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Survey and characterization of groundwater quality in Rewari block of district Rewari, Haryana

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Abstract
In present study, the quality of groundwater in Rewari block of Rewari district of Haryana state was examined. The district is surrounded by Jhajjar and Bhiwani districts in North, Gurgaon district in north-east, Mahendergarh district in west and Alwar district of Rajasthan in the South and South-East. In total, 143 groundwater samples from running tube wells from the block were analysed during 2013-2014 for ionic concentration of CO_3^{2-}, HCO_3^-, Cl^-, SO_4^{2-}, NO_3^-, F^-, Ca^{2+}, Mg^{2+}, Na^+, K^+. Subsequently, electrical conductivity (EC), sodium absorption ratio (SAR) and residual sodium carbonate (RSC) were also calculated. According to AICRP classification, 39, 18, 10, 17, 3, 9 and 4 % waters in Rewari block were found to be in good, marginal saline, saline, high SAR saline, marginal alkali, alkali and highly alkali, respectively. Whereas according to Manchanda classification, 41, 19, 10, 13 and 17 % waters of Rewari block were classified under good, marginal, saline, sodic and saline sodic categories, respectively. The highest ECe in Rewari block was observed in village Chandawas (6.29 $dSm^{-1)}$ and lowest was found in village Janti (1.30 dSm^{-1}). Residual sodium carbonate (RSC) and sodium absorption ratio (SAR) varied from nil to 9.65 me l^{-1}, 1.14to 19.45 (mmol -1)$^{1/2}$. Spatial variable maps of EC, SAR, RSC and water quality of groundwater used for irrigation in the block were prepared through GIS to study spatial variability.

Keywords: Rewari, Groundwater, Water quality

Introduction
Water is the basic and essential natural resource, needed to ensure food security, feed livestock, and maintain organic life, industrial production and to conserve the biodiversity and environment. However with increasing demand, due to growing population and unsustainable lifestyle, it is becoming the limiting factor for development in almost all parts of the world (Hazra and Avishek, 2010) [7]. Major consumption of water is for agriculture, industrial production and domestic purposes, apart from being used for fishery, hydro-power generation, transportation and maintaining biodiversity and ecological balance. Agriculture sector is the major user (89 %) of this resource but the estimates showed that the growing demands from municipalities, industries and energy generation, will claim about 23 % (24.3 m ha-m year−1) of the total water resources (105 m ha-m year−1) by the year 2025AD, thereby, further reducing the good quality water supply for irrigation (Minhas and Tyagi, 1998) [10].

Indiscriminate use of poor quality water for irrigating agricultural crops decreases the productivity because of development of salinity, sodicity and toxic effects on crop plants. Saline irrigation water contains dissolved salts where most of the salts present in irrigation water are chlorides, sulfates, carbonates, and bicarbonates of calcium, magnesium, sodium and potassium. Sodicity refers specifically to the excess amount of sodium present in the irrigation water. The saline water negatively affects soil chemical and biological properties whereas sodic water adversely impact soil physical, chemical and biological properties, making it difficult for plant growth and ultimately reduces crop yield (Emdad *et al.*, 2006) [4]. Degree of deterioration of soil depends on number of factors such as nature and contents of soluble salts in the applied water, soil type, water table depth, nature of crop grown and the water management practices followed in an agro climatic zone.

Haryana is primarily an agricultural state with 1.4 % of the total geographical area and is the second largest contributor of food grains in national food reserves (Abrol *et al.*, 2013) [1]. The cultivable area in the state is about 3.8 million hectare (m ha) and the net irrigated area accounts for 2.99 m ha (84 % of net sown area).

The total potential of surface and ground water resource is estimated at 1.51 and 1.24 m ha, respectively. In the state, 37 % of water is of good quality, 8 % normal and 55 % is of poor quality. Out of this poor quality water, 11 % is saline, 18 % is alkali and 26 % as saline-alkali (Manchanda, 1976) [9]. District Rewari of Haryana state lays in south western zone of the state where the main source of the irrigation is tube-wells which constitutes about 98 % of the total irrigated area (Yadav *et al*., 2008) [12]. Most of the ground water quality of this zone varies from marginal to poor quality i.e. saline, sodic and saline sodic (Dalal *et al*., 2014) [3]. On an average, around 35 % waters in the district were of good quality, whereas 65 % were affected with varying degree of salinity /sodicity (Yadav *et al*., 2008) [12]. The farmers are using these poor quality ground waters due to limited availability of canal water as well as good quality ground water for sustainable crop production.

In recent years, a large number of shallow wells or tube wells have been installed to provide supplemental irrigation to major cropping systems under the existing farming system of pearl millet – wheat and pearl millet- mustard in Rewari block of district Rewari thereby enhancing over exploitation of ground water Therefore, an appraisal on the nature, properties and quality of irrigation water is essential for sound irrigation so as to asses any possibility of development of secondary salinization/sodification in this region.

Material and Methods

The Rewari block lies between 27.95 º N to 28.47 º N latitudes and 76.28 º E to 76.85 º E longitudes. To characterize the groundwater quality of Rewari block of district Rewari one hundred forty three ground water samples were collected from running tube wells during the year 2015 randomly at an interval of three to four km location of sampling point given in Fig 1. These tube wells were being extensively utilized for irrigation purpose. The position of sampling points was recorded by GPS at each location. After this the samples were analyzed for various chemical parameters, viz., pH, EC, anions (CO_3^{2-}, HCO_3^-, Cl^-, SO_4^{2-}, NO_3^-, F^-) and cations (Ca^{2+}, Mg^{2+}, Na^+, K^+) by the procedure outlined in USDA Handbook No. 60 (Richards,1954) [11] and categorized on the basis of criteria adopted by All India Coordinated Research Project (AICRP) on Management of Salt Affected Soil and Use of Saline Water in Agriculture through the values of EC, SAR and RSC of water samples (Gupta *et al.*,2004) [6]. SAR and RSC were calculated as described the following equations:

$$\text{SAR (mmol l}^{-1})^{1/2} = \frac{Na^+}{\sqrt{\frac{Ca^{2+} + Mg^{2+}}{2}}} \quad \text{..... (i)}$$

$$\text{RSC (me l}^{-1}) = (CO_3^{2-} + HCO_3^-) - (Ca^{2+} + Mg^{2+}) \text{..... (ii)}$$

Results and Discussion

The electrical conductivity values ranged from 0.28 to 13.38 dS m^{-1} with a mean of 3.20 dS m^{-1} (Table 1). The lowest EC of 0.28 dS m^{-1} in water sample was observed in village Budani and the highest value of 13.38 dS m^{-1} in village Khalilpuri. To study the spatial distribution of EC in the whole block, a spatial variability map was prepared by using ArcGIS through the interpolation of the available data at 143 sampling points (Fig. 2). The variation of EC in Rewari block is grouped into 10 classes with a class interval of 1 dS/m. The most dominating range of EC is 0-1 and 1-2 dS/m which occupied maximum area in the block. The next dominating range was 2-3 dS/m. EC ranging from 4-9 dS/m was very scattered and in the form of small spots in the block. EC greater than 9 dS/m was observed only at one spot in the block (Table 2). The pH values of water samples ranged from 7.45 to 9.11 with a mean of 8.36 (Table 1). The lowest pH values (7.45) was observed in village Padhiawas and the highest pH value (9.11) in village Budana (Table 1). The SAR ranged from 1.14 to 19.45 (mmol $l^{-1})^{1/2}$ with a mean of 7.25 (mmol l−1)$^{1/2}$. The lowest SAR value was observed in village Ghatal Mahaniawas while the highest value was in village Gangaicha Jat. The spatial varability of SAR of groundwater of Rewari block is given in Fig 3. The RSC varied from nil to 9.65 me l^{-1} with a mean of 1.08 me l^{-1} and maximum value of RSC 9.65 me l^{-1} was found in the village Khalilpuri. The spatial varability of RSC of groundwater of Rewari block is given in Fig 4.

In case of anions, chloride was the dominant anion with maximum value of 90.60me/l, observed in village Kaluwas and minimum value of 0.60 me/l was recorded in village Budani. Bicarbonate ranged from 0.78 to 18.50 me/l, the maximum value was observed in village Nangli Godha and minimum value was found in village Gokalgarh. The mean values for $CO3^{2-}$, HCO_3^-, Cl^-, SO_4^{2-}, NO_3^- and F^- were found to be 0.98, 4.70, 16.91, 8.49, 0.01 and 0.03 me/l, respectively (Table 1). Among cations, Na^+ was highest and also varied widely from 1.29 to 86.70 me/l (Table 1), minimum value was observed in Ramgarh village and maximum value was observed in Khalilpuri village followed by magnesium (0.56-39.20 me/l) and calcium (0.18 to 12.89 me/l). Mean values for Na^+, Mg^{2+}, Ca^{2+} and K^+ were 19.0, 8.86, 2.94 and 0.50 me/l, respectively (Table 1). Gagandeep *et al.* (2016) observed that in Hodal block of Palwal district maximum value of EC (10.94 dS m^{-1}) was found in village Sundernagar. RSC and SAR varied from 0.00 to 4.70 me l^{-1} and 5.66-19.94 (mmol $l^{-1})^{1/2}$. Same results was observed by Gagandeep *et al.* (2017) [5] they surveyed the Palwal block of Palwal district, Haryana, India and found that in Palwal block 34.8% water samples of good quality, 49.2% saline and 16% of alkali in nature. Kumar *et al*. (2016) [8] reported that in Meham block of Rohtak district, Haryana 75% samples showed EC value upto 3dS/m and maximum values of EC was found as 7.34 dS/m and he also reported that according to AICRP classification 22.9% water samples of good quality, 45.8% of saline and 31.3% sodic in nature was found in Meham block of Rohtak district. The reasons for carbonate (CO_3^{2-}) and bicarbonate (HCO_3^-) concentrations in groundwater can be ascribed to carbonate weathering as well as from the dissolution of carbonic acid in the aquifers. The occurrence of sulphate in groundwater results from the oxidation of sulphur in igneous rocks, the solution of the other sulphur bearing minerals and the oxidation of merasite and pyrite. Earlier observations by Amin (2014) [2] reported similar trend of enhancement of Na^+ and Cl^- in ground water in Gohana block of Sonipat district.

The mean chemical composition and related quality parameters in different EC classes of block Rewaril and percent distribution of sample in different EC classes are shown in Table 2. Rewari block out of 143 samples collected, 38 samples showed EC < 1 dSm-1 followed by 38 in range of 1-2 dSm-1,16 in 2-3 dS m-1, 12 in 3-4 dS m-1, 5 in 4-5 dS m^{-1}, 7 in 5-6 dS m^{-1}, 8 in 6-7 dSm-1, 4 in 7-8 dS m-1 and 7 in 8-9 dSm-1.Whereas, eight water samples had EC more than 9 dSm-1. The groundwater samples having higher electrical conductivity were less in number.

Conclusion

It was found out of 143 water samples 39 percent samples were of good quality, 45 percent saline and 16 percent alkali in nature. Out of the saline water 18, 10 and 17 percent were in marginally saline, saline and high SAR saline, respectively. In alkali group 3, 9 and 4 percent were marginally alkali, alkali and highly alkali (Table 3) Good quality and marginally saline waters can be successfully used for crop production without any hazardous effect on soil and plant. Alkali waters can be used with special management practices depending upon soil type, crop to be grown and rain fall of the region. Waters classified as saline and high SAR saline are generally unfit for crops can be used in conjection with canal water by cyclic mode or applying gypsum as amendment to neutralize the RSC of the irrigation waters.

Table 1: Range and Mean values of different water quality parameters in Rewari block

Sr. No.	Parameters	Range	Mean
1.	pH	7.45- 9.11	8.36
2.	EC (dS m^{-1})	0.28-13.38	3.20
3.	CO_3^{2-} (me l^{-1})	Nil - 5.60	0.98
4.	HCO_3^- (me l^{-1})	0.78-18.50	4.70
5.	Cl^- (me l^{-1})	0.60-90.60	16.91
6.	SO_4^{2-} (me l^{-1})	0.03-84.56	8.49
7.	NO_3^- (me l^{-1})	Nil - 0.19	0.01
8.	F^- (me l^{-1})	Nil - 0.22	0.03
9.	Ca^{2+} (me l^{-1})	0.18-12.89	2.94
10.	Mg^{2+} (me l^{-1})	0.56-39.20	8.86
11.	Na^+ (me l^{-1})	1.29-86.70	19.00
12.	K^+ (me l^{-1})	Nil- 2.45	0.50
13.	SAR(m $mol^{-1})^{1/2}$	1.14-19.45	7.25
14.	RSC (me l^{-1})	Nil- 9.65	1.08

Table 2: Mean chemical composition of groundwater samples of Rewari block in different EC asses

EC classes (dS m^{-1})	No. of samples	pH	CO_3^{2-}	HCO_3^-	Cl^-	SO_4^{2-}	NO_3^-	F^-	Na^+	Ca^{2+}	Mg^{2+}	K^+	RSC	SAR
			(me l^{-1})											(m mol $l^{-1})^{1/2}$
0–1	38	8.46	0.45	3.34	1.96	0.74	0.01	0.03	0.86	2.39	3.15	0.26	0.96	2.61
1-2	38	8.48	1.32	4.81	5.19	2.77	0.01	0.03	1.20	3.52	9.02	0.47	2.44	6.23
2-3	16	8.38	0.85	5.69	9.85	6.24	0.02	0.03	2.11	6.30	14.28	0.43	1.14	7.20
3-4	12	8.41	1.26	3.79	16.78	11.46	0.02	0.02	2.99	9.20	21.21	0.27	0.44	8.84
4-5	5	8.48	1.94	4.51	21.38	16.70	0.06	0.03	3.72	12.00	28.40	0.40	Nil	10.54
5-6	7	8.18	1.71	4.76	29.88	18.08	0.04	0.01	5.36	16.32	31.96	0.99	Nil	10.01
6-7	8	8.25	0.54	3.70	45.15	13.98	0.01	0.04	6.93	20.88	34.93	0.77	Nil	9.64
7-8	4	8.15	0.70	5.57	56.97	10.65	0.01	0.02	5.01	15.20	53.05	0.66	Nil	16.91
8-9	7	7.98	1.21	9.40	52.86	19.96	0.02	0.04	8.36	25.16	49.42	1.12	Nil	12.23
>9	8	7.91	0.84	5.46	64.81	42.86	0.05	0.07	10.63	31.73	70.72	1.07	Nil	15.54

Table 3: Groundwater quality classification of Rewari block (AICRP, 1989)

Water quality	Class	Percentage
Good	A	39
Saline	B	
Marginally Saline	B_1	18
Saline	B_2	10
High SAR Saline	B_3	17
Alkali Water	C	
Marginally Alkali	C_1	3
Alkali	C_2	9
Highly alkali	C_3	4

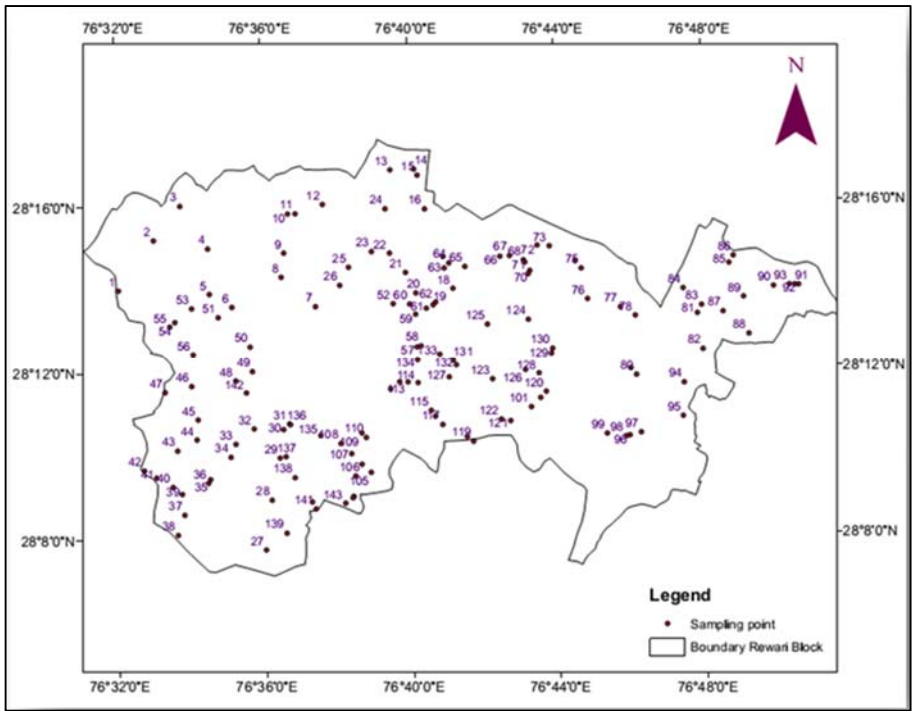

Fig 1: Location map of the sampling points of Rewari block

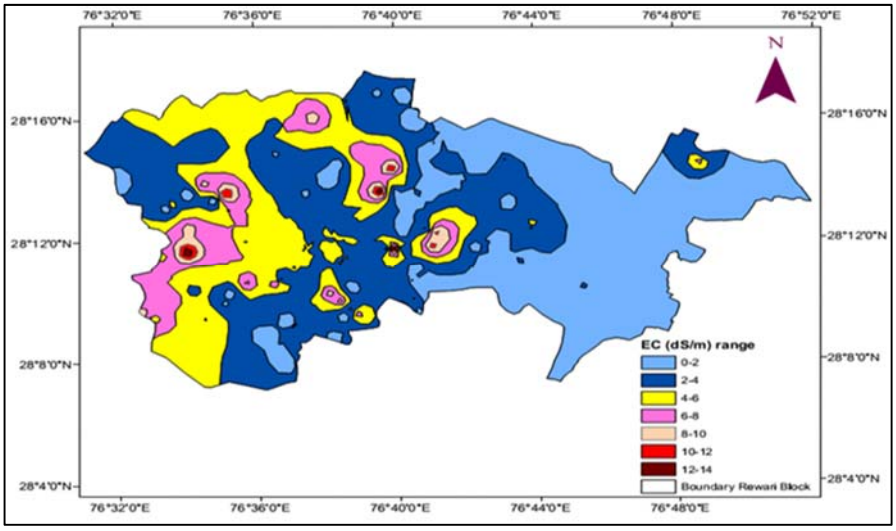

Fig 2: Spatial variability of EC of groundwater used for irrigation in Rewari block

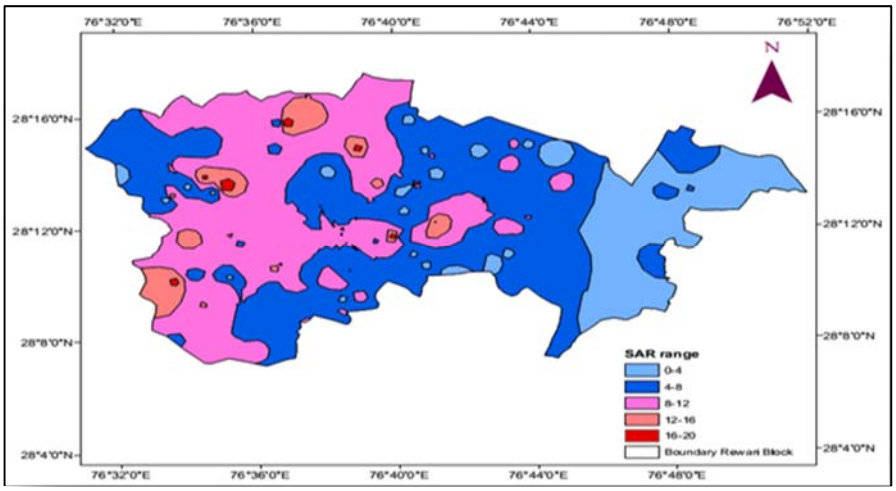

Fig 3: Spatial variability of SAR of groundwater of Rewari block

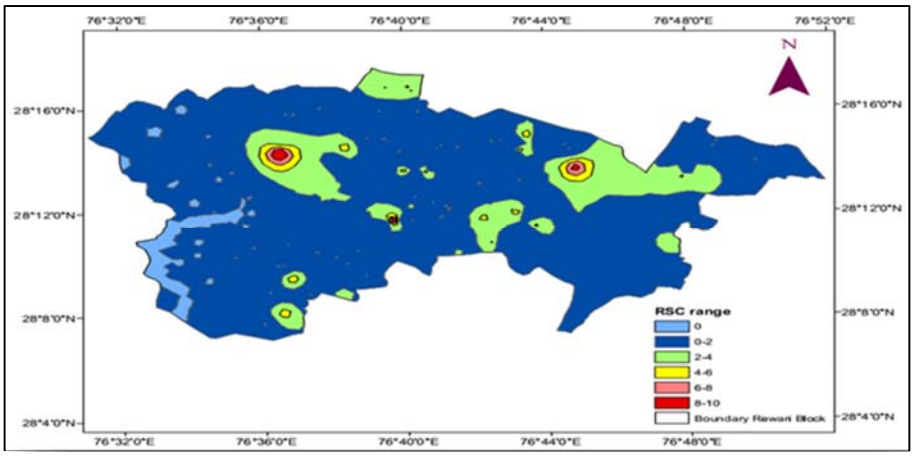

Fig 4: Spatial variability of RSC of groundwater of Rewari block

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