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STUDIES ON PHYSICO-CHEMICAL PARAMETERS OF IRRIGATION WATER, PRANTIJ, GUJARAT (INDIA)

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ABSTRACT

Chemical quality of the surface and groundwater is as important as the quantity. Groundwater quality in an inevitable factor for the sustainable agriculture as a source of irrigation water. Therefore, the study was conducted is an irrigated alluvial area to evaluate the groundwater quvality for irrigation. Agriculture, mainly through irrigation is the majar user of fresh water resource, accounting for 70 % of total global fresh water withdrawals. For successful irrigated agriculture, the quality of surface and ground water is as important as the fertility of soil. The physico-chemical analysis of ground water has been done to assess the quality of water for irrigation needs. 20 Water samples were collected from dug-cum bored wells tapping shallow to deep aquifers. The quality analysis was made through the estimation of chloride, bicarbonate, sodium, calcium, total hardness, totle dissolved solids, EC, pH, calculation of sodium adsorption ratio and percentage of sodium. The analytical data are processed and interpreted as per standard laboratory method of APHA. Regarding the suitability of groundwater for irrigational purposes, TDS, EC and SAR are within the safe limits except few samples. Total dissolved solids in ground water ranged between 375-1490 mg/L during the period of investigation, which revealed that irrigation using groundwater of the study area would not cause salinity hazards.

Key word: Groundwater quality, Irrigation, Total dissolved solids, Sodium adsorption ratio.

INTRODUCTION

Water plays a vital role in human life. The consequence of urbanization and industrialization leads to contamination of water. For agricultural purposes ground water is explored in rural areas especially in those areas, where other sources of water like dam and river or canal is not available. During last decade, this is observed that the ground water gets polluted drastically because of increased human activities[1,2]. Consequently number of cases of water borne diseases have been seen, which leads to health hazards[7,8]. So, basic monitoring of water quality has been necessitated to observe the demand and pollution level

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of ground water[5]. A good number of water analysis experiments are regularly conducted by different groups of chemists and biologists across the country[6-9].

Ground water geochemistry is an interdisciplinary science concerned with the human consumption, crop production and industrial usages. The natural state of ground water is generally of excellent quality although harmful concentration of certain ions such as iron and sodium; which can occur naturally, leads to problems. Groundwater quality is the physical and chemical characterization of groundwater, which measures its suitability for human and animal consumption, irrigation and other purposes. The chemical comparison of the water that enters in the ground water reservoir and reacts with the minerals present in the rocks and soils that may modify the its composition.

Groundwater is a main source of drinking water and its quality has made source of water useful. However, the advancement of human civilization and agriculture has put serious questions to the safe use of groundwater for drinking due to production and release of diverse wastes into the environment, which can contaminate groundwaters. Continued development and increasing use of groundwater combined with its reuse, its quality suffers unless due consideration is given to protect it. Any purpose for which this water is required, its quality is a matter of great importance. The chemical quality of water is a factor, which is of paramount importance in its utilization for drinking, municipal, irrigation and industrial uses[1,2]. Suitability of groundwater for irrigational purposes depends upon the salinity, conductivity and hardness of water[10,11]. These parameters are increasing due to the poor sanitation, release of waste and sewage. In the recent years, there is a concern for groundwater quality in irrigation water supplies. There must be sound planning to ensure that the quality of water available is put to the best use[11,12].

Groundwater contains a varying amount of different kinds of ions such as carbonate, bicarbonate, calcium, magnesium, sulphate, hardness, etc.[4] Among them, the major cations are calcium, magnesium and sodium, which influence the suitability of groundwater for human consumption, agricultural irrigation and other purposes. Some of these cations are beneficial to crop production at expected concentration, otherwise they cause toxicity to plant, affect properties of soil and management practices[6,13]. The soil properties, crop yield and quality will deteriorate, if low quality of water is used for irrigation[8]. The physiochemical analysis of ground water evaluates drinking water quality[13]. Similar attempts have been made in the different parts of country[14-16].

The people of North Gujarat region have been facing potable water crisis due to inadequate rains in Gujarat and hence, ground water is considered as the first water resource for irrigation and other uses. The climate of the Prantij plain can be described as being hot,

windy and arid with humidity, air temperature is over 43°C in the period from May to September. The source of drinking water in Sabarkantha city is only ground water. The aim of this study was to investigate the quality of the ground water. Samples were collected from the Prantij wells. Chemical and physical characteristics were determined analytically.

In all, about 20 samples of water were examined for electrical conductivity, pH and the proportion of various cations and anions. The chemical analysis was carried out following standard procedures. Chemical analysis of the water samples is given in Table 3, which presents different ratios to judge the quality of these water samples from irrigation viewpoints.

EXPERIMENTAL

Materials and methods

Sample collection

The ground water samples were collected from 20 bore wells in selected stations of Prantij taluka region. The samples were collected as per the standard methods recommended by APHA (1995)[2]. Before water sampling, all the double-stoppered polythene containers were cleaned and rinsed thoroughly with water samples to be analyzed. The physico-chemical analysis was done using the standard methods (Dhyan singh and P. N. Pandey, 1998).

Ground water quality analysis

The physico-chemical analysis was done using the standard methods (Dhyan singh and P. N. Pandey, 1998). The groundwater samples were analysed for total dissolved solids (TDS), sodium (Na), calcium (Ca) and magnesium (Mg). TDS in the water utilizated for irrigational use depends on many factors, such as texture, composition of soil, type of crop, climate, irrigational practices and chemical quality of groundwater. The groundwater samples were analysed. To judge its suitability for irrigational uses, various irrigational parameters like sodium adsorption ratio (SAR), percentage of sodium (Na %), total dissolved solids (TDS) and electrical conductivity were measured in the study area.

RESULTS AND DISCUSSION

The pH values ranged between 7.32 – 8.62. The lowest value was observed in Tajpur and the highest in Galteshwar (Table 3). It was observed that 76 % of the water samples lies in the range of 6.5 – 8.5 prescribed by Bureau of Indian Standards (Table 2).

Electrical conductivity is a useful tool to evaluate the purity of water. Maximum electrical conductivity was recorded is Nutanwadi (2.941 mmhos/cm) and the minimum EC at Amodara-1 (0.746 mmhos/cm). The results indicate that almost all the water samples are within the permissible limits of 2.250 mmhos/cm (Table 1).

Table 1: Rating of different parameters in irrigation water

	Parameter			
pH	**Acidic**	**Normal**	**Saline**	**Alkaline**
Total No. of sample	< 7.00	7.00 to 7.50	7.50 to 8.50	> 8.50
	00	01	08	01
E.C. (mmhos cm^{-1})	**Good**	**Safe**	**Marginal**	**Unfit**
Total No. of sample	< 0.250	0.250 to 0.750	0.750 to 2.250	> 2.250
	00	03	16	01
SAR	**Low**	**Medium**	**High**	**Very high**
Total No. of sample	< 10.0	10.0 to 18.0	18.0 to 26.0	> 26.0
	06	04	00	00
RSC (meq L^{-1})	**Safe**	**Marginal**	**Doubtful**	
Total No. of sample	< 1.25	1.25 to 2.50	> 2.50	
	07	04	10	

Total dissolved solids (TDS)

The TDS of the water samples ranged from 380 mg/L (Amodra-1) to 1490 mg/L (Nutanwadi). The ISI standard for dissolved solid is up to 500 mg/L and the maximum permissible quantity is 2000 mg/L (WHO, 1994). The TDS values of all the water samples of the selected places are under permissible limit of 2000 mg/L (Table 2).

Ca^{2+} + Mg^{2+} cause the greatest portion of the hardness occurring in natural waters. Hardness of the water is objectionable from the viewpoint of its use. Ca^{2+} + Mg^{2+} values of the water samples ranged from 2.6 to 10.2 meq/L. The lowest value of 2.6 meq/L is at Galteshwar, whereas the highest value of 10.2 meq/L was recorded in water samples from

Tajpur. The values of total hardness of 77% samples are within the permissible range. The highest desirable limit of total hardness is 6.0 meq/L (300 mg/L) (ICMR 1975) (Table 2).

Table 2: Standard of physical and chemical water quality

Prescribed by the Bureau of India Standard (IS: -10500:1991)			**Prescribed by ICMR (1975)**			
Parameters	**Required desirable limit**	**Permissible limit in the absence of alternate source**	**Highest desirable level**	**Maximum permissible level**	**USPH standard**	**Onland for irrigation (IS: 3307-1974)**
TDS (mg/L)	500	2000	500	1500	500	2100
pH Value	6.5 to 8.5	No relaxation	7.0 to 8.5	6.5 to 9.2	6.0 to 8.5	6.5 to 9.0
Calcium (mg/L)	75	200	75	200	100	-
Magnesium (mg/L)	30	100	-	-	30	-
Chlorides (mg/L)	250	1000	200	1000	250	600
Sulphate (mg/L)	200	400	200	400	250	1000
Percent sodium	-	-	-	-	-	60
Fluoride (mg/L)	1.0	1.5	1.0	1.5	1.5	-
Phosphate (mg/L)	-	-	-	-	0.1	-

Sodium contents of the groundwaters of Prantij taluka ranges from 3.37 meq/L (Saupad) to 21.48 meq/L (Nutanwadi) (Table 3). About 61% of the water samples show sodium higher than the permissible limit of 50 ppm (9 meq/L) in irrigation water as prescribed by BIS (1983).

Table 3: Physico-chemical characteristics of irrigation water in Prantij taluka (N. Gujarat)

Location/ Villages	pH	TDS mg/L	Cond. Mmh s/cm	$Ca^{2+}+Mg^{2+}$ meq/L	Na^{+} meq/L	K^{+} meq/L	CO_3^{2-} meq/L	HCO_3^{-} meq/L	RSC	SAR meq/L	SSP (%)	Cl^{-} meq/L	F^{-} mg/L	SO_4^{2-} mg/L	PO_4^{3-} mg/L
Tajpur	7.32	840	1.320	10.2	5.15	0.28	0.4	7.7	-2.1	2.28	32.95	7.0	0.58	98.4	24.9
Mauchha	8.37	640	1.256	4.7	9.48	0.02	0.5	14.5	10.3	6.18	66.76	4.8	2.60	96.2	32.8
Rampura	8.39	617	1.210	4.0	10.43	0.02	0.6	12.4	9.0	7.37	72.18	5.0	2.60	130.5	48.3
Amodara-1	7.80	380	0.746	4.2	3.87	0.02	0.0	6.6	2.4	2.67	47.84	3.2	1.10	150.0	22.9
Amodara-2	7.70	401	0.790	4.8	3.78	0.02	0.0	7.0	2.2	2.44	43.95	3.6	1.10	78.0	21.0
Podalu	7.85	478	0.929	4.6	5.06	0.02	0.3	8.7	4.4	3.34	52.27	3.2	0.54	90.5	3.4
Kotasan	8.11	422	1.602	5.7	13.26	0.03	0.5	11.0	5.8	7.85	69.83	10.4	1.20	101.3	20.0
Adraspur	8.02	819	1.611	5.6	13.26	0.03	0.5	11.1	6.0	7.92	70.20	9.0	1.20	150.0	50.0
Anavarpur	8.31	854	1.671	4.0	15.30	0.01	1.0	11.0	8.0	10.82	79.23	8.2	1.40	90.0	37.8
Sadoliya	8.13	865	1.696	4.2	15.30	0.01	0.5	11.8	8.1	10.56	78.42	8.4	1.50	98.0	40.2
Prantij	7.92	467	0.912	5.5	4.67	0.02	0.0	8.2	2.7	2.82	45.83	4.4	0.54	37.5	14.5
Galteshwar	8.62	800	1.573	2.6	15.52	0.02	1.0	12.5	10.9	13.61	85.56	6.8	1.50	85.0	50.0
Ashapur	8.41	817	1.594	2.8	14.87	0.02	0.7	12.5	10.4	12.57	84.06	7.0	1.50	78.3	45.9
Lobha	8.17	375	0.736	5.0	3.41	0.03	0.4	5.8	1.2	2.16	40.40	4.0	0.85	89.5	42.5
Jambudi	8.23	470	0.920	6.0	4.06	0.12	0.5	5.5	0.0	2.34	39.88	5.2	0.83	109.9	90.7
Saupad	8.07	398	0.782	5.9	3.37	0.02	0.4	6.8	1.3	1.96	36.27	4.0	1.30	153.8	95.0
Nutanwadi	7.92	1490	2.941	9.8	21.48	0.17	0.3	6.1	-3.4	9.70	68.30	23.0	0.75	201.0	96.2
Majra	7.69	692	1.364	9.6	4.85	0.02	0.4	5.6	-3.6	2.21	33.52	8.0	0.57	189.0	36.2
Kamalpur	8.00	614	1.196	7.2	5.15	0.21	0.1	6.9	-0.2	2.71	41.00	7.4	0.92	130.4	96.5
Dalilpur	8.07	382	0.752	5.5	3.48	0.03	0.3	5.9	0.7	2.10	38.62	4.0	0.82	210.0	56.5

In the present study, all the water samples have potassium higher than the permissible limit of 0.5 meq/L as prescribed by BIS and ranges from 0.01 meq/L (Anavarpur) to 0.28 meq/L (Tajpur). The values of HCO_3^- in the water samples varied from 5.50 to 14.50 meq/L (Table 3). The lowest value of 5.50 meq/L was observed in the water sample obtained from Jambudi where as the highest value of 14.50 meq/L was observed in Moochha Village. All the samples are far below than the permissible limit of 120 meq/L. It is observed that around 53% of the samples have chlorides higher than the permissible limit of 10.0 meq/L. The highest concentration of chlorides was recorded in Nutanwadi (23.00 meq/L) and the lowest at Podalu (3.20 meq/L). High chloride content in ground water can be attributted to lack of under ground drainage system and poor maintenance of environment around the sources.

Fluoride contents of ground water samples of the study areas ranges from 0.54 (Prantij) to 2.60 mg/L (Mauchha). Maximum allowed limit is 1.5 ppm (WHO, 1984) (Table 2). It is under permissible limit. Small concentration of fluoride in drinking water has beneficial effect on human body. Low concentration of fluoride below 0.5 ppm causes dental caries and higher concentration beyond 1.5 ppm causes dental and skeletal fluorosis.

Higher sulfate contents of 189.0, 201.00, and 210.00 mg/L was recoded at Majra, Nutanwadi and Dalipur, respectively. The presence of high concentration of sulfates in the study area can be attributed the discharge of domestic sewage and littering of organic wastes in the region.

Sodium adsorption ratio

The suitability of the well and bore well water samples was judged by determining the SAR value and these were categorized under different irrigation classes on the basis of salinity and alkalinity hazards. Sodium adsorption ratio (SAR) is the proportion of sodium to calcium and magnesium, which affects the availability of the water to the crop. SAR is computed by the equation (1) and are given in Table 1.

$$SAR = \frac{Na^+}{(Ca^{2+} + Mg^{2+})/2} \quad \ldots(1)$$

Richards [13] classify the irrigation water with SAR less than 10 as excellent, between 10 - 18, 18 – 26 as fair and greater than 26 as of poor quality. Based on the values alone, the groundwater samples in the study area are excellent with the SAR values less than 10 (In all, about 16 samples in the study area).

Residual sodium carbonates (RSC) was computed by using values of anions of sodium (CO_3^{2-} and HCO_3^{1-}) and cations (Ca^{2+} + Mg^{2+}) where the ionic concentration is in meq/L. The RSC values varied from – 3.60 to 10.90 (Table 3).

Percentage of sodium

Sodium content is computed by the equation (2) and are given in Table 3.

$$\% \text{ Na} = \frac{(\text{Na} + \text{K})}{(\text{Ca} + \text{Mg} + \text{Na} + \text{K})} \times 100 \qquad \ldots(2)$$

The soluble sodium percentage (SSP) values of the water samples of Prantij taluka ranged from 32.95 to 85.56. The lowest value of 32.95 per cent was observed in Tajpur whereas the highest values of 85.56 per cent was recorded in the water sample from Galteshwar Village. Further, the data revealed that about 61.53 per cent of the water samples have high values (> 60) of SSP.

CONCLUSION

The SAR values of the study area samples (16 samples) are less than 10 and TDS in less than 1500 and hence, these water sources could be utilized for irrigation on the basis of U.S. Salinity laboratory diagram. Ground water of the study area contains desirable level of TDS, percentage Na, SAR value for irrigation, which indicated that there is be no possibility of any hazards from using this ground water for irrigation. However, ground water of the study area is moderately hard.

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REFERENCES

1. A. Abdul Jameel, Poll. Res., **17(2)**, 111-114 (1998).
2. APHA, Standard methods for the examination of water and waste water; Washington DC, USA, (1995).
3. B. K. Handa, J. Indian Soc. Soil Sci., **13** 227-232 (1965).
4. B. S. Kanwar and J. S. Kanwar, Indian J.Agric. Sci., **41**, 54-66 (1971).

5. G. L. Maliwal and K .V. Paliwal, Indian J. Agric Sci., **52**, 593-599 (1982).
6. K. V. Paliwal, et al., Pl. Soil, **43**, 523-536 (1975).
7. P. N. Ramteke, J. W. Battacharjee and N. Karlo, J. Appl. Bact., **72**, 352 (1992).
8. I. M. Rao, Proc. Sem. Sea Salt and Plants, Bhavnagar, (1967) pp. 55-58.
9. D. R. Singh, M. Sc. Ag. Thesis, Agra University, Agra (1994).
10. K. M. Elizabeth and L. Premnath Naik, Poll. Res., **24(2)**, 337-340 (2005).
11. Guidelines for Drinking Water Quality- WHO, Geneva, 2nd Ed., (1999) pp. 97-100.
12. P. V. Desai, Poll. Res., **(4)**, 377-382 (1995).
13. D. Nath, J. Inland Fresh. Soc. India, **33(2)**, 37-41 (2001).
14. A. G. Sirkar et al., J. IWWA, 215-220 (1996).
15. O. S. Tomar and J. S. P. Yadav, Indian J. Forestiy., **3(4)**, 58-62 (1980).
16. Vijender Singh, Res. J. Chem. Env., **10(3)**, 62-66 (2006).

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