



Ground water quality assessment for irrigation in Palwal block of Palwal district, Haryana, India

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Abstract: The present study examined the quality of groundwater for agriculture purpose in a 49785 ha region comprising Palwal block of Palwal district of Haryana state by focusing on spatial variability of electrical conductivity (EC), cationic and anionic composition of CO_3^{2-} , HCO_3^- , Cl^- , SO_4^{2-} , Ca^{2+} , Mg^{2+} , Na^+ and K^+ of the ground water. It was found 75% of the samples showed EC values up to 4 dS/m and the maximum value of EC was found as 10.55 dS/m. Out of one hundred thirty three ground water samples 34.8 % were of good quality, 49.2 % saline and 16.0 % alkali in nature. Out of the saline water, 24.2, 1.5 and 23.5 % were marginally saline, saline and high SAR saline, respectively. In alkali group, 2.3, 2.3 and 11.4 % were marginally alkali, alkali and high alkali, respectively. Residual sodium carbonate (RSC) and sodium adsorption ratio (SAR) varied from nil to 5.50 me L^{-1} and 2.50 to 23.41 (m mol L^{-1})^{1/2}, respectively. Counter map 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: Block, Haryana, Palwal groundwater, Salinity

INTRODUCTION

Groundwater is major source of water for domestic, agricultural and industrial purposes in many countries India accounts for 2.2% of the global land and 4% of the world water resources and 16% of the world population (Ramesh and Elango, 2011). The groundwater quality is influenced by natural and anthropogenic effects including local climate, geology irrigation practices and industrial pollution. Once undesirable constituents enter the ground, it is difficult to control their dissolution the chemical characteristics of ground water play an important role in classifying and assessing water quality. Due to over exploitation of groundwater Average water table decline in 16 districts of Haryana state is 9.76 m between 1974-2011, whereas its over exploitation of groundwater in five districts has showed rise of 2.86 m (Anonymous, 2011). The present trend of declining groundwater depth (0.66% per year) could reduce India's total food grain production by around 25% or more by 2050 (Gupta and Deshpande, 2004). This variable withdrawal of ground water along with scanty rainfall has led the change in water quality; on the other hand water composition may concentrate salts in soil and water to such an extent that a crop yield is affected.

Soil and water are the two indispensable natural resources of the earth. Therefore, this calls for optimum utilization of the available land and water

resources, their conservation and effective management. This needs detailed information on land, water resources and agriculture in the region for meticulous planning of strategies and effective implementation. Indiscriminate use of poor quality water for irrigating agricultural crops deteriorates the productivity of soils through salinity, sodicity and toxic effects. In addition to reduced productivity, the use of poor quality water deteriorates the quality of produce and also limits the choice of cultivable crops. Nevertheless, concerted efforts at different research centers located in different agro climatic zones of the country have yielded valuable concepts and viable technologies for the sustainable irrigation with poor quality water (Minhas, 1998). Possibilities have emerged to safely use water otherwise designated unfit if the characteristics of water, soil and intended crops are known. Increasing knowledge of geochemical processes that control groundwater chemical composition in arid and semi-arid regions could lead to improved understanding of hydro chemical systems in such areas. Understanding relations can improve management and utilization of the groundwater resource by clarifying relations among groundwater quality, aquifer lithology, and recharge type. Groundwater is the primary source of water for human consumption, as well as for agriculture and industrial uses (Jalali, 2009).

In Haryana state, out of total cultivated area of 3.62 mha, 1.24 mha is canal irrigated 1.65 mha is irrigated by tube wells which often contain water of dubious

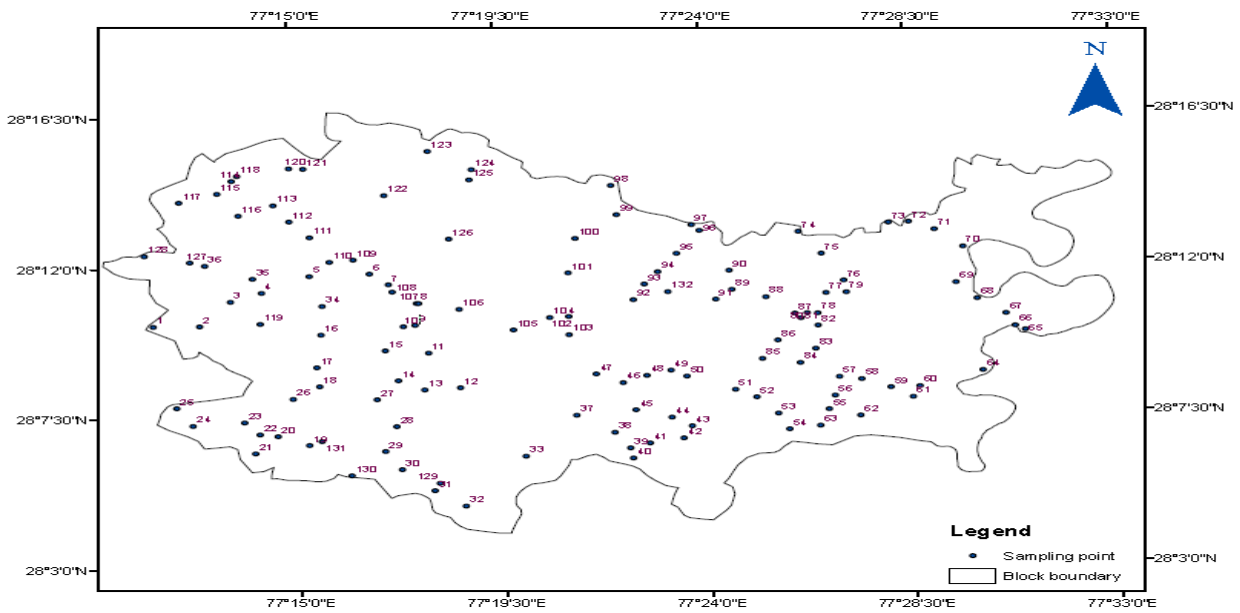


Fig.2. Location map of the sampling points in Palwal block of Palwal district, Haryana.

Table 1. Range and mean of different water quality parameters for Palwal block on the basis of 133 water samples analysis.

Quality parameter	Range	Mean
pH	6.48 – 9.45	7.46
EC (dSm ⁻¹)	0.79 -10.55	3.05
RSC (me l ⁻¹)	Nil – 5.50	0.79
SAR (mmol l ⁻¹) ^{1/2}	2.51 – 23.41	9.05
Ca ²⁺ (me l ⁻¹)	0.60-7.20	2.33
Mg ²⁺ (me l ⁻¹)	1.75 – 22.40	6.97
Na ⁺ (me l ⁻¹)	3.89 -73.56	20.20
K ⁺ (me l ⁻¹)	0.04 -0.93	0.20
CO ₃ ²⁻ (me l ⁻¹)	Nil –4.00	1.61
HCO ₃ ⁻ (me l ⁻¹)	Nil – 10.5	4.32
Cl ⁻ (me l ⁻¹)	4.10– 82.10	20.90
SO ₄ ²⁻ (me l ⁻¹)	0.29– 11.5	2.87
NO ₃ ⁻ (me l ⁻¹)	Nil-1.06	0.30

quality. 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).

In recent years a large number of shallow wells or tube wells have been installed to provide supplemental

irrigation to rice wheat cropping sequence of district. Palwal the success and sustainability of saline irrigation hinges on the fact that how best and least degrading way we manage poor quality water. GIS can be used as a powerful tool for developing solutions for water resources problems for developing solutions for water resources problems for assessing water quality, determining water availability, preventing flooding, understanding the natural environment and managing water resources on local or regional scale (Ferry et al., 2003). Therefore, the present study envisaged categorization of the ground water of Palwal block in Palwal district and illustrates the spatial variability of various parameters of groundwater quality i.e. electrical conductivity (EC), sodium adsorption ratio (SAR), residual sodium carbonate (RSC) and quality categorisation by using the geographic information system (GIS).

MATERIALS AND METHODS

The survey and characterization of ground water of Palwal block of Palwal district was undertaken during

Table 2. Chemical composition of groundwater samples of Palwal block in different EC classes.

EC Classes (dSm ⁻¹)	Percent samples	Na ⁺	Ca ²⁺	Mg ²⁺	K ⁺	CO ₃ ⁻²	HCO ₃ ⁻	Cl ⁻	SO ₄ ⁻²	NO ₃ ⁻	RSC	SAR (mmol l ⁻¹) ^{1/2}
		(me l ⁻¹)										
0-1	6.80	5.09	0.86	2.44	0.11	0.04	1.08	6.52	1.07	0.04	0.00	4.04
1-2	34.10	9.20	1.31	3.95	0.17	1.21	3.08	9.09	1.33	0.20	0.71	5.85
2-3	22.70	17.01	1.82	5.37	0.23	1.97	5.50	14.95	2.25	0.34	2.11	9.54
3-4	11.40	20.22	3.33	10.22	0.14	1.41	3.73	24.95	4.11	0.19	0.33	8.13
4-5	8.30	31.69	3.13	9.22	0.24	2.18	5.54	32.57	3.84	0.39	0.23	12.88
5-6	6.80	37.71	3.54	10.52	0.31	2.13	4.84	39.47	4.86	0.65	0.10	14.25
6-7	3.00	44.59	4.25	13.75	0.21	2.15	6.30	46.86	6.39	0.42	0.00	15.17
7-8	3.80	51.17	5.87	15.91	0.34	2.51	7.16	56.88	5.98	0.75	0.00	15.54
8-9	0.80	56.91	6.20	19.90	0.17	3.20	8.12	60.21	10.87	1.06	0.00	15.75
9-10	1.50	69.96	5.25	18.50	0.30	3.15	9.70	70.70	9.80	0.04	0.00	20.74
10-11	0.80	73.56	6.80	17.80	0.63	3.50	8.50	82.10	8.40	1.02	0.00	20.97

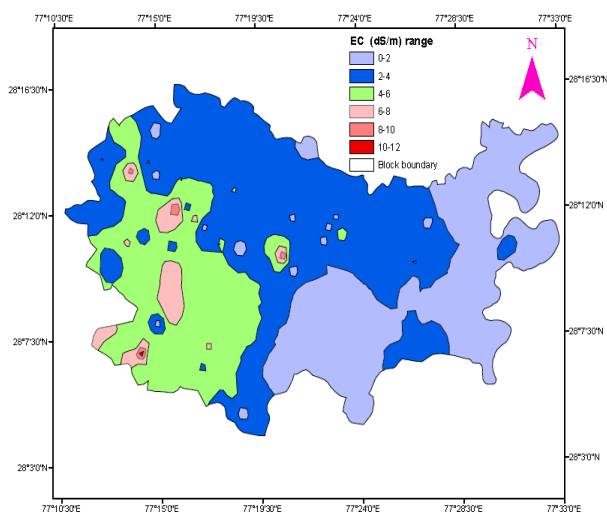


Fig. 3. Spatial variability of EC of groundwater used for irrigation in Palwal block, Haryana.

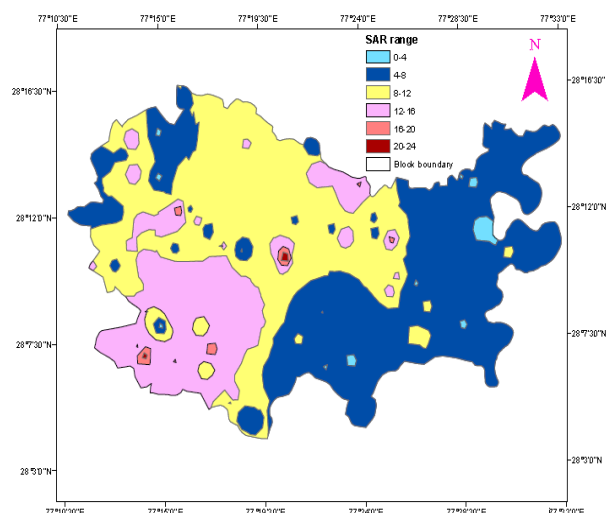


Fig. 4. Spatial variability of SAR of groundwater of Palwal block, Haryana.

2014-15. One hundred thirty three ground water samples were collected from running tube wells during the year 2015 randomly at an interval of three to four km. 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) 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.,1994). SAR and RSC were calculated as described the following equations:

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

$$\text{RSC (me l}^{-1}\text{)} = (\text{CO}_3^{2-} + \text{HCO}_3^-) - (\text{Ca}^{2+} + \text{Mg}^{2+}) \dots\text{(ii)}$$

RESULTS AND DISCUSSION

The electrical conductivity (EC) in Palwal block was found to be ranged between 0.79 to 10.55 dSm^{-1} with a mean of 3.05 dSm^{-1} (Table 1). The lowest electrical conductivity was recorded in Chandat village and highest electrical conductivity in Rakhuta village. 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 133 sampling points (Fig. 2). The variation of EC in Palwal block is grouped into 6 classes with a class interval of 2 dS/m. The most dominating range of EC is 2-4 dS/m which occupied maximum area in the block by covering from upper part of the block. The

next dominating range was 0-2 dS/m which was covering the eastern side of the block. EC ranging from 6-12 dS/m was very scattered and in the form of small spots in the block. EC greater than 10 dS/m was observed only at one spot in the block. The EC ranged from 4-6 dS/m covered the south-western part of the block. The pH ranged from 6.48 to 9.45 with a mean of 7.46 (Table 1). The lowest pH 6.48 in water samples was observed in village Nagli Pachanki and the highest value 9.50 was recorded in village Agwanpur. The SAR ranged from 2.51 to 23.41 $(\text{m mol/l})^{1/2}$ with a mean value of 9.05 $(\text{m mol/l})^{1/2}$, the lowest SAR 2.51 $(\text{m mol/l})^{1/2}$ value was recorded in village Bhambu Ka Nagla and the highest value of 23.40 $(\text{mmol/l})^{1/2}$ was observed in Purohiton Ki Patali village. The variation of SAR are shown in Fig.4. The RSC ranged from nil to 5.50 me/l with a mean value of 0.79 me/l Fig.5 and the highest value was recorded in Pahladpur village. In case of anions, chloride was the dominant anion with maximum value of 82.10 me/l, observed in village Nagli Pachanki and minimum value of 4.10 me/l was recorded in village Misa. Bicarbonate ranged from nil to 10.5 me/l, the maximum value was observed in village Purohiton Ki Patali and minimum value was found in village Nagla Rampur Khor. The mean values for CO_3^{2-} , HCO_3^- , Cl^- , SO_4^{2-} and NO_3^- were found to be 1.61, 4.32, 20.90, 2.87 and 0.30 me/l, respectively (Table 1). Among cations, Na^+ was highest and also varied widely from 3.89 to 73.56 me/l (Table 1), minimum value was observed in Bhambu Ka Nagla village and maximum value was observed in Nagli Pachanki village followed by magnesium (1.75-22.40 me/l) and calcium (0.60 to 7.20 me/l). Mean values for Na^+ , Mg^{2+} , Ca^{2+} and K^+ were 20.20, 6.97, 2.33 and 0.20 me/l, respectively (Table 1). Shahid et al. (2008) reported that the range and mean of different groundwater quality parameters of Julana block and found that the lowest salt content in water was observed in village

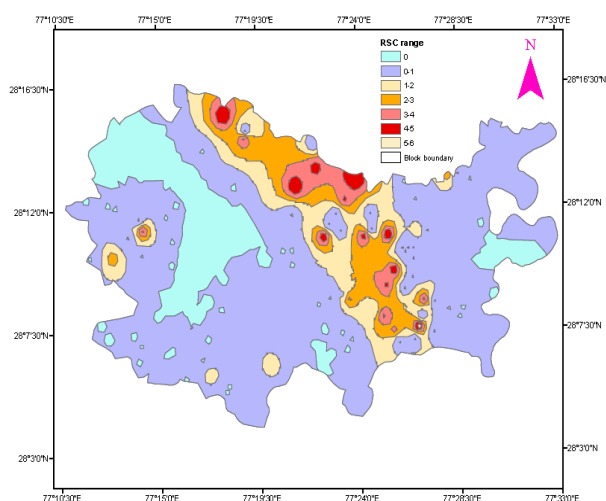


Fig. 5. Spatial variability of RSC of groundwater of Palwal block, Haryana.

Ramkali and the highest value was recorded in village Desh Khera. The mean EC and SAR value in the block were 3.61 dSm^{-1} and $5.34 (\text{mmol}^{-1})^{1/2}$, respectively. Kumar *et al.* (2012) assessed the ground water quality of Rohtak block of Rohtak district and observed that cations and anions in ground water followed the order $\text{Na} > \text{Mg} > \text{Ca} > \text{K}$ and $\text{Cl} > \text{HCO}_3 > \text{SO}_4 > \text{CO}_3 > \text{NO}_3$, respectively. 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) reported similar trend of enhancement of Na^+ and Cl^- in ground water in Gohana block of Sonapat district.

The mean chemical composition and related quality parameters in different EC classes of block Palwal and percent distribution of sample in different EC classes are shown in Table 2 and Fig. 3. Percentage of samples in different EC classes is different, its highest percentage (34.1) was found in EC class of 1-2 dS/m and its lowest percentage (0.8) was found in EC of class 8-9 dS/m and 10-11 dS/m. In EC range of 0-2 dS/m, there was 40.9 percent sample which is nearly an indication of good quality groundwater according to AICRP criteria on the basis of EC only. Kumar *et al.* (2016) reported that in Mehram 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 Mehram block of Rohtak district.

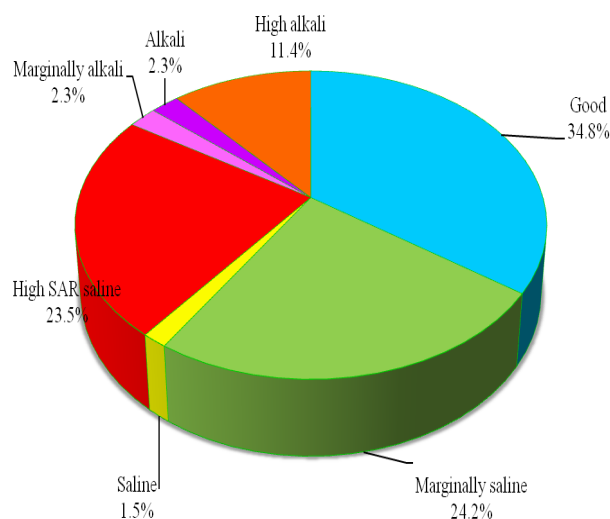


Fig. 6. Quality of groundwater (percent) in Palwal block of Palwal District.

The spatial distribution maps generated for various parameters and groundwater quality by using GIS techniques could be useful for planners and decision maker to start with developmental activities (Adhikary *et al.*, 2011).

Conclusion

It was found that 34.8 percent samples were of good quality, 49.2 percent saline and 16.0 percent alkali in nature. Out of the saline water 24.2, 1.5 and 23.5 percent were in marginally saline, saline and high SAR saline, respectively. In alkali group 2.3, 2.3 and 11.4 percent were marginally alkali, alkali and highly alkali. 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 conjunction with canal water by cyclic mode or applying gypsum as amendment to neutralize the RSC of the irrigation waters.

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