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Irrigation Water Quality Based on Hydro Chemical Analysis, Jaffna, Sri Lanka

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Abstract: The hydro chemical study reveals the quality of water and its suitability for drinking, agriculture and industrial purposes. Presence of excessive quantities of salts in groundwater is one of the major constrains in agro-well farming in Jaffna Peninsula. Irrigation with poor quality waters may bring undesirable elements to the soil in excessive quantities affecting its fertility. Electrical conductivity (EC), Sodium percentage (Na %), Sodium adsorption ratio (SAR), Residual sodium carbonate (RSC) can be used as a criterion for finding the suitability of irrigation waters. The objective of this study is to evaluate the suitability of the irrigation water quality of the Jaffna Peninsula. Major cations; Na^+, Ca^{2+}, Mg^{2+}, K^+ and major anions; Cl^-, SO_4^{2-}, HCO_3^-, CO_3^{2-}, were determined from 34 wells, randomly located in Peninsula from October 2008 to April 2009 to assess the hazards of salinity, sodium and bicarbonate. Out of selected wells, based on EC, 44% of the wells have medium salinity water, 47 % of the wells have high salinity water and 9 % of the wells have very high salinity water. Based on percent of sodium, 3% of the wells have excellent irrigation water quality, 18 % of the wells have good irrigation water quality, 44% of the wells have permissible irrigation water quality, 32% of the wells have doubtful irrigation water quality and 3% of the wells have unsuitable irrigation water quality. Based on SAR, almost all the wells have the good quality irrigation water. Based on RSC, 61% of the wells have good irrigation water quality, 15% of the wells have doubtful irrigation water quality and 24% of the wells have unsuitable irrigation water quality. In overall assessment of tested wells, 20.6% of the wells have good quality water for irrigation, 44.1% of the wells have permissible to doubtful irrigation water quality, 35.3% of the wells have unsuitable irrigation water quality, in which bicarbonate hazard was identified as major hazard which is due to the influence of carbonate rock dissolution.

Key words: Irrigation water quality · Salinity hazard · Sodium hazard · Bicarbonate hazard · Jaffna Peninsula

INTRODUCTION

The Jaffna Peninsula lies in the northern-most part of Sri Lanka. The peninsula is dependent on groundwater for all its water requirements [1]. The hydro chemical study reveals the quality of water that is suitable for drinking, agriculture and industrial purposes. The chemical parameters of groundwater play a significant role in assessing water quality which is suitable for irrigation [2]. Presence of excessive quantities of salts in groundwater is one of the major constrains in agro-well farming in the dry zone of Sri Lanka [3]. Irrigation with poor quality waters may bring undesirable elements to the soil in excessive quantities affecting its fertility. The quality of groundwater has definite command over the yield of crops through its effect on soil environment which is the soul of infinite life [4]. Hence the study was focused on evaluation of groundwater for its suitability for irrigation.

MATERIALS AND METHODS

Selection of Wells and Collection of Water Samples: Groundwater samples were collected from 34 locations from Jaffna Peninsula and were analyzed from October 2008 to April 2009 at monthly interval. Water samples were collected according to prerequisite for the analysis. The collected samples were transported to the laboratory of National Water Supply and Drainage Board (NWS and DB), Jaffna.

Analytical Procedure: The procedures of the analysis were based on Sri Lankan standard 614 [5]. Na^+, K^+, Mg^{2+}, Ca^{2+}, Cl^-, SO_4^{2-}, HCO_3^-, CO_3^{2-} are the major ions in

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groundwater of Jaffna peninsula. Calcium and Magnesium content were determined by EDTA titration using Eriochrome black T as indicator. Sodium and potassium content were determined by using a flame photometer. Chloride concentration was measured by silver nitrate titration. Carbonate and bicarbonate content were measured by acid-base titration. Sulphate content was measured by using colorimetric-spectrophotometer. There are no any Mn^{2+}, As^{2+}, Fe^{2+} in considerable level. CE 470 conductivity meter was used to measure the Electrical Conductivity. The accuracy of the analysis for major ions was cross checked from the electrical balance (E.B), since the sum of positive and negative charges in the water should be equal [6].

RESULTS AND DISCUSSION

Salinity Hazard: Water with high salinity is toxic to plants and poses a salinity hazard. Soils with high levels of total salinity are called saline soils. High concentrations of salt in the soil can result in a "physiological" drought condition. That is, even though the field appears to have plenty of moisture, the plants wilt because the roots are unable to absorb the water. Water salinity is usually measured by the TDS (total dissolved solids) or the EC (electric conductivity). Classification of groundwater based on salinity hazard was done according to the recommendation of Sadashivaiah, *et al*., [2]. It was grouped as Excellent / low salinity water (100-250 µs/cm), Good / medium salinity water (250-750µs/cm), Doubtful/ High salinity (750-2,250 µs/cm), Unsuitable / very high salinity water (> 2,250µs/cm).Out of selected wells, based on Electrical Conductivity, 44% of the wells have medium salinity water, 47% of the wells have high salinity water, 9% of the wells have very high salinity water.

Sodium Hazard: Irrigation water containing large amounts of sodium is of special concern due to sodium's effects on the soil and poses a sodium hazard. Excess sodium in waters produces the undesirable effects of changing soil properties and reducing soil permeability. Hence, the assessment of sodium concentration is necessary while considering the suitability for irrigation.

Na % = (Na^+) X 100 / ($Ca^{2+} + Mg^{2+} + Na^+ + K^+$) where the quantities of all cations are expressed in milliequivalents per liter (epm).

The classification of groundwater was grouped based on percent Sodium as Excellent (<20 %), Good (20-40 %), Permissible (40-60%), Doubtful (60-80%) and Unsuitable (> 80%) [2]. Out of selected wells, based on percent Sodium, 3% of the wells have excellent irrigation water quality, 18 % of the wells have good irrigation water quality, 44% of the wells have permissible irrigation water quality, 32% of the wells have doubtful irrigation water quality and 3% of the wells have unsuitable irrigation water quality.

Sodium hazard is also usually expressed in terms of the sodium adsorption ratio (SAR). SAR is calculated from the ratio of sodium to calcium and magnesium. The latter two ions are important since they tend to counter the effects of sodium. Continued use of water having a high SAR leads to a breakdown in the physical structure of the soil. Sodium is adsorbed and becomes attached to soil particles. The soil then becomes hard and compact when dry and increasingly impervious to water penetration. The degree to which irrigation water tends to enter into cation-exchange reactions in soil can be indicated by the sodium adsorption ratio. Sodium replacing adsorbed calcium and magnesium is a hazard as it causes damage to the soil structure. It becomes compact and impervious. SAR is an important parameter for the determination of the suitability of irrigation water because it is responsible for the sodium hazard [7].

$$SAR = \frac{Na^+}{\left\{\frac{Ca^{2+} + Mg^2}{2}\right\}^{1/2}}$$

All ionic concentrations are expressed in epm.

Groundwater could be also classified based on Sodium Adsorption ratio (SAR) as Excellent (10), Good (10-18), Doubtful (18-26) and Unsuitable (> 26) [2].

Out of selected wells, based on SAR, almost all the wells have the good quality irrigation water.

Bicarbonate Hazard: Bicarbonate hazard is usually expressed in terms of RSC (Residual Sodium Carbonate). RSC is calculated using the following equation.

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

In waters having high concentration of bicarbonates, there is tendency for calcium and magnesium to precipitate as the water in the soil becomes more concentrated. As a result, the relative proportion of sodium in the water is increased in the form of sodium bicarbonate [2]. Residual carbonate levels less than 1.25 epm are considered safe. Waters with RSC of 1.25-2.50 epm are within the marginal range. These waters

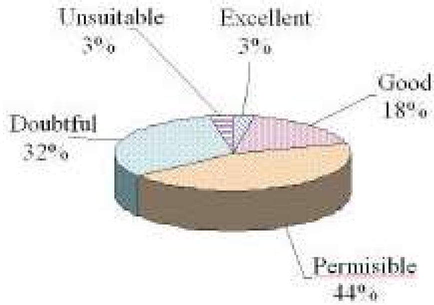

Fig. 1: Irrigation water quality based on Na %

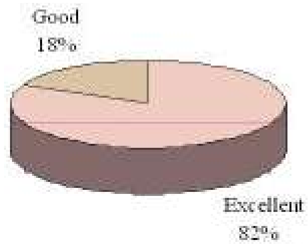

Fig. 2: Irrigation water quality based on SAR

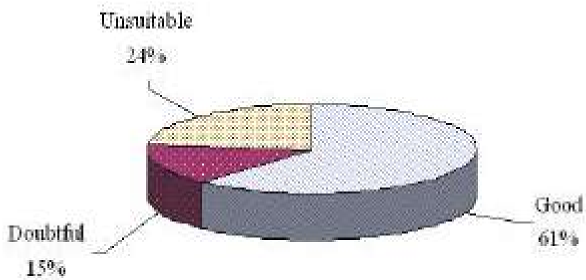

Fig. 3: Irrigation water quality based on RSC

should be used with good irrigation management techniques and soil salinity monitored by laboratory analysis. Risk is lowest with waters for which the RSC is at the low end of the range and which are being applied to permeable, well-drained, coarse-textured soils in high rainfall areas. Groundwater could be classified based on RSC. It was grouped as Good (< 1.25), Doubtful (1.25-2.5) and Unsuitable (> 2.5) [2].Out of tested wells based on Residual Sodium Carbonate (RSC), 61% of the wells have good irrigation water quality, 15% of the wells have doubtful irrigation water quality, 24% of the wells have unsuitable irrigation water quality,

Out of tested wells, 20.6% of the wells have good quality irrigation water, 44.1% of the wells have permissible to doubtful irrigation water quality, 35.3% of the wells have unsuitable irrigation water quality, in which 25% of the wells have salinity hazard, 8.3% of the wells have sodium hazard, 66.7% of the wells have bicarbonate hazard which is due to the influence of carbonate rock dissolution.

Continues use of waters having RSC more than 2.5 meq/l leads to salt build up which may hinder the air and water movement by clogging the soil pores and lead to degradation of the physical condition of soil. RSC (2.5-4) can be used effectively with the addition of gypsum. Sodic soils could be used with gypsum addition and green manuaring. [4].

CONCLUSION

Irrigation water quality was determined based on salinity hazard, sodium hazard and bicarbonate hazard. Out of tested wells, 20.6% of the wells have good quality irrigation water, 35.3% of the wells have unsuitable irrigation water quality. We can manage the poor irrigation water by increasing salt tolerance of plants and improving irrigation management technologies. The physical, economic, social and institutional costs and feasibility requirements for salt disposal will have to be met as part of the necessary and sufficient conditions for a prosperous long-term agriculture.

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