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## The cultivation period effects on heavy metals content of some soils of Sohag governorate

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### Abstract

The main objectives of this study are to assess the levels of some heavy metals (i.e. Mn, Cd, Zn, Co, and Cu) in some soils of Sohag governorate under different lands in the respect of cultivation period; and to quantify the metal contamination of these soils. Total number of 114 soil samples was collected from 57 different locations under various land-uses (i.e. old cultivated lands, new cultivated lands, and un-cultivated lands). Un-cultivated soils are considered as a control soil, while old cultivated soils are the oldest soils compared to new reclaimed ones in between. Soil samples were collected from two layers 0-30 cm and 30-60 cm depth to reflect the various fertilizers application used in studied soils. The geo-coordinates of the studied sites were identified using the global Positioning System (GPS). Soil samples were prepared and analyzed for their physicochemical properties as well as for their content of DTPA-extractable heavy metals in the soil testing laboratories using the standard methods of analysis. Maps of DTPA-extractable heavy metals were generated. Correlations between the concentration of the studied elements and some soil properties (i.e. primary sand, silt, clay, pH, OM, CaCO<sub>3</sub>) was developed whereas, a positive correlation was observed between clay content and heavy metal. The obtained results indicated that the highest concentrations of heavy metals were found in the old cultivated soils compared to un-cultivated soils and newly reclaimed soils. Therefore, it should be mentioned that, the cultivation period affects the levels and quantities of these heavy metals in the studied soils. This may be due to agricultural activities such as the use of chemical fertilization.

### Keywords:

Contamination, heavy metals, Sohag, Soil.

## INTRODUCTION

The majority of farmers use very large amounts of fertilizers to achieve maximum yields from their agricultural lands. Excessive application of chemical fertilizer in agricultural soil had caused serious environmental problems, deterioration of soil physical structures, nutrients unbalance of soil, and water eutrophication. These wrong practices are considered as a crime against the natural resources (Jantschi, 2008).

Fertilization is one of the most agricultural practices that increase surface soil content of trace metals in many parts of the world. Basically, the extensive utilization of the chemical fertilizers leads to the soil contamination. Moreover, these chemical fertilizers contain concentrations of heavy metals such as Manganese, Cadmium, Zinc, Cobalt, and Copper. Fertilizers, especially phosphates, are a significant source of nickel in soil. Elevated heavy metal concentrations in the soil can be uptake by growing crops which decreased in their yield and quality. Furthermore, these heavy metals are considered as a potential threat to human health as main consumer (Malidareh et al., 2014). The cultivation periods affect the level of the micro-nutrients in soils. In this scope, the study of heavy metals' behavior and mobility in soils is very crucial.

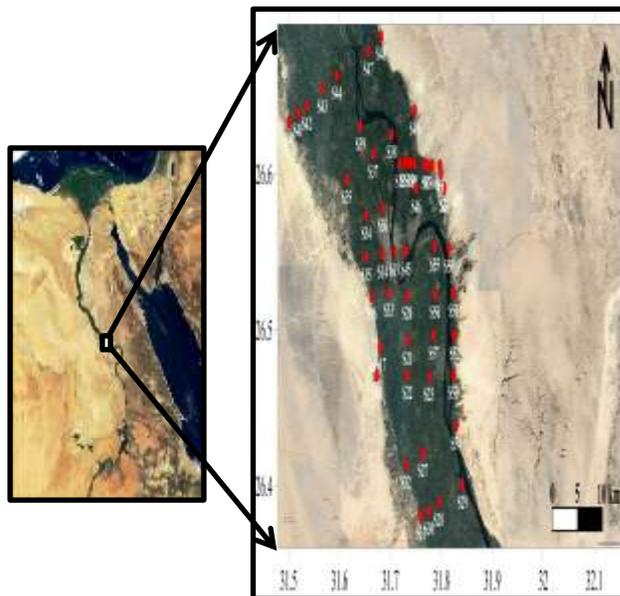
Therefore, it is important to evaluate the availability and mobility of heavy metals in soils as well as in plant to develop environmental guidelines for their potential toxic hazards. Assessment of heavy metals' levels in soil is crucial for understanding the chemical behavior and fate of these contaminants in polluted soils. Excessive metals in human nutrition can be toxic and can cause acute and chronic diseases (Alkhader, 2015).

Thus, on the scope of the previous brief introduction, the main objectives of this study are (i) to assess the levels of some selected heavy metals (i.e. Mn, Cd, Zn, Co, and Cu) in some soils of Sohag Governorate under different land-uses (i.e. old cultivated, new cultivated and un-cultivated) in the respect of cultivation period; and (ii) to quantify the metal contamination of these soils.

## MATERIALS AND METHODS

### The study area

The study area covers fifty seven sites in Sohag Governorate as shown in figure (1). These sites were selected to be assessed for their content of heavy metals. These sites are spatially distributed through various land-uses (i.e. old cultivated lands, new cultivated lands and un-cultivated lands).



### Soil Sampling

Total number of 114 soil samples was collected from different 57 locations. These samples were collected from two depths 0-30 cm and 30-60 cm to reflect the various fertilizers application used in studied soils. The geo-coordinates of each study site were recorded using the Garmin-etrex GPS. All soil samples were prepared in the soil testing laboratories which air-dried, sieved through a 2mm sieve and then stored in air-tight polyethylene bottles to be analyzed for their chemical and physical properties.

### Soil analysis

Particle-size distribution was determined using pipette method as described by Day (1965). Soil pH was measured using glass-electrode of Orion pH meter in (1:5) soil water suspension following the recommended method of Jackson (1973). Total soluble salts were determined using the electrical conductivity meter in the soil water extract (Jackson, 1973). Total calcium carbonates

content was determined volumetrically using Collis Calcimeter (Cottenie et. al., 1982). Organic matter content was determined by the rapid titration method (Walkley and Black, 1934). Soluble cations and anions were determined using the methods described by (Jackson, 1973). Heavy metals were extracted using DTPA method of extraction as described by Lindsay and Norvell (1978), then measured using ICP-OES instrument.

### Statistical analysis

Descriptive statistical analysis of the data of soil properties was developed. Main statistical parameters (i.e. minimum, maximum, and mean) were calculated. Correlation between DTPA-extractable heavy metals and other physicochemical parameters was generated and correlation coefficient values were calculated. All statistical work has been done using Microsoft excel software.

### Mapping of DTPA-extractable heavy metals heavy metals

Golden server v10 software was utilized for mapping the spatial variability of heavy metals through the study area. Geo-coordinates of each sampling sites and corresponding data of DTPA-extractable heavy metals were used as inputs of mapping process.

## RESULTS AND DISCUSSION

### Soil characterization of the studied soils

Table (1) presented some physiochemical properties of the samples collected from studied soils. The obtained data revealed that, the soils under study ranged from slightly to strongly calcareous. The highest  $\text{CaCO}_3$  content increased toward the desert areas in both the new cultivated and uncultivated soils. The results of particle-size distribution of collected soil samples from the studied area showed that the texture class ranging from sandy to clay texture. Most of the soils under consideration fell into low to moderate organic matter. It was observed that the high content of OM (3.77 %) was observed in areas irrigated from canals contaminated with sewage effluent.

Tables (2, 3, and 4) showed some chemical properties of old cultivated soils, new cultivated lands, and un-cultivated lands, respectively. The obtained data revealed that the pH values of the investigated sites ranged from 6.8 to 8.6. The highest pH values were found in subsurface layer of soil sample of sites 32 (S32B) while the lowest one (6.8) was recorded in surface soil sample No. 51 (S51A) and subsurface layer of soil No. 48 (S48B). This result is consistent with those of (Vaseghi et. al., 2005; Brasileira and Solo, 2011) reported that after irrigation with different dilution of sewage water, the pH of the soil decreased significantly that it may be due to the decomposition of organic matter and production of organic acids in the soils irrigated with wastewater.

The studied soils differed from non-saline to moderately saline at the  $\text{EC}_e$  values ranged from 0.38 to 4.02  $\text{dS m}^{-1}$  except those of the sampling from the uncultivated site NO.3 that ranged from 31 to 34.5  $\text{dS m}^{-1}$  due to accumulation of salts in the soils as result of increasing evaporation rate and decreasing the leaching process.

The cationic composition of the soluble salts in the cultivated and uncultivated soil samples was mostly dominated by calcium and /or sodium followed by magnesium and then, potassium which was the least in most of locations . In general, the concentration of soluble cations followed the order of  $\text{Ca} > \text{Na} > \text{Mg} > \text{K}$ . In most of samples of old cultivated soils, the soluble cations followed the order of  $\text{Na} > \text{Ca} > \text{Mg} > \text{K}$  . Exceptional cases were found in sites 4, 11, 28, 35 and 53 where soluble cations followed the order of  $\text{Na} > \text{Mg} > \text{Ca} > \text{K}$  . In this respect, the results showed also that sites 9, 29, 40 and 49 followed the order of  $\text{Ca} > \text{Mg} > \text{Na} > \text{K}$ . Meanwhile, the anionic distribution has variable trends. Therefore, the expected salts were calcium chloride or bicarbonate and sodium chloride or sulphates. Generally, the soluble anions were dominated by Cl followed by bicarbonate in the studied soil samples.

### Soil content of heavy metals in the studied sites

Table (5) showed the concentration of the DTPA-extractable Zinc, manganese, Cobalt, Copper, and Cadmium in the old cultivated soils, new

cultivated soils, and un-cultivated soils, respectively.

#### **DTPA- extractable manganese**

The DTPA-Extractable Mn in old cultivated soils ranged in surface and subsurface layers from 0.42 to 9.96 mg kg<sup>-1</sup>, (mean value of 3.03 mg kg<sup>-1</sup>), from 0.42 -7.86 mg kg<sup>-1</sup> (mean value of 3.28mg kg<sup>-1</sup>), respectively.

Regarding the new cultivated soil samples, the DTPA-extractable Mn in surface and subsurface layers were from 0.12 to 8.04 mg kg<sup>-1</sup> (mean value of 3.10 mg kg<sup>-1</sup>), and from 0.12-12.96 mg kg<sup>-1</sup> (mean value of 4.00 mg kg<sup>-1</sup>).

The DTPA-extractable Mn of the surface and subsurface layers of uncultivated soils ranging from 2.35 to 2.42 mg kg<sup>-1</sup> (mean value of 2.39 mg kg<sup>-1</sup>), and from 2.60 -2.66 mg kg<sup>-1</sup> (mean value of 2.63 mg kg<sup>-1</sup>), respectively.

The level of DTPA-extractable Mn in all studied soil sampling sites ranged from 0.12 to 12.96 mg kg<sup>-1</sup>. Levels of DTPA-extractable Mn in the surface layers were relatively higher in the old cultivated soils compared to the other land use. It was observed that the high concentrations of Mn could be attributed to high level of clay or silt contents in the cultivated soils. These results agree with those obtained by (Bilos et. al., 2001; Koch and Rotard 2001).

#### **DTPA- extractable cadmium**

The concentration of the cadmium in the old cultivated soil samples ranged in surface and subsurface layers from 0.001 to 0.008 mg kg<sup>-1</sup>, (mean value of .03 mg kg<sup>-1</sup>), respectively. The DTPA-extractable Cd in surface and subsurface layers of new cultivated soils varied between 0.01 to .06 mg kg<sup>-1</sup> (mean value of 0.03 mg kg<sup>-1</sup>), while the mean value in un-cultivated soil was 0.07mg/kg<sup>-1</sup> in surface soil and in sub surface soil was 0.03mg/kg<sup>-1</sup>. The measured available Cd in the all studied soils ranged from 0.01 to 0.08. Alloway (1995) mentioned that 0.001 mg kg<sup>-1</sup> of cadmium in the soils indicated non-contamination, 0.001–0.003 mg kg<sup>-1</sup> indicated slight contamination and 0.003–0.01 mg kg<sup>-1</sup> indicated a contaminated soil. In this respect, the samples collected from different locations contained more Cd than 0.003 mg kg<sup>-1</sup> and could be considered as contaminated. This is due to the

lack of sanitary sewage services. Some villages of Sohag governorate dump the sewage water into a trench system first and then into water drains or directly into the water drains. In addition, cadmium enters the soil through various anthropogenic sources including applications of phosphate fertilizers, wastewater, Cd contaminated sewage sludge and manures and metal industries.

#### **DTPA- extractable Zinc**

In the old cultivated soils, the DTPA-extractable Zn in surface and subsurface layers ranged from 0.02 to 0.3.83 mg kg<sup>-1</sup>, (mean value of 0.41 mg/kg<sup>-1</sup>) and from 0.02 to 2.66 (mean value of 0.31mg/kg-1), respectively.

In new cultivated soil samples, the DTPA-extractable Zn in surface and subsurface layers were from 0.02 to .42 mg kg<sup>-1</sup> (mean value of 0.19 mg kg<sup>-1</sup>), and from 0.02 to 1.41 mg kg<sup>-1</sup> (mean value of .25 mg kg<sup>-1</sup>), respectively.

The DTPA-extractable Zn of the surface and subsurface layers of uncultivated soils ranged from 0.79 to 0.83 mg kg<sup>-1</sup> (mean value of 0.81 mg kg<sup>-1</sup>), and from 0.80 to 0.88 mg kg<sup>-1</sup> (mean value of 0.03 mg kg<sup>-1</sup>), respectively.

Generally, the DTPA-extractable Zn decreased with depth where the high level of Zn was found in surface layers. This could be attributed to agricultural activity like fertilization with manure and chemical fertilizers. Similar data have been reported by (Mathur, 2006).

#### **DTPA- extractable cobalt**

Regarding the DTPA-extractable Co content of all soil samples ranged between 0.46 to 3.68 mg kg<sup>-1</sup>. The concentration of the Cobalt in the old cultivated soil samples ranged in surface and subsurface layers from 0.46 to 3.68 mg kg<sup>-1</sup>, (mean value of 1.20 mg/kg<sup>-1</sup>) and from 0.46 to 2.76 (mean value of 0.99 mg/kg<sup>-1</sup>), respectively.

In new cultivated soil samples, the DTPA-extractable Co in surface and subsurface layers were from 0.46 to 2.30 mg kg<sup>-1</sup> (mean value of 0.82 mg kg<sup>-1</sup>), and from 0.46 to 0.92 mg kg<sup>-1</sup> (mean value of 0.66 mg kg<sup>-1</sup>), respectively.

The DTPA-extractable Co of the surface and subsurface layers of uncultivated soils ranged from 1.30 to 1.43 mg kg<sup>-1</sup> (mean value of 1.37 mg

kg<sup>-1</sup>), and from 0.46 -0.47 mg kg<sup>-1</sup> (mean value of 0.46 mg kg<sup>-1</sup>), respectively.

The highest cobalt concentration (3.68 mg kg<sup>-1</sup>) in these old cultivated soil samples was found at surface layer of site 20. The DTPA-extractable Co levels of the surface soils of old cultivated soils are high due to the higher clay content compared to others considering 0.25 mg kg<sup>-1</sup> of the available Co as the critical limit (Stewart, 1953). The toxicity of cobalt under the present soil conditions depends not only on the absolute concentrations of cobalt in the soil but also, on several other factors such as pH, fixation and /or complexation of cobalt by organic matter, and relative concentrations of other nutrients (Maher and Youssef, 2008). It was observed that the high concentrations of cobalt were associated with the high clay content and the industrial zone samples. This suggests that there might be possibility of the soil Co to reach the critical toxic levels around some factories which may be attributed to the passage of industrial wastewater along that sampling area. These results agree with those obtained by (Krishna and Govil, 2007).

#### **DTPA- extractable copper**

The obtained data showed that the DTPA-extractable Cu values in all studied soil sites ranged from 0.01 to 3.00 mg/ kg<sup>-1</sup>. The DTPA-extractable Cu of the old cultivated soil ranged in surface and subsurface layers from 0.01 to 2.59 mg/kg<sup>-1</sup> (mean value of 1.19 mg/kg<sup>-1</sup>) and from 0.14 to 3.00 mg/kg<sup>-1</sup> (mean value 0.14 mg/kg<sup>-1</sup>), respectively.

Regarding the new cultivated soils, the DTPA-extractable Cu in surface and subsurface layers were 0.00 to 1.32 mg/kg<sup>-1</sup> (mean value 0.92 mg/kg<sup>-1</sup>) and 0.00 to 2.95 mg/kg<sup>-1</sup> (mean value 1.01 mg/kg<sup>-1</sup>), respectively.

The DTPA-extractable Cu of the un-cultivated soil samples ranged in surface and subsurface layers from 0.3 to 0.38 mg/kg<sup>-1</sup> (mean value of 0.33 mg/kg<sup>-1</sup>) and from 0.09 to 0.9 mg/kg<sup>-1</sup> (mean value 0.6 mg/kg<sup>-1</sup>), respectively.

The highest content of Cu was observed in the old cultivated soils compared to these found in new cultivated and uncultivated soils. It is observed that Cu content in surface layer of old cultivated soil was higher than that in subsurface layer. In contrary the concentration of available Cu was

higher in subsurface than surface layers in new cultivated soil. The soil contaminated by Cu results from its utilization of materials containing Cu such as fertilizers, sprays and agricultural and organic wastes as well as industrial emissions.

The distribution of the DTPA-extractable Cu in soils was classified into five classes of very low (<0.3 mg kg<sup>-1</sup>), low (0.3-0.8 mg kg<sup>-1</sup>), sufficient (0.8-1.5 mg kg<sup>-1</sup>) high (1.5-3 mg kg<sup>-1</sup>) and very high (>3 mg kg<sup>-1</sup>). According to MAFF (1988), most of the studied soil samples had sufficient Cu levels followed by these of high levels and then of low levels. Although the levels of heavy metals in the agricultural soils are very small, the repeated use of organic and inorganic fertilizer and the long persistence time for metals, dangerously high accumulation of some metal could occur (Verkleji, 1993).

#### **Mapping of DTPA-extractable heavy metals**

Figures 2, 3, 4, 5, and 6 showed the spatial variability maps of DTPA-extractable heavy metals heavy metals in the study area. Each map consists of various classes with different colors. Each class shows a range of soil content of DTPS-extractable heavy metal.

#### **Correlation between DTPA-extractable heavy metals and some soil properties.**

In order to quantify the inter-variable relationship among the studied soils through the whole study area, the correlation coefficient was calculated for the estimated heavy metals and pH, OM, CaCO<sub>3</sub>, sand, silt and clay content. The calculated correlation coefficient are given in table (6).

The DTPA-extractable Mn showed a significant positive correlation (r=0.108, 0.068 and 0.032) with the sand content, pH and OM content, respectively but a negative correlation (r = -0.076, 0.064 and 0.247) with the silt content, clay content and CaCO<sub>3</sub> content, respectively. These results are in good agreement with those obtained by (Ibrahim et al., 2017).

A significantly negative correlation was also found between the DTPA-extractable Co and the sand content, pH r=-0.103 and 0.012 respectively. The availability of Co decreases with increasing pH value and sand content of the soil, due to the lower solubility of Zn minerals and increasing the adsorption of Zn by negatively charged colloidal soil particles (Alloway, 1995).

Moreover, the positive correlation ( $r=0.116$ ,  $0.006$ ,  $0.047$  and  $0.258$ ) were found between DTPA extractable Co and silt, clay OM and  $\text{CaCO}_3$  content, respectively. Insignificantly negative correlations were found between the DTPA-extractable Cu and pH and  $\text{CaCO}_3$  with  $r$  values of  $-0.059$ , and  $-0.042$ , respectively.

The results also showed that significantly negative correlations of  $r$  value of  $-0.126$  was found between the DTPA-extractable Cu sand content. In addition, positive correlations  $r=0.058$ ,  $0.113$ ,  $0.348$  were found between the DTPA-extractable Cu and silt, clay, OM content, respectively.

The results showed that non-significantly negative correlations ( $r=0.104$  and  $-0.099$ ) were found between the DTPA-extractable Cu and  $\text{CaCO}_3$  and silt content of the cultivated soil samples, respectively. The results also showed that non-significantly negative correlations ( $r=-0.041$  and  $-0.065$ ) were found between the DTPA-extractable Zn and sand, calcium carbonate content, respectively. In addition, insignificant positive correlations  $r=0.023$ ,  $0.32$ ,  $0.040$  and  $0.158$  were found between the DTPA-extractable Zn and the silt, clay pH and OM content of soil samples, respectively.

Negative correlations ( $r=-0.052$ ,  $0.001$  and  $-0.002$ ) were found between the DTPA-extractable

Cd and sand, pH and OM content, respectively. Gray and McLaren (2006) found that the total Cd content, soil pH and total carbon content were found to be significant predictors of the soluble Cd concentration. The effects of soil pH on the Cd uptake by crops are due to the increased availability at lower soil pH values, However, positive correlations ( $r=0.024$ ,  $0.047$  and  $0.082$ ) were found between the DTPA-extractable Cd and silt, clay and  $\text{CaCO}_3$  contents in soil samples, respectively.

## CONCLUSION

This study indicated that most heavy metal were above the natural heavy metal concentration. Heavy metal concentrations in old cultivated soil samples are mostly higher than control soil and New cultivated due to metals emitted anthropogenic sources including applications of phosphate fertilizers, wastewater, sewage sludge and manures and metal industries. Correlations between the concentration of the studied elements and some soil properties, primary sand, silt, clay, pH, OM,  $\text{CaCO}_3$ . Positive correlation were observed between clay content and heavy metal.

Table (1) Some physiochemical properties of the studied soils.

Statistical parameter	Particle size distribution			Texture class	SP	OM	CaCO <sub>3</sub>
	Sand	Clay	Silt				
	%						
<b>Old Cultivated Soils</b>							
<b>Min</b>	4.54	3.20	0.74	???	21.67	0.05	0.21
<b>Max</b>	94.44	60.80	82.44	???	100.00	3.23	12.47
<b>Average</b>	51.67	24.13	24.51	???	54.64	1.37	3.08
<b>New Cultivated Soils</b>							
<b>Min</b>	15.04	1.60	1.42	???	16.67	0.05	2.47
<b>Max</b>	89.90	47.32	77.78	???	67.50	3.77	42.82
<b>Average</b>	57.32	17.64	25.03	???	41.13	1.45	15.69
<b>Uncultivated Soils</b>							
<b>Min</b>	90.56	1.04	5.30	???	20.00	0.30	34.42
<b>Max</b>	93.34	4.14	5.62	???	45.00	0.40	35.24
<b>Average</b>	91.95	2.59	5.46	???	32.50	0.35	34.83

Table (2) Some chemical properties of the soil samples collected from new cultivated soils

Sample No.	pH	ECe	Ca	Mg	Na	K	HCO <sub>3</sub>	Cl	SO <sub>4</sub>
		ds/m							
<b>S1A</b>	7.80	1.79	3.15	1.58	4.36	0.26	2.10	6.83	0.49
<b>S1B</b>	7.90	0.69	1.00	0.45	1.95	0.15	1.00	2.00	0.47
<b>S2A</b>	7.40	1.29	2.15	0.86	4.74	0.12	2.46	3.69	1.75
<b>S2B</b>	8.10	1.39	1.80	1.08	5.22	0.24	1.80	4.20	2.34
<b>S4A</b>	7.90	1.68	1.52	0.76	3.91	0.15	1.52	3.04	1.81
<b>S4B</b>	8.00	2.00	1.48	0.93	1.15	0.02	0.74	2.22	0.74
<b>S5A</b>	7.90	2.92	4.00	3.00	7.15	0.20	1.00	12.5	1.10
<b>S5B</b>	7.70	0.80	0.32	0.19	2.02	0.03	0.64	1.60	0.32
<b>S6A</b>	7.50	0.99	0.90	0.47	2.80	0.13	1.29	2.58	0.39
<b>S6B</b>	7.60	0.99	0.90	0.45	2.58	0.16	1.23	2.05	0.77
<b>S16A</b>	8.20	1.68	2.29	1.15	5.79	0.17	2.29	5.73	1.62
<b>S16B</b>	8.10	1.49	2.20	1.22	5.12	0.24	3.05	4.88	1.18
<b>S17A</b>	7.90	0.70	1.82	0.54	2.09	0.20	1.35	2.03	1.34
<b>S17B</b>	8.40	1.68	1.73	0.69	3.29	0.03	1.04	4.16	0.62
<b>S18A</b>	8.40	1.13	0.63	0.21	1.53	0.11	0.84	1.26	0.28
<b>S18B</b>	8.50	0.92	0.43	0.17	0.90	0.05	0.50	1.00	0.03
<b>S40A</b>	7.80	1.49	0.45	0.17	1.82	0.03	0.50	1.67	0.32
<b>S40B</b>	7.40	1.26	0.25	0.10	1.98	0.04	0.38	1.71	0.30

Table (4) Some chemical properties of the soil samples collected from old cultivated soils

Sample No.	pH	ECe ds/m	Ca	Mg	Na	K	HCO <sub>3</sub>	Cl	SO <sub>4</sub>
S7A	7.8	0.6	1.1	0.7	1.9	0.1	0.6	3.0	0.2
S7B	8.0	0.6	1.2	0.3	2.0	0.1	1.2	1.8	0.6
S8A	7.8	0.5	0.6	0.3	2.2	0.1	1.3	1.9	0.1
S8B	8.0	0.9	1.8	1.2	1.9	0.1	1.8	3.0	0.4
S9A	7.9	0.9	1.4	1.4	3.0	0.1	1.4	3.5	1.2
S9B	7.8	0.8	2.0	0.7	2.5	0.1	2.0	2.7	0.5
S10A	7.8	0.7	1.3	0.5	2.0	0.5	1.3	2.6	0.4
S10B	7.7	0.6	1.0	0.2	2.0	0.1	1.3	2.0	0.4
S11A	8.0	1.2	3.7	2.2	2.8	0.4	4.5	3.7	1.0
S11B	8.0	1.0	1.1	0.6	1.3	0.1	0.6	1.7	0.6
S12A	7.9	1.9	3.1	1.2	2.4	0.4	1.5	3.9	1.8
S12B	7.7	1.0	1.3	0.4	1.7	0.4	1.3	2.1	0.8
S13A	7.8	1.2	2.8	1.4	1.5	0.0	1.9	3.2	0.5
S13B	7.9	1.0	1.8	0.4	1.6	0.3	1.3	2.6	0.3
S14A	8.1	0.9	1.5	0.8	1.8	0.2	1.0	2.0	1.4
S14B	8.0	0.8	1.2	0.8	1.2	0.1	0.8	2.4	0.1
S15A	8.0	1.1	0.8	0.4	3.1	0.1	0.8	3.3	0.3
S15B	8.1	0.7	1.2	0.4	0.8	0.2	0.8	1.5	0.3
S19A	8.4	2.5	2.9	1.6	3.5	0.2	1.0	6.5	0.8
S19B	8.4	2.3	2.2	1.3	3.2	0.5	1.6	5.1	0.5
S20A	7.3	0.6	1.1	0.8	1.1	0.2	1.1	1.7	0.3
S20B	7.0	0.5	1.1	0.5	1.3	0.1	1.1	1.6	0.2
S21A	7.5	1.3	1.6	0.6	4.5	0.1	2.1	3.6	1.1
S21B	7.4	1.2	0.3	5.8	5.4	0.2	1.2	5.2	0.6
S22A	7.7	0.9	1.0	0.3	4.2	0.2	1.3	3.2	1.2
S22B	7.3	0.8	1.3	0.7	3.1	0.1	1.3	2.7	1.2
S23A	7.2	0.5	0.6	0.3	1.5	0.2	0.6	1.7	0.3
S23B	7.1	0.5	0.4	0.3	1.9	0.1	1.5	1.0	0.1
S24A	7.3	0.5	0.8	0.3	0.8	0.2	0.4	1.2	0.5
S24B	7.4	0.8	0.6	0.2	1.5	0.0	0.7	1.7	0.3
S25A	7.5	0.7	0.7	0.4	2.7	0.3	1.3	2.5	0.3
S25B	7.5	0.6	1.1	0.5	1.6	0.2	1.2	1.8	0.3
S26A	7.4	0.5	0.3	0.1	1.2	0.1	0.7	0.7	0.4
S26B	7.7	0.7	1.2	0.4	0.9	0.1	1.2	0.8	0.6
S27A	7.4	0.8	1.3	0.7	2.9	0.4	1.9	2.5	0.5
S27B	7.8	0.8	0.8	0.7	3.0	0.2	1.2	2.9	0.6
S28A	8.2	0.7	1.1	0.5	2.6	0.2	1.2	2.5	0.7
S28B	8.0	0.4	0.8	0.3	1.1	0.1	0.6	1.1	0.4
S29A	7.7	1.1	2.0	1.0	2.3	0.3	1.5	3.5	0.6
S29B	8.2	1.1	1.6	0.5	3.4	0.2	2.1	3.1	0.5
S30A	8.2	1.2	1.7	0.7	4.1	0.2	1.7	3.4	1.7
S30B	7.9	1.4	1.7	0.8	5.3	0.1	1.7	5.0	1.2
S31A	8.1	1.6	2.4	1.8	5.8	0.2	1.8	6.6	1.3
S31B	8.4	1.4	2.5	1.9	3.7	0.2	0.6	3.1	4.6
S32A	8.2	4.0	6.9	4.5	15.7	0.3	5.3	18.7	2.8
S32B	8.4	3.1	5.3	4.5	14.9	0.1	3.8	18.2	1.3
S33A	8.2	0.6	1.8	0.4	1.3	0.1	0.6	1.8	1.1
S33B	7.3	0.8	1.3	0.7	2.3	0.1	1.8	2.4	0.3
S34A	7.3	0.7	1.3	0.6	1.8	0.2	1.5	2.0	0.1

Sample No.	pH	ECe ds/m	Ca	Mg	Na	K	HCO <sub>3</sub>	Cl	SO <sub>4</sub>
S34B	7.5	0.5	0.8	0.5	1.1	0.1	0.6	1.7	0.3
S35A	7.5	0.6	0.9	0.3	1.8	0.2	1.1	1.7	0.3
S35B	7.7	0.7	1.1	0.7	2.2	0.1	1.3	2.5	0.3
S36A	7.5	0.5	0.9	0.4	1.2	0.1	1.0	1.0	0.4
S36B	7.1	0.6	1.3	0.7	1.0	0.1	1.0	1.5	0.5
S37A	7.5	0.7	1.3	0.6	1.7	0.2	0.6	1.8	1.5
S37B	7.3	0.7	1.7	1.3	3.6	0.3	2.0	3.0	1.6
S38A	7.6	0.6	0.3	0.1	0.8	0.0	0.7	0.4	0.1
S38B	7.5	0.4	0.5	0.2	1.1	0.1	0.9	0.5	0.5
S39A	7.4	0.7	1.3	1.0	4.3	0.2	1.0	3.0	2.6
S39B	7.4	0.8	1.1	0.5	2.6	0.1	1.1	2.3	1.0
S41A	7.1	0.5	0.7	0.3	1.5	0.2	1.0	1.0	0.6
S41B	7.7	0.3	0.3	0.2	1.0	0.1	0.6	0.6	0.5
S42A	7.5	0.9	0.6	0.5	3.5	0.1	1.1	2.8	1.1
S42B	7.5	1.5	1.7	0.4	7.5	0.1	2.1	6.3	2.0
S43A	7.2	0.9	1.6	0.8	3.1	0.4	1.7	3.5	0.2
S43B	7.0	0.9	1.2	0.6	2.9	0.3	2.4	2.4	0.6
S44A	7.0	0.4	1.0	0.4	1.0	0.1	0.6	0.6	1.0
S44B	7.1	0.8	1.4	1.4	2.1	0.1	1.4	3.4	0.5
S45A	7.2	0.8	1.6	0.8	1.4	0.2	1.6	2.2	0.5
S45B	7.1	0.6	1.2	0.6	1.4	0.1	1.1	1.6	0.6
S46A	7.3	0.5	1.0	0.5	1.0	0.2	0.5	1.5	0.7
S46B	7.2	0.5	0.7	0.9	1.5	0.1	1.1	1.1	0.5
S47A	7.0	0.7	0.8	0.3	3.9	0.1	2.0	2.0	0.5
S47B	7.4	0.7	1.1	0.4	3.7	0.1	2.2	2.9	0.1
S48A	7.0	0.8	1.4	0.8	3.0	0.1	2.1	2.8	0.4
S48B	6.8	0.6	1.7	0.8	1.9	0.1	2.2	1.4	0.9
S49A	7.1	0.6	0.9	0.3	2.2	0.1	0.6	1.2	1.7
S49B	7.0	0.5	0.9	0.3	1.3	0.1	0.6	1.8	0.3
S50A	7.6	0.4	1.1	0.3	1.3	0.3	0.8	1.7	0.6
S50B	7.3	0.3	0.6	0.2	0.8	0.1	0.5	0.5	0.6
S51A	6.8	0.4	0.6	0.3	1.1	0.1	0.6	1.2	0.3
S51B	7.3	0.3	0.3	0.1	0.5	0.1	0.4	0.4	0.2
S52A	7.0	0.5	1.5	0.3	1.0	0.1	1.1	1.1	0.7
S52B	7.1	0.8	2.1	0.6	1.4	0.1	1.6	2.1	0.
S53A	7.3	0.7	1.4	0.4	1.2	0.1	0.9	1.4	0.8
S53B	6.8	0.5	1.2	0.3	0.4	0.1	1.2	0.8	0.1
S54A	6.9	0.7	1.5	0.2	0.9	0.1	0.8	1.2	0.7
S54B	7.3	0.5	0.5	0.1	0.7	0.3	0.7	0.7	0.4
S55A	7.7	0.6	0.5	0.2	1.2	0.0	0.8	0.8	0.7
S55B	7.5	0.5	0.8	0.2	1.0	0.1	0.8	0.8	0.4
S56A	7.1	1.0	2.1	0.3	2.8	0.3	2.1	2.6	0.7
S56B	7.3	0.9	1.3	0.9	1.4	0.0	1.3	1.7	0.8
S57A	7.1	0.6	1.8	0.6	1.1	0.1	1.3	1.3	1.1
S57B	7.2	0.4	0.5	0.2	0.6	0.0	0.4	0.9	0.4

Table (5) Some chemical properties of the soil samples collected from un-cultivated soils

Sample No.	pH	ECe	Ca	Mg	Na	K	HCO <sub>3</sub>	Cl	SO <sub>4</sub>
		ds/m	meq/100g						
S3A	7.30	34.50	18	10	32.02	9.01	2.00	66.00	1.00
S3B	7.60	31.10	25	5.98	40.46	8.71	1.56	78.26	1.04

Table (6) Available heavy metals content in the studied sites.

Depth	Statistical parameter	Zn	Mn	Co	Cu	Cd
		mg/kg <sup>-1</sup>				
<b>Old Cultivated Soils</b>						
A	Min	0.02	0.42	0.46	0.01	0.01
	Max	3.83	9.96	3.68	2.59	0.08
	Mean	0.41	3.03	1.20	1.19	0.03
B	Min	0.02	0.42	0.46	0.14	0.01
	Max	2.66	7.86	2.76	3.00	0.08
	Mean	0.31	3.28	0.99	1.12	0.04
<b>New Cultivated Soils</b>						
A	Min	0.02	0.12	0.46	0.00	0.01
	Max	0.42	8.04	2.30	1.32	0.06
	Mean	0.19	3.10	0.82	0.92	0.03
B	Min	0.02	0.12	0.46	0.00	0.01
	Max	1.41	12.96	0.92	2.95	0.0
	Mean	0.25	4.00	0.66	1.01	0.04
<b>Un Cultivated Soils</b>						
A	Min	0.79	2.35	1.30	0.30	0.06
	Max	0.83	2.42	1.43	0.38	0.08
	Mean	0.81	2.39	1.37	0.33	0.07
B	Min	0.80	2.60	0.46	0.09	0.03
	Max	0.88	2.66	0.47	0.90	0.03
	Mean	0.84	2.63	0.46	0.60	0.03

Table (7) Correlation between DTPA-extractable heavy metals and some soil properties.

Correlation matrix	pH	Sand	Silt	Clay	OM	CaCO <sub>3</sub>
	%					
DTPA-Mn mg/kg-1	0.068	0.108	-0.076	-0.064	0.032	-0.247
DTPA-Co mg/kg-1	-0.012	-0.103	0.116	0.006	0.047	0.258
DTPA-Cu mg/kg-1	-0.059	-0.126	0.058	0.113	0.348	-0.042
DTPA-Zn mg/kg-1	0.04	-0.041	0.023	0.032	0.158	-0.065
DTPA-Cd mg/kg-1	-0.001	-0.052	0.024	0.047	-0.002	0.082

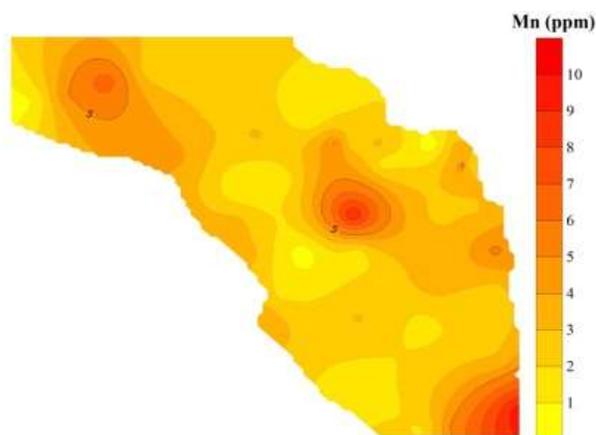


Figure (2) DTPA-extractable Mn ( $\text{mg kg}^{-1}$ ) in the studied soil samples.

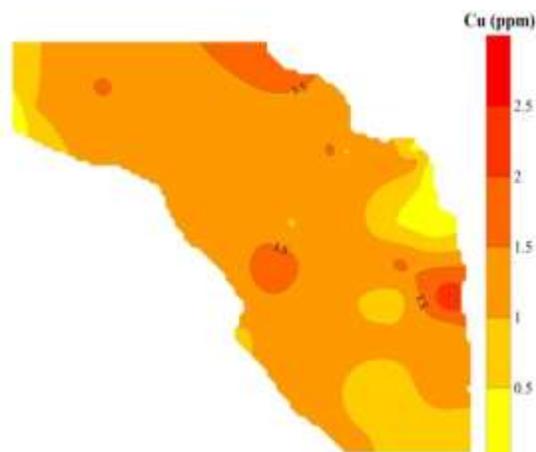


Figure (5) DTPA-extractable Cu ( $\text{mg kg}^{-1}$ ) in the studied soil samples

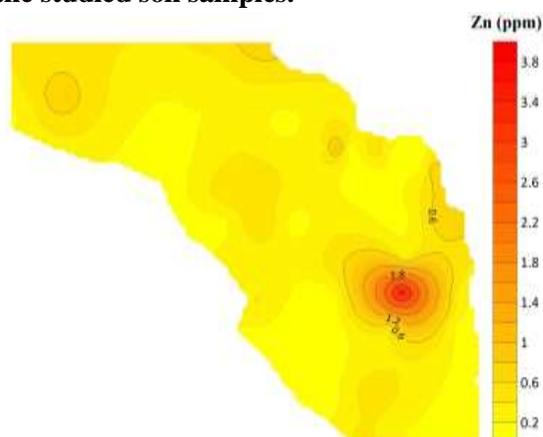


Figure (3) DTPA-extractable Zn ( $\text{mg kg}^{-1}$ ) in the studied soil samples.

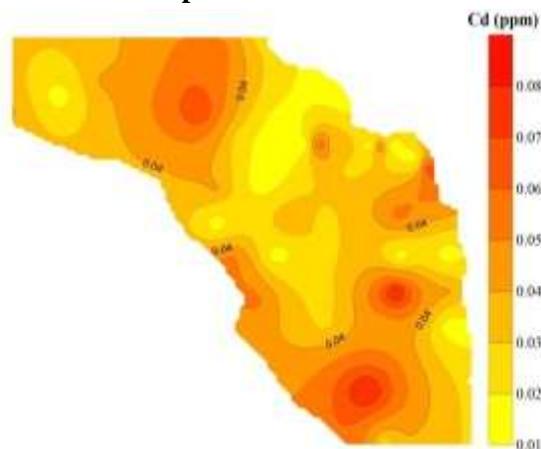


Figure (6) DTPA-extractable Cd ( $\text{mg kg}^{-1}$ ) in the studied soil samples

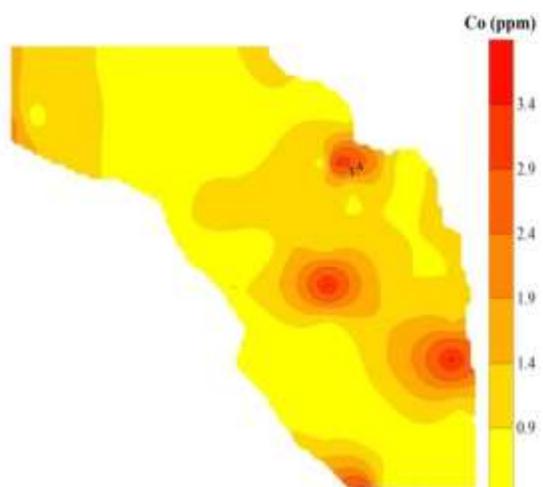


Figure (4) DTPA-extractable Co ( $\text{mg kg}^{-1}$ ) in the studied soil samples.

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## أثر فترة الزراعة على محتوى المعادن الثقيلة في

### بعض ترب محافظة سوهاج

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تتمثل الأهداف الرئيسية لهذه الدراسة في تقييم مستويات بعض المعادن الثقيلة (مثل Mn و Cd و Zn و Co و Cu) في بعض ترب محافظة سوهاج تحت الأراضي المختلفة فيما يتعلق بفترة الزراعة. ولتحديد التلوث المعدني لهذه التربة. تم جمع 114 عينة تربة من 57 موقعا مختلفا تحت استخدامات مختلفة للأراضي (أي الأراضي المزروعة القديمة ، والأراضي المزروعة الجديدة ، والأراضي غير المزروعة). تعتبر التربة غير المزروعة تربة ضابطة ، في حين أن التربة المزروعة القديمة هي أقدم أنواع التربة مقارنة بالتربة المستصلحة الجديدة بينهما. تم جمع عينات التربة من طبقتين بعمق 0-30 سم وعمق 30-60 سم لتعكس استخدامات الأسمدة المختلفة المستخدمة في التربة المدروسة. تم تحديد الإحداثيات الجغرافية للمواقع المدروسة باستخدام نظام تحديد المواقع العالمي (GPS). تم تحضير عينات التربة وتحليلها

لخصائصها الفيزيائية والكيميائية وكذلك لمحتواها من المعادن الثقيلة القابلة للاستخراج DTPA في معامل اختبار التربة باستخدام طرق التحليل القياسية. تم إنشاء خرائط للمعادن الثقيلة القابلة للاستخراج DTPA. تم تطوير العلاقات الارتباطية بين تركيز العناصر المدروسة وبعض خواص التربة (مثل الرمل الأولي ، الطمي ، الطين ، الأس الهيدروجيني ، المادة العضوية، كربونات الكالسيوم) حيث لوحظ وجود علاقة موجبة بين محتوى الطين والمعادن الثقيلة. أشارت النتائج المتحصل عليها إلى وجود أعلى تراكيز من المعادن الثقيلة في التربة المزروعة القديمة مقارنة بالتربة غير المزروعة والأراضي المستصلحة حديثاً. لذلك يجدر بالذكر أن فترة الزراعة تؤثر على مستويات وكميات هذه المعادن الثقيلة في التربة المدروسة. قد يكون هذا بسبب الأنشطة الزراعية مثل استخدام التسميد الكيميائي.