The Nature and Properties of Salt Affected Soil in South Khartoum

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***Abstract*—**The salt affected soils in South Khartoum have been a challenge to agricultural production. In order to understand the nature and extent of these salt affected soils, salinity study was carried out in some farms in the area. The result showed that the main cause of salinity was poor irrigation water management, shallow saline ground water table. However, there are several natural saline seeps in the region, which can contribute to salinization.

Accumulation of salts was high on the surface soil due to capillary rise during fallow season, which resulted in secondary salinization. High free evaporation of water from the surface aggravated the salinization process. Saline and saline-sodic soils were the major salt-affected soils in the region.

Most of these salts are easily soluble. While sodium was in excess in saline-sodic, calcium was in excess in saline soils. Chloride was the dominant anion in salt-affected soils. Ground water depth was shallower during the rainy months (July-September) and its salinity was lower than dry months. Irrigation water salinity was also low from July to September. The borehole salinity showed no significant relationships with the depth of the borehole.

***Keywords*—** electrical conductivity, salinity, sodic soil, sodium adsorption ratio.

I. Introduction

SALT-affected soils occur in all continents and under almost all climatic conditions. Their distribution, however, is relatively more extensive in the arid and semi-arid regions compared to the humid regions. The nature and properties of these soils are also diverse such that they require specific approaches for their reclamation and management to maintain their long term productivity [10]. When plants grow under saline conditions, they are subjected to three types of stress, water stress caused by the osmotic pressure, mineral toxicity stress caused by the salt and disturbances in the balance of mineral [1].

Salinity becomes a problem when enough salts accumulate in the root zone to negatively affect plant growth. Excess salts in the root zone hinder plant roots from withdrawing water from the surrounding soil. This lowers the amount of water available to the plant, regardless of the amount of water actually in the root zone [2].

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Salt affected soils are grouped according to their content of soluble salts and sodium as saline soil, contains EC greater than 4mmos/cm, pH less than 8.5 and SAR less than 13, sodic soil, contains EC less than 4mmos/cm, pH between 8.5 - 10 and SAR greater than 13 and saline -sodic soil, contains EC greater than 4mmos/cm, pH less than 8.5 and SAR greater than 13 [7].

Total salt-affected soils in Sudan are 4.8 million hectares, of which 2.1 million hectares are saline and 2.7 million hectares are sodic soils. The majority of salt-affected areas are located in the low rainfall regions in northern Sudan in the higher terraces along the Nile river, south Khartoum, north Gezira and the white Nile schemes, natural causes of weathering of salt bearing rocks, poor soil and water management in irrigated areas including insufficient drainage system [5].The potential of utilizing these salty soils in Sudan for agricultural production is very great due to their proximity to large consumption centers. Moreover, the availability of good quality irrigation water from the two Niles in addition to the presence of some basic infrastructure such as roads, power supply, telecommunications, etc. Justify giving these areas high priority in development programs [11].

More frequent irrigation has been assumed to reduce the effect of salinity. This usually accompanied by high evaporation from the soil surface which will result in the concentration of salts in the surface layers. Moreover, roots tend to absorb water preferentially from the upper soil layers when they are frequently wetted, while the uptake proceeds in deeper layers if the soil surface is allowed to dry under less frequent irrigation [12].

II. Materials And Methods

The study was carried out at Jebal Awlia area, 70 km south of Khartoum city on the eastern bank of the White Nile at latitude 150 N and longitude 320 E, about 380 m above mean sea level. The study area falls in the 'arid' climatic zone of the Sudan just to the south of the fringes of the semi-desert/arid climatic zone. According to the climatologically norms of Khartoum meteorological station, the mean annual temperature is 29.90C. Relative humidity is 44.5%. The average annual rainfall is about 121 mm falling mainly in July and August. The area also falls under the effects of northerly winds in October through May and south westerly winds from late June through October. Five farms were selected randomly in the experimental area, soil samples were augured on grid basis from 0-30cm, 30-60cm and 60-90 cm soil depths. Sodium adsorption ratio (SAR) and Exchangeable Sodium Percentage (ESP) were calculated by the procedure set forth in Hand Book No.60 (12). Bulk density was determined by core method. A simple method used to estimate the percent sand, silt and clay was a pipette method. Organic matter was determined by the modified procedure of Walkley and Black (4). Cation exchange capacity (CEC) and exchangeable cations were determined from neutral 1N ammonium acetate extracts. Sodium (Na) and potassium (K) were determined by flame photometry. Magnesium (Mg) and calcium (Ca) were determined by titration method. Calcium carbonate (CaCO3) was determined by acid neutralization method using HCl. The soil pH was determined from saturated soil paste extract using WG PYE model 290 pH meter. Electrical conductivity was measured from a soil saturation extract by conductivity meter.

III. Results And Discussion

Table I shows the average physical and chemical analysis of the irrigation water in the area of the study. In which the electrical conductivity was found to be 0.704 ds/m which is good as mentioned by [3]. Total dissolved solid was 355mg/l which is in the range that has no harmful effect to the plant and soil as mentioned by [9]. As for chloride, the content was found to be 38mg/l which causes no hazard, also fluoride, sulphate, nitrite, nitrate and iron, all of them are in the permissible range for irrigation.

For sodicity the analysis gave 32.0, 43.2,76.2 and 2.81mg/l for calcium, magnesium, sodium and potassium respectively. The sodium adsorption ratio was found to be8.8 (less than 13) which is in the permissible range of using the water for irrigation.

Table II shows average clay, silt and sand percentages at different depths (0 – 30, 30 – 60 and 60 – 90cm) of the experimental site. The average percentages of all depths are, 34.0, 12.5 and 53.5 for the clay, silt and sand respectively. According to the USDA soil texture classification, the soil texture is sandy clay loam.

Table III shows average soil pH in the five farms, there are no significant differences between the three depths, but, pH increase as we go from thouth to north. The increase in pH values may be due to the large amount of free carbonates which resisted any decline in soil pH as mentioned by [11].

Table IV shows an average soil SAR in the five farms, there were highly significant difference ($P \leq 0.01$) between different depths, in which depths 30 – 60cm and 60 – 90cm gave higher values over 0 – 30cm depth but no significant difference was found between 30 – 60cm and 60 – 90cm depths. Also SAR increases as we go from south to north. This result indicated that irrigation water leached salts from the upper layer to the lower ones as mentioned by [6]. Also this pattern was attributed to the decreasing Ca2+: Na+ ratio in the soil solution as it moved down the profile displacing exchangeable Na+ as mentioned by [8].

Table V shows an average soil CaCO3% in the five farms, there were significant difference between different depths ($P \leq 0.01$), in which depths 30 – 60cm and 60 – 90cm gave higher values over 0 – 30cm depth, but no significant difference between 30 – 60cm and 60 – 90cm depths. These results indicated that salt was leached from the upper layer to the lower ones. [2] mentioned that when water applied is sufficient, some soluble salts are dissolved and carried further down the soil profile.

Table VI shows an average soil ECe in the five farms, there were significant difference between different depths ($P \leq 0.05$), in which, 60 – 90cm depth showed a higher significant value over 0 – 30cm depth but no significant difference between 60 – 90cm and 30 – 60cm and between 30 – 60cm and 0 – 30cm depth. Also ECe increases as we go from south to north. This result indicated that salts were leached from the upper layer to lower ones as mentioned by [3].

Table VII shows the average chemical composition of the soil of the site as affected by soil depths. The average saturation percentage increases from surface downward with an average of 43.00%. Total nitrogen percentage, 0 – 30cm depth showed higher value over the other depths with an average value of 0.035%. This result indicated that the site is deficient of nitrogen. Organic matter percentage of the soil showed also higher value in the 0 – 30cm depth as compared with the other depths with an average of 0.07%. Soil organic matter is the foundation of a healthy and productive soil fertility, water availability, susceptibility to erosion, soil compaction and even resistance to insects and diseases. Phosphorous content in the soil shows values of 3.52, 3.49 and 3.44ppm for the depths 0 – 30cm, 30 – 60cm and 60 – 90cm, respectively, with the average value of 3.48ppm. The soil requires addition of phosphorous fertilizer. Cation exchangeable capacity increases with depths with an average of 30.47mmol+/100g. A high CEC soil requires a higher soil cation level, to provide adequate crop nutrition, which indicate that a soil has a greater capacity to hold cations. Therefore, it requires higher rates of fertilizer or lime as mentioned by [4]. Where as, for exchangeable sodium, the values increase with depths with an average value of 2.27mmol+/100g.

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TABLE I

PHYSICAL AND CHEMICAL ANALYSIS OF IRRIGATION WATER

Parameter	Value	Unit
Turbidity	2.200	NTU
pH	7.500	
Temperature	34.00	C°
E. Conductivity	704.0	lls/cm
T.D.S	355.0	Mg/l
T.Alkalinity	320.0	Mg/l
T.Hardness	260.0	Mg/l
Chloride	38.00	Mg/l
Flouride	0.500	Mg/l
Sulfate	39.40	Mg/l
Nitrite	0.016	Mg/l
Nitrate	5.200	Mg/l
Iron	0.190	Mg/l
Calcium	32.00	Mg/l
Magnesium	43.20	Mg/l
Sodium	76.20	Mg/l
Potassium	2.810	Mg/l

TABLE II

AVERAGE SOIL TEXTURE AT DIFFERENT DEPTHS

Soil depth (cm)	Clay%	Silt %	Sand%	Soil texture
0 – 30	31.84	12.48	55.67	Sandy clay loam
30 – 60	34.77	12.58	52.65	Sandy clay loam
60 – 90	35.23	12.49	52.29	Sandy clay loam
Average	33.95	12.52	53.54	Sandy clay loam

TABLE III

EFFECT OF SOIL DEPTHS ON SOIL PH

Depth	Farm (1)	Farm (2)	Farm (3)	Farm (4)	Farm (5)	Aver.
0 – 30	8.78	8.78	8.80	8.82	8.87	8.81a
30 - 60	8.80	8.84	8.88	8.91	8.97	8.88a
60 - 90	8.82	8.85	8.88	8.87	8.88	8.86a
S.E ±						0.03

TABLE IV

EFFECT OF SOIL DEPTHS ON SOIL SAR

Depth	Farm (1)	Farm (2)	Farm (3)	Farm (4)	Farm (5)	Average
0 – 30	2.07	2.06	2.15	2.18	2.14	2.12b
30 - 60	2.97	2.90	2.95	2.99	2.99	2.96a
60 - 90	2.98	2.93	2.96	2.99	2.94	2.96a
S.E ±						0.1

TABLE V

EFFECT OF SOIL DEPTHS ON SOIL $CACO_3$

Depth	Farm (1)	Farm (2)	Farm (3)	Farm (4)	Farm (5)	Average
0 - 30	4.00	4.36	4.86	5.02	5.96	4.84b
30 - 60	5.00	5.07	5.13	5.18	5.27	5.13a
60 - 90	5.12	5.17	5.20	5.36	5.60	5.29a
S.E ±						0.08

TABLE VI

EFFECT OF SOIL DEPTHS ON SOIL ECE

Depth	Farm (1)	Farm (2)	Farm (3)	Farm (4)	Farm (5)	Average
0 – 30	0.82	0.84	0.89	0.93	0.92	0.88b
30 - 60	1.07	1.07	1.10	1.10	1.11	1.09ab
60 - 90	1.19	1.16	1.18	1.22	1.20	1.19a
S.E ±						0.02

TABLE VII

SOIL CHEMICAL COMPOSITION FOR THE SITE OF THE EXPERIMENT

Depth (cm)	Saturation percentage	Total nitrogen %	Organic matter %	Phosph. ppm	Cation exch. capacity mmol/ 100g	Exch. sodium mmol+/ 100g
0– 30	40.35	0.038	0.08	3.52	28.58	1.62
30-60	44.08	0.030	0.06	3.49	31.21	2.10
60 -90	44.56	0.036	0.06	3.44	31.62	3.08
Mean	43.00	0.035	0.07	3.48	30.47	2.27

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