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STUDY OF UNDERGROUND IRRIGATION WATER QUALITY AROUND BADRASAR VILLAGE OF BIKANER DISTRICT OF RAJASTHAN

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A study was conducted to determine the quality of underground water of Badrasar village of Bikaner district of Rajasthan; based on classification, 31.25% of irrigation water was normal waters (SAR 5 - 10) followed by 62.5% low sodic waters (SAR 10-20) and 6.25% medium sodic waters (SAR 20-30), while 50% of irrigation water was low alkali waters (RSC < 2.5 me L^{-1}) followed by 31.25 % medium alkali waters (RSC 2.5 - 5.0 me L^{-1}) , 12.50% high alkali waters (RSC 5-10 me L^{-1}) and 6.25 % high alkali waters (RSC >10.0 me L^{-1}. In underground water, Na^+ cation concentration was higher followed by Ca^{++} while in anions HCO_3^- was higher followed by Cl^- and CO_3^{--}in anions. Increasing salt concentration in irrigation water was due to decreasing water table every year because of erratic or low rain fall. In sandy loam soils, higher values of EC, pH, sodium absorption ratio and residual sodium carbonates were recorded in comparison to the sandy soils.

Key words*:* Alkaline water, Badrasar village, Bikaner district, Poor quality water, RSC water, SAR water, Underground water

Introduction

The soils of arid region are very poor in macro and micronutrients as well as physical properties of soil. The soils of the north-western arid region are recognized as 'desert soils' comes within the Aridisols which is light textured[5]. The ground water resource is not only inadequate due to poor surface and sub-surface drainage but is also saline in feature. In the region, the irrigation water resources are seasonal rivers and rivulets, surface wells, canal irrigation in arid region and some runoff water storage methods like *tanka, khadins and nadi,* thus, the water resources in arid region are inadequate and 4% of the area can irrigate only.

Water is precious input in hot arid region of the country therefore, implementation of micro-irrigation system is advantageous to save lots of water and improve productivity. For arid environment, the variety is required which are resistant to biotic and abiotic stresses for sustainable production.

For agricultural production in water scares of arid region, saline or alkali waters comprise a vital source of irrigation. Irrigation of crops with poor quality waters created salinity and alkalinity problems of soil in Rajasthan which are further prominent by the aridity of the Rajasthan. Irrigation water from ground in Rajasthan has diversity of quality problems[14]. In the Rajasthan state regarding quality of under-ground water distribution, 68% underground water is poor quality while 16% is good rest

16% is marginal. Further, 16, 35 and 49%, water are saline, sodic and saline sodic waters, respectively[24] which is under poor quality water category. In dry-hot areas, the good quality water availability is very limited by low rainfall and high evapotranspiration[6] and is exacerbated under current global climate change, with severe weather events accompanied by long dry periods[20]. The increasing of the population needs more and more food, but at the same time, the consequences of global climate change are compromising crops production[15]. In order to reach reasonable and stable crop yields, irrigation can be vital. The agriculture sector is the largest consumer of water, especially in the region of arid and semi-arid, where irrigation water represents from 50% up to almost 90% of total used water[7]. Irrigation systems with advanced technologies along with good practices can increase irrigation effectiveness and decrease the water wastage[16, 23, 2]. Only a few vital parameters are essential for estimating appraisal of irrigation water quality which considers the crop/plant species to be given irrigation and the kind of irrigation system and strategy applied/ adopted for management, can be a trouble-free and bendable technique for maximizing the use again of low-quality water for crop production purposes[2, 18].

The comprehensive in sequence is missing as regard of appraisal of irrigation water of underground of around Badrasar village of Bikaner district. Hence, it is very indispensable to classify the underground waters utilize for irrigation of field with respect to their fittingness for growing of crops and impact assessment of soils of arid region.

Materials and Methods

The study was carried out in areas of Badrasar village of Bikaner district situated in North-western of part of Rajasthan state of India during 2018-2019. Soil of the Badrasar village falls under type of course grain sandy soils of arid region. The colour of soils ranges from greyish brown to white. Textures of soil are sandy and sandy loam loam. The climate of this area is arid type, erratic rainfall (100 - 420 mm/year), high evapo-transpiration (1500 - 2000 mm/year) and poor soil physical and fertility conditions are prevalent in this region. The major sources of irrigation are canals, seepage water from canal in dug well, tube well/Bore wells, Pond, etc.

Representative ground water samples were collected from Badrasar village of Bikaner district situated in North-western of part of Rajasthan state of India and analyzed for cationic and anionic composition according to standard methods[19]. SO_4^{--} was estimated by using Chesnin and Yien's method[4]. Ground waters were grouped on the basis of availability of SAR, and RSC values[9]. Sodium adsorption ratio of water samples were estimated as per U.S.D.A. Hand book 60[19].

Sodium adsorption ratio of irrigation water (SAR):

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

Residual sodium carbonate: It is calculated from the analysis data for carbonates, bicarbonates and Ca plus Mg as follows (all expressed in me/litre):

$$RSC\ (me/litre) = (CO_3^{2-} + HCO_3^{-}) - (Ca^{2+} + Mg^{2+})$$

Results and Discussion

Results revealed that cationic and anionic concentration varied from field to field, location to location and depth of water table (Table 3 and 4).

Mean maximum concentration of Na^{+} , K^{+} , Ca^{++} , Mg^{++} , CO_3^{--}, HCO_3^{-}, Cl^{-} and SO_4^{--} was 101.10, 0.13 14.44, 20.03, 1.74, 51.02, 74.09, 4.50, 21.94 0.13, 2.64, 2.97, 1.74,

5.24, 20.33 and 4.50 me L^{-1} and minimum concentration was 11.67, 0.09, 0.77, 1.40, 0.82, 2.78, 8.17, and 2.01 me L^{-1} with mean value 24.45, 0.12, 2.87, 4.00, 1.86, 9.13, 18.18 and 3.30, respectively. The sources of major cations, such as Ca^{2+} and Mg^{2+}, in groundwater can be the weathering of calcium and magnesium minerals[13]. In the areas of increased clay rich soil dispersed and where Na^+ concentration is higher[25], the Mg^{2+} concentration is relatively higher than that of Ca^{2+}. The ratio HCO_3^- : Na^+ can also be used to assess the weathering process[13] that occurs in groundwater. When the HCO_3^- : Na^+ ratio is greater than 1, carbonate weathering occurs, while a ratio A ratio of Na^+ /(Na^+ + Cl^-) higher than 0.5 had only one samples, suggesting that ion exchange process is very low. On the whole, the groundwater samples have the concentration of Na^+ higher than that of K^+, because of the greater resistance of K^+ to chemical weathering and its adsorption on clay minerals[17]. This suggests that when there is lack of rain, the decomposition of organic matter by bacterial organisms in the soil would not provide the appropriate CO_2 to the rock/ water interaction in dry season.

The Na^+ concentration in soil layers can influence the scattering of clay particles, the soil water characteristics, soil aggregate stability, and the formation of soil crusts. Dispersion of soil particles may cause clogging of soil pores, which reduces the soil permeability, soil porosity, and soil water conductivity[3,8,11,12,21].

Sodium hazard (SAR)

It represents the comparative activity of Na^+ ions in the exchange reactions. This ration measures the relative concentration of Na^+ to Ca^{++} and Mg^{++}. SAR of irrigation water varied from location to location. The classification of irrigation waters with respect to sodic hazard on the basis of SAR is based principally on the increase of exchangeable Na^+ and its effect on the physical conditions of soils. Given below irrigation water may be classified into six classes on the basis of SAR [9] (Table 1).

Levels	Irrigation water classification	Remarks
S_0	Non sodic waters (SAR < 5)	Non sodic waters can be used for irrigation on nearly all type of soils for every one crops even those sensitive to sodium.
S_1	Normal waters (SAR 5 - 10)	Normal waters can be utilized for irrigating field or crops in all types of soils with slight threat of development of detrimental levels of exchangeable Na^+ for growing all crops except sensitive to Na^+.
S_2	Low sodic waters (SAR 10 - 20)	Low sodic waters 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 soil, these waters can be used more successfully.
S_3	Medium sodic waters (SAR 20 - 30)	Medium sodic waters can be used only for crops which are tolerant to sodium on soils provided with good drainage such that leaching fraction is always greater than 0.3.
S_4	High sodic waters (SAR 30 - 40)	These waters are directly not suitable for irrigation but may be used in cycle or conjunction with low sodicity waters or with the use of amendments such as gypsum.
S_5	Very high sodic waters (SAR >40)	These waters are directly not suitable for irrigation without drastic treatment.

Table1: Sodium hazard (SAR) of irrigation water classification

Based on above classification (Fig 1), 31.25% of irrigation water was normal waters (SAR 5 - 10) followed by 62.5% low

sodic waters (SAR 10-20) and 6.25% medium sodic waters (SAR 20-30), Suitability for irrigation, plants intake water from soil by osmosis and osmotic pressure is proportional to the salt content, which affects the growth of plants, soil structure and permeability[10]. Sodium Adsorption Ratio of irrigation water is a key parameter for the finding out of the suitability of irrigation water because it is accountable for the sodium hazard[22].

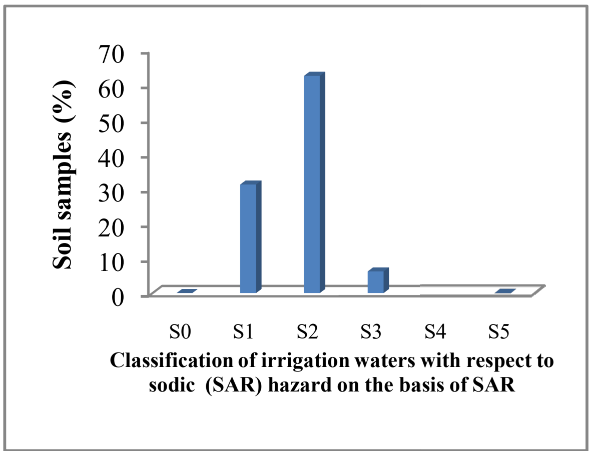

Fig. 1: Classification of irrigation waters with respect to sodic (SAR) hazard on the basis of SAR

Alkali hazard (RSC)

The carbonate or bicarbonate (alkali) hazard on the basis of residual sodium carbonate is primarily based on the precipitation of calcium and/or magnesium and pairing of residual carbonate (CO_3^{--}) or bicarbonate (HCO_3^{-}) with sodium and formation of sodium carbonate (Na_2CO_3) in the soil and increasing SAR/ESP characterizing it as alkali soil. RSC should be calculated for high pH (> 8.5) waters. On the basis of RSC (Table 2), given below irrigation waters may be classified into six classes[9].

Levels	Irrigation water classification	Remarks
A_0	Non-alkali waters (RSC Negative)	Non-alkali waters can be used for irrigation on almost all soils for all crops for indefinitely long periods without any problem.
A_1	Normal waters (RSC 0 me L^{-1})	Normal waters can be used for irrigation on almost all soils for all crops even those are sensitive to carbonates or bicarbonates
A_2	Low alkali waters (RSC < 2.5 me L^{-1})	Low alkali waters can be used for irrigation on almost all soils for all crops.
A_3	Medium alkali waters (RSC 2.5 - 5.0 me L^{-1})	Medium alkali waters can be used for irrigation on approximately all kind of soil with slight threat of the development of damaging levels of alkali conditions for growing all crops except sensitive to CO_3^{--}, and HCO_3^{-}
A_4	High alkali waters (RSC 5.0 - 10.0 me L^{-1})	High alkali waters can be used for irrigation on soils provided with good drainage such that leaching fraction is not less than 0.3 for growing semi-tolerant and tolerant crops to sodium. EC should be < 3.0 dS m^{-1} and SAR should be <10.0
A_5	Very high alkali waters (RSC > 10.0 me L^{-1})	These waters are directly not suitable for irrigation but may be used in conjunction with low alkalinity waters or with the use of amendments.

Table 2: Alkali hazard (RSC) of irrigation water classification

Based on above classification (Fig.2), 50% of irrigation water was low alkali waters (RSC < 2.5 me L^{-1}) followed by 31.25 % medium alkali waters (RSC 2.5 - 5.0 me L^{-1}), 12.50% high alkali waters (RSC 50-10 me L^{-1}) and 6.25 % high alkali waters (RSC >10.0 me L^{-1}). The comparative large magnitude of Na^{+} with respect to sodic soils, and the magnitude of CO_3^{2-} and HCO_3^{-}in surplus of sodic soils also affected the fittingness of irrigation water for irrigating crops/vegetables. This excess is denoted by

'Residual sodium carbonate' (RSC). A negative RSC value indicates that the total concentration of CO_3^{2-} and HCO_3^{-} is lower than the sum of the Ca^{2+} and Mg^{2+} concentrations, reflecting that there is no residual carbonate to react with Na^{+} to increase the Na hazard in the soil. Trace metals including were concentrations were

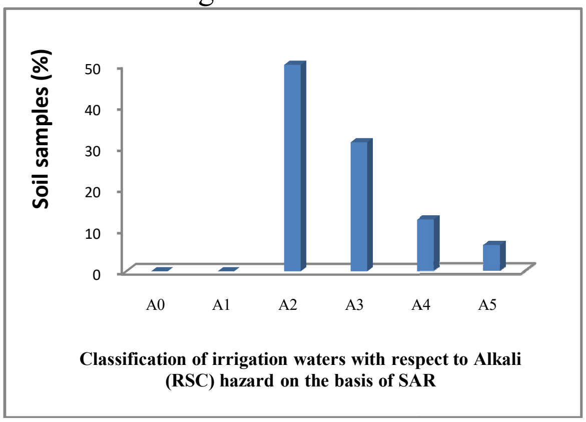

Fig. 2: Classification of irrigation waters with respect to Alkali (RSC) hazard on the basis of SAR

low and considered to be suitable for crop production and the soil environment[1]. In the places/villages/locations, where Indira Gandhi Nahar Project (IGNP) water is available for irrigating the field, but in sufficient quantities of irrigation water is not available to meet out the evapotranspirational demand of crops. Underneath these circumstances, the strategies for obtaining higher crop productivity could include mixing of poor quality irrigation water with good quality water to get irrigation water of average quality of water for use throughout the year for different crops. On the other hand, good quality of irrigation water may be used at the most critical stages of growth and therefore the saline water at the stages where the crop has comparatively more tolerance. Further research is desired to identify the best options considering the tolerance of crops at various growth stages[2].

Conclusion

Problematic soil in semi arid region is formed because of indiscriminate application of irrigation with poor quality under-ground water. Low irrigation water quality i.e. saline, it is unfit for irrigation in alkali and highly alkali soils and their haphazard use created secondary salinization and sodication in the soil which may affect crop performance or crop growth may be stopped/ceased.

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Badrasar Village	Cationic conc. (me L^{-1})				Anionic conc. (me L^{-1})			
	Na^+	K^+	Ca^{++}	Mg^{++}	CO_3^{--}	HCO_3^-	Cl^-	SO_4^{--}
Mean	24.45	0.12	2.87	4.00	1.86	9.13	18.18	3.30
Minimum	11.67	0.09	0.77	1.40	0.82	2.78	8.17	2.01
Maximum	101.10	0.13	14.44	20.03	1.74	51.02	74.09	4.50
Median	19.19	0.12	2.09	2.87	1.23	4.96	13.25	3.25
Standard Deviation	21.09	0.01	3.26	4.47	0.25	11.82	15.54	0.74

Table 3: Quality of underground irrigation water of Badrasar village of Bikaner district of Rajasthan

Badrasar Village	SAR	RSC
Mean	11.99	4.12
Minimum	9.20	0.12
Maximum	24.35	24.65
Median	10.88	2.60
Standard Deviation	3.71	5.93

Table 4: SAR and RSC of underground irrigation water of Badrasar village of Bikaner district of Rajasthan

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