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RESEARCH ARTICLE

EVALUATION OF QUALITY OF UNDERGROUND IRRIGATION WATER OF NAGAUR DISTRICT WITH SALINITY, SODICITY AND ALKALINITY CONTAMINATION

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Abstract: In this study, some important chemical parameters of underground water of the area were evaluated for the criteria of irrigation water quality. Higher values of pH, EC, SAR and RSC make the underground water unfit for irrigation purposes. One hundred fifty underground irrigation water samples were collected from various tehsils of Nagaur district during 2018-19. Based on salinity the classes of irrigation water were recorded normal water (0.66%), Low salinity water (39.34%), Medium salinity water (60%) and based on sodicity the classes of irrigation water were recorded normal water (2%), Low sodicity water (74.66%), medium sodicity water (23.34%) and based on alkalinity the classes of irrigation water were recorded non alkaline water (30%), Normal water (2%), Low alkalinity water (44.66%), medium alkalinity water (16%), high alkalinity water (7.34%). Majority of the water samples are fall under low to medium suitable category of water for irrigation purposes.

Keywords: Irrigation water quality, pH, Electrical conductivity, Sodium absorption ratio, Residual sodium carbonate

INTRODUCTION

Quality of underground water is one of the major factors to be considered in irrigation purpose. The soil properties *viz.* physical, chemical and biological properties are generally associated with use of underground water which can alter soil properties as well as plant characteristics (Khan *et al*., 2014). The arid and semi arid zone of Rajasthan is characterized with deep and generally saline ground water (Khan and Sharma 2007), ranging from 2.1 to 9.1 dS m^{-1} salinity in underground irrigation water of Rajasthan (Agrawal *et al*., 2002). In the arid and semi-arid regions, irrigation is essential for successful agriculture and in some areas, particularly in the arid zone, the main source of irrigation is underground irrigation water which is usually saline with varying degree of salt concentration. Such saline waters have been in the use since decades with adverse effects on physical, chemical and biological properties of irrigated soils and ultimately the crop growth (Chopra *et al*., 2014).

Sodium content is another limiting factor of underground irrigation water under arid and semi arid condition. The use of high-SAR irrigation water was found to reduce the efficiency of the irrigations (Emdad *et al*., 2006). Excess sodium in underground water causes soil particles to repel each other, preventing the formation of soil aggregates (Batarseh 2017).

High carbonate and bicarbonate concentration in irrigation water leads to precipitation of calcium and magnesium as carbonate and bicarbonate in the soil solution. This result in loss of Ca^{2+} and Mg^{2+} ions and increase of Na^{+} ion on the exchange complex. These soils become highly sodic (Naga *et al*., 2017).

The literature showed that no studies had been undertaken within the study area with regard to chemical properties of water yet. So the aim of this study turns out to be to analyze the satisfactory of underground water with special connection with the awareness of sodicity and salinity.

MATERIALS AND METHODS

Study area and its location

The area studied lied in the agro climatic zone IIA (Internal drainage dry zone) of Rajasthan. The present district of Nagaur finds a place in the heart of the Rajasthan state at 26^0 25' & 27^0 40' North latitude and 73^0 10' & 75^0 15' East longitude, comprising of five tehsils, *viz.* Nagaur, Jayal, Didwana, Ladnu, Nawa.

Collection of ground water samples

Georeferenced 150 water samples of tube well/open well were collected where the waters are being used for irrigation for last few years. Water samples were

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collected in various tehsils of Nagaur district. In order to get representative samples, pump was kept in operation before collecting the sample. Collected samples were stored in cleaned, rinsed and properly label bottles. Before the bottles were corked, few drops of toluene were also added to check the microbial growth.

- pH = pH meter
- EC = Conductivity meter
- Sodium Adsorption Ratio (SAR) =

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

- Residual Sodium Carbonate (RSC) = RSC = $(CO_3^{2-} + HCO_3^{-}) - (Ca^{2+} + Mg^{2+})$

Classification of irrigation water on the basis of salinity (EC), sodicity (SAR) and alkalinity (RSC) (Gupta, 1986)

Salinity

The classification of irrigation water on the basis of EC is based primarily on the development of salinity in the soil to the extent that yields of crops are adversely affected. On the basis of electrical conductivity, the irrigation water may be classified into six salinity classes as proposed by Gupta (1986).

C-0 non-saline waters (EC <0.2 dS m^{-1}) may create severe permeability problem in the soil because infiltration rate into the soil is adversely affected due to lack of salts in the water to such an extent that the crop is not adequately supplied with water and yield is reduced.

C-1 normal water (EC 0.2-1.5 dS m^{-1}) can be used for irrigation for most crops on most soils with little likelihood that soil salinity will develop.

C-2 Low salinity water (EC 1.5-3.0 dS m^{-1}) can be used if a moderate amount of leaching occurs under the current irrigation practices. Most of the crops except sensitive ones can be grown on all soils except very heavy textured soils with impeded drainage.

Sodicity

The classification of irrigation water with respect to sodic hazard on the basis of SAR is based primarily on the increase of exchangeable sodium and its effect on the physical condition of the soil. On the basis of SAR, the irrigation waters may be classified in six classes as proposed by Gupta (1986).

S-0 Non-sodic water (SAR < 5) can be used for irrigation on almost all soils for all crops even those sensitive to sodium.

S-1 Normal water (SAR 5-10) can be used for irrigation on almost all soils with little danger of the development of harmful level of exchangeable sodium for growing all crops except sensitive to sodium.

S-2 Low sodicity water (SAR 10-20) can be used for crops which are semi-tolerant or tolerant to sodium on almost all soils such that leaching fraction is around 0.3. If there is a presence of gypsum or calcium carbonate in the soil, these waters can be used more successfully.

Alkalinity

The alkalinity hazard is based on RSC and primarily caused by the precipitation of Ca^{2+} or Mg^{2+} and pairing of residual CO_3^{-2} or HCO_3^{-} with sodium and formation of Na_2CO_3 in the soil and increasing SAR/ESP, characterizing it as alkali soil. On the basis of RSC, the irrigation water may be classified in six classes as proposed by Gupta (1986).

A-0 Non-alkaline water (RSC negative) can be used for irrigation on almost all soils for all crops for indefinitely long periods without any problem.

A-1 Normal water (RSC 0 me L^{-1}) can be used for irrigation on almost all soils for all crops even those were sensitive to carbonates or bicarbonates.

A-2 Low alkalinity water (RSC < 2.5 me L^{-1}) can be used for irrigation on almost all soils for all crops.

A-3 Medium alkalinity water (RSC 2.5-5.0 me L^{-1}) can be used for irrigation on almost all soils with little danger of the development of harmful levels of alkali for growing all crops except sensitive to carbonates or bicarbonates.

A-4 High alkalinity water (RSC 5.0-10.0 me L^{-1}) can be used for irrigation on soils provided with good drainage such that leaching fractions (L.F.) is not less than 0.3 for growing semi tolerant and tolerant crops to sodium. EC should be < 3.0 dS m-1 and < 10 SAR.

RESULTS AND DISCUSSION

One hundred fifty irrigation water samples were taken from five tehsils of Nagaur District. The irrigation water samples were analyzed for their chemical properties and the results obtained have been presented and discussed in the light of past findings and that of present investigation.

The classification of underground irrigation water on the basis of combind effect of salinity (EC), sodicity (SAR) and alkalinity (RSC) of the irrigation water as the characteristics proposed by Gupta (1986).

Table 1. Classification of irrigation water based on EC (dS m^{-1}), SAR and RSC (me L^{-1})

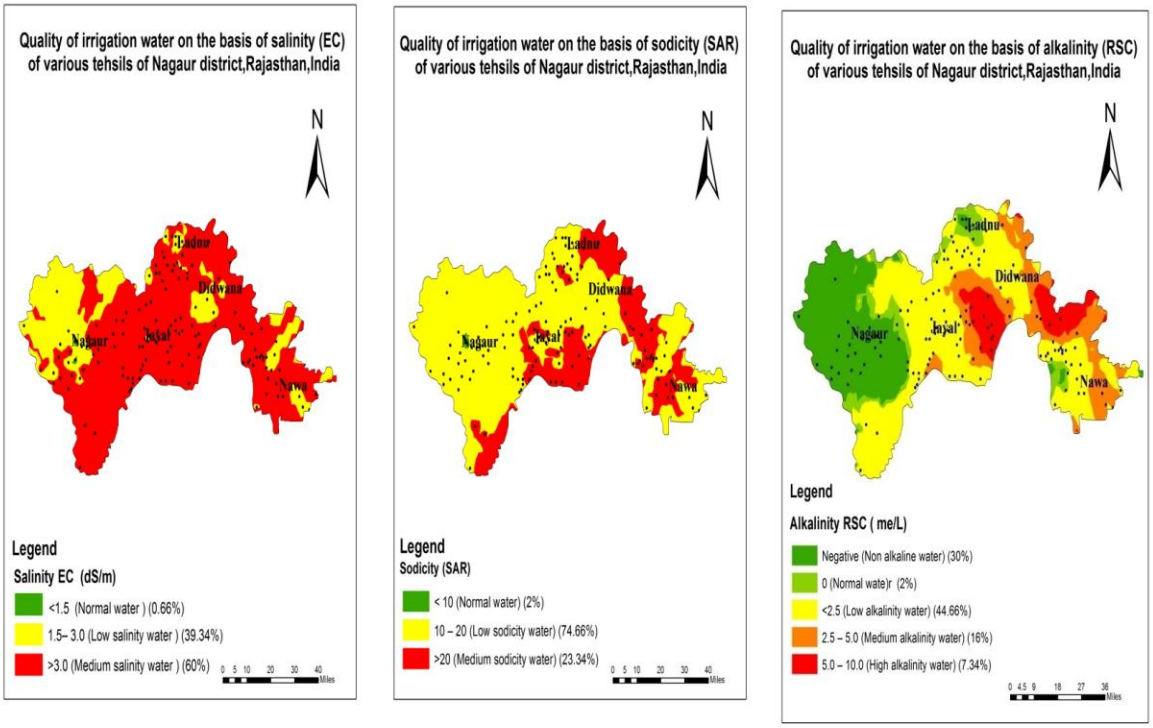
S.No.	Water quality	Symbol	EC (dS m^{-1})	No. of water sample	Percent of water sample
A.	**Salinity**				
1.	Non saline water	C-0	<0.2	1	0.66%

2.	Normal water	C-1	0.2-1.5	59	39.34%
3.	Low salinity water	C-2	1.5-3.0	90	60%
B.	**Sodicity**		**SAR**		
1.	Non sodicity water	S-0	< 5	3	2%
2.	Normal water	S-1	5-10	112	74.66%
3.	Low sodicity water	S-2	10-20	35	23.34%
C.	**Alkalinity**		**RSC (me L^{-1})**		
1.	Non-alkaline water	A-0	Negative	45	30%
2.	Normal water	A-1	0	3	2%
3.	Low alkalinity water	A-2	<2.5	67	44.66%
4.	Medium alkalinity water	A-3	2.5-5.0	24	16%
5.	High alkalinity water	A-4	5.0-10.0	11	7.34%

Table 2. Chemical properties of irrigation water of various tehsils of Nagaur district

Tehsils	**Ph**	**EC (dS m^{-1})**	**SAR**	**RSC (me L^{-1})**
NAGAUR				
Max	8.70	4.60	22.78	3.70
Min	7.20	1.20	8.50	-3.30
Mean	8.00	3.10	15.05	0.40
JAYAL				
Max	8.80	4.70	24.35	6.60
Min	7.20	2.20	10.88	-1.90
Mean	8.10	3.60	18.15	1.40
DIDWANA				
Max	8.90	5.00	26.51	6.40
Min	7.40	2.20	9.53	-1.80
Mean	8.10	3.40	17.71	2.00
LADNU				
Max	8.70	4.70	23.89	5.90
Min	7.30	1.70	9.21	-2.00
Mean	8.10	3.30	16.77	1.00
NAWA				

Max	8.90	4.90	28.40	5.80
Min	7.20	1.90	10.35	-1.80
Mean	8.10	3.40	18.50	1.60



pH

The pH of underground irrigation water of various tehsils was recorded from 7.20 to 8.70 with the average value of 8.00 in Nagaur, 7.20 to 8.80 with the average value of 8.10 in Jayal, 7.40 to 8.90 with the average value of 8.10 in Didwana, 7.30 to 8.70 with the average value of 8.10 in Ladnu, 7.20 to 8.90 with the average value of 8.10 in Nawa, respectively. Similar result was also reported by Pradeep and Singh (2016), Singh *et al*., (2018). According to Ayers and Westcot (1976) the quality of underground irrigation water regarded 6.5 to 8.4 as a normal range of pH for safe irrigation.

Electrical conductivity (EC)

The EC of underground irrigation water of various tehsils was varied from 1.20 to 4.60 dS m^{-1} with the average value of 3.10 dS m^{-1} in Nagaur, 2.20 to 4.70 dS m^{-1} with the average value of 3.60 dS m^{-1} in Jayal, 2.20 to 5.00 dS m^{-1} with the average value of 3.40 dS m^{-1} in Didwana, 1.70 to 4.70 dS m^{-1} with the average value of 3.30 dS m^{-1} in Ladnu, 1.90 to 4.90 dS m^{-1} with the average value of 3.40 dS m^{-1} in Nawa, respectively. Similar result was also reported by Arora *et al*., (2012), Riaz *et al*., (2018).

Sodium adsorption ratio (SAR)

The sodium adsorption ratio of underground irrigation water of various tehsils was recorded from 8.50 to 22.78 with the average value of 15.05 in Nagaur, 10.88 to 24.35 with the average value of 18.15 in Jayal, 9.53 to 26.51 with the average value of 17.71 in Didwana, 9.21 to 23.89 with the average value of 16.77 in Ladnu, 10.35 to 28.40 with the average value of 18.50 in Nawa, respectively. Similar results were also obtained by Chopra *et al*., (2014), Singh *et al*., (2016).

Residual sodium carbonate (RSC)

The RSC values of underground irrigation water of various tehsils was recorded from -3.30 to 3.70 me L^{-1} with the mean value of 0.40 me L^{-1} in Nagaur, -1.90 to 6.60 me L^{-1} with the mean value of 1.40 me L^{-1} in Jayal, -1.80 to 6.40 me L^{-1} with the mean value of 2.00 me L^{-1} in Didwana, -2.00 to 5.90 me L^{-1} with the mean value of 1.00 me L^{-1} in Ladnu, -1.80 to 5.80 me L^{-1} with the mean value of 1.60 me L^{-1} in Nawa, respectively. Similar results also reported by Singh *et al*., (2016), More *et al*., (2017).

Soluble cations

The cations *viz*. Na^{+}, Ca^{2+}, Mg^{2+}, and K^{+} of underground irrigation water varied from 9.12 to 38.80, 1.10 to 4.40, 1.20 to 4.20 and 0.10 to 0.48 me L^{-1} with the mean value 24.84, 2.63, 2.89 and 0.24 me L^{-1} in Nagaur, 17.20 to 38.86, 1.40 to 3.80, 1.40 to 4.20 and 0.10 to 0.50 me L^{-1} with the mean value 30.19, 2.86, 2.74 and 0.26 me L^{-1} in Jayal, 15.80 to

42.50, 1.60 to 4.40, 1.40 to 4.20 and 0.10 to 0.41 me L^{-1} with the mean value 28.82, 2.63, 2.66 and 0.25 me L^{-1} in Didwana, 14.20 to 40.10, 1.10 to 4.10, 1.50 to 4.50 and 0.10 to 0.40 me L^{-1} with the mean value 27.36, 2.78, 2.61 and 0.24 me L^{-1} in Ladnu, 16.20 to 42.50, 1.40 to 4.20, 0.60 to 3.80 and 0.10 to 0.45 me L^{-1} with the mean value 29.04, 2.59, 2.50 and 0.24 me L^{-1} in Nawa, respectively. The results of the present investigation are in accordance with the findings of Reddy (2013) and Singh *et al*., (2018). In general Na^+ was found dominant cation in these underground irrigation waters followed by Mg^{2+}, Ca^{2+} and K^+.

Soluble cations

The anions *viz*. Cl^-, CO_3^{2-}, HCO_3^- and SO_4^{2-} of underground irrigation water ranged from 8.40 to 32.80, 0.30 to 2.00, 2.10 to 8.40 and 0.60 to 6.50 me L^{-1} with the mean value 21.01, 0.86, 5.01 and 3.74 me L^{-1} in Nagaur, 11.20 to 36.20, 0.40 to 2.00, 3.20 to 9.80 and 1.20 to 7.96 me L^{-1} with the mean value 24.86, 1.00, 5.97 and 4.16 me L^{-1} in Jayal, 8.80 to 38.20, 0.40 to 2.00, 3.20 to 9.20 and 1.10 to 9.56 me L^{-1} with the mean value 22.89, 1.20, 6.13 and 4.19 me L^{-1} in Didwana, 9.80 to 37.80, 0.20 to 1.60, 2.20 to 8.60 and 0.60 to 9.15 me L^{-1} with the mean value 22.85, 0.85, 5.58, 3.82 me L^{-1} in Ladnu, 10.60 to 40.60, 0.40 to 2.00, 2.50 to 8.80 and 0.58 to 8.20 me L^{-1} with the mean value 23.74, 1.00, 5.71 and 3.95 me L^{-1} in Nawa, respectively.. In general chloride was found dominant anion in these irrigation water samples followed by HCO_3^-, SO_4^{2-} and CO_3^{2-}. Similar results were also reported by Ramkumar *et al*., (2010), Singh *et al*., (2018).

Table 3. Ionic composition of irrigation water of various tehsils of Nagaur district

Tehsils	Cations (me L^{-1})				Anions (me L^{-1})			
	Na^+	Ca^{2+}	Mg^{2+}	K^+	Cl^-	CO_3^{2-}	HCO_3^-	SO_4^{2-}
NAGAUR								
Max	38.80	4.40	4.20	0.48	32.80	2.00	8.40	6.50
Min	9.12	1.10	1.20	0.10	8.40	0.30	2.10	0.60
Mean	24.84	2.63	2.89	0.24	21.01	0.86	5.01	3.74
JAYAL								
Max	38.86	3.80	4.20	0.50	36.20	2.00	9.80	7.96
Min	17.20	1.40	1.40	0.10	11.20	0.40	3.20	1.20
Mean	30.19	2.86	2.74	0.26	24.86	1.00	5.97	4.16
DIDWANA								
Max	42.50	4.40	4.20	0.41	38.20	2.0	9.20	9.56
Min	15.80	1.60	1.40	0.10	8.80	0.4	3.20	1.10
Mean	28.82	2.63	2.66	0.25	22.89	1.2	6.13	4.19
LADNUN								
Max	40.10	4.10	4.50	0.40	37.80	1.60	8.60	9.15
Min	14.20	1.10	1.50	0.10	9.80	0.20	2.20	0.60
Mean	27.36	2.78	2.61	0.24	22.85	0.85	5.58	3.82
NAWA								
Max	42.50	4.20	3.80	0.45	40.60	2.0	8.80	8.20
Min	16.20	1.40	0.60	0.10	10.60	0.4	2.50	0.58
Mean	29.04	2.59	2.50	0.24	23.74	1.0	5.71	3.95

CONCLUSION

Monitoring of the quality of underground irrigation water is done by collecting representative water samples and analysis of physico-chemical characteristics of water samples at different locations of Nagaur district. The majority of irrigation water samples were low to medium in salinity (EC), sodicity (SAR) and alkalinity (RSC).

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