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Physico-chemical and microbial analysis of drinking water in Rajkot district, Gujarat (India)

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ABSTRACT

Diseases related to contamination of drinking water constitute a major burden on human health. Interventions to improve the quality of drinking-water provide significant benefits to health. Therefore, in this study 28 drinking-water samples from Government Supply and Tube wells of 14 major towns of Rajkot District, Gujarat (India), where no information is available were collected. The various Physico-Chemical parameters studied were Colour, Odour, Taste, pH, Turbidity, TDS, TSS, DO, BOD, COD, EC, Total Hardness, Calcium, Magnesium, Chloride, Sulphate, Nitrate, Phosphate and Iron. The result indicated that physical parameters Colour, Odour, Taste, pH, TSS and DO were within the permissible limit. BOD and COD values were high, indicating high pollution load. EC and TDS in all samples exceeded the ICMR value, and particularly tube wells contained high concentration. The total hardness, concentration of calcium and magnesium in tube wells were more than potability limit. The concentration of chloride, sulphate and nitrate in tube wells were high and the concentration of phosphate and sulphate were within the permissible limit. In our investigation it was found that almost all sources were positive for TC and *Salmonella* differential analysis. This investigation revealed that only 50% source was completely fit for drinking purpose with respect to Physico-chemical parameters studied.

Keywords: Drinking water, Physico-chemical and microbial parameters, Rajkot district, Government supply water samples, Tube well water samples.

1. Introduction

Water is essential to sustain life, and a satisfactory (adequate, safe and accessible) supply must be available to all. Improving access to safe drinking-water can result in tangible benefits to health. Every effort should be made to achieve drinking-water that is as safe as practicable.

Water fit for human consumption is called drinking water or 'potable water'. The problem of drinking water contamination, water conservation and water quality management has assumed a very complex shape[2]. Attention on water contamination and its management has become a need of an hour because of its far reaching impact on human health[3]. Due to population exploitation, urbanization, industrialization and use of modern agricultural techniques and massive waste disposal to environment, there is a threat to ground water quaity[4]. Testing of water quality on a regular basis is, therefore an important part of maintaining a safe and reliable source. Comparison of water test results with WHO guideline values, ISI tolerance limits and EPA standards of USA helps to address the specific problems of water source[5]. The quality of water is described by its physical, chemical and microbial characteristics. These characteristics are many and interlinked.

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The population of Rajkot district faces the problems of water born diseases like kidney failure, ulcer, gastrointestinal troubles etc. Recognizing the severity of the problem and as no earlier water quality parameter of Rajkot district is available; our present study undertaken with specific view of the national regional water quality database.

2. Material and methods

2.1 Study area

Rajkot district is one of the 26 districts of the Indian state of Gujarat. It is the third-most advanced district in Gujarat. Rajkot district is situated between 23°08' to 20°58' North latitude and 71°40' to 70°20' East longitudes. Rajkot has relatively pleasant climate. The district comprises 14 talukas. These are Maliya, Morbi, Tankara, Paddhari, Lodhika, Dhoraji, Wankaner, Rajkot, Jetpur, Jam Kandorna, Upleta, Kotda Sangani, Jasdan and Gondal. The rainy season spans from July to September. The average amount of rainfall received by the place is 550 mm. The winter months are October to February.

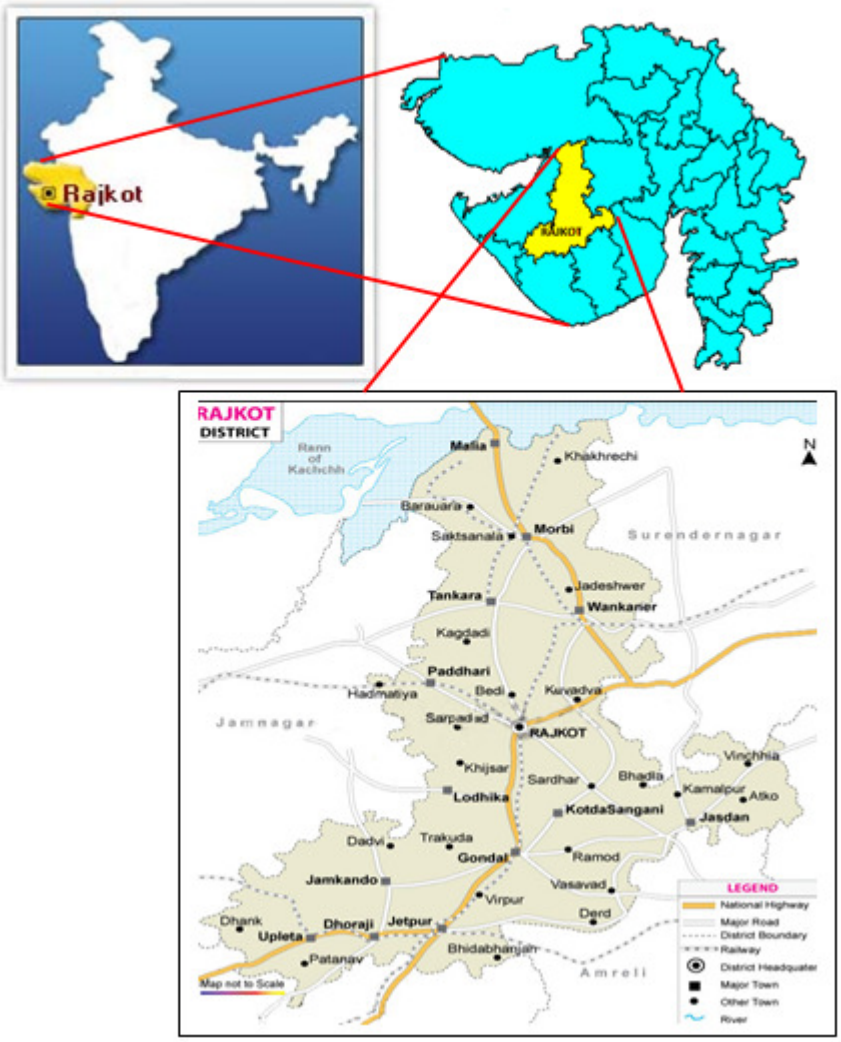

Figure 1: Location map of study area of Rajkot district, Gujarat (India)

The development of small scale industries in Rajkot district is very impressive. Rajkot district has 29630 numbers of small scale and 69 numbers of Medium and Large scale Industries. Being situated in Central place in Saurashtra Region; Rajkot has also large numbers to Industries developed there at. But, due to various industries, a chance of ground water and water reservoir which is supplied by the government is also high. Since, no water quality parameter of Rajkot district is available; we tried to focus on all 14 talukas of Rajkot district. Location map of study area has been shown here in Figure 1.

2.2 Sampling

The water samples were collected from all major towns of Rajkot district (Figure 1) in separate container for Physico-Chemical and Microbial analysis during September – October 2011. The water samples were collected from bore-wells and Government supply drinking water. Samples were collected and stored in plastic bottles (PVC 1L) and were sealed. Bottles were stored at 4^{o}C in cold room. Sample locations are given in Table 1.

Table 1: Water sampling locations

Town	SI No.	Sample No.	Source of Water
Rajkot	1	1A	Government Supply Water
	2	1B	Tube Well
Wankaner	3	2A	Government Supply Water
	4	2B	Tube Well
Gondal	5	3A	Government Supply Water
	6	3B	Tube Well
Lodhika	7	4A	Government Supply Water
	8	4B	Tube Well
Kotda Sangani	9	5A	Government Supply Water
	10	5B	Tube Well
Jasdan	11	6A	Government Supply Water
	12	6B	Tube Well
Dhoraji	13	7A	Government Supply Water
	14	7B	Tube Well
Jetpur	15	8A	Government Supply Water
	16	8B	Tube Well
Morbi	17	9A	Government Supply Water
	18	9B	Tube Well
Maliya	19	10A	Government Supply Water
	20	10B	Tube Well
Upleta	21	11A	Government Supply Water
	22	11B	Tube Well
Tankara	23	12A	Government Supply Water
	24	12B	Tube Well
Paddhari	25	13A	Government Supply Water
	26	13B	Tube Well
Jam Kandorna	27	14A	Government Supply Water
	28	14B	Tube Well

2.3 Analysis

The water samples are analyzed for various physicochemical parameters using standards methods recommended by WHO guideline, Edition of the Drinking Water Standards and Health Advisories, Indian Standard for Drinking Water Bureau of Indian Standards and 21st

edition of American Public Health Association. Physical parameter like pH and electronic conductivity (EC) was determined quickly after sampling and other parameters like turbidity, total dissolved solids (TDS), total suspended solids (TSS); chemical parameter hardness, chloride, sulphate, nitrate, phosphate, calcium, magnesium, dissolve oxygen (DO), biological oxygen demand (BOD) and chemical oxygen demand (COD) were determine latter. Microbial studies by total count (TC) and *Salmonella* differential analysis were done. Standard analytical techniques were adopted for physical and chemical analysis of water samples[4]. The various methods used for analysis is shown in Table 2. The instruments used were of precise accuracy and the chemicals used were of analytical grade.

Table 2: The methods applied for analysis of various parameters

Parameters	**Methods**
pH	Digital pH meter
EC	Conductivity meter
Turbidity	Nephelometric method
TDS, TSS	Sample filtration and drying the filtrate and filter at higher temperature
DO	Azide Modification method
BOD	5 days test
COD	Dichromate reflux method
Hardness	EDTA titration method
Chloride	Argentometric titration method
Sulphate, Nitrate, Phosphate	Spectrometry
Calcium	Titrimetric method
Magnesium	In complex form with Ca by EBT indicator
TC	Heterotrophic plate count

3. Result and discussion

3.1 Physico chemical parameter of drinking water

The mean values of water quality parameters of present study are presented in Table 3, Table 4 and Table 5 and discussed on the basis of its comparison with Drinking Water Standards. The water samples collected from all towns had almost clear appearance, unobjectable odour and agreeable taste. The pH values ranged from 7.1 to 8.0. The term pH is used to indicate the alkalinity or acidity of substance. The pH of all samples was neutral to slightly alkaline. Mostly water is slightly alkaline due to presence of carbonates and bicarbonates. However, the pH never exceeded the desirable limit[9] of 8.5 in all samples under study, so samples are fit for consumption as far as pH is concerned.

The turbidity varied from 1.0 to 3.5 NTU. That is, turbidity never exceeded the desired limit[9] of 5 NTU in all the samples under study. TDS indicates the general nature of salinity of water. The TDS fluctuated from 200 to 534 mg/L in all Government Supply Water samples under study, satisfying the standard limit[1] of 600 mg/L. The TDS of Tube Well samples fluctuated from 252 to 2490 mg/L. TDS observed in ground water was very high compare to standard limit, indicating presence of several soluble organic matters in water. The TSS of all samples fall in standard limit[1] of 500mg/L, indicating low level of insoluble organic matters and other contaminant in water samples.

Table 3: Physico-chemical analysis of water samples

Sample	Colour	Odour	Taste	pH	Turbidity NTU
1A	CL	UO	AG	7.6	1.8
1B	CL	UO	AG	7.1	1.5
2A	UC	UO	AG	7.8	1.7
2B	CL	UO	AG	7.3	1.6
3A	UC	UO	AG	7.7	2.7
3B	CL	UO	AG	7.3	1.6
4A	CL	UO	AG	8.0	1.8
4B	CL	UO	AG	7.4	1.0
5A	UC	UO	AG	7.7	3.5
5B	CL	UO	AG	7.2	1.9
6A	CL	UO	AG	7.6	2.0
6B	CL	UO	AG	7.6	1.5
7A	CL	UO	AG	7.9	1.8
7B	CL	UO	AG	7.5	1.4
8A	UC	UO	AG	7.7	1.9
8B	CL	UO	AG	7.1	1.2
9A	CL	UO	AG	8.0	3.5
9B	CL	UO	AG	7.9	2.8
10A	UC	UO	AG	7.8	2.6
10B	CL	UO	AG	7.5	1.9
11A	CL	UO	AG	7.6	2.0
11B	CL	UO	AG	7.2	1.4
12A	CL	UO	AG	7.7	2.2
12B	CL	UO	AG	7.2	2.0
13A	UC	UO	AG	8.0	1.7
13B	CL	UO	AG	7.4	1.3
14A	UC	UO	AG	7.6	2.6
14B	CL	UO	AG	7.2	1.5

Electric conductivity is ability of a solution to conduct an electrical current governed by migration of solutions. Electric conductivity varied from 276 to 1966 µS/cm. ICMR limit for EC of drinking water is 300 µS/cm. EC observed in ground water was very high. Conductivity in water is affected by the presence of inorganic dissolved solids and organic compounds present in it[4].

The DO values varied from 7.2 to 9.2 mg/L in temperature ranged from 26ºC to 37ºC. DO is the important parameter in assessing water quality and reflects the physical and biological processes prevailing in water. The value obtained of water samples indicates negligible organic load and values falls under limit[9]: 14.6 mg/L. The COD values ranged between 4 to 16 mg/L. The high values of COD may be because of high pollution load. Samples 2B, 7A, 7B and 10A show COD value higher than portability limit[9] of 10 mg/L. The BOD values varied from 1 to 52 mg/L. The high values of BOD reflected high pollution level by sewage wastes.

The Total Hardness values in Government Supply Water ranged from 43 to 116 mg/L which is well under the limit[1] of 300 mg/L. The TH values in Tube Well Water ranged from 57 to 339 mg/L, samples 2B, 7B and 14B shows higher TH value then potability limit. Hardness of water is due to the concentration on multivalent metallic ions of calcium and magnesium

present in water. The Calcium concentration varied from 17.3 to 63 mg/L in Government Supply Water and 21.8 to 84.9 mg/L in Tube Well Water. Samples 1B 7B and 12B i.e. Tube Well Water shows higher concentration of calcium compared to permissible limit[1,9] of 75 mg/L. The magnesium concentration varied from 1.4 to 69.1 mg/L. Mg occurs in all kinds of water with Ca. Mg concentration in higher in Tube Well samples 2B, 3B 5B and 14B.

Table 4: Physico-chemical analysis of water samples

Sample	TDS mg/L	TSS mg/L	DO mg/L	BOD mg/L	COD mg/L	EC µS
1A	208	62	8.2	1	8.0	344
1B	932	168	8.2	3	0.0	1273
2A	200	144	7.2	52	0.0	276
2B	1960	258	9.2	15	16.0	1371
3A	268	62	8.0	27	8.0	419
3B	1196	140	8.1	0.0	4.0	1727
4A	534	66	8.4	25	8.0	792
4B	1298	76	7.8	10	8.0	1626
5A	442	46	8.1	20	8.0	704
5B	1500	152	8.0	10	4.0	1872
6A	484	36	8.0	32	8.0	573
6B	458	42	8.2	3	8.0	695
7A	324	22	8.0	10	12.0	443
7B	2490	142	7.8	10	12.0	1966
8A	230	20	9.0	10	8.0	372
8B	700	238	8.4	5	8.0	947
9A	228	26	8.4	15	0.0	351
9B	252	56	8.4	10	8.0	381
10A	353	20	8.2	15	12.0	320
10B	601	82	8.6	12	6.0	1214
11A	471	40	7.2	48	8.0	400
11B	498	150	7.8	21	10.0	1326
12A	252	67	7.2	54	4.0	248
12B	943	182	8.1	28	0.0	923
13A	489	154	7.6	11	8.0	344
13B	1692	285	8.8	16	8.0	1210
14A	354	33	7.2	52	5.0	564
14B	2198	140	8.4	31	4.0	789

Chloride in drinking water is generally not harmful to human beings. Portable limit[1,9] is 250 mg/L. All Government Supply Water samples under study had chloride concentration ranged between 42.5 to 117.5 mg/L, satisfying the standards. In Tube Well Water, chloride concentration ranged between 72.5 to 592.5 mg/L. Tube Well samples 2B, 3B, 4B 7B and 12B shows higher chloride concentration compared to acceptable limit[9,1] of 250 mg/L. Very high amount of chloride in water affects persons suffering from diseases of heart and kidney.

The Nitrate concentration in water samples were 0.2 to 5.1 mg/L in Government Supply Water and 1.7 to 26.3 mg/L in Tube Well Water. During the investigation, all the water samples had nitrate content within the permissible limit[1] of 45 mg/L. Nitrate concentration was found high i.e. 21.8, 22.3 and 26.3 in Tube Well Water, this may be due to excessive application of nitrogenous fertilizers, manures, irrigation, leakage from septic tanks, human and animal waste contamination etc.

The Phosphate concentration ranged between 0.2 to 1.25 mg/L which is very low compare to standard limit[9] of 5 mg/L. Also Sulphate concentration ranged between 20 to 60 mg/L which were below the permissible limit[1] of 200 mg/L, but higher sulphate concentration were found in Tube Well Water, because sulphate is soluble in water and it is not precipitated. The sulphate is thus likely to be accumulated in groundwater.

Table 5: Physico-chemical analysis of water samples

Sample	Hardness mg/L	Calcium mg/L	Magnesium mg/L	Chloride mg/L	Sulphate mg/L	Nitrate mg/L	Phosphate mg/L
1A	48	19.2	0.0	51.7	30	0.4	1.2
1B	216	84.1	1.4	168.2	58	14.9	0.6
2A	43	20.0	Nil	42.5	32	2.0	0.4
2B	339	21.9	69.1	592.5	47	21.9	0.5
3A	55	25.9	2.3	56.0	38	3.3	0.3
3B	258	48.9	33.0	322.0	48	16.8	1.2
4A	90	17.3	11.3	90.0	47	2.4	0.5
4B	285	65.4	29.6	260.0	54	22.4	0.6
5A	116	63.0	Nil	82.7	30	5.1	1.2
5B	298	43.2	46.2	195.0	60	26.3	0.2
6A	59	27.2	Nil	117.5	20	0.9	1.0
6B	137	36.2	11.3	103.2	48	6.9	0.5
7A	67	29.6	Nil	80.0	28	2.9	0.3
7B	308	85.0	23.3	368.2	54	24.0	0.5
8A	54	25.0	Nil	62.5	25	3.0	0.2
8B	179	67.0	2.9	167.5	45	14.9	0.1
9A	47	23.4	Nil	67.5	39	1.6	1.1
9B	57	24.2	Nil	72.5	45	1.7	0.3
10A	47	25.0	Nil	49.0	37	0.2	0.3
10B	128	64.0	5.4	520.0	45	15.6	0.2
11A	86	25.6	Nil	58.0	46	0.6	1.3
11B	136	70.3	Nil	94.0	50	9.9	0.4
12A	49	28.8	Nil	110.0	27	1.4	0.9
12B	220	84.7	2.1	350.0	59	18.0	1.1
13A	56	19.2	2.0	69.0	21	0.5	1.4
13B	138	69.3	Nil	101.0	41	8.6	0.8
14A	83	32.0	4.0	49.5	25	2.1	0.5
14B	311	36.4	53.5	97.0	40	20.5	0.1

3.2 Microbial analysis of drinking water

All samples collected were positive for Total Coliforms (TC). TC was found in the range 10 to 1300; it's higher than the permissible limit[10]. The bacteriological analysis of water samples is shown in Table 6. The bacterial contamination of water sources may be attributed to poor sanitary condition around water sources, improper drainage facilities near tube wells. Salmonella Differential Agar media from HiMedia lab were used for identification and differentiation of *Salmonella species* from members of *Enterobacteriaceae,* especially Proteus species based on lactose fermentation and hydrogen sulphide production. All the drinking water samples show presence of *Salmonella* along with *Escherichia coli* in few water samples which are a serious problem in potability of water.

Table 6: Microbial analyses of water samples

Sample	TC CFU/100ml	*Salmonella* differential analysis
1A	190	++++
1B	580	++
2A	lawn	++++
2B	lawn	+#
3A	100	+#
3B	240	+
4A	980	+
4B	130	++++#
5A	200	+
5B	260	+
6A	1300	+++
6B	540	++
7A	10	+
7B	140	+
8A	130	+++
8B	lawn	++++
9A	100	+
9B	400	++
10A	330	+
10B	704	++++#
11A	80	++
11B	240	+++
12A	59	+
12B	90	++
13A	79	+
13B	80	+++
14A	160	+
14B	980	++++

In above table '+' indicates colonies between 1 to 5
# indicates presence of *E.coli*

4. Conclusion

The water sources considered for this study have been used for drinking purpose. All the data were compared with standard values for potability of drinking water (Table 6). On the basis of the above discussion, it may be concluded that the underground drinking water at almost all the sites in Rajkot district is not potable. Therefore, the use of ordinary tube wells should be discouraged. The great majority of evident water related health problems are the result of microbial contamination. Nevertheless, an appreciable number of serious health concerns may occur as a result of the chemical contamination of drinking water. Thus, to adopt indigenous technologies to make water fit for drinking and public awareness regarding present water quality and its health consequences are the need of an hour.

Table 7: Standard values for portability

Parameter	ISI standards
pH	6.5 – 8.5
Turbidity	5 NTU
TDS	600
TSS	500
DO	14.6

BOD	2 (WHO)
COD	10
EC	300µS (ICMR)
Hardness	300
Calcium	75
Magnesium	30
Chloride	250
Sulphate	200 (WHO)
Nitrate	10
Phosphate	5
Iron	0.3 (WHO)
TC	Nil/100ml

* Except pH the values for all the parameters are given in mg/L. ICMR – Indian Council of Medical Research. ISI – Indian Standard Institution.WHO – World Health Organization.

5. References

1. WHO, Guideline for Drinking Water Quality, 2011, 4th edition.

2. Bodhaditya D., Umlong I.M, Saika L.B, Borah K, Kalita H and Srivastava R.B., (2008), A study on the physico-chemical characteristics of ground and surface water of north and south district of Tripura, Proceeding of 53rd Annual Technical Session of Assam Science Society, 9

3. Sinha D.K and Srivastava A.K., (1995), Physico-chemical characteristic of river Sai at Raebareli, Indian journal of environmental health, 37(3), pp 205-210.

4. APHA, Standard methods for the examination of water and wastewater (2005), 21st edn., American public health association, New York.

5. Mridul Buragohain, Bhabajit Bhuyan and H.P.Sarma., (2010), Distribution of water quality parameters in Dhemaji district, Assam (India), Journal of environmental science and engineering, 52(3), pp 241-244

6. Karunakaran K, Samon N A, Manjunathan S, Dorothy A, Raja M and Srividhya D., (2005), A study on the physic-chemical characteristic of groundwater in Salem corporation, Indian journal of environmental protection, 25(16) pp 510-51

7. Muthulakshmi L., Ramu A. and Kannan N., (2010), Assesment of groundwater quality in Virudhnagar district (India): A statistical approach, Journal of environmental science and engineering, 52(3), pp 229-234

8. Pranab Sabhapandit and Abanikr Mishra, (2011), Physico-chemical characteristic of ground and surface water in Gohpur sub-division of Sonitpur district, Assam (India), Journal of environmental science and engineering, 53(1), pp 89-96

9. BIS:IS:10500, Indian standard for drinking water bureau of Indian standards, New Delhi, India, 1991, Second revision of IS:10500, 24/12/2009.

10. EPA 820-R-11-002, 2011, Edition of the drinking water standards and health advisories, Office of water, U.S. Environmental protection agency, Washington, D.C.