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Soil Physiochemical Properties in Relation to Heavy Metals Status of Agricultural Soils in El-Minia Governorate, Egypt.

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ABSTRACT

This researchconducted to evaluate the relationship between status of total and available Cr,Cd, Ni and Pb and physiochemical properties of different agricultural soils of El-Minia Governorate, Egypt. To realize this goal, combined twenty one surface soil samples (30-cm depth) signifying the main soil great groups of El-Minia Governorate were collected and tested for different soil properties in relation toheavy metals status of soil.Positive and negative high significant correlations were found between total and available soil contents of all studied heavy elements and soil physiochemical properties.Statistical analyses show that, total and available Cr, Cd, Ni and Pb are positively high significant correlated with CEC $cmol_c kg^{-1}$, OM %, WHC%, silt % and clay % but negatively significant correlated with sand % and soil reaction (pH). The total and available Cr, Cd, Ni and Pb were positively but not significantly correlated with the soil property of EC (dSm^{-1}), while negatively but not significantly correlated with $CaCO_3$%, indicating difficulty of predicting the availability of these heavy metals from these soil properties. Concentrations of total and available Cr, Ni, Cd and Pb in the cultivated soilscollected from Nile West and Nile East were less than the critical values for plant growth. However, concentrations of Cr, Ni, Cd and Pb in cultivated soils collected from the Nile Valley surpassed the critical values for plant growth in general. Attentions should be alarmed to prevent the continuous accumulation of these metals in agricultural soils by anthropogenic activities and agricultural management, which may lastlyinitiate the soil pollution at a toxic level. In the future, using such agricultural soils for cultivation of edible crops may give rise to chronic health risks to human if not managed properly.

Keywords: human health;heavy metals; significant correlation; soil pollution.

INTRODUCTION

In agricultural soils, the occurrence of heavy metals is of growing concern since they have the potential to be accumulated, transferred into soil solution and subsequently deteriorate the soil, crop and groundwater quality. The food crops constitute an important source of human oral exposure to metals (Zheng *et al*., 2013), and as a result careful monitoring of metal levels in agricultural soils is of great importance for protecting its quality and ensuring future sustainability (Kelepertzis, 2014). The natural concentrations of heavy metals in these soils tend to remain low depending on the geological parent material composition (Shan *et al*., 2013).

On the other hand, anthropogenicinputs in agricultural soils that contribute to an increase of the contentof some toxic heavy metals have reported including wastewater irrigation(Liu *et al.*, 2006), petrochemical activities (Li *et al.*, 2009) and theexcessive usage of fertilizers and manures (Lu *et al.*, 2012). Although fertilizers are essentialfor providing adequate nutrients and ensuring successful harvests,long-term repeated application of fertilizers and metal-containingpesticides can progressively add potential harmfullevels in soils (Jiao *et al.*, 2012).

In Egypt, the heavy metal status of agricultural soils must be widely investigated because of the growing contamination problems accompanying the rapid urban and peri-urban growth and the establishment of new industrial zones. In addition, in order to meet the growing need for food, agricultural soils forced to achieve maximum efficiency and highest quality product. Therefore, farmers intensively, irrigate soil, combat pests, and fertilize soil to make more capable soils. Excessive fertilization and mindless intensive irrigation with polluted water resulted in soil salinity, heavy metal accumulation, and as a consequence soil pollution.

Soils under intensive irrigated cropping systems normally experience heavy metals pollution and changes of chemical, physical, and biological properties at an extent that varies in accordance with the quality and quantity of applied water and fertilizers and land uses of these soils. These heavy metals absorption by plants is regulated by soil physiochemical properties such as soil pH, cationexchange capacity, temperature, soil ions, organic matter content of the soil, texture, metal concentration and type of plants species (Liu, *et al*., 2006).

Therefore, the knowledge on total variability and availability status of heavy metals in agricultural soils in relation to soil physiochemical properties are critical to sidestep phytotoxicity.Therefore,the main aim of this research is to associate the total and available status of heavy metals in relation to soil physicochemical properties in top soil samples of agricultural soils dominant in some Districts of El-Minia Governorate.

MATERIALS AND METHODS

Twenty one combinedsoil samples (0-30 cm depth) were dug at three different locations in seven districts to represent agriculturalsoilsdominant in El-Minia Governorate for soil analyses.Soil samples were collected from the surface horizons of ten hectare area for each agricultural soil (Nile West soil, Nile East soil, Nile Valley soil) distributed over each district of El-Minia Governorate. In addition, a soil pit was dug at each location in order to notice and describe the external morphological profile characteristics of the soil.

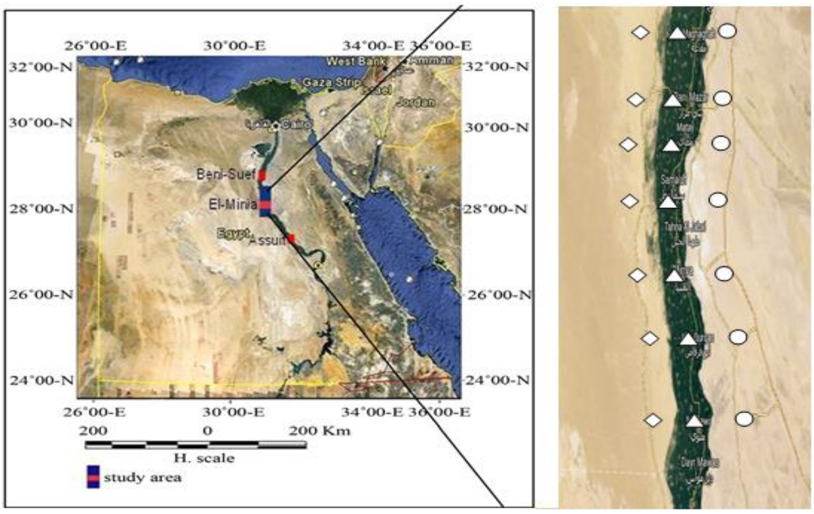
Soils were collected in harmony with the Manual Soil Map of Egypt Information (Egyptian Academy of Scientific Research and Technology, 1982). The area under examination lies between latitudes 27˚35'N and 28˚45'N and longitudes 30˚35'E and 30˚55'E, within El Minia Province, northern Upper Egypt (Map 1). The geographical coordinates of these locations were determined using a Garmin global positioning system (GPS).The Manual Soil Map of Egypt was well-appointed by the Soils and Water Resources Research

Council of the Academy of Scientific Research and Technology in co-operation with Egyptian Universities and Soil Survey Division of the Ministry of Agriculture. They located and distinguished the soil great groups present in El-Minia Governorate as following:

1. Torrifluvents (Eftt).
2. Quartzipsamments (Epqt).
3. Torriorthents (Eott).

General characteristics of these soil great groups are summarized as following:

- Torrifluvents (Eftt): These soil great groups are naturally alluvial, formed in recent water deposited sediments mainly in flood plains and deltas of rivers, representing those of arid climates. The dominant clay mineral in this Nile valley soil is the montmorillonite, being heavy clayey textural soils.
- Quartzipsamments (Epqt): These soil great groups represent the freely drained quartz in mid or low latitudes. They have a moisture regime other than torric and contain a sand fraction that is 95% or more quartz, zircon and tourmaline that do not weather to liberate iron or aluminum; therefore, they have no mottles.
- Torriorthents (Eott): These soil great groups represent the vertisols of arid and semi-arid climates. They represent the dry soils and they are may be alkaline, calcareous and salty variant. They have a torric moisture regime with a sandy skeletal size class.



○ **Quartzipsamments (Epqt) soils.** △ **Torrifluvents (Eftt) soils.** ◇ **Torriorthents (Eott) soils.**

Map (1):Locations of the investigated soil sites over seven districts in El-Minia Governorate.

The soil samples were air-dried, gradually crushed, passed through a 2-mm sieve. Selected soil physiochemical properties relevant to control the total and bioavailability of heavy metals were analyzed (table 1a and 1b) according to the standard routine methods derived from Page (1994).

Analyses of total heavy metals content (Cr, Ni, Cd and Pb) in the soil samples per mg kg-1 were determined by digestion in boiling aqua regia prepared in accordance with ISO 11466 (1995). Available cations (Cr, Ni, Cd and Pb) were determined in the samples by 0.005 M DTPA solution buffered at pH 7.3 (Lindsay and Norvell, 1978). Both total and available heavy metals were measured by Electro-thermal Atomic Absorption Spectrometry. Simple linear correlation analysis was done to show the relationship between total and available trace metals and other soil physiochemical properties.

RESULTS

Characteristicsof Soil Samples.

Soils investigated in the current study exhibited a wide range ofphysical and chemical properties as reported in Table (1a and 1b). The results of this study indicated that the textural grades of all soil samples from Nile East desert were sand, Nile Westdesert were sandy loam and Nile valley were heavy clay. These components are importantadsorption media for heavy metals in soils. The clay soilretains high amount of metals when matched to sandysoil (Olaniya and Chude, 2010).

The results of this study indicated that all the soil samples from agricultural Nile East desert, Nile Westdesert and Nile valley were above neutral to alkaline in soil reaction. The pH of these soils varied from 7.51 to 8.67 with mean values of 8.56 in Nile East soils, 8.08 in Nile West soils and 7.54 in Nile Valley soils.The availabilityof heavy metalstends to decrease as pH increases(Mckenzie, 2003; Sherene, 2010). The exact mechanismsresponsible for reducing availability differ for each nutrientbut may include; formation of low solubility compounds,greater retention by soil colloids and conversionof soluble forms to ions that plant cannot absorb.Neverthelessat pH values above 7, some heavy metals tend to form hydroxy–complexes which will increase the solubility of the metal in question.

Table (1a): Soil Physiochemical properties of the soilsinvestigated.

Samples site^A	Particle size distribution%						F.C %	W.P %	W.H.C %	A.W %
	Coarse sand	Fine sand	Total Sand	Silt	Clay	Texture				
1Nile East	32.18	36.07	68.25	16.70	15.05	Sandy loam	24.96	10.63	42.56	14.33
1 Nile Valley	4.85	22.34	27.19	24.56	48.25	Clay	32.86	14.56	49.56	18.3
1 Nile West	20.70	70.25	90.95	6.34	2.71	Sand	18.73	7.13	29.06	11.6
2 Nile East	33.06	35.18	68.24	12.45	19.31	Sandy loam	28.06	11.15	40.93	16.91
2 Nile Valley	4.67	22.49	27.16	25.02	47.82	Clay	32.36	14.81	49.22	17.55
2 Nile West	20.12	71.98	92.1	5.48	2.42	Sand	15.73	7.06	30.43	8.67
3 Nile East	32.48	36.97	64.45	24.50	11.05	Sandy loam	28.23	13.56	42.23	14.67
3 Nile Valley	4.76	22.48	27.24	25.07	47.69	Clay	35.44	17.53	48.43	17.91
3 Nile West	25.38	65.12	90.5	6.51	2.99	Sand	17.33	7.39	32.26	9.94
4 Nile East	32.19	37.15	55.34	28.37	16.29	Sandy loam	25.98	11.46	41.06	14.52
4 Nile Valley	4.81	22.45	27.26	25.05	47.69	Clay	36.34	15.53	49.84	20.81
4 Nile West	15.19	74.90	90.09	7.60	2.31	Sand	15.25	7.46	31.06	7.79
5 Nile East	33.09	36.90	65.99	18.48	15.53	Sandy loam	25.26	10.73	42.56	14.53
5 Nile Valley	3.90	23.19	27.09	24.88	48.03	Clay	35.53	15.92	48.26	19.61
5 Nile West	20.05	69.70	89.75	8.54	1.71	Sand	16.36	6.61	30.23	9.75
6 Nile East	32.56	37.08	52.64	38.51	8.85	Sandy loam	25.13	11.06	41.8	14.07
6 Nile Valley	4.24	22.90	27.14	24.50	48.36	Clay	36.36	16.13	47.66	20.23
6 Nile West	17.90	68.70	86.6	4.48	4.92	Sand	17.96	6.13	31.43	11.83
7 Nile East	31.90	37.32	69.22	12.56	18.22	Sandy loam	26.33	10.63	42.45	15.7
7 Nile Valley	4.90	22.11	27.01	23.90	49.09	Clay	34.24	14.06	48.33	20.18
7 Nile West	17.05	68.20	85.25	9.42	5.33	Sand	18.73	7.56	29.93	11.17

Table (1b): Soil Physiochemical properties of the soilsinvestigated.

Samples site*	pH	CECcmol$_c$kg^{-1}	OM%	EC(dSm^{-1})	CaCO$_3$%
1 Nile East	8.48	16.58	0.93	5.22	20.39
1 Nile Valley	7.54	30.43	1.78	3.08	7.71
1 Nile West	8.16	9.37	0.34	1.01	1.04
2 Nile East	8.67	18.20	0.96	4.58	26.87
2 Nile Valley	7.56	32.56	1.47	2.9	4.57
2 Nile West	8.09	8.67	0.23	0.83	2.15
3 Nile East	8.59	23.45	0.84	4.91	23.24
3 Nile Valley	7.51	37.57	2.66	3.20	5.76
3 Nile West	8.22	12.54	0.34	1.08	2.56
4 Nile East	8.55	21.58	0.79	5.33	19.4
4 Nile Valley	7.57	35.60	2.11	2.95	6.87
4 Nile West	8.14	13.26	0.43	1.40	3.66
5 Nile East	8.51	23.85	1.53	5.65	25.37
5 Nile Valley	7.53	36.22	2.57	3.67	6.22
5 Nile West	8.06	14.82	0.45	1.16	3.71
6 Nile East	8.66	20.16	1.11	4.98	21.3
6 Nile valley	7.59	38.57	2.64	3.05	4.79
6 Nile West	7.98	10.48	0.25	2.28	1.39
7 Nile East	8.48	19.51	1.19	5.29	27.14
7 Nile Valley	7.52	31.75	1.73	3.64	5.18
7 Nile West	7.97	12.62	0.35	1.78	3.44

Sample with the same number taken from same district: 1 Maghagh, 2 Bani-Mazar, 3 Matay, 4 Samalout, 5 Elminia, 6 Aboqurqas, 7 Malawy.

Electrical conductivity of soils was varied from 4.58 to 5.65 dSm^{-1} with average value of 5.13 dSm^{-1},from 0.83 to 2.28 dSm^{-1} with average value of 1.36 dSm^{-1} and 2.9 to 3.67 dSm^{-1} with average value of 3.21 dSm^{-1}respectively in Nile East, Nile West and Nile Valley soils. Khan*et al.*, (1993) revealed that the lessened adsorption capacityof soils with respect to heavy metals due to the highconcentration of salts could increase the availability of contaminantsto plants.

The organic matter content of soils was varied from 0.79 to 1.53% with an average value of 1.05% in Nile East, 0.23 to 0.45% with an average value of 0.34% in Nile West and 1.47 to 2.64% with an average value of 2.13% in Nile Valley soils. It indicates that these soils were very low to moderate in organic matter content. The moderate content of organic matterin Nile Valley soils might be due to addition of organic matter through recent water deposited sediments mainly in Nile flood plains, representing those fertile soils of arid climates.

Organic matter is important for the retention of metals by soil solids, thus decreasing mobility and bioavailability. However because of the complexation of metals by soluble OM, the addition of OM can result in release of metals from solids to the soil solution (Sherene, 2010).Higher solubility of heavy metals in soil solution atalkaline pH was attributed to enhanced formation of organicmatter metal complexes after ionization of weak acid groups(Temminghoff*et al.*, 1998).

Soil reaction (pH) is of prime important in controllingthe availability of heavy/trace metals, since it affects directlytheir solubility as well as activity in the soil environment(Diatta*et al.*, 2014).On the other hand, in organic soils the availability and fate of heavy metalsshould be strongly controlled by organic carbon content.

Calcium carbonate content was varied from 19.4 to 27.14%with a mean value of 23.38% in Nile East soils, 1.04 to 3.71% with a mean value of 2.56% in Nile West and 4.57 to 7.71% with a mean value of 5.87% in Nile Valley. These mean values indicating non-calcareous to highly calcareous soil nature.(Sherene, 2010)reported that, mobility of heavy metal is enhanced byincreasing acidity. But liming decreased the mobility of metals in organic horizon.

Cationexchangecapacity was varied from 16.58 to 23.85cmol$_c$kg^{-1} with a mean value of 20.51cmol$_c$kg^{-1} in Nile East soils, 8.67to 14.82 cmol$_c$kg^{-1} with a mean value of 11.73cmol$_c$kg^{-1} in Nile West soils and 30.43 to 38.57cmol$_c$kg^{-1} with a mean value of34.67 cmol$_c$kg^{-1} in Nile Valley soils.

Water holding capacitiesof the investigated soilswere varied from 40.93 to 42.56% with a mean value of 41.94% in Nile East soils, 29.06 to 32.26% with a mean value of 30.62% in Nile West and 47.66 to 49.84% with a mean value of 48.75% in Nile Valley.Tisdale *et al.*,(2003) stated that micronutrients have positive relation with the fine mineral fractions like clay and silt while negative relations with coarser sand particles. This is because their high retention of moisture induces the diffusion of these elements (Tisdale *et al.*, 2003).

Status of Total and Available Heavy Metals:

Data in Table 2 show the total and available Cr, Ni, Cd, and Pb contents in the investigated soils. Concentrations of Cr, Ni, Cd, and Pbwere significantly different among different locations of the investigatedagricultural soils. The highest concentrationstotal or available of Cr, Ni, Cd, and Pb mg kg^{-1}, wereconstantlyobserved in agricultural soils of Nile Valleyentrapped by congested towns and irrigated bydrainage water from Almoheet drain,and alongsidethe agricultural highway in El-Minia governorate, while the lowest levels weredetected in agricultural soils collected from Nile West soils due to their high content of sand which is very poor in its elements content.

Zaki*et al.*, (2015) reported that soils irrigated by surface and groundwater are polluted by some heavy metals. These heavy metals may be caused by leaching from the anthropogenic activities (*i.e.*, El Moheet drain and its branches, where they receive wastewater from the factories of Abo-Qurqas Sugar and Maghagha Onion industries, as well as agricultural and urban wastewater).

Table 2. Total and available Cr, Ni, Cd and Pb in the soils investigated.

Sample Site	Total (mgkg^{-1})				Available (mgkg^{-1})			
	Cr	Ni	Cd	Pb	Cr	Ni	Cd	Pb
1 Nile East	68.89	75.14	4.21	69.12	3.15	1.23	0.07	0.32
1 Nile Valley	138.23	186.23	7.27	163.68	8.77	2.39	0.54	0.86
1 Nile West	56.13	31.65	3.78	52.54	1.77	0.22	0.04	0.12
2Nile East	55.78	88.32	5.19	39.89	1.64	0.12	0.11	0.33
2Nile Valley	99.03	166.24	11.23	115.69	6.07	1.78	0.23	0.96
2Nile West	38.23	76.29	4.78	12.69	1.41	0.08	0.09	0.17
3 Nile West	48.99	59.39	3.64	48.73	0.86	0.04	0.03	0.32
3Nile East	85.45	77.25	5.71	67.29	2.17	0.06	0.15	0.57
3Nile Valley	146.77	171.48	9.67	174.29	7.04	0.89	0.29	1.79
4 Nile West	34.15	47.44	2.23	32.90	1.08	0.42	0.05	0.19
4Nile East	47.67	52.37	3.47	36.39	1.98	0.45	0.14	0.44
4Nile Valley	106.12	126.14	8.54	89.94	5.88	1.54	0.92	1.71
5 Nile East	36.19	107.45	5.66	55.87	2.56	0.56	0.08	0.31
5 Nile West	25.37	71.35	4.92	39.85	1.76	0.21	0.05	0.18
5Nile Valley	99.67	211.46	7.36	142.68	10.34	1.69	0.67	1.79
6 Nile East	67.69	73.94	5.57	29.45	2.18	0.66	0.16	0.66
6 Nile valley	116.39	134.56	9.03	112.96	6.34	1.87	0.36	1.88
6 Nile West	46.29	61.71	4.20	15.66	3.64	0.31	0.09	0.51
7 Nile East	32.78	42.76	3.96	78.29	4.76	0.22	0.05	0.42
7 Nile West	27.98	16.67	2.77	46.83	2.33	0.07	0.03	0.17
7Nile Valley	128.14	163.93	11.48	156.04	11.86	1.09	0.61	0.86
CV*	75	100	8	200				
BC**	80-200	1-100	0.2	12-20				
EUS***	150	75	3	300				

***Critical value for plant growth (Source: Linzon, 1978).**
****Background concentration (Source: Alloway, 1990).**
*****EUS= European Union Standards (EU 2002).**

Table 2 shows that the total maximum Cr, Ni, Cd and Pb contents in the Nile Valley soils investigated were equal to 146.77, 211.46, 11.48and 174.29 mg kg^{-1}, respectively. The total levels of heavy metalsapart from chromium(Table 3) in all the investigated Nile Valley soils were above the typicalbackground concentrations cited in the literature (Hasan, 2007; Yobouet*et al.*, 2010). Table 3 indicates these soils were heavily polluted with Cd and Ni metals that are part of the most dangerous industrial and municipal waste.This wide range of heavy metals content in the Nile Valley soils is apparently associated with soil texture and might be due to metals deposited sediments in Nile flood plains and continuous addition of fertilizers and manures, which is in a good agreement with El-Saadani*et al.*, (1987).

Table 3: Comparison studied average metal concentrations (mg kg^{-1}) with cited literature and standards:

Heavy metal Obtained in this study	Critical value for plant growth (Source: Linzon, 1978)	Background concentration (Source: Alloway, 1990)	European Union Standards (EU 2002)
Cr (25.37-146.77)	75	80-200	150
Ni (16.67-211.46)	100	1-100	75
Cd (2.23-11.48)	8	0.2	3
Pb (12.69-174.29)	200	12-20	300

Concentrations of total and available Cr, Ni, Cd and Pb in surficial agricultural soils collected from Nile West and Nile East were less than the critical values of 75 mg Cr/kg, 100 mg Ni/kg, 8 mg Cd/kgand 200 mg Pb/kg for plant growth. However, concentrations of Cr, Ni, Cd and Pb in agricultural soils collected from the Nile Valley exceeded the critical values for plant growth in general.Data presented in Table (2) show that the values of chemically available (DTPA-extractable) heavy metals contents in the soils investigated ranges between 0.86 and 11.86 mg kg^{-1} for chromium, 0.04 and 2.39mg kg^{-1} for nickel, 0.03 and 0.92 mg kg^{-1}for cadmium and 0.012 and 1.88 mg kg^{-1}for lead. The highest values of available metals were found in the soil samples that represent the soil of Nile Valley, while the lowest ones belongs to the coarse-textured desert sandy soils of Nile East and West.

It is worthy to note that soils of the Nile Valley contained amounts of total and available heavy metals exceeding the critical limits for plant growth. These soils are characterized by their high content of clay and fairly low content of $CaCO_3$. Therefore, the results obtained in this study revealed that the average mean values of total and available heavy metals were in high range for the safe production of crop plants and might pose phytotoxicity in the future. Generally, the wide range of total and available heavy metals in the studied soils can be attributed to the differences in the anthropogenic activities, quality of irrigation water, soil type and nature of soil materials.

Heavy Metals in connection with Soil Physiochemical Properties.

The drive of this research was to monitor heavy metals status in agricultural soils prevailing in El-Minia Governorate, as related to soil physio-chemical properties. Results of the correlation analyses between total and available heavy metals and soil properties are presented in Table4. The results revealed that heavy metal contentsarelargely dependent on soil structure, soil reaction (pH), organic matter content and cation exchange capacity of soils. Generally, soils having high pH, clay content, CaCO^3 and cation exchange capacity (CEC) retained more heavy metals. Soil organic matter metal-complexes and soluble organic compounds can increase the solubility of heavy metals and consequently its availability in soils (Srivastava and Gupta, 1996).

Table 4:Simple correlation coefficients (r) between soil characteristics, total and available heavy metals.

Soil characteristics	Total heavy metals mg kg^{-1}			
	Cr	Cd	Ni	Pb
Clay %	0.885**	0.879**	0.894**	0.898**
Silt %	0.633**	0.582**	0.558**	0.505**
Sand %	-0.882**	-0.859**	-0.862**	-0.841**
W.H.C %	0.808**	0.787**	0.807**	0.789**
pH	-0.679**	-0.689**	-0.703**	-0.724**
CEC Cmol$_c$kg^{-1}	0.845**	0.845**	0.854**	0.842**
OM %	0.806**	0.771**	0.838**	0.833**
EC (dSm^{-1})	0.148 N.S	0.135 N.S	0.158 N.S	0.156 N.S
$CaCo_3$%	-0.180 N.S	-0.178 N.S	-0.159 N.S	-0.161 N.S
	Available heavy metals mg kg^{-1}			
Clay %	0.884**	0.822**	0.852**	0.858**
Silt %	0.476*	0.536**	0.576**	0.600**
Sand %	-0.828**	-0.800**	-0.837**	-0.852**
W.H.C %	0.749**	0.720**	0.778**	0.760**
pH	-0.757**	-0.684**	-0.676**	-0.687**
CEC cmol$_c$kg^{-1}	0.785**	0.775**	0.782**	0.904**
OM %	0.777**	0.738**	0.758**	0.916**
EC (dSm^{-1})	0.148 N.S	0.090 N.S	0.158 N.S	0.136 N.S
$CaCo_3$%	-0.210 N.S	-0.207 N.S	-0.182 N.S	-0.196 N.S

*** Significant at probability level of 5%, ** Significant at probability level 1%. NS. Non-significant.**

Statistical analyses show that, total and available Cr, Cd, Ni and Pbare positively high significant correlated with CEC cmol$_c$kg^{-1}, OM %, WHC%, silt % and clay % but negatively significantcorrelated with sand % and soil reaction (pH) (Figures, 1 and 2).Factors affecting the availability of micronutrients are parent material, soil reaction, soil texture, and soil organic matter (Brady and Weil, 2002).These findings are in accordance with the results of Ragab*et al*., (2007).Factors affecting the availability of micronutrients are parent material, soil reaction, soil texture, and soil organic matter (Brady and Weil, 2002).

The total and available Cr, Cd, Ni and Pb were positively but not significantly correlated with the soil property of EC (dSm^{-1}), while negativelybut not significantly correlated with $CaCO_3$%, indicating difficulty of predicting the availability of theseheavy metals from these soil properties. The presence of high calcium carbonate content, withmoderate contents of organic matter and percentages of clay and consequently high CEC in most soil samples may suggest that trace metals could be retained in these soils, as these properties increase the adsorption capacity of metals by calcareous soils.This was in agreement with Kparmwang*et al*., (2000) on sandstone and shale soils in Benue valley, Nigeria.

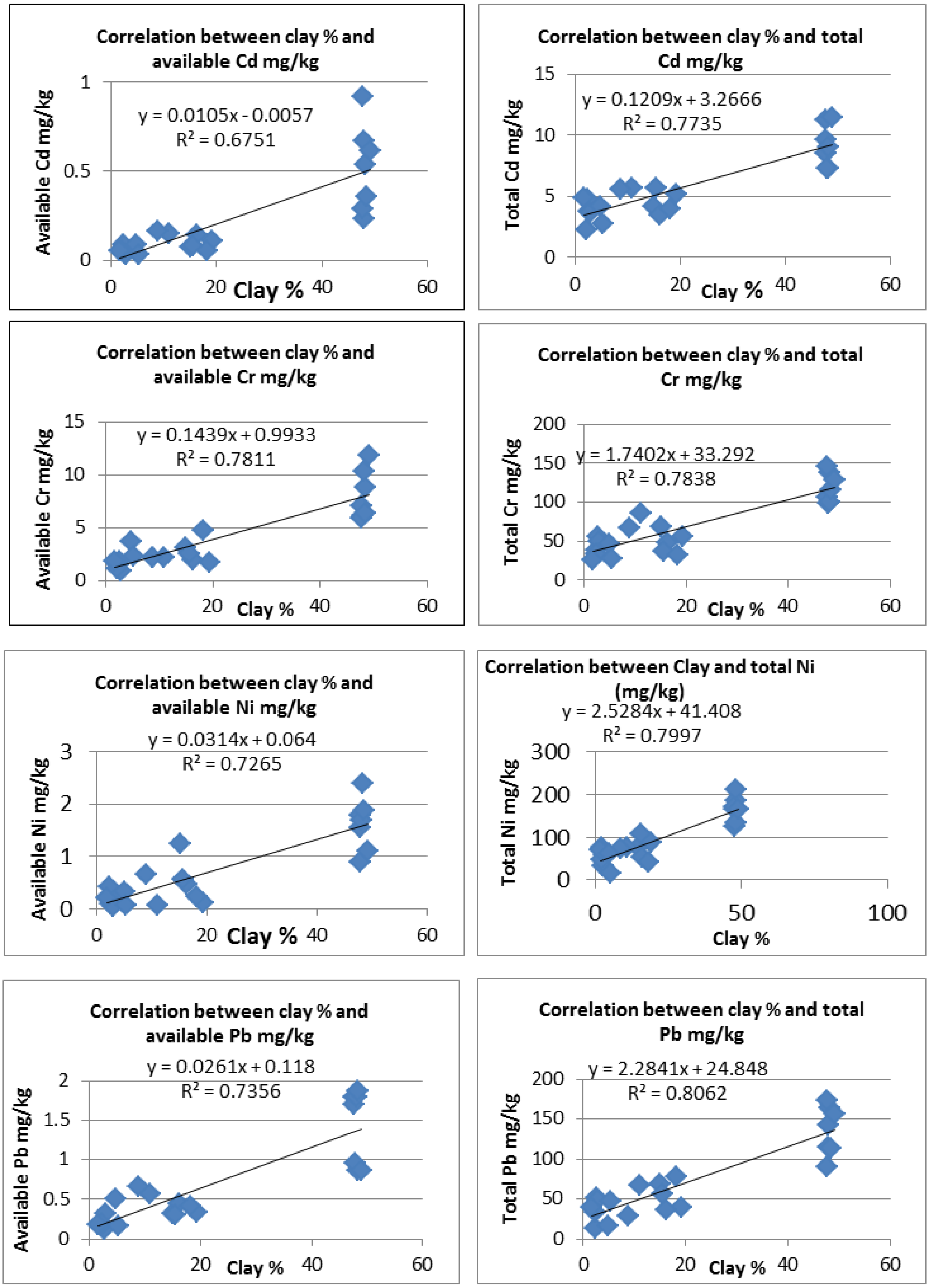


Figure (1): Total and available heavy metals as affected by clay %.

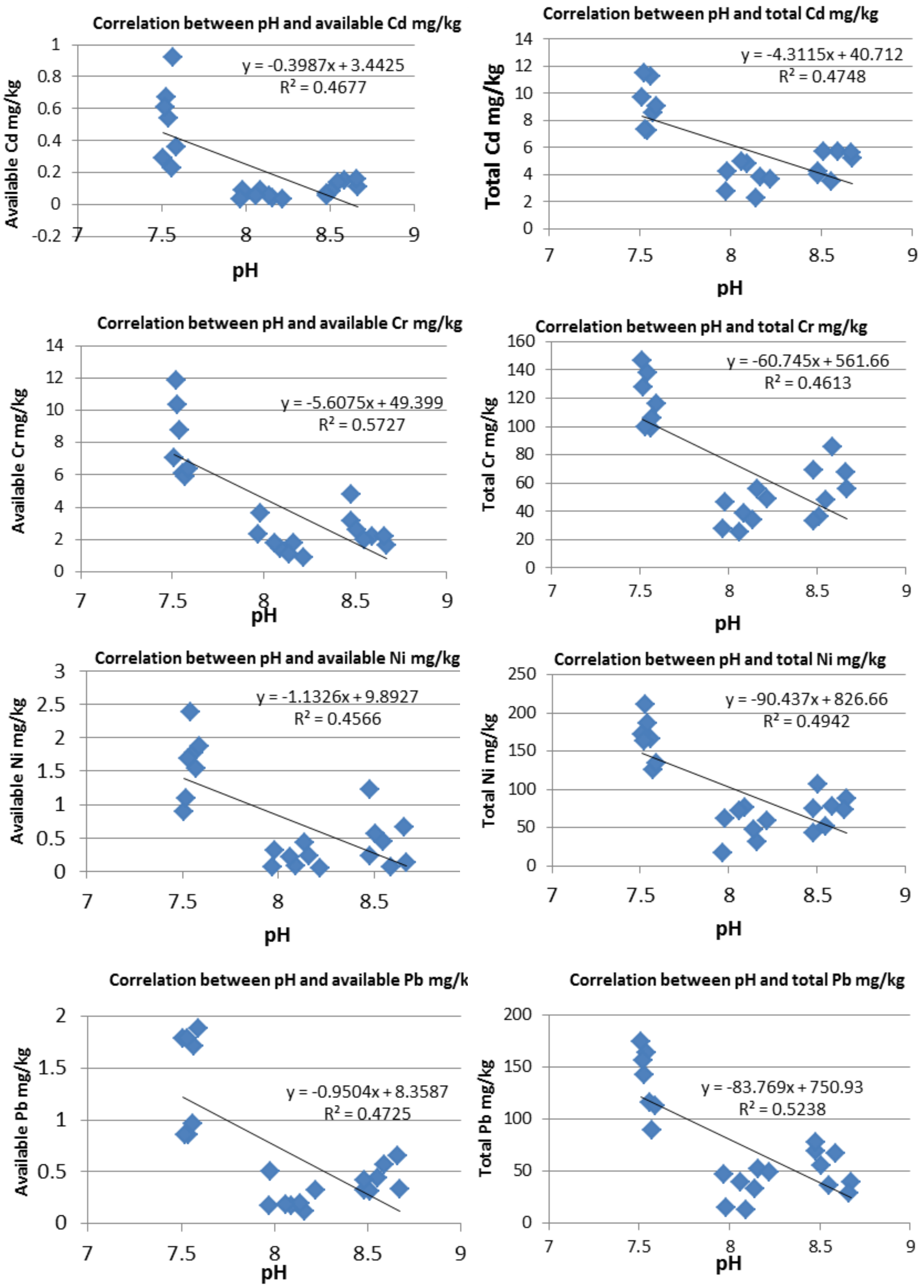


Figure (2): Total and available heavy metals as affected by soil pH.

DISCUSSIONS

The governorate of El-Minia is densely populated alongside the constricted strip of the Nile Valley and is the center of the local sugar and onion industries in Upper Egypt. Huge untreated quantities of urban and industrial wastewater are discharged directly into drainage and irrigation canals which contribute to heavy metals augmentation in the cultivated soils through irrigation. Cultivated soils being entrapped by towns and irrigated with polluted water might be the direct route for the higher concentration observed heavy metals in the investigated soils.

Higher amounts of Cr, Cd, Ni and Pb identified in agricultural soils from Nile Valley may be ascribed to high anthropogenic activities and concentrations of urbanization at these locations. Lower concentrations of Cr, Cd, Ni and Pb identified in agricultural soils from Nile west desert may be due to high sand content, low industrialization and limited anthropogenic activities at these locations. These results are in agreement with Al-Naggar*el al.* (2014). Concentrations of Cr, Cd, Ni and Pb in agricultural soils detected during this research were greater than those conveyed by Nassef*et al*., (2006). These variations might be related to different anthropogenic activities and agricultural management practices at each site. It is conceivable that environmental pollution with metals differs from area to area as the application of fertilizers and other human activities vary at each site (Zhou*et al.*, 1994).

Zaki*et al.*, (2015) stated that soils irrigated by River Nile water contaminated with Mn at El Biadia village (Malawi city) refers to domestic activities, while soils irrigated by El Moheet drain water contaminated with B, Fe, Cu, Zn, Mn, Pb, Cd, Cr and Se at Malawi city, Abo Qorkas city, El Minia city, Samalut city; and Maghagha city. They also reported that soils irrigated with groundwater are polluted by some heavy metals (B, Fe and Cu) and all soils irrigated with drainage water exceeded the permissible level due to recharged of domestic and industrial effluents in El-Minia Governorate-Egypt.

Application of excessive fertilizers and pesticides are another source of heavy metals pollution in agricultural soils from El-Minia governorate. High levels of heavy metals were noticed in agricultural soil from locations adjacent to highway roads indicating that vehicular emission was the source of pollution (Mmolawa, *et al.*, 2011). Many authors recommended that soils should be sheltered from excessive inputs of heavy metals by fixing maximum acceptable levels of these metals in soils, corresponding to the amounts which will not cause any risk for crop flop or water pollution and human health.

CONCLUSIONS

These research results indicated that irrigated agricultural soils of El-Minia governorate-Egypt contain considerable amounts of Cr, Cd, Ni and Pb in comparison with literature results. Heavy metal-contaminated soils in the investigated area are mainly affected by the anthropogenic activities, polluted irrigation water and fertilizers and soil parent materials. In brief, consuming edible crops grown on such heavy metal-contaminated soils in the Nile Valley may bring about chronic health risks for human. Moreover, concentrations of these toxic elements detected in this research might be a potential contamination source of these metals in the future in the agricultural soils of Nile East and West locations if not managed properly.

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الصفات الفيزيوكيميائية للتربة وعلاقتها بحالة العناصر الثقيلة في الأراضي الزراعية لمحافظة المنيا- مصر

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اجري هذا البحث لتقييم العلاقة بين التركيز الكلي والميسر لعناصر الكروميوم والكادميوم والنيكل والخارصين والصفات الفيزيوكيماوية لمختلف الأراضي الزراعية لمحافظة المنيا – مصر. لتحقيق هذا الهدف تم جمع 21 عينة تربة ممثلة من عمق 30 سم للتربة وتم تحليل صفاتها الفيزيوكيماوية وعلاقتها بتركيزات العناصر الثقيلة في التربة. ولقد دلت النتائج أن هناك أرتباط عالي المعنوية سواء سالب أو موجب بين هذة الصفات والتركيز الكلي او الميسر من العناصر الثقيلة تحت الدراسة. ولقد اوضح التحليل الأحصائي ان هناك ارتباط موجب عالي المعنوية بين التركيز الكلي والميسر لعناصر الكروميوم والكادميوم والنيكل والخارصين مع السعة التبادلية الكاتيونية للتربة ، والمادة العضوية في التربة , وسعة التربة لحفظ الماء , والنسبة المئوية للسلت والطين بالتربة ولكن يوجد هناك ارتباط سالب عالي المعنوية بين التركيز الكلي والميسر لهذه العناصر وبين النسبة المئوية للرمل بالتربة وأيضا درجة تفاعل التربة (pH) . ولقد اوضح التحليل الأحصائي ايضا ان هناك ارتباط موجب غير معنوي بين التركيز الكلي والميسر لعناصر الكروميوم والكادميوم والنيكل والخارصين مع درجة التوصيل الكهربائي للتربة ولكن يوجد هناك ارتباط سالب غير معنوي بين التركيز الكلي والميسر لهذه العناصر وبين النسبة المئوية لكربونات الكالسيوم بالتربة مما يدل علي صعوبة التنبؤ بتيسر هذه العناصر بمعرفة وتحديد هذه الصفات. التركيزات الكلي والميسر لعناصر الكروميوم والكادميوم والنيكل والخارصين في الأراضي الزراعية الموجودة شرق أو غرب النيل في محافظة المنيا كانت أقل من الحدود الحرجة لنمو النباتات , بينما التركيزات الكلي والميسر لعناصر الكروميوم والكادميوم والنيكل والخارصين في الأراضي الزراعية الموجودة في وادي النيل في محافظة المنيا تخطت الحدود الحرجة لنمو النباتات بشكل عام. يجب شد الأنتباه لمنع التراكم المستمر لهذه العناصر الثقيلة في الأراضي الزراعية من خلال الأنشطة البشرية المختلفة واسلوب الأدارة المزرعية والتي من الممكن أن تصل بالتربة الي مستوي السمية. مستقبلا أستعمال مثل هذه الأراضي الزراعية في زراعة المحاصيل التي ياكلها الأنسان ربما تسبب مخاطر صحية مزمنة للأنسان اذا لم تدار مزرعيا بشكل جيد.