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Tracking Changes in Soil Fertility at North Nile Delta, Egypt Using GIS Techniques

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ABSTRACT

Tracking changes in soil fertility is important to make essential decisions and strategies to achieve more sustainable agricultural systems. The main objective of this research was to evaluate and tracking changes of soil fertility status after 9 years ago from its first time of evaluation in the same area. The study area is situated at the latitude 31˚ 14´ to 31˚ 29 E and 31˚ 14´ to 31˚ 30 N (total area about 705 km^2) in North Nile Delta soils using GIS techniques to prepare the soil fertility status map. Accordingly, 16 soil samples were collected based on the variability of land at a depth of 0-20 cm according to the previous study. The soil samples were analyzed for their some physiochemical properties and fertility properties. Evaluation of soil fertility and calculation of Fertility Index was performed using the Agriculture Land Evaluation System for arid and semi-arid regions (ASLE). The products of data of studied area were classified into four classes Fair, Poor, Very poor and Non agriculture according to fertility index, while studied previous was classified into three classes Fair, Poor, Very poor according to FI. Fertility index maps illustrate that some of the studied area have an increase in soil fertility and others have decline in soil fertility comparing with the previous study.

Keywords: Soil fertility tracking, Soil fertility evaluation, Fertility index, Decline, ASLE, GIS.

INTRODUCTION

Food shortage is one of the most serious problems facing the world, especially with limited resources and fast population growth. The world's population is expected to nearly double between now and 2050, which will inevitably put a great strain on food supplies. Food and Agriculture Organization of the United Nations (FAO) defines food security as "when all people, at all times, have physical and economic access to adequate, safe and nutritious food to meet their food needs and food preferences for an active and healthy life."(FAO, 2006 and FAO, 2009). According to Von Grebmer *et al.* (2008), more than one billion out of 6.5 billion people are affected by hunger and 33 countries have "alarming" or "extremely alarming" levels of hunger. A number of factors hinder the ability to provide food; current agricultural land is facing deterioration and, consequently, low yield, restrictions on potential agricultural land to expand agricultural production are increasing due to competing land uses such as biofuel production, urbanization, and long–term climate change (Sustainability Team Discussion Paper, 2010).

Arid and semi-arid regions occupy nearly about 66.7 million km^2, which represent 45.4% of the terrestrial surface, where approximately 2 billion habitats are living (Pravalie, 2016). Intensive agricultural systems caused several deterioration of the plant diversity, abnormalities in soil seed bank, nutrient availability, taxonomic and functional species diversity, and soil structural quality. These substantial alterations are able to reduce carbon sequestration in the ecosystem and increase CO_2 emissions to the atmosphere (Filhoa *et al.* , 2019).

Ability of soil to yield crops has always been concerned by scientists of agricultural systems. Recently, Soil Science Society of America has provided the term "Soil productivity" as the capacity of soil to cultivate particular sequence of crops under a specified system of management (Soil Science Society of America, 1997). The studies of scientists on soil productivity are mainly categorized into two major pillars: (i) assessing the productivity of soils, and (ii) studying factors influencing soil productivity. Soil productivity can be evaluated based on either qualitative or quantitative characters. The qualitative evaluation produced a qualitative description of soil characters through intensive field diagnosis and observation studies (National Soil Survey Office of China, 1994). Meanwhile, quantitative evaluation can be divided into factor evaluation and model evaluation. On the other hand, the productivity of soils not only related to its pedoginic and physicochemical characters; but, several factors (e.g. land use policies, soil tillage, manures and fertilizers application, irrigation as well as soil and water conservation against degradation potentials(Gu *et al.*, 2018). Consequently, research studies onto soil productivity deterioration have attracted research attention, especially under climatic change threats.

Soil fertility is defined by Food and Agriculture Organization (FAO) as the ability of the soil to supply nutrients required by plants in adequate quantities and correct proportions (Jin *el at.*, 2011). Soil fertility is one of the most important factors. Which, depend on soil chemical, physical and biological properties. Soil chemical and physical properties are very critical in case of soil fertility is measured

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in terms of the highest practical-level of productivity. Soil fertility controls farmers' options for agricultural production and agricultural practices (use of fertilizers, fertilization and soil and water conservation systems).

Several computer-based systems have been optimized in order to evaluate agricultural limitations that might hinder soil capability under obstacle conditions. These computer-based systems aim to better acquire sufficient details to understand soil characters and identifying obstacles that might hinder soil productivity potentialities (Elnaggar, 2017). Several computer-based systems are widely used in this regard including ALES, LECS and GIS (Ganzorig, 1995). These systems are able to provide sufficient knowledge to judge what has been called "land suitability", which is the capacity of soil for specific type of land use under its current conditions (actual suitability) of after improvement (potential suitability). Soil fertility index can be evaluated by using the Applied System for Land Evaluation for arid and semi-arid regions (ASLE) (Ismail *et al.*, 1994).

Geographic Information Systems (GIS) is a powerful set of tools for collecting, storing, retrieving, converting and displaying spatial data (Burrough and McDonnell, 1998), which provided important tools for evaluating and mapping soil fertility. Soil fertility maps can support decision makers through providing more accurate information needed in developing fertility management programs in order to improve the agricultural practices, (El-Sirafy *et al.* , 2011 and Elnaggar *et al.* , 2016). Soil fertility map depend on spatial distribution of nutrient elements in soil such as total-N, available-PK , Mg, I and Mn and soil chemical properties (e.g. exchange cations, salinity, OC, and pH (Bagherzadeh *et al.* , 2018).

Computer-based systems have been developed to monitor the degradation of soil quality over the time. In Ghana, the annual depletion rate of nutrients are quantified as 30 kg N, 3 kg P and 17 kg K h^{-1} over the period between 1982–1984 (Bationo *et al.*, 2018). Another investigation has been carried out in India showed a dramatic reduction in the arable soils from 68.9847 km2 in 2000 to 15.26 km2 in 2014 due to the progressive increase in soil EC and pH.

The objective of this study is to evaluate the soil fertility of some soils at North Nile Delta, Egypt using GIS techniques after 9 years ago from its first time of evaluation.

MATERAILS AND METHODS

Field work:

The studied area which about 705 km^2 is located at North Nile Delta Soils (31° 14′ 20 to 31° 29 E and 31° 14′ to 31° 30 N). and it elevation ranges is between 0.1 to 5 m above the sea level (ASL) (Fig. 1).

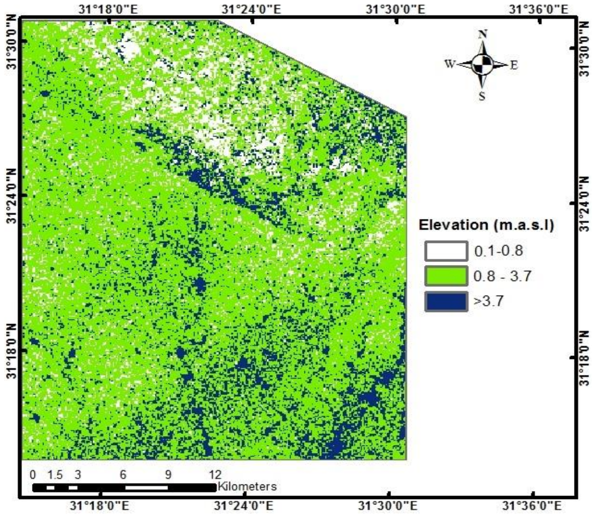

Fig. 1.Elevation ranges map of the study area

Also, the soil of this area is almost leveled slope varies from 0 to 2%. Based on the topographic nature of military survey maps (1: 50000), sixteen sites were selected from this area representing the different landforms as shown in Fig. (2).

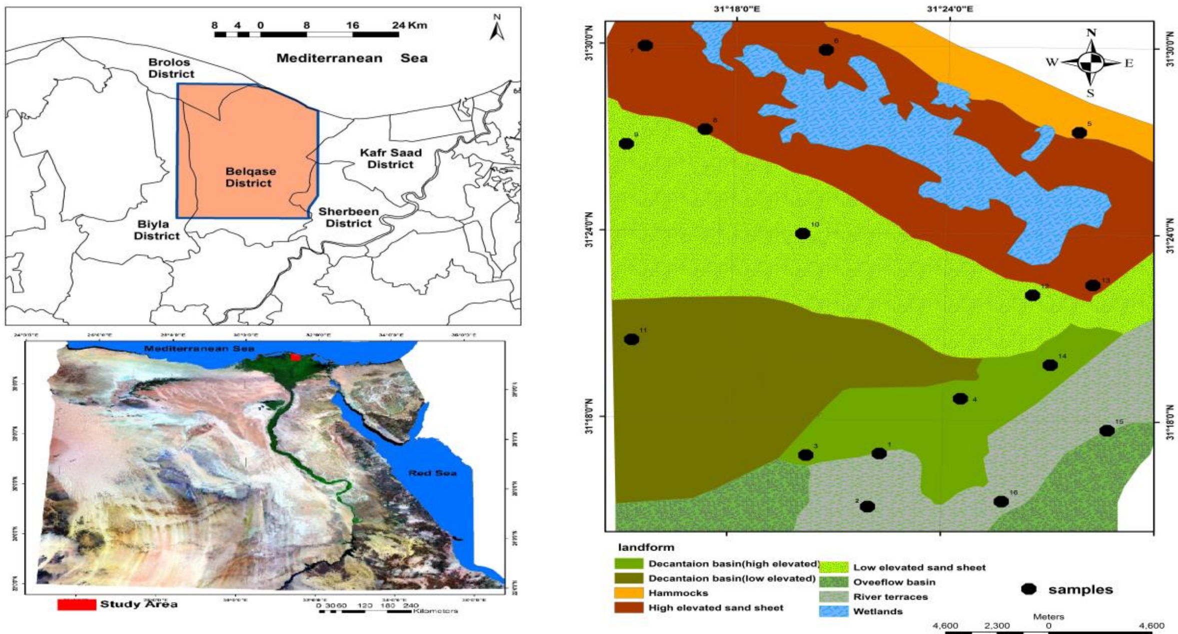

Fig. 2. Location map of the study area and spatial distribution of soil samples on landforms of the study area. (After Abdel Kawy and Ali, 2012)

Soil samples preparation:

Sixteen representing the studied sites were taken at the soil depth 0-20 cm. Coordinates of studied locations were recorded using the Global Positioning System (GPS).

These samples were air-dried, crushed and passed through a 2-mm sieve. The fine fraction (less than 2-mm diameter) was used for determine their some physical and chemical properties.

Data of both fieldwork and laboratory analyses were imported to Arc–GIS 10.3. Inverse Distance Weight (IDW) of spatial interpolation model was used to build a continuous map with estimating values of the unmeasured locations in the study area based on the distance between the known points and the unmeasured points and on the overall geostatistical relationships among the known points. (IDW) of Arc–GIS 10.3 software has been used to interpolate organic matter (OM), electrical conductivity (EC), CEC (cation exchange capacity), available nitrogen (N), available phosphorus (P), available potassium (K) and soil fertility index.

Physical analyses:

Particle size distribution was determined according to the international pipette method as described by Piper (1947). Bulk density was determined by the methods described by Dewis and Freitas (1970). Total soil porosity was calculated based on soil real and bulk densities using the following equation: Porosity = $(1 - D_b/ D_r) \times 100$ Where, D_b is soil bulk density (g cm^{-3}) and D_r is soil real density (it was estimated as 2.65 g cm^{-3}).

Chemical analyses:

Soil content of total soluble salts (dSm^{-1}) was determined in a soil-water extract (1:2) using EC meter according to Dellavalle, (1992). Soil pH value was determined in a 1:2 (soil: water) suspension using pH meter as described by Schofield and Taylor (1955). Soil organic matter was determined by Walkley and Black method as described by Hesse (1971). Cation exchange capacity was determined using sodium and ammonium acetate according to the method described by Hesse (1971). Exchangeable cations were determined in extract of 1.0 M ammonium acetate (pH 7.0) according to Hesse (1971). Available nitrogen in soil was extracted by 2.0 M KCl according to Hesse (1971) and determined by micro-kjeldahl apparatus. Available phosphorus in the soil was extracted using 0.5 N $NaHCO_3$ solution (pH 8.5) and determined colorimetrically as phosphomolybdenum blue with ascorbic acid at a wave length of 660 nm (Olsen and Sommers, 1982). Available potassium in soil was extracted using 1.0 N ammonium acetate solution (pH 7) and determined using flame photometer according to Hesse (1971). Total nitrogen was calculated by using the following equation $TN = 0.026 + 0.067\ OC$ according to Rashidi and Seilsepour, (2009) were: TN is total nitrogen (%) and OC is total carbon (%).

Soil fertility evaluation:

Comparative study of soil fertility evaluation was carried out using ASLE (The Applied System of Land Evaluation) computer program according to Ismail *et al.* (1994) as shown in Fig. (3), to calculate of the fertility index value and it compared after 9 years ago for the same area from its first time of evaluation (after Omar, 2010). Soil fertility classification was identified using ASLE program as described in Table, (1) (Storie, 1933 and Storie, 1944). Also, the soil fertility evaluation according to critical fertility levels in soils for the used soil properties as described in Table, (2).

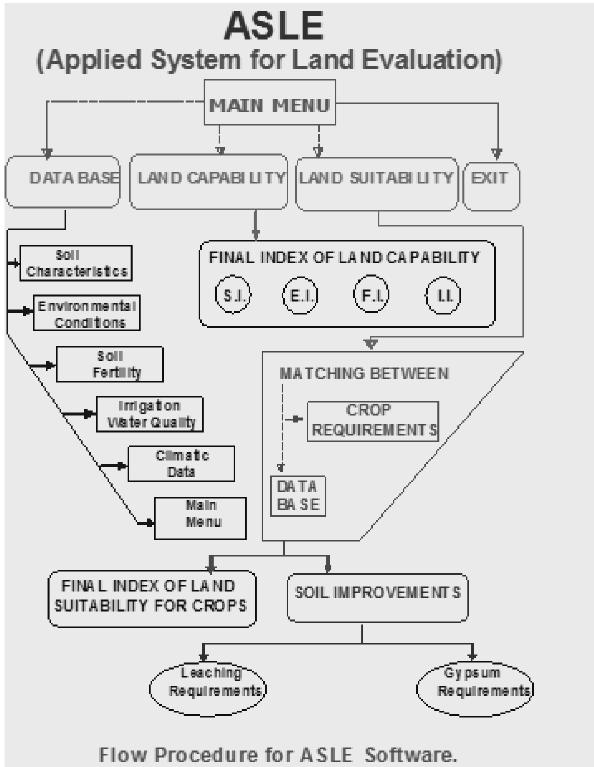

Fig. 3. Flow chart of land evaluation program-ASLE- (El-Seedy, 2019)

Table 1. Land productivity classes according to Storie, (1933 and 1944)

Class	Degree of suitability	Final index of fertility evaluation%
C1	Excelent	> 80
C2	Good	< 80 - > 60
C3	Fair	< 60 - > 40
C4	Poor	< 40 - > 20
C5	Very poor	< 20 - >10
C6	Non agriculture	< 10

Table 2. Classification of critical fertility levels in soils for the used soil properties

Parameter	Unit	Critical fertility level		
		Low	Medium	High
Available N*	($mgkg^{-1}$)	< 108	108 - 217	> 217
Available P*	($mgkg^{-1}$)	< 5	5 - 9	> 9
Available K*	($mgkg^{-1}$)	< 45	45 - 112	> 112
Total (N)**	(%)	< 0.125	0.125 - 0.225	> 0.225
Organic Carbon*	(%)	< 0.4	0.4 - 0.75	> 0.75
C/N ratio**		> 14 = poor	10 - 14 = medium	< 10 = good

*** (Verma *et al.* 2005). ** (Enang *et al.* 2016)**

RERSULTS AND DISCUSSION

Soil physical properties in the studied area:

Data in Table (3) show the ranges, averages, standard deviations (STDEV) and coefficient of variation (C.V) values of some soil physical properties of the studied area. Soil textures in the studied area were ranged from sandy to clay loam. Bulk density (BD) ranged between 0.99 and 1.67 g cm^{-3} with an average of 1.19 g cm^{-3}. Bulk density of soil depends on its organic matter content as well as the particles size distribution and chemical constitution of its mineral particles. In this regard, there are negative relationships between soil bulk density and SOM as shown Fig. (4), porosity, Si, C, total macro and total micro nutrients content; however, there is a positive relationship with its sand content (Chaudhari *et al.* , 2013 and Ahad *et al.* , 2015). Porosity varied from 36.87 to 62.72 % with an average of 55.14 %.

Table 3. Ranges of soil physical properties in the soils of the studied area.

Physical properties	Min.	Max.	Average	STDEV[1]	C.V[2]
Texture	Sandy to clay loam			---	---
Clay %	0.00	45.45	25.92	16.15	62.30
Bulk density gcm^{-3}	0.99	1.67	1.19	0.21	17.4
Porosity %	36.87	62.72	55.14	7.825	14.19

[1]Standard deviation [2]Coefficient of variation

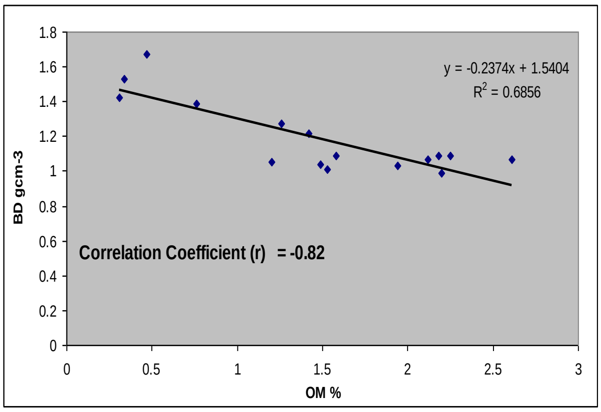

Fig. 4. Correlation between OM % and BD gcm^{-3} in the soils of the studied area.

Soil chemical properties:

Descriptive statistics for the ranges, averages, STDEV and C.V of some soil chemical properties of the studied area are given in Table (4). Electrical conductivity (EC) in the soils of the studied area varied between 0.2 and 10.7 dSm^{-1} (with average value 1.90 dSm^{-1}). according to EC values , the soils of the studied are ranging from non-saline to very strongly saline (0.40 -3.20 dSm^{-1}) according to Dellavalle (1992). The spatial variability within EC in the studied soils is illustrated in Fig. (5). Salinization is a factor contributes in soil degradation, which affects soil crop productivity (Prapagar *et al.* 2015). Data also revealed that soil pH ranged between 8.21 and 9.02 (with average value 8.49). Soil reaction is varied significantly based on climatic conditions of the study areas (GÖL, 2017). Exchangeable K^+ ranged between 0.10 and 2.15 cmol kg^{-1} (with average value 0.84 cmolkg^{-1}). The average exchangeable Na^+ was 2.73 cmol kg^{-1} soil (varied from 0.10 and 5.13 cmol kg^{-1} soil), and the exchangeable Ca^{2+} varied between 0.42 and 24.22 cmol kg^{-1} (recorded average value of 10.78 cmol kg^{-1}), (Zamil *et al* 2009). Meanwhile, exchangeable Mg^{2+} ranged between 1.28 and 14.70 cmol kg^{-1} (with mean value 8.39 cmolkg^{-1}), (Zamil *et al* 2009).

Table 4. Ranges of soil chemical properties in the soils of the studied area.

Chemical properties		Min.	Max.	Average	STDEV	C.V
EC (dSm^{-1}) (1:2)		0.20	10.70	1.90	2.64	138.94
pH (1:2)		8.21	9.02	8.49	0.22	2.64
Exchangeable	K	0.10	2.15	0.84	0.61	73.06
cations	Na	0.10	10.20	2.73	3.33	122.12
(cmol kg^{-1})	Ca	0.42	24.22	10.78	7.33	68.00
	Mg	1.28	14.70	8.39	4. 50	53.58
CEC (cmol kg^{-1})		2.24	41.42	23.57	13.47	57.16
ESP (%)		2.19	26.80	9.27	8.57	92.47
Organic matter (%)		0.31	2.61	1.48	0.72	48.90

The CEC values varied from 2.24 to 41.42 cmol kg^{-1} (with average value of 23.57 cmol kg^{-1}). Spatial distribution of CEC in studied soils is illustrated in Fig. (5). The aforementioned results revealed that exchangeable cations and CEC values were low with sandy-textured soil, and showed a progressive increase as the clay content increased in the studied soils. It is well known that CEC and exchangeable cations increased with increasing SOM (as shown Fig. 6) and clay content taking into consideration the abundance of active sorption sites onto their internal and external surfaces (Peinemann, *et al.* 2000).

Total exchangeable cations and CEC are two significant concepts in soil fertility and its long-term productivity (Hodges, 2010). Fig. (7) illustrates relationships between Total exchangeable cations and CEC with Fertility index in the studied soils. Whereas, linear relationships between Total exchangeable cations and CEC with FI were observed with correlation coefficient values (R2) of 0.70 and 0.79, respectively. On the other hand, the ESP values ranged between 2.19 and 26.80 % (recorded average value of 9.27 %), which indicates that most of the studied soils were non sodic soils.

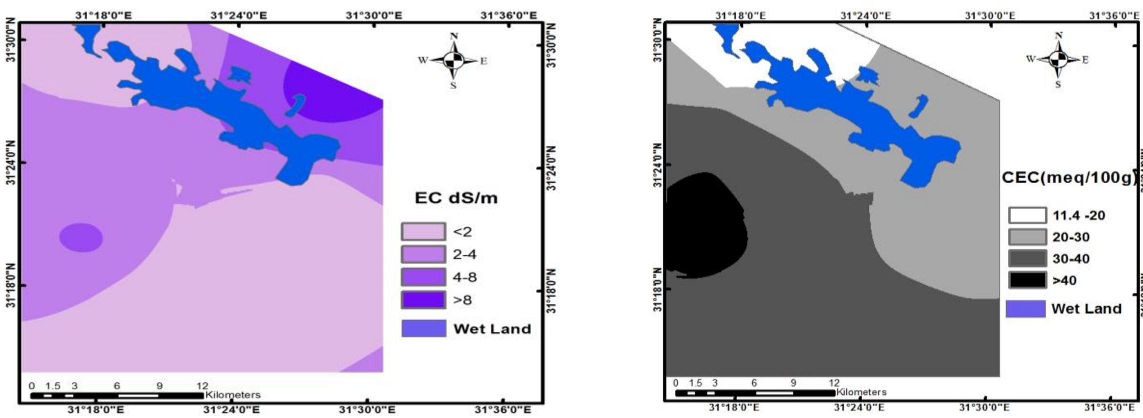

Fig. 5. Spatial distribution of EC and CEC in the studied area.

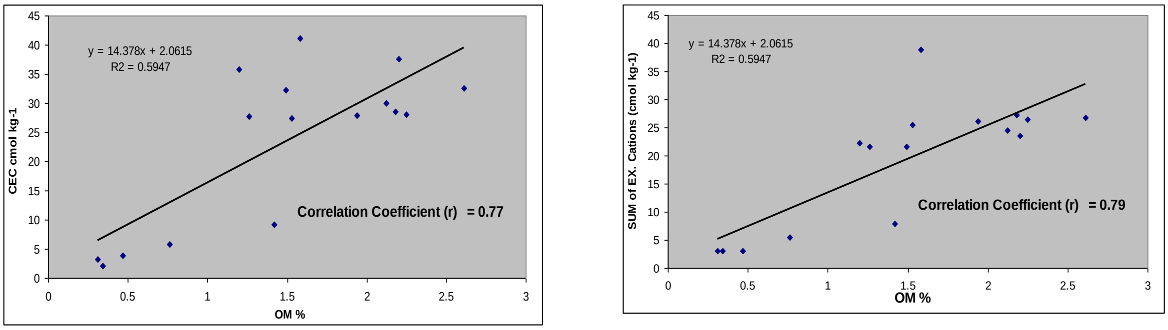

Fig. 6. Correlation between OM % with CEC (cmol kg^{-1}) and total exchangeable cations (cmol kg^{-1})in the studied soils.

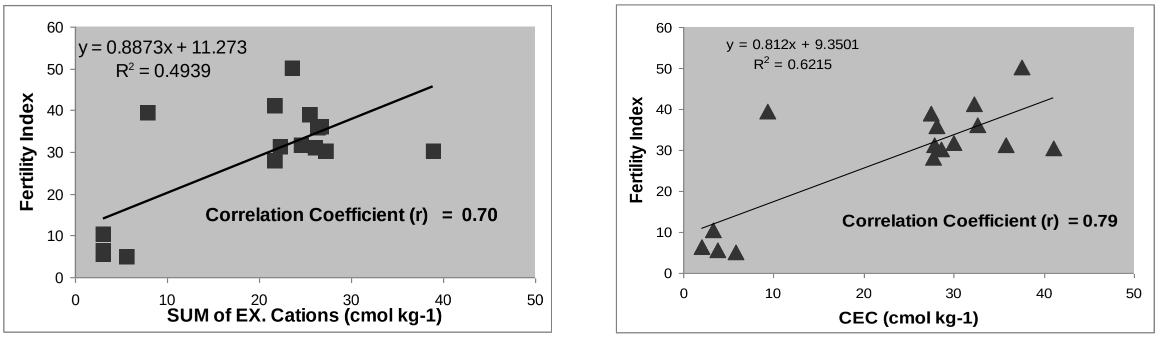

Fig. 7. Linear relationships between total exchangeable cations and CEC with fertility index in the studied soils.

Organic matter was generally low in the studied soils and ranged between 0.31% in sandy soils and 2.61 % in clay loam soils with an average of 1.48. Fig.(8) showed the spatial surface distribution (20 cm) of OM within the studied soils.

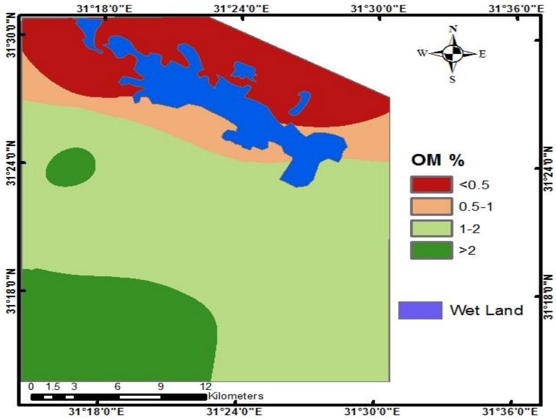

Fig. 8. Spatial distribution of organic matter in the studied area.

The noticeable variation of soil organic matter among the studied sites is mainly related to the obvious variation in particle size distribution of soil. Soil texture affects soil C stocks based on its ability to sequester OC against the fast decomposition in soil. Several reports have studied the relationship between SOM and its clay content and found that SOM content at <1.0 % (very low) up to low and progressively increased as the clay content increased in soil matrix (Plante *et al.* , 2006 and Hartati and Sudarmadji, 2016).

Soil organic matter plays several key-roles for improving soil quality indices. For instance, SOM is an important pool for nitrogen and carbon in soil matrix. In arid and semi-arid regions, the fast decomposition of soil organic matter caused several agro-environmental problems associated with the progressive degradation and decline in soil quality index (Golabi, *et al.* 2004, Thomas *et al.* 2006, GÖL 2017).

Soil fertility properties:

Data in Table (5) showed ranges, average values, (STDEV) and (C.V) of available NPK, total nitrogen (TN), organic carbon (OC), C/N ratio and fertility index in the soils of the studied area. Soil fertility characteristics according to Verma *et al.* (2005), and Enang *et al.* (2016) were as follows: Available nitrogen was relatively low and ranged between 10.43 and 103.10 mg kg-1 (with average value of 34.16 mg kg^{-1}).

Table 5. Ranges of available NPK, total nitrogen (TN %), organic carbon (OC %), C/N ratio, and fertility index in the studied soil area.

Fertility Properties		Min.	Max.	Average	STDEV	C.V	Fertility index #
Available	N	10.43	103.10	34.16	27.33	80.00	L
NPK	P	4.79	22.30	10.00	5.72	57.22	H
(mg kg^{-1})	K	54.33	901.26	374.12	233.47	62.41	H
TN %		0.03	0.13	0.08	0.03	41.83	L
OC %		0.18	1.51	0.86	0.42	48.76	H
C/N Ratio		4.74	11.90	9.57	2.35	24.52	G
Fertility index (ASLE)		5.04	50.23	28.29	13.89	49.10	- -
Fertility class (ASLE)		C3	C6	C4 - C5	- -	- -	- -

 # according to Verma *et al.* (2005), and Enang *et al.* (2016) - H = High, M= Medium, L= Low, G = good

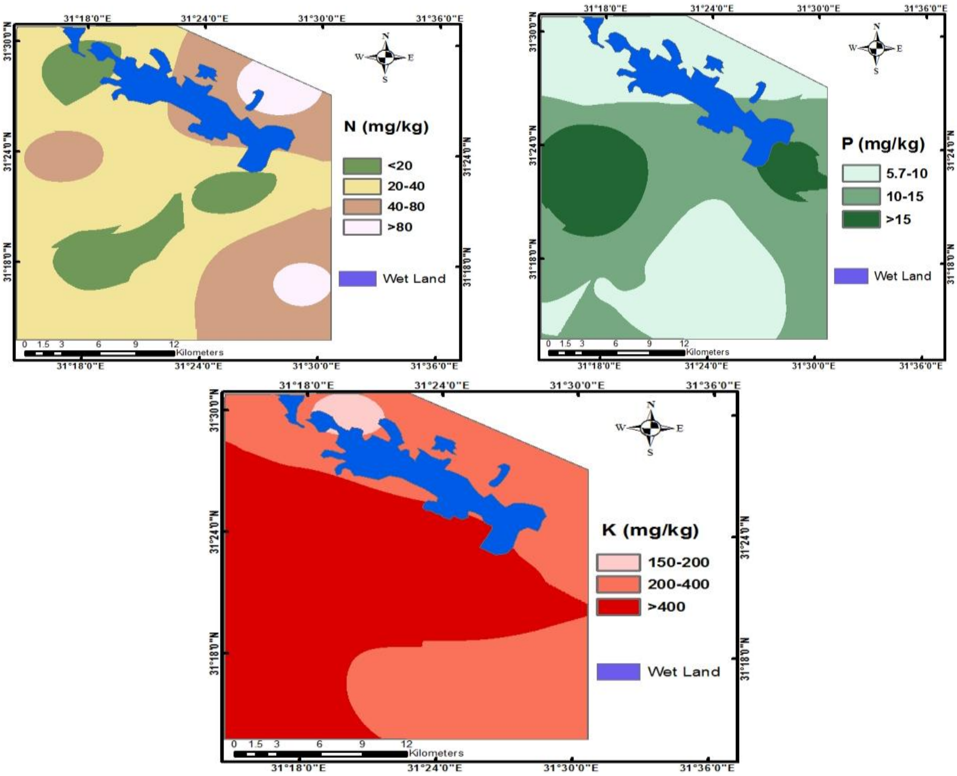

Fig. 9. Spatial distribution of Available NPK in the studied area.

Meanwhile, Soil available phosphorus was relatively high and varied from 4.79 to 22.3 mg kg^{-1} (with average value of 10.00 mg kg^{-1}). Also, soil available potassium was high in general and ranged between 54.33 and 901.26 mg kg^{-1} (with average value of 374.12 mg kg^{-1}). Evaluation of soil fertility in most samples of the studied soils was low with respect to available-N (Thomas *et al.* 2006), and was high with available-PK. The spatial variability within available NPK values in the studied soils is illustrated in Fig. (9). Total N values were low, varied from 0.03 and 0.13 % (about 0.08 % in average. While, organic carbon (OC) values were high, ranged between 0.18 and 1.51 % (average about 0.86 %). The C/N ratio values were good varied between 4.74 and 11.90 (average about 9.57), which indicated that nitrogen mineralization is the dominant process in the studied soils.

Data in Table (5) and (6) showed that the fertility index (FI) according to ASLE program varied from 5.04 and 50.23 (average about 28.29). Fertility index was fit into 4 classes, which are Fair-C3, Poor-C4, Very poor-C5 and Non agriculture-C5 (Thomas *et al.* 2006).

Fig. (10) illustrates some of the linear relationships between some soil properties and FI % in the studied Soils. Whereas, linear relationships between OC, sum of available NPK and TN with FI were observed with correlation coefficient values (R2) of 0.80, 0.64, 0.84 and 0.85, respectively).

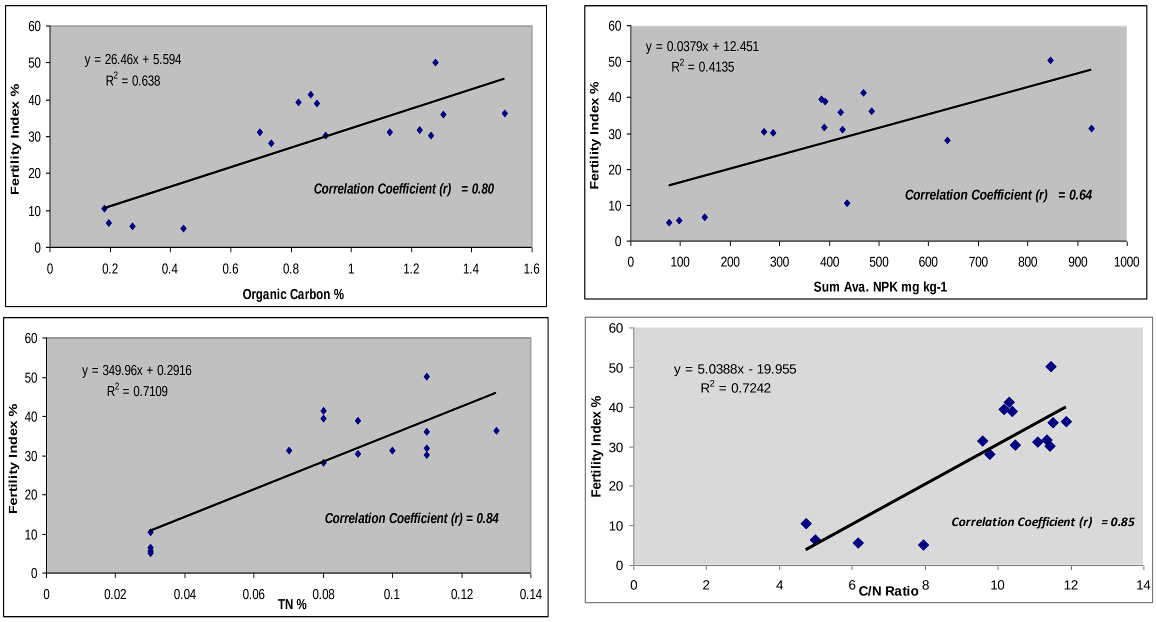

Fig. 10. Linear relationships between some soil properties and FI % in the studied Soils.

Table 6. Ranges of Soil fertility index previous (9 years ago) and current in the soils of the studied areas.

Soil Samples	Fertility Index previous[1]	Fertility Index current	Fertility Class Previous[1]	Fertility Class current	Average	STDEV	C.V	Increase % or decline % at 9 years ago	Fertility Index prediction
1	36.64	30.16	C4	C4	33.40	4.58	13.72	-21.49	23.68
2	30.7	35.99	C4	C4	33.35	3.74	11.22	14.69	41.28
3	36.35	31.75	C4	C4	34.05	3.25	9.55	-14.49	27.15
4	48.38	31.17	C3	C4	39.78	12.17	30.60	-55.21	13.96
5	21.13	10.44	C4	C5	15.79	7.56	47.89	-102.40	-0.25
6	21.11	5.6	C4	C6	13.36	10.97	82.12	-277	-9.91
7	12.53	6.52	C5	C6	9.53	4.25	44.62	-92.18	0.51
8	17.54	5.04	C5	C6	11.29	8.84	78.29	-248	-7.46
9	25.28	31.3	C5	C4	28.29	4.26	15.05	19.23	37.32
10	41.55	50.23	C3	C3	45.89	6.14	13.37	17.28	58.91
11	44.81	41.27	C3	C3	43.04	2.50	5.82	-8.58	37.73
12	26.27	28.16	C4	C4	27.22	1.34	4.91	6.71	30.05
13	49.88	39.44	C3	C4	44.66	7.38	16.53	-26.47	29.00
14	39.91	38.9	C4	C4	39.41	0.71	1.81	-2.60	37.89
15	39.28	30.41	C4	C4	34.85	6.27	18.00	-29.17	21.54
16	32.36	36.24	C4	C4	34.30	2.74	8.00	10.71	40.12
Min.	12.5	5.04	- -	- -	0.71	9.53	1.81	-277	-9.91
Max.	49.9	50.2	- -	- -	12.2	45.9	82.1	19.23	58.91
Average	32.7	28.3	- -	- -	5.42	30.5	25.1	-50.56	23.85
STDEV	11.2	13.9	- -	- -	3.3	12	25.2	90.44	20.34
C.V	34.3	49.1	- -	- -	60.9	39.3	101	-178.90	85.27

1 (after Omar, 2010). C3= Fair, C4= Poor, C5= Very poor and C6= Non agriculture.

Monitoring and comparing of soil fertility

Data in Table (6) showed ranges, averages, (STDEV), (C.V), (increase % or decline %) and fertility index prediction of fertility index previous and fertility index current in the soils of the studied area. When compared data of fertility index previous (nine years ago) with current of fertility index it is observed that fertility index increased in some locations, while fertility index declined in others locations as shown in Fig. (11).

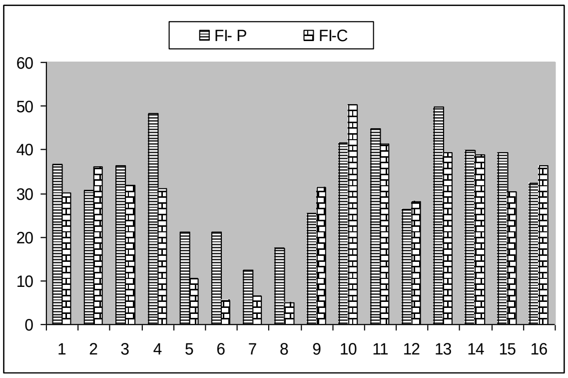

Fig. 11. Comparative between soil fertility index previous (FI-P) and fertility index current (FI-C) in the soils of the studied areas.

This change in fertility might be due to many factors such as environmental conditions of the arid and semi-arid region and increase of both OM, available NPK, and TN in some locations and its decrease in others (Thomas *et al.* 2006). In addition, these results may be due to diversity and variation in agricultural practices for soil fertility management (Okalebo *et al.* 2006).

Accordingly, the fertility class of previous study (9 years ago) for the studied area was under 3 classes; C3, C4 and C5 namely Fair, Poor and Very poor, respectively. While fertility class (present study) was fit into 4 classes (C3, C4, C5 and C6) Fair, Poor, Very poor and Non agriculture, respectively as illustrated in Fig (12).

Fig. (13A) illustrates the linear relationship between previous and current soil fertility in some areas, which is predicted by future decline of soil fertility if soil fertility management continues under the same conditions and the same agricultural practices. On the other hand, the linear relationship between previous and current soil fertility in some areas, which is predicted by future soil fertility increases if soil fertility management continues under the same conditions and the same agricultural practices as showed Fig. (13B).

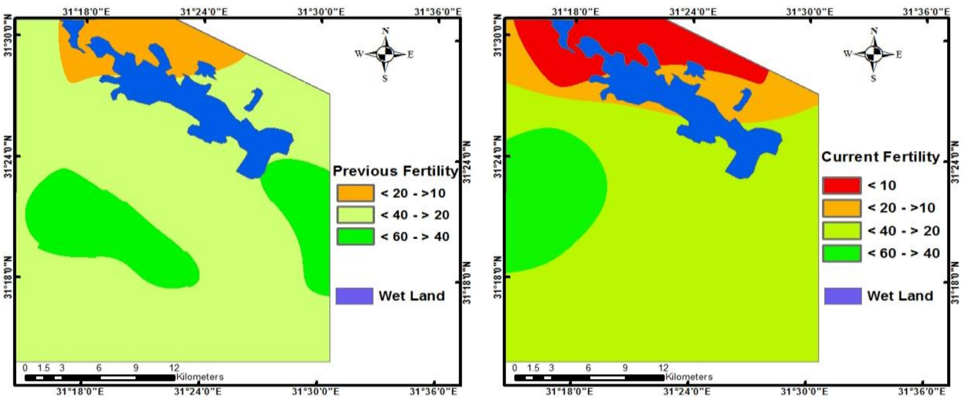

Fig. 12. Spatial distribution of fertility index previous and current in the soils of the studied areas.

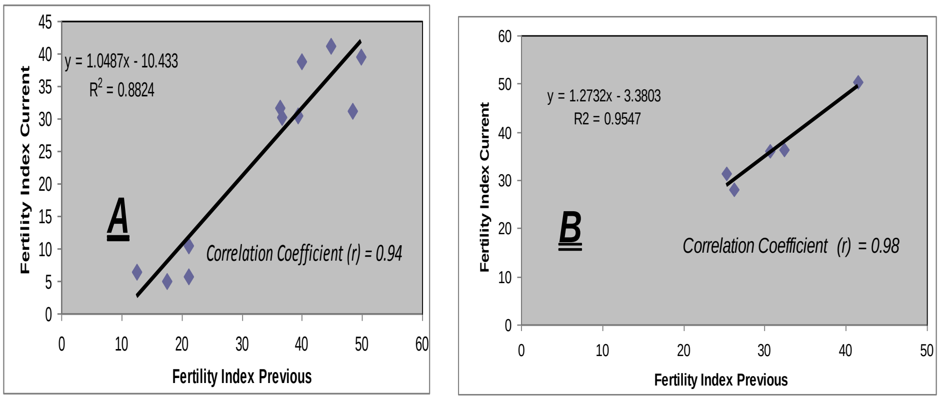

Fig. 13.A and B. Linear relationships between fertility index previous and fertility index current

The soil fertility index current of the study area classified to Fair-C3 (80.49 km2), Poor-C4 (470.90 km2), Very poor-C5 (57.84 km2) and Non agriculture-C6 (65.77 km2) classes which comprises 11.93 %, 69.76 %, 8.57 and 9.74 % of the surface area, respectively as shown in Table (7) (Bagherzadeh *et al*., 2018). This change in soil fertility comparative with the previous has resulted in a change fertility area.

Table 7. Fertility indices of the studied soils current and previous.

Current study			Previous study		
Class	**Area (km^2)**	**%**	**Class**	**Area (km^2)**	**%**
C3	80.49	11.93	C3	113.90	16.87
C4	470.90	69.76	C4	506.70	75.07
C5	57.84	8.57	C5	54.40	8.06
C6	65.77	9.74			
total	675	100	total	675	100

CONCLUSION

Routine work for Soil fertility evaluation and degradation using GIS can support decision makes to develop fertility management programs, and helps improvement of agricultural practices to increase soil agricultural productivity. Soils in the studied area varied from Fair to Non agriculture according to fertility index current. Also, it was observed that some of studied area increased in soil fertility while most of studied area declined in it fertility. The current fertility levels and sustainable soil fertility management need to more of study in the future to know how increase and conservation soil fertility. In addition, farmers must be learning practice of soil fertility management for conservation and increase of soil fertility and productivity.

REFERENCES

Abdel Kawy, W. A. M. and R.R. Ali (2012). Assessment of soil degradation and resilience at northeast Nile Delta, Egypt: The impact on soil productivity. Egypt. J. Remote Sens. Space Sci., 15 (1) 19-30

Ahad, T.; T. A. Kanth; and S. Nabi (2015). Soil bulk density as related to texture, organic matter content and porosity in Kandi soils of District Kupwara (Kashmir valley), India. IJSR – Int. J. Sci. Res., 4: 198–200.

Bagherzadeh, A.; A. Gholizadeh; and A. Keshavarzi (2018). Assessment of soil fertility index for potato production using integrated Fuzzy and AHP approaches, Northeast of Iran. Eurasian J Soil Sci., 7 (3) 203 – 212.

Bationo, A.; D. Ngaradoum; S. Youl; F. Lompo and J. O. Fening, (Eds.). (2018). Improving the Profitability, Sustainability and Efficiency of Nutrients Through Site Specific Fertilizer Recommendations in West Africa Agro-Ecosystems (Vol. 1). Springer.

Burrough, P. A. and R. A. McDonnell (1998). Principle of Geographic Information Systems. Oxford University Press, Oxford, UK.

Chaudhari P. R.; D. V. Ahire; V. D. Ahire; M. Chkravarty and S. Maity (2013). Soil bulk density as related to soil texture, organic matter content and available total nutrients of coimbatore soil. International Journal of Scientific & Research Publications, 3: 1–8.

Dellavalle, N.B. (ed.) (1992). Determination of Specific Conductance in Supernatant 1:2 Soil: Water solution. In Handbook on Reference Methods for Soil Analysis. Pp. 44-50. Soil and Plant Analysis Council, Inc. Athens, GA.

Dewis, J. and F. Freitas (1970).“Physical and Chemical Methods of Soil and Water Analysis”. Soil Bultin 10, FAO, Rome.

Elnaggar, A.A., (2017). Development of land capability and suitability maps for Bahariya Oasis, Egypt. Egypt. J. Soil Sci., 57: 489 – 503.

Elnaggar, A. A.; A. A. Mosa; G. El-Shebiny; M. E. El-Seedy; and F. A. El-Bakry (2016). Evaluation of soil fertility by using GIS techniques for some soils of Dakahlia Governorate, Egypt. J.Soil Sci. and Agric. Eng., Mansoura Univ., 7(10), 713- 720.

El-Seedy, M. E. (2019). Evaluation of land capability and suitability using ASLE program and GIS techniques: A Case study on some soils of East Nile Delta, Dakahlia Governorate, Egypt. J. Soil Sci. and Agric. Eng., Mansoura Univ., 10 (8), 491 - 498.

El-Sirafy, Z.M.; A. M. El-Ghamry; A. A. Elnaggar and M. E. El-Seedy (2011). Spatial distribution of some soil physiochemical properties in Kalabshowfarm using geostatistics. J. Soil Sci. and Agric. Eng., Mansoura Univ., 2 (12), 1291 – 1301.

Enang, R. K.; B. P. K. Yerima and G. K. Kome (2016). Soil physico-chemical properties and land suitability evaluation for maize (Zea mays), beans (Phaseolus vulgaris) and Irish potatoes (Solanum tuberosum) in tephra soils of the western slopes of mount Kupe (Cameroon). African Journal of Agricultural Research, 11(45): 4571-4583.

FAO (2006). Policy Brief, Issue 2: Food Security. Rome.

FAO (2009). Declaration of the World Summit on Food Security, WSFS 2009/2, 16 November 2009.

Filhoa, J. O. J. N.Vieirab; E. M. R. da Silvac; J. G. B., de Oliveirad; M. G., Pereirab and F. G. Brasileiro (2019). Assessing the effects of 17 years of grazing exclusion in degraded semi-arid soils: Evaluation of soil fertility, nutrients pools and stoichiometry. Journal of Arid Environments, 166: 1–10.

Ganzorig, D. A. (1995). A knowledge-based approach for land evaluation using RS and GIS techniques. 16th Asian Conference on Remote Sensing was held on November 20-24, Thailand.

GÖL, C. (2017). Assessing the amount of soil organic matter and soil properties in high mountain forests in Central Anatolia and the effects of climate and altitude. J. of sci., 63 (5), 199–205.

Golabi, M. H.; M. J. Denney and C. Iyekar (2004). Use of composted organic wastes as alternative to synthetic fertilizers for enhancing crop productivity and agricultural sustainability on the tropical Island of Guam. International Soil Conservation Organization Conference (ISCO) – 13th – Brisbane, Australia.

Gu, Z., Y. Xie; Y. Gao; X. Ren; C. Cheng and S. Wang, (2018). Quantitative assessment of soil productivity and predicted impacts of water erosion in the black soil region of Northeastern China. Science of the Total Environment, 637: 706-716.

Hartati W. and T. Sudarmadji (2016). Relationship between soil texture and soil organic matter content on mined-out lands in Berau, East Kalimantan, Indonesia. Nusantara Bioscience 8 (1), 83-88.

Hesse, P. R. (1971). "A Text Book of Soil Chemical Analysis".John Murry (Publishers) Ltd, 50 Albermarle Street, London.

Hodges, S.C.(2010). Soil Fertility Basics, Soil Science Extension, North Carolina State University.

Ismail, H. A.; S. M. Marei and M. E. El-Fayoumy (1994). A modified approach for land evaluation under arid and semi-arid conditions: I. Basis and computer program. J. Agric. Sci., Mansoura Univ., 19(10) 3483-3495.

Jin, J.; Y. Xu; H. Ye; C. Shen and Y. Huang (2011). Effect of land use and soil management practices on soil fertility quality in North China Cities' urban fringe. African Journal of Agricultural Research, 6(9), 2059-2065.

National Soil Survey Office of China, (1994). Chinese Soil Ethnograph. Vol.2. China Agriculture Press, Beijing, 276–326 (in Chinese).

Okalebo, J.R.; C. O. Othieno; P. L. Woomer; N. K. Karanja; R. M. Semoka; M. A. Bekunda; D. N. Mugendi; R. M. Muasya; A. Bationo and E. J. Mukhwana (2006). Available technologies to replenish soil fertility in East Africa. Nutr. Cycl. Agroecost, 76:153–170.

Olsen, S. R. and L. F. Sommers (1982). "Methods of Soil Analysis ".Part 2.Chemical microbiological Properties. Agron. J. Amer. Soc. Agron. Madison, Wiss, USA: 403-430.

Omar, M. M. M. (2010). Land suitability classification of some soils in Nile - Delta, Egypt. Ph.D. Thesis, Fac. of Agric., Mansoura Univ., Egypt.

Peinemann, N.; N. M. Amiotti; P. Zalba and M. B. Villamil (2000). Effect of clay minerals and organic matter on the cation exchange capacity of silt fractions. J. Plant Nutr. Soil Sci., 163: 47–52.

Piper, C. S. (1947)."Soil and Plant Analysis".Inter. Science Publishers Inc. New York.

Plante, A. F.; R. T. Conant; C. E. Stewart; K. Paustian and J. Six (2006). Impact of soil texture on the distribution of soil organic matter in physical and chemical fractions. Soil Sci Soc Am J 70:287–296.

Prapagar K.; S . Dasina and W. Shanika (2015). Effect of different salinity levels of a soil on nutrient availability of manure amended soil. 5th International Symposium., 246- 253.

Pravalie, R. (2016). Drylands extent and environmental issues. A global approach. Earth Sci. Rev., 161: 259–278.

Rashidi, M. and M. Seilsepour (2009). Modeling of soil total nitrogen based on soil organic carbon. ARPN J. Agric. Biol. Sci., 4: 1-5.

Schofield, R. K. and A. W. Taylor (1955). The measurement of soil pH, Soil Sci. Soc. Amer. Proc., 19:164-167.

Soil Science Society of America (1997). Glossary of Soil Science Terms (Madison, WI).

Storie, R. E. (1933). An index for rating the agriculture values of soils. Bull. Calif. Agric. Exp. Stn. No 556.

Storie, R. E. (1944). Revision of the soil rating chart. Leaf. Calif. Agric. Exp. Stn. No. 122.

Thomas, R. J.; H. El-Dessougi and A. Tubeileh (2006). Soil system management under arid and semi-arid conditions. En: Uphoff, N.; A. S. Ball; C. Palm; E. Fernandes; J. Pretty; H. Herren; P. Sanchez; O. Husson; N. Sanginga; M. Laing and J. Thies, (Eds.) Biological Approaches to Sustainable Soil Systems. Taylor and Francis, CRC Press, Boca Raton, pp. 41-58.

Verma V. K.; L. B. Pa tel; G. S. Toor and P. K. Sharma (2005). Spatial distribution of macronutrients in soils of arid tract of Punjab, India. International Journal of Agricultural and Biology, 7:295 -297.

Von Grebmer, K., .; H. Fritschel, H.,; B. Nestorova, B.,; T. Olofinbiyi, T.,; R. Pandya-Lorch, R., & and Y. Yohannes, Y. (2008). Global hunger index: The challenge of hunger 2008 (No. 594-2016-39943)

Wu, J.; X. Dong and X . Cai (2017). Assessment of soil fertility changes over 7 years after strip clearcutting and afforestation in a low-quality forest stand in china. J Biodivers Manage Forestry 6:3.

Zamil, B. A.; M. A. Allah; G. A. El-Salam and M. I. El-Shahawy, (2009) Land evaluation of old irrigated soils in North Delta Region (Rewena Canal Area) at Kafr El Sheikh Governorate, (8): 214-228.

تتبع التغيرات في خصوبة التربة في شمال دلتا النيل ، مصر باستخدام تقنيات نظم المعلومات الجغرافية

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تتبع التغييرات في خصوبة التربة مهم لاتخاذ القرارات والاستراتيجيات الأساسية لتحقيق نظم زراعية أكثر استدامة. كان الهدف الرئيسي من هذه الدراسة هو تقييم التغير في حالة خصوبة التربة بعد 9 سنوات من التقييم لنفس المنطقة. تقع منطقة الدراسة بين خطي عرض ´14 °31 الي 29 °31 E و ´14 °31 الي 30 °31 N (المساحة الإجمالية حوالي 705 كم^2) لبعض أراضي شمال دلتا النيل باستخدام تقنيات نظم المعلومات الجغرافية لإعداد خريطة حالة خصوبة التربة . تبعا لذلك ، ، تم جمع 16 عينة من التربة بناءً على تباين الأرض على عمق 0-20 سم وفقًا للدراسة السابقة ، وقد تم تحليل بعض خصائصها الفيزيائية والكيميائية والخصوبة. تم إجراء تقييم لخصوبة التربة وحساب مؤشر الخصوبة باستخدام نظام تقييم الأراضي الزراعية للمناطق القاحلة وشبه القاحلة (ASLE). تم تصنيف بيانات المنطقة المدروسة إلى أربعة فئات "عادلة" و "ضعيفة" و "رديئة للغاية" و "غير زراعية" وفقًا لمؤشر الخصوبة ، في حين صنفت الدراسة السابقة هذه الأراضي الي ثلاثة فئات "عادلة" و "ضعيفة" و "ضعيفة جدًا" توضح خرائط مؤشر الخصوبة أن بعض المناطق التي شملتها الدراسة حدث لها زيادة في خصوبة التربة وبعضها الآخر حدث له انخفاض في خصوبة التربة مقارنة بالدراسة السابقة.