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USE OF SALINE GROUND WATER FOR IRRIGATED SOILS IN WESTERN RAJASTHAN

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Irrigated agriculture in the arid and semi-arid zone of western Rajasthan is largely dependent on ground water resources. Canal irrigation on large scale is practised only in the district of Ganganagar; in rest of the area, out of 3,20,000 ha. of irrigated land nearly 95% is irrigated from shallow to deep dug wells. The water quality is generally poor according to the hitherto accepted standards. The use of saline waters for irrigation is of vital importance, therefore, to grow successful crops to meet the demand of the growing population of this region.

The quality of irrigation waters is determined mainly on the basis of its salinity status, sodium adsorption ratio, boron and bicarbonate content etc. whereas the knowledge of the complex inter-relationship between water, soil and plants is often not taken into consideration though it is of paramount importance. The studies should, therefore, include the effect of saline irrigation waters not only on the plant growth but also on the physical and chemical properties of the soils during different periods of the year, the ameliorative effect of rainfall and fallowing of the lands, seasonal variations in the quality of irrigation waters and such other interrelated aspects.

GROUND WATER CHARACTERISTICS IN WESTERN RAJASTHAN

Studies on the quality of ground waters have been made by several groups of scientists working at Central Arid Zone Research Institute, Jodhpur; Defence Laboratory, Jodhpur; State Department of Agriculture, Rajasthan and University of Udaipur (Bhargava *et al.*, 1966; Darra and Mehta, 1963; Darra *et al.*, 1964; Mehta *et al.*, 1970; Paliwal & Gandhi, 1969; Paliwal & Maliwal, 1966; Shankaranarayana *et al.*, 1965; Talati *et al.*, 1966). A perusal of the data contained in the above publications reveals the following :

1. About eighty-five per cent of the ground waters have electrical conductivity between 2,250 and 10,000 micromhos/cm at 25°C in different districts of western Rajasthan.
2. About seventy-five per cent of the ground waters (EC 2,250 to 10,000 micromhos/cm) have sodium adsorption ratio between 10 and 34.
3. All saline ground waters contain boron. About seventy to eighty per cent of these waters have boron in the range of 0.1 to 4 ppm. Toxic concentrations of boron however could be reduced with gypsum (Gupta & Chandra, 1972).

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4. Carbonate content of the ground waters seldom exceed 5.0 me/l and bicarbonate ions are rarely greater than 10.0 me/l.
5. Nitrates are found in the range of 0.3 to 11.0 ppm, in ground waters of Jodhpur and Pali districts and 0.12 to 2.26 ppm in Nagaur district.
6. The saline ground waters in western Rajasthan contain very low amounts of potassium ions which seldom exceed 1.0 me/l.
7. In waters of electrical conductivity of more than 2,250 micromhos/cm sodium forms the major bulk of cations and megnesium is the second dominant cation. The ratio of Mg to Ca, usually varies from more than 1 to 5. Among anions, chlorides are greatest. In water of salinity of less than 2,250 micromhos/cm, divalent cations usually dominate.
8. Information on the occurrence of toxic elements, other than boron like lithium, selenium etc, is not available. The saline ground waters of elctrical conductivity of more than 4,000 micromhos/cm from Mathura district of U.P. have been found to contain toxic concentration of lithium i.e. higher than 0.05 ppm (Gupta, 1972).
9. Electrical conductivity of well waters is highly correlated with SAR, TSS and principal cations and anions.
10. Gypsum is effective in reducing sodium hazard of high RSC waters.

Classification of Waters

Since long, irrigation waters have been evaluated in terms of their electrical conductivity and relative proportion of sodium to other cations, but the various classification standards developed in several countries by different workers, are highly variable and there is hardly any single classification which could be found of universal applicability. Due to several factors which affect the quality of waters, such standards are only of academic value and in practice these are having serious limitations. In western Rajasthan, most of the scientists have classified irrigation waters on the basis of United States Department of Agriculture classification as reported by Richards (1954), but their actual utilization in the field in western Rajasthan does not conform well. According to this classification, the upper limit for electrical conductivity is 2,250 micromhos/cm, sodium adsorption ratio is 26, boron 2 ppm and residual sodium carbonate is 2.5 me/l for all irrigation waters that could be used successfully for salt tolerant crops on permeable soils. But in western Rajasthan ground waters having electrical conductivity of about 10,000 micromhos/cm (Gupta & Abichandani, 1968; Paliwal & Gandhi, 1969; Shankaranarayana *et al.*, 1965); sodium adsorption ratio 26-35 (Paliwal & Gandhi, 1969); boron 3 to 4 ppm (Mathur *et al.*, 1966); and residual sodium carbonate 2.5 to 5.0 me/l (Saxena *et al.*, 1966); otherwise classified as unusable are being used successfully for growing salt-tolerant crops like *Kharchi* wheat and barley, on permeable soils. The use of water having dominance of divalent cations rich in magnesium does not result in problem of high exchangeable sodium percentage (Gupta & Abichandani, 1970b).

Seasonal Variations in the Quality of Saline Ground Waters

Though a good number of publications have appeared on quality of waters but the adequate information on seasonal variation in quality of water is lacking. The salinity status of well waters is subject to variation during different seasons which depends upon the quantum of its use and gradual variation in recharge potential and continued contact of recharge waters with minerals at lower depth after the cessation of the monsoon. It is the sum total of these changes that will ultimately determine the salt balance and sodic effects on soils irrigated by these waters. Gupta and Abichandani (1967) studied seasonal variations in the salt composition of some irrigation waters during different seasons of the year at some locations in western Rajasthan.

It was seen that after rainfall which occurred during the period of June to August, there was considerable change in the salt composition of the waters in the wells and the site near recharge source showed more seasonal fluctuations in salinity levels than the site with recharge source farther away. The waters which were predominantly Cl-SO_4-Na-Mg type prior to on-set of rains in the site near the recharge source, tended to be Cl-HCO_3-Na-Mg type after the monsoon and this change was accompanied by sharp drop in the SAR values. It may be interesting to note that irrigation of wheat and barley generally starts in late October or early November and continues till March in the region and it is during this period that most of the irrigation waters have a lesser salt content as compared to that of hot summer months.

Characteristics of Saline Water Irrigated Soils in Western Rajasthan

Gupta and Abichandani (1968) studied the salt composition of some soils of light and medium texture of western Rajasthan which had been irrigated with saline groundwater of 2,000 to 10,000 micromhos/cm electrical conductivity for last 30 to 50 years. The soil samples were collected in April about one month after previous irrigation of *rabi* season was over. A perusal of the data reported therein revealed the following:

1. *p*H(1 : 2 soil water suspension) varied between 8 and 9.5 at different depths but surface soil showed *p*H less than 8.5.
2. Electrical conductivity of the saturation extract of soils exceeded much beyond 4 mmhos/cm at the end of irrigation. Accumulation of soluble salts was highest in the surface and in most of the sites ECe was between 10 and 20 millimhos/cm at 0-20 cm depth.
3. The soluble sodium percentage in soil solution was over 75 and exchangeable sodium percentage exceeded 30 at most of the experimental sites.
4. Soluble sodium percentage in saturation extract of the soil was nearly equal or more than the sodium percentage in the respective irrigation waters.
5. SAR value of saturation extract of different soil layers was far above SAR of the respective irrigation waters.
6. Calcium concentration in the saturation extract of the soils was far below 15 me/l and amounts of potassium and carbonate ions were insignificant.
7. The irrigation waters had calcium contents between 2.5 and 7.7 me/l but sum of calcium and magnesium exceeded 12 me/l; magnesium in general

dominated over calcium. The waters having magnesium greater than calcium perhaps resulted in large accumulation of magnesium in soil solution.

The salt tolerant variety of wheat and barley continue to be taken on these lands in usual manner, though the yields might be low by about 10 to 25% as compared to soils being irrigated with low salinity waters having EC less than 2,250 micromhos/cm. The explanation of the successful crops of wheat and barley on these soils without the aid of any amendment lies in the amelioration effect of the rainfall which exerts marked influence over soluble salts and exchangeable sodium percentage, the associated soils being calcareous. Saline water irrigated lands are however cultivated during *rabi* season only and no *kharif* crop is taken. These lands are cultivated every alternate year or after every two years depending on quality and quantity of available water.

Effect of Rainfall on the Salt Composition of Saline Water Irrigated Soils

The changes occurring in the salt composition of saline water irrigated soils as affected by leaching due to rainfall (35 to 45 cm) have been reported by Gupta and Abichandani (1970a, b). It was observed from the data that after the rain, initial high salt concentration in the soils was reduced to 10-20%, thus making surface 40 cm almost non-saline. ECe after rainfall in surface 0-20 cm of the soil was less than 3 mmhos/cm; at 20-40 cm depth was less than 4 mmhos/cm. The hydrolysis of Na-clay appeared to be of small significance and leaching did not result in high sodicity. On the other hand in highly calcareous soils, simultaneous with soluble salt removal, sodium percentage was also reduced to a low level. The surface soils of Na-Mg-Cl-SO_4 type before rainfall became Na-Ca-Cl-HCO_3 type after rainfall. The level of soluble salts (ECe 4 to 9 mmhos/cm at 25°C) and exchangeable sodium percentage (15 to 30) which prevailed in top 20 cm soil during the growing period of wheat did not seem to affect significant reduction in the yield potential. However, in situations where adequate irrigations norms failed to match with the actual requirement of the crop or in drought years when rainfall deviates sharply from the average, yields might be significantly low.

Conclusions

In arid and semiarid zones of western Rajasthan, about 85% of the groundwaters have electrical conductivity between 2250 and 10,000 micromhos/cm, whose sodium adsorption ratio varies largely between 10 and 34, and contain mainly sodium chloride followed by magnesium chloride or sulphate. The quality of the waters varied in different seasons of the year, the effect of rainfall being more pronounced. The calcareous soils irrigated by such of saline ground waters show high salinity and exchangeable sodium percentage in hot summer months when these are fallow but rainfall amounting to 35-45 cm exerts marked influence and surface soils become again low in salinity and exchangeable sodium percentage. The level of salts and sodium which prevail during growing period of *rabi* season crops are not sufficiently high to affect adversely the growth of salt tolerant species of wheat and barley. In order to assess the usability of saline ground waters and irrigated soils, for growing *rabi* season crops, samples should be collected after rainfall and then at some intervals during the growing period.

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