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Assessment of Irrigation Groundwater Quality in Different Blocks of Jaipur District, Rajasthan, India

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Authors' contributions

This work was carried out in collaboration among all authors. All authors read and approved the final manuscript.

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ABSTRACT

A survey experiment conducted for irrigation water quality status checking of three different blocks (Chomu, Sanganer, Shahpura) of Jaipur district of Rajasthan and each block three villages were selected during the year 2021-22. Total nine irrigation water samples were collected from nine farmers tubewell in water bottles and analysed. Different results were reported. E.C., pH, Ca^{2+}, Mg^{2+}, Na^{+}, CO_3^{2-}, HCO_3^{-}, Cl^{-}, SO_4^{2-}, RSC, SAR ranges of irrigation ground water were reported 0.76-2.81 dS/m., 7.3-9.0, 1.3-4.0 me/L, 5.5-26.0 me/L, 1.0-2.0 me/L, 1.7-4.0 me/L, 1.5-3.5 me/L, 3.4-18.7 me/L, 1.0-3.8 me/L, 7.46-26.0. The study indicated that a majority of the collected samples suppressed the established thresholds for critical levels of irrigation water quality. Suitable crops required to grow at study area.

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Keywords: Ground water; samples collection sites; analysis methods; RSC; SAR; etc.

1. INTRODUCTION

The importance of groundwater for the existence of human society cannot be overemphasized and without it, we cannot imagine our life. Earths ¾ part covered by water but we are unable to use this water. Groundwater is the major source of drinking water and irrigation. Around 95 percent of human population in both rural and urban areas of India is mainly depending on groundwater for drinking purpose [1,2]. Besides, it is an important source of water for the agricultural and the industrial sector [3].

In many parts of arid and semi-arid regions, ground water which is often of poor quality is used as major source of irrigation. The continuous use of such water for irrigation creates salinity or sodicity in soil. The soil degradation due to salinity and sodicity problems had affected significant areas of fertile tracts particularly in arid and semi- arid regions of country and caused significant loss to crop productivity. These salt-contaminated soils are found in most states across the country. The problem is aggravated in areas where saline/calcareous groundwater is used as the main source of irrigation due to lack of good quality water. Salt-affected soils cover an area of nearly 13.8 million hectares in the country [4] and 1.24 million hectares in Rajasthan and occur to a greater or lesser extent in virtually all districts of the state [5].

The ground water of north- western Rajasthan is typical water with problem of high salinity flanked with high chloride and sulphates. Such water is continuously in use for the groundwater in North western Rajasthan is a typical water with the problem of high salinity flanked by high chloride and sulphate levels. This water is constantly used for agriculture depending on the level of hazardous constituents. In addition, several farmers have abandoned their underground irrigation source due to soil degradation, resulting in drastic crop yield losses. Although the irrigation water in these areas is of poor quality, it is inevitable because there is no alternative source of irrigation in these areas. The salinity of groundwater ranged from 2.1 to 9.1 dSm^{-1} in the wells of Rajasthan [6].

The unscientific and indiscriminate use of saline water for irrigation leads to accumulation of soluble salts in the root zone and adversely affects the physical and chemical properties of irrigated soils, which in turn reduces crop productivity due to reduced water availability [7].

Plant growth is either impaired or prevented altogether by the excessive increase in soil salinity resulting from irrigation with saline water. In addition to osmotic stress, plant productivity is affected by specific ionic toxicities, inadequate nutrient availability, and cationic imbalances in plants. These soils, underlain by poor quality groundwater in arid and semiarid regions, have low organic matter content and are therefore not very fertile [8,9]. Therefore, prudent management of irrigation water in these soils is as important as their reclamation.

2. MATERIALS AND METHODS

2.1 Present Study Area

Jaipur, located in the state of Rajasthan, serves as both the capital and the largest city of the state. Geographically, Jaipur district is positioned at a latitude of 26.9124° N and a longitude of 75.7873° E. The district covers a total geographical area of 11,06,148 hectares or 11,061.48 square kilometers. Within the city, the gross cropped area spans across 8,48,313 hectares, out of which the net sown area occupies 6,63,167 hectares. Among the net sown area, only 3,02,428 hectares are designated as Net Irrigated area. In other words, this means that out of the total cropped area, a portion of land is cultivated for agricultural purposes, with a smaller portion being irrigated for enhanced productivity. Jaipur district is situated in agro-climatic zone 3-A, specifically the semi-arid eastern plain zone. The district experiences a mild winter and hot summer climate. The average maximum temperature in the area reaches 40.6 degrees Celsius, while the average minimum temperature is 6.2 degrees Celsius. Temperature fluctuations can be significant, with highs of up to 47 degrees Celsius in May and June and lows of around 1.0 degree Celsius in January. The district receives an annual rainfall of approximately 650 millimeters, resulting in a relatively humid climate. The monsoon season occurs from June to September, during which heavy rains and thunderstorms are common. Throughout the year, temperatures tend to remain on the higher side in Jaipur district [10].

2.2 Ground Water Samples Collection Sites

According to Table 1, Total nine tube well from water samples were gathered form nine villages, specifically for irrigation purposes, considering the past five years of usage. To ensure the samples were representative, the pump was kept operational before each collection. 500 ml nerrow neck plastic water sampling bottles were used for collection of water. The collected samples were then carefully stored in water sampling bottles that had been thoroughly cleaned, rinsed, and appropriately labelled. Prior to sealing the bottles, a small amount of toluene was added to monitor potential microbial growth.

2.3 Analysis of Physico-Chemical Parameters of Groundwater Samples

According Table 2, these methods were used to check the irrigation groundwater quality collected from Farmers Tubewells. During the premonsoon period in May 2021, a total of nine representative irrigation water samples were collected from nine different villages within the Chomu. Sanganer, Shahpura blocks. The villages involved in the study were Keshav Nagar, Morija, Nindola, Goner, Shrikishanpura, Durgapura, Shivpuri, Manoharpur, Nawalpura. To prevent any microbial growth, 2-3 drops of toluene were added to each water sample before being transported to the laboratory for further analysis. In the laboratory, the water quality analysis was carried out following standard methods outlined in the APHA (American Public Health Association) guidelines from 1992. The specific parameters analyzed were as follows:

1. pH: The pH level of each water sample was determined using a pH meter, which measures the acidity or alkalinity of the water.
2. Electrical Conductivity (EC): An EC meter was used to measure the electrical conductivity of the water samples. This measurement provides an indication of the concentration of dissolved salts or ions, which influences the water's salinity.
3. Chlorides: The concentration of chlorides in the water samples was estimated using Mohr's titration method with the assistance of 0.02N silver nitrate and potassium chromate indicator.
4. Carbonates and Bicarbonates: The content of carbonates and bicarbonates in the water samples was determined through the simple acidimetric titration method described by Richards in 1954.
5. Water-Soluble Sodium and Potassium: A flame photometer was employed to measure the levels of water-soluble sodium and potassium in the water samples.
6. Total Ca^{2+} + Mg^{2+}: The total concentration of calcium (Ca2+) and magnesium (Mg2+) ions was determined using a complexometric titration method that involved the use of ethylenediaminetetraacetic acid (EDTA).
7. SO_4^{-2}: The turbidimetric method for the analysis of sulfate in irrigation water.

Aside from the primary water quality parameters mentioned above, secondary water quality parameters were also calculated based on the data obtained. These secondary parameters included the Sodium Adsorption Ratio (SAR), Residual Sodium Carbonate (RSC), Soluble Sodium Percentage (SSP). These secondary parameters help assess the suitability of water for irrigation and the potential risks associated with sodium and salinity levels in the water.

Table 1. Water samples collection sites

S. No.	Blocks	Village	Latitude (^{0}N)	Longitude (^{0}E)
1.	Chomu (B_1)	Keshav Nagar (V_1)	26.9039^0	75.7844^0
		Morija (V_2)	27.2068^0	75.7582^0
		Nindola (V_3)	27.3185^0	75.7081^0
2.	Sanganer (B_2)	Goner (V_4)	26.8865^0	75.8341^0
		Shrikishanpura (V_5)	26.7998^0	75.8582^0
		Durgapura (V_6)	26.8518^0	75.7862^0
3.	Shahpura (B_3)	Shivpuri (V_7)	26.9426^0	75.7526^0
		Manoharpur (V_8)	26.2994^0	75.9571^0
		Nwalpura (V_9)	26.8103^0	75.8365^0

Table 2. Methods to be used for checking of irrigation groundwater quality

S. No.	Experiment	Method	Reference
1.	EC	With the help of EC meter as permethod (4b) USDA Hand book No. 60	Richards (1954)
2.	pH	pH meter	Richards (1954)
3.	$Ca^{2+} + Mg^{2+}$	With standard EDTA solution as per method No. 7 USDA, Hand book No. 60	Richards (1954)
4.	Na^{+}	With the help of flame photometer as per method (10a) USDA, Hand bookNo. 60.	Richards (1954)
5.	CO_3^{2-} & HCO_3^{-}	With standard H_2SO_4 as per method12, USDA, Hand book No. 60.	Richards (1954)
6.	Cl^{-}	With standard $AgNO_3$ as per methodNo. 13, USDA Hand Book No. 60	Richards (1954)
7.	SAR	$SAR = Na^+ / [(Ca^{2+} + Mg^{2+})/2]^{0.5}$ Where soluble cations are in me/L	Richards (1954)
8.	RSC	$(CO_3^{2-} + HCO_3^{-}) – (Ca^{2+} + Mg^{2+})$ Where CO_3^{2-}, HCO_3^{-}, Ca^{2+} and Mg^{2+} are in me/ L	Richards (1954)
9.	SO_4^{-2}	Turbidimetric method	Richards (1954)

3. RESULTS AND DISCUSSION

In Table 3 and Fig. 1, minimum E.C. of irrigation water was found 0.76 dS/m in village Morija (V_2) and maximum 2.81 dS/m in village Shivpuri (V_7). pH was reported minimum 7.3 in village Shrikishanpura (V_5) and maximum pH 9.0 was recorded in village Morija (V_2). Ca^{2+} & Mg^{2+} minimum was found 1.3 me/L in village Nindola (V_3) and Ca^{2+} & Mg^{2+} maximum 4.0 me/L was detected in village Shivpuri (V_7). Maximum available Na^+ was found 26.0 me/L at in village Shrikishanpura (V_5) and minimum available Na^+ was found 5.5 me/L in village Goner (V_4). Maximum available CO_3^{2-} was found 2.0 me/L at in village Shivpuri (V_7) and minimum available CO_3^{2-} was found 1.0 me/L in village Goner (V_4). Maximum available HCO_3^- was found 4.0 me/L at in village Shivpuri (V_7) and minimum available HCO_3^- was found 1.7 me/L in village Morija (V_2). Maximum available Cl^- was found 3.5 me/L at in village Shrikishanpura (V_5) and minimum available HCO_3^- was found 1.7 me/L in village Morija (V_2). Maximum available SO_4^{2-} was found 18.7 me/L at in village Shrikishanpura (V_5) and minimum available SO_4^{2-} was found 3.4 me/L in village Morija (V_2). Maximum available RSC was found 3.8 me/L at in village Shrikishanpura (V_5) and minimum available RSC was found 1.0 me/L in village Goner (V_4). The maximum available SAR was found 26.00 meq/L at in village Shrikishanpura (V_5) and minimum available SAR was found 5.0 meq/L in village Morija (V_2). Similar results were also reported by Gurjer et al. [11], Bhange et al. [12] and Yadav and Singh [13] in their studies at different locations.

Table 3. Different results are shown in study areas

Blocks	Villages	EC (dS/m)	pH	Ca^{2+} & Mg^{2+} (me/L)	Na^+ (me/L)	CO_3^{2-} (me/L)	HCO_3^- (me/L)	Cl^- (me/L)	SO_4^{2-} (me/L)	RSC (me/L)	SAR
B_1	V_1	1.30	8.4	1.6	11.4	2.0	2.5	3.0	5.50	2.90	12.80
	V_2	0.76	9.0	1.4	6.2	1.1	1.7	1.5	3.40	1.30	7.46
	V_3	1.28	8.5	1.3	11.5	1.5	3.5	3.5	4.30	3.70	14.37
B_2	V_4	0.80	8.9	2.5	5.5	1.0	2.5	1.5	3.50	1.00	5.00
	V_5	2.80	7.3	2.0	26.0	2.0	3.8	3.5	18.7	3.80	26.00
	V_6	1.85	8.0	2.0	16.5	1.5	2.0	2.5	12.5	1.50	16.50
B_3	V_7	2.81	7.5	4.0	24.0	2.0	4.0	3.5	18.5	2.00	17.02
	V_8	1.85	8.0	2.9	15.6	1.7	2.5	2.0	12.3	1.30	13.00
	V_9	1.35	8.4	2.4	11.1	1.8	2.0	2.9	6.80	2.50	10.18

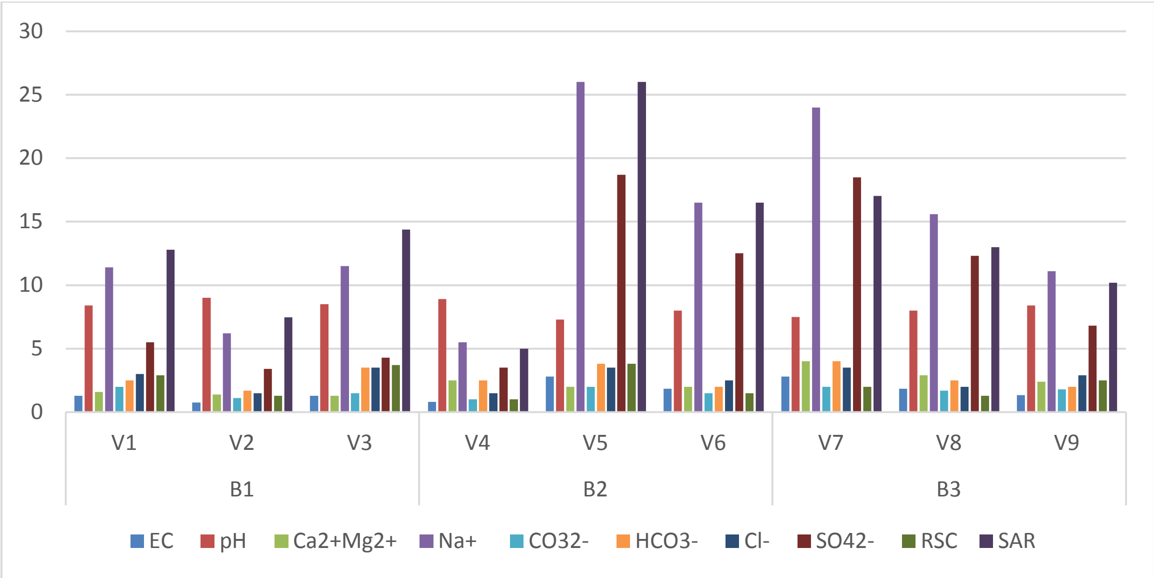

Fig. 1. Status of irrigation ground water quality

4. CONCLUSION

In survey area, the number of major anions and cations have very high in irrigation groundwater. The studied groundwater for irrigation purposes has high alkalinity. The groundwater quality of the 3 blocks of Jaipur district is not suitable for irrigation. Long term use of groundwater may increase the problems of salinity and alkalinity in the soils. Therefore, there is an urgent need to improve irrigation practices and develop resistant crop varieties that can grow without sacrificing yield.

COMPETING INTERESTS

Authors have declared that no competing interests exist.

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