



Studies on Groundwater Quality of Palanpur City, Gujarat, India

J. R. Prajapati and B. V. Raol

Deptt. of Biology, Shri P. H. G. Muni. Arts and Science College, Kalol-382 721, North Gujarat

Deptt. of Microbiology, Shri P. H. G. Muni. Arts and Science College, Kalol-382 721, North Gujarat

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ABSTRACT

The present study deals with the groundwater quality of Palanpur city, north Gujarat. The groundwater quality was assessed by examining various physicochemical and bacteriological characteristics like temperature, turbidity, pH, dissolved oxygen, free CO₂, total hardness, Ca and Mg hardness, TDS, total alkalinity, chloride, sulphate, nitrite, total iron, fluoride and MPN of coliforms. The bore well water samples were collected from north, south, east and west zones of Palanpur city during summer, winter and monsoon seasons. TDS, Ca-hardness, sulphate, total iron, fluoride and MPN count of coliforms were above the permissible limit prescribed by IS: 10500. On the basis of TDS value, drinking water samples collected from east zone were rated as fair and the samples collected from north, south and west zones were rated as unacceptable for their taste. On the basis of total hardness the bore well water samples collected from Palanpur were classified as hard to very hard. Except one sample collected from the west zone during winter, rest of the samples showed sulphate values within the permissible limit of 400 mg/L. The total iron values exceeded the permissible limit of 1.0 mg/L and imparted bitter astringent taste to the water. In most cases fluoride values exceeded the desirable limit of 1.0 mg/L and even exceeded the permissible limit of 1.5 mg/L. Most of the zones (except east zone) showed MPN of coliforms beyond the desirable limit of 10 coliforms beyond the desirable limit of 10 coliforms/100 mL, therefore, these samples were regarded bacteriologically unsafe for drinking. The defluoridation and disinfection of bore well water of Palanpur city were the two principal measures recommended to ensure the health of population residing in this area.

INTRODUCTION

Groundwater is an invaluable commodity available in limited quality to man and other living beings. Most Indian towns and cities do not have access to safe drinking water. Groundwater supplies are recharged naturally by rain. The groundwater areas that are recharged at a higher rate are generally more vulnerable to pollution than those recharged at a slower rate. Unconfined aquifers lacking cover of dense layer of clay material are more susceptible to contamination than confined deep aquifers. Groundwater can be polluted by landfills, septic tank, live stock yards, silos, petroleum tanks, manure stack and overuse of fertilizers and pesticides. To help protect water wells against contamination, it is important to use natural protection that soil provides by maintaining adequate separation distance between bore wells and potential sources of contamination (<http://ga.water>).

Banaskantha (Palanpur) district of north Gujarat region covers total area of 10,400 sq. km. It includes 1246 villages and 12 talukas with total population of 25,02,843. The average rainfall is around 30.80 cm. The soil texture is sandy saline and loamy, hilly and silty. Wheat, bajara, jowar, pulses, sugarcane, groundnut and potato are the main cultivated crops. Palanpur city is the main centre of the Banaskantha district.

The present investigation was undertaken with a view to study quality and degree of faecal pollution of groundwater of Palanpur city.

MATERIALS AND METHODS

Borewell water samples were collected in clean polyethylene carboy of 2 litres capacity. The water samples were collected from north, south, east and west zone during summer, monsoon and winter. These water samples were transported to the laboratory within 6 hours and pH, temperature, electrical conductivity and dissolved oxygen were measured immediately. The water samples were stored in refrigerator to avoid any microbial decomposition. The physicochemical and bacteriological parameters like colour, odour, pH, turbidity, DO, Free CO₂, total hardness, TDS, total alkalinity, sulphate, Ca and Mg-hardness, nitrite, total iron, fluoride and MPN of coliforms were estimated in laboratory following the standard methods (Clesceri et al. 1998, Maiti 2001, Saxena 1998).

RESULTS AND DISCUSSION

The data on physicochemical and bacteriological analyses of drinking water samples are given in Table 1. The characteristics were examined in the light of the IS : 10500, 1991 standards prescribed by BIS for potability of water, wholly accepted by the ministry of Health, Govt. of India. The BIS standard values are represented in Table 2.

TDS, total iron and MPN counts of coliforms were above the permissible limit prescribed by IS: 10500, 1991. All the drinking water samples were colourless and have unobjectionable odour. Temperature ranged from 29 to 32°C throughout the year. The pH values were within the desirable limit of pH 8.5. The dissolving oxygen values ranged from 3.43 to 6.56 mg/L. There is no standard for DO. Generally, DO values of freshwater at one atmospheric pressure reach 8 and 7 mg/L at the temperature of 25°C and 35°C (Maiti 2001). It means that the DO values of groundwater of Palanpur city were low. Comparatively, high DO values were observed during monsoon and decreased during winter (Abbasi 1998). The total alkalinity values ranged from 200 to 300 mg/L and never exceeded the permissible limit of 600 mg/L. The higher total alkalinity values were found during the winter months for samples collected from north and south zones. The bicarbonate ions were present in the higher concentration, therefore, in addition to free CO₂ bicarbonate ion was the major factor contribution to the higher total alkalinity.

The higher total alkalinity values were found during summer for water samples collected from east and west zones. The hydroxide and carbonate ions were absent in the water samples. Bicarbonate ions and free CO₂ were present in higher concentration during summer months. Therefore, these were the two important factors contributing to higher total alkalinity.

The free CO₂ value ranged from 30 to 50 mg/L in groundwater. However, the free CO₂ value ranged from 20 to 120 mg/L during the present study. The higher free CO₂ values were found particularly during summer months. Free CO₂ is accumulated in the water due to microbial activity and respiration of organisms. It means that microbial activity and respiration might be higher during the summer. TDS values ranged from 800 to 2040 mg/L and were above desirable limit of 500 mg/L, but within or nearer to the permissible limit of 2000 mg/L. On the basis of TDS value drinking water samples collected from east zone were rated as fair, and the samples collected from north, south and west zones were rated as unacceptable for their taste.

On the basis of total hardness, the borewell samples collected from Palanpur city were rated as hard to very hard. The higher values of the total hardness were observed during summer and winter

months. The water samples collected from north zone showed total hardness within desirable limit of 300 mg/L, while the samples collected from south, east and west zones showed total hardness value beyond desirable limit of 300 mg/L. In case of samples collected from west zone, total hardness value even exceeded the permissible limit of 600 mg/L except during monsoon. The samples collected from north, east and west zones showed higher total hardness values during winter whereas the samples collected from north zone showed higher total hardness during summer.

Ca-hardness values of bore well samples ranged from 52.50 to 506.50 mg/L and were generally beyond the permissible limit of 200 mg/L in south, east and west zones. Ca-hardness reduces the utility of water for domestic uses. Mg-hardness values of bore well samples ranged from 1.46 to 60.26 mg/L, which were within the permissible limit of 100 mg/L. Chloride values of bore well samples ranged from 74.97 to 324.87 mg/L and were within the permissible limit of 1000 mg/L.

Sulphate ranged from 70 to above 400 mg/L. The sulphate values were within the permissible limit of 400 mg/L. Only the water sample collected from west zone during winter showed sulphate value exceeding the permissible limit of 400 mg/L. Water with about 400 mg/L sulphate have bitter taste and those with 1000 mg/L or more of sulphate may cause intestinal disorders (WHO 1996). The nitrite values of bore well samples ranged from 0.01 to 0.09 mg/L. No standard has been prescribed for nitrite in ISO: 10500 by BIS (1991). However WHO (1998) has prescribed 3.0 mg/L as the permissible limit of nitrite for drinking water. The nitrite values of bore well samples were within the permissible limit 3.0 mg/L. Total iron values of bore well samples ranged from 2.00 to above 10.00

Table 1: Physico-chemical and bacteriological analyses of drinking water samples collected during different seasons from borewells situated in different zones of Palanpur city (Dist. Banaskatha), Gujarat.

Parameters	North			South		
	Summer	Monsoon	Winter	Summer	Monsoon	Winter
Colour	Nil	Nil	Nil	Nil	Nil	Nil
Odour	UO	UO	UO	UO	UO	UO
Temperature	31.00	31.80	31.20	29.00	32.00	30.40
Turbidity	0	0	0.015	0	0.05	0
pH	8.32	8.25	8.30	8.03	8.10	8.05
DO	4.94	5.55	3.53	5.35	5.65	4.84
Free CO ₂	100.00	20.00	24.00	80.00	30.00	50.00
TDS	1840	2040	1960	1320	1840	1240
Total alkalinity	264.00	272.00	280.00	262.00	246.00	300.00
HCO ₃ ⁻ ion	322.08	331.84	341.60	319.64	300.12	366.00
Total CO ₂	383.43	312.01	324.60	361.28	294.10	372.08
Total hardness	220.00	210.00	230.00	440.00	80.00	420.00
Calcium	56.34	49.61	52.98	105.12	21.02	105.12
Ca-hardness	140.70	123.90	132.30	262.50	52.50	262.50
Mg-hardness	19.34	21.00	23.83	43.31	6.71	38.43
Chloride	104.95	107.45	109.95	187.42	204.91	145.44
Sulphate	85.00	77.50	200.00	100.00	90.00	200.00
Nitrite	0.05	0.02	0.01	0.03	0.05	0.02
Total iron	2.00	2.30	2.00	2.40	2.60	>10.00
Fluoride	1.65	1.60	0.85	0.85	1.60	0.50
MPN of coliforms	17	240	4	33	17	4
IMViC tests	<i>E.a.</i>	<i>E.a.</i>	<i>E.a.</i>	<i>E.a.</i>	<i>E.a.</i>	<i>E.coli</i>

Table cont....

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Parameters	East			West			Average
	Summer	Monsoon	Winter	Summer	Monsoon	Winter	
Colour	Nil	Nil	Nil	Nil	Nil	Nil	Nil
Odour	UO	UO	UO	UO	UO	UO	UO
Temperature	31.00	31.70	31.20	31.00	31.60	30.60	29.00-32.00
Turbidity	0	0	0	0	0.05	0	0-0.05
EC	0.095	0.095	0.095	0.110	0.105	0.105	0.085-0.110
pH	8.05	8.01	8.05	8.06	8.40	8.00	8.00-8.40
DO	6.56	5.15	3.53	5.65	5.75	3.43	3.43-6.56
Free CO ₂	110.00	20.00	32.00	120.00	28.00	56.00	20.00-120.00
TDS	840	800	960	1680	2040	1600	800-2040
Total alkalinity	272.00	260.00	240.00	268.00	200.00	240.00	200.00-300.00
HCO ₃ ⁻ ion	331.84	317.20	292.80	326.96	244.00	292.80	244.00-366.00
Total CO ₂	402.01	299.13	289.66	407.72	242.72	313.66	242.72-407.72
Total hardness	380.00	370.00	380.00	646.00	90.00	650.00	80.00-650.00
Calcium	100.92	98.39	101.76	159.79	33.64	202.68	21.02-202.68
Ca-hardness	252.00	245.70	254.10	399.00	84.00	506.10	52.50-506.10
Mg-hardness	31.23	30.32	30.71	60.26	1.46	35.11	1.46-60.26
Chloride	74.97	77.96	81.46	284.88	319.87	324.87	74.97-324.87
Sulphate	70.00	75.00	82.00	280.00	232.00	>400.00	70.00->400.00
Nitrite	0.045	0.03	0.01	0.09	0.02	0.01	0.01-0.09
Total iron	2.40	2.30	2.60	2.00	2.30	2.60	2.00->10.00
Fluoride	1.10	1.00	0.85	0.35	1.30	0.25	0.25-1.65
MPN of coliforms	0	0	8	2400	17	2	0-2400
IMViC tests	Nil	Nil	<i>E.a.</i>	<i>E.a.</i>	<i>E.a.</i>	<i>E.a.</i>	

UO = Unobjectionable, Units: Except Temperature (°C) pH (units), Turbidity (O.D. at 420 nm), MPN of coliforms per 100 mL, rest of values are in mg/L, Alkalinity = phenolphthalein alkalinity, Hydroxide alkalinity/OH ion, carbonate ion values were zero. Therefore, Total alkalinity = Bicarbonate alkalinity *E.a.* = *Ent. aerogenes*

mg/L and exceeded the permissible limit of 1.0 mg/L. The high total iron values usually impart bitter astringent taste to water (Maiti 2001).

Fluoride values the samples ranged from 0.25 to 1.65 mg/L. In most cases fluoride value exceeded the desirable limit of 1.0 mg/L and even exceeded the permissible limit of 1.5 mg/L (up to 1.65 mg/L). At higher concentration (1.5 to 2.0 mg/L) fluoride affects adversely and leads to dental fluorosis (Choubisa 1997). The teeth lose their appearance and chalky black, grey or white patches develop on them. The coliforms ranged from 0 to 2400 per 100 mL of water samples. Most of the zones (except east zone) showed MPN values of coliforms beyond the desirable limit of 10 coliforms/100 mL, therefore, these samples were regarded bacteriologically unsafe for drinking purpose. However, the routine laboratory tests for the detection of coliforms as well as biochemical tests (IMViC tests) for differentiation of *E. coli* and *Ent. aerogenes* showed the presence of *Ent. aerogenes* in water samples. The typical coliforms (*E. coli*) were not detected during the present study. However, on the basis of high value of MPN count borewell samples from Palanpur city can be regarded as bacteriologically unsafe. It is recommended that drinking water from these sources should be treated before use to safeguard health of the population.

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Table 2: BIS standards for drinking water (IS: 10500).

S. No.	Parameters	IS : 10500, 1991	
		Requirement (Desirable limit)	Permissible limit in the absence of alternate source
1	Colour	5 HU	25 HU
2	Odour	UO	UO
3	Temperature	-	-
4	pH	6.5 to 8.5	No relaxation
5	Turbidity	5	10
6	EC	-	-
7	D.O.	-	-
8	Free CO ₂	-	-
9	Total hardness as CaCO ₃	300	600
10	Total solids	500	2000
11	Total alkalinity	200	600
12	Chloride	250	1000
13	Sulphate	200	400
14	Calcium as Ca	75	200
15	Magnesium	30	100
16	Nitrite	-	*
17	Total iron	0.3	1.0
18	Fluoride	1.0	1.5
19	MPN of coliforms	Free from Coliforms	10 or < 10 Coliforms

Note: - = No standards; UO = Unobjectionable; * = Standard for nitrite is 3.0 mg/L (WHO 1994); Units: Except Colour (Hazen Unit), Temperature (°C), pH (Units), Turbidity (NTU), EC (mhos/cm), MPN (coliforms per 100 mL of water) rest of values are in mg/L.

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