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Effect of Irrigation Salinity Water on Soil Properties of Nagaur Region, Rajasthan, India

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ABSTRACT

A survey was undertaken area to determine the quality of underground irrigation water, its effect on soil properties in the irrigated areas. One hundred water samples collected from irrigated area of Nagaur district of Rajasthan revealed that 0.66 per cent water samples were good water, 1.33 per cent were marginally saline, 16.67 per cent were saline, 18 per cent were high SAR saline, 32 per cent were marginally alkali, 20 per cent were alkali and 11.34 were per cent high alkali categories, respectively. These results indicate that brackish water irrigation aggravates the degree of soil salinization and alkalization.Most of these waters had dominance of sodium followed by calcium, magnesium and potassium in cations and chloride as major anion followed by bicarbonate, carbonates and sulphate. The pH of irrigation water had significant and positive correlation with pH and SAR of soil, whereas, significant but negative correlation was found with micro nutrient Zn, Cu, Fe, Mn and microbial biomass C, N and P. The EC of irrigation water had significant and positive correlation with EC of soil, whereas, significant but negative correlation was found with pH of soil. The resulted significantly reduction of EC, pH, ESP and bulk density, improvement in infiltration rate and availability of N, P, K and micronutrients.

***Key words*:**Bulk density, EC, ESP, pH, N, P, K, Zn, Cu, Fe and Mn

INTRODUCTION

The poor quality of underground irrigation water has marked effects on soil properties. The most important constituent in soil organic matter which is also affected, an appreciable amount of it in the soil tremendously increase the soil fertility. Decay of organic matter release nitrogen, phosphorus and mineral nutrient in available form to soil (Manimalika *et al.*, 2017).

Groundwater is the major source of irrigation in most of the arid and semi-arid regions of the country. Irrigation water salinity not only accelerates the process of soil salinization and alkalization but also affects the available soil nitrogen, enzymes, microorganisms, nitrification, and denitrification (Irshad *et al*., 2005).The irrigation water quality is defined by the type and concentrations of derived salts and substances (Etteieb *et al*., 2017).

As regards the distribution of irrigation water quality in Rajasthan state, only 16 per cent groundwater has good quality, 16 per cent marginal and 68 per cent underground water is of poor quality (Yadav and Kumar, 1995).Similarly, use of poor quality water in agriculture production not only adversely affects crop yields but also leads to land degradation in the long-run. Since, land and water use are closely intertwined underground water quality plays an important role in crop production programme (Vishwanath *et al*. 2016).

MATERIAL AND METHODS

Experimental Site- The study was carried out in Nagaur district situated in North-Eastern part of Rajasthan state of India located at 26^0 25' 40” & 27^0 40' 35” North latitude and 73^0 10' 22” & 75^0 15' 55” East longitude. Ground water samples and irrigated soil samples from 150 tube wells/open wells were collected randomly during 2018-19 distributed in 150villages of command area of Nagaur district.

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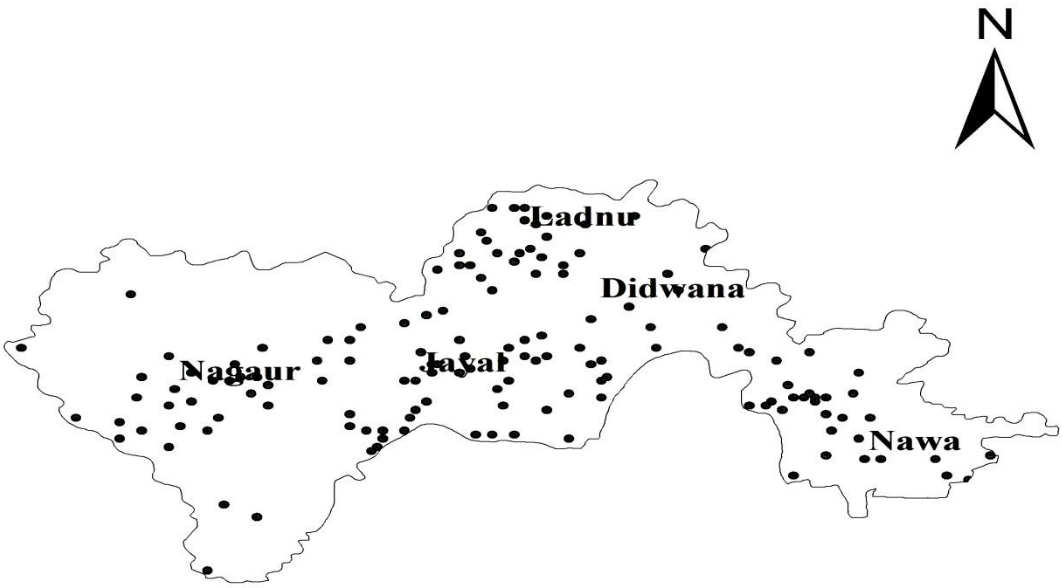

Fig: 1 Location map of study site

Analysis of samples

The pH of soil paste was determined by using digital pH meter (USSL, 1954). The determination of electrical conductivity of saturation extract (EC_e) was done by digital conductivity meter (USSL, 1954). Sodium and potassium concentration were determined in soil saturation extract by flame photometer (Richards, 1954). Calcium and Magnesium were estimated by EDTA-Versanate method (Richards, 1954). Carbonate and bicarbonate in saturation extract of soil were determined by titration with H_2SO_4 (Richards, 1954). Chloride in saturation extract of soil was determined by titration with silver nitrate ($AgNO_3$) using potassium chromate (K_2CrO_4) as indicator (USSL, 1954). Sulphate in saturation extract of soil was estimated by turbidimetric method (Chesnin and Yien, 1950).

The values obtained were used to compute for sodium adsorption ratio (SAR) and residual sodium carbonate (RSC) as under:

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

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

Correlation coefficient

The correlation coefficient (‘r’ value) was used to measure the relationship between dependent and independent variables. The correlation coefficient between two groups was calculated by using the following formula.

$$r = \frac{\sum(XY) - \frac{\sum X \sum Y}{n}}{\sqrt{\left[\sum X^2 - \frac{(\sum X)^2}{n}\right]\left[\sum Y^2 - \frac{(\sum Y)^2}{n}\right]}}$$

Where, r = Correlation Coefficient, X = Independent variable, Y = Dependent variable, n = Total number of respondents

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RESULT AND DISSCUSION

The ranges of chemical constituents of groundwater are reported in Table 1. The pH is important parameter for determining acidity, neutrality or alkalinity of water.The dominance of major ions was in the order of Na^{+}> Ca^{2+}> Mg^{2+}> K^{+} and Cl^{-}> HCO_3^{-}> SO_4^{2} for cations and anions, respectively. The high Na^{+} and Cl^{-} contents in water samples may suggest the dissolution of chloride salts (Jalali 2005).

Electrical conductivity (EC)

The perusal of data mentioned in table 1 revealed that EC of underground irrigation water ranged 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) and 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. The sodium adsorption ratio is an underground irrigation water quality parameter used in the management of sodium-affected soils. It is an indicator of the suitability of water for irrigation, as determined from the concentrations of the sodium present in the water. Similar result was also reported by Chopra *et al*. (2014) and 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 meL^{-1} with the mean value of 0.40 meL^{-1} in Nagaur, -1.90 to 6.60 meL^{-1} with the mean value of 1.40 meL^{-1} in Jayal, -1.80 to 6.40 meL^{-1} with the mean value of 2.00 meL^{-1} in Didwana, -2.00 to 5.90 meL^{-1} with the mean value of 1.00 meL^{-1} in Ladnu, -1.80 to 5.80 meL^{-1} with the mean value of 1.60 meL^{-1} in Nawa, respectively.The Residual sodium carbonate indicates the excess of carbonate and bicarbonate over calcium and magnesium in irrigation water. Similar results also reported by Singh *et al*. (2016) and More *et al*. (2017).

Table: 1. Chemical properties of irrigation water of various tehsils of Nagaur district

Tehsils	pH	EC (dS m^{-1})	SAR	RSC (me L^{-1})	Cations (meL^{-1})				Anions (meL^{-1})			
					Na^{+}	Ca^{2+}	Mg^{2+}	K^{+}	Cl^{-}	CO_3^{2-}	HCO_3^{-}	SO_4^{2-}
NAGAUR												
Max	8.70	4.60	22.78	3.70	38.80	4.40	4.20	0.48	32.80	2.00	8.40	6.50
Min	7.20	1.20	8.50	-3.30	9.12	1.10	1.20	0.10	8.40	0.30	2.10	0.60
Mean	8.00	3.10	15.05	0.40	24.84	2.63	2.89	0.24	21.01	0.86	5.01	3.74
JAYAL												
Max	8.80	4.70	24.35	6.60	38.86	3.80	4.20	0.50	36.20	2.00	9.80	7.96
Min	7.20	2.20	10.88	-1.90	17.20	1.40	1.40	0.10	11.20	0.40	3.20	1.20
Mean	8.10	3.60	18.15	1.40	30.19	2.86	2.74	0.26	24.86	1.00	5.97	4.16
DIDWANA												
Max	8.90	5.00	26.51	6.40	42.50	4.40	4.20	0.41	38.20	2.00	9.20	9.56
Min	7.40	2.20	9.53	-1.80	15.80	1.60	1.40	0.10	8.80	0.40	3.20	1.10
Mean	8.10	3.40	17.71	2.00	28.82	2.63	2.66	0.25	22.89	1.20	6.13	4.19
LADNUN												

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Max	8.70	4.70	23.89	5.90	40.10	4.10	4.50	0.40	37.80	1.60	8.60	9.15
Min	7.30	1.70	9.21	-2.00	14.20	1.10	1.50	0.10	9.80	0.20	2.20	0.60
Mean	8.10	3.30	16.77	1.00	27.36	2.78	2.61	0.24	22.85	0.85	5.58	3.82
NAWA												
Max	8.90	4.90	28.40	5.80	42.50	4.20	3.80	0.45	40.60	2.00	8.80	8.20
Min	7.20	1.90	10.35	-1.80	16.20	1.40	0.60	0.10	10.60	0.40	2.50	0.58
Mean	8.10	3.40	18.50	1.60	29.04	2.59	2.50	0.24	23.74	1.00	5.71	3.95

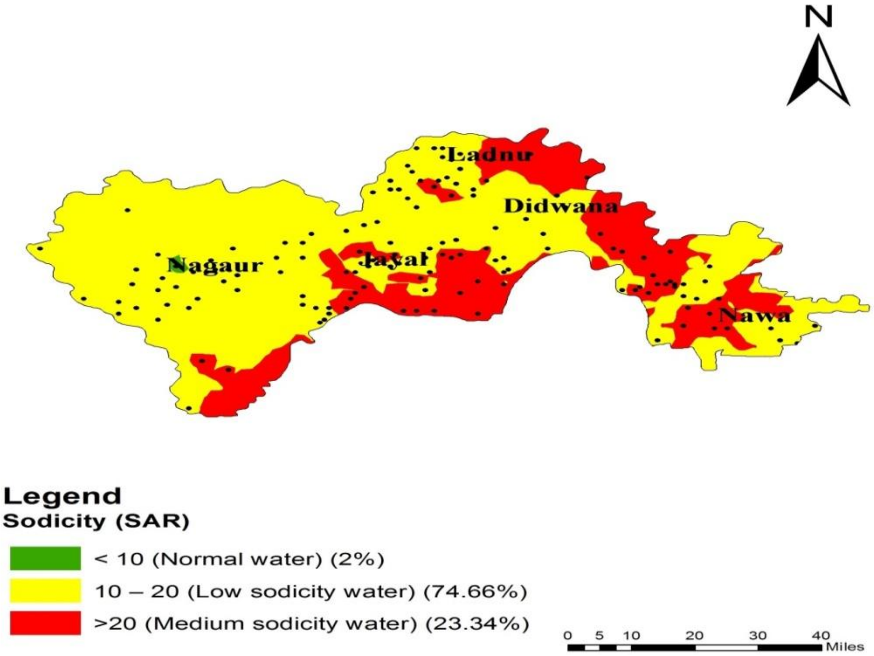

Fig: 2. Quality of irrigation water on the basis of sodicity of various tehsils, Nagaur district, Rajasthan, India

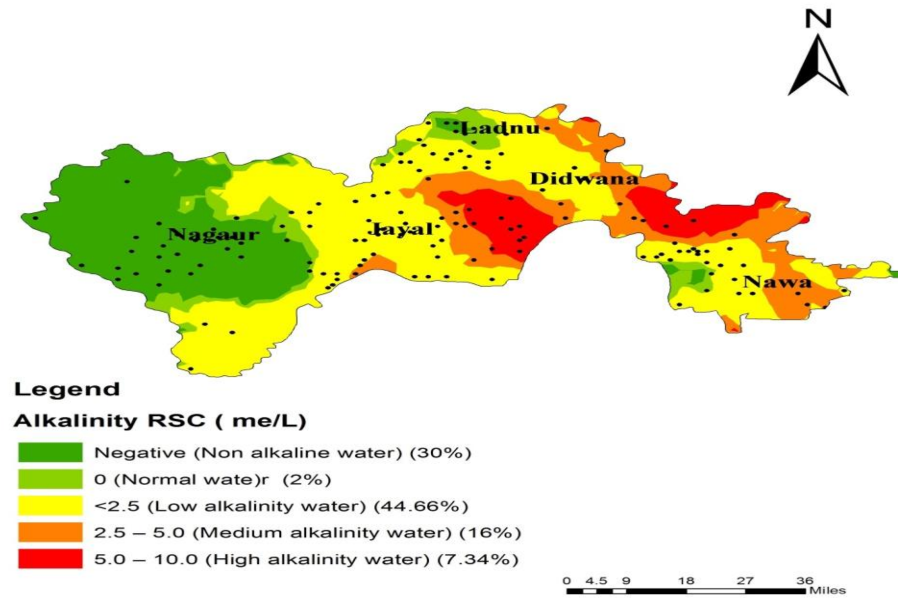

Fig: 3. Quality of irrigation water on the basis of alkalinity of various tehsils, Nagaur district, Rajasthan, India

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Correlation between different propertiesof irrigation water and soil

The EC of irrigated soil has fairly good correlation with ECof irrigation water. A positive significant correlation between EC of irrigation water and EC_e of soil (r = 0.343**) was obtained. It indicates that EC_e of soils were markedly influenced by the concentration of the soluble salts of the irrigation water (Table 2). Similar results were also reported by Huang *et al*. (2010) and Singh and Dubey (2015). The correlation between pH of irrigation water and pH of irrigated soils was found significant positive (r = 0.224**). It indicates that the pH of irrigated soils increases with the increase in pH of the irrigation water. Similar result was also reported by Chopra (2012) and Gurjer (2014).

The correlation between pH of irrigation water with available Zn, Fe, Cu and Mn of irrigated soils was found significantly negative (r = -0.383**, -0.410**, -0.278** and -0.244**). The correlation between pH of irrigation water and OC of irrigated soils was found significantly negative (r = -0.354**). The higher contents of salinity, pH and ions in irrigation water adversely affect the soil organic carbon content (Table 2). Similar results were were reported by Singh *et al*. (2014).

The available N, P and K content of soil decreased significantly with increasing levels of SAR of irrigation water (r = -0.168*, r = -0.212**, r = -0.219**). This may be explained on the basis that increasing SAR in irrigation water, the ESP and pH of soil also increased accordingly resulting into decreased availability of plant nutrients in soil but increased the availability of Na. The higher amount of Na may adversely affect the physico-chemical and biochemical properties of soil. The correlation between RSC of irrigation water and organic carbon of irrigated soils was found significantly negative (r = -0.236**). The decrease in OC at high RSC in irrigation water might be due to low biological activity, which is not conducive for the accumulation of organic matter and its mineralization. Similar results were also reported by Naga *et al*. (2013) and Dogra *et al*. (2017).

Table 2:Correlation coefficient between water and soil propertiesof various tehsils of Nagaur district

Soil / Water	pH_s	EC_e	OC	SAR	BD	Av. N	Av. P_2O_5	Av. K_2O
pH	0.224**	-0.076	-0.354**	0.173*	0.325**	-0.321**	-0.258**	-0.408**
EC	-0.141	0.343**	-0.106	0.116	0.146	-0.128	-0.178*	-0.089
SAR	0.008	0.282**	-0.162*	0.164*	0.191*	-0.168*	-0.212**	-0.219**
RSC	0.251**	-0.047	-0.236**	0.138	0.199*	-0.215**	-0.065	-0.183*
Mg/Ca ratio	-0.152	0.013	0.108	-0.010	-0.044	0.116	-0.043	0.047
Adj.SAR	0.018	0.282**	-0.204*	0.153	0.219**	-0.217**	-0.188*	-0.199*
B (ppm)	0.159	-0.067	-0.071	0.153	0.037	-0.032	-0.175*	-0.160*
Potential salinity	-0.163*	0.350**	-0.059	0.101	0.101	-0.085	-0.165*	-0.056

*indicates significant at 5 per cent level, **indicates significant at 1 per cent level of significance

Ground water quality classification for irrigation purpose

The groundwater of Nagaur district was classified into 7 classes for irrigation purpose (Gupta *et al*., 1994) and details are presented in Table 3. The 0.66% samples were of good quality, 1.33% was of marginally saline, 16.67% of saline, 18% of high SAR saline, 32% of marginally alkali, 20% of alkali and 11.34% of highly alkali (Fig. 4).

Table 3: Classification of underground irrigation water on the basis of EC, SAR and RSC

S.No.	Water quality classes	No. of water samples	Percent of water samples
1	Good	1	0.66%
2	Marginally saline	2	1.33%
3	Saline	25	16.67%
4	High SAR saline	27	18%
5	Marginally alkali	48	32%
6	Alkali	30	20%
7	Highly alkali	17	11.34%

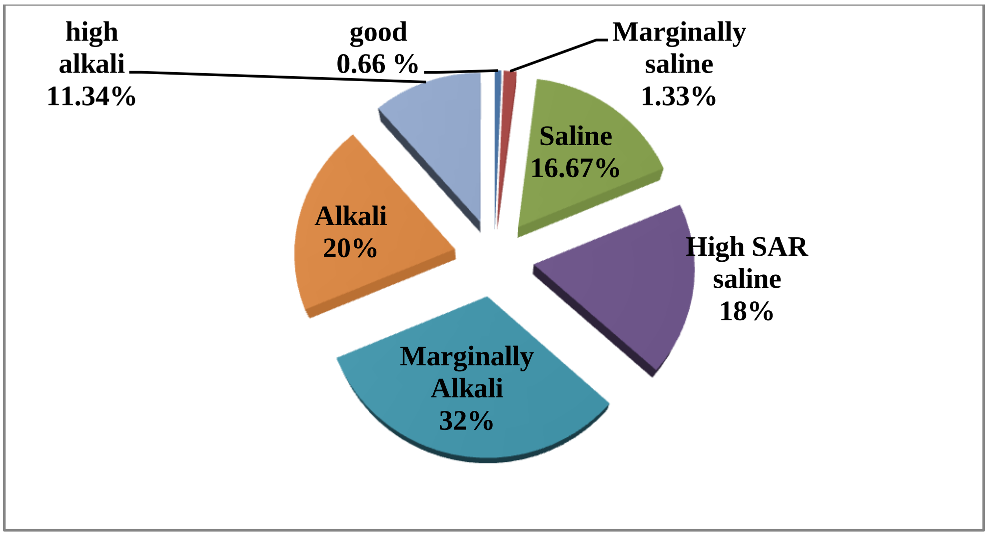

Fig. 4. Pie chart depicting distribution of water quality of Nagaur region

CONCLUSIONS

The correlation analysis introduce first rate tool for the prediction of parameters values within a reasonable degree of accuracy. It is also useful in exact measurement of underground water quality. Present study indicates that groundwater of study area is highly contaminated, so reclamation of water is essential to do before its use for agriculture production.

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