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Determination of Sodium Exchangeable Percentages (ESP) and Organic Carbon in Sedimentary Soil in the Red Sea State - Sudan (Case Study: Toker Delta)

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Abstract: ***Red Sea State lies in arid and semi arid area in Sudan. Years ago the state exposed to several drought period, which led to physical and chemical deterioration of agricultural soil and change the characterization of arable soil .This study aims to assess deterioration in the sedimentary soils depends on ESP. and O.C. determination in Toker area as important agricultural project in all country and sedimentary soil, compared the results study with the previous studies. Samples were withdrawn from the three sides in study area: western Delta, central Delta and the eastern Delta. Nine samples were collected from the each zone. Standardized methods were used for estimating pH, Electrical conductivity (Ece), Exchangeable Sodium Percentages (ESP) and Organic Carbon (O.C). Also displays search to certain physical properties such as soil texture and color. Results of the soil analysis showed clear changes in all the mentioned areas, especially in western and eastern sides in Delta if we compared it with pervious study in Toker, the results was show the rise of ESP, EC, where the ESP reached more than 21% in western, and close to 17% in eastern area (high salinity). The central Delta (relatively high plainly area) ESP less than 8%, the average of O.C. was 0.4%, high level of Ece was 7.5 dsm-1(medium salinity). These results mean that there is acute and rapid deterioration in these soils due to different and varied reasons (mentioned later),and rehabilitation of those sedimentary soils require great efforts. In field survey, there are clear effects of salts in surface soil in large area in all zones mentioned, the eastern region of the Delta has become barren, salty and has very little vegetation cover, soil type is sandy and there are scattered sandy dunes and gravels. The western region less affected by the east side, the central region is well established, agricultural activity and production are concentrated to provide good irrigation in this area. The percentage of clay in the soil of the central Delta ranged between 43-46% with light color of the surface, also there are salt marshes and sandy dunes in an increasing situation. The study recommends that, government interest and financial expenditure on the project, wash and reduce the salts in highly -efficiency drainage system, and solve the problem of land holdings and follow agricultural cycles.***

Keywords: Delta: The low area whose sedimentary soil was formed from high elevations

1. Introduction

The eastern region in general and Red Sea state in particular is considered as one of the most dry areas. This region is situated between longitude (23º - 38.5º) east, and latitudes (17º - 22º) north, in an area of 212.410.000 km^2. Bordering with Egypt in the north, the Red Sea in the east, the River Nile state in the west and Eritria and Kassala state in south. The Red Sea state is a coastal district extends along 750 km of the red sea coast. (Fatima Ali, 2007). (Gadalla,1994).

The Red Sea coast extends to about 750 km it is narrow plain that lies between the Red Sea and red sea mountains. This plain is divided to three units:-

1) The coastal plain: Located between Red Sea and mountain chain, is the semi – desert climate extents in the form of line presentation ranged between 20-30 km. it is location of population density especially in central and southern parts (cities parts). Soil change from saline soil near the coast to the fertile land whenever away from the coast (Arbaat – Toker – Hoshiry), where the soil turns to sandy stone near the mountains. (Ali and Mohammed, 1991).
2) Properties of soil: High ESP (Sodium Exchangeable percentages), high concentrations of PH, CL^-, SO_4^{2-}, CO_3^{2-}, Ca^{2+}, and Na^+. There are some sedimentary silt soils, where pastoral lands and forests and set Deltas practiced by agricultural activity and cultivates many crops, these areas including Delta Arbaat with fertile sedimentary and arable land. (Ali and Mohammed, 1991).
3) Heights of Red Sea: central region between the coastal plain and western plain, mountains ranges between 900-1200 meters above the sea. It considered a line of the division of water and spent a large number of streams quick run. (Eltom, 1989). The soil of mountains is affected by:
   a) High wind erosion.
   b) Disintegration of soil and poverty.
   c) Human practices such as cutting trees and overgrazing.
4) Western plains: West mountains bordering the river Nile state. is dry desert, where is about 43.8% of the area of Red Sea state, and there are many valleys sloping toward the Nile, which helps to form sediment area.

The soil in western plains is poor, the vegetation is *acacia spp*, grasses, and weeds. (Ali and Mohammed, 1991), (Suliaman and Musa, 1989).

Lagoons and entrances environment aqueous one of special ecosystem in the Red Sea state which constitute the sedimentation soil and water sources. There is a group streams (Khors), descend from the top of the mountain to the coastal plains, sediment the clay and organic matter, those Khors formed Delta in each of Tokar and Arbaat and Saloom and others. These streams called by the local names such as Baraka, Arbaat, Aichenk, Hoshery and other. (Mohammed, 2002).

Delta Toker is the best fertility soil types in Sudan, this land sedimentary do not need fertilizer because it renews itself every year .Also the location of state wide make the region far from the native agricultural pest, and reduced the cost of protection and production, in addition to the ease of external marketing for the good geographical location.

ACSAD (2009) reported that the region of Toker can produce the majority of field and horticultural crops, where in recent years have been all sedimentary soils in the state rescued by the drought and the risk of mesquite (*Prosopis chilinsis*), these factors lead to lack of plants prevailing in that region, also causes low production, and increasing the cost of production. According to Ministry of Agriculture, (1996), that the mesquite (*Prosopis chilinsis*) covered more than 50% of agricultural land in Toker, and there are efforts to protect the schemes from invasive plant with a high cost. Cotton, peanuts, tomatoes, corn, millet, cultivated in sediment soil in Toker, and most of vegetables production marketing in Port Sudan town. There are other problems such as the lack of rain and erosion processes, overgrazing and unregulated cutting, it all led to a negative impact on these sedimentary soils, and their characteristics and fertility declined year after year (Eltom, 1989).

2. Material and Methods

2.1 Study area

The Delta-Tokar project is located in the Eastern Southern Province between 37-38 North latitude and 13.5- 18.40 East. Delta lands 110 km south of Swakin port and 170 km south of Port Sudan port.

Soil samples were collected from three locations in Toker, the area of sedimentation soil in Red Sea state. At each site, the samples were collected at the depth 0-30 cm. Three replicates for each depth were used. The total number of samples at each sampling point was nine from western side and the same number from other two locations (study areas). Therefore the total number of soil samples of whole area was 27. All samples were thoroughly mixed and stored in polyethylene bags and later used for determination of some chemical and physical properties. (Jackson, 1960).

The PH of soil samples were measured using pH meter with glass electrode and conductivity meter was used to measure ECe (Chapman, and pratt,1961).(Hoffman,1971). Exchangeable Sodium Percentages (ESP) was determined according to sodium exchangeable rate and exchangeable cations capacity (ECE).

Calculation:

$$ESP = \frac{\text{(Exchangeable Sodium)}}{\text{(Total of cations exchangeable)}} * 100 \text{ (Bower, 1952)}$$

Organic Carbon was measured according to (Roades, 1982) methods. Soil texture (Fine texture soil and Coarse textured soils) was determined according to Soil Survey Staff, (1972).

3. Results and Discussion

Eastern Delta

Table (1) show the soil characterization in eastern zone in Toker, so the ECe values in this side was high .the results may be attributed to the drought and the location of this area .that far away from the water streams, in addition to the free zone of agricultural activity. The rises of Ece and ESP due to accumulation of salts, this finding agree with Abdel Karim and Babker (1991), who stated the higher salinity values are unique and maybe for hot climate and higher rate of evaporation .and generally low mean of rain fall, all these factors have gathered in this region.

In the eastern side the PH reached 7.9,ECe range between 12 -42 ds/m ,and ESP averages of all sample was 17.5 %.According to Yasin (2013),who classified the soil depend on ESP, ECe, PH, the eastern area of Toker Delta is saline sodic soil (ECe>4ds/m, ESP more than15%, PH less than 8.5).The soil of eastern Delta in Toker fill with sandy dunes ,white color, and salts march , and there are large stones and gravels stretch in different areas of the region, and very poor land of plants.

Table 1: Determination of PH, ESP, O.C, Soil texture and Color in Eastern side Toker

Parameters / Replicates	PH	ESP (%)	ECe (dsm^{-1})	O.C (%)	Color	Soil types
R_1	7.7	17	12	0.1	light	Sandy
R_2	7.8	17	16	0.1	light	Sandy
R_3	7.8	17	16	0.1	light	Sandy
R_4	7.9	21	20	0.1	light	Sandy
R_5	7.9	22	21	0.1	light	Sandy
R_6	8.0	22	24	0.1	Light	sandy
R_7	7.5	14	32	0.2	light	Sandy loamy
R_8	7.6	14	42	0.2	light	Sandy loamy
R_9	7.8	14	32	0.1	light	Sandy loamy
Averages	**7.7**	**17.5**	**23.8**	**0.12**		

Western Delta

Table no (2) gives the data of western Delta ,recorded high values of ESP reached 22%, O.C not exceed of 0.2%.It is similar to eastern Delta with relative superiority. Soil types is sandy loam, and white color, they are classified within the saline sodic, according to ESP, ECe, and PH values. The soil in this side is very friable and sandy with gravels, low capacity of water and low organic matter, salts march, the causes due to lack of rain, and climate factors that help the deposition and accumulation of these salts.

The relatively low plainly area (western and eastern region) is poor land and the lack of attention diverted these area to desert.

Table 2: Determination of PH, ESP, O.C, Soil texture and Color in in Wastern side Toker

Parameters / Replicates	PH	ESP (%)	ECe (dsm^{-1})	O.C (%)	Color	Soil types
R_1	7.8	15	13	0.1	light	Sandy loam
R_2	7.9	15	14	0.2	light	Sandy loam
R_3	8.1	15	14	0.2	light	Sandy loam
R_4	7.6	22	23	0.2	light	Sandy loam
R_5	7.5	21	25	0.2	light	Sandy loam
R_6	8.2	21	25	0.2	light	Sandy loam
R_7	7.9	16	40	0.1	light	Sandy
R_8	8.1	16	39	0.2	light	Sandy
R_9	7.9	18	32	0.2	light	Sandy
Averages	**7.9**	**17.7**	**25**	**0.18**		

Central Delta:

High values of PH and ECe in all samples that were collected from this area not exceed 7.5, 5.6 ds/m, respectively. Organic carbon increase in central Delta reached 0.4% (Table 3), while close to 0.2 %,as a higher number in other study area (western-eastern), This explained by agriculture activity ,and sediment of clay and organic matter comes with Khors (Baraka).(Relatively high plainly areas).

ESP reached 9% as a higher number in all samples in this area, small one if we compared with other study area.

Texture of soil in central Delta is clay sandy loam in most area, the clay percentage range between 40-55%.

Table (4) the averages of all parameters in central region is less than other regions, these result due to leaching of salts from the soil , when Khor Baraka comes from mountains (Red Sea hills), and decreasing the concentration of ECe. ESP, PH.

In table (4) show clear variation and significant different of O.C averages in three zones, the ESP averages in western and eastern Delta reached 17.7,17.5 %,the rises of ESP in soil stopped the roots of plants grow and decreased the cations exchange in the soil ,also causes a high salinity. (Yasin, 2013).

Table 3: Determination of PH, ESP, O.C, Soil texture and Color in in Central side Toker

Parameters / Replicates	PH	ESP (%)	ECe (dsm^{-1})	O.C (%)	Color	Soil types
R_1	7.3	7.0	5.5	0.3	Umber	Sandy clay loam
R_2	7.2	7.9	5.5	0.3	Umber	Sandy clay loam
R_3	7.1	9.0	5.5	0.3	umber	Sandy clay loam
R_4	6.9	6.6	3.0	0.4	dark	Clay sandy loam
R_5	7.5	6.6	3.3	0.3	dark	Clay sandy loam
R_6	7.2	5.5	3.7	0.3	dark	Clay sandy loam
R_7	7.4	5.8	4.0	0.3	dark	Clay sandy loam
R_8	7.4	6.1	5.6	0.4	dark	Clay sandy loam
R_9	7.2	6.0	4.4	0.4	dark	Clay sandy loam
Averages	**7.2**	**6.7**	**4.5**	**0.33**		

Pervious data:

- The results in line with (ACSAD, 2009) study, that conducted in Red Sea state (survey and sampling), finding the PH in relatively low plainly area (western and eastern Delta) between (7,5-8), ECe reached 41.2ds/m ,ESP more than 15%,and O.C range (0.4 -0.9%).
- In relatively high plainly area (central Delta) PH (6.8 - 7.8), ECe less than 4.5ds/m, ESP less than 6%, and the O.C less than 0.5%.
- Ali and Mohammed (1991) who stated that the soil change from saline near the coast to the fertile land when ever away from the coast (Toker- Arbaat), that mean the increasing of concentration of PH, SO_4, CO_3, and Na^+, decrease in some sedimentary soil ,where pastoral and forests and set Delta practiced.
- Abubaker. B.Abubaker (2015) who stated that, the O.C less than 0.5 ,0.3,0.4,0.1% in each of Tokar, Arbaat , Salloum and Hoshery respectively.

The percentage of clay in the soil of the Toker Delta (schemes) ranged between 43-46% with light color of the surface.

Table 4: The averages of parameters PH,Ece,ESP,O.C , in the three study regions

Parameters / Zones	PH	ESP (%)	ECe (dsm^{-1})	O.C (%)
Eastern side	7.7	17.5	23.8	0.12
Western side	7.9	17.7	25	0.18
Central side	7.2	6.7	4.5	0.33

4. Conclusion and Recommendation

Results of the soil analysis showed clear changes in all the mentioned areas, especially in western and eastern sides in Delta if we compared it with pervious study in Toker.

These results mean that. There is acute and rapid deterioration in these soils due to different and varied reasons, and Rehabilitation of those sedimentary soils require great efforts , As you need to spend large money to control the Mesquite ((*Prosopis chilinsis*), which dominated the Delta Central, As well as a new scientific administration so as not to turn these fertile lands into the desert and forests of Mesquite.

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