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STUDIES ON GROUND WATER QUALITY OF PATAN CITY, NORTH GUJARAT, INDIA

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ABSTRACT

The present study deals with the ground water quality of Patan city, north Gujarat. The ground water quality was assessed by examining various physico-chemical and bacteriological characteristics. The bore well water samples were collected from north, south, east and west zones of Patan city during summer, winter and monsoon seasons. The physico-chemical and bacteriological parameters like temperature, turbidity, pH, EC, dissolved oxygen, free CO₂, total hardness, Ca and Mg hardness, TDS, total alkalinity, chloride, sulphate, nitrite, total iron, fluoride and MPN of coliforms have been analysed. Total alkalinity, TDS, Ca-hardness, sulphate, total iron, fluoride and MPN count of coliforms were above the permissible limit as per IS: 10500 (BIS 1991). All the samples collected from Patan city were rated as unacceptable for their taste on the basis of TDS values and hard on the basis of total hardness.

Waters with 300-400 mg/L sulphate have a bitter taste and those with 1000 mg/L or more sulphate may cause intestinal disorders. Total iron values exceeded the permissible limit and imparted bitter astringent taste to the water. The present investigation revealed that Patan city is facing the problem of high fluoride concentration in bore well samples employed for drinking purpose. Fluoride in concentration beyond 1.5 mg/L causes dental fluorosis. The bore well samples from north and east zones were regarded as bacteriologically unsafe for drinking purpose. The defluoridation and disinfection of bore well water of Patan city were the two principal measures recommended to ensure the health of population residing in this area.

INTRODUCTION

Ground water is an invaluable commodity available in very limited quality to man and other living beings. Most of Indian towns and cities do not have access to safe drinking water. Ground water supplies are recharged naturally by rain. The ground water 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, livestock yards, silos, petroleum tanks, manure stack and from 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>).

Patan district of north Gujarat covers total area of 5,742.59 sq. km. It includes 516 villages and 8 talukas with total population of 11,81,941. The average rainfall is around 500 millimetre. The soil texture is sandy, saline and loamy. Bajara, jowar, cumin seeds, arhar, pulses, wheat, mung and cotton are the main cultivated crops. Patan city is the main centre of this district. The present investigation was undertaken with a view to study quality and degree of faecal pollution of groundwater of Patan city.

MATERIALS AND METHODS

Bore well water samples were collected in clean polyethylene carboys of 2-litre 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, the electrical conductivity and dissolved oxygen were measured immediately. The water samples were stored in refrigerator to avoid any microbiological decomposition. The physico-chemical and bacteriological parameters were estimated in laboratory following the standard methods (Clesceri et al. 1998, Maiti 2001).

RESULTS AND DISCUSSION

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

TDS, sulphate, total iron, fluoride and MPN counts of coliforms were above the permissible limits. All the drinking water samples were colourless and have unobjectionable odour. Temperature ranged from 26.00 to 32.60°C throughout the year. EC values ranged from 0.105 to 0.125 mmhos/cm during different seasons of the year. The pH values were generally within the desirable limit of pH 8.5 with an exception of slightly higher pH value of 8.62 for the monsoon samples collected from east zone. The dissolved oxygen (D.O.) values ranged from 3.63 to 7.07 mg/L. There is no standard for D.O. Generally D.O. values of freshwater at one atmospheric pressure reaches 8 mg/L and 7 mg/L at the temperature of 25°C and 35°C respectively (Maiti 2001). It means that the D.O. values of ground water of Patan city were comparatively low. Comparatively high D.O. values were observed during monsoon. D.O. values decreased during winter. The total alkalinity values ranged from 340.00 to 480.00 mg/L and never exceeded the permissible limit of 600 mg/L. The relatively total alkalinity values were observed during the summer months. This can be correlated with higher free CO₂ values found during the summer months in the present investigation. It was also observed that bicarbonate ions were present in the range of 414.80 to 585.60 mg/L. The higher bicarbonate ion values were also found during summer months. Hence, bicarbonate and free CO₂ were the major factors contributing to the higher total alkalinity during summer. The west zone showed higher total alkalinity values compared to east, south and north zones.

The free CO₂ value usually ranges from 30-50 mg/L in ground waters, but they ranged from 16 to 186 mg/L during the present study. The higher free CO₂ values were found particularly during summer months. Free CO₂ is accumulated in the waters due to microbial activity and respiration of organisms. It means that microbial activity and respiration might be higher during the summer. On the basis of TDS all the samples collected from Patan city were rated as unacceptable for their taste. TDS values ranged from 1240 to 2920 mg/L and were above desirable limit of 500 mg/L and even exceeded the permissible limit of 2000 mg/L.

On the basis of total hardness, the bore well samples were rated as hard (Maiti 2001). The total hardness values ranged from 60 to 320 mg/L and never exceeded the desirable limit of 300 mg/L, except two samples in west zone during summer and winter. Samples collected from north and west zones showed highest total hardness values during summer months whereas samples collected from north, south and east zones showed highest total hardness values during winter.

Ca-hardness values of bore well samples ranged from 42.00 to 174.30 mg/L, which was within the permissible limit of 200 mg/L. Mg-hardness values of bore well samples ranged from 3.87 to 42.21

Table 1: Physico-chemical and bacteriological analyses of drinking water samples collected during different seasons from borewells situated in different zones of Patan city.

Parameters	North			South		
	Summer	Monsoon	Winter	Summer	Monsoon	Winter
1. Colour	Nil	Nil	Nil	Nil	Nil	Nil
2. Odour	UO	UO	UO	UO	UO	UO
3. Temperature	26.00	32.60	31.60	31.00	30.60	30.00
4. Turbidity	0	0	0	0	0	0
5. EC	0.120	0.120	0.110	0.110	0.110	0.110
6. pH	8.28	8.23	8.25	8.50	8.42	8.41
7. D.O.	3.93	3.93	3.63	5.05	5.35	4.54
8. Free CO ₂	90.0	30.00	40.00	88.00	20.00	20.00
9. TDS	1560	2720	2920	1440	2040	1840
10. Total/HCO ₃ alkalinity	456.00	428.00	440.00	376.00	372.00	340.00
11. HCO ₃ ⁻ ion	556.32	522.16	536.80	458.72	453.84	414.80
12. Total CO ₂	579.56	489.50	512.38	487.37	423.67	385.02
13. Total hardness	200.00	110.00	196.00	150.00	110.00	176.00
14. Calcium	35.32	33.64	42.89	24.38	29.43	33.64
15. Ca-hardness	88.20	84.00	107.10	60.90	73.50	84.00
16. Mg-hardness	27.27	6.34	21.69	21.74	8.90	22.44
17. Chloride	529.78	549.78	539.78	419.83	459.81	499.80
18. Sulphate	> 400	>400	>400	350	>400	>400
19. Nitrite	0.18	0.05	0.10	0.04	0.01	0.01
20. Total iron	4.70	3.80	7.00	2.00	2.00	2.00
21. Fluoride	2.25	>3.50	2.25	1.40	2.00	1.40
22. MPN of coliforms	23	0	0	0	0	0
23. IMViC tests	<i>E.a.</i>	Nil	Nil	Nil	Nil	Nil

Continued Table 1

	East			West			Average
	Summer	Monsoon	Winter	Summer	Monsoon	Winter	
1. Colour	Nil	Nil	Nil	Nil	Nil	Nil	Nil
2. Odour	UO	UO	UO	UO	UO	UO	
3. Temperature	28.00	31.60	30.00	31.00	32.40	31.40	26.00-32.60
4. Turbidity	0	0	0	0	0	0	0-0
5. EC	0.105	0.105	0.105	0.125	0.125	0.125	0.105-0.125
6. pH	8.50	8.62	8.60	8.25	8.30	8.23	8.23-8.62
7. D.O.	6.86	6.36	4.64	7.07	6.86	4.54	3.63-7.07
8. Free CO ₂	98.00	20.00	16.00	186.00	40.00	20.00	16.00-186.00
9. TDS	1240	1320	1680	2040	2120	2400	1240-2920
10. Total/HCO ₃ alkalinity	420.00	408.00	410.00	480.00	456.00	460.00	340.00-480.00
11. HCO ₃ ⁻ ion	512.40	497.76	500.20	585.60	556.32	561.20	414.80-585.60
12. Total CO ₂	548.91	458.02	456.17	701.32	529.56	513.85	385.02-701.32
13. Total hardness	110.00	60.00	120.00	320.00	120.00	320.00	60.00-320.00
14. Calcium	16.82	17.66	29.43	58.87	37.84	69.80	16.82-69.80
15. Ca-hardness	42.00	44.10	73.50	147.00	94.50	174.30	42.00-174.30
16. Mg-hardness	16.59	3.87	11.34	42.21	6.22	35.55	3.87-42.21
17. Chloride	309.87	314.87	361.85	639.74	639.74	674.73	309.87-674.73
18. Sulphate	350	270	>400	>400	>400	>400	270->400
19. Nitrite	0.04	0.01	0.01	0.04	0.01	0.01	0.01-0.18
20. Total iron	3.80	2.00	2.00	1.60	2.00	1.60	1.60-7.00
21. Fluoride	3.00	>5.00	2.40	1.80	2.50	1.60	1.40->5.00
22. MPN of coliforms	0	300	17	0	0	0	0-300

Cont. Table 1

23. IMViC tests	Nil	<i>E. coli</i>	<i>E. a.</i>	Nil	Nil	Nil	Nil- <i>E. coli</i> , <i>E. a.</i>
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Note: UO = Unobjectionable; Units: Except Temperature ($^{\circ}\text{C}$), pH (units), Turbidity (O.D. at 420 nm), EC (mmhos/cm), MPN of coliforms per 100 mL, rest of values are in mg/L; Alkalinity = phenolphthalein alkalinity; Hydroxide alkalinity/ OH^- ion, Carbonate/ CO_3^{2-} ion values were zero. Therefore, Total alkalinity = Bicarbonate alkalinity, *E. a.* = *Ent. aerogenes*

Table 2: BIS drinking water standards.

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 ($^{\circ}\text{C}$), pH (Units), Turbidity (NTU), EC (mhos/cm), MPN (coliforms per 100 mL of water) rest of values are in mg/L.

mg/L and it was also within the permissible limit of 100 mg/L. Chloride values of bore well samples ranged from 309.87 to 674.73 mg/L, which was within the permissible limit of 1000 mg/L.

Sulphate values of bore well samples ranged from 270.00 to more than 400.00 mg/L. The sulphate values were generally beyond the permissible limit of 400 mg/L. Waters 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 0.18 mg/L. No standard has been prescribed for nitrite by BIS. However, WHO (1998) has prescribed 3.0 mg/L as the permissible limit of nitrite in drinking water. The nitrite values of bore well samples were within the permissible limit of 3.0 mg/L. Total iron values of bore well samples ranged from 1.60 to 7.00 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 of bore well samples ranged from 1.40 to more than 5.00 mg/L. The samples collected from south zone showed the fluoride value of 1.40 mg/L during summer and winter months i.e., beyond the desirable limit of 1.0 mg/L but within permissible limit of 1.5 mg/L. The samples

collected from north, east and west zones showed the fluoride values exceeding the permissible limit of 1.5 mg/L. The present investigation reveals that Patan city is facing the problem of high fluoride concentration in bore well samples utilized for drinking purpose.

Fluoride content of 1 mg/L in drinking water has no biological side effect. If fluoride is in excess of 1.5 mg/L, it will cause serious dental disorder. Choubisa (1997) studied fluoride distribution and prevalence of fluorosis in about 144 villages of Banswara district in Rajasthan. Except few, most of water sources (hand pump, open wells and perennial surface waters) showed the presence of fluoride in the range of 0.1 to 5.5 mg/L. The prevalence of dental and skeletal fluorosis in villagers has also been observed in 13 villages having fluoride concentration in the range of 1.6 to 4.7 mg/L in drinking water.

Marfani (2001) has analysed drinking water samples (bore well/open well) collected from 5 different villages for Patan district and reported the fluoride value in the range of 0.80 to 2.00 mg/L. In present investigation the drinking water samples (bore well samples) collected from Patan city showed fluoride in the range of 1.40 to 3.50 mg/L, with an exception of one sample showing higher value of even more than 5 mg/L. At higher concentration (1.5-2.0 mg/L) fluoride affects adversely and leads to dental fluorosis. Teeth lose their appearance and chalk, black, gray or white patches develop on them. At still higher concentration (3-6 mg/L) skeletal fluorosis may occur. The disease affects the bone and ligaments.

Coliforms were absent in the bore well samples collected from south and west zones, whereas the bore well samples collected from north and east zones revealed the MPN of coliforms exceeding the desirable limit of 10 coliforms/100 mL. Therefore these samples were regarded as bacteriologically unsafe for drinking purpose. In case of north zone, coliforms were absent during monsoon and winter, but were found to be present in summer with count of 23 coliforms/100 mL. However, in the routine laboratory tests the detection of coliforms as well as biochemical tests (IMViC test) for differentiation of *E. coli* and *Ent. aerogenes* revealed the presence of *Ent. aerogenes* in case of east zone. Coliforms were absent during summer but were present during monsoon and winter. During monsoon the bore well samples collected from east zone showed MPN count of 300 coliforms/100 mL. The routine laboratory tests revealed the presence of *E. coli*. The MPN count more than 10 coliforms/100 mL and the presence of *E. coli*, the typical coliforms, indicated that the bore well samples collected from east zone during monsoon were bacteriologically not safe for drinking purpose due to faecal pollution.

Physico-chemical parameters like colour odour, turbidity, total alkalinity, Ca-hardness, Mg hardness, total hardness and nitrite were within the permissible limits. The parameters like temperature, EC, D.O. and free CO₂, for which there are no permissible limits prescribed, were also relatively low. The five parameters TDS, sulphate, total iron, fluoride and MPN counts of coliforms were above the permissible limit prescribed by BIS. The higher values of these parameters make bore well waters of Patan city nonpalatable (due to high TDS), bitter (due to high sulphate), astringent in taste (due to high total iron) and pose the risk of dental and skeletal fluorosis (due to high fluoride), and gastrointestinal tract infections (due to high MPN counts).

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