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Fertility Status and Indices of Micronutrients in Nile Valley Soils, East of the Nile River, Assiut Governorate, Egypt

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SOIL surface and subsurface samples were collected using Global Position System (GPS) from selected soil profiles represented the different soils of 4 eastern districts (Abnub, El-Fateh, Sahel saleem and El- Badary) of Assiut Governorate, to evaluate the fertility status and indices of some micronutrients (Fe, Mn, Zn and Cu) as well as their correlations with some chemical properties of these soils. The area of these studied districts that lies in the east of the river Nile was divided into 7 transects. A number of soil profiles was selected in each transect according to the Nile valley width.

Most of the studied soil samples showed neutral to moderately alkaline soil pH, safe soil salinity (EC_e) levels and low to moderate contents of $CaCO_3$. All studied soil samples contained sufficient amounts of the extractable Mn in both surface and subsurface layers, deficient to moderate amounts of the extractable Zn. On the other hand, DTPA- extractable Fe and Cu were always sufficient except for few surface soil samples in Sahel Seleem and subsurface soil samples in Abnub districts which had marginal levels of Fe and Cu, respectively.

All collected soil samples had high nutrient index value (NIV) for both DTPA-Cu and Mn, while they showed medium NIV for DTPA-Zn. On the other hand, both El-Fateh and Sahel Seleem district soils were high NIV of 2.38 and 2.50, respectively, whereas Abnob and El-Badary ones revealed medium NIV of 2.33 and 2.17, respectively for the DTPA- Fe. Significant negative correlations were recorded between the investigated extracted micronutrients and soil pH, EC_e and $CaCO_3$ content, whereas they were positively correlated to OM and CEC.

Key words: Micronutrient status, Nutrient index, Soil chemical properties

Introduction

The continuous cropping over a period of time, especially if the micronutrient fertilization is neglected, may cause depletion in the soil fertility and micronutrient contents in soils. Hence, maintaining or improving of the soil fertility needs a re-evaluation of nutrient levels in the soils every several years. Faragallah (1995) reported that the DTPA- extractable Fe varied from 1.5 to 18.5 mg/kg in some soils located east of Assiut city. Moreover, Amin (2008) found that the DTPA- extractable Fe, Zn, Cu and Mn in soils of Assiut governorate ranged from 2.48 to 67.20 mg/kg, 0.07 to 8.86 mg/kg, 0.10 to 6.55 mg/kg and 1.31 to 98.88 mg/kg, respectively. On the other hand, DTPA- extractable level of Fe, Cu, Zn and Mn in the soils of Azad Jammu and Kashmir, India ranged from 5.73 to 23.36 mg/kg, 0.59 to 4.38 mg/kg, 0.74 to 2.08 mg/kg and 4.59 to 21.08 mg/kg, respectively (Nazif et al., 2006) and in the soils of Rajasthan, India varied from 2.5 to 6.5 mg/kg, 0.11 to 4.1 mg/kg, 0.29 to 3.9 mg/kg and 2.2 to 11.8 mg/kg, respectively (Yadav, 2011). In addition, Kumar et al. (2013) reported that the DTPA- extractable range of Zn and Cu was higher in the surface soil layers of Muzaffarangar district of western Uttar Pradesh (0.46 to 5.80 mg/kg and

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1.64 to 6.16 mg/kg, respectively) compared to that of the subsurface ones (0.332 to 2.65 mg/kg and 1.024 to 4.37 mg/kg, respectively).

Many researchers indicated that the availability of micronutrients may be controlled by some soil properties such as pH, CEC, texture, organic matter content and $CaCO_3$ (Rieuwert et al., 1998), dominant clay minerals, soil drainage and seasonal variations in climatic conditions (Prasad, 1991) as well as crop species and their demands for micronutrients (Mcbride et al., 2003). Positive significant correlations were recorded between the soil organic carbon content and Cu (Mahashabde and Sarashbhai, 2012), Mn and Fe (Yadav and Meena, 2009), as well as Zn (Nofal et al., 2013) extracted by the DTPA. However, negative correlations were reported between the DTPA- extractable Mn, Fe or Zn and both soil pH and CEC, but an opposite trend was found with the extractable Cu (Yadav, 2011). Haribhushan et al., (2013) also revealed that Mn availability was positively affected with the low soil pH. Moreover, the availability of micronutrients increase with increasing the soil fine fraction content (silt and clay) due to the improvement of soil structure and reactions which increase the nutrient availability (Kumar and Babel, 2010).

This research was conducted to evaluate the status and indices of some micronutrients (Fe, Mn, Cu and Zn) in the soils of the districts located east of the Nile river, Assiut governorate, Egypt using the Global Position System (GPS) as a starting point to re- evaluate the same soil at the same points each several years and conducting the availability variation of micronutrients in these soils.

Materials and Methods

Assiut governorate is located in upper Egypt between latitude of 26°50′ to 27°37′ N and longitude of 30°39′ to 31°35′ E. Its total area is about 1558 km^2, representing 0.15% of the total area of Egypt (Amin, 2008). Soils of Assiut Governorate have an irregular relief, whereas, the land surface varies from smooth to almost flat and slightly slopes toward the west. The predominant climate is arid. The daily temperature varies from 5 to 21°C in winter and from 20 to 41°C in summer. The rainfall in the area is practically nil, except some light showers that rarely fall during winter and some unrecorded flash floods coming from the eastern desert. Assiut governorate area in the eastern part of the Nile valley was divided into 7 transects, with a distance about 12 km between successive transects leaving 4 km north of the first transect and south of the last one. Seventeen soil profiles were selected according to the Nile valley width in each transect using the Global Positioning System (GPS), a navigational system involving satellites and computers that can determine the latitude and longitude of any place on earth by computing the time difference for signals from different satellites, for localizing each soil profile. The selected soil profiles represented 4 districts of Assiut governorate (Abnoub, El-Fateh, Sahel Seleem and El-Badary) that are located in the east of the Nile River (Fig. 1)

These soil profiles represented the soils of 6 villages (Shaqalqail, Bni Mohamed, Arab El-Awamer, Abnub, El-Hamam and Arab Motteir villages) for Abnoub district, 4 vellages (Bani Murr, EL-Qassar, El-Sheikh Seweif and Bani talib villages) for El-Fateh district, 4 vellages (El-Mattmer, El-Louka, El-Afadrah and Deir Tasa villages) for Sahel Seleem district and 3 villages (Tel Zaied, El-Hamamia and Jazeret El-Hamamia villages) for El-Badary district. Each profile was dug to the appropriate depth depending upon the level of ground water, the type and nature of the soil material and the presence of hardpan layers. Surface (0 to 30 cm) and subsurface (30 to 60 cm) soil samples were collected from each soil profile in the summer of 2014 after the harvest of wheat that was grown on most of these soils.

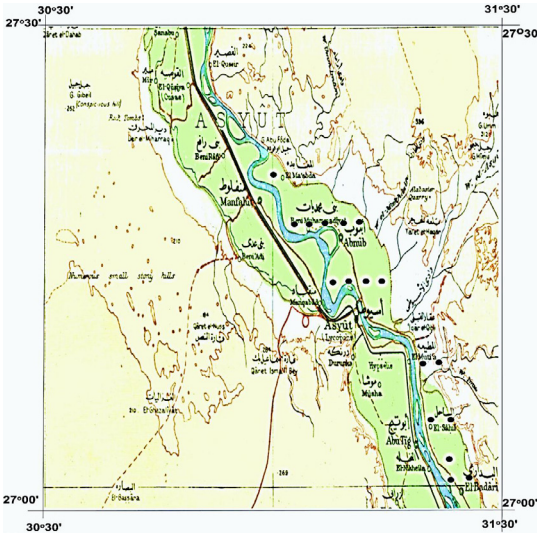

Fig.1. Location map of the soil profiles that represent 4 districts located in the east of the Nile River, Assiut Governorate.

Soil chemical analysis

The soil samples were ground, passed through a 2mm sieve and stored for analysis. The available micronutrient cations were extracted using 0.005 M DTPA diethlene triamine penta-acetic acid (DTPA) at pH 7.3 according to Lindsay and Norvell (1978). DTPA-extractable Fe, Mn, Zn and Cu were determined by atomic absorption sepctrophotometer (GBC). Soil pH was determined by a glass electrode in 1:2.5 ratio of a soil-deionized water suspension. Soil organic matter was determined using the Walkley-Black method **(**Jackson, 1973). Calcium carbonate in the soil was estimated using a volumetric calcium carbonate calcimeter (Nelson, 1982). Electrical conductivity of the saturated soil paste extract (EC_e) was measured as described by Hesse (1998). Cation exchange capacity (CEC) of the soil was measured using 1 M sodium acetate solution at pH 8.2 as a saturation solution and then, exchangeable Na^+ was replaced by NH_4^+ using 1 M ammonium acetate solution at pH 7.0. The replaced Na^+ ions were measured by flame photometer (Baruah and Barthakur, 1997). The soil nutrient index was calculated according to Ravikumar and Somashekar (2013), which in turn it was used to develop the soil fertility index, using the following equation:

$$\text{trient Index} = \frac{(2 \text{ X no. of samples in medium category}) + (3 \text{ X no. of samples in high category})}{\text{Total number of samples}}$$

Results and Discussion

Soil chemical properties

Most of the studied soil samples had a moderately alkaline soil reaction (Table 1). It ranged from 7.56 to 8.43, 7.96 to 8.07, 7.91 to 8.22 and 7.88 to 8.11 in the surface samples, and from 8.01 to 8.71, 7.91 to 8.17, 7.94 to 8.28 and 8.03 to 8.22 in the subsurface ones of Abnub, El-Fateh, Sahel Salem and El-Badary districts, respectively. These results are in a full agreement with those reported by Amin (2008) and Jibhakate et al. (2009). However, the salinity (EC_e) of the soil samples varied from 0.86 to 3.51 dS/m, 0.82 to 1.22 dS/m, 0.85 to 1.48 dS/m and 0.88 and 1.87 dS/m in the surface samples and from 0.79 to 2.71 dS/m, 0.77 to 1.10 dS/m, 0.84 to 1.26 dS/m and 0.84 to 2.34 dS/m in the subsurface ones of Abnub, El-Fateh, Sahel Salem and El-Badary districts, respectively. Most samples

under investigation fall in the category of normal soils according to (Jyoti and Patel, 2012). This can be explained by the continuous irrigation with the Nile water in these studied areas which it contains low amounts of salts and can be used in huge amounts to flush the soluble salts out the soils. Due to the surface application of organic matter (OM), the mean soil OM contents were always higher in the surface samples (1.83, 1.98, 2.08 and 3.03 %) compared to the subsurface ones (1.08, 1.46, 1.22 and 1.79 %) in Abnub, El-Fateh, Sahel Salem and El-Badary districts, respectively. Similar findings were also reported by Nazif et al. (2006) and Amin (2008).

TABLE 1. Range and average values of pH, EC_e, OM, $CaCO_3$, CEC as well as DTPA- extractable Fe, Mn, Zn and Cu of surface and subsurface soil samples of 4 districts located east of Assiut governorate.

District	Depth	pH	EC_e (dS/m)	OM (%)	$CaCO_3$ (%)	CEC (cmol / kg)	DTPA-Fe (mg/kg)	DTPA-Mn (mg/kg)	DTPA-Zn (mg/kg)	DTPA–Cu (mg/kg)
Abnub	Surface	7.56-8.43 (8.16)	0.86-3.51 (1.58)	1.00-2.24 (1.83)	0.46-22.90 (9.94)	20- 43 (35)	6.78-9.22 (7.79)	21.29-93.30 (66.96)	0.40-0.69 (0.55)	0.72-3.11 (1.96)
	Subsurface	8.01-8.71 (8.36)	0.79-2.71 (1.81)	0.24-1.85 (1.08)	1.91-29.77 (11.96)	22- 42 (34)	5.06-10.61 (8.55)	23.84-85.40 (57.78)	0.25-0.80 (0.43)	0.33-3.03 (1.82)
El-Fateh	Surface	7.96-8.07 (8.01)	0.82-1.22 (1.06)	1.45-2.31 (1.98)	2.94-7.25 (5.24)	37- 43 (39)	5.20-11.21 (8.21)	70.21-85.04 (77.89)	0.63-1.5 (1.00)	2.38-3.18 (2.73)
	Subsurface	7.91-8.17 (8.05)	0.77-1.10 (0.91)	1.27-1.75 (1.46)	3.51-6.83 (5.13)	36- 39 (38)	7.12-10.01 (8.42)	64.58-87.19 (77.25)	0.48-0.80 (0.67)	2.39-3.14 (2.75)
Sahel Salem	Surface	7.91-8.22 (8.02)	0.85-1.48 (1.12)	1.20-2.62 (2.08)	3.70-13.51 (7.18)	40- 43 (41)	4.01-10.25 (7.69)	61.56-81.23 (72.68)	0.60-1.03 (0.73)	2.41-3.28 (2.82)
	Subsurface	7.94-8.28 (8.09)	0.84-1.26 (1.03)	0.93-1.63 (1.22)	2.48-16.95 (7.19)	32- 47 (41)	7.90-10.73 (9.35)	48.42-67.55 (58.84)	0.34-0.61 (0.47)	1.68-2.70 (2.33)
El-Badary	Surface	7.88-8.11 (7.98)	0.88-1.87 (1.47)	2.62-3.63 (3.03)	3.32-4.66 (4.18)	38- 47 42.75	7.40-8.65 (8.14)	80.69-88.40 (84.50)	0.88-1.60 (1.19)	2.79-3.65 (3.15)
		8.03-8.22 (8.12)	0.84-2.34 (1.61)	1.21-2.47 (1.79)	3.24-4.77 (4.09)	40- 46 (42)	8.45-9.58 (8.97)	74.95-84.22 (79.75)	0.50-0.83 (0.63)	2.40-3.64 (3.05)

Both El-Fateh and El- Badary districts had considerably low contents of $CaCO_3$ that ranged from 2.94 to 7.25 % and from 3.32 to 4.66 %, respectively, in the surface soil samples and from 3.51to 6.83 % and 3.24 to 4.77 %, respectively, in the subsurface ones. On the other hand, both Sahel Salem and Abnub districts contained higher amounts of $CaCO_3$ and some samples were calcareous with ranges from 3.70 to 13.51 % and from 0.46 to 22.90 %, respectively, in surface soil samples and from 2.48 to 16.95 % and 1.91to 29.77%, respectively, in the subsurface ones. These results match with those reported by Gomah (2001) and Amin (2008). Cation exchange capacity (CEC) ranged from 20 to 43 cmol/kg, 37 to 43 cmol/kg, 40 to 43 cmol/kg and 38 to 47 cmol/kg in the surface soil samples of Abnub, El- Fateh. Sahel Salem and El- Badary districts, respectively, and from 22 to 42 cmol/kg and 36 to 39 cmol/kg, 32 to 47 cmol/kg and 40- 46 cmol/kg, respectively, in the subsurface ones.

Soil micronutrients

Distribution of DTPA- extractable Fe, Mn, Zn and Cu levels (mg/kg) in the surface and subsurface soil samples of the eastern districts of Assiut governorate are shown in Table 1 and illustrated in Fig. 2 - 5. The DTPA- extractable Fe ranged from 6.78 to 9.22 mg/kg, 5.20 to 11.21 mg/kg, 4,01 to 10.25 mg/kg and 7.40 to 8.65 mg/kg in the surface samples and from 5.06 to 10.61 mg/kg, 7.12 to 10.01 mg/kg, 7.70 to10.73 mg/kg and 8.45 to 9.58 mg/kg in the subsurface ones of Abnub, El-Fateh, Sahel Salem and El-Badary districts, respectively. These results are similar to those of Verma et al. (2012). On the other hand, the DTPA- extractable Mn was very high in all soil samples recording ranges of 21.29 to 93.30 mg/kg, 70.21 to 85.04 mg/kg, 61.56 to 81.23 mg/kg and 80.69 to 88.40 mg/kg in the surface soil samples and 23.84 to 85.40 mg/kg, 64.58 to 87.19 mg/kg, 48.42 to 67.55 mg/kg and 74.95 to 84.22 mg/kg in the subsurface ones of Abnub, El-Fateh, Sahel Salem and El-Badary districts, respectively. These results are in the same lines as those obtained by Amin (2008). The mean values of the DTPA- extractable Zn in the surface samples of Abnub, El-Fateh, Sahel Salem and El-Badary districts were 0.55, 1.00, 0.73 and 1.19 mg/kg, respectively, while in the subsurface ones they recorded 0.43, 0.67, 0.47 and 0.63 mg/kg. Moreover, the respective DTPA- extractable Cu in the surface samples of these districts ranged from 0.72 to 3.11 mg/kg, 2.38 to 3.18 mg/kg, 2.14 to 3.28 mg/kg and 2.79 to 3.65 mg/kg, but it varied in the subsurface ones from 0.33 to 3.03 mg/kg, 2.39 to 3.14 mg/kg, 1.68 to 2.70 mg/kg and 2.40 to 3.64 mg/kg. These results coincide with those of Ibrahim et al. (2001).

The levels of DTPA- extractable Mn in the studied soils were always sufficient for plants in both surface and subsurface layers according to Follet and Lindsay (1970) who reported that levels of DTPA- Fe, Mn, Zn and Cu in the soil are considered deficient for plants when they are less than 2.5, 1.0, 0.5 and 0.2 mg/kg, respectively. While they are sufficient for plant needs when they are higher than 4.5, 2.0, 1.0 and 0.5 mg/kg, respectively. According to these results, most of the investigated soil samples are considered deficient to moderate in the extractable Zn. Thus, the plants that are grown on some soils of these studied districts may suffer from Zn deficiency. So, Zn fertilizers should be added to these soils. On the other hand, DTPA- extractable Fe was always sufficient except for few surface soil samples in Sahel Seleem district which had marginal levels of the and thus, they may need Fe fertilization. Whereas, DTPA- extractable Cu was always sufficient except for few subsurface soil samples in Abnub that were marginal.

Soil nutrient index values (NIV)

All investigated soil samples of the studied districts showed high nutrient index values (NIV) for both DTPA- extractable Cu and Mn and medium nutrient index values for the DTPA-extractable Zn (Table 2).On the other hand, both El-Fateh and Sahel Seleem district soils recorded high Fe index values (2.38 and 2.50, respectively) whereas Abnob and El-Badary ones revealed respective medium Fe index values of 2.33 and 2.17. The high nutrient index value for the DTPA Mn was 3.0 in all studied districts, and it was 2.92, 3.0, 3.0 and 3.0 for the DTPA- extractable Cu in Abnob, EL-Fateh, Sahel Seleem and El-Badary districts, respectively. On the other hand, medium NIV's for the DTPA- extractable Zn of 1.42, 2.00, 1.63 and 1.83 were found in Abnob, El-Fateh, Sahel Seleem and El-Badary districts, respectively. All these NIV's are in accordance with the fertility index values that were reported by Dhamak et al. (2014). They reported that the NIV's that are less than 1.67 indicated low fertility status, from 1.67 to 2.33 shows medium fertility status and greater than 2.33 has high fertility status of the soil.

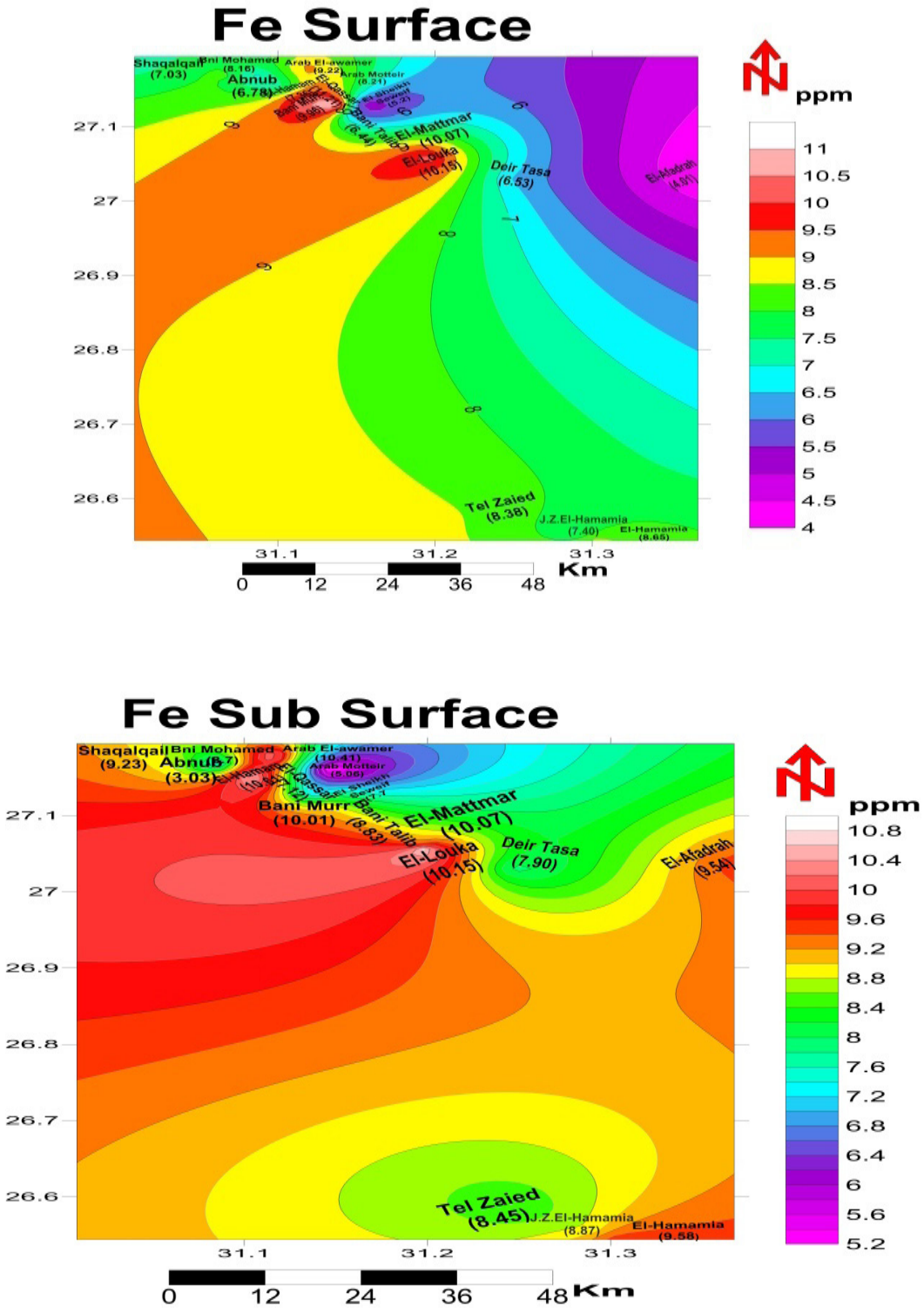

Fig 2. Location map of DTPA- Fe (mg/kg) distribution in the surface and subsurface samples of the studied districts of Assiut Governorate

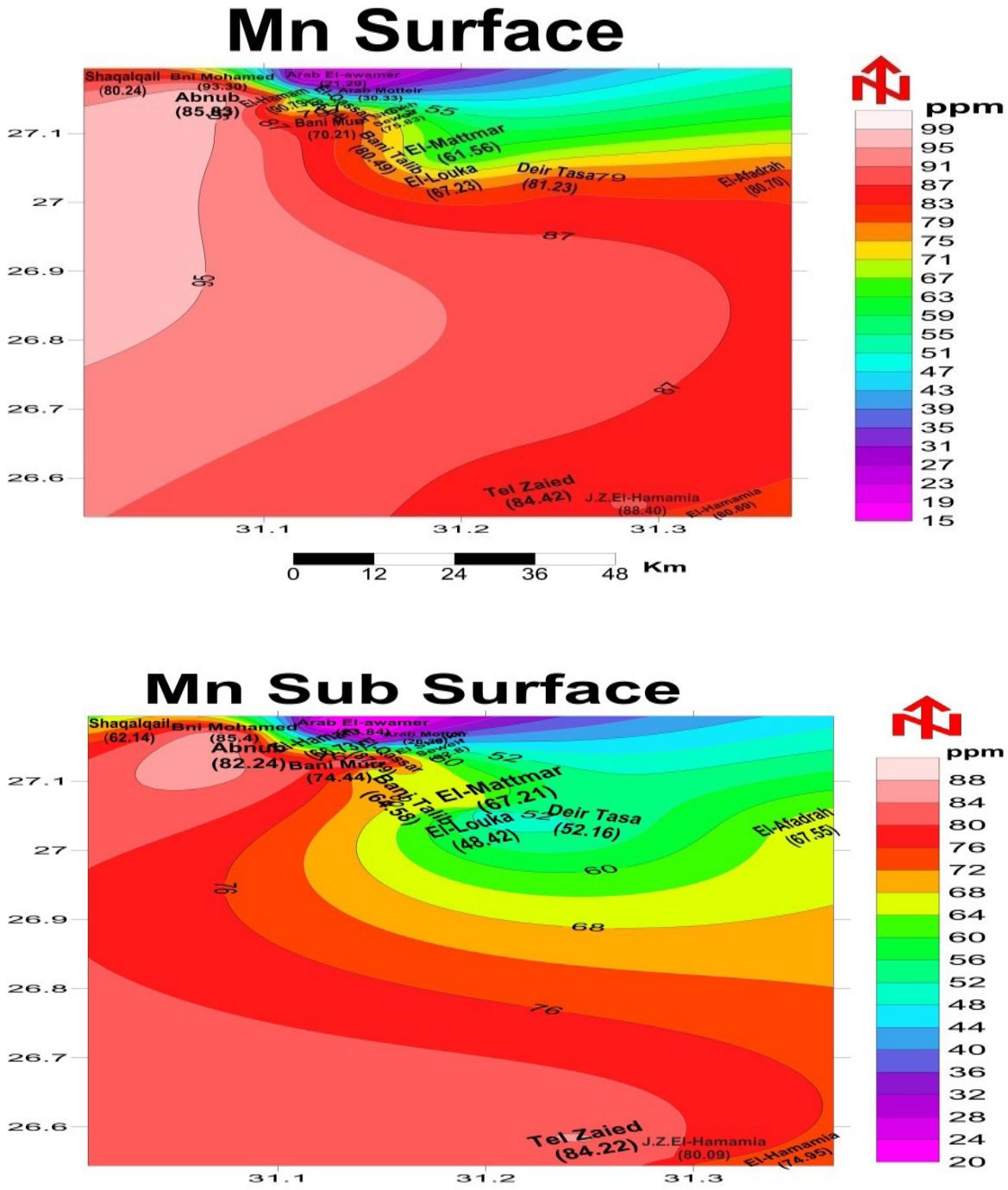

Fig 3. Location map of DTPA- Mn (mg/kg) distribution in the surface and subsurface samples of the studied districts of Assiut Governorate

Soil micronutrient- chemical property correlations

Significant correlations between the investigated micronutrients were always negative with pH, EC_e and $CaCO_3$, and positive with OM and CEC (Table 3). The DTPA-Cu of the surface and subsurface samples had a significantly negative correlation with the soil pH with r values of -0.559* and -0.605*, respectively. These results match with these of Pierzynski et al. (2000). The negative correlation with the soil pH is due to the neutral to alkaline pH values of the tested soil samples which cause a decrease in micronutrient availability. Significantly negative correlations were also observed between the soil

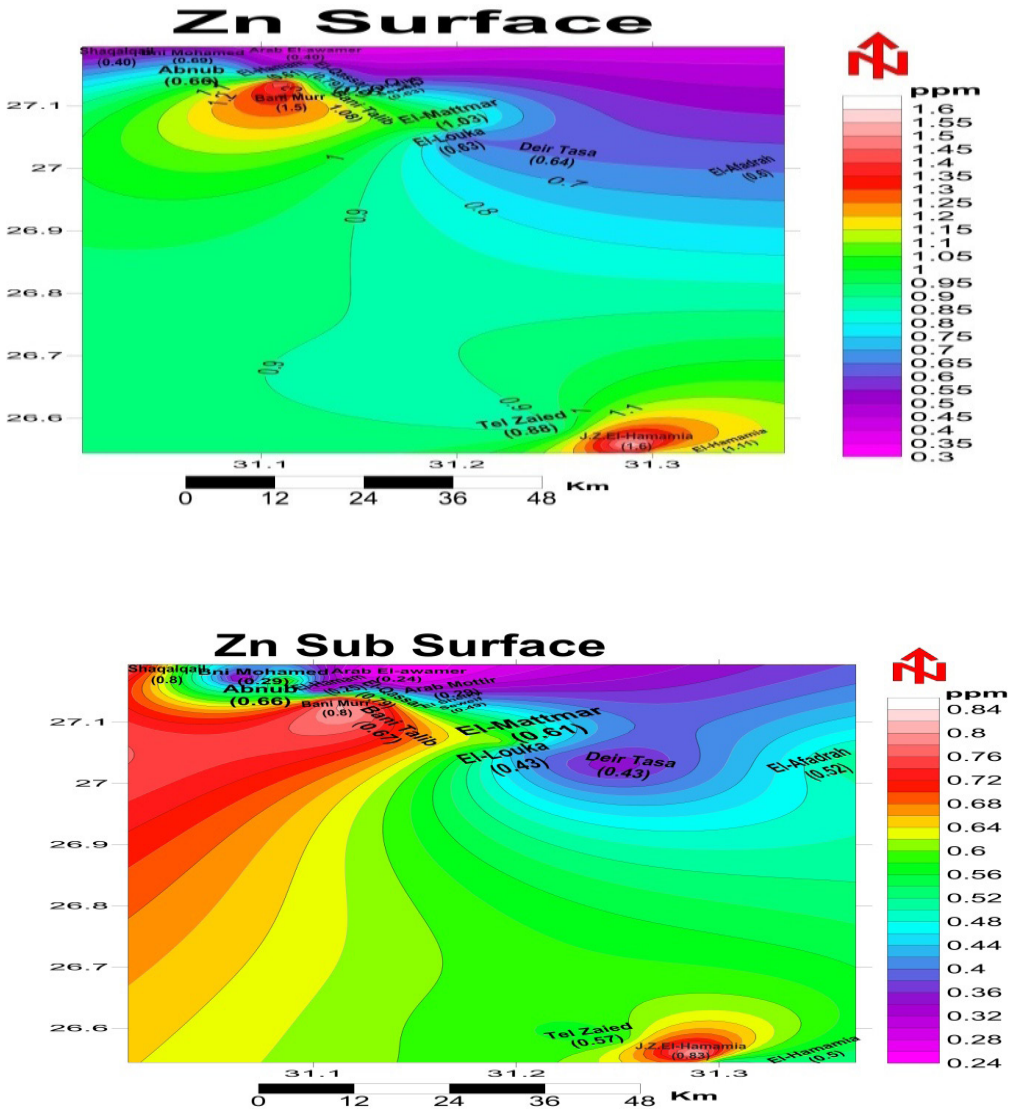

Fig 4. Location map of DTPA- Zn (mg/kg) distribution in the surface and subsurface samples of the studied districts of Assiut Governorate.

TABLE 2. Nutrient index values (NIV) of the DTPA- extractable Fe, Mn, Zn and Cu in 4 districts east of Assiut governorate.

District	DTPA – Fe		DTPA – Mn		DTPA – Zn		DTPA – Cu	
	NIV	Category	NIV	Category	NIV	Category	NIV	Category
Abnub	2.33	Medium	3.00	High	1.42	Medium	2.92	High
El-Fateh	2.38	High	3.00	High	2.00	Medium	3.00	High
Sahel Salem	2.50	High	3.00	High	1.63	Medium	3.00	High
El-Badary	2.17	Medium	3.00	High	1.83	Medium	3.00	High

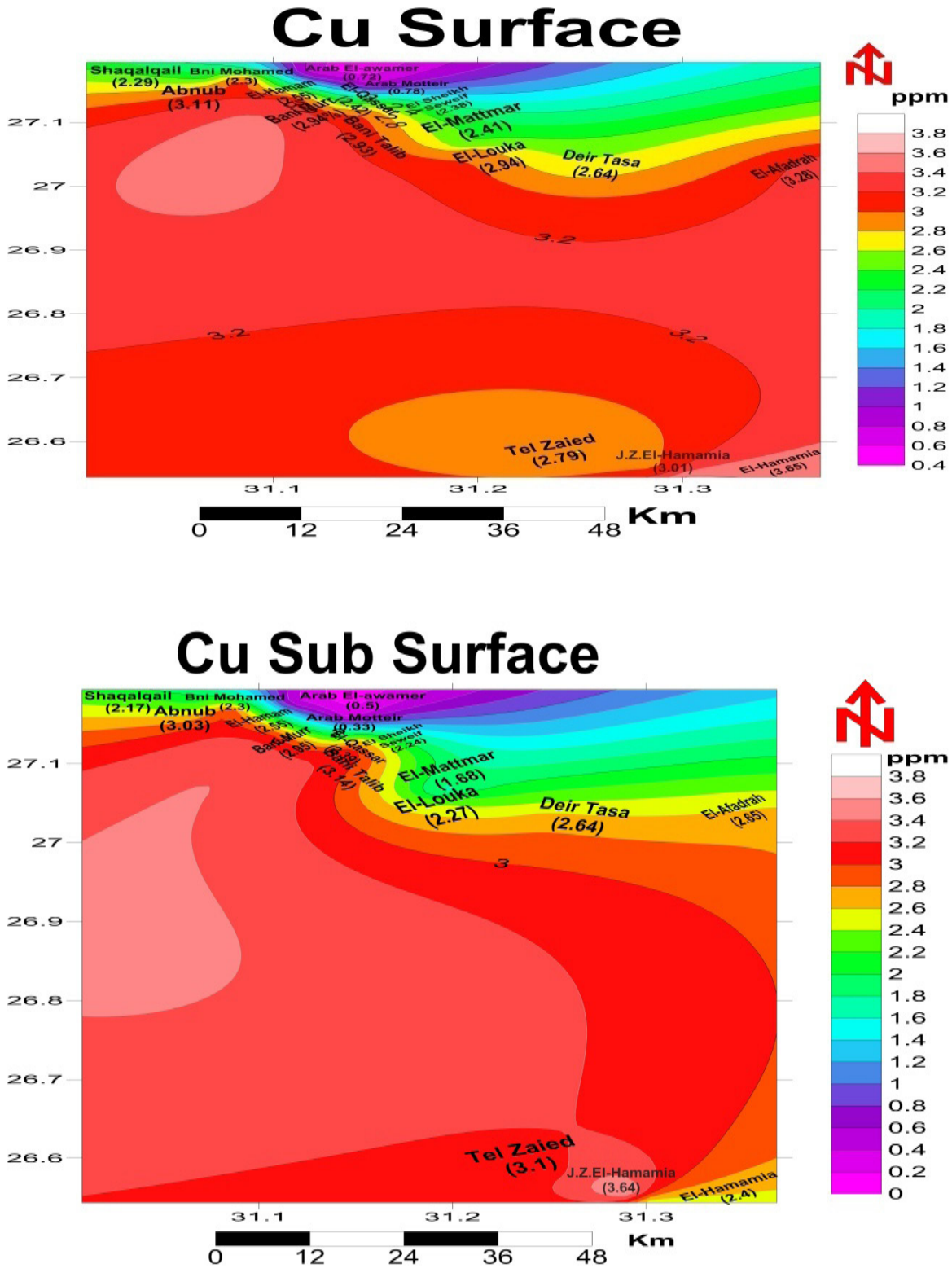

Fig 5. Location map of DTPA- Cu (mg/kg) distribution in the surface and subsurface samples of the studied districts of Assiut Governorate

TABLE 3. Correlation coefficients (r) between some soil properties and DTPA- extractable Fe, Mn, Zn and Cu of the surface and subsurface soil samples of the eastern districts of Assiut governorate.

Chemical Property	DTPA – Fe		DTPA – Mn		DTPA – Zn		DTPA – Cu	
	Surface	Subsurface	Surface	Subsurface	Surface	Subsurface	Surface	Subsurface
pH	-0.066	-0.286	-0.456	-0.366	-0.351	-0.550*	-0.559*	-0.605*
EC_e	0.279	-0.351	-0.716**	-0.446	-0.086	-0.357	-0.666**	-0.530*
OM	-0.045	0.026	0.333	0.787**	0.398	0.607**	0.452	0.858**
$CaCO_3$	0.185	-0.382	-0.916**	-0.726**	-0.328	-0.380	-0.872**	-0.885**
CEC	-0.039	0.096	0.669**	0.724**	0.264	0.402	0.667**	0.798**

*Significant at p= 0.05 level : 0.482, ** Significant at p= 0.01 level: 0.606

salinity (EC_e) and the DTPA- extractable Mn of the surface samples (r=-0.716**) and the DTPA-extractable Cu of the surface and subsurface samples (r=-0.666** and -0.530*, respectively). In addition, the DTPA- extractable Mn and Cu of the surface and subsurface soil samples were highly significantly negatively correlated to the $CaCO_3$ content with r values of -0.916** and -0.726**, respectively, for Mn and -0.872** and -0.885**, respectively, for Cu. Papdopouls and Rowell (1989) indicated that Cu precipitates as hydroxide or hydroxy carbonate resulting in a negative correlation between Cu and $CaCO_3$. The DTPA- extractable Mn ,Zn and Cu were highly significantly positively correlated to the soil OM content of the subsurface soil samples with r values of 0.787**,0.607**and 0.858**, respectively. Ibrahim et al. (2001) showed similar correlation results. The significant positive correlation of the micronutrients with OM is due to their release in the soil from the organic matter decomposition. Zinc solubility increases due to the application of OM which forms soluble organo- metallic complexes (Almas et al., 2000). Both extractable Mn and Cu were recorded to be highly significantly positively correlated to the cation exchangeable capacity (CEC) of the soil samples with r values of 0.669**and o.667**, respectively, in the surface samples as well as 0.724** and 0.789**, respectively, in the subsurface ones. These results agree with those of Amin (2008). The positive relation between the CEC and the available micronutrients is due to the large exchange sites occurred on the clay minerals that allow the micronutrient to be adsorbed in exchangeable and available forms.

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حالة الخصوبه و قيم مؤشرات العناصر الصغرى فى اراضى وادى النيل الواقعه شرق نهر النيل محافظة اسيوط- مصر

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تم جمع عينات تربه سطحيه و تحت سطحيه من بعض القطاعات الارضيه التى تمثل اربع مراكز شرق محافظة اسيوط (ابنوب- الفتح – ساحل سليم – البدارى) وذلك باستخدام نظام تحديد المواقع العالمى لتقدير حالة الخصوبه وقيم مؤشرات بعض العناصر الصغرى (الحديد – المنجنيز – الزنك – النحاس) وعلاقتها ببعض الصفات الكيميائيه للتربه. تم تقسيم المنطقه الواقعه شرق النيل لمحافظة اسيوط الى 7 مقاطع عرضيه وكل مقطع تم تقسيمه الى عدد من القطاعات الارضيه.

كانت معظم الاراضى تحت الدراسه متعادلة الى قلويه خفيفه ، امنه فى محتواها من الاملاح و تتراوح بين الجيريه الخفيفه و المتوسطه.احتوت جميع عينات التربه السطحيه و التحت سطحيه على كميات كافيه من المنجنيز المستخلص و كميات قليله او متوسطه من الزنك. بينما كانت كميات الحديد و النحاس المسخلصه دائما كافيه فيما عدا بعض عينات الطبقه السطحيه لساحل سليم و الطبقه التحت سطحيه لابنوب التى احتوت على كميات متوسطه من الحديد و النحاس على التوالى.

وجد ان كلا من النحاس و المنجنيز المستخلص عالى فى قيم المؤشرات العنصريه فى كل عينات التربه تحت الدراسه بينما كان الزنك دائما متوسط. كما وجد ان اراضى مركزى الفتح وساحل سليم تحتوى على قيم مؤشرات عنصريه عاليه للحديد (2.38 و 2.50 على التوالى) بينما اراضى مركزى ابنوب و البدارى يحتويان على قيم مؤشرات عنصريه متوسطه (2.33 و 2.17 على التوالى). كانت العلاقات المعنويه سلبيه دائما بين العناصر الصغرى المستخلصه كل من كمية الاملاح و درجة الحموضه وكمية كربونات الكالسيوم فى التربه بينما كانت موجبه دائما مع الماده العضويه و السعه التبادليه الكاتيونيه.