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RESEARCH ARTICLE

GROUNDWATER QUALITY ASSESSMENT, CHARACTERIZATION AND MAPPING FOR DADRI-I BLOCK OF CHARKHI DADRI DISTRICT FOR IRRIGATION PURPOSE

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Abstract: Survey, characterization, and classification of groundwater quality across Dadri-I block of Dadri districts of Haryana was conducted, involving the collection and analysis of 20 groundwater samples The samples were tested in the laboratory for electrical conductivity (EC), pH, and concentrations of major cations (Na^+, K^+, Ca^{2+}, Mg^{2+}) and anions (CO_3^{2-}, HCO_3^-, Cl^-, SO_4^{2-}). Based on EC, Sodium Adsorption Ratio (SAR), and Residual Sodium Carbonate (RSC), the samples were classified into irrigation water quality classes according to the criteria of the Central Soil Salinity Research Institute (CSSRI), Karnal, which include good quality water, three saline subclasses, and three alkali subclasses. Most samples in the good water class showed a dominance of Na^+ followed by Ca^{2+} and Mg^{2+}, while Cl^- was the dominant anion, followed by HCO^- and CO^{2-}. Spatial distribution maps for EC, pH, SAR, and RSC were developed using ArcMap GIS (version 9.3.1), and their intersection helped to generate a groundwater quality map for irrigation purposes, allowing calculation of area under each water quality class. The results showed that 45% of the samples belonged to the good quality class, followed by 35% in marginally saline (B1),15% in high SAR saline and 5% in marginally alkali (C1) categories.

Keywords: Groundwater, SAR, RSC, Cations, Anions, Spatial variability

INTRODUCTION

In India, the scarceness of water is burning issue which is going to escalate because of climate change. This is unquestionable particularly in arid and semi-arid areas of the country owing to the vagaries of monsoon and paucity of surface water. During the past few decades, the competition for economic development linked with the population boom and urbanization has led to the substantial changes in land use thereby ensue more demand of water for agriculture, household and industrial activities (Nag and Das, 2014). Besides air, water is the inexpensive raw material available in the world. The exceptional physical and chemical characteristics determine the use of the water. The utilizable water supply is not adequate to irrigate the arable area. Therefore, efforts are required to amplify the chances of water for irrigation in agriculture (Sharma, 2005; Ahamed *et al*., 2013). The exploitation and contamination with numerous chemical and biological sources has lead to retreating of worldwide surface water sources thereby increasing tremendous pressure on groundwater resources (Singh *et al*., 2006; Bhat *et al*., 2016). The quality of groundwater encompasses the physical, chemical and biological features of groundwater. The suitability of groundwater for different uses mainly reckons on its quality, therefore, evaluation of groundwater is a major concern (Packialakshmi *et al*., 2011). Since, groundwater is the main source of irrigation in arid and semi-arid regions of the world, thus, farming is restricted due to dearth of suitable irrigation water. The quality of irrigation water profoundly impacts crop production and has strong bearing on physical and chemical properties (Jalali, 2010).

On account of being devoted to agricultural usage, the groundwater quality must be appraised to protect public health and environment. Accordingly, comprehensive groundwater quality supervision is an effective tool not only to assess the suitability of groundwater for irrigation but also to assure a competent management of water resources. It is imperative that the natural resources should be used judiciously not only for the welfare of current population but also to satisfy the needs and ambition of future generations for overall sustainable development of the society. Ground water is one of the valuable resource for which a planned approach is needed (Jain *et al*., 2012). The chemical make-up of groundwater determines its suitability for different uses which require various standards. The quality of groundwater depends upon distinct natural (precipitation, rock-water interaction, geology, geomorphology etc) and anthropogenic (agriculture, industry, domestic, land use etc.) activities that eventually make the groundwater vulnerable.

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Vulnerability is the characteristic of the aquifer to receive and carry contaminant from anthropogenic sources (Vrba and Zoporozec, 1994; Adhikary *et al*., 2014). The quality of water for agricultural purposes is ascertained by examining the effect of water on superiority and yield of the crops in addition to distinctive changes in the soil (FAO, 1985; Zinabu *et al.*, 2010). The problems confronted in soil which are used as a base for evaluation of water quality are those associated to salinity, water infiltration rate, toxicity and set of other heterogenous problems (Richardson, 1954; Zinabu *et al.*, 2010). Therefore, the quality of groundwater monitoring is obligation because we need good quality water for irrigation purposes in order to prevent the secondary salinization. Keeping in view the aforementioned facts, the present study was undertaken to evaluate the quality of groundwater for irrigation purposes in Dadri-1 block of district Charkhi dadri district of Haryana.

MATERIALS AND METHODS

The study area of block Dadri -I falls in the district Charkhi Dadri, Haryana and is surrounded by district Bhiwani, Mhandergarh,Jhajjar, Rohtak and Rewari. The climate of study are can be classified as tropical steppe, semiarid and hot (above 40^{o}C in May and June) which is mainly dry with very hot summer and cold winter (near about 7^{o}C in January) except during monsoon season when moist air of oceanic origin penetrates into the district. The soils of the block are sandy to sandy loam in texture. The dominating cropping system in this region cotton-wheat and pearlmillet -mustard under sprinkle irrigation the other main crops grown in the area are jowar, bajra, culsterbean and gram.

In order to assess water quality of the study area, 20 groundwater samples were collected to cover the entire study area and locations were recorded using hand held GPS. The location map of the sampling point is presented in Fig 1.

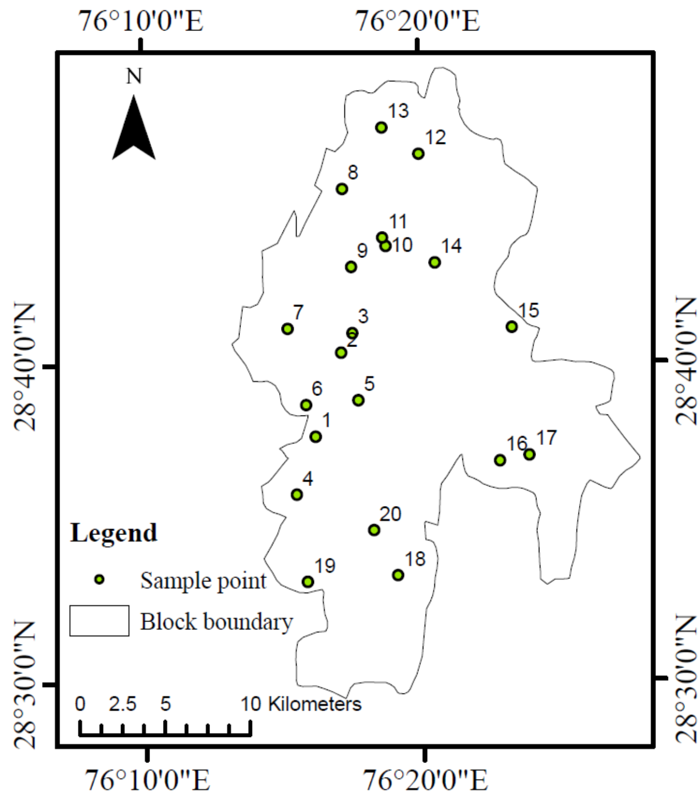

Fig.1: Location map of sampling points in Dadri 1block

Sampling was carried out using pre-cleaned plastic bottles, which were rinsed thrice with sample water prior to sample collection. Before analysis of groundwater, the instruments were calibrated in accordance with the manufacturer's recommendations. The chemical analysis was accomplished as per the standard methods relevant to the analysis of groundwater (Table1). Electrical Conductivity (EC) was measured by conductivity meter and pH by pH meter. Sodium (Na^{+}) and potassium (K^{+}) were measured by flame photometer. Calcium and magnesium were determined with standard EDTA solution titrimetrically. Carbonate and bicarbonate were estimated by titration with H_2SO_4, Chloride by titrating against standard silver nitrate ($AgNO_3$) solution. The colorimetric analysis of sulphate and nitrate was done by spectrophometer.

Table 1. Methods used for estimation of different hydrochemical parameters of groundwater in the study area

Parameters	**Method used**
pH	Glass electrode (Richards, 1954)
EC (Electrical Conductivity)	Conductivity Bridge method (Richards, 1954)
Na^+ (Sodium)	Flame Photometric method (Osborn and Johns, 1951)
K^+ (Potassium)	Flame Photometric method (Osborn and Johns, 1951)
Ca^{2+} (Calcium)	EDTA titration method (Richards, 1954)
Mg^{2+} (Magnesium)	EDTA titration method (Richards, 1954)
CO_3^{2-} (Carbonate)	Acid titration method (Richards, 1954)
HCO_3^-(Bicarbonate)	Acid titration method (Richards, 1954)
Cl^- (Chloride)	Mohr's titration method (Richards, 1954)
NO_3^- (Nitrate)	Spectrophotometric method (Richards, 1954)
SO_4^{2-} (Sulphate)	Turbidity method using $CaCl_2$(Chesnin and Yien, 1950)

The water quality indices viz., SAR (Richards, 1954) and RSC (Eaton, 1950) are calculated as:

a) $$SAR=\frac{Na^+}{\sqrt{\frac{Ca^{2+}+Mg^{2+}}{2}}}$$

b) $$RSC\left(meq\ l^{-1}\right)=\left(HCO_3^-+CO_3^{2-}\right)-\left(Ca^{2+}+Mg^{2+}\right)$$

Based on EC, SAR and RSC, water samples were classified into different categories as per the classification of All India Coordinated Research Project (AICRP) on management of salt affected soils and use of saline water in agriculture (Gupta *et al*., 1994).

RESULTS AND DISCUSSION

In the Dadri I block, the electrical conductivity (EC) of the water samples ranged from 0.41 to 12.60 dSm^{-1} with a mean of 2.85 dSm^{-1} (Table 2).

Table 2. Range and mean of different water quality parameters in Dadri 1 block

Sr. No.	**Quality Parameter**	**Range**	**Mean**
1	pH	7.20-8.23	7.88
2	EC (dSm^{-1})	0.41-12.60	2.85
3	RSC (me l^{-1})	0.00-2.60	0.46
4	SAR (mmol $l^{-1})^{1/2}$	4.67-12.61	10.29
5	Ca^{2+} (me l^{-1})	0.20-14.22	1.97
6	Mg^{2+} (me l^{-1})	0.60-28.40	4.80
7	Na^+ (me l^{-1})	3.30-77.20	20.49
8	K^+ (me l^{-1})	0.10-3.20	0.72
9	CO_3^{2-} (me l^{-1})	0.00-1.40	0.54
10	HCO3− (me l-1)	0.40-7.90	2.87
11	Cl− (me l-1)	3.90-111.30	23.71
12	SO42− (me l-1)	0.60-1.90	0.89

To study the spatial distribution of EC in the whole block, a spatial variability map was prepared by using Arc GIS through the interpolation of the available data at 20 sampling point fig 2.

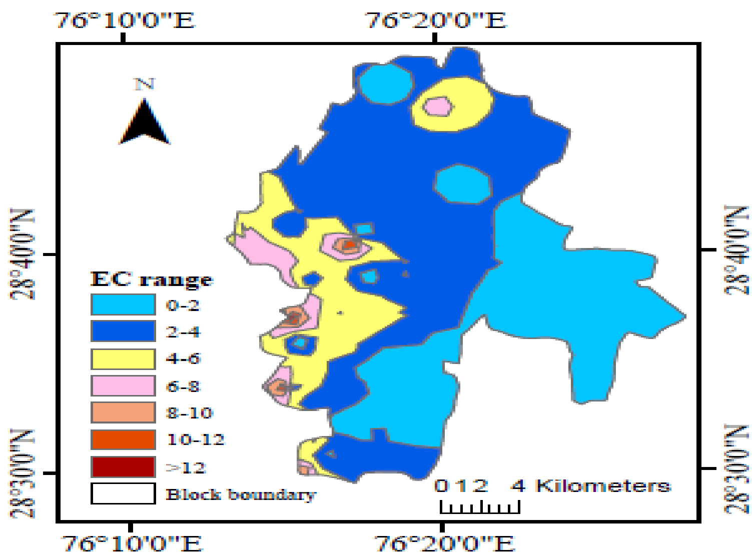

Fig.2: Spatial variable map for EC of groundwater in Dadri 1block

The pH of the water samples ranged from 7.20 to 8.23 with a mean of 7.88. Bhat *et al*. (2016) reported pH in range of 7.19 - 9.72 in Gohana block of Sonipat district. Kumar *et al*. (2013) reported that EC varied from 0.79-9.38 dSm^{-1} in Lakhan Majra Block of Rohtak district. Gagandeep *et al*. (2017) reported that the mean chemical composition and related quality parameters in different EC classes of block Palwal and percent distribution of sample in different EC classes. The sodium adsorption ratio (SAR) of ground water samples ranged from 4.67 12.61 (mmol $l^{-1})^{1/2}$ with a mean value 10.29 (mmol $l^{-1})^{1/2}$. Spatial variable map for SAR of groundwater in Dadri I block presented in Fig.3 Bhat *et al*. (2016) reported that SAR varied from 4.03-24.16 (mmol $l^{-1})^{1/2}$ in groundwater of Gohana block, Haryana. Isaac *et al*. (2009) ascertained that the SAR of soil solution is increased with the increase in SAR of irrigation water which eventually increases the exchangeable sodium of the soil.

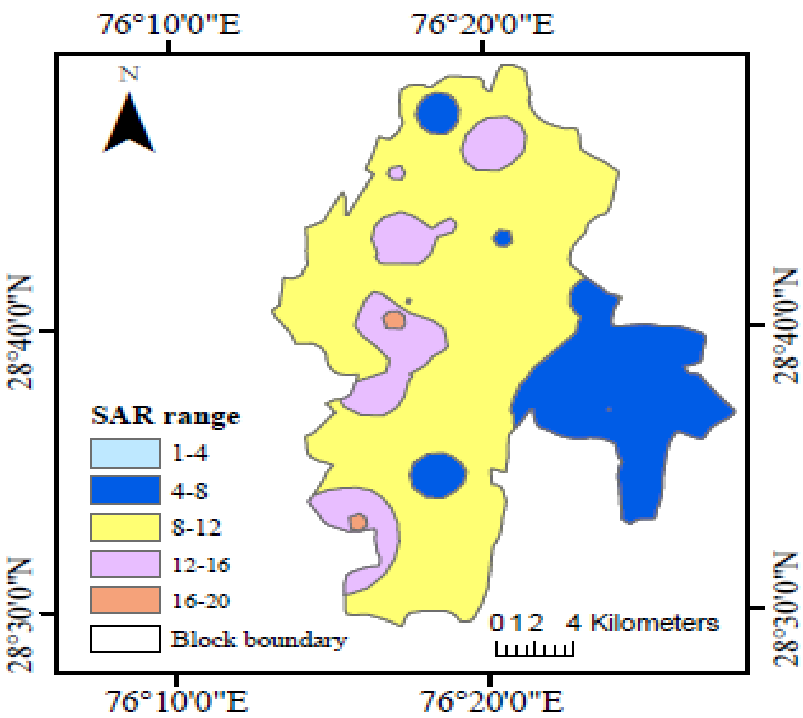

Fig.3: Spatial variable map of SAR of groundwater in Dadri 1

The RSC ranged from 0.00 to 2.60 mel^{-1} with a mean value of 0.46 mel^{-1}. Spatial variable map for RSC of groundwater in Dadri I block presented in Fig.4 Naseem *et al*. (2010) reported that pH, EC and SAR of the irrigation water are significantly influenced by RSC.

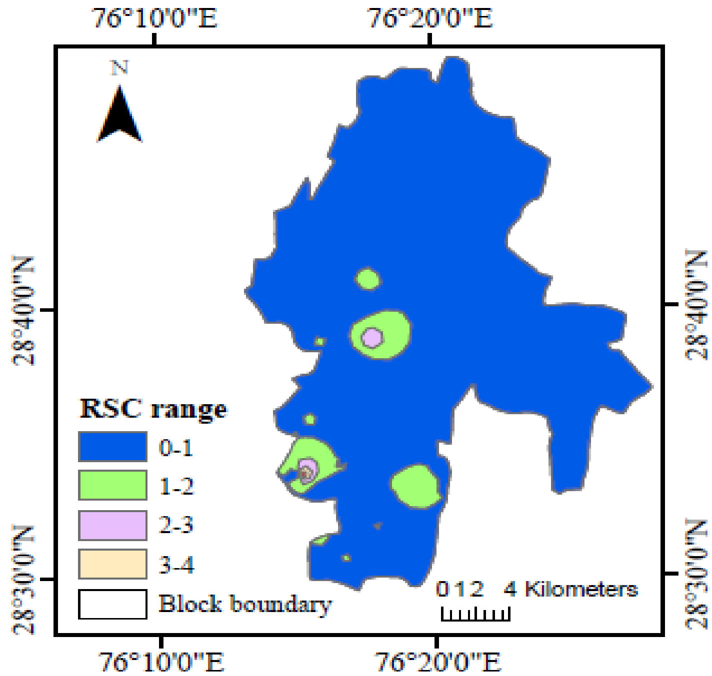

Fig.4: Spatial variable map of RSC of groundwater in Dadri 1

In case of anions, chloride was the dominant anion with the maximum value of 111.30me/l and the minimum value of 3.90 me/l was recorded. Bicarbonate ranged from 0.40 to 7.90 mel^{-1} with a mean value 2.87 me l^{-1}. The mean values for CO_3^{2-}, HCO_3^-, Cl^- and SO_4^{2-} were found to be 0.54, 2.87, 23.714 and 0.89 me/l, respectively (Table 2). Among cations, Na^+ was highest and also varied widely from 3.30 to 77.20 me/l (Table 2), followed by magnesium (0.60–28.40 me/l) and calcium (0.20-14.22 me/l). Average values for Na^+, Mg^{2+}, Ca^{2+} and K^+ were 20.49, 4.80, 1.97 and 0.72 me/l, respectively (Table 2). The mean cationic composition was observed in order of $Na^+ > Mg^{2+} > Ca^{2+} > K^+$ likewise the anionic composition was observed in order of $Cl^- > HCO_3^- > SO_4^{2-} > CO_3^{2-}$. 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.

Kumar *et al*. (2013) analyzed groundwater quality of Lakhan Majra Block of Rohtak district and reported that the order of abundance of cations was $Na^+ > Mg^+ > Ca^+ > K^+$ and those of the anions were $Cl^- > HCO_3^- > SO_4^{2-} > CO_3^{2-}$. The presence of sodium in groundwater primarily results from the chemical decomposition of feldspars, feldspathoid and some iron, magnesium minerals. The amount of Na^+ ions in the water predicts the sodicity danger of the water (Singh, 2000).

According to All India Coordinated Research Project (AICRP) on management of salt affected soils and use of saline water in agriculture classification, out of 20 water In Dadri I block of Charkhi Dadri district 45.00, 35.00, 15.00 and 5.00 per cent samples were found in good, marginally saline, High SAR saline and marginally alkali categories (Table3), respectively.

Table 3. Ground water quality classification of Dadri-1 Block

Water quality	Class	Percentage
Good	A	45.00
Marginally saline	B1	35.00
Saline	B_2	0.00
High SAR saline	B_3	15.00
Marginally alkali	C1	5.00
Alkali	C2	0.00
Highly alkali	C3	0.00
Total	20	

The spatial distribution map using GIS techniques of Dadri 1 block is presented in fig 5.

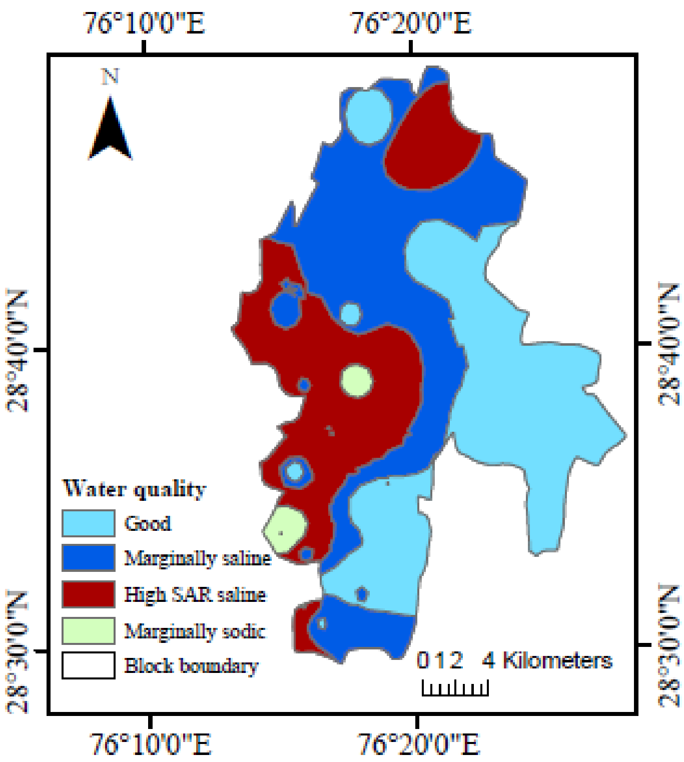

Fig.5: Spatial variable map of groundwater quality in Dadri I of Charkhi Dadri district

CONCLUSION

The groundwater analysis showed that various constituents are in permissible limits, therefore, the groundwater in Gulha block can be used for irrigation purpose without any harm. In Guhla block, anions were found in order of $HCO_3^- > Cl^- > SO_4^{2-} > CO_3^{2-} > NO_3^-$ and cations followed the order $Na^+ > Mg^{2+} > Ca^{2+} > K^+$. However, at some places where the water is of doubtful category, care is to be taken to use the water for irrigation. The spatial distribution maps generated for various physico-chemical parameters using GIS techniques could be valuable for policy makers for initiating groundwater quality monitoring in the area.

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