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Evaluation of groundwater quality in Sirsa block of Haryana for agricultural use

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Abstract

Groundwater is a critical resource for agriculture in the Sirsa block of Sirsa District in Haryana, where canal water is insufficient to meet irrigation demands. This study assessed groundwater quality by analysing 450 samples collected from various villages over three years (2021-2023) by Krishi Vigyan Kendra, Sirsa. Key parameters measured included electrical conductivity (EC), pH, residual sodium carbonate (RSC), sodium adsorption ratio (SAR), and major ions (Ca^{2+} , Mg^{2+} , Na^+ , CO_3^{2-} , HCO_3^- , Cl^-). The results indicated substantial spatial variation in groundwater quality. EC ranged from 0.4 to 14.0 dS/m, with 49% of the samples classified as suitable for irrigation. Sodium emerged as the dominant cation, while bicarbonate and chloride were the prevalent anions. Based on EC, SAR, and RSC, 40% of the water samples were classified as good quality, while 26% were marginally saline, 5% saline, and 7% high SAR saline. Additionally, 14% were marginally alkali, 7% alkali, and 1% highly alkali. While good and marginally saline waters could be used directly, saline and alkaline waters required management interventions like gypsum application, water blending, or cyclic irrigation. The findings underscore the importance of regular monitoring and sustainable management of groundwater resources to maintain soil health and optimize crop yields. This study provides valuable insights for policymakers and farmers, suggesting practical solutions to address water quality issues and promote sustainable agriculture.

Keywords: Sirsa block, Electrical Conductivity (EC), Sodium Adsorption Ratio (SAR), Residual Sodium Carbonate (RSC), saline water, alkaline water, groundwater quality

Introduction

Groundwater is a vital natural resource that plays a crucial role in supporting agriculture, activities. In regions such as the Sirsa, groundwater serves as a significant source of irrigation as the canal water available is not sufficient to meet out irrigation needs of crop grown. The exploitation and contamination of surface water sources had created tremendous pressure on groundwater resources (Singh *et al.* 2006; Bhat *et al.*, 2016) ^[1, 2]. The suitability of groundwater for different uses mainly reckons on its quality, therefore, evaluation of groundwater is a major concern (Packia Lakshmi, *et al.*, 2011; Vishwanath *et al.*, 2016) ^[3, 4]. Being semi arid region, mapping of ground water quality for irrigation is decisive in safe use of water and selection of crops to be grown under the available water resources. Classification of waters by considering the However, concerns about groundwater quality have arisen due to various anthropogenic factors such as agricultural runoff, industrial waste, and urban development. These factors can introduce contaminants into the groundwater system, potentially compromising its safety and suitability for use. Although ground water is widely distributed and renewable resources of the earth but the quality of this is not assured. Excessive pumping, low recharge, wrong agricultural practices have led to the situation of shrinkage groundwater and ground water becoming brackish (Venu and Rishi, 2010) ^[6]. The quality of water profoundly impacts crop production and has strong bearing on physical and chemical properties.

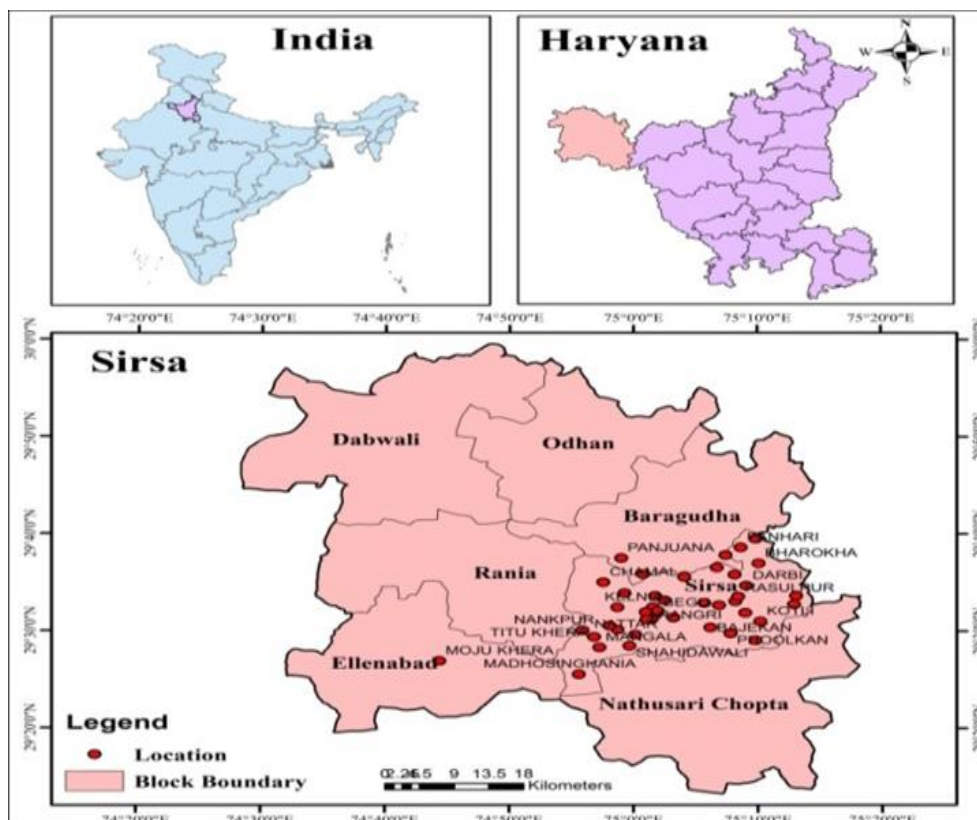
This paper aims to provide an overview of the groundwater quality in the Sirsa block of the Sirsa district in Haryana, focusing on the assessment of tube well water quality. The study will examine key water quality parameters such as EC, RSC, SAR and concentrations of major ions and heavy metals. By assessing these parameters, the paper seeks to identify potential sources of contamination and evaluate the suitability of groundwater for various uses, including irrigation and drinking water supply.

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The results of this study are intended to inform local policymakers, stakeholders, and residents about the current state of groundwater quality in the region and measures which may be adopted so that the water can be used safely and effect of problematic water may be minimised by using

it with certain prescriptions. This knowledge can help guide future efforts to manage and protect groundwater resources in a sustainable and responsible manner.

Materials and Methods



Sirsa is located in 29.14-30 N latitude and 74.19-75.18 East longitudes. The topography of the area is almost flat with a gentle slope towards southwest direction. A seasonal river, Ghaggar passes through the block on banks of which large number of good water tubewells has been installed. The soil type is sandyloam and source of irrigation are tubewells and rivers.

Sampling: Krishi Vigyan Kendra Sirsa has a soil and water testing lab and a large number of samples are received in the laboratory throughout the year. The record of farmer name, village name, block and depth of tubewell is maintained. Out of these samples, about 450 samples were selected from different villages of the block so that all villages of the block are covered. In this way samples received during three consecutive years 2021, 2022 and 2023 from various villages of Sirsa block were analysed in a view to have an overall illusion of ground water quality of the district. These samples were then analyzed for hydrochemical parameters viz. calcium (Ca^{++}), magnesium (Mg^{++}) and sodium (Na^{+}).

The physical parameters like pH and electrical conductivity were also measured by using respective measuring devices. All chemical parameters are expressed in milli equivalent per liter except EC. To categorise quality of ground water, SAR and RSC were calculated using following formulae: The formula for calculating the sodium adsorption ratio (SAR) is:

$$SAR = \frac{[\text{Na}^{+}]}{\left\{ \frac{([\text{Ca}^{2+}] + [\text{Mg}^{2+}])}{2} \right\}^{1/2}}$$

Likewise,

$$\text{RSC (meL}^{-1}\text{)} = (\text{CO}_3^{2-} + \text{HCO}_3^{-}) - (\text{Ca}^{2+} + \text{Mg}^{2+})$$

Based on EC, SAR and RSC, water samples were classified in to different categories as per the classification of All India Coordinated Research Project on Management of Salt-affected Soils and Use of saline Water in Agriculture. (AICRP, 1989) [5].

Table 1: Geometric Mean and Range of different quality parameters for Sirsa block on the basis of analysis of 381 samples

Quality Parameters	Range	Mean
EC (dS m^{-1})	0.4 - 14.0	03.08
CO_3^{2-} (me L^{-1})	0.1- 4.2	1.10
HCO_3^{-} (me L^{-1})	0.5 - 8.9	04.42
Cl (me L^{-1})	1.2 - 120.7	14.31
Ca + Mg (me L^{-1})	0.3 - 43.0	09.70
RSC (me L^{-1})	0.01 - 10.7	02.70
Ca (me L^{-1})	0.10 - 14.33	03.23
Na (me L^{-1})	1.2 - 140	18.81
SAR (m mol L^{-1}) ^{1/2}	0.73 - 38.53	07.99

Results and Discussion

The ground water samples were analysed for Cations (Ca^{+} , Mg^{+} , and Na^{+}) and Anions (CO_3^{-} , HCO_3^{-} , Cl^{-} and SO_4). From these cations and anions, RSC and SAR were calculated

EC and pH

The EC and pH of the samples from different locations ranged from 0.4 to 14.0 dSm^{-1} and 7.0 to 10.2 respectively. The respective mean values of EC and pH was 3.08 and 8.5. The lowest EC values were in the villages near the rivers viz. Panihari whereas higher EC values were found in the villages away from the seasonal canals or river banks eg Baruwali, Phulkan. Kumar *et al.* (2020) [7] observed that electrical conductivity in the parts of block Badagudha was comparatively lower in the parts which were lying adjoining to Ghaggar River. Out of all the samples, 49 percent of the samples were in the range of 0 to 2 dSm^{-1} , 23.29 percent were in the range 2-4 dSm^{-1} ; 20.33 percent samples in the range 4-8 dSm^{-1} , 5.91 samples were in the range 8-12 dSm^{-1} where as in 1.29 percent samples EC was more than 12 dSm^{-1} . Jakhar *et al.* (2017) [8] while characterising ground water samples of district Sirsa, found that 38, 28 and 25% water samples had an EC of 0.2-2.0, 2.1-4.0 and 4.1-8.0 dSm^{-1} , respectively and only 2 to 6 per cent samples during different years showed very high EC up to the range of 16 dSm^{-1} .

The highest pH was found in the village Bhavdin whereas lowest pH was found in the village Begu. Among all the cations Na was the dominant cation ranging from 1.2 to 140 with a mean value of 18.81 and was found lowest in the village Farwai and highest in the village Kotli. Gagandeep *et al.* (2017) [9] recorded lowest pH (6.48) in the village Gagli Panchanki and highest pH (9.5) in the village Agwanpur while accessing ground water quality in Palwal block of Palwal district in Haryana (Amandeep Gahlawat, 2022) [18].

Cations and Anions

Among the cations, values of Ca ranged from 0.3- 43.0 with a mean value of 3.23 and was found lowest in the village Vaidwala the respective highest values were found in the village Bhavdin. Similar trend was observed in case of Mg and the lowest and highest values were found in the villages Jhorarnali and Madhosinghana respectively. Among the anions HCO_3 , Cl^{-} and CO_3 were prominent in all the samples. HCO_3 ranged 0.5 to 14.2 with a mean value of 4.42. The highest value of HCO_3 was noticed in the village Kelnia whereas lowest value was noticed in the village Kusumbhi. The mean values of CO_3^{-} and Cl^{-} were 14.31 respectively. Kumar *et al.* (2020) [7] characterised ground water quality of Badagudha block in Sirsa district and based on Cations and Anions concentration in Badagudha Block of Sirsa district in Haryana.

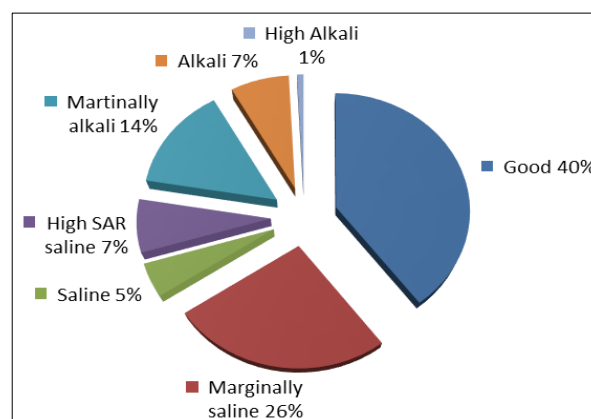
Table 2: Chemical composition of of ground water samples of Sirsa Block in Sirsa district under different EC classes

EC (dS m^{-1})	Percent	CO_3^{-} (me L^{-1})	HCO_3^{-} (me L^{-1})	Cl^{-} (me L^{-1})	Ca+Mg (me L^{-1})	RSC (me L^{-1})	Ca (me L^{-1})	Na^{+} (me L^{-1})	SAR ($\text{mmol}^{1/2}$)
0-2	49.16	0.8	4.34	5.02	3.09	1.93	1.03	3.8	3.76
2-4	23.29	1.2	4.42	14.06	8.93	0.55	2.98	12.98	7.52
4-8	20.33	2.3	4.48	26.31	19.54	0.14	6.26	38.21	13.37
8-12	5.91	3.7	5.11	37.50	29.69	0.02	9.90	78.08	21.36
>12	1.29	4.5	4.80	64.04	27.70	0.00	9.23	133.3	34.40

The mean chemical composition related to different values of quality parameters have been presented in Table 2 of all the samples analysed, highest percentage was found in the EC range 0-2 dS m^{-1} whereas lowest percentage was found in the EC class more than 12.0 dS m^{-1} . More number of samples in the range of 0-2 dS m^{-1} suggests that half of samples received was suitable for all the crops depending on soil types and rainfall received. The per cent of samples in the range 2-4, 4-8 and 8-12 were 23, 20 and 5.91 per cent respectively. In the table 2 mean anions according to the EC classes, Cl^{-} (64.04 me L^{-1}) was highest and it increased with increase in EC. The lowest mean value (5.02 me L^{-1}) was found in the EC class 0-2 dSm^{-1} . The variation in HCO_3^{-} concentration at different EC levels was very less.

Among the cations, the value of Na^{+} was highest and ranged from 3.8 to 133.3 me L^{-1} and the values increased with increase in the EC

Sr. No.	Water Class	No of Samples	Percent of water samples
1.	Good	151	40
2.	Marginally saline	99	26
3.	Saline	18	5
4	High SAR saline	28	7
5.	Marginally alkali	54	14
6.	Alkali	28	7
7.	High alkali	3	1



According to AICRP classification, it was found that 40 percent samples were of good quality, 38 percent were saline and 22 percent samples were alkali. Out of saline water 26, 5 and 7 percent waters were in marginally saline, saline and high SAR saline category respectively. Among alkali group, 14, 7 and 1 percent water were found in marginally alkali, alkali and high alkali group. Shahid *et al.* (2008) [11] also reported similar results in Julana block of Jind district, Kumar *et al.* (2012) [12] in Rohtak block of Rohtak district and Ram Prakash *et al.* (2016) [2] in Hodal block of Palwal district. The reasons for carbonate (CO_3^{2-}) and bicarbonate (HCO_3^{-}) concentrations in ground water can be attributed 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. Similar results were confirmed by Pradhan *et al.* (2011) ^[15] Rahman *et al.* (2013) ^[16], Kumaresan and Riyazuddin (2005) ^[17]. Earlier observations by Amin (2014) ^[19] reported similar trend of enhancement of Na⁺ and Cl⁻ in ground water in arid and semi-arid areas.

Conclusion

It may be concluded that 40 percent samples were of good quality 5 percent samples were saline and 7 percent were alkali in nature. Likewise in alkali samples, 14 percent samples were marginally alkali, 7 percent alkali and 1% samples were highly alkali. Good quality, low alkali and marginally saline waters can be used without or with certain prescriptions. They can be used to grow large variety of crops without any hazardous effect on the soil and without a decrease in the crops yields. All the remaining waters which can threat salinity and alkalinity hazards may be used with certain management practices which depend upon soil type, rainfall etc. Higher alkaline waters should be neutralized with suitable amount of Gypsum whereas saline waters can be managed with mixing in canal water or in cyclic mode with canal water. Singh and Sharma (2023) while classifying ground water quality of Nagaur district of Rajasthan revealed that 0.66 percent water samples were good, 1.33 were marginally saline, 16.67 percent were saline, 18 percent were high SAR saline 32 percent was marginally alkali, 20 percent were alkali and 11.34 were percent high alkali categories, respectively.

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