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PHYSICO-CHEMICAL CHARACTERISTICS AND QUALITY ASSESSMENT OF SOME GROUND WATER SAMPLES FROM VAPI TOWN, GUJARAT, INDIA

Nivruti T. Nirgude[1]*, Sanjay Shukla [2] and A. Venkatachalam[3]
[1]Department of Chemistry, N.B. Mehta Sc. College, Bordi, Dist. Thane-401701.
[2]Department of Chemistry, Thakur College, Kandivali, Mumbai.
[3]Department of P. G. Studies and Research in Chemistry, Bhavan's College, Andheri (w), Mumbai - 58.
*E-mail: ntnirgude214@gmail.com

ABSTRACT

Physico-chemical analysis of ground water samples collected from different sources from Vapi town, Gujarat for five months period from March 2009 to July 2009 has been carried out. However, only study of March 2009 is presented in this paper. The study showed the pollution effect of industrial effluents on ground water. The parameters like pH, Colour, EC, TDS, TH, BOD, COD, DO, Cl^-,SO_4^{-2}, Na^{+1},K^{+1} Ca^{+2}, Mg^{+2} have been studied for their concentration in the ground water Samples. Statistical study has been carried out by calculating the correlation coefficient between different parameters and applied for checking their significance. The observed values of physico-chemical parameters of water samples were compared with standard values recommended by WHO. The study revealed that all the physico-chemical parameters are well above the permissible limits suggested by WHO and USEPA for drinking water. Proper treatment methods are suggested for these ground water samples to be used for the drinking purpose; however they can be used for irrigation purpose.

Keywords: Ground Water, Vapi town, physico chemical, parameters, limits of WHO correlation coefficient 'r'.

INTRODUCTION

Ground water plays an important role in the development of township, water is extremely essential for the survival of all living organism. The quality of water is of vital for the mankind, since it is directly linked to life human, animal, and plant kingdom. The quality of public health is related to the quality of water consumed which should be clean and fresh. In India most of the population is dependent on the ground water as it is the only source of drinking water supply. The ground water is believed to be comparatively cleaner and free from pollution than surface water. The modern civilization, urbanization, and prolonged discharge of industrial effluents, domestic sewage and solid waste dump, causes the ground water to become polluted and unfit for drinking and sometimes even for irrigation. Hence there is a need for the protection and management for groundwater quality.[1]

EXPERIMENTAL

Vapi GIDC in District Valsad, Gujarat, is one of the large industrial areas in Asia. There are about 832 industries of which around 759 are polluting ones. The industries include those manufacturing fine chemicals, Pharmaceuticals, dyes, dye intermediate, textiles, pesticides, agrochemicals, various metals, alloys and many more. The remaining are mostly Pulp & paper mills, plastic, and food processing units[2]. In December 2009 Central Pollution Control Board (CPCB) released the list of critically polluted areas by using comprehensive environmental pollution index (CEPI) in which Vapi GIDC was second most polluted industrial area with CEPI index 88.29 and Ankleshwar was Ist with CEPI index 88.5 in India[3]. Most of the industries are not giving a primary treatment to their own industrial effluents and releasing large quantity of effluents containing unbearable amount pollutants. Several times, factories in Vapi dump

their spoilt batches, and waste material at several illegal places like Balitha, Kolak River and Bhil Khadi. These materials contain chemicals that are highly toxic. A large quantity of partially treated but highly polluted effluents is discharged into Damanganga, Kolak River, nallas, and pollute the ground water. People who live near the area use the water from the river or open wells and bore wells for domestic purposes. The objective of this study was therefore to assess the extent of affects of effluent pollution on ground water in Vapi town.

Table-1:Sampling Stations

Sample Number	Sample source of Ground Water	Habitat	Location
GW1	Hand Pump	Residential Area	Mukesh Chowl, Udiabad Kuchawa GIDC,Vapi
GW2	Dug well	Commercial area.	Packaging zone, III rd Phase, GIDC, Vapi
GW3	Bore well	Residential area.	Premnagar Society, Dungrifalia, Near Solid Waste Management GIDC, Vapi
GW4	Hand Pump	Residential	Millat Nagar,Dongrifalia, Vapi.
GW5	Hand Pump	Residential	Gala Masala. Chiri, Vapi.
GW6	Bore well	Residential	Desai Wada Chiri, Vapi.
GW7	Hand Pump	Residential	Nayi Nagari, Charwada Ramjanwadi,Vapi.
GW8	Hand Pump	Residential	Bhadakmora, Near Ist Phase GIDC,Vapi.
GW9		Residential	Chanodgam, Vapi.
SW10	Surface Water	Residential.	200 meter downstream of outlet of CETP in Damanganga River.

Table-2: Study of Physico Chemical parameters of ground water from Vapi town

Sample No.	Colour	PH	EC	TDS	TH	BOD	COD
GW1	Light Yellow	7.35	4972	3330	375	22	112
GW2	Colourless	7.13	295	197	114	40	179
GW3	Light Yellow	7.33	2684	1800	596	30	91
GW4	Whitish Turbid	6.50	4952	3319	376	10	56
GE5	Reddish	6.82	3647	2443	1786	26	51
GW6	Whitish Turbid	7.70	592	397	241	16	52
GW7	Colourless	7.24	2595	1741	963	28	106
GW8	Colourless	7.12	1152	772	519	20	52
GW9	Light Yellow	7.13	2574	1728	993	14	51
SW10	Dark reddishYellow	7.02	12406	8313	1975	170	621
Average	----	6.77	3587	2404	793.8	37.6	137.1
WHO HDL	----	7-8.5	1400	500	100	--	--
WHO MDL	----	6.5-9.5	---	1000	500	--	255

(Except pH and electrical conductivity (µS / cm) all values are expressed in mg/L. (EC = Electrical Conductivity,TDS=Total Dissolved Solid, TH = Total Hardness, BOD = Biological Oxygen Demand, COD = Chemical Oxygen Demand)

Sampling

Ten sampling stations were selected for ground water in the present study. The sampling locations, source and corresponding habitat is shown in Table-1. Ground water samples were collected in previously washed and dried polythene container of 2 liters capacity. The samples were collected from bore well, deep hand pumps as wells as surface water from Damanganga River 300 meters downstream of CETP Vapi outlet[4].

Table-3: Study of concentration of various ions in ground water from Vapi town

Sample No.	Cl^{-1}	NO_3^{-1}	SO_4^{-2}	Na	K	Ca	Mg
GW1	126.4	4.15	53.82	182.5	0.77	73.39	52.02
GW2	14.2	7.91	19.35	16.1	1.77	24.32	10.42
GW3	457.8	26.21	235.4	349.84	0.91	117.9	45.27
GW4	1186.6	28.05	228.02	184.01	0.72	71.99	52.81
GE5	342	183.97	933.56	228.24	15.26	453	56.79
GW6	23.8	7.26	23.88	31.18	0.37	39.52	32.15
GW7	506.5	24.03	115.93	119.29	0.81	173.5	127.31
GW8	79.9	30.47	122.19	52.86	4.10	101.8	49.32
GW9	496	27.26	68.26	111.55	1.08	219.7	92.26
SW10	2956.3	31.34	1666.22	2176.3	140.62	405.4	143.50
Average	618.5	36.7	346.2	344.8	16.1	167.5	75.37
WHO HDL	--	0.0	200	--	--	75	30
WHO MDL	250	45	400	200	--	200	150

(All values are expressed in mg/L)

Sample analysis and Instrumentation

All the chemicals used were A. R. grade and were purchased from S.D. Fine chemicals Ltd. PH, Electrical conductivity, TDS were determined by Elico model pH meter and Conductivity TDS analyzer. Total Hardness, Biological Oxygen Demand, Chemical Oxygen Demand, Chlorides, Nitrate, Sulphate, were determined as per standard procedures. Flame Photometer (Model Elico CL-178) was for determination of Na^+, K^+, Ca^+, and Mg^+ ions.[5]

RESULTS AND DISCUSSION

The various sampling stations are given in Table -1, and the physico-chemical parameters of ground water samples are given in Table-2, and Table No.3. In most natural waters pH values are dependent on carbon dioxide, carbonate and bicarbonate equilibrium. Samples of water from deep aquifer and hot springs may undergo considerable changes in pH during transit from the point collection to the laboratory. The PH values were ranged 6.37 to 7.36. It has been reported that PH up to 7.41 is best for tube well water as per WHO 2004. The observed values of PH of all the samples are within the permissible limits (6.5-8.5).[6]

The relationship between conductivity and resistivity changes significantly with temperature. In the present study the electrical conductivity values varied from 295-4952 µs/cm, and12406µs/cm for surface water but the maximum allowable limit is 1400 µs/cm. (WHO 1996). The high electrical conductivity values could be due to anthropogenic pollution with large amount soluble salt[7]. High concentration of

TDS increases the turbidity. In the present study the TDS fluctuated between 197 to 8313 mg/L, lowest values were recorded at two sampling stations GW_2 and GW_6 below desirable limit of WHO, where as high values are recorded in the remaining samples. This may be due to the presence of bicarbonates, sulphates and chlorides of calcium and magnesium and affects the density of water, reduces utility for drinking and irrigation purpose.[8] The total hardness (TH) is varying between 114-1786 mg/L. but the permissible limits for ground water is 500 mg/L. Total hardness is the property of the water, which prevents the lather formation with soap and increases the boiling point of water[9]. The chloride content in water increases normally as the mineral content increases. For Chlorides, the limit is 250 mg/L but the samples showed the chloride concentration between 14.2- 1186.8 mg/L and 2956.3 mg/L for surface water. Biological Oxygen Demand levels can be used as a measure of organic load. In the present study, the BOD varied between 10–170 mg/l in Vapi city. Chemical Oxygen Demand (COD) is the oxygen required by the organic substances in water oxidizes them by a strong chemical oxidant. In the present study, COD levels fluctuated between 51 to 621 mg/L. Most of the samples have shown the high COD concentration which was more than the limit set up by WHO (20.0 mg/L) for drinking water (Table- 2). For ground water samples the WHO allowed limits for Sulphate is 400 mg/L, but the ground water samples showed between 19.35 to 933.56 mg/L, and surface water in Damanganga River 1666.22 mg/L. The ground water samples showed Na^+ concentration 16-2176 mg/L. Most of the water samples showed low concentration of potassium. For Ca^{+2} and $Mg^{+2}$the allowed limits are 75 and 30 mg/L. but the samples showed higher limits 24.3.2- 453 mg/L and 10.42 – 127.31 mg/L for Mg^{+2} respectively.

Table -4: Correlation coefficient for physicochemical parameters (N=10)

	PH	EC	TDS	TH	BOD	COD	Cl-	SO_4^{-2}	NO_3^{-1}	Na+	Ca+2	K+	Mg+2
PH	1.000												
EC	-0.347	1.000											
TDS	-0.347	0.919	1.000										
TH	-0.085	0.809	0.680	1.000									
BOD	-0.084	0.836	0.8373	0.636	1.000								
COD	-0.081	0.835	0.835	0.555	0.990	1.000							
Chloride	-0.387	0.930	0.931	0.648	0.870	0.863	1.000						
Sulphate	-0.351	0.846	0.847	0.875	0.855	0.798	0.8325	1.000					
Nitrate	-0.439	0.080	0.0809	0.634	-0.026	-0.124	0.0008	0.460	1.000				
Sodium	-0.158	0.917	0.921	0.686	0.971	0.953	0.990	0.892	0.091	1.000			
Calcium	-0.361	0.089	0.604	0.985	0.546	0.460	0.554	0.907	0.744	0.600	1.000		
Potasium	-0.163	0.604	0.921	0.707	0.980	-0.057	0.911	0.907	0.061	0.028	0.722	1.000	
Magnesium	-0.139	0.604	0.682	0.723	0.604	0.582	0.709	0.709	0.034	0.654	0.609	-0.020	1.000

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Statistical Analysis

The correlation coefficient 'r' was calculated using the equation-

$$\text{correlation coefficient (r)} = \frac{\Sigma XY}{\sqrt{x2}\ X\sqrt{y2}}$$

Where X and Y represents two different parameters.

The correlation coefficient (r) amongst various ground water quality parameters are given in Table No.4. Out of 63correlation coefficient found between two parameters. 54 were found to be significant. Positive correlations were found between all parameters except between PH and other parameters.[10-11]

CONCLUSION

All the physico chemical parameters of some ground water samples of Vapi town are exceeds the highest desirable limits set WHO except PH. The ground water samples recorded higher values of TDS, TH, Sulphate, Chloride, Sodium, Calcium and Magnesium; this may be due to the proximity of sampling stations to the Vapi GIDC and polluted rivers Damanganga and Kolak in which effluents discharged by industries. A large number of factors and geological conditions affect the correlations between different pairs directly or indirectly. Appreciable significant positive correlations have been recorded for electrical conductivity Na^+, Cl^-. TDS with Cl^-, Na^+, K^+ with Cl^-, $SO4^{-2}$ and TDS. From the various physic-chemical parameters analysis, it can be concluded that that the ground is not suitable for drinking purpose. It has been observed that, in ground water samples, many physic-chemical parameters are quite high concentration and hence such waters can be used for only irrigation purpose but not for drinking purpose, provided they are pre treated to reduce the pollution level.

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