International Journal of Agriculture Sciences
ISSN: 0975-3710&E-ISSN: 0975-9107, Volume 8, Issue 54, 2016, pp.-2923-2925.
Available online at http://www.bioinfopublication.org/jouarchive.php?opt=&jouid=BPJ0000217

Research Article

EVALUATION OF UNDERGROUND WATER QUALITY OF BARA TRACT OF BHARUCH DISTRICT (GUJARAT)

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Received: October 19, 2016; Revised: October 22, 2016; Accepted: October 24, 2016; Published: November 06, 2016

Abstract- The quality of irrigation water is the foremost matter in irrigated condition. However, injudicious use of good quality water may turn a good soils into saline/ or sodic soils. Thus, it has large bearing on the productivity of soil as well as crop yield. So, total 50 nos. of water samples (40: ground water and 10: canal water) were collected from different sources during year 2015 from irrigated and rainfed area of studied area, Bharuch district for evaluate the ground water based on USDA classification. The result revealed that major cases ground water samples were found unsafe for irrigation due to high salinity problems (C4S1), though sodicity problem along with salinity may also arise to certain extent. During scarcity of good quality water, ground water can be used only by mixing with good quality water /rain water/ canal water or alternately with good quality water as supplementary/ life-saving irrigation to sustain crop yield and soil health.

Keywords- Bara tract, Salinity class, Soil health, Water quality

Citation: Kumar Shrvan, et al., (2016) Evaluation of Underground Water Quality of Bara Tract of Bharuch District (Gujarat). International Journal of Agriculture Sciences, ISSN: 0975-3710 & E-ISSN: 0975-9107, Volume 8, Issue 54, pp.-2923-2925.

Academic Editor / Reviewer: Jivraj Chaudhary

Introduction

Quality of irrigation water is of crucial importance in irrigated agriculture, not only for sustainable crop yield and soil health, but also from environmental point of view. Bara tract area is endowed with river like Dhadhar, Bhukhi and Narmada. Irrigations are done not only by lifting water from Dhadhar and Bhukhi river and also from canal network system of Narmada river, but also partly from tube well / bore well (ground water). Thus, it is imperative that depending upon of sources of water, quality of water might differ to certain extent. Though, Bara tract area under study is endowed with Narmada Canal irrigation facility, yet some farmers are compelled to use ground water owing to crisis of water in sufficient quantity during post monsoon period. Some farmers are also using ground water for irrigation in the event of prolonged dry spell, particularly at critical growth stages of crop during monsoon season (Nayak *et al*., 2004) [6]. Similarly, the very few farmers also practice combined use of canal and ground water during *rabi* season and during hot seasons in very specific cases. In view of this, it is worth to assess the quality of ground water from irrigation point of view.

Materials and Methods

The Western region of Narmada river command area, an alluvial coastal plains adjoining the Gulf of Khambhat and lying between 21° 40' to 22° 13' N latitude and 72° 32' to 72° 55' E longitude is known as "Bara tract" which consists of Amod, Vagra and Jambusar talukas of Bharuch district of Gujarat. Total fifty of water samples were collected from different sources during year 2015 from irrigated and rainfed area of studied area, Bharuch district. Out of total 50 samples, 40 nos. ground water samples and 10 nos. canal water were collected and all the samples were analysed for quality parameters *viz*., pH, EC, Ca^{2+}, Mg^{2+}, Na^{+}, CO_3^{2-}, Cl^{-}, HCO_3^{-}, SO_4^{2-}, NO_3^{-} as per the standard methods outlined by Richards (1954). Based on the content of soluble cations in the water samples, index of sodicity, sodium adsorption ration (SAR) and residual sodium carbonate (RSC) were computed. Various water quality parameters analysed in accordance with the Standard methods for examination of water (APHA, WWA and WEF, 2005) [2] and Wilcox (1948) [9]. Carbonate (CO_3^{2-}) and Bicarbonate (HCO_3^{-}) contents were determined by titration with HCl as described by Richards (1954) [8] Electrical Conductivity (EC) and pH were measured following Jackson (1967) [4].

Results and Discussion

The study area comes under semiarid zone, which is receiving an average annual rainfall of 747 mm (during June to October). Though, Bara tract area under study is endowed with Narmada Canal irrigation facility, yet some farmers are compelled to use ground water owing to crisis of water in sufficient quantity during post monsoon period. Some farmers are also using ground water for irrigation in the event of prolonged dry spell, particularly at critical growth stages of crop during monsoon season. The result revealed that the pH of ground water [Table-1] and [Fig-1] samples varied from 7.3 to 8.7 (neutral to strongly alkaline) with a mean value of 7.9, which indicated that in study area water resources were moderately alkaline in reaction. From salinity point of view, EC ranged from 1.0 to 12.0 dSm^{-1} (medium to very high salinity) with a mean value 4.9 dSm^{-1} (high salinity), which falls under salinity class C4 *i.e.* very high salinity indicating unsuitability for irrigation. However, out of 40 samples, 7 samples came under C3 class i.e. high salinity class (0.75 to 2.25 dS m^{-1}) which might create salinity problems in soils, 14 samples came under C4 salinity class i.e. very high salinity class (>2.25 dS m^{-1}) which also might create salinity problems in soil and 19 samples belonged to C5 class *i.e.* very high salinity class (5-20 dS m^{-1}) and hence is not advisable to irrigation purposes due to possibility of high salinity development in soil [Table-1] and [Fig-1]. SAR valued ranged from 1.9 to 18.2 *i.e.* from sodicity class S1 to marginally S3 class, which indicated that some water samples were of medium

sodicity class. However, mean value of SAR was 9.5, which fell into sodicity class (S1). Out of 40 water samples 14 samples belonged to S1 class i.e. very low sodicity and can be used safely for irrigation purposes, 15 samples came under S2 class i.e. medium sodicity class and only 1 samples was of marginally high sodicity class, which indicated that development of sodicity might arise in the soil if these waters are taken for irrigation purposes.

Table-1 *Ground water quality of Bara tract of Bharuch district*

S.N.	pH	EC (dS m^{-1})	Ca^{2+}	Mg^{2+}	Na^{+}	K^{+}	CO_3^{2-}	HCO_3^{-}	Cl^{-}	SO_4^{2-}	NO_3^{-} (ppm)	RSC	SAR	Salinity class
			me l^{-1}											
1	7.8	5.1	5.5	12.0	24.9	0.1	2.5	3.0	34.8	2.5	1.1	-12.0	8.4	C5S1
2	8.1	5.4	4.0	11.0	29.4	0.1	2.5	2.5	34.8	1.9	2.1	-10.0	10.7	C5S2
3	7.9	7.8	5.0	15.8	46.6	0.0	2.0	2.5	55.5	2.9	5.6	-16.3	14.5	C5S2
4	7.7	6.2	5.0	17.3	31.2	0.1	1.5	3.0	45.0	2.2	3.2	-17.8	9.4	C5S1
5	7.8	5.2	5.0	14.5	25.6	0.1	2.0	4.3	35.0	2.5	6.1	-13.3	8.2	C5S1
6	7.8	3.3	4.0	7.8	17.2	0.1	2.0	2.0	23.0	1.3	4.8	-7.8	7.1	C4S1
7	8.0	6.4	4.5	12.8	36.4	0.1	2.5	3.0	43.3	2.1	1.3	-11.8	12.4	C5S2
8	8.2	2.3	2.8	8.5	10.1	0.1	2.0	3.8	14.5	0.4	3.5	-5.5	4.3	C4S1
9	8.1	2.5	1.5	5.0	15.9	0.1	2.5	2.5	14.3	2.1	2.3	-1.5	8.8	C4S1
10	7.7	3.3	4.8	13.0	7.7	0.1	1.5	2.0	22.5	1.0	18.6	-14.3	2.6	C4S1
11	8.6	2.2	1.5	3.0	17.1	0.1	1.5	3.8	13.8	1.2	6.1	0.8	11.4	C4S2
12	8.7	1.8	1.0	3.3	14.2	0.1	3.5	6.5	6.0	0.1	4.0	**5.8**	9.7	C3S1
13	8.2	2.5	1.8	2.0	20.5	0.1	5.0	7.0	8.8	0.3	11.9	**8.3**	15.0	C4S2
14	7.7	8.5	5.5	18.5	50.9	0.3	2.0	2.5	53.8	6.1	33.1	-19.5	14.7	C5S2
15	7.6	2.9	4.3	10.3	11.3	0.2	2.0	2.0	20.0	0.8	5.6	-10.5	4.2	C4S1
16	7.9	8.6	8.3	13.8	60.5	0.2	1.5	2.3	76.3	2.9	5.5	-18.3	18.2	C5S3
17	7.9	1.3	1.0	3.8	7.6	0.1	2.0	4.0	6.0	0.4	8.6	1.3	4.9	C3S1
18	7.8	2.7	4.3	3.8	14.3	0.1	1.0	2.8	17.0	0.5	4.3	-4.3	7.2	C4S1
19	8.1	2.1	2.8	8.3	6.3	0.1	3.0	1.5	13.8	0.2	1.0	-6.5	2.7	C3S1
20	7.8	7.0	6.3	20.0	34.1	0.6	3.0	3.5	46.3	3.3	7.1	-19.8	9.4	C5S1
21	7.5	12.0	11.5	25.5	74.3	0.3	0.0	2.0	93.8	4.5	15.7	-35.0	17.3	C5S2
22	7.7	2.0	2.8	3.5	13.2	0.1	2.0	3.3	11.8	0.8	19.8	-1.0	7.5	C3S1
23	8.0	3.0	2.5	8.0	17.3	0.1	2.5	2.8	18.3	2.3	9.1	-5.3	7.6	C4S1
24	8.0	7.8	6.5	16.0	48.2	0.2	3.0	3.0	54.5	2.5	40.4	-16.5	14.4	C5S2
25	8.1	6.6	3.8	12.3	45.9	0.2	3.0	2.3	45.0	4.6	7.0	-10.8	16.2	C5S2
26	7.7	2.0	2.8	8.0	6.5	0.1	1.5	4.0	14.5	0.7	2.8	-5.3	2.8	C3S1
27	7.5	3.1	4.3	14.0	7.7	0.1	1.5	3.0	19.3	1.0	21.0	-13.8	2.5	C4S1
28	8.0	4.6	3.8	11.3	28.5	0.1	2.0	3.3	3.5	2.9	4.9	-9.8	10.4	C4S2
29	8.0	1.0	2.0	4.0	3.3	0.0	2.0	3.3	3.5	0.2	3.4	-0.8	1.9	C3S1
30	8.0	7.5	6.8	16.8	50.2	0.3	1.5	2.3	64.0	6.0	7.1	-19.8	14.6	C5S2
31	8.0	8.9	12.0	26.0	45.8	0.3	1.0	2.0	72.0	2.7	9.3	-35.0	10.5	C5S2
32	8.0	3.7	4.8	8.6	23.2	0.1	2.5	3.8	26.5	1.5	9.9	-7.1	9.0	C4S1
33	8.3	3.1	2.5	7.5	19.9	0.1	2.5	6.3	16.5	1.0	10.5	-1.3	8.9	C4S1
34	7.8	3.8	3.5	12.3	17.2	0.1	2.0	3.3	23.5	2.2	10.0	-10.5	6.1	C4S1
35	8.2	1.8	2.8	7.0	7.5	0.1	2.0	2.3	10.5	0.7	12.8	-5.5	3.4	C3S1
36	8.0	5.5	4.3	15.3	30.9	0.1	4.0	3.8	33.8	3.3	9.5	-11.8	9.9	C5S1
37	7.3	10.0	8.3	18.5	59.4	0.2	2.0	1.8	64.3	4.1	1.4	-23.0	16.2	C5S2
38	7.7	9.2	11.8	15.8	57.7	0.2	1.0	1.5	70.0	2.5	3.6	-25.0	15.6	C5S2
39	7.7	8.4	8.3	13.8	60.5	0.2	1.5	2.3	76.3	2.9	5.5	-18.3	18.2	C5S3
40	7.5	5.5	1.0	1.3	3.1	0.1	1.2	1.3	2.6	0.4	4.2	0.2	2.9	C5S1
Min	**7.3**	**1.0**	**1.0**	**1.3**	**3.1**	**0.0**	**0.0**	**1.3**	**2.6**	**0.1**	**1.0**	**-35.0**	**1.9**	
Max	**8.7**	**12.0**	**12.0**	**26.0**	**74.3**	**0.6**	**5.0**	**7.0**	**93.8**	**6.1**	**40.4**	**8.3**	**18.2**	
Mean	**7.9**	**4.9**	**4.6**	**11.2**	**27.6**	**0.1**	**2.1**	**3.0**	**32.7**	**2.0**	**8.6**	**-10.7**	**9.5**	**C4S1**

S.N. 1 to 40: Villages: Kurchan-N, Kurchan-S, Keshlu, Kurchan-W, Vantaras, Ghamnad,, Tancha, Vasna, Azamnagar, Malkinpura, Amod, Achhod-W, Achhod-E, Kerwada, Dora-N, Pisad, Pahaj, Ochhan, Vichyad, Saran, Vagra, Dora-E, Sarbhan, Bodka, Rohad, Malkinpura, Danda-S, Sarbhan, Danda, Nahiyar-1, Dora-E, Keshlu, Kothi, Vedcha, Dora, Anor, Samni TW-1, Samni TW-2, Pisad, Nahiyar-2, respectively. N, S, E, W= North, south, east, west direction, respectively. Salinity class: C1, C2, C3, C4, C5 means <0.25 (safe), 0.25-0.75 (medium salinity), 0.75-2.25 (high salinity), >2.25 (very high salinity) and 5-20 dS m^{-1} (very very high salinity), respectively. Sodicity class: S1, S2, S3, S4 means 0-10 (low sodicity), 10-18 (mediusodicity), 18-26 (high sodicity) and > 26 (very high sodicity), respectively; RSC: <1.2 (Safe), 1.25-2.5 (marginal) and >2.5 me l-1 (Unsuitable), respectively

Combining salinity class with sodicity class, quality of water samples varied from C3S1 to C5S3. Out of 40 samples, 7 samples came under C3S1 (high salinity with low sodicity class), 11 samples came under C4S1 (very high salinity with low sodicity class), 3 samples came under C4S2 (very high salinity with medium sodicity class), 6 samples came under C5S1 (very very high salinity with low sodicity class), 11 samples came under C5S2 (very very high salinity with medium sodicity class) and 2 samples came under C5S3 (very very high salinity with high sodicity class). In major cases water samples were unsafe for irrigation due to high salinity problems [Table-1] and [Fig-1], though sodicity problem along with salinity may also arise to certain extent. The highest salinity and sodicity problems were observed in Saran village (Vagra) and Danda village (Amod), respectively, while the lowest salinity and sodicity was recorded in Danda village (Vagra). The data of RSC revealed that all the ground water samples came under the category of safe group, except two samples which had RSC values >2.5 and belonged to unsafe category (Achhod village). The mostly of ground water samples had low RSC due to the dominance of Mg^{2+} ion concentration. When all the parameters were considered, the ground water sources which are being used for irrigation, was found unsuitable for irrigation purposes in study area [Table-1] and [Fig-1].

NO_3^- content in ground water varied from 1.0 to 40.4 ppm (low to high based on Richards, 1954) with mean value of 8.6 (medium). However, out of 40 samples, 16, 23 and 1 samples came, respectively under 'low' (<5 NO_3^- mg kg^{-1}), 'medium' (5-30 NO_3^- mg kg^{-1}) and 'high' (>30 NO_3^- mg kg^{-1}) category [Table-1] and [Fig-1].

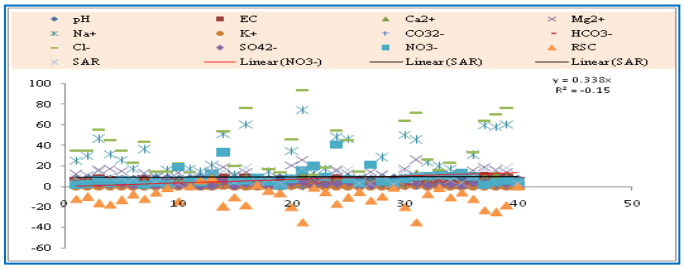

Fig-1 Ground water quality parameters of Bara tract area of Bharuch district (Gujarat)

High NO_3^- content of ground water can cause higher concentration of N in the fodder which might create poising effect to animals. The maximum NO_3^- concentration was found in Bodka village (Amod) and the minimum concentration of it was noticed in Vichyad village (Amod). Similar results for irrigation water quality parameters were supported by Admau*et al.* (2013) [1] and Dabral *et al.* (2014) [3]. Results of irrigation water on black soils of Amravati district of Maharashtra as reported by Padekar*et al.* (2016) [7] was corroborated with the present study, where they found that irrigation water fell under C3 and C4 classes, indicating their unsuitability for irrigation and also fells under medium category of sodicity (S2) and low (S1), high RSC (>2.5 me l^{-1}).

In case of canal water, result revealed that the pH of water samples varied from 7.1 to 7.5 (neutral) with a mean value of 7.2 [Table-2]. From salinity point of view, EC ranged from 0.10 to 0.40 (very low to low) with a mean value 0.30 dSm^{-1} (low). SAR of all the samples <1.0 i.e. no sodicity problem and all the samples came under S1 sodicity class.

Table 2 *Canal water quality of study area*

S.N.	pH	EC (dS m^{-1})	Ca^{2+}	Mg^{2+}	Na^+	K^+	CO_3^{2-}	HCO_3^-	Cl^-	SO_4^{2-}	NO_3^- (ppm)	RSC	SAR	Salinity class
			me l^{-1}											
1	7.3	0.4	3.0	0.0	0.7	0.0	2.1	0.0	0.5	0.03	1.0	-0.9	0.6	C2S1
2	7.2	0.2	1.5	0.0	0.6	0.1	1.3	0.0	0.8	0.04	1.4	-0.2	0.6	C2S1
3	7.1	0.2	1.2	0.0	0.5	0.1	1.2	0.0	0.5	0.05	1.3	0.0	0.6	C2S1
4	7.3	0.3	1.6	0.0	0.7	0.1	1.6	0.0	0.5	0.03	0.7	0.0	0.8	C2S1
5	7.5	0.4	2.6	0.0	1.0	0.2	2.3	0.0	1.0	0.04	0.9	-0.3	0.9	C2S1
6	7.1	0.2	0.8	0.0	0.4	0.1	1.0	0.0	0.3	0.05	0.6	0.2	0.6	C2S1
7	7.1	0.1	0.7	0.0	0.2	0.0	0.6	0.0	0.2	0.02	1.0	-0.1	0.4	C2S1
8	7.4	0.4	2.4	0.0	0.8	0.1	2.5	0.0	0.8	0.08	1.4	0.1	0.8	C2S1
9	7.3	0.2	1.4	0.0	0.5	0.1	1.3	0.0	0.5	0.04	2.5	-0.1	0.6	C2S1
10	7.3	0.2	1.6	0.0	0.6	0.1	1.4	0.0	0.6	0.05	1.0	-0.2	0.7	C2S1
Min	**7.1**	**0.1**	**0.7**	**0.0**	**0.2**	**0.0**	**0.6**	**0.0**	**0.2**	**0.0**	**0.6**	**-0.9**	**0.4**	
Max	**7.5**	**0.4**	**3.0**	**0.0**	**1.0**	**0.2**	**2.5**	**0.0**	**1.0**	**0.1**	**2.5**	**0.2**	**0.9**	
Mean	**7.2**	**0.3**	**1.7**	**0.0**	**0.6**	**0.1**	**1.5**	**0.0**	**0.6**	**0.0**	**1.2**	**-0.1**	**0.7**	**C2S1**

Salinity class: C1, C2, C3, C4, C5 means <0.25 (safe), 0.25-0.75 (medium salinity), 0.75-2.25 (high salinity), >2.25 (very high salinity) and 5-20 dS m^{-1} (very very high salinity), respectively. Sodicity class: S1, S2, S3, S4 means 0-10 (low sodicity), 10-18 (medium sodicity), 18-26 (high sodicity) and > 26 (very high sodicity), respectively; RSC: <1.2 (Safe), 1.25-2.5 (marginal) and >2.5 me l-1 (Unsuitable), respectively.

In case of salinity class, all the samples came under C2 salinity i.e. suitabile for irrigation with moderate leaching, while no sodicity problems (S1). Combined class of salinity and sodicity class was C2S1 for all samples i.e. all the samples were suitable for irrigation with moderate leaching due to low salinity and sodicity problems [Table-2]. The data of RSC revealed that all the water samples came under the category of safe group. NO_3^- content in canal water varied from 0.6 to 2.5 mg kg^{-1} ('low' based on Richards, 1954) with mean value of 1.2 mg kg^{-1}. Similar results for irrigation water quality parameters were supported by Kankal*et al.* (2012) [5]and found that pH and nitrate content of SardarSarovar Canal water were at Viramgam-Ahmedabad area (Gujarat) within the range of WHO standard, whereby pH and nitrate ranged from 6.4-8.6 and 5.0-5.4 mg l^{-1}, respectively.

Conclusion

In major cases ground water samples were found unsafe for irrigation due to high salinity problems (C4S1), though sodicity problem along with salinity may also arise to certain extent. Owing to low rainfall and its aberrant distribution in this semiarid study area, rainwater harvesting and recycling, making of field bunds for maximum moisture storage in soils would be highly advantageous particularly under rainfed situation for getting higher crop yield. As the ground water is saline and unsafe for irrigation in the entire tract, under both irrigated and rainfed situation during scarcity of good quality water, ground water can be used only by mixing with good quality water /rain water/ canal water or alternately with good quality water as supplementary/ life-saving irrigation to sustain crop yield and soil health.

Conflict of Interest: None declared

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