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Estimation of soil sodium adsorption ratio without soluble sodium Na^+ on sandy clay loam soil, Khartoum, Sudan

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Abstract

Prediction of sodium adsorption ratio using available soil properties and simple empirical models have become particularly urgent to reduce the time and cost of some complex soil properties. The aim of this study is to estimate the sodium adsorption ratio (SAR) from soil electrical conductivity (EC), soluble calcium (Ca^{++}) and magnesium (Mg^{++}) to this end, a new equation was modified from soil SAR equation (M_{SAR}). For this purpose, 30 soil samples were collected from the field of experiment, Jabal Awliya, south of Khartoum state, Sudan. Sodium adsorption ratio (SAR) was estimated as a function of soil EC, soluble Ca^{++} and Mg^{++} in order to compare the predicted results with measured SAR using laboratory tests. The results show that on saline soil samples, the standard error of mean (SEM) of predicted SAR obtained by M_{SAR} was (0.8029) and the p-value was (0.6433). On non-saline soil samples, the standard error of mean (SEM) of predicted SAR acquired by M_{SAR} was (0.4203) and the p-value was (0.2197). The statistical results indicated that M_{SAR} has a high performance in predicting soil SAR and it can be recommended for both saline soil and non-saline soil samples.

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Introduction

Soil salinity has a negative impact on crop production, particularly in arid and semi-arid regions. (Graaff and Patterson, 2001; Robert and Ulery, 2011) stated that soil salinity refers to the total concentration of soluble salts in the soil. (Rashidi and Seilsepour, 2008) noticed that two different criteria as indices of soil salinity, these are the soil electrical conductivity (EC) and the soil sodium adsorption ratio (SAR). The soil electrical conductivity is abbreviated as EC with units of dS m^{-1} or mmhos cm^{-1} both are equivalent units of measurement and give the same numerical value. (Elbashier *et al.*, 2016) explained that soil sodium adsorption ratio (SAR) is defined as Eq. (1):

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

Where:

SAR= Sodium Adsorption Ratio

Na^+, Mg^{++} and Ca^{++} = Soluble cations in soil solution (meq/L).

The SAR of the soil is considered as one of the important chemical characteristics of the soil in terms of distribution soil particles and the probability of depositing on the drainage pipes (Moasher and Foroughifar, 2013). The monitoring of some soil properties will often be done only where simple, rapid methods are available meanwhile the Soil pH and total soluble soil salt measurements are simple and rapid (Robbins, 1993; Valente *et al.*, 2012). There is a close relationship between soil properties and salinity and alkalinity therefore, a number of rapid total soluble soil salts and exchangeable cations measurement methods have recently been developed by many researchers (Sudduth *et al.*, 2001; Kalkhajeh *et al.*, 2012; Keshavarzi and Sarmadian, 2012) and there were some modifications derived by (South Dakota State University, Agricultural Experiment Station, 2006) to simplify the measurement of soil SAR.

The aim of this study is to estimate the sodium adsorption ratio (SAR) from soil electrical conductivity (EC), soluble calcium (Ca^{++}) and magnesium (Mg^{++}) without soluble sodium (Na^+) in saline and non-saline soil samples.

Materials and methods

Soil sampling

Thirteen soil samples (fifteen soil samples represented saline soil samples and fifteen soil samples exemplified non-saline soil) were taken randomly from the field of experiment, Jabal Awliya, south of Khartoum state, Sudan. All the soil samples were mixed thoroughly and then air-dried. Then, the soil samples were sieved through a 2-mm sieve. The soil electrical conductivity (EC), soil pH, texture, calcium, magnesium and SAR were measured using laboratory tests as described by (Richards, 1954). Some chemical and physical properties of the soil under investigation are shown in Table 1. In this paper, a new equation that modified from soil SAR equation (M_{SAR}) defined as Eq. (2) was used.

$$\mathrm{SAR} = ((10\times \mathrm{EC}) - (\mathrm{Ca^{++}}+\mathrm{Mg^{++}}))/((\mathrm{Ca^{++}}+\mathrm{Mg^{++}})/2)^{0.5} \qquad (2)$$

The results of this equation were directly compared with the laboratory experimental ones using some statistical measurements.

Table 1. Some chemical and physical analysis for soil samples.

Parameter	Saline soil	Non-saline soil
ECe (dS/m)	3.5 to 12.0	0.7 to 3.0
pH	7.7 to 8.6	7.7 to 8.6
Texture	Sandy Clay Loam	Sandy Clay Loam

ECe: Electrical Conductivity of soil saturated extract.

Statistical analysis

A paired samples t-test analyses; the mean difference confidence interval, the standard deviation of difference, standard Error of Mean (SEM) and p-value were used to compare the soil SAR values predicted using M_{SAR} with the soil ESP values measured by laboratory tests. The statistical analyses were performed using GraphPad Prism 6.

Results

Table 2 and Table 3 show the chemical properties (EC, Ca^{++} and Mg^{++}) of soil used for predicting soil SAR by M_{SAR} on saline and non- saline soil samples, respectively. Table 4 and Table 5 show the results of the statistical analyses using paired samples t-test on comparing soil SAR values predicted using M_{SAR} with the soil ESP values measured by laboratory tests on saline and non- saline soil samples, respectively.

Table 2. Chemical properties of soil used for predicting soil SAR by M_{SAR} on saline soil samples.

Sample No.	EC dS/m	Ca^{++} + Mg^{++} Meq/L	Laboratory tested SAR	Predicted SAR by M_{SAR}
1	7.1	18.0	16	17.67
2	5.0	5.2	27	27.78
3	4.9	11.1	13	16.09
4	3.6	5.2	21	19.01
5	8.0	13.9	25	25.07
6	3.5	5.0	17	19.0
7	15	16.4	14	14.12
8	5.7	4.0	36	25.46
9	4.0	28.0	23	22.98
10	12.0	34.8	20	20.43
11	3.9	3.1	28	28.84
12	4.1	9.0	15	15.1
13	5.5	11.7	18	17.9
14	4.4	4.6	26	26.0
15	4.2	8.1	19	16.85

Table 3. Chemical properties of soil used for predicting soil SAR by M_{SAR} on non-saline soil samples.

Sample No.	EC dS/m	Ca^{++} + Mg^{++} Meq/L	Laboratory tested SAR	Predicted SAR by M_{SAR}
1	2.3	3.6	18	14.46
2	2.4	5.0	13	12.02
3	2.7	4.8	15	14.33
4	1.8	3.2	12	14.64
5	1.0	4.0	8	4.24
6	1.9	9.1	4	4.64
7	2.0	8.0	7	6.0
8	0.7	3.0	2.6	3.27
9	2.8	20.0	3	2.53
10	0.4	3.0	1.8	0.82
11	0.8	4.0	3.4	2.83
12	1.7	10.0	3.2	3.13
13	1.3	8.0	2.9	2.5
14	0.75	1.8	7	6.01
15	3.0	4.0	17	18.38

Table 4. Paired samples t-test analyses on comparing soil SAR determination methods on saline soil samples.

Determination method	Average Difference (%)	Standard deviation of difference (%)	Standard Error of Mean (SEM)	p-value	95% confidence intervals for the difference in means
M_{SAR} & laboratory test	-0.3800	3.110	0.8029	0.6433	-2.102 to 1.342

Table 5. Paired samples t-test analyses on comparing soil SAR determination methods on non-saline soil samples.

Determination method	Average Difference (%)	Standard deviation of difference (%)	Standard Error of Mean (SEM)	p-value	95% confidence intervals for the difference in means
M_{SAR} & laboratory test	-0.5400	1.628	0.4203	0.2197	-1.44 to 0.3614

Discussion

Prediction of soil SAR on saline soil samples

A paired samples t-test analyses and the mean difference confidence interval approach were used to compare the soil SAR values predicted using the M_{SAR} with the soil SAR values measured by laboratory tests as shown in Table 4. The mean of soil SAR difference between the M_{SAR} and measured SAR was -0.3800.

The 95% confidence interval was -2.102 to 1.342. A p-value for the M_{SAR} was 0.6433 and the standard deviation of the soil ESP differences was 3.110. The Standard Error of Mean (SEM) of predicted SAR acquired by M_{SAR} related to the measured SAR was 0.8029. The paired samples t-test results indicated that the soil SAR values predicted with M_{SAR} were not significantly different with the soil SAR measured by laboratory tests (Table 4). Fig. 1 shows the measured SAR and predicted SAR values using the M_{SAR} on saline soil samples. It clear from *Fig*. 1 that the M_{SAR} demonstrated a high degree of agreement with the experimentally measured values.

Prediction of soil SAR on non-saline soil samples

The mean of soil SAR difference between the M_{SAR} and measured SAR was -0.5400. The 95% confidence interval was -1.441 to 0.3614 and p-value was 0.2197. The standard deviation of the soil SAR differences between M_{SAR} values and laboratory tests SAR values was 1.628. The Standard Error of Mean (SEM) of predicted SAR was 0.4203 (Table 5). For non-saline soil samples, it clear from *Fig*. 2 that the M_{SAR} showed a high degree of agreement with the experimentally measured values. The results of paired samples t-test showed that the soil SAR values predicted by M_{SAR} were not significantly different with the soil SAR measured by laboratory tests.

Generally, using of soil EC to predict SAR showed a high degree of agreement with the results of Rashidi and Seilsepour (2008) and Robbins (1993). Furthermore, the South Dakota State University, Agricultural Experiment Station, (2006) suggested a modification to general equation of soil SAR, Eq. (1) to simplify the measurement of soil SAR without Ca^{++} and Mg^{++} by using soluble Na and EC. On this paper, our modification based on measurement of Soil SAR function to EC, Ca^{++} and Mg^{++} without sodium due to the determination of soluble Ca^{++} and Mg^{++} is more easy than determination of soluble Na^{+}, Valente *et al.*, (2012), Richards, (1954).

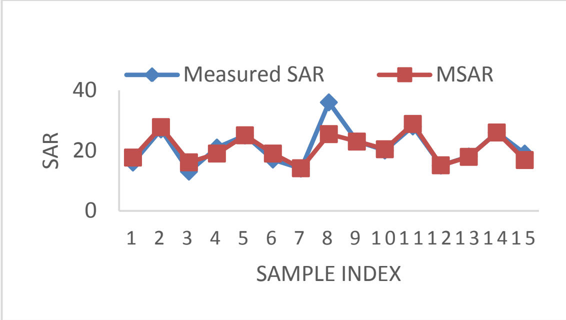

Fig. 1. Measured SAR and predicted SAR values using the M_{SAR} on saline soil samples.

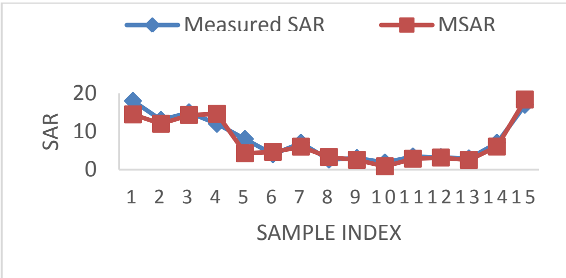

Fig. 2. Measured SAR and predicted SAR values using the M_{SAR} on non-saline soil samples.

Conclusion

A new equation was modified from soil SAR equation (M_{SAR}) was used in this paper to predict soil SAR from soil electrical conductivity, calcium and magnesium in saline and non-saline soil samples. The statistical results on saline soil samples indicated that there was no difference between the SAR values predicted by the M_{SAR} and the measured values by laboratory tests ($p>0.05$, SEM was 0.8029). The paired samples t-test results on non-saline soil samples showed that there was no difference between the SAR values predicted by the M_{SAR} and the measured values by laboratory tests ($p>0.05$, SEM was 0.4203). The M_{SAR} can be recommended for prediction of soil SAR using soil electrical conductivity, calcium and magnesium in both saline and non-saline soil samples.

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References

Elbashier MM, Ebrahim MH, Musa AA, Ali AA, Mohammed MA. 2016**.** Efficiency of Two Models for Prediction of Exchangeable Sodium Percentage from Sodium Adsorption Ratio on Saline and Non Saline Soil. Universal Journal of Agricultural Research **4 (1),** 32-36.

Graaff R, Patterson RA. 2001**.** Explaining the Mysteries of Salinity, Sodicity, SAR and ESP in On-site Practice in Proceedings of On-site '01 Conference: Advancing On-site Wastewater Systems, Lanfax Laboratories, Armidale 361- 368.

Kalkhajeh YK, Arshad RR, Amerikhah H, Sami M. 2012**.** Comparison of multiple linear regressions and artificial intelligence-based modeling techniques for prediction the soil cation exchange capacity of Aridisols and Entisols in a semiarid region. Australian Journal of Agricultural Engineering **3**, 39-46.

Keshavarzi A, Sarmadian F. 2012**.** Mapping of Spatial Distribution of Soil Salinity and Alkalinity in a Semi-arid Region, Annals of Warsaw University of Life Sciences, Land Reclamation **44**, 3-14.

Moasheri SA, Foroughifar H. 2013**.** Estimation of the values of soil absorption ratio using integrated geostatistical and artificial neural network methods. International Journal of Agriculture and Crop Sciences **5**, 2423-2433.

Plant Science Department, South Dakota State University, Agricultural Experiment Station. 2006**.** Soil Testing and Plant Analysis 76-78.

Rashidi M, Seilsepour M. 2008**.** Sodium Adsorption Ratio Pedotransfer Function for Calcareous Soils of Varamin Region, International Journal of Agriculture & Biology **10**, 715-718.

Richards LA. 1954**.** Diagnosis and Improvement of Saline and Alkali Soils, Determination of the properties of saline and alkali soils United States Department of Agriculture, Washington DC **26,** 72.

Robbins CW. 1993**.** Coefficients for Estimating SAR from Soil pH and EC Data and Calculating pH from SAR and EC Values in Salinity Models. Arid Soil Research and Rehabilitation **7,** 29-38.

Robert F, Ulery A. 2011**.** An Introduction to Soil Salinity and Sodium Issues in New Mexico, las cruces, circular **656,** 1-6.

Sudduth KA, Drummond ST, Kitchen NR. 2001**.** Accuracy issues in electromagnetic induction sensing of soil electrical conductivity for precision agriculture. Computers and Electronics in Agriculture **31**, 239-264.

Valente DS, Queiroz DM, Pinto FD, Santos NT, Santos FL. 2012**.** The relationship between apparent soil electrical conductivity and soil properties. Revista Ciencia Agronomica **43(4),** 683-690.