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Prediction of Soil Exchangeable Sodium Ratio Based on Soil Sodium Adsorption Ratio

M. Siosemarde, F. Kave, E. Pazira, H. Sedghi and S. J. Ghaderi

***Abstract*—**Researchers have long had trouble in measurement of Exchangeable Sodium Ratio (ESR) at salt-affected soils. this parameter are often determined using laborious and time consuming laboratory tests, but it may be more appropriate and economical to develop a method which uses a more simple soil salinity index. The aim of this study was to determine the relationship between exchangeable sodium ratio (ESR) and sodium adsorption ratio (SAR) in some salt-affected soils of Khuzestan plain. To this purpose, two experimental areas (S1, S2) of Khuzestan province-IRAN were selected and four treatments with three replications by series of double rings were applied. The treatments were included 25cm, 50cm, 75cm and 100cm water application. The statistical results of the study indicated that in order to predict soil ESR based on soil SAR the linear regression model ESR=0.2048+0.0066 SAR (R^2=0.53) & ESR=0.0564+0.0171 SAR (R^2=0.76) can be recommended in Pilot S1 and S2 respectively.

***Keywords*—**exchangeable sodium ratio, Khuzestan plain, salt-affected soils and sodium adsorption ratio.

I. Introduction

SALINE soils are of increasing importance both in Iran and world-wide. In Iran, approximately 44.5 M ha of arable land are affected by dry land salinity [1]. The sodium absorption ratio (SAR) of soil solution extracts has been an important tool for predicting the equilibrium exchangeable sodium ratio (ESR) in salt affected soils. The degree of sodium hazard in the soil has then been related to the soil ESR (U.S. Salinity Laboratory Staff, 1954) [2]. SAR is usually defined as:

$$SAR = \frac{Na^{+}}{\sqrt{\frac{Ca^{2+} + Mg^{2+}}{2}}} \quad (1)$$

Where the cation concentrations are in meq/1

M. Siosemarde is with the PhD in Irrigation and Drainage Engineering, Water Engineering Department, Islamic Azad University (IAU), Mahabad Branch, Mahabad, Iran (e-mail: maroof_33m@yahoo.com).

F. Kave is Associate Professor, Water Engineering Department, Islamic Azad University (IAU), Science & Research Branch, Tehran, Iran (e-mail: fhnkaveh@yahoo.com).

E. Pazira is Professor, Soil Engineering Department, Islamic Azad University (IAU), Science & Research Branch, Tehran, Iran (e-mail: epazira675@yahoo.com).

H. Sedghi is Professor, Water Engineering Department, Islamic Azad University (IAU), Science & Research Branch, Tehran, Iran (e-mail: hsedgh@yahoo.com).

S. J. Ghaderi is Assistant Professor, Water Engineering Department, Islamic Azad University (IAU), Mahabad Branch, Mahabad, Iran (e-mail: ghaderi.jamil@gmail.com).

The ESR is usually defined as:

$$ESR = 100 \times \frac{\text{Exchangeable Na}}{\text{CEC - Exchangeable Na}} \quad (2)$$

Where CEC is the cation exchange capacity or calculated from the total exchangeable cations. The CEC and the exchangeable Na have traditionally been expressed in meq/100 g soil [3]. As shown in Eq. (2), for determining soil ESR, it is necessary to have soil Cation Exchange Capacity (CEC). But, as soil CEC are often determined using laborious and But, as soil CEC are often determined using laborious and time consuming laboratory tests [4,5]. The relationship between SAR and ESR has been used in expressions ranging in complexity from $\text{ESR} = \frac{\text{SAR}}{100 - \text{SAR}}$ [6], which does not allow SAR to exceed 100, through a series of expressions discussed by Oster and Sposito (1980), to the empirical relationship;

$$ESR = (-0.0126 + 0.01475\ \text{SAR}) \quad (3)$$

As developed from statistical analysis of many soil sample data (U.S. Salinity Laboratory Staff, 1954).

Previously researches report a relationship between the Sodium Adsorption Ratio (SAR) with a reported soil ESR and SAR [7-11].

The purpose of this study was to determine the relationship between exchangeable sodium ratio (ESR) and sodium adsorption ratio (SAR) in some salt-affected soils of northern Ahwaz Khuzestan plain.

II. Materials and Methods

In all, soil samples were taken along the northern Ahwaz, Khuzestan province, south eastern Iran. Every soil sample was taken in lands with a high risk of salinization and/or sodification. Climate in this region is characterized by dry summers and winters, with 252.1 mm/year rainfall, and 3222.5 mm/year evapotranspiration. These conditions, in addition to the use of high to medium salt-content irrigation water and/or bad drainage, lead to an increased risk of salinization and/or sodification in agricultural areas.

In this work, two experimental areas (Pilot 1 with silty clay texture & S_4A_4 Will Cox classification and Pilot 2 with sandy loam texture & S_3A_2 Will Cox classification) were selected and four treatments with three replications by series of double rings were designed. The treatments were included 25cm, 50cm, 75cm and 100 cm water application by Karoon River that Result of chemical analysis listed in Table 1.

TABLE I
RESULT OF CHEMICAL ANALYSIS OF LEACHING WATER QUALITY

Parameters		Pilot S1	Pilot S2
$EC(\frac{dS}{m})$		1.7	1.4
concentration (meq/lit)	Na^{1+}	9.5	7.5
	$Ca^{2+}+Mg^{2+}$	6.9	6.5
pH		8.25	7.98
T.D.S (mg/lit)		1260	993
S.A.R		5.11	4.16
Will Cox classification		C3-S2	C3-S2

EC = electrical conductivity, T.D.S = total dissolved solids, S.A.R = sodium absorption ratio.

The soil samples were air-dried and sieved to 2 mm with subsequent preparation of the saturation extract for each one. The soil saturation extracts samples were analyzed for various physiochemical parameters such as EC, carbonates, bicarbonates, chlorides, nitrates, sulfates, sodium, potassium, calcium, magnesium, hardness, alkalinity and sulphate as per APHA standards.

The aim of this research was study of evaluating the Linear model for predicting of ESR, Y, based on SAR, X, and comparing those models with statistics of Correlation Coefficient (R), Root Mean Square Error (RMSE), Significant, Mean Bias Error (MBE), Mean Absolute Error (MAE), Maximum Error (ME), Relative Error (RE), Coefficient of Residual Mass (CRM), Standard Error (SE) and Coefficient of Variation (CV).

III. RESULT AND DISCUSSION

Table 2 & table 3 were indicated the various statistics of linear models of predicting exchangeable sodium ratio (ESR) based on sodium adsorption ratio (SAR) in Pilot S1 & S2 respectively.

TABLE II
VARIOUS STATISTICS OF LINEAR MODELS TO RELATE *ESR* TO *SAR* IN PILOT S1

Statistics	MODEL	
	ESR=-0.0126+0.01475 SAR	ESR=0.2048+0.0066 SAR
Correlation Coefficient	0.78	0.73
Root Mean Square Error	10.27	9.51
Significant	0.000	0.000
Mean Bias Error	1.456	1.818
Mean Absolute Error	6.79	7.33
Maximum Error	26.19	28.5
Relative Error	25.26	27.25
Coefficient of Residual Mass	-0.054	-0.068
Standard Error	14.84	7.22
Coefficient of Variation	55.22	26.85

Various statistics were used to compare the soil exchangeable sodium ratio (ESR) values predicted using the soil ESR-SAR linear regression model with the soil ESR values predicted by the US Salinity Laboratory (USSL) equation.

TABLE III
VARIOUS STATISTICS OF LINEAR MODELS TO RELATE *ESR* TO *SAR* IN PILOT S2

Statistics	MODEL	
	ESR=-0.0126+0.01475 SAR	ESR=0.0564+0.0171 SAR
Correlation Coefficient	0.86	0.87
Root Mean Square Error	8.03	5.90
Significant	0.000	0.000
Mean Bias Error	-5.58	0.63
Mean Absolute Error	6.75	4.63
Maximum Error	21.26	20.96
Relative Error	25.67	17.62
Coefficient of Residual Mass	0.22	-0.02
Standard Error	12.73	11.13
Coefficient of Variation	48.41	42.34

The results showed although the new linear regression model has less RMSE than USSL equation but it has less Correlation than USSL equation in pilot S1. The results showed that new linear regression model was the better model than USSL equation that correlation coefficient and RMSE in the new linear regression model were 0.87 & and 5.90 and correlation coefficient & RMSE in the USSL equation were 0.86 & 8.03 respectively. Therefore, the soil ESR-SAR model can provide to estimate soil ESR in pilot S2.

The calculated linear equation in pilot S1 is as follows:

$$ESR=0.2048+0.0066\ SAR \quad (4)$$

Also the Comparison between observed and predicted data obtained from the mentioned model has been depicted that indicates week match (Fig. 1).

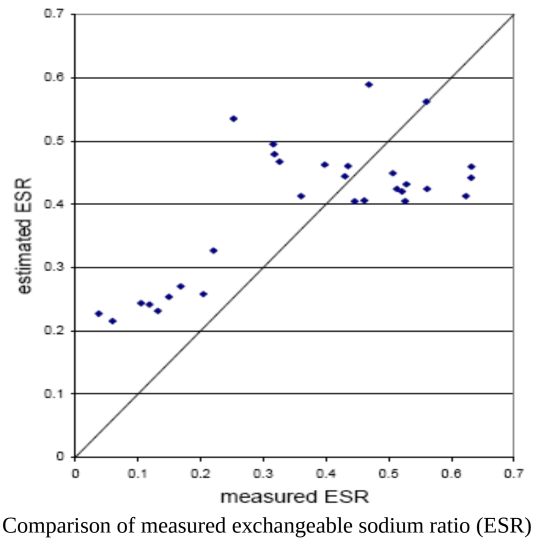

Fig. 1 Comparison of measured exchangeable sodium ratio (ESR) and ESR estimated from SAR in pilot S1.

The calculated linear equation in pilot S2 is as follows:

$$ESR=0.0564+0.0171\ SAR \quad (5)$$

Also the Comparison between observed and predicted data obtained from the mentioned model has been depicted that indicates good match (Fig. 2).

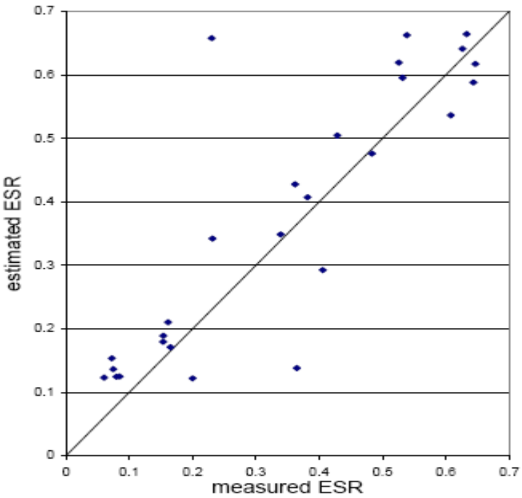

Fig. 2 Comparison of measured exchangeable sodium ratio (ESR) and ESR estimated from SAR in pilot S2.

IV. Conclusion

Overall from the study, it is concluded that tow new linear regression models to relate exchangeable sodium ratio (ESR) to sodium adsorption ratio (SAR) in soil saturation extracts have been the better models than USSL equation. Furthermore, USSL equation can be less correlation & precision than mentioned models, and it was shown that the appropriate model depend on various physiochemical parameters such as salinity of soil saturation extracts, EC, sodium, potassium, calcium, magnesium, alkalinity and etc. Finally it is concluded that ESR-SAR model may not be same for all soil saturation extracts and it varies widely with in themselves. Therefore, the specific objective of the study presented here was to determine a soil ESR-SAR model for Khuzestan plain (northern Ahwaz) in Iran, and to verify the developed model by comparing its results with those of the laboratory tests.

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