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THE RELATIONSHIP BETWEEN ESP AND SAR AT SALT AFFECTED SOILS IN THE NORTH NILE DELTA

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ABSTRACT

143 soil samples representing 80 profiles (analyzed as soil paste extract) were taken from three districts in Kafr El-Sheikh governorate at North Delta, Egypt namely: El-Zawia (53 profiles), Gharb El-Mansour (14 profiles) and Motobes (13 profiles) (during 2007 -2008). These samples were chemically analyzed representing the highly salt affected soils to hand out different purposes that accomplish some experimental objectives. The opportunity was seized through the chemical analysis of these samples and values of sodium adsorption ratio (SAR) were calculated to modify, derive or fit the best fit equation representing the relationship between SAR and exchangeable sodium percentage (ESP). The following empirical equation was fitted with the highest coefficient of determination among the other formulas:

$ESP = 1.8667+ 0.9228 (SAR) + 0.001 (SAR)^2$

(R^2=0.9545)

Statistical measurements such as: t-test, f-test chi-square test and correlation coefficient between the actual and predicted values of ESP using the current formula compared to the actual and predicted values of ESP using the own formulas of some other authors showed that the current formula significantly surpassed any other equation derived or modified before.

The relationship between SAR and ESP with that formula and high coefficient of determination could safely and significantly enable to predict the values of ESP as soon as SAR values were calculated for the rotine work.

Keywords: ESP, SAR, cation exchange capacity (C E C) and prediction.

INTRODUCTION

As it is known that cations in the soil solution replace the adsorbed cations on the soil complex and vise versa, what is called “Cation Exchange” according to the following equation:

$$CaX_2 + 2NaCl \rightleftharpoons 2NaX + CaCl_2 \qquad (1)$$

Where: X designated the soil exchange complex.

Cation exchange is significantly affected by several factors e. g. soil texture, topography, ground water table quality and level, irrigation water quality, drainage efficiency and climate conditions. Exchangeable cations markedly influence the physical and chemical soil properties. So, determination of exchangeable cations is very useful. Exchangeable cations determination is subject to various difficulties that prevent accurate determination of Exchangeable cations. (Richards *et al.* , 1954). Errors have been occurred during the chemical determination especially cation exchange capacity (C E C) in alkali soils. Kelley (1957) stated several sources of errors in the determination of C E C.

So, and according to the abovementioned factors, conditions and difficulties so many workers have proposed different equations to express and simulate the equilibrium state of pairs of cations between the exchangeable and soluble forms. For example U. S. Sal. Lab . Staff have derived the following empirical equation: (Richards *et al.* , 1954).

$$ESP = \frac{100(-0.0126 + 0.01475\ SAR)}{1 + (-0.0126 + 0.01475\ SAR)} \quad (2)$$

where: ESP = exchangeable sodium percentage,
SAR = sodium adsorption ratio,

After Richards *et al.* , (1954), many authors followed the same principle of equation (2) to derive an equation of there own data. e. g. Balba, (1962), Gohar et al. (1970) and Kaoud (1979), But all these relationships depend on a linear relation between ESP and SAR with the same formula ESP = b + a * SAR, and then get the constants a and b using least square method. Thereafter substitute this relation to get the indirect relationship between ESP and SAR. With a common formula as such:

$$ESP = \frac{100(b + a\ SAR)}{1 + (b + a\ SAR)} \quad (3)$$

Many authors used the formula of equation (3) to obtain the average relation between SAR and ESP (e. g. Shainberg and Letey (1984) Bresler et. al . (1982) and DANR (1998). But it is very important to notice that U. S. Salinity Lab. Method followed in this manner have been subject to two assumptions, namely: 1) potassium cation (K^+) could be neglected and 2) Mg^{++} has approximately the same ease of release from the clloid surface as Ca^{++}, and both of these assumptions may be unrealistic.

Also, Van Der Melon ((Richards *et al.* , 1954). Derived another equation following another formula represented as follows:

$$U = K\ V 2 Log\ \Sigma C \quad (4)$$

Where: U = Na / S represents the fraction of exchangeable sodium among the exchange capacity (S),
Σ C = Total concenteration in meq / l. ,
V = Na / Σ C is the corresponding fraction of soluble Na in the solution.
K = Constant (Van Der Melon found its value to be 0.22).

Moreover Gazia (2001) derived another equation taking in consederation another concept which state that the relationship between ESP and SAR is not necessary to be linear but may be quadratic, this concept is reasonable because the reaction ability between soil solution and soil complex is changeable and different according to the concentration of cations in both soil solution and soil complex.

The objective of the current study is to derive another equation representing the relationship between SAR and ESP based on direct quadratic relation subject to salt affected soils under the different conditions of North Delta. Beyond the previous formulas which indirectly relate SAR to

ESP that result in some bias, consequently lead to inaccurate and inconsistent estimates. Then by using different statistical measurements and tests try to compare the calculated values of ESP derived using all these formulas.

MATERIALS AND METHODS

143 soil samples analysed in this study were taken through 80 Profiles from three districts, in Kafr El-Sheikh Governarate: namely El-Zawia district 53 profiles, Gharb El-Mansour 14 profiles and Motobes district 13 profiles. These samples represent a wide range of salinity and exchangeable sodium. The soluble sodium was determined using flame photometer and soluble Ca^{++} and Mg^{++} using versinate method in the soil paste extract(Jackson, 1967). Cation exchange capacity (C E C) of the soils was determined following the modified Hissink's method (Gohar, 1954). Sodium released was determined as above. The exchangeable sodium was determined using ammonium acetate method (Richards *et al.* , 1954). Sodium adsorption ratio (SAR) and exchangeable sodium percentage (ESP) were calculated using the following formulas:

$$SAR = \frac{Na^{+}}{\left(\frac{Ca^{++}+Mg^{++}}{2}\right)^{1/2}}$$ *Na, Ca and Mg are in meq/l.*

$$ESP = \frac{\text{exchangeable Na}}{\text{Cation exchange capacity}} \times 100$$

Table (1, a and b) represents the summary of the soil chemical and physical properties as the range from the minimum and the maximum values of the studied soil samples.

Least squares method was applied to fit the best quadratic relationship between SAR and ESP according to Pindyck and Rubinfeld, (1976) and Johnston, (1972).

Table (1a):Summary of the soil chemical properties for the three studied districts.

District	EC dS/m	SAR	ESP	C E C	PH (1:2.5)
El-Zawia	8.2-89.8	17.0-68.6	19.0-68.0	33.2-59.6	7.2-8.4
Gharb El-Mansour	11.5-88.0	24.0-68.6	25.0-66.0	33.5-62.4	7.8-8.3
Motobes	4.5-80.0	12.0-65.8	14.0-63.0	31.1-43.4	7.8-9.2

Table (1b):Summary of the soil physical properties for the three studied districts.

District	Sand	Silt	Clay	Texture class	Order
El-Zawia	2.0-20.0	20.0-30.0	50.0-78.0	Clayey	Entisol
Gharb El-Mansour	6.0-20.0	10.0-40.0	40.0-85.0	Clayey	Entisol
Motobes	6.0-10.0	30.0-40.0	50.0-64.0	Clayey	Entisol

RESULTS AND DISCUSSION

As it is seen in Tables (1, a and b) that soil samples in the three districts have a wide range of salinity and alkalinty. Several trials were experimented on the actual data of SAR and ESP using different formulas: e. g. linear, logarithmic, sime-log, exponential, reciprocal and polynomial with quadratic and cubic powers. These formulas were tested to find out the best relationship between SAR and ESP the best one with the highest coefficient of determination (R^2=0.9545) was the quadratic form, fig (1) which is reasonably and statistically accepted. This formula is represented as follows:

$$ESP = 1.8667 + 0.9228\ (SAR) + 0.001\ (SAR)^2 \qquad (5)$$

(R^2=0.9545)

Statistical measurements were used to compare the predicted values using this formula (5) with the analytical values. It was found that they were satisfactorily closed together. Moreover the current formula was implemented on the actual data given by BAlba, (1962), Gohar et al, (1970) and Kaoud, (1979).

$$ESP = \frac{100(0.0868 + 0.00792\ SAR)}{1 + (0.0868 + 0.00792\ SAR)} \qquad \text{Balba (1962)} \quad (6)$$

$$ESP = \frac{100(0.02209 + 0.02253SAR)}{1 + (0.02209 + 0.02253SAR)} \qquad \text{Gohar (1970)} \quad (7)$$

$$ESP = \frac{100(0.00698 + 0.01933\ SAR)}{1 + (0.00698 + 0.01933\ SAR)} \qquad \text{Kaoud (1979)} \quad (8)$$

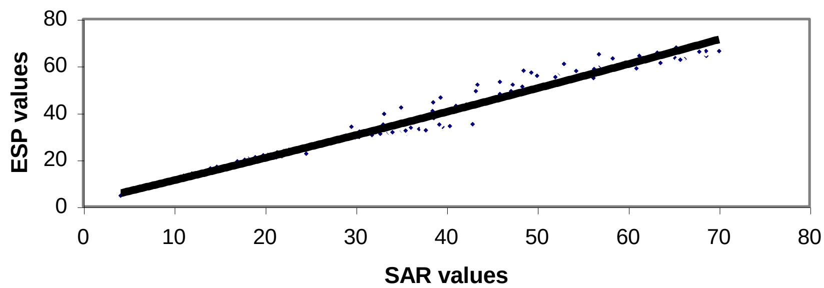

Fig (1): the relationship between SAR and ESP

Statistical measurements e. g. t-test, f-test, Chi-square test and simple correlation coefficient (r) were calculated to compare the relation between the predicted values using the current fitted formula and the actual data compared to the relation between the predicted values using each of their own formula and his own actual data. Table (2) summarized these comparisons. It is shown that the current fitted equation (5) is mostly surpassed all the other equations: 6, 7 and 8. when it is applied on their own actual data.

Table (2): Compared values of some statistical measurements using the fitted formula versus some other formulas.

Statistical measure	Balba data		Gohar data		Kaoud data	
	Balba own formula (6)	Formula (5)	Gohar own formula (7)	Formula (5)	Kaoud formula (8)	Formula (5)
t-test	0.9755	0.0052	0.9823	0.0017	0.7731	0.0301
f-test	0.4512	0.0496	0.4703	0.4565	0.5743	0.0363
Chi-square test	0.9943	0.0046	0.9284	0.1258	0.00006	5.35E-16
r value	0.8928	0.8950	0.9590	0.9552	0.803	0.804

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أنسب علاقة بين النسبة المئوية للصوديوم المتبادل ونسبة إدمصاص الصوديوم للأراضي المتأثرة بالأملاح في منطقة شمال الدلتا

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تم تحليل مستخلص عجينة التربة لعدد 143 عينة أرضية مأخوذة من 80 قطاع من ثلاث مناطق في محافظة كفر الشيخ بشمال الدلتا , مصر 2007 - 2008 لتمثل الأراضي شديدة التأثر بالملوحة. هذه المناطق هي: قطاع الزاوية , قطاع غرب المنصور وقطاع مطوبس.. أجري التحليل الكيميائي لهذه العينات لخدمة الأغراض البحثية وقد تم انتهاز فرصة توفر التحليل الكيميائي وحساب نسبة إدمصاص الصوديوم (SAR) لتعديل أو اشتقاق أو توفيق أنسب علاقة بين نسبة إدمصاص الصوديوم (SAR) والنسبة المئوية للصوديوم المتبادل (ESP) والتي تتخذ كمؤشر لقياس درجة قلوية الأراضي. وقد تم التوصل إلي الصيغة التالية والتي تعتبر أنسب صيغة تمثل العلاقة بين SAR و ESP وذات أعلي معامل تحديد من بين الصور المتاحة الأخرى .

ESP = 1.8667+ 0.9228 (SAR) + 0.001 $(SAR)^2$
$(R^2=0.9545)$

وهذه العلاقة بين SAR و ESP بهذه الصيغة ومعامل التحديد المرتفع تمكن من التنبؤ بقيمة ESP بدرجة عالية من الأمان والثقة وذلك بمجرد حساب قيمة SAR .

وقد استخدمت المقاييس الإحصائية مثل: اختبار ت واختبار ف واختبار كا ^{2} ومعامل الارتباط بين كل من القيم الفعلية والمتوقعة باستخدام هذه الصيغة مقارنة بالقيم الفعلية والمتوقعة باستخدام الصيغ الأخرى التي سبق اشتقاقها بواسطة باحثين آخرين باستخدام البيانات الفعلية المنشورة لأولئك الباحثين. حيث أوضحت هذه المقاييس الإحصائية معنوية وتفوق هذه الصيغة علي الصيغ الأخرى المشتقة بواسطة أولئك الباحثين عندما جربت هذه الصيغة علي البيانات الفعلية المنشورة لهم.