.0090	106.443	88.70	1.9479	0.0092
E. C.	300	0.0019	172.057	57.35	1.7586	0.0033	140.277	46.76	1.6699	0.0032
Turbidity	5	0.1138	1.777	35.54	1.5507	0.1765	2.093	41.86	1.6218	0.1846
COD	100	0.0057	33.043	33.04	1.5191	0.0086	31.300	31.30	1.4955	0.0085
Nitrate	20	0.0285	0.031	0.16	-0.8097	-0.0230	0.054	0.27	-0.5686	-0.0162
Calcium	200	0.0028	21.414	10.71	1.0297	0.0029	11.653	5.83	0.7654	0.0022
					$\sum(W_n \log q_n) = 1.5501$				$\sum(W_n \log q_n) = 1.6169$	
					WQI = 35.4920				**WQI = 41.3904**	

Table 2e. Water quality indices for Spot 'I' and 'J'

Parameter	S_n	$W_n = K/S_n$	Spot I				Spot J			
			V_n	$q_n = (V_n/S_n)\ 100$	Log q_n	$W_n \log q_n$	V_n	$q_n = (V_n/S_n)\ 100$	$\log q_n$	$W_n \log q_n$
BOD	1	0.5691	2.880	288.00	2.4594	1.3995	1.507	150.70	2.1781	1.2395
pH	8.5	0.0669	6.77	15.33	1.1855	0.0794	7.15	10.00	1.0000	0.0669
TDS	500	0.0011	146.860	29.37	1.4679	0.0017	40.193	8.04	0.9052	0.0010
Hardness	300	0.0019	96.00	32.00	1.5051	0.0029	44.443	14.81	1.1707	0.0022
Alkalinity	120	0.0047	92.557	77.13	1.8872	0.0089	35.277	29.40	1.4683	0.0070
E. C.	300	0.0019	119.057	39.69	1.5986	0.0030	92.390	30.80	1.4885	0.0028
Turbidity	5	0.1138	1.308	26.16	1.4176	0.1631	1.588	31.76	1.5019	0.1709
COD	100	0.0057	28.817	28.82	1.4596	0.0083	26.950	26.95	1.4306	0.0081
Nitrate	20	0.0285	0.049	0.25	-0.6108	-0.0174	0.042	0.21	-0.6778	-0.0193
Calcium	200	0.0028	6.153	3.08	0.4881	0.0014	3.889	1.94	0.2888	0.0008
					$\sum(W_n \log q_n) = 1.6491$				$\sum(W_n \log q_n) = 1.4801$	
					WQI = 44.5737				**WQI = 30.2065**	

Table 2f. Water quality indices for Spot 'K'

Parameter	S_n	$W_n = K/S_n$	Spot K			
			V_n	$q_n = (V_n/S_n)\ 100$	Log q_n	$W_n \log q_n$
BOD	1	0.5691	1.387	138.70	2.1421	1.2190
pH	8.5	0.0669	7.63	42.00	1.6232	0.1087
TDS	500	0.0011	39.917	7.98	0.9022	0.0010
Hardness	300	0.0019	35.500	11.83	1.0731	0.0020
Alkalinity	120	0.0047	37.783	31.49	1.4981	0.0071
E. C.	300	0.0019	86.833	28.94	1.4616	0.0028
Turbidity	5	0.1138	1.943	38.86	1.5895	0.1809
COD	100	0.0057	25.257	25.26	1.4024	0.0080
Nitrate	20	0.0285	0.04	0.20	-0.6990	-0.0199
Calcium	200	0.0028	3.597	1.80	0.2549	0.0007
					$\sum(W_n \log q_n) = 1.5103$	

WQI = 32.3820

To calculate WQI, annual averages (Table 1) of ten parameters *viz.* BOD, pH, TDS, Total Hardness as $CaCO_3$, Total Alkalinity, Electrical Conductivity, Turbidity, COD, Nitrate and Calcium were used. WQI as calculated for selected spots are given in the Table Number 2a to 2f.

$$WQI = Anti\log \sum_{n=1}^{10} W_n \log q_n \text{ ---------- (1)}$$

Where,

Wn = Unit weight for n^{th} parameters; calculated as:

$$Wn = \frac{K}{S_n}$$

Sn = (n = 1, 2, 3… 6) HDL for n^{th} water quality parameters; (HDL: Highest Density Level)

K= constant of proportionality; calculated as:

$$K = \frac{1}{\sum_{n=1}^{6} \frac{1}{S_n}}$$

$$K = \frac{1}{[1/S_n(\text{BOD})]+[1/S_n(\text{pH})]+[1/S_n(\text{TDS})]+[1/S_n(\text{Hard.})]+[1/S_n(\text{Alk.})] +[1/S_n(\text{EC})]+[1/S_n(\text{Tur.})]+[1/S_n(\text{COD})]+[1/S_n(\text{Nitrate})]+[1/S_n(\text{Cal.})]}$$

q_n = quality rating of n^{th} water quality parameter.

The quality rating (q_n) for the n^{th} water quality parameters may be obtained for all parameters as follows; except pH and DO (Tiwari and Manzoor Ali, 1986).

$$q_n = 100\frac{V_n}{S_n} \text{ ---------- (2).}$$

Where, Vn = Observed value; Sn= recommended standard value for n^{th} parameter.

Equation 2 ensures that q_n = 0, when a pollutant (n^{th} parameter) is absent in the water, while q_n = 100, if the observed value of parameter is just equal to its desirable limit or standard for drinking water.

For pH the quality rating q_{pH} can be calculated from the relation.

$$q_{pH} = 100\frac{(V_{pH} - 7.0)}{(8.5 - 7)} \text{ ---------- (3)}$$

Where, V_{pH} is observed value of pH and the (-) means simply the numerical difference between V_{pH} and 7, ignoring its algebraic sign. 8.5 is the permissible value of pH and the pH of neutral water is 7, which is ideal value.

The standard water quality index and status are given in Table No.4, where as the water quality indices of all the samples are given in Table 3.

Table 3. Status of water at different spots in Chiplun Town

Spot	Area	WQI	Status
A	Peth Map	49.0535	Good
B	Khend	44.8436	Good
C	Desai Mohalla	50.2458	Poor
D	Shankarwadi	49.1813	Good
E	Markandi	35.6999	Good
F	Pag	48.8427	Good
G	Kaviltali	35.4920	Good
H	Bahadurshaikh	41.3904	Good
I	Raotale	44.5737	Good
J	Municipal Tap	30.2065	Good
K	River	32.3820	Good

Table 4. Standard Water Quality Index

WQI	Status
0 - 25	Excellent
25.1 - 50	Good
50.1 - 75	Poor
75.1 - 100	Very poor
Above 100	Unfit for drinking

DISCUSSION

The pH scale of water indicates its nature as acidic (pH less than 7), neutral (pH 7) and alkaline (pH more than 7). As per (BIS, 1992) desirable limit of pH of potable water lies between 6.7 and 8.5. The low pH of water may be due to dissolution of acidic impurities due to which water becomes unfit for drinking purpose (Jayasree, 2002). In the present investigation water samples were slightly acidic at spots A, E, F, G, H and I; but were slightly alkaline at spots B, C, D, J and K. Amongst them the minimum pH 6.53 and maximum of 7.63 were recorded at spot G and K, respectively. The alkaline nature of water samples might be due to photosynthetic activities in water as reported by King (1970) and due to presence of alkaline earth metals as reported by Mishra and Patel (2001). Higher pH reduces the germicidal potentiality of chloride and reduces formation of toxic tri-halo-methanes (Trivedi and Goel, 1986). Turbidity of water sample depends upon the amount of suspended particles in it. According to ICMR (1975), the desirable limit of turbidity in potable water is 5 NTU. In the present study, turbidity of water samples was well below the desirable limit and ranged between 0.961 NTU at spot B and 3.139 NTU at spot E, indicated clean appearance of waters.

Electrical conductivity is related to total dissolved solids present in it. Chemically pure water does not conduct electricity. Any rise in electrical conductivity of water indicates pollution (Mishra and Patel, 2002). Electrical conductivity of water samples from all the spots of present study ranged between 86.833 S/cm and 673.193 S/cm at spot K and C; respectively and indicate that all the samples were within the permissible limit of 300 S/cm (WHO, 1994). The desirable level of total dissolved solids in any potable water is 300 ppm (ICMR, 1975). In the light of such standard value, all the water samples, except at spot B and C, contained lower TDS. At spot B (987.5 ppm) and C (564.777 ppm) the desirable limit was exceeded, which might be due to solid waste disposal around the dug well and bore well (Babar and Kaplay, 1999); and due to dissolution of rocks (Tiwari, 1999). The TDS beyond 500 ppm may cause Gastro-intestinal irritation (Park and Park, 1980), hence spot B and C falls in this category. Total hardness is generally due to the natural accumulation of salts of calcium and magnesium from soil and geological formations or it may enter from direct pollution by effluents (Manivaskam, 1994).

Total hardness of all the water samples ranged from 35.5 ppm to 117.860 ppm at spot K and C, respectively, and indicated that they lie within the desirable limit of 300 ppm (ICMR, 1975) except at spot C, where it slightly exceeded the limit that may cause encrustation in water supply structure (Pillai *et al*, 1999). As per Durfer and Baker's classification, waters having 75.00 to 150.00 ppm as $CaCO_3$ equivalent hardness are categorized as moderately hard water. In the present study water samples at spots A, B, D, F, G, H and I belonged to moderately hard category. Drinking water usually has a BOD of less than 1 ppm and water is considered to be fairly pure with BOD of 3 ppm and of doubtful purity when the BOD values reach 5 ppm (Rao, 1997). In the present investigation, the values of BOD for all the water samples exceeded the desirable limit of 1 ppm (WHO, 1994) and indicated contamination of waters with organic matters through seepage, etc. (Jayaraman et al, 2003) also recorded the high level of BOD. Since proper drainage system in Chiplun town is lacking, there are several chances of percolation of domestic sewage to the ground water sources, which might have enhanced BOD levels. High levels of COD are usually due to chemically oxidizable organic matter of natural as well as anthropogenic inputs in the water sources, which indicate the incidence of pollution (Jayaraman, *et al*, 2003). The values of COD for all the water samples under investigation were within the permissible limit of 100 ppm (BIS, 1992) indicating chemically oxidizable organic matter in the water sources are comparatively low. Jayasree (2002) also reported similar results indicating that the intensity of pollution is low. Total alkalinity of water is due to carbonate and bicarbonate (Patil, *et al*, 2001), and its desirable limit in water is 120 ppm (ICMR, 1975).

Except at two spots such as D and E, total alkalinity values at all other spots of the present study remained well below the desirable limit. The exceeded level of alkalinity at spot D (126.417 ppm) and E (140.043 ppm) indicated that there might be input of carbonates and bicarbonates (Mishra and Patel, 2002). Goel *et al,* (1985) and Khabade, *et al*, (2002), also reported analogous variations in alkalinity. Though the nitrogen is essential to maintain the life balance in natural ecosystem, its presence in the form of nitrate is hazardous to man and animal. High nitrate content in the drinking water may be due to anthropogenic activities and fertilizers from fields, which during rainy season get dissolved and leached in to the bore wells, dug wells and finally to the rivers (Zusthi and Khan, 1998) and may lead to disease like goiter, cancer and methaemoglobinaemia (Manivaskam, 1994). In the present study, concentration of nitrate found in all the water samples was much below the accepted drinking water standards (20 mg/l – ICMR; 45 mg/l – ISI, 1991) and revealed the unpolluted nature of water by nitrogen. Similar results were reported by Datta and Sinha (1993) and Desai *et. al,* (1995).

The maximum allowable concentration and the permissible concentration of calcium in drinking water are 75 ppm (BIS) and 200 ppm (WHO). In the present investigation, calcium content of water samples ranged from 3.597 ppm to 48.514 ppm and indicated that all the samples were below desirable limit. Similar results are reported by Mishra and Patel (2001); Sukumaran *et al,* (2001) and Khabade *et al,* (2002). Calcium is an essential constituent of human being. The low content of calcium in drinking water may cause Rickets and defective teeth. It is essential for nervous system, cardiac function and coagulation of blood (Naik and Purohit, 2001). Based on the extent of pollution, water quality has been designated as excellent, good, poor, very poor and unfit for drinking. WQI varied between 30.2064 at spot J and 50.2458 at spot C. Waters at all the spots were of good quality, except spot C; where, it was of poor quality. The spot C (Desai Mohalla) is a bore well, where; civil construction activity was in progress. Because of use of large quantity of cement for construction activity, detergents used by workers, and other domestic activities in the surrounding, the materials might have leached through highly porous soil strata and reached to the ground water. This might be the probable reason for comparatively high WQI at this spot.

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