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SPECIATION AND MOBILITY OF LEAD AND ZINC IN SOME CONTAMINATED SOILS OF EGYPT

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ABSTRACT

Heavy and trace elements are potentially toxic to human life and the environment. Element toxicity depends on chemical associations in soils. Therefore, determining the chemical form of an element in soils is important to evaluate its mobility and bioavailability. In this study, three polluted soil profiles representing the most predominant soil types (ie, clayey, calcareous and sandy soils) of Egypt were investigated for the distribution and chemical fractions of Pb and Zn and their mobility in relation to soil properties. Sequential extraction was used to fractionate Pb and Zn into six operationally defined groups: water soluble (F1), exchangeable (F2), carbonate (F3), Fe-Mn oxide (F4), organic (F5) and residual (F6). This sequential extraction procedure is based on operationally defined mobile (F1 to F3) and immobile (F4 to F6). The obtained results indicated that the residual fraction was the dominant pool for the studied elements examined in the different soils, and accordingly the potential availability of these studied elements was extremely low. In contaminated clay soil, Pb and Zn were mostly concentrated in the residual and oxide-bound fractions, while in contaminated calcareous soil the Pb and Zn was mostly concentrated in the residual and carbonate-bound fractions. In contaminated sandy soil, Pb and Zn bound to organic matter was the dominant fraction where Pb and Zn distribution pattern followed the order: organic-bound> residual> oxides-bound> carbonate-bound> exchangeable> water soluble fractions. The values of mobility factor (MF = [sum (F1 to F3) x 100/sum F1 to F6)] showed that Zn is more mobile than Pb metal in the studied soils. Therefore, Zn is likely to be easily taken up by vegetation grown in these contaminated soils. For Pb and Zn the MF values were highest (19.20 – 22.24%, respectively) in contaminated clay soil and lowest (7.43 – 9.71%) in sandy soil, while intermediate (13.58 – 18.06%, respectively) in calcareous soil. The correlation of Pb and Zn forms with some soil properties showed that soil organic matter content and pH were the most important factors controlling Pb and Zn distribution and subsequently, its bioavailability in contaminated clay and calcareous soils, while in contaminated sandy soil, the most effective soil properties on Pb and Zn speciation were organic matter and clay contents followed by soil pH.

Keywords: Heavy metals, Pb, Zn, speciation, sewage effluents and soil properties.

INTRODUCTION

Heavy metals may be entering into the soil matrix through mineral fertilization, using low quality water for irrigation purpose, atmospheric depositions or application of solid wastes. Although total analysis is a good indicator of the possible enrichment of soil with heavy metals, the mobilization capacity and the potential environmental risk of these pollutants depends primary on their speciation in the soil rather than the total concentration. Speciation is defined as the identification and quantification of the different, defined species , forms, or phases in which an element occurs and is essentially a function of the mineralogy and chemistry of the soil sample examined (Vijver *et al.,* 2004; Jin *et al.,* 2005 and Powell *et al.,* 2005). The total amount of metals can be distributed among different forms: free ion in the soil solution, adsorbed and exchanged on the colloidal phase (composed of clay particles, humid compounds, Fe and Al hydroxides), chelated with some organic compounds forming complexes or precipitated under the effect of redox potential of the soil. Only those forms, which are soluble or may be solubilised, are bio-available. Abou Zied (1999) has stated that using of sequential extraction techniques to separate the soil metals into different forms can be helpful in understanding the process of metal movement in the soil profile. Sequential extraction of trace metals from soils is potentially valuable in predicting bio-availability, metal leaching rates, and transformations between different chemical forms in agricultural soils (Elsokkary, 1980, Miller and McFe, 1983 and El-Gendi, 1994). Brummer (1986); Dudka and Chlopecka (1990) reported that forms of trace metals occurring in soils determine the element mobility, plant availability and chemical reactivity. Andersson (1977) showed that in most cases, trace elements added through different wastes were either retained in the top soil or moved only a few centimeters below the treated layer. Therefore, movement is essentially related to the physicochemical forms of the metals in soil because these forms have different potentials for mobilization by inorganic or organic ligands in soil solution (Petruzzelli and Lubrano 1994; McBride 1989). The chemical forms of the trace element determine its chemical behavior in the environment and its remobilization capacity (Ma and Rao, 1997). The chemical forms of heavy metals depend on their origin and physico-chemical properties of soils. The main factors, which affect metal mobility are pH, organic matter content, cation exchange capacity, texture and redox conditions (Kashem and Singh, 2004; Rieuwerts *et al.,* 2006).

Therefore, identification and quantification of the different species or forms of phases in which the heavy metals occur is very important to determine their bioavailability in the environment. This study was therefore undertaken to: (i) investigate the distribution of lead and zinc in soil profiles differing widely in their properties; (ii) assess the mobility and bio-availability of metals within soil profiles; and (iii) investigate the relationship between soil properties and the chemical fractions of the two studied metals.

MATERIALS AND METHODS

Three polluted soil profiles representing the most predominant soil types of Egypt (ie, clayey, calcareous and sandy soils) were selected. Clay soil profile was taken from Kafr Al-zayat, El-Gharbia Governorate. Calcareous soil profile was taken from Borg El-Arab, Alexanderia Governorate. Sandy soil profile was taken from Abou Rawash farm, Giza Governorate. The source of contamination in Kafr Al-zayat soil samples was due to its location near some factories (acid and sodium hydroxide manufacture factories) beside irrigation by Nile water polluted by the drainage of these factories. In Borg El-Arab soil samples contamination was created from using sewage water for irrigation for about 20 years. Meanwhile, in Abou Rawash soil contamination was created from using sewage water for irrigation for about 30 years. The three selected soil profiles were divided into six layers 0-5 cm, 5-10 cm, 10-15 cm, 15-30 cm, 30-60 cm, and 60-90 cm. All soil samples were air dried and ground to pass through a 2-mm sieve. The electrical conductivity (EC) of soils was determined in soil paste extract. Particle size distribution was determined by the pipette method according to Dewis and Freitas, (1970). Soils were also characterized for their carbonate content, soil pH (in 1:2.5 suspension) and organic mater (OM) according to Cottenie *et al.,* (1982).

Sequential extraction was used to fractionate Pb and Zn into six operationally defined groups according to the procedure of Salbu et al. (1998), which is a modified version of Tessier et al. (1979). It was designed to separate heavy metals into six operationally defined fractions as: water-soluble metals (F1) extracted with water; exchangeable (F2) extracted with 1 M NH_4OAc at pH 7; specifically sorbed and carbonate bound (F3) extracted with 1 M NH_4OAc at pH 5; metals associated (sorbed or occluded) mainly on iron and manganese oxides (F4) extracted with hydroxylamine; strongly complexed by organic matter (F5) extracted with H_2O_2 in 1 M HNO_3 ; and residual (F6) extracted with 7 M HNO_3. The total form of these elements was extracted using concentrated $HClO_4$ + HF + HCl and determined according to Jackson (1960). Heavy metals concentrations in extracts were determined by atomic absorption spectrophotometer (AAS).

Calculation and statistical analysis:

The relative index was calculated as a mobility factor, MF (Salbu *et al.,* 1998; Kabala and Singh, 2001) as: MF =[(F1 + F2+ F3) × 100/(F1 + F2 + F3 + F4 + F5 + F6)]. Pearson correlations coefficient was determined using Minitab Inc (1992).

RESULTS AND DISCUSSION

Soil characteristics:

A brief summary of soil properties is presented in Table (1). The results showed that soil EC varied from 1.13 – 4.95 dSm^{-1}, pH values of the soils ranged from 6.72 - 8.64, organic matter content varied from 0.59 – 2.78%, total calcium carbonate content ranged from 0.19 – 48.40% and clay with a range of 7.22 – 56.69%.

Table (1) some chemical characteristics of the studied soil profiles:

Soil types	Depth (cm)	EC (dSm^{-1})	Soil (pH)	Organic matter (%)	CaCO3 (%)	Clay content (%)
Clayey	(0 - 5)	3.32	8.06	2.54	1.45	56.69
	(5- 10)	2.78	8.14	2.45	1.94	54.36
	(10-15)	4.13	8.17	2.29	2.17	53.65
	(15-30)	4.56	8.24	2.08	1.45	52.23
	(30-60)	4.14	8.30	1.99	1.69	54.73
	(60-90)	4.95	8.37	1.74	1.94	56.32
Calcareous	(0 - 5)	2.79	8.18	2.05	38.72	20.61
	(5- 10)	1.76	8.37	1.45	40.65	19.47
	(10-15)	1.96	8.42	1.32	48.40	18.86
	(15-30)	1.45	8.55	0.95	41.62	19.27
	(30-60)	1.56	8.60	0.62	47.43	17.09
	(60-90)	1.15	8.64	0.48	44.52	18.29
Sandy	(0 - 5)	2.12	6.72	2.78	0.55	09.33
	(5- 10)	2.06	6.75	2.44	0.34	09.06
	(10-15)	1.41	6.75	2.25	0.48	08.30
	(15-30)	1.35	6.83	1.83	0.36	08.06
	(30-60)	1.33	7.07	0.69	0.19	07.84
	(60-90)	1.13	7.18	0.59	0.38	07.22

Speciation of Pb and Zn in the studied soils:

Data in Table 3 show Pb and Zn fractions expressed as percentage of sum of all fractions in the surface layer of different studied soils.

1) speciation of Pb in each fraction of the studied soils:

There was a large variation in the Pb concentrations extracted from the individual fractions and among soils (Table 2 and Fig. 1). According to Table (3) the highest amounts of Pb in contaminated clay soils were mainly detected in the residual fraction (F6) and oxide-bound (F4) fraction (32.37 and 26.74%, respectively), and substantial amounts of Pb (21.69%) were found in organically-bound fraction (F5). Pb distribution pattern followed the order: residual> oxides-bound> organic-bound> carbonate-bound> exchangeable> water soluble fractions. These results were in accordance with those obtained by Abd El Razek (2013) and Zaghloul *et al.,* (2006). In calcareous contaminated soil, Pb was strongly associated with the residual fraction (79.05%) followed by carbonate bound fraction, F3 (12.83%). Pb distribution pattern followed the order: residual> carbonate-bound> organic-bound> oxides-bound> exchangeable> water soluble fractions. The percentage recovery of Pb as residual fraction in three soils ranged from 28.68 to 60.84% of Pb (Fig. 1). This result agreed with the findings of Oluwatosin et al. (2008) who reported that around 65% of Pb was associated with residual fraction of soils. In sandy contaminated soils the highest amount of Pb (52.15%) was found in the organic form (F5) and the lowest amount (0.1%) was detected in the water soluble form (F1). This result could be attributed to the high affinity of Pb to form complexes with organic substances. Pb distribution pattern in the contaminated sandy soils followed the order: organic-bound> residual> oxides-bound> carbonate-bound> exchangeable> water soluble fractions. These results were supported by Badawy and Helal (2002). The low amounts of Pb in contaminated clay and sandy soils were obtained in water soluble, exchangeable and carbonate fractions which represent the mobile fraction in the soils. Metals associated with organic fractions and oxides are less dangerous for the environment than water soluble, exchangeable and carbonate fractions because these fractions are less extractable, but when the environment becomes increasingly reducing or oxidizing, they can be mobilized (Yobouet *et al.,* 2010).

Data in Table (2) also indicated that the recovery of total Pb (the sum of the amount of metal removed in each step divided by total metal) was in a range of 91.1 to 99.91% and this is a good recovery according to Ma and Rao (1997) where it fall in a range of 100+/-10%.

2) speciation of Zn in each fraction of the studied soils:

Data in Table (3) indicated that in contaminated clay soil, among the fractions, Zn was mostly concentrated in the residual and oxide-bound fractions (36.17 and 34.18%, respectivily). The greatest amount of Zn in oxide-bound fraction suggested that sesquioxides provide large surface area for Zn adsorption or may be occluded in the structure in soils. Several investigators have reported Zn to be associated with Fe-Mn oxides (Kuo *et al.,* 1983; Ma and Rao, 1997; Ramos *et al.,* 1994). Zn distribution pattern followed the order: residual> oxides-bound > carbonate-bound> organic-bound> exchangeable> water soluble fractions. These results were in accordance with those obtained by Zaghloul *et al.,* (2006) and Abul Kashem *et al.,* (2011). While in the contaminated calcareous soil the Zn was mostly concentrated in the residual fraction followed by carbonate-bound fraction (72.05 and 16.49%, respectively). These results are in agreement with many previous observations (Yesrebi *et al.,* 1994; Obrador *et al.,* 2003; Abollino *et al.,* 2006; Saffari *et al.,* 2009). Zn distribution pattern in the calcareous soils followed the order: residual> carbonate-bound> organic-bound> oxides-bound> exchangeable> water soluble fractions. In contaminated sandy soil, zinc bound to organic matter was the dominant with amount of 53.79% of the total Zn. Zn distribution pattern in the sandy soils followed the order: organic-bound> residual> oxides-bound> carbonate-bound> exchangeable> water soluble fractions. These results are supported by El-Gendi *et al.,* (1999).

A good recovery was observed for the total Zn where it falls in a range of 90.48 to 98.37% according to data presented in Table (2).

1

2

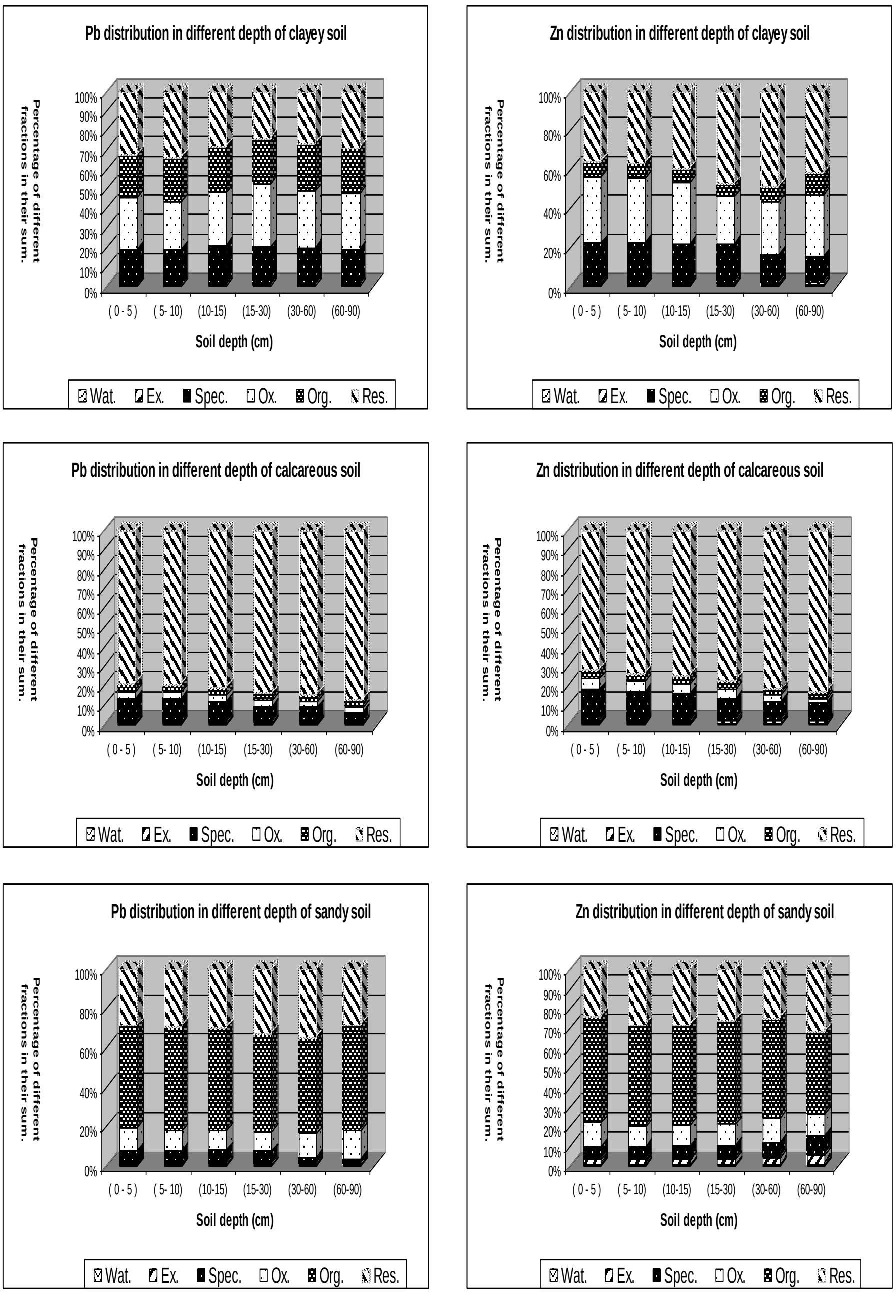

Fig. (1): Distribution of Pb and Zn in various fractions of soils based on total concentration.

Mobility of Pb and Zn in different soil types:

The sequential extraction procedure used in our study is based on operationally defined mobile fractions (F1 to F3) and immobile fractions (F4 to F6).

Data in Table (3) indicted that the mobility factor (MF) varied in individual soil and between the two studied metals (Pb and Zn). In general, the MF values (expressed as percentage of sum of all fractions in the surface layer of soils) in the studied soils showed that Zn is more mobile than Pb where MF values in the surface layer were higher for Zn (9.71 – 22.24%) than that for Pb (7.43 – 19.2%). The mobility of Pb and Zn was decreased with soil depth where the values of MF in the surface layers of the three studied soils were higher than those in the subsurface layers.

For Pb and Zn the MF values were highest (19.20 – 22.24%, respectively) in contaminated clay soil and lowest (7.43 – 9.71%) in sandy soil, while intermediate (13.58 – 18.06%, respectively) in calcareous soil. Many investigators studied the adsorption of heavy metals on soil components such as clay minerals, metal oxides and humic substances. The selectivity with which the cation exchange sites of different clay minerals adsorb heavy metals cations was in the order of Zn < Pb (Abd- Elfattah and Wada, 1981). The selectivity in adsorption of Zn and Pb on the hydrated oxides and oxides of iron and aluminum was almost the same as that on clay minerals (McKenzie, 1980 and Benjamin and Leckie, 1981). These results supported well the order of heavy metals in the mobile fractions found in our study. The data also confirmed that Zn was more mobile than Pb metal in the studied soils. Therefore, Zn was likely to be easily taken up by vegetation grown in these contaminated soils. These results are in accordance with those obtained by Abul Kashem *et al.,* (2011).

Correlation analysis between soil properties and Pb & Zn fractions:

Data in the Table (4) indicted that both of organic mater and clay contents are positively correlated to Pb and Zn fractions in different soil types, while soil pH showed negative correlations. Based on values of correlation coefficients, the effect of different soil properties on Pb and Zn fractionation in different soil types could be detected and the soil properties that give the highest correlation could be considered as the most effective properties. Therefore, the results indicated that, in clay and calcareous soils, the most important factors controlling distribution of Pb and Zn were organic matter content and soil pH and to a lesser extent clay content and electrical conductivity. While in sandy soil, the most effective soil properties on Pb and Zn speciation were organic matter and clay contents followed by soil pH and to a lesser extent electrical conductivity. These results were supported by those obtained by Kashem and Singh (2004) and Rieuwerts *et al.,* (2006). The high correlation coefficients between the soil organic matter content and the organically bound fraction are ascribed to the strong chelating power of soil organic matter with Zn as well as to the surface adsorption of Zn onto soil organic matter (Chahal *et al.,* 2005).

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CONCLUSION

The obtained results from sequential extraction indicated that Pb and Zn were mostly concentrated in the residual and oxide-bound fractions in the contaminated clayey soil, while in the contaminated calcareous soil the Pb and Zn were mostly concentrated in the residual and carbonate-bound fractions. In the contaminated sandy soil, Zn and Pb bound to organic matter were the dominant. The mobility factor values indicated that Zn was more mobile than Pb metal in the studied soils. Therefore, Zn was likely to be easily taken up by vegetation grown in these contaminated soils. The correlation of Pb and Zn forms with some soil properties showed that soil organic matter content and pH were the most important factors controlling Pb and Zn distribution and subsequently its bioavailability in the contaminated clayey and calcareous soils while in sandy contaminated soil, the most effective soil properties on Pb and Zn speciation were organic matter and clay contents followed by soil pH.

REFERENCES

Abd El Razek, A.A. (2013). The mobility and speciation of lead and cadmium in Bahr El Baqar region, Egypt. J. Environ. Chem. Eng. http://dx.doi.org/10.1016/j.jece.2013.11.006

Abd-Elfattah, A. and K. Wada (1981). Adsorption of lead, copper, zinc, cobalt and cadmium by soil that differ in cation-exchange materials. J. Soil Sci., 32: 271-283.

Abollino, O.; A. Giacomino; M. Malandrino; E. Mentasti; M. Aceto and R. Barberis (2006). Assessment of metal availability in a contaminated soil by sequential extraction. Water, Air, Soil Poll., 137: 315-338. DOI: 10.1007/sl1270-005-9006.

Abou Zied, M.M.A. (1999). Fractionation of some heavy metals in soil profiles affected by different sources of pollution. Zagazig J. Agric., Res. Vol. 26, No. 38, pp. 877-894.

Abul Kashem, M.d.; B.R. Singh; S.M. Imamul Huq and S., Kawai (2011). Fractionation and mobility of cadmium, lead and zinc in some contaminated and non-contaminated soils of Japan. J. of Soil Sci. and Environ. Management. 3(9): 241-249.

Andersson, A.J. (1977). Heavy metals in Swedish soils: On their retention distribution, and amounts Swed . J. Agric. Res. 7:7-20.

Badawy, S.H. and M.I.D. Helal (2002). Chemical forms and movements of heavy metals in sandy soil irrigated with sewage effluent. Egypt J. Soil Sci., 42(3): 417-434.

Benjamin, M.M. and J.O. Leckie (1981). Competitive adsorption of Cd, Cu, Zn and Pb on amorphous iron hydroxides. J. Colloid Interface Sci., 83: 410-419.

Brummer, G.W. (1986). Heavy metal species: Mobility and availability in soils. In the importance of chemical “speciation” in environmental processes, ed. M. Bernhard, F.E. Brinckman & P. J. Sadlers Springer- Verlag, Berlin, Germany, pp. 169-192.

Chahal, D.S.; B.D. Sharma and P.K. Singh (2005). Distribution of forms of Zinc and their association with soil properties and uptake in different soil orders in semi-arid soils of Punjab, India. Commum. Soil Sci. Plant Anal., 36: 2857-2874. DOI: 10.1080/00103620500306031.

Cottenie, A.; M. Verloo; L. Kikens; G. Veighe and R. Camerlynck (1982). Analytical Problems and Methods in chemical plant and soil analysis. Handbook, Ed. A. Cottenie, Gent, Belgium.

Dewis, J. and F. Freitas (1970). Physical and chemical methods of soil and water analysis. Soil Bulletin 10, FAO, Rome, and 275 pages.

Dudka, S. and A. Chlopecka (1990). Effect of solid- phase speciation on metal mobility and phytoavailability in sludge-amended soil. Water Air Pollut. 51: 153-160.

El-Gendi, S.A. (1994). Chemical equilibrium of some heavy metals. Ph.D. thesis. Fac. of Agric., Cairo Univ., Egypt.

El-Gendi, S.A.; A.H. Somaya; M. Abu-Sinna, and N.F. Kandil (1999). Fractionation and accumulation of some heavy metals in soils and plants irrigated with sewage effluent. Egypt. Soil Sci. Vol. 39 No. 2,pp. 211-221.

Elsokkary, L.H. (1980). Contamination of edible parts of seven plant crops and soils by heavy metals in urban area by air pollution in Alex. District. Egypt. Atmospheric Pollo. The 14th Intern. Colloq. Paris. France. 433-438.

Jackson, M.L. (1960). Soil chemical analysis. Prentice-hall, Inc., Englewood Cliffs, N.J.

Jin, C.W.; S.J. Zheng; Y.F. He; G.D. Zhou and Z.X. Zhou (2005). Lead contamination in tea garden soils and factors affecting its bioavailability. Chemosphere, 59: 1151-1159.

Kabala, C. and B.R. Singh (2001). Fractionation of copper, lead and zinc in soil profiles in the vicinity of copper smelter. J. Environ. Qual., 30: 485-492.

Kashem, M.A. and B.R. Singh (2004). Transformation in solid phase species of metals as affected by flooding and organic matter additions in contaminated soil. Commun. Soil Sci. Plant Anal., 35: 1435 – 1456.

Kuo, S.; P.E. Heilman and A.S. Baker (1983). Distribution and forms of copper, zinc, cadmium, iron and manganese in soils near a copper smelter. Soil Sci. 135, 101-109.

Ma, L.Q. and G.N. Rao (1997). Effects of phosphate rock on sequential chemical extraction of lead in contaminated soils. Journal-of-Environmental-Quality. 26: 3, 788-794; 30.

McBride, M.B. (1989). Reactions controlling heavy metals solubility in soils. Adv. Soil Sci. 10: 1-57.

McKenzie, R.M. (1980). The adsorption of lead and other heavy metals on oxides of manganese and iron. Aust. J. Soil Res., 18: 61-73.

Miller, W.P. and W.W. McFe (1983). Distribution of cadmium, zinc, copper and lead in soils of industrial North Western Indiana. J. Environ. Qual. 12, 29.

Minitab Inc (1992). Minitab Handbook, Second Edition.

Obrador, A.; J. Novillo and J.M. Alvarez (2003). Mobility and availability to plants of two zinc sources applied to calcareous soil. Soil Sci. Soc. Am. J. 67, 564-572.

Oluwatosin, G.A.; O.D. Adeyolanu; T.O. Dauda and G.E. Akinbola (2008). Levels and geochemical fractions of Cd, Pb and Zn in vally bottom soils of some urban cities in South-Western Nigeria. African Journal of Biotechnology, 7(19): 3455-3465.

Petruzzelli, G. and L. Lubrano (1994). Soil sorption of heavy metals as influenced by sewage sludge addition. J. Environ. Sci. Health, A29, 31-50.

Powell, K.J.; P. L. Brown; R.H. Byrne; T. Gajda; G. Hefter; S. Sjoberg and H. Wanner (2005). Chemical speciation of environmentally significant heavy metals with inorganic ligands. Part 1: The . $^{2+}$, Cl^-, OH^-, CO_3^{-2}, SO_4^{-2} and PO_4^{-3} aqueous systems. Pure Appl. Chem., 77: 739-800.

Ramos, L.; L.M. Hernandez and M.J. Gozalez (1994). Sequential fractionation of copper, lead, cadmium and zinc in soils from or near Donana-National Park. Environmental Quality 23: 50-57.

Rieuwerts, J.S.; M.R. Ashnore; M.E. Farago; I. Thornton (2006). The influence of soil characteristics on the extractability of Cd, Pb and Zn in upland and moorland soils. Sci. Total Environ., 366: 864-875.

Saffari, M.; J. Yasrebi; N. Karimian and X.Q. Shan (2009). Evaluation of three sequential extraction methods for fractionation of zinc in calcareous and acidic soils. Research J. Biological. Sci. 4(7): 848-857.

Salbu, B; T. Krekling and D.H. Oughton (1998). Characterization of radioactive particles in the environment. Analyst, 123: 843-849.

Tessier, A.; P.G.C. Cambell; and M. Bisson (1979). Sequential extraction procedure for the speciation of particulate trace metals. Anal. Chem. 51, 844-850.

Vijver, M.G.; C.A.M. Van Gestel; R.P. Lanno; N.M. Van Straalen and W.J.G.M. Peijnenburg (2004). Internal metal sequestration and its ecolotoxicological relevance: a review. Environ. Sci. Technol., 38: 4705-4712.

Yasrebi, J.; N. Karimian; M. Maftoun; A. Abtahi and A.M. Sameni (1994). Distribution of zinc in highly calcareous soils as affected by soil physical and chemical properties and application of zinc sulphate. Commun. Soil Sci. Plant Anal., 25: 2133-2145. DOI: 10.1080/00103629409369177.

Yobouet, Y.A.; K. Adouby; A. Trokourey and B. Yao (2010). Cadmium, copper, lead and zinc speciation in contaminated soils, Int. J. Eng. Sci. Technol. 2 802–812.

Zaghloul, A.M.; Camilia; El-Dewiny and R.A. Youssef (2006). Distribution of Lead Zinc in some Egyptian Soils. J. of Appl. Sci. Res. 2(5): 284-289.

توزيع وحركية الرصاص والزنك في بعض الأراضي الملوثة في مصر

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تعد العناصر الثقيلة من الأشياء التي قد تسبب تسمم للحياة البشرية والبيئة. وتعتمد سمية العنصر على ارتباطاته الكيميائية في التربة. لذلك فان دراسة الصور الكيميائية للعنصر في التربة لها أهمية كبرى لتقييم حركية وتيسر هذا العنصر. في هذه الدراسة تم اختيار ثلاثة قطاعات لأراضى ملوثة ممثلة لأكثر أنواع الأراضي شيوعا في مصر (طينية – جيرية – رملية) وذلك لدراسة التوزيع والصور الكيميائية لعنصري الرصاص والزنك في هذه الأراضي وعلاقته بخواص التربة. حيث تم استخدام الاستخلاص التتابعى لتجزيئ الرصاص والزنك لستة مجموعات وهى: الذائبة في الماء (F1)، المتبادلة (F2)، المرتبطة بالكربونات (F3)، المرتبطة بأكاسيد الحديد والمنجنيز (F4)، المرتبطة بالمادة العضوية (F5) والمتبقية (F6). وقد أوضحت النتائج المتحصل عليها ما يلي: الجزء المتبقي هو الصورة الغالبة لعنصري الرصاص والزنك في الأراضي المختلفة المستخدمة في هذه الدراسة وهذا يدلل على قلة الكمية الميسرة لهذه العناصر بدرجة كبيرة. في الأراضي الطينية الملوثة تركز معظم الرصاص والزنك في الجزء المتبقي والجزء المرتبط بأكاسيد الحديد والمنجنيز بينما تركز معظم هذه العناصر في الجزء المتبقي والجزء المرتبط بالكربونات للأراضي الجيرية الملوثة. و في الأراضي الرملية الملوثة كان الجزء الأكبر من عنصري الدراسة هو الجزء المرتبط بالمادة العضوية للتربة حيث شغل توزيع الرصاص والزنك الترتيب الأتي: الجزء المرتبط بالمادة العضوية> الجزء المتبقي> الجزء المرتبط بأكاسيد الحديد والمنجنيز> الجزء المرتبط بالكربونات> الجزء المتبادل> الجزء الذائب في الماء. أظهرت قيم معامل الحركية (مجموع كميات العناصر المرتبطة بالأجزاء من F1 إلى F3 / مجموع الكميات المرتبطة بالأجزاء من F1 إلى F6 X 100) أن عنصر الزنك أكثر حركية من الرصاص مما يؤكد سهولة امتصاصه عن طريق النبات المنزرع في هذه الاراضى بصورة أكثر من الرصاص. سجلت أعلى قيم لمعامل الحركية لعنصري الزنك والرصاص في الاراضى الطينية بينما وجدت اقل القيم في الاراضى الرملية وقد شغل معامل الحركية قيما متوسطة في الاراضى الجيرية. أوضحت نتائج الارتباط بين صور الرصاص والزنك المختلفة مع بعض خواص التربة أن محتوى التربة من المادة العضوية ودرجة الpH لها من أهم العوامل التي تؤثر في توزيع و تيسر هذه العناصر في الاراضى الطينية والجيرية الملوثة بينما كانت محتويات التربة من المادة العضوية والطين يليهم درجة الpH للتربة أكثر الخواص تأثيرا على توزيع وتيسر الرصاص والزنك في الاراضى الرملية الملوثة.

Table (2): Concentration of Pb and Zn in individual fraction of soil and total of soil (mg kg^{-1}).

Soil types	Depth (cm)	Pb in polluted soil									Zn in polluted soil								
		Wat. (F1)	Ex. (F2)	Spec. (F3)	Ox. (F4)	Org. (F5)	Res. (F6)	Sum.	Total	Recovery** %	Wat. (F1)	Ex. (F2)	Spec. (F3)	Ox. (F4)	Org. (F5)	Res. (F6)	Sum	Total	Recovery %
Clayey	(0 - 5)	0.10	0.16	14.57	20.65	16.75	25.00	77.23	80.00	96.54	0.55	1.09	22.95	37.80	8.20	40.00	110.59	115.26	95.95
	(5- 10)	0.10	0.14	14.02	18.25	16.51	25.00	74.02	77.25	95.82	0.53	1.00	20.70	32.25	7.65	36.00	98.13	103.55	94.77
	(10-15)	0.09	0.14	13.25	17.36	15.08	18.00	63.92	66.25	96.48	0.50	0.93	19.35	29.75	6.60	37.00	94.13	97.54	96.50
	(15-30)	0.07	0.11	10.78	17.52	12.58	13.00	54.06	54.11	99.91	0.45	0.81	17.40	20.20	5.35	40.00	84.21	88.00	95.69
	(30-60)	0.07	0.10	10.25	15.05	12.50	14.00	51.97	53.00	98.06	0.39	0.74	9.45	17.25	5.10	31.00	63.93	66.21	96.56
	(60-90)	0.05	0.08	8.57	12.90	10.55	13.00	45.15	46.32	97.47	0.31	0.61	6.00	14.44	4.90	19.00	45.26	48.30	93.71
Calcareous	(0 - 5)	0.17	0.15	5.52	1.42	1.75	34.00	43.01	47.21	91.10	0.45	0.84	13.50	4.60	3.50	59.00	81.89	83.25	98.37
	(5- 10)	0.15	0.14	5.25	1.35	1.52	33.00	41.41	45.00	92.02	0.44	0.80	11.10	3.65	2.75	53.00	71.74	74.36	96.48
	(10-15)	0.13	0.13	4.35	1.22	1.50	31.00	38.33	40.00	95.83	0.40	0.77	9.15	3.20	2.70	48.00	64.22	66.32	96.83
	(15-30)	0.11	0.13	3.00	1.05	1.21	29.00	34.50	37.22	92.69	0.38	0.66	5.70	2.40	2.00	38.00	49.14	52.00	94.50
	(30-60)	0.09	0.11	2.55	0.89	1.12	26.00	30.76	32.00	96.13	0.32	0.51	4.35	1.55	1.00	35.00	42.73	45.00	94.96
	(60-90)	0.07	0.10	1.62	0.65	1.00	24.00	27.44	30.00	91.47	0.30	0.46	3.75	0.90	1.25	33.00	39.66	41.02	96.68
Sandy	(0 - 5)	0.12	0.23	8.20	13.50	60.00	33.00	115.05	118.11	97.41	0.75	4.05	11.10	19.75	88.05	40.00	163.70	170.11	96.23
	(5- 10)	0.11	0.20	7.20	10.00	53.25	29.00	99.76	103.54	96.35	0.58	3.69	10.15	14.40	75.75	42.00	146.57	150.22	97.57
	(10-15)	0.10	0.18	6.65	8.66	46.23	26.00	87.82	91.00	96.51	0.50	3.62	9.05	13.95	67.25	37.00	131.37	135.55	96.92
	(15-30)	0.08	0.15	5.50	8.10	40.00	26.00	79.83	83.20	95.95	0.48	3.50	7.90	13.05	62.10	31.00	118.03	121.36	97.26
	(30-60)	0.08	0.11	2.25	6.90	28.18	20.00	57.52	60.00	95.87	0.45	3.25	7.34	12.30	48.60	24.00	95.94	101.23	94.77
	(60-90)	0.06	0.10	1.45	6.60	24.75	13.00	45.96	46.52	98.80	0.33	3.04	6.21	7.05	26.50	20.00	63.13	69.77	90.48

Sum* = sum of F1 + F2 + F3 + F4 + F5 + F6
Recovery = (sum/total) x 100**

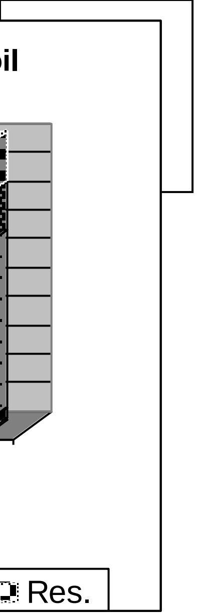

Table (3): Pb and Zn fractions and the MF[*] values expressed as percentage of sum of all fractions in the surface layer of different studied soils:

Soil types	Depth (cm)	Pb in polluted soil							Zn in polluted soil						
		Wat. % (F1)	Ex. % (F2)	Spec. % (F3)	Ox. % (F4)	Org. % (F5)	Res. % (F6)	MF %	Wat. % (F1)	Ex. % (F2)	Spec. % (F3)	Ox. % (F4)	Org. % (F5)	Res. % (F6)	MF %
Clayey	(0 - 5)	0.13	0.21	18.87	26.74	21.69	32.37	19.20	0.50	0.99	20.75	34.18	7.41	36.17	22.24
	(5- 10)	0.13	0.18	18.15	23.63	21.38	32.37	18.46	0.48	0.90	18.72	29.16	6.92	32.55	20.10
	(10-15)	0.12	0.18	17.16	22.48	19.53	23.31	17.45	0.45	0.84	17.50	26.90	5.97	33.46	18.79
	(15-30)	0.09	0.14	13.96	22.69	16.29	16.83	14.19	0.41	0.73	15.73	18.27	4.84	36.17	16.87
	(30-60)	0.09	0.13	13.27	19.49	16.19	18.13	13.49	0.35	0.67	8.55	15.60	4.61	28.03	9.57
	(60-90)	0.06	0.10	11.10	16.70	13.66	16.83	11.27	0.28	0.55	5.43	13.06	4.43	17.18	6.26
Calcareous	(0 - 5)	0.40	0.35	12.83	3.30	4.07	79.05	13.58	0.55	1.03	16.49	5.62	4.27	72.05	18.06
	(5- 10)	0.35	0.33	12.21	3.14	3.53	76.73	12.88	0.54	0.98	13.55	4.46	3.36	64.72	15.07
	(10-15)	0.30	0.30	10.11	2.84	3.49	72.08	10.72	0.49	0.94	11.17	3.91	3.30	58.62	12.60
	(15-30)	0.26	0.30	6.98	2.44	2.81	67.43	7.53	0.46	0.81	6.96	2.93	2.44	46.40	8.23
	(30-60)	0.21	0.26	5.93	2.07	2.60	60.45	6.39	0.39	0.62	5.31	1.89	1.22	42.74	6.33
	(60-90)	0.16	0.23	3.77	1.51	2.33	55.80	4.16	0.37	0.56	4.58	1.10	1.53	40.30	5.51
Sandy	(0 - 5)	0.10	0.20	7.13	11.73	52.15	28.68	7.43	0.46	2.47	6.78	12.06	53.79	24.43	9.71
	(5- 10)	0.10	0.17	6.26	8.69	46.28	25.21	6.53	0.35	2.25	6.20	8.80	46.27	25.66	8.81
	(10-15)	0.09	0.16	5.78	7.53	40.18	22.60	6.02	0.31	2.21	5.53	8.52	41.08	22.60	8.05
	(15-30)	0.07	0.13	4.78	7.04	34.77	22.60	4.98	0.29	2.14	4.83	7.97	37.94	18.94	7.26
	(30-60)	0.07	0.10	1.96	6.00	24.49	17.38	2.12	0.27	1.99	4.48	7.51	29.69	14.66	6.74
	(60-90)	0.05	0.09	1.26	5.74	21.51	11.30	1.40	0.20	1.86	3.79	4.31	16.19	12.22	5.85

MF* = (F1 + F2+ F3)/(F1 + F2 + F3 + F4 + F5 + F6) × 100).