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Assessment of Soil Degradation Around Edku Lake

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Abstract

The objective of this work is to assess the soil degradation status around Edku lake and know the effect of the lake on this area. So, soil samples were collected from different dimensions and directions from Edku lake, and physical and chemical properties of the collected soil were determined. Soil degradation was assessed based on the methodology developed by the Food and Agriculture Organization. The results of soil samples analysis showed that the total salts value in soil extract ranges between 1.44 ds /m and 21.63 dS/m, with an average of 7.14 dS/m. the study area is divided into four categories of salinity levels according to the FAO guide, they are low in salinity, medium salinity, high salinity, and very high salinity and it represents 58.33%, 12.50%, 8.33% and 20.83%, respectively of the study area. The results of soil chemical degradation index showed that 17% of the study area was soil of medium chemical degradation, and 29% of the study area was soil of high chemical degradation, while 54% of the study area was soil of very high chemical degradation. Also soil biological degradation index illustrates that 58% of the study area was soil of medium biological degradation, and 42% of the study area was soil of high biological degradation.

Key words: soil chemical degradation index, soil biological degradation index, edku lake.

Introduction

Soils are renowned as the main part of the landscape and their characteristics are largely controlled by the landforms on which they are formed **(Ali and Moghanm. 2013).** Soil is a vital non-renewable resource that provides habitats with critical support and occurs in various activities and properties around the globe. Its maintenance is critical for food security and a sustainable future **(FAO 2015 and Aksoy et al. 2009).** According to **FAO (2015)**, about 33% from the world wide land is moderately to highly degraded land due to various forms of degradation. Current rate of land loss threatens future generations' ability to satisfy their most basic needs. Sustainable management of the soil is related to much diverse areas of sustainable development such as poverty reduction, economic growth and environmental protection. Therefore, urgent sustainable soil management strategies are required to stop or limit land degradation in its various types. The old agricultural land in Egypt is under continuous threat by different forms of land degradation. Of the various forms of land degradation, chemical soil degradation is of essence and has been noticed in the irrigated soil of the Nile Delta by several soil researchers **(Abdel Kawy and Ali 2012, Shalaby et al. 2012, Wahab et al. 2010, Darwish and Abdel Kawy 2008).** The main drivers of chemical soil degradation are soil salinization, alkalinization and water logging, which produced by untenable soil usages and managing practices. Soil salinization is the process of accumulation of different salts on or near the soil surface, but the increased content of exchangeable sodium in a soil is referred to as sodification or alkalinization. Salinization and/or alkalinization reduce soil productivity and agricultural production **(Kavvadias 2014, Shalaby et al. 2012, and FAO 2009).** Soil salinization of irrigated agrarian lands is a global environmental problem affecting the sustainable usage of soil resources, environmental health, agricultural production, and food security. This process of salinization ultimately results in soil degradation **(Gorji et al. 2015; Zewdu et al. 2017).** As part of the solution to soil degradation is soil use planning. Land suitability assessment is considered as an important tool for rational soil use planning and sustainable land management **(Rossiter 1996).** Generally, soil fittingness assessment for agrarian purposes involve categorization of the biophysical and environmental characteristics of an area rendering agrarian potential of the soil **(Olaniyi et al. 2015).** From this prospective, finding procedure to limit soil degradation is an urgent need. The first process of this procedure involves identification and assessment of the soil degradation status and the second is establishing a strategy to increase soil productivity and combat soil degradation. Several methodologies have been developed to provide a procedure for land degradation assessment. The areas around Edku Lake are regarded as problematic land, the cost of reclaiming these areas is very high **(MALR, 1994).** Lake Edku is the third major shore water body northwest of the Nile Delta, located inside the El Beheira Governorate. The lagoon's margin is along its northern border and its eastern margin is bounded by Edku drain **(Siam and Ghobrial 2000).** Edku drain, which cover-ups the northeast Western Delta part,and Umoum drain, situated between Edku drain and the nearby Nubaria canal in the western desert, are the major drainage systems that feed this lake **(Shaban et al. 2010).** Due to the new discharge it receives from the Edku drain, water in this lagoon is typically characterised as brackish with a marked variation in its salinity **(Siam and Ghobrial 2000).** In Egypt, soil reclamation projects in the northern part of the delta started as early as 1948 **(Abdel-Khalek et al. 2003).** Since that time, parts of Lake Edku (30%) were dried to establish new soils for agriculture **(Abdel-Khalek et al. 2003 and Khalil et al. 2008).** Therefore, the objectives of this work is assess the soil degradation status around Edku Lake and to know the effect of the lake on this area

Material And Methods

Studyarea

The study area is located to the West of the Nile Delta, and extended between 29° 51′ & 30° 31′ East, and 30° 59′ & 30° 26′ North, fig.1, around Lake Edku. The region is classified by the climate of the Mediterranean Sea, with hot arid summers and winters with little rain. The average temperatures in the dry season are exceptionally high, ranging from 25 to 30°C with an intermediate temperature of 21°C. In the November-February cold season, the rainfall distribution concentrations occur. The total annual rainfall is 193.0 mm per year. Maximum rainfall values range from 50.0 to 56.3 mm in January and December. The evaporation can range from 3.3 to 4.8 mm/day with an average of 4.25 mm/day **(Zaki and Swelam 2017).** The soil texture in this area is recognized as clayey soils with recently reclaimed sandy soils **(El-Dars et al. 2014).** The slope of soil surface is flat. Soil depths differ considerably, ranging from moderately deep to deep, and well match the water table depths. Soil colors range from dark grayish brown to yellow **(Hegab 2014).**

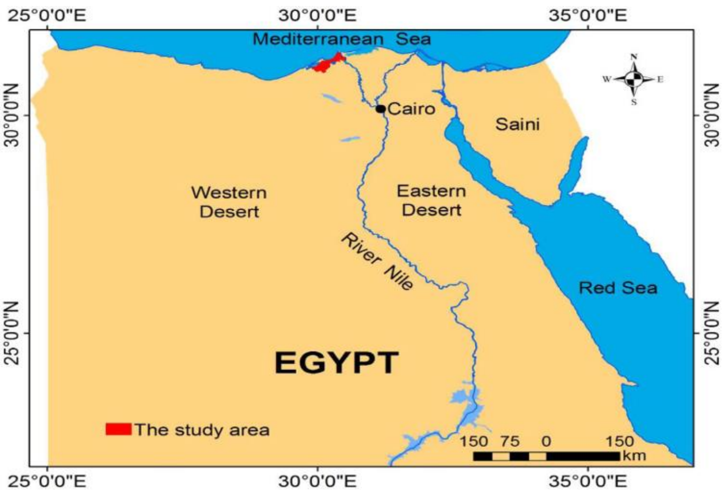

Fig.1: Location of the study area.

Sampledprofiles

Soil samples were collected during September 2019.Where collected fifty soil samples from Twenty-four soil profiles. Soil samples were obtained to represent different depths: 0-30 cm, 30-60 cm, 60-90 cm and 90-120 cm. On various dimensions and directions from Lake Edku table2. with avoid urban areas and water bodies.

Soil physical and chemicalcharacterization

Soil samples have been air-dried and sifted through a 2-mm mesh. EC is often used to express soil salinity. EC is usually wont to express soil salinity. EC was measured during a 1:2.5 soil-water extract for coarse-textured soils, while it had been measured in saturated paste extract for fine-textured soils. The EC was measured via an electronic bridge. consistent with **FAO (1988)**, EC values using to classify the amount of soil salinity. Physical and chemical characteristics of the collected profile soils were determined consistent with standard methods **USDA 2004.**

Soil degradation assessment

Processes of degradation of soil are complex, with several interrelations among drivers and properties. As the degradation status for all this complexity cannot be solved by the use of just one index, the degradation status is best defined by an index for each step of degradation. Such indices should however be as simple as possible, **(De Paz et al. 2006 and Moore et al. 1993).** In order to measure soil degradation, multiple authors have suggested indices **(Doran and Parkin 1994, Snakin et al. 1996, Lopez-Bermudez and Barbera 1998, and Hess et al. 2000)** with different parameters On the basis of the goals. To pick the deterioration indices, we adopted the simplicity and data availability criteria. Chemical and biological indices of degradation of soil were therefore chosen on the basis of the methodology developed by **FAO-PNUMA- UNESCO in 1980** and implemented throughout area of the Mediterranean by **Sanchez et al. (1998, 1999) and De Paz et al. (2006).**

Chemical Degradation Index (CDI): Soil productivity can be decreased under semi-arid conditions, largely due to salinization or alkalization. Both processes are considered into account by CDI. A soil with a low cation exchange capacity under either or both of these processes will fit soils with a higher chemical degradation index, whether the source of degradation is normal or anthropogenic. **(De Paz et al. 2006).** Chemical degradation index was calculated using the following equations:

$CDI = \frac{Salts + Na}{CEC}$ …… eq.1 **(FAO-PNUMA- UNESCO 1980)**

Salts (meq/100g) = (13.5 * EC * Hs)/1000…. eq.2 **(De Paz et al. 2006)**

Hs = 28.215 + 6.09 * OM + 0.243 * Clay (%) – 0.11 * Sand (%) … eq.3 **(De Paz et al. 2006)**

Where: Salts is soluble salt content (meq/100g), Hs is soil water content at saturation (%), Na is exchangeable sodium (meq/100g), EC is soil electrical conductivity (dS/m), OM is organic matter content (%), and CEC is cation exchange capacity (meq/100 g).

Biological degradation index (BDI): Biological degradation is related to the high organic matter decomposition rate under semiarid conditions. Organic matter (OM) is one of the main nutrient sources for plants and microorganisms. It affects soil aggregation and prevents crusting (De Paz et al. 2006). The key cause of biological degradation is considered by BDI to be organic matter content alone Description of the chemical and biological degradation degree was addressed according to the rating assigned in table 1. BDI = $\frac{1}{OM}$ … eq.4 **(FAO-PNUMA- UNESCO 1980)**

Table 1 Degree and index rating of soil chemical and biological degradation **(De Paz et al. 2006).**

Degradation Degree	Chemical degradation index	Biological degradation Index
Very low	0-0.0081	0-0.3
Low	0.0081-0.021	0.3-0.6
Moderate	0.021-0.046	0.6-1
High	0.046-0.085	1-2.5
Very high	> 0.085	> 2.5

Results And Discussion

Hydrogen ion concentration (pH)

The results in table 2 indicated that the lowest mean value of soil pH (7.85), while the highest one (8.33) and average value pH (8.06 ± 0.15). These findings are in accordance with previous reports made by Abdel Hamid and Shrestha **(Abdel-Hamid and Shrestha 1992)** in which they indicated that formerly reclaimed soils and coastal area soils had pH range of 7.9-8.5. As well, Abdel Kawy and Ali **(Abdel Kawy and Ali 2012)** indicated that lake reclaimed soils had a soil reaction (pH) that was slightly alkaline (8.0-8.31).

Electrical Conductivity(EC)

The spatial distribution of the EC over the study area is illustrated in table2. The EC values are range from 1.44 to 21.63 dS/m. It was observed that higher EC values are found in locations which are characterized by shallow water table because it encourages the movements of salts up to the surface of the soil **(Rasha et al. 2018).** In addition, the high EC values were detected in soils around Edku Lake, which is in accordance with the findings of Rasha et al, Ali and Moghanm. **(Rasha et al. 2018, Ali and Moghanm. 2013).** The results indicated that the soil salinity varies excessively over this area (SD = 7.27). Note that the EC values increase to ward Edku Lake. This increase may be due to the leakage from the saline Edku Lake into neighboring areas, which enhance the shallow groundwater level **(Hegab 2014).** The results indicated that the soil depth ranges from 40 cm (shallow) to 120 cm (deep) with a mean value of 83 cm (moderately shallow). And There was a positive relationship between depth of groundwater and distance from the lake fig. 2. but there is an inverse relationship between electrical conductivity of sample and distance from the lake fig. 3.

Table 2: Depth of groundwater, PH, EC, CDI, and BDI of the studied profiles.

The direction from the lake	Distance from the lake (Km)	Profile NO.	depth of groundwater (cm)	PH	EC (ds/m)	OM (%)	CDI	BDI
North eastern	0	1	40	7.91	20.12	0.70	0.895	1.429
	3	2	50	7.9	5.8	0.90	0.504	1.111
	6	3	120	8.02	2.15	1.01	0.176	0.990
	9	4	120	8	2.12	1.10	0.128	0.909
East	0	5	40	7.85	19.98	0.83	0.722	1.205
	3	6	50	7.92	8.13	1.03	0.308	0.971
	6	7	80	8	2.24	1.11	0.048	0.901
	9	8	120	7.98	2.14	1.04	0.042	0.962
West	0	9	40	8	13.25	0.74	0.726	1.351
	3	10	70	8.14	3.62	0.91	0.172	1.099
	6	11	100	8.1	2.25	0.88	0.126	1.136
	9	12	100	8.16	1.44	0.98	0.062	1.020
South	0	13	50	8.31	18.17	0.78	0.676	1.282
	3	14	90	8.3	3.29	1.04	0.065	0.962
	6	15	120	8.33	2.11	1.19	0.035	0.840
	9	16	120	8.33	2.11	1.15	0.030	0.870
South eastern	0	17	40	7.88	21.63	0.87	0.832	1.149
	3	18	80	7.95	4.15	1.17	0.071	0.855
	6	19	120	8.01	2.75	1.33	0.050	0.752
	9	20	120	7.98	2.05	1.21	0.036	0.826
South western	0	21	40	8.08	20.37	0.87	0.725	1.149
	3	22	80	8.01	7.16	1.04	0.237	0.962
	6	23	90	8.05	2.21	1.21	0.066	0.826
	9	24	120	8.2	2.12	1.11	0.050	0.901
Min			40	7.85	1.44	0.70	0.030	0.752
Max			120	8.33	21.63	1.33	0.895	1.429
Average			83	8.06	7.14	1.01	0.283	1.019
SD			32	0.15	7.27	0.16	0.305	0.177

Min Minimum, Max Maximum, SD Standard Deviation.

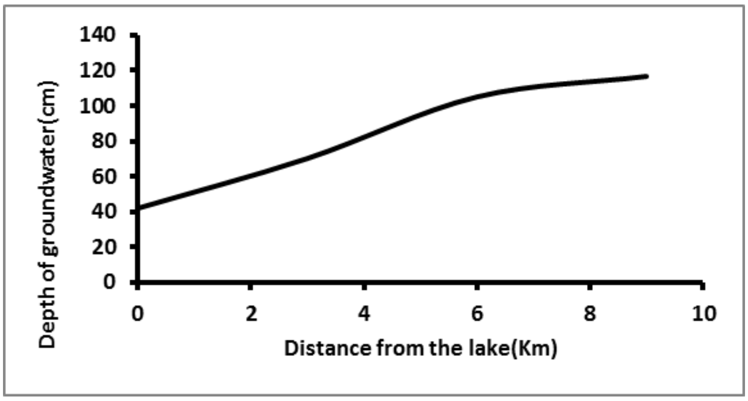

Fig. 2: relationship between depth of groundwater and distance from the lake.

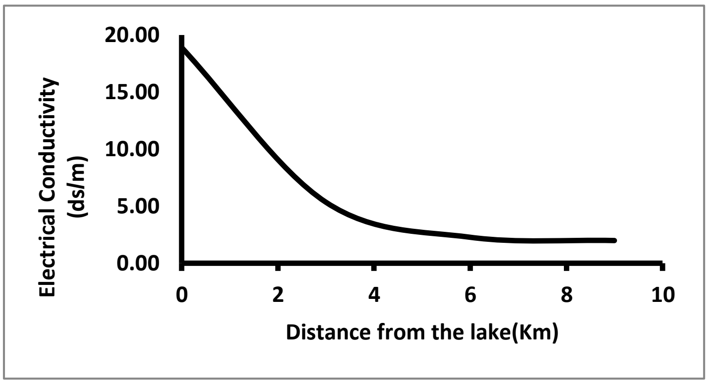

Fig. 3: relationship between electrical conductivity of sample and distance from the lake.

Soil salinity classes derived from measured EC

The EC values over the study area is divided into four classes of salinity levels according to **FAO (1988).** The classes are none to slightly saline, moderately saline, strongly saline, and very strongly saline. None to slightly saline soils accounted for the largest area, representing approximately 58.33% of the total study area. Moderately saline soils accounted for 12.50% of the total area. It was obvious that the strongly and very strongly saline soils were concentrated in those areas adjacent to Edku Lake and covered 8.33 and 20.83% of the total study area, respectively. The spatial extents of the salinity classes derived from the measured EC are shown in table3. The class degree clearly increased with proximity to Edku Lake, likely because of the seepage from the lake into nearby areas.

Table 3: Salinity classes derived from measured EC

Salinity level (dS/m)	Salinity class	Profile NO.	Profile (%)
< 4	None to slightly saline	3,4,7,8,10,11,12,14, 15,16,19,20,23,24	58.33
4–8	Moderately saline	2,18,22	12.50
8–16	Strongly saline	6,9	8.33
> 16	Very strongly saline	1,5,13,17,21	20.83
Total		24	100.00

(OM) The spatial distribution of organic matter (OM) shows that the area is attributed by low organic matter content, as it varies between 0.7% and 1.33% and average 1.01 ± 0.16. The results are expected under the arid climatic condition, which encourages organic matter decomposition.

Soil degradation

The results of the average weight data for soil profile analyses were used in the estimation of degradation indices (CDI and BDI) and assessment of soil degradation. A correlation analysis was performed in order to identify the most influential variables controlling the CDI for the investigated soils. In this analysis, the selected variables (soluble salts, exchangeable sodium and CEC) were varied within a particular range, and the effect on CDI was addressed. The results in fig. 4 and fig 5 revealed a strong positive correlation (r = 0.92 and 0.96) between CDI on one side and the soluble salt content and the exchangeable sodium on the other side, respectively. Fig.6 showed moderate negative correlation (r = - 0.52) was observed between CDI and CEC. This means that slight variations in the soluble salt content and the exchangeable sodium lead to a remarkable change in the chemical degradation degree. The high effect of the soluble salts content and exchangeable sodium on CDI could be regarded to their high levels which cannot be buffered by CEC, since the high salt content in general and the high sodium content in particular affect the soil hydraulic properties and increase the rate of soil salinization and alkalinization **(Hassan et al. 2017).**

The results of soil chemical degradation showed that the CDI levels vary from moderate (0.021-0.046) to very high (> 0.085) table2 .The spatial extent of chemical degradation degrees is depicted in table 4, where 17% of the investigated area was moderately degraded soil (CDI from 0.030 to 0.042) this area average value soluble salts1.33 meq/100g and average value exchangeable sodium 0.88 meq/100g, 29% of the investigated area was high degraded soil (CDI from 0.048 to 0.071) this area average value soluble salts1.50 meq/100g and average value exchangeable sodium 1.18 meq/100g,and 54% of the investigated area was very high degraded soil (CDI from 0.126 to 0.895) this area average value soluble salts 4.75 meq/100g and average value exchangeable sodium 5.21 meq/100g.

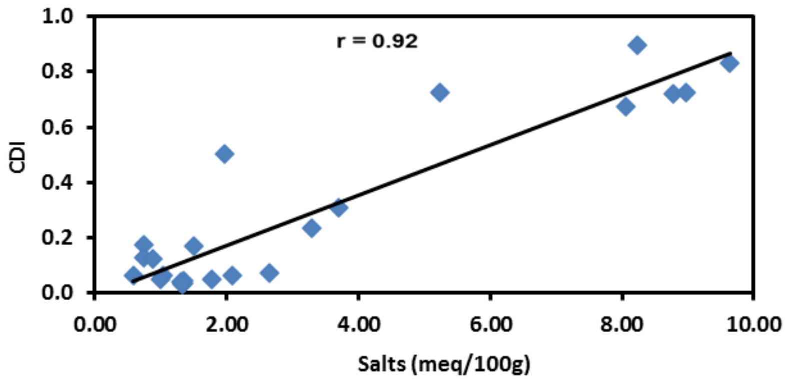

Fig. 4: Effects of soluble salts content on CDI.

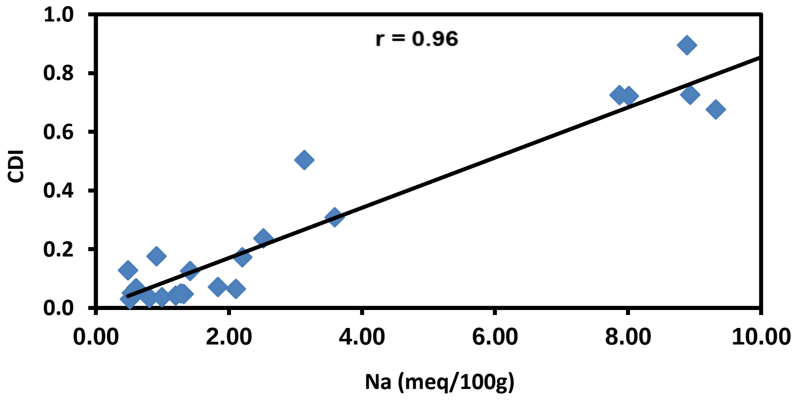

Fig. 5: Effects of exchangeable sodium on CDI.

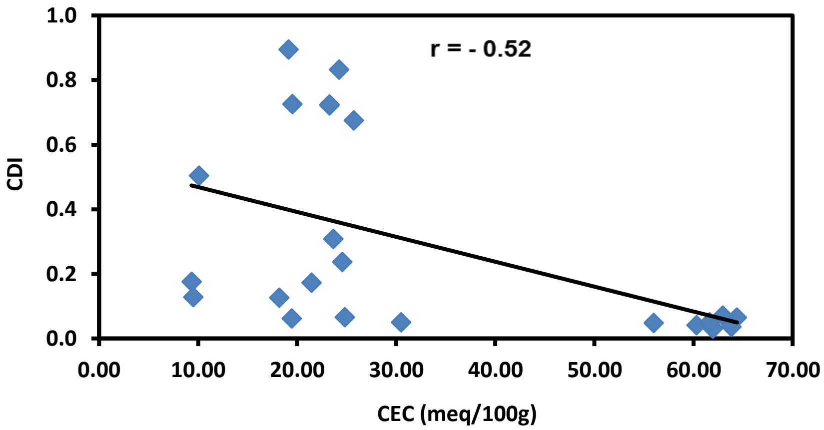

Fig. 6: Effect of cation exchange capacity on CDI.

Table 4: chemical degradation and biological degradation of Study area

Chemical degradation				
Study area %	Degradation Degree	CDI Range	Salts meq/100g average	Na meq/100g average
17	Moderate	0.030 – 0.042	1.33	0.88
29	High	0.048 – 0.071	1.50	1.18
54	Very high	0.126 – 0.895	4.75	5.21
Biological degradation				
Study area %	Degradation Degree	BDI Range	OM % average	
58	Moderate	0.75 – 0.99	1.12	
42	High	1.02 – 1.43	0.85	

Also, table 2 showed the results BDI from 0.752 to 1.429, degradation degree from moderate to high, and OM from 1.21% to 0.70 %.

biological degradation index (BDI) was strong negative correlation (r = - 0.98) with organic matter content (OM) fig 7. The spatial extent of biological degradation degrees is depicted in table4, where 58% of the investigated area was moderately degraded soil (BDI from 0.75 to 0.99) this area average value organic matter content 1.12% and 42% of the investigated area was high degraded soil (BDI from 1.02 to 1.43) this area average value organic matter content 0.85%.

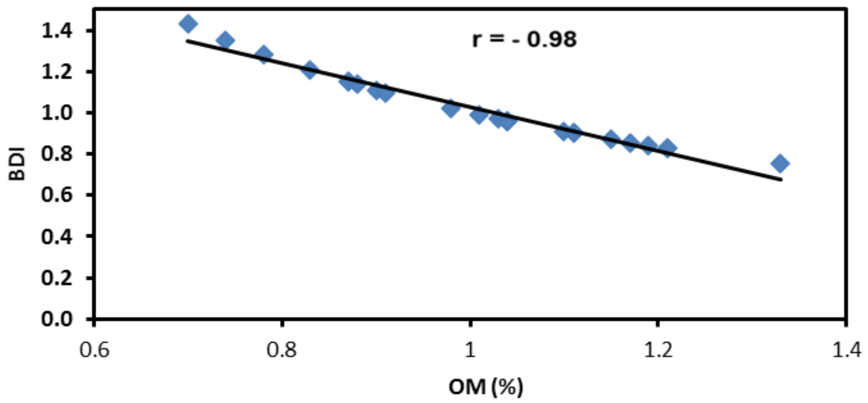

Fig. 7: Effects of organic matter on BDI

Conclusions

Soil is a vital non-renewable resource and its maintenance is critical for food security and a sustainable future. Therefore, urgent sustainable soil management strategies are required to stop or limit land degradation in its various types. Therefore, the objectives of this work is assess the soil degradation status around edku lake and to know the effect of the lake on this area. So collected fifty soil samples representing different depths from twenty-four profiles on different dimensions and directions of edku lake. The physical and chemical properties of the collected soil were determined in accordance with the 2004 USDA. Soil degradation was assessed by chemical and biological indicators of soil degradation on the basis of the methodology developed by FAO and UNESCO in 1980. After analysis and discussion, series of derived conclusions are:

(1) Lowest value of the soil pH is 7.85, while the highest value is 8.33, with an average of 8.06 ± 0.15.

(2) The total salts value in soil extract ranges between 1.44 ds /m and 21.63 dS/m,

with an average of 7.14 dS/m, it has been observed that the higher values are found in areas characterized by a shallow groundwater level because it encourages the movement of salts to the surface of the soil, which are the areas adjacent to the lake due to the intrusion of the salty lake water to it, and the study area is divided into four categories of salinity levels according to the 1988 FAO guide, they are low in salinity (less than 4 dS/m), medium salinity (4-8 dS/m), high salinity (8-16 dS/m), very high salinity (greater than 16 dS/m). And it represents 58.33%, 12.50%, 8.33% and 20.83%, respectively, of the total study area.

(3) values of the depth of the groundwater level in the study area were from 40 cm to 120 cm,with an average of 83 cm, and the distance from soil profile to lake was directly proportional to the depth of the groundwater table in soil, and inversely with the soil salinity values.

(4) As well the study area has low organic matter content, ranging between 0.7% and 1.33% with an average of 1.01% ± 0.16, and these results are expected under dry climatic conditions that encourage the decomposition of organic matter in the soil.

(5) There was a strong positive correlation between soil chemical degradation index and both the exchangeable sodium (r = 0.96) and the soluble salts content (r = 0.92), while there was a moderate negative correlation between soil chemical degradation index and the Cation exchange capacity (r = -0.52).And The results of soil chemical degradation index showed that 17% of the study area was soil of medium chemical degradation, and 29% soil of high chemical degradation, while 54% soil of very high chemical degradation.

(6) There was a strong negative correlation between soil biological degradation index and organic matter content (r =- 0.98), 58% of the study area was soil of medium biological degradation, and 42% of the study area was soil of high biological degradation.

After summarizing, results of soil analyses indicated that the major type of land degradation in the study area is the chemical soil degradation. The main drivers of chemical soil degradation are soil salinization and water logging, which produced by untenable soil usages and managing practices, and due to may because to effect lake edku at research zone.

References

Abdel-Hamid M.A., D.P.Shrestha.(1992). Soil Salinity Mapping In the Nile Delta, Egypt Using Remote SensingTechniques, International Society For Photogrammetry and Remote Sensing (ISPRS) Archives, Washington,D.C., USA, 29(Part B7), 783-787

Abdel Kawy W.A.M., R.R.Ali.(2012). Assessment of soil degradation and resilience at northeast Nile Delta, Egypt: The impact on soil productivity, The Egyptian Journal of Remote Sensing and Space Sciences, 15, 19-30

Abdel-Khalek M.A., F.El Gamal, M.El Kady, A.Hamdy . (2003). Agricultural drainage water reuse options, potential, costs and guidelines, In: Regional Action Programme (RAP): Water Resources Management And Water Saving In Irrigated

Agriculture (WASIA PROJECT), A.Hamdy, (Ed); Bari: CIHEAM, (Options Méditerranéennes: Série B.Etudes et Recherches; n. 44), 137-162.

Ali. R.R., F.S. Moghanm.(2013). Variation of soil properties over the landforms around Idku lake, The Egyptian Journal of Remote Sensing and Space Sciences. 16, 91–101.

Aksoy, E., Ozsoy G., and M. Dirim S. (2009). Soil mapping approach in GIS using Landsat satellite imagery and DEM data. African Journal of Agricultural Research. 4 (11), pp. 1295-1302.

Darwish Kh. And Abde l Kawy W. A. (2008). Quantitive Assessment of Soil Degradation in some Areas North Nile Delta, Egypt. International Journal of Geology. 2(2), pp 17- 22.

De Paz, J.M., Sanchez, J., Visconti, F. (2006). Combined use of GIS and environmental indicators for assessment of chemical, physical and biological soil degradation in a Spanish Mediterranean region; Journal of Environmental Management, 79, 150-162.

Doran, J.W., and Parkin, T.B. (1994). Defining and assessing soil quality. In: Doran, J.W., Coleman, D.C., Bezdicek, D.F., Stewart, B.A. (Eds.), Defining soil quality for sustainable environment. Soil Sci.Soc. Am. Special publication N. 35, Madison, Wisconsin, US, pp. 3–21.

El-Dars, F. M., Salem,W. A., & Fahim, M. M. (2014). Soil spatial variability in arable land south of Lake Idku, north-west Nile Delta, Egypt. Environmental Science: An Indian Journal, 9(10), 325–344.

FAO (2015). Soil is a non-renewable resource. 2015 international year of soils. Food and Agriculture Organization. Rome, Italy. http://www.fao.org/3/a-i4373e.pdf

FAO (2009). Advances in the assessment and monitoring of salinization and status of biosaline agriculture. Food and Agriculture Organization. Rome, Italy.

FAO (1988). World agriculture toward 2000: an FAO study. In N. Alexandratos (ed.). London: Bellhaven Press. 338 pp.

FAO, PNUMA, UNESCO (1980). Metodologı´a provisional para la evaluacio´n de la degradacio´n de los suelos. FAO, Rome

Gorji, T., Tanik, A., & Sertel, E. (2015). Soil salinity prediction, monitoring and mapping using modern technologies. Procedia Earth and Planetary Science, 15, 507–512.

Hassan A. Ismail, Osama R. Abd EL-Kawy, Haytham M. Yehia, and Mohamed A. Allam. (2017). Assessment of Soil Degradation and Agricultural Land Suitability for Sustainable Land Management in Alexandria and El-Behiera Governorates, Egypt. Alex. J. Agric. Sci. 62(6), 423-434.

Hegab, I. A. (2014). Restrictions of bordering Idku lake low soil productivity, north Nile Delta. Soil Science and Agriculture Engineering, 5(2), 157–167.

Hess, G.R., Lee, C., Fiscus, D.A., Hellkamp, A.S., McQuaid, B.F., Munster, M.J., Peck, S.L., and Shafer, S.R. (2000). A conceptual model and indicators for assessing the ecological condition of agricultural lands. J.Environ. Qual. 29, 728–737.

Kavvadias V. (2014). Soil degradation. Soil science institute of Athens-National Agricultural Research Foundation.

Khalil M.T., S.H.Shakir, A.H.A.Saad, G.M.El Shabrawy, M.M.Hassan .(2008). Physico -chemical environment of Lake Edku, Egypt, Egypt J.Aquat.Biol. & Fish., 12(2), 119-132.

Lopez-Bermudez, F., and Barbera, G.G. (1998). Indicators of degradation in semiarid Mediterranean agroecosystem of southeastern Spain, Proceedings of the

International Seminar of Indicators for Assessing Desertification in the Mediterranean. Porto Torres, Italy.

MALR, (1994). New Lands Agricultural Services Project (Appraisal Report). Ministry of Agriculture and Land Reclamation, Cairo, Egypt.

Moore, I.D., Turner, A.K., Wilson, J.P., Jenson, S.K., Band, L.E. (1993). GIS and land-surface subsurface process modeling. In: Goodchild, M.F., Goodchild, M.F. (Eds.), Environmental modeling with GIS. Oxford University Press, pp. 196–230.

Olaniyi A., Ajiboye, A.J., Abdullah, A.M., and Sood, A.M. (2015). Agricultural land use suitability assessment in Malaysia. Bulgarian Journal of Agricultural Science, 21 (3), 560- 572.

Rossiter, D.G. (1996). A theoretical frame work for land evaluation. Geoderma, 72(3-4): 165–190.

Sanchez, J., Boluda, R., Morell, C., Colomer, J.C., and Artiago, A. (1998). Degradation index of desertification threatened soils in the Mediterranean region. Application in Castilla- La Mancha (Spain). The soil as a strategic resource: degradation processes and conservation measures. Geoforma ediciones, Logrono, Spain pp. 441–448.

Sanchez, J., Boluda, R., Morell, C., Colomer, J.C., and Artiago, A. (1999). Assessment of soil degradation within the EFEDA area. In: Balabanis, P., Peter, D., Ghazi, A., Sogas, M.T. (Eds.), Mediterranean Desertification: Research Results and Policy Implications, pp. 387–396.

Shaban M, B.Urban, A.El Saadi, M.Faisal.(2010). Detection and mapping of water pollution variation in the Nile Delta using multivariate clustering and GIS techniques, Journal of Environmental Management, 91, 1785-1793.

Shalaby, A., Ali, R., and Gad, A. (2012). Land Degradation Monitoring in the Nile Delta of Egypt, using Remote Sensing and GIS. International Journal of Basic and Applied Sciences. Vol. 1 No.4. 2012. Pp. 292-303.

Siam E, M. Ghobrial .(2000). Pollution Influence on Bacterial Abundance and Chlorophyll-*A* Concentration: Case Study at Idku Lagoon, Egypt Sci.Mar., 64(1), 1-8.

Snakin, V.V., Krechetov, P.P., Kuzovnikova, T.A., Alyabina, I.O., Gurov, A.F., and Stepichev, A.V. (1996). The system of assessment of soil degradation. Soil Techno. 8, 331–343.

USDA, (2004). Soil Survey Laboratory Methods Manual. Soil Survey Investigation Report No. 42 Version 4.0 November, USA.

Wahab M. A., Rasheed M. A., and Youssef R. A. (2010). Degradation Hazard Assessment of Some Soils North Nile Delta, Egypt. Journal of American Science. 6(6), pp 156-161.

Zaki, A., & Swelam, A. (2017). The climatology of Nile Delta, Egypt. International Center for Agricultural Research in the Dry Areas (ICARDA) (pp. 1–32).

Zewdu, S., Suryabhagavan, K., & Balakrishnan, M. (2017). Geospatial approach for soil salinity mapping in Sego Irrigation Farm, South Ethiopia. Journal of the Saudi Society of Agricultural Sciences, 16(1), 16–24.