Testing the applicability of some mathematical equations to calculate the exchangeable sodium percent (ESP) of salt-affected soils in Sebha city

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Abstract:

Thirty-Three salt affected soil samples were collected from three experimental stations follows to Agricultural research center in Sebha city and they were used to cover a wide range of salinity in order to calculate the values of ESP through the results of laboratory analysis and through the use of mathematical equations proposed by Richard, 1954 and Balba, 1962. The results obtained from this study shown that the difference between the values of ESP obtained by the two methods mentioned above at 0.05 significant level, statistically was not significant. Therefore, we confirm that the validity and possibility of using these two equations referred in this study to calculate the ESP of salt affected soils in experimental stations in Sebha city.

المستخلص باللغة العربية:

تم جمع ثلاثة وثلاثين عينة تربة من الترب المتأثرة بالملوحة من عدد ثلاث محطات تجارب بمدينة سبها لحساب نسبة الصوديوم المتبادل (ESP) من خلال المعادلتين قيد الدراسة ومن خلال التحاليل المختبرية ومقارنة النتائج المتحصل عليها، هذا وقد أظهرت النتائج التي تم الحصول عليها بان الفرق بين قيم (ESP) المتحصل عليها من خلال النتائج المعملية والقيم المحسوبة باستخدام المعادلات الرياضية المقترحة من (Richard, 1954 and Balba, 1962) عند مستوى (0.05)

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احصائيا كان غير معنوي وعليه نؤكد صلاحية وامكانية استخدام تلك المعادلتين المشار إليهما في هذه الدراسة لحساب (ESP) للترب المتأثرة بالملوحة في مدينة سبها.

Introduction

High salt concentrations of the soil solution is directly toxic to plants and high sodium saturation of the soil results in unfavorable physical and hydro-physical properties indirectly responsible for the low fertility of salt affected soil. The thermodynamic theory of cation exchange is consistent with the empirical ESR-SAR relation over the range of sodium sdsorption ratio (SAR) values that has practical importance in the management of sodium-affected soils (Oster and Sposito, 1980).

Knowledges of sodium status in proportion to other cation on the soil exchange complex is essential from the stand point of evaluating sodicity of salt- affected soils because of the difficulties and complexities involved in direct determination of exchangeable sodium and the corresponding exchangeable sodium percentage (ESP). Narjes et al., 2021 found that the effect of calcium carbonate dissolution on exchangeable calcium value has a significant impact on selectivity coefficients and thermodynamic parameters of exchange in calcareous soil.

The need for a reliable parameter that can easily be determined in the solution phase of the soil system is evident. The U.S. Salinity Laboratory staff (Richards, 1954) after examining the relationship between soluble and exchangeable sodium in 59 soil samples from 9 Western States in the U.S. has developed a well-known and widely used parameter termed sodium adsorption ratio (SAR). A number of equations (Kerr, 1928, Vanselow, 1932 and Gapon, 1933) have been proposed with different assumptions and all these equations have merits, demerits and usually are site-specific.

Based upon Gapon's exchange equation SAR is directly related to exchangeable sodium ratio (ESR) and hence to ESP. The Gapon equation is not consistent with thermodynamics of exchange reactions. However, the Vanselow exchange equation, on the other hand, is consistent with thermodynamics of exchange (Evangelou and Phillips, 1988).

Rieu et al., 1991 reported that the power-law relationships appeared very simple and accurate for producing both a direct estimate of the composition of the adsorbed phase and the calculation of the equilibrium exchange constant.

Empirical equations relating the SAR of the soil saturation extract to the ESR and the ESP of the soil were also developed by the U.S. Salinity Laboratory staff where

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

Where all concentrations expressed in miliequivalent per liter.

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

Proposed by U.S. Sal Lab (Richards, 1954)

Nevertheless, little informations has been published on its validity in predicting the exchangeable sodium status in soils different from those under which it was developed. Another empirical equation for SAR – ESP relationship was developed by Balba (1962).

$$ESP = \frac{100\,(0.00868+0.00792\,SAR)}{1+(0.00868+0.00792\,SAR)} \qquad (2)$$

Proposed by Balba (1962).

This study aims to determine the validity and possibility of applying these mathematical equations to calculate the ESP of salt- affected soils in experimental stations follows to Agricultural research center in Sebha city.

Materials and Methods:

Thirty-three salt affected soil samples were collected from eleven profile in three experimental stations in Sebha, Hatiya experimental station, Brak experimental station and Trgahen experimental station. The soil samples used were covered a wide range of salinity and exchangeable sodium. Soil saturation paste

extract was analysed for soluble cations, Ca++ and Mg++ using the versinate method and for Na+, K+, photometrically (Jackson, 1958). The cation exchange capacity (CEC) was determined based on the measurement of the total quantity of negative charges per unit weight of the soil, by the replacement of adsorbed sodium from the soil sample by extraction with neutral 1 M ammonium acetate solution (Bower et al., 1952). Cation exchangeable sodium was determined after washing off the soluble salts, then the samples were leached with normal chlorides solution adjusted to PH 7.0

then Na released was determined photometrically (Jackson, 1958).

After calculating the sodium absorption ratio (SAR) and the exchangeable sodium percent (ESP) of the soil samples under study from the laboratory results obtained. After estimating the laboratory values, two mathematical equationan one proposed by Richards (1954) and anther proposed by Balba (1962) were applied to estimate the ESP values mathematically, and then the values obtained by those two different methods were compared and the statistical differences between them were made using Chi-square test.

Results and discussion:

The ESP values calculated from equations (1) and (2) were listed in comparison with the ESP values determined from the analytical results were shown in (Table 1).

from Table 1 it can be seen that the calculated values of ESP using both empirical equations (Cal 1, Cal 2) are satisfactory close to the experimental values Chi square technique was used to test the goodness to fit for applying equations 1 and 2. It was found that both equations were applied satisfactorily because the difference between the calculated and experimental values of ESP at 0.05 significant level statistically was not significant.

From the obtained results, therefore, we can conclude that the validity and possibility of using these two equations referred in this study to calculate the ESP of salt affected soils in Sebha experimental stations.

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Table 1. SAR of the saturation extract of soil paste (meq / l), CEC and E S (meq/100 g dry soil) and the determined and calculated ESP of the soil samples used.

Prof. No.	Sample No	Depth in cm	SAR	CEC Meq/100 g dry sssoil	E.S Meq/100 g dry soil	ESP		
						Deter	Cal. 1	Cal. 2
1	1	0-40	25.17	4.98	0.731	14.70	26.40	16.00
	2	40-80	89.10	4.62	0.162	3.50	56.60	41.10
	3	80-120	123.74	5.33	0.02	0.40	64.40	49.30
2	4	0-40	96.08	6.15	2.544	41.40	58.40	42.90
	5	40-80	85.75	7.24	1.594	22.00	55.60	40.10
3	6	0-15	360.80	5.49	4.90	89.30	84.10	74.00
	7	15-40	42.49	7.91	2.00	25.30	38.00	24.70
4	8	5-35	76.38	4.84	3.978	82.19	52.70	37.35
	9	35-100	62.46	7.18	1.978	27.55	47.61	32.70
	10	100-200	7.75	8.20	0.627	7.65	9.23	5.00
5	11	0-15	91.02	10.20	1.30	12.75	57.08	41.59
	12	15-50	185.70	6.70	0.70	10.51	73.16	59.38
	13	50-100	59.70	10.30	0.75	7.31	46.47	31.70
	14	100-150	17.44	7.25	0.12	1.7	19.66	11.46
6	15	0-30	96.96	6.12	5.09	83.27	58.64	43.16
	16	30-50	18.71	4.95	1.05	21.29	20.85	12.24
7	17	0-23	16.48	4.85	1.16	24.00	18.73	10.86
	18	23-60	18.91	2.64	1.30	49.24	21.03	12.36
	19	60-115	10.16	3.21	0.07	2.72	12.07	6.70
	20	115-170	6.51	2.71	0.14	5.13	7.70	4.11
	21	170-220	4.90	4.02	0.20	4.98	5.63	2.93
	22	220-250	2.04	3.13	0.27	8.79	1.72	0.74

prof no	Sample no	Depth in cm	SAR	CEC	ES	ESP		
						Deter	Cal. 1	Cal. 2
8	23	0-10	21.45	8.86	1.914	21.6	23.30	13.88
	24	10-80	23.90	8.97	2.123	23.66	25.37	15.30
	25	80-130	1.62	4.36	0.098	2.24	1.12	0.42
9	26	0-20	12.01	2.37	1.43	60.50	14.13	7.96
	27	20-50	8.32	2.26	0.93	41.30	9.92	5.41
	28	50-70	39.29	2.02	1.18	58.51	36.18	23.22
10	29	0-35	57.90	3.51	1.49	42.53	45.71	31.04
	30	35-70	243.00	3.00	2.37	79.30	78.12	65.70
11	31	0-30	406.38	10.19	8.52	83.60	85.70	76.25
	32	30-60	70.52	8.28	5.47	66.10	50.70	35.48
	33	60-80	135.36	4.15	3.72	89.60	66.50	51.53

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