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Spatial Variability of some Soil Physical, Chemical and Fertility Properties in Northern Nile-Delta of Egypt

Elnaggar, A. A.*; Kh. H. El-Hamdi; A. E. Gohar and M. Omar

Soils Dept., Faculty of Agriculture, Mansoura University, Egypt.

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ABSTRACT

Availability of more accurate soil's data is very limited for most areas worldwide; however, these data are very crucial for the management and sustainability of land resources. The main objectives of this work were to provide more accurate data about soil physical, chemical and fertility properties and their spatial variability within the studied area northern of Nile-Delta in Egypt. Therefore 19 representative soil profiles were dug throughout the studied area. Fifty-nine soil samples were collected from the identified horizons and these samples were analyzed for their soil physical, chemical and fertility properties. The inverse distant weighting (IDW) approach was used in developing the spatial interpolation maps of these properties. The obtained results revealed that the studied soil physical, chemical and fertility properties were highly associated with soil parent material. Coarse-textured soils developed on sand dunes were higher in their bulk density and total carbonates; whereas they were lower in total porosity, saturation percentage (SP), organic matter (OM), CEC and NPK. On the contrary, fine-textured soils developed on Nile-silt deposits were higher in their total porosity, SP, OM, CEC and NPK. It was also found that one third of the studied soils were affected by soil salinity. Areas affected by soil-alkalinity due to magnesium were larger than those caused by sodium. This could be attributed to their proximity from the lakes in the area and/ or see water intrusion. Accordingly, the studied area was affected by soil salinity and poor fertility which needs to the application of proper management and sustainability programs.

Keywords: land resources, soil analysis, soil salinity, soil sodicity, Nile-delta, Inverse Distance Weighting (IDW), GIS

INTRODUCTION

Soil reclamation and cultivation projects are of urgent priority now in Egypt in order to meet the over increasing population and the increasing need for food and fibre. These projects in return require the availability of more accurate data about land and water resources that will be used in these projects. However, the availability of more accurate soil data is limited not only for soils in Egypt but also worldwide Zinck and Valenzuala, (1990); El-Menshawy and Yehia, (2006); Elnaggar, (2007); El Baroudy, (2016). These data are very critical for the management and sustainability of land resources. Accordingly, great efforts are needed to make these data available for the stakeholders, resource managers and planners. Moreover, the old cultivated areas are subject to land degradation due to many factors such as soil salinity, sodicity, urban encroachment, loss of fertility due to crop intensification… etc Darwish and Abdel Kawy, (2008); Elnaggar, (2020). These areas need also to be studied in details to find out the dominant land degradation factors in each area to be used in their remediation AbdelRahman *et al*., (2018).

Nowadays, spatial interpolation techniques of soil properties have become one of the most useful approaches for spatial characterization of soil variability and agricultural practices Robinson and Metternicht, (2006); Karydas *et al.*, (2009) and Piikki *et al*., (2013). They are used in estimating the values of a certain soil property at un-sampled locations based on the measurements that were carried on other known sampled locations. This helps in studying the spatial variability of a set of soil properties in the sampling network at different sizes and scales. These techniques range in their complexity from simple techniques such as the linear and multiple regressions to complex techniques such as the inverse distance weighting IDW), Kriging and co-kriging El-Menshawy and Yehia, (2006); El-Sirafy *et al*., (2011); Elnaggar, (2017).

The IDW for instance is a widely used interpolation technique, where its robustness and simplicity motivates its continuity. Gotway *et al*., (1996); Babak and Deutsch, (2009); and Yasrebi *et al*., (2009) used the IDW technique in mapping the spatial variability within soil pH, P, K, Ca and Mg. They found higher correlations with the obtained results from soil analyses. Tuncay *et al*., (2016) and Mousavi *et al*., (2017) employed the IDW in studying the spatial distribution within soil organic matter (OM), calcium carbonate, clay content, and cation exchange capacity (CEC). They found that the interpolated values were comparable with the obtained values from soil analysis. Abdelrahman *et al*., (2021) found that IDW revealed higher efficiency than other techniques as a prediction method for mapping these soil properties (available NPK, EC, pH, SP, ESP, CEC, OC and $CaCO_3$). The investigated soils in their work are very similar to those in our study area.

Some of newly cultivated and old soils in the northern Nile-Delta are located at the end of irrigation canals, where fresh water is not available and the farmers have to irrigate their crops with drainage water World Bank, (2005); El-Alfy *et al*., (2017). Accordingly, most of these areas are subject to land degradation due to poor drainage, increasing soil salinity and loss of soil fertility El-Nahry and Doluschitz, (2010); Elnaggar, (2020). These land degradation factors result in deteriorating soil physical, chemical and fertility properties. Therefore, these soil properties need to be accurately evaluated to be used in land resource management and sustainability. Accordingly, the main objectives of this work were to provide more accurate data about soil physical, chemical and fertility properties, and to study their

* **Corresponding author.**
E-mail address: elnaggar@mans.edu.eg
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spatial variability within the studied area northern of the Nile-Delta in Egypt.

MATERIALS AND METHODS

1.Description of study area

The study area is located in the northern Nile-Delta of Egypt along the Mediterranean Sea coast. It is extended between these coordinates 30°10' - 31°50' E and 31°16' - 31°31' N. It has an area of about 896 km^2 as illustrated in Fig. (1). Its elevation ranges between 0 and 2 m above the sea level and this area is almost levelled. It is also distributed throughout four governorates (Damietta, Dakahlia, Kafr El-Sheik and Bahira).

Fig. 1. Location map of the study area and distribution of soil profiles.

The study area has a Mediterranean Sea climate, which is characterized by a hot-dry summer and a cold-wet winter. The mean temperature ranges between 15.0 and 30.5 ºC in December and August, respectively. The annual rainfall is about 167 mm year $^{-1}$, where it reaches its maximum value in January and December. The mean annual evaporation is about at 7 mm day^{-1} and it reaches its maximum in August. The lowest values are observed in January and December, where the temperature is relatively low. On the contrary, the highest values are recorded during the period from June to September (National Meteorological Authority, unpublished data). The geological formations in the study area include stabilized sand dunes, which cover the majority of the area. This is in addition to Nile silt deposits, undifferentiated quaternary deposits and sabkha deposits Conoco, (1987); and Said, (1993).

2.Soil samples and their analyses

Nineteen representative soil-profiles were dug at different locations within the studied area. The coordinates of these locations were recorded using a GPS unit (Garmin legend) as represented in Fig. (1). A total of 59 soil samples, representing the different soil horizons of the studied profiles were collected and prepared for analysis. These samples were analysed for:

– Particle size distribution according to Piper (1950),
– Bulk density (BD) as described by Dewis and Freitas (1970),
– Real density (RD) as described by Black (1965) ,
– Field capacity (FC) according to Cassel and Nielsen (1986)
– Total porosity (TP) was calculated using the following equation:

TP= (1-BD/RD)*100

– Organic matter was determined using Walkely and Black rapid titration method Jackson, (1973),
– Total carbonates were determined using Collin's calcimeter according to Page *et al*. (1982),
– Soil pH, in soil paste according to Hesse (1971).
– Electrical conductivity (EC) in saturation soil extract according to Hesse (1971).
– Soluble cations and anions as described by Jackson (1973).
– Exchangeable cations according to Hesse (1971).
– Cation exchange capacity (CEC) as described by Hesse (1971),
– Exchangeable sodium percentage (ESP) as described by Hesse (1971)
– Exchangeable magnesium percentage (EMP) according to Dewis and Freitas (1970),
– Available soil nitrogen, phosphorus and potassium as described by Dewis and Freitas (1970).

3.Geo-statistical analyses

The spatial distribution of the studied soil parameters was carried out using the Inverse Distance Weighting (IDW) algorithm under the geostatistical analyst in ArcGIS Desktop (ver. 10.5). This approach assumes that the value at an unknown location can be estimated based on a weighted average of the values of known points within a certain distance from that point or from a given number of known points in close vicinity from the estimated point. Weights are usually inversely proportional to a power of distance from the unsampled point location Lu and Wong, (2008); Chen and Liu, (2012); and Sajid *et al*, (2013).

RESULTS AND DISCUSSION

1. Soil physical properties and their spatial distribution

Data in Table 1 show the values of particle size distribution and the soil textural class of the studied profiles. The percentage of coarse sand (CS) ranged between 28.60 and 70.90% with an average of 37.05%. Fine sand (FS) varied from 23.05 to 80.43% with an average of 48.76%. Total sand ranged between 45.61 and 96% with an average of 85.80% . This wide variability in total sand is associated with the type of soil parent material or land use management of the studied soil. The higher values were observed in the soil developed on both the undifferentiated quaternary deposits and sand dunes in the northern and western parts of the studied area. On the other hand, the lower values were found in the soils developed on Nile-silt deposits which are located near the Nile branches and at the southern parts near the Burullus Lake. The spatial distribution of total sand in soil layers within the studied area is represented in Figs. (2).

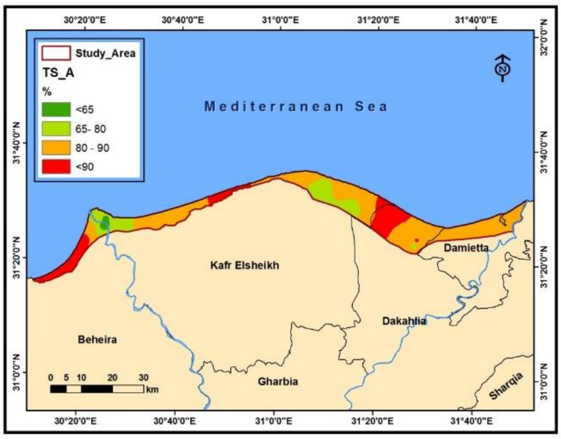

Fig. 2. Spatial variability of total sand content in the surface soil layer (A) of the studied area.

Silt content varied from 1.85 to 18.88% with an average of 4.67%. Clay content ranged between 2.00 and 52.12 % with an average of 9.53%. The spatial distribution of both silt and clay took an opposite trend to that of total sand within the studied area as it is also associated with soil parent material Figs. (3 and 4). According to these results, the predominant soil texture in the studied area is sandy. These results are in agreement with those obtained by Tayel *et al.* (2010); and El-Gammal *et al.* (2012).

Table 1. Particle size distribution (%) and soil textural classes at different in the studied profiles.

Property	Min.	Max.	Average	STD*
Coarse sand %	28.6	70.9	37.05	16.72
Fine sand %	23.05	80.43	48.76	14.1
Total sand %	45.61	96	85.8	10.95
Silt %	1.85	18.88	4.67	3.32
Clay %	2	52.12	9.53	9.99
Soil Texture	--	--	loamy sand	--

STD= Standard deviation of the studied variables.

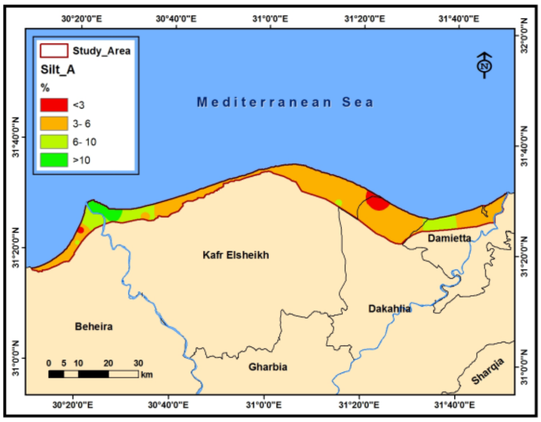

Fig. 3. Spatial variability of silt content in the surface soil layer (layer A) of the studied area.

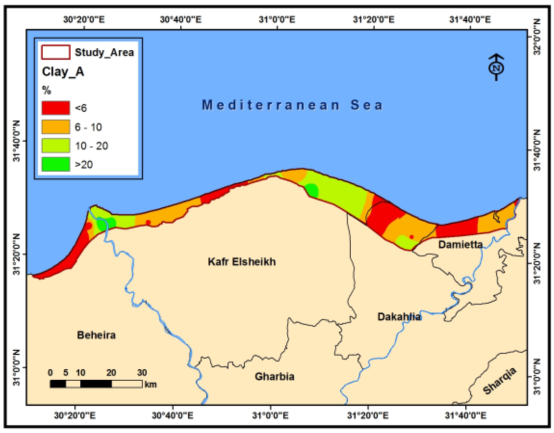

Fig. 4. Spatial variability of Clay content in the surface soil layer (layer A) of the studied area.

Data in Table 2 represent the values of field capacity (FC), saturation percentage (SP), bulk density (BD), real density (RD), total porosity, organic matter (OM) and calcium carbonates in the studied soil samples. Soil FC varied from 9.97 to 36.77% with an average of 15.52%. These values were associated with the clay content and organic matter in the studied soils. A highly significant correlation (P= 0.001) was found between the FC and clay and OM in the studied soils (r= 0.74 and 0.83; respectively). Similarly, the values of SP varied from19.95 to 73.54% with an average of 31.05%. These values took a similar trend as the FC values. They were correlated with clay and OM values in the studied soil samples.

Bulk density (BD) varied from 1.07 to 1.72 g cm^{-3} with an average of 1.42 g cm^{-3}. The lower values were found in the fine-textured soils and the higher values were found in coarse-textured soils. Real density (RD) varied from 2.13 to 2.85 g cm^{-3} with an average of 2.60 g cm^{-3}. These values were associated with the mineral and OM contents of the studied soils. Accordingly, total soil porosity varied from 32.28 to 61.75% with an average of 45.41%. The lower values were associated with the coarse-textured soils, whereas the higher values were related to fine-textured soils.

The studied soils were low in their OM content, which is typical to arid and semi-arid areas. It ranged between 0.13 and 5.1% with an average of 0.89%. The lower values were found in the coarse-textured soils and the higher values were in the fine-textured soils. It was also found that the OM content is decreasing with soil depth. The spatial distribution of OM in the studied layers is demonstrated in Fig. (5). Total $CaCO_3$ values ranged between 0.00 and 8.08% with an average of 1.00%. The higher values were found in the middle and western parts of the studied area as shown in Fig. (6).

Table 2. Field capacity, saturation percentage, bulk density, real density, total porosity, organic matter and $CaCO_3$ content of the studied profiles.

Property	Min.	Max.	Average	STD*
Field capacity %	9.97	36.77	15.52	5.9
Saturation percentage %	19.95	73.54	31.05	11.79
Bulk density g cm^3	1.07	1.72	1.42	0.14
Real density g cm^3	2.13	2.85	2.6	0.12
Porosity %	32.28	61.75	45.41	4.87
Organic Matter %	0.13	5.1	0.89	0.86
$CaCO_3$ %	0	8.08	1	1.63

***STD= Standard deviation of the studied variables.**

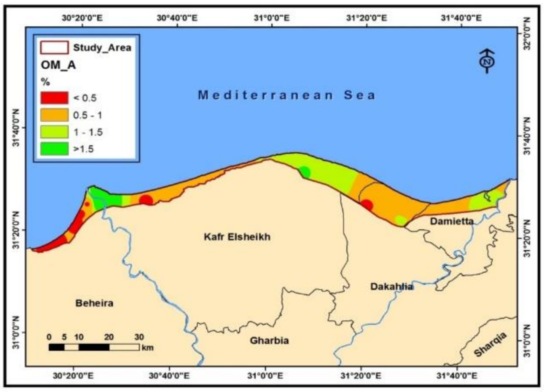

Fig. 5. Spatial variability of organic matter content in the surface soil layer (layer A) of the studied area.

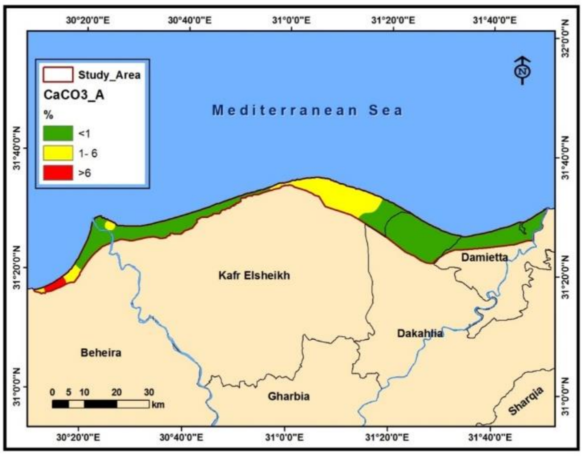

Fig. 6. Spatial variability of total carbonate content in the surface soil layer (layer A) of the studied area.

2- Soil chemical properties and their spatial distribution:

Data in Table 3 represent the values of some soil chemical properties in the studied soil sample. Sodium was the prevailing cation in the soil solution of the studied soils. This was followed by calcium, magnesium, and potassium ions; respectively. Sodium ions (Na^+) ranged between 0.05 and 2.78 Cmol kg^{-1} with an average of 0.44 Cmol kg^{-1}. Calcium ions (Ca^{2+}) varied from 0.03 to 1.03 Cmol kg^{-1} with an average of 0.15 Cmol kg^{-1}. Magnesium ions (Mg^{2+}) varied from 0.01 to 1.31 Cmol kg^{-1} with an average of 0.17 Cmol kg^{-1}. Potassium ions (K^+) ranged between 0.001 and 0.063 Cmol kg^{-1} with an average of 0.019 Cmol kg^{-1}.

On the other hand, chlorides were the dominant anions followed by bicarbonates, sulphates and carbonates; respectively. Chlorides ranged between 0.03 and 4.55 Cmol kg^{-1} with an average of 0.57 Cmol kg^{-1}. Bicarbonates varied from 0.00 to 0.22 Cmol kg^{-1} with an average of 0.09 Cmol kg^{-1}. Sulphates varied from 0.02 to 0.48 Cmol kg^{-1} with an average of 0.10 Cmol kg^{-1}. Carbonates varied from 0.00 to 0.20 Cmol kg^{-1} with an average of 0.03 Cmol kg^{-1}. The majority of soils in the studied area were highly alkaline, where the pH values ranged between 8.30 and 10.30 with an average of 8.99 (STD = 0.43). Electrical conductivity (EC) varied from 0.42 to 13.55 dSm^{-1} with an average of 2.53 dSm^{-1}. The spatial distribution of EC values in the studied soils is illustrated in Figs. (7 to 9). It indicates that the higher EC values above 4 dSm^{-1} are associated with the areas that have higher clay contents and poor drainage.

Exchangeable calcium was the dominant cation in the studied soils followed by magnesium, sodium, and potassium; respectively. Exchangeable calcium (Ca^{2+}) ranged between 1.96 and 32.58 Cmol kg^{-1} and it has an average of 9.44 Cmol kg^{-1}. Exchangeable Magnesium ions (Mg^{2+}) varied from 0.16 to 22.87 Cmol kg^{-1} with an average of 4.11 Cmol kg^{-1}. Exchangeable sodium (Na^+) varied from 0.48 to 3.20 Cmol kg^{-1} with an average of 1.27 Cmol kg^{-1}. Exchangeable potassium (K^+) ranged between 0.10 and 1.55 Cmol kg^{-1} and it has an average of 0.39 Cmol kg^{-1}.

Table 3. Some soil chemical properties of the studied soils samples.

Property	Min.	Max.	Average	STD*
Na^+ (Cmol kg^{-1})	0.05	2.78	0.44	0.5
K^+ (Cmol kg^{-1})	0.001	0.06	0.02	0.02
Ca^{2+} (Cmol kg^{-1})	0.03	1.03	0.15	0.17
Mg^{2+} (Cmol kg^{-1})	0.01	1.31	0.17	0.24
CO_3^{2-} (Cmol kg^{-1})	0	0.2	0.03	0.04
HCO_3^- (Cmol kg^{-1})	0	0.22	0.09	0.05
Cl^- (Cmol kg^{-1})	0.03	4.55	0.57	0.73
SO_4^{2-} (Cmol kg^{-1})	0.02	0.48	0.1	0.08
pH	8.3	10.3	8.99	0.43
EC dS m^{-1}	0.42	13.55	2.53	2.46
CEC (Cmol kg-1)	5.98	55.49	16.68	12.55
Ex. Na^+ (Cmol kg-1)	0.48	3.2	1.27	0.67
Ex. K^+ (Cmol kg-1)	0.1	1.55	0.39	0.31
Ex. Ca^{2+} (Cmol kg-1)	1.96	32.58	9.44	7.64
Ex. Mg^{2+} (Cmol kg-1)	0.16	22.87	4.11	4.36
ESP %	2.03	27.23	9.73	5.38
EMP %	1.89	47.49	22.14	11.69

STD= standard deviation, ESP= exchangeable sodium percentage, EMP= exchangeable magnesium percentage

The CEC values ranged between 5.98 and 55.49 Cmol kg^{-1} with an average of 16.68 Cmol kg^{-1}. These values were associated with the OM content and soil texture as demonstrated in Fig. (10). The exchangeable sodium percentage (ESP) varied from 2.03 to % 27.23 with an average of 9.73 %. These values indicate that the majority of soils in the studied area are non-sodic soils. The higher values were found in the western parts of the studied area close to the Burullus Lake and in the eastern parts close to Damietta governorate as illustrated in Figs. (11 to 13). The exchangeable magnesium percentage (EMP) varied from 1.89 to % 47.49 and it has an average of 22.14 %. The higher EMP values were observed in the middle parts of the studied area close to the Burullus Lake as demonstrated in Figs (14 to 16). The higher EMP values above 40% indicate an alkali soil by magnesium ions, which is common in soils developed on lake deposits of at proximity from lakes. These results are in agreement with those reported by Ismail *et al.* (2005); and El-Gammal *et al.* (2012).

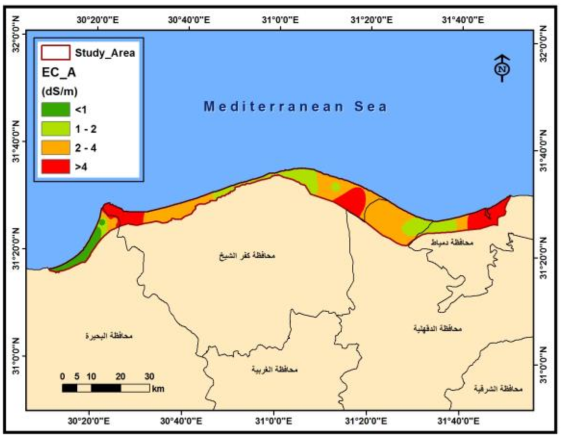

Fig. 7. Spatial variability of the EC values in the surface layer (A) of the studied profiles.

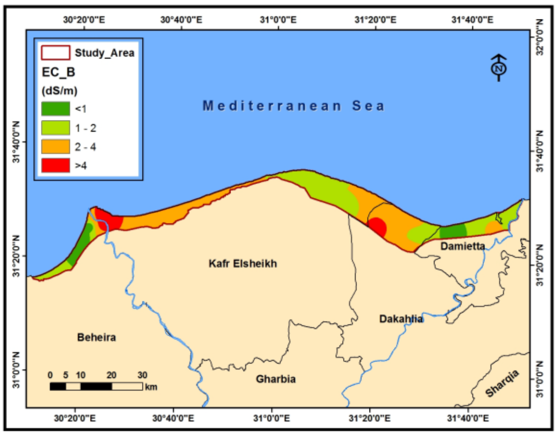

Fig. 8. Spatial variability of EC values in the first subsurface layer (layer B) of the studied area.

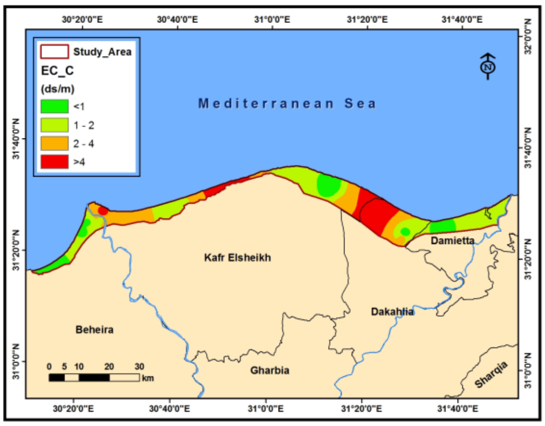

Fig. 9. Spatial variability of EC values in the second subsurface layer (layer C) of studied area.

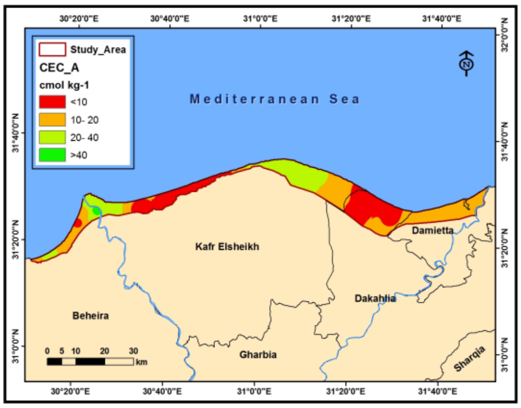

Fig. 10. Spatial variability of CEC values in the surface layer (A) of the studied soil profiles.

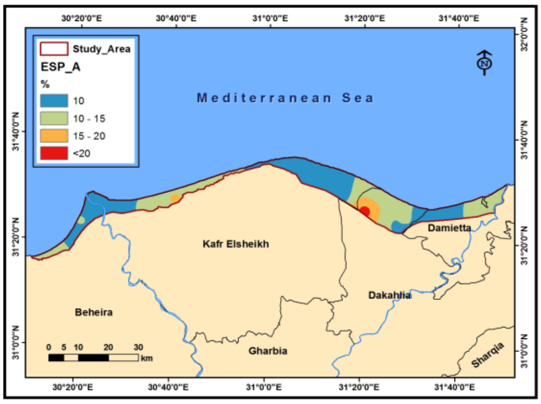

Fig. 11. Spatial variability of ESP values in the surface layer (A) of the studied soil profiles.

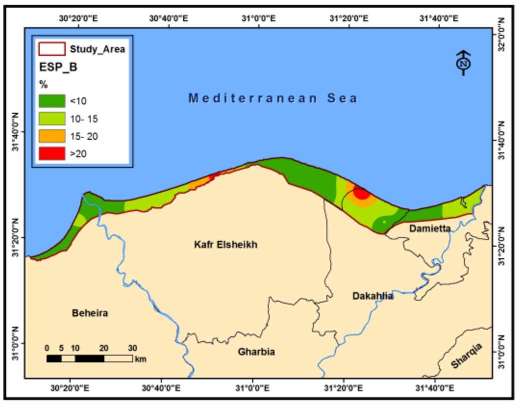

Fig. 12. Spatial variability of ESP values in the first subsurface layer (layer B) of the studied area.

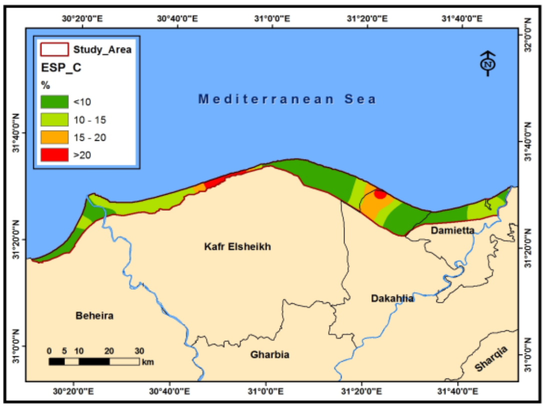

Fig. 13. Spatial variability of ESP values in the second subsurface layer (layer C) of the studied area.

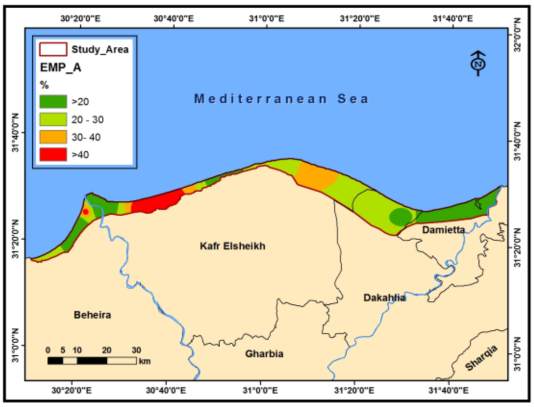

Fig. 14. Spatial variability of EMP values in the surface layer (A) of the studied soil profiles.

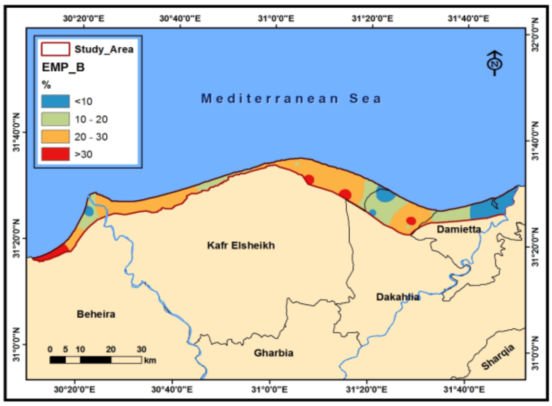

Fig. 15. Spatial variability of EMP values in the first subsurface layer (layer B) of the studied area.

3. Properties of soil fertility and their spatial distribution

Table 4 shows the values of available nitrogen, phosphorus, and potassium in the studied soil samples. Available nitrogen, in general, was low in most of the studied soils and it ranged between 4.69 and 80.31 mg kg^{-1} with an average of 26.73 mg kg^{-1}. The higher values were found in fine-textured soils, which are higher in their content of organic matter. On the other hand, the lower values were found in the western and northern parts of the studied area, which are coarser in their texture and lower in their OM content as demonstrated in Fig. (17).

Available phosphorus was moderate in most of the studied soils. Its values ranged between 5.86 and 25.47 mg kg^{-1} with an average of 14.49 mg kg^{-1}. There was no obvious spatial distribution pattern in these values within the studied area as illustrated in Fig. (18). Available potassium on the other hand ranged between 25.68 and 606.39 mg kg^{-1} with an average of 158.63 mg kg^{-1}. These values indicate that the studied soils vary from very poor to very high in their available potassium content. The higher values were also found in the fine-textured soil, whereas the lower values were found in the coarse-textured soils as represented in Fig. (19).

Table 3. Values of available nitrogen, phosphorus, and potassium in the studied soil samples.

Property	Min.	Max.	Average	STD	Median
Available N (mg kg^{-1})	4.69	80.31	26.73	16.18	28.12
Available P (mg kg^{-1})	5.86	25.47	14.49	4.72	14.28
Available K (mg kg^{-1})	25.68	606.39	158.63	123.81	128.54

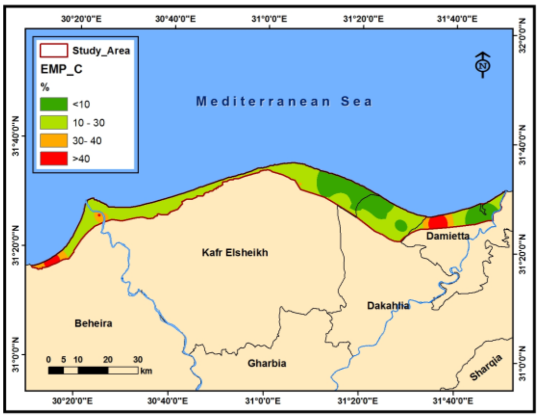

Fig. 16. Spatial variability of EMP values in the second subsurface layer (layer C) of the studied area.

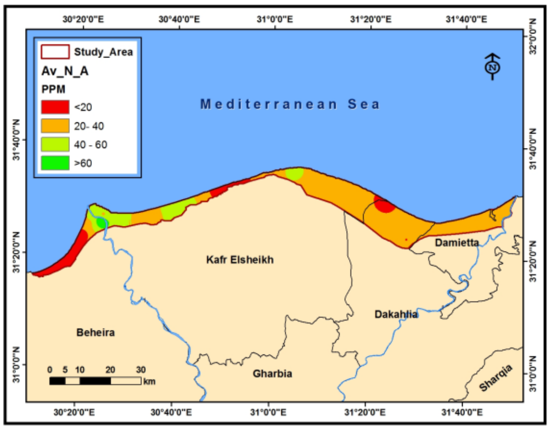

Fig. 17. Spatial variability of available N in the surface layer (A) of the studied soil profiles.

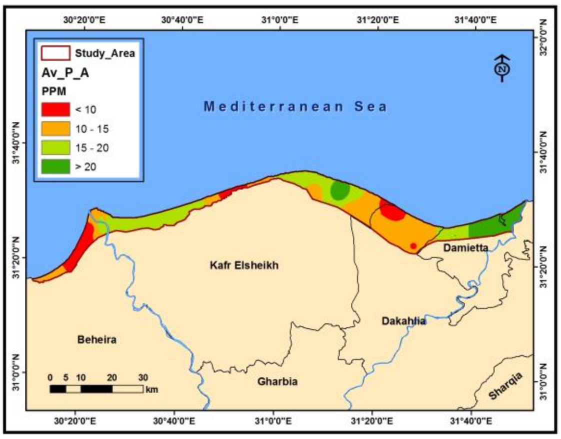

Fig. 18. Spatial variability of available P in the surface layer (A) of the studied soil profiles.

4.Salt-affected soils in the studied area.

Data in Table 4 represent the areas of salt-affected soils and their percentages in the studied area. These data indicate that saline soils based on the EC values in the surface soil layer cover an area of about 212 km^2, which represent about 23.65% of the total area. Sodic soils based on the ESP values in the same soil layer cover an area of about 55.40 km^2 (6.18%). This means that about 30% of the studied area was salt-affected soils. The area of saline soils was decreased to about 71.64 km^2 (7.99%) in Layer B, whereas the area of sodic soils was increased to about 91.58 km^2 (10.21%) in the same layer. In Layer C, the area of saline soils was also decreased to about 57.27 km^2 (6.39%), the area of sodic soils was decreased to about 11.92 km (1.33%) and the area of saline-sodic soils was about 106.66 km^2 (11.89) in the same layer. These results indicate that soil salinity was decreased with soil depth in the studied area, which could be attributed to the higher evaporation rates in this area and the accumulation of salts at or near the soil surface. On the contrary, the areas of sodic and/or saline-sodic soils were increased with soil depth. This could be associated with higher clay content in the subsurface layers Ali and Moghanm, (2013); AbdelRahman *et al.* (2018). The areas of alkali soils caused by magnesium ions were about 83.99 km^2 (9.37%) in the surface layer (A) and about 37.49 km^2 (4.18%) in layer C. These areas were higher than those caused by sodium ions, which could be attributed to the proximity from lakes in the area and the development of some soils in the area on Lacustrine deposits Wahab *et al.*, (2010); El Baroudy and Moghanm, (2014). The spatial distribution of salt-affected soils in the studied area is illustrated in Figs. (20 to 22).

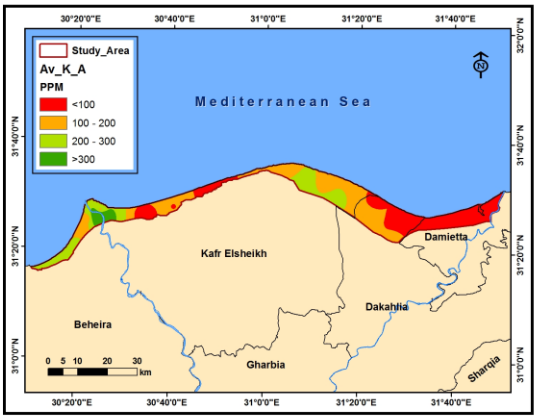

Fig. 19. Spatial variability of available K in the surface layer (A) of the studied soil profiles.

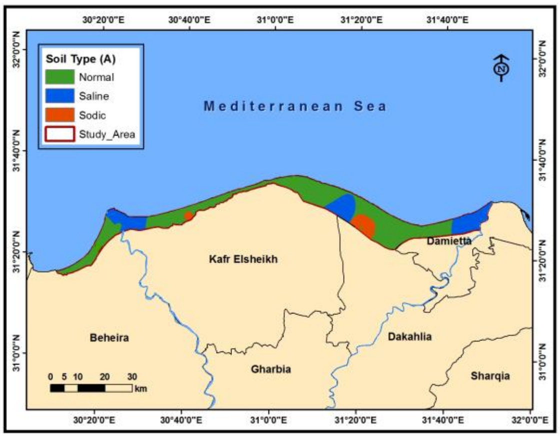

Fig. 20. Spatial distribution of salt-affected soils in the surface soil layer (A) of the studied soil profiles.

Table 4. Areas and percentages of salt-affected soils in the studied area.

Soil Type	Layer A		Layer B		Layer C	
	Area (km²)	%	Area (km²)	%	Area (km²)	%
Normal	629.35	70.18	733.52	81.79	720.95	80.39
Saline	212.05	23.65	71.64	7.99	57.27	6.39
Sodic	55.40	6.18	91.58	10.21	11.92	1.33
Saline & Sodic	0.00	0.00	0.05	0.01	106.66	11.89
Total	896.79	100.00	896.79	100.00	896.79	100.00
Soil Alkalinity by Mg	83.99	9.37	0.00	0.00	37.49	4.18

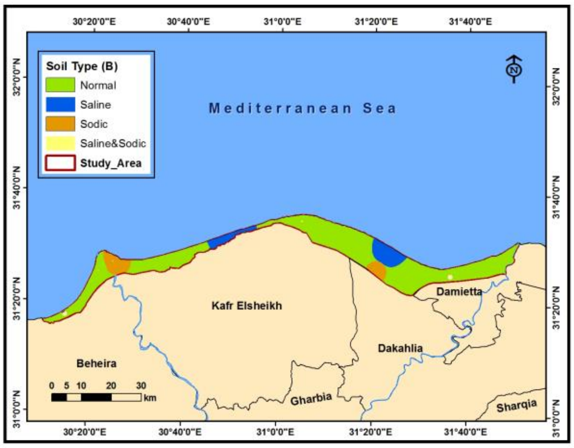

Fig. 21. Spatial distribution of salt-affected soils in the first subsurface soil layer (B).

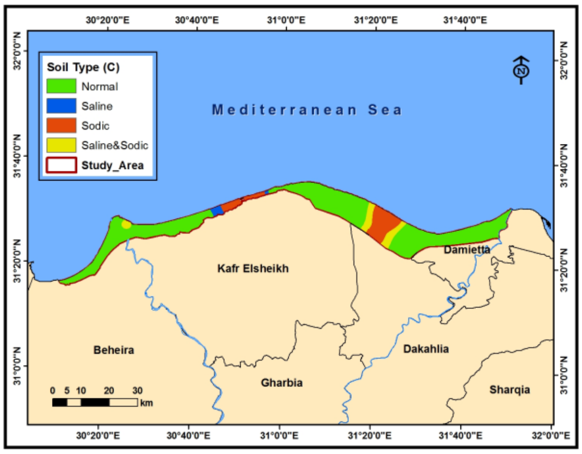

Fig. 22. Spatial distribution of salt-affected soils in the second subsurface soil layer (C).

CONCLUSION

It could be concluded that the use of spatial interpolation techniques particularly the IDW could be very helpful in the interpolation of soil physical, chemical and fertility properties and could provide more accurate information about their spatial distribution within the studied area. It was found that most of the studied soil properties were associated with the soil parent material. Sandy textured soils, which cover the majority of the area, were developed over the sand dune deposits. On the contrary, fine-textured soils were developed on the Nile-silt deposits. Sandy soils were characterized by their higher values of bulk density and total carbonates; however, they have lower values of total porosity, saturation percentage (SP), organic matter (OM), CEC and available NPK. On the other hand, fine-textured soils had higher values of total porosity, SP, OM, CEC and available NPK. It was also found that saline soils were associated with the fine textured soils. These soils cover about one third of the studied area. Soil salinity was concentrated at the surface layer, whereas it was decreased with soil depth. Areas affected by soil-alkalinity due to magnesium, were larger than those caused by sodium. This could be due to proximity from the local lakes in the area and/ or see water intrusion. The majority of soils in the studied area was poor in their contents of nitrogen and potassium, whereas they were fair in phosphorous.

In conclusion, the studied area was affected by soil salinity and poor soil fertility; however, these problems can be mitigated through the application of proper land reclamation and management programs.

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التوزيع المكانى لبعض الخصائص الفزيوكيميائية والخصوبة في شمال دلتا النيل ـ مصر

عبد الحميد احمد النجار*، خالد حسن الحامدي، احمد استفتاح جوهر و محمود موسي عمر

قسم الأراضى ـ كلية الزراعة ـ جامعة المنصورة

يعتبر توافر بيانات دقيقة للتربة قليل للغاية بالنسبة لمعظم المناطق على مستوى العالم ؛ على الرغم من الأهمية البالغة لهذه البيانات فى إدارة واستدامة الموارد الأراضية. والهدف الرئيسي من هذا العمل هو توفير بيانات أكثر دقة عن خصائص التربة الفيزيوكيميائية والخصوبة وتباينها المكاني داخل منطقة الدراسة شمال دلتا النيل في مصر. لذلك تم حفر 19 قطاعا أرضى ممثل للتربة في جميع أنحاء منطقة الدراسة. وتم جمع 59 عينة تربة من الآفاق المحددة و تحليلها للتعرف على خصائصها الفيزيائية والكيميائية والخصوبة. ولقد تم استخدام أسلوب الوزن العكسى المرجح للمسافة (IDW) في تطوير خرائط الاستكمال المكاني لهذه الخصائص. وأوضحت النتائج المتحصل عليها أن الخواص الفيزيائية والكيميائية للتربة المدروسة وخصائص الخصوبة كانت مرتبطة بشكل كبير بمواد الأصل التربة. حيث كانت التربة الخشنة القوام والتي تطورت على الكثبان الرملية أعلى فى الكثافة الظاهرية والكربونات الكلية ؛ بينما كانت أقل في المسامية الكلية ونسبة التشبع (SP) والمواد العضوية (OM) والسعة التبادلية الكاتيونية CEC والعناصر الميسرة الـ NPK. على العكس من ذلك ، كانت التربة الناعمة القوام والتي تطورت على رواسب الطمي النيلي أعلى في المسامية الكلية و SP و OMو CECو .NPK كما وجد أن ثلث الأراضى المدروسة متأثر بملوحة التربة. وكانت المناطق المتأثرة بقلوية التربة الناتجة عن المغنيسيوم أكبر من تلك الناتجة عن الصوديوم. ويمكن أن يعزى ذلك إلى القرب من البحيرات في المنطقة و / أو زحف مياة البحر. وعليه ، فإن منطقة الدراسة متأثرة بالملوحة وتعانى من ضعف الخصوبة مما يتطلب تطبيق البرامج الملاء مة لإدارة واستدامة التربة.