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EFFECT OF INCUBATION PERIODS ON THE BEHAVIOUR OF SOME HEAVY METALS IN SOME SOILS OF EGYPT

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ABSTRACT

Pot experiments were conducted to study the effect of incubation periods on the behaviour of Cd, Pb and Ni in sandy, Nile alluvial and calcareous soils. The treatments were 0, 2.5, 5, 10 and 20 mg Cd kg^{-1} soil; 0, 50, 100, 200 and 400 mg Pb kg^{-1} soil; and 0, 5, 10, 20 and 40 mg Ni kg^{-1} soil in the forms of Cd SO_4, Pb $(NO_3)_2$ and $NiSO_4$, respectively . The different soils were exposed to soil removal after 0, 7, 14 and 45 days of incubation for extracting the available Cd, Pb and Ni. The results showed that increasing the levels of Cd, Pb or Ni added to the different studied soils was associated with a progressive significant increases in their availability. Increasing the time of incubation was accompanied by a gradual decreases in the available contents of Cd, Pb and Ni. .Multiple regression analysis showed the important of OM and pH in influencing the availability of Cd ,Pb and Ni in different soils.

Keywords: Incubation periods, Heavy metals (Cd, Pb, Ni), sandy, Nile alluvial and calcareous soils.

INTRODUCTION

In Egypt, most of the industrial factories lies in and around the agricultural land. Thus, the occurrence of soil pollution with heavy metals such as Cd , Pb and Ni would be expected. So the behaviour of these metals in some soils of Egypt must be taken into consideration. In this concern, Alloway (1990) mentioned that various soil parameters are known to affect the availability of Cd, soil pH is considered one of the major factors influencing the Cd content of plants. Martinez and Motto (2000) reported that the total dissolved concentration of Pb increased with decreasing in pH. Evans *et al.* (1995) revealed that the accumulation of Cd, Pb and Ni increased markedly as the pH decreased below pH 5.0.

Harter (1983) showed that the amounts of Pb and Ni that can be retained by any soil is strongly influenced by the soil pH, but response did vary widely with the type of soil metal. Anderson and Christensen (1988) found that soil organic matter may also be an important factor for Cd and Ni removal. Rautengarten *et al.* (1995) reported that the sensitivity of soils to Cd mobility based on metals deposition, soil type, soil texture, organic matter content and acid deposition. . El-Sayad and Hegazy (1993) reported that the highest amounts of DTPA extractable Cd and Ni were found in the Nile alluvial soils, followed by calcareous soils and the lowest values were extracted from the sandy soils. Pelzer (1987) found that high clay levels lowered the distribution of Pb, Cd and Ni.

Therefore the purpose of this investigation is to study the behaviour of some heavy metals in some soils of Egypt incubated for different periods.

MATERIALS AND METHODS

Incubation experiments were conducted to study the behavior of Cd, Pb and Ni treatments added to the soil individually. Three surface (0-30 cm) soils, namely calcareous, alluvial and sandy soils having physical and chemical characteristics reported in Table (1),

Table (1): Some physical and chemical characteristics of the investigated soil

Characteristics	Nile alluvial	Calcareous	Sand
Particle size distribution %:			
Coarse sand	29.64	35.70	76.10
Fine sand	15.96	7.70	13.73
Silt	23.20	20.70	5.20
Clay	31.20	35.90	5.00
Textural class	Clay loam	Clay loam	Sand
Field capacity %	28.60	19.50	7.60
Soil chemical analysis:			
pH (1:2.5, soil water suspension)	7.69	8.16	7.52
$CaCO_3$ %	2.40	22.40	0.62
O.M. %	1.76	0.67	0.07
C.E.C. me / 100g soil	28.90	17.21	7.30
EC_e dS/m (Soil paste extract)	2.65	3.30	0.75
Soluble cations (meq/l)			
Ca^{++}	5.70	11.61	3.27
Mg^{++}	3.40	7.50	2.03
Na^{+}	16.80	13.40	1.62
K^{+}	0.98	1.20	0.36
Soluble anions (meq/l)			
CO_3^{--}	0.00	0.00	0.00
HCO_3^{-}	3.56	4.34	1.87
Cl^{-}	13.40	12.40	1.45
SO_4^{--}	9.92	16.97	3.96
Available macronutrients(mg kg^{-1}soil)			
N	35.80	14.50	9.80
P	13.90	5.20	9.30
K	210.70	180.90	80.80
Available heavy metals: (mg kg^{-1} soil)			
Cd	1.14	0.42	0.16
Pb	4.66	3.78	0.76
Ni	1.78	1.59	0.42

were selected from Agric. Res. Stations of Nubaria, Giza and Ismailia, respectively. The soil samples were air dried, and ground to pass through a 2 mm sieve. One hundred gram of the soil were placed in plastic cup and received 0, 2.5, 5, 10 and 20 mg Cd Kg^{-1} soil in the form of $CdSO_4$, ; 0, 50, 100, 200 and 400 mg Pb Kg^{-1} soil in the form of $Pb(NO_3)_2$, ; and 0, 5, 10, 20 and 40 mg Ni Kg^{-1} soil as the form of $NiSO_4$. The soils were watered to field capacity and allowed to equilibrate at intervals 0 , 7, 14 and 45 days. The cups were covered with a plastic sheet to minimize evaporation and incubated at room temperature. The moisture was maintained at field capacity by periodically water addition following sample weighting. The design of the experiment was factorial with complete randomized with three replicates. Individual cups representing each soil treatment were exposed to soil removal after 0 , 7, 14 and 45 days for extracting the available Cd, Pb and Ni using 0.005 M DTPA solution and 1 M NH_4HCO_3 at pH 7.6 according to Sultanpour and Schwab (1977).

The initial measurements of extractable Cd, Pb, and Ni were made after 2 h. of the applied treatments equilibration.

RESULTS AND DISCUSSION

1. Behaviour of cadmium in soils:

Data in Table (2) show that increasing level of added Cd to the different soils was associated with a progressive significant increase in its availability at any incubation period. On the other hand, the availability of Cd show a gradual decrease with the increase in time.

Table (2): Effect of applied cadmium treatments on the available Cd (mg kg^{-1}) in the investigated soils at different incubation periods

Cd treatment (mg kg^{-1})	Incubation periods (day) 0	7	14	45
		Sandy soil		
0	0.18	0.16	0.15	0.14
2.5	2.34	2.24	2.18	1.94
5	4.46	4.24	3.66	3.48
10	9.8	9.8	8.8	7.75
20	16.65	11.7	11.15	11.16
Means	6.69	5.63	5.19	4.89
L.S.D. 0.05	Cd = 1.64	Periods = N.S.	Cd × periods = N.S.	
		The Nile alluvial soil		
0	1.26	0.73	0.36	0.37
2.5	2.57	1.90	1.68	1.18
5	4.00	3.34	2.72	2.06
10	10.45	8.25	5.60	6.00
20	16.50	14.90	9.35	8.35
Means	6.96	5.82	3.94	3.59
L.S.D. 0.05	Cd = 1.01	periods = 0.91	Cd × periods = 2.02	
		Calcareous soil		
0	0.65	0.40	0.10	0.29
2.5	3.08	1.52	1.20	1.14
5	3.22	2.40	2.18	2.32
10	4.20	4.30	3.90	3.75
20	10.65	9.25	9.35	8.55
Means	4.36	3.57	3.35	3.21
L.S.D. 0.05	Cd = 0.68	periods = 0.61	Cd × periods = N.S.	

This decrease in the available Cd with time was significant for the Nile alluvial and calcareous soils, but was not significant in sandy soil. On the other hand, the unextractable Cd in the studied soils at the highest level of the applied Cd (20 mg kg^{-1}) within the initial 2 h. of reaction were 16.75, 17.50 and 46.75 % for sandy, the Nile alluvial and calcareous soils, respectively. After the initial 2 h., the extractable values of Cd declined and reached 11.16, 8.35 and 8.55 mg kg^{-1} soil after 45 days from incubation at the same order. These differences may be due to the variations in physical and chemical characteristic of soils, such as cation exchange capacity, organic matter content, $CaCO_3$ content, nutrients content (N, P & K) and soil pH. In fact, clay content and $CaCO_3$ content were important determinations for Cd availability in soils. High $CaCO_3$ content of calcareous soil (22.40 %) and high clay content (31.20 %) of the Nile alluvial soil as well as relatively higher pH values of both soils resulted in a higher decrease in the available Cd when compared with that obtained in case of sandy soil. These results are consistent with those of Pelzer (1987) for clay and O. M.; Eriksson (1989) and Kabata-Pendias and Pendias (1992) for pH. and Hegazy *et al* (1996) and Abd El-Hamied *et al* (1996) for Ca CO_3; Statistical relationships between soil parameters (Table, 3) and available Cd (Table, 2) in different soils are presented in Table (4). The linear regression analysis indicated a significant positive correlation between organic matter content in different soils and available Cd, where the values of the regression coefficient (r) were 0.66^{**}, 0.55^{*} and 0.58^{**} for sandy, the Nile alluvial and calcareous soils, respectively. In this concern, Pelzer (1987) reported that organic matter increases the solubility of Cd in the alkaline range. On the other hand,a negative trend was found between the pH values and available Cd in different soils, but this trend was not significant. Also the same result was found between each of N, P and K and available Cd in different soils, but this trend was not significant for the Nile alluvial soil and for sandy soil with P and K.

2. Behaviour of lead in soils:

The results obtained in Table (5) show a marked differences in the extractability of added Pb among the studied soils. Increasing concentration of the applied Pb resulted in a significantly increase for available Pb in the different tested soils, at the different incubation periods. On the other hand, data show a significant decline in the available Pb in different studied soils with increasing periods of incubation. This finding was more pronounced at latter period (45 days), particularly in the Nile alluvial and sandy soils .This decrease in Pb available mainly attributed to increasing phosphrous concentration. In this connection, Abd El-Aziz *et al.* (1993) showed that the high content of P in soil was accompanied with the decrease in Pb content of soil.

Moreover, statistical relationships between soil parameters (Table, 6) and available Pb (Table, 5) in different studied soil are presented in Table (7). The linear regression analysis revealed that the pH values in different soils showed highly significant and negatively affected the availability of Pb, where the regression coefficients (r) were -0.806^{**}, -0.905^{**} and -0.738^{**} for sandy, the Nile alluvial and calcareous soils, respective. Leshber and Davis

Table (3): The content of macro nutrients, pH and O.M. under different levels of Cd in the investigated soils at different incubation periods.

Cd Treat. mgkg^{-1}	Incubation periods (day) 0					7					14					45				
	pH 1:2.5	O.M. %	N mg kg^{-1}	P mg kg^{-1}	K mg kg^{-1}	pH 1:2.5	O.M. %	N mg kg^{-1}	P mg kg^{-1}	K mg kg^{-1}	pH 1:2.5	O.M. %	N mg kg^{-1}	P mg kg^{-1}	K mg kg^{-1}	pH 1:2.5	O.M. %	N mg kg^{-1}	P mg kg^{-1}	K mg kg^{-1}
Sandy soil																				
0	7.95	0.09	9.63	9.60	81.9	7.80	0.08	9.63	8.09	93.8	7.75	0.07	10.50	6.36	94.1	7.60	0.06	11.39	3.98	97.4
2.5	7.90	0.11	6.13	8.02	81.9	7.80	0.09	8.75	7.66	93.8	7.75	0.09	10.50	3.98	93.4	7.45	0.06	10.50	1.97	95.1
5.0	7.90	0.11	5.25	7.58	77.2	7.75	0.09	8.75	7.58	89.0	7.65	0.09	7.88	1.68	91.4	7.45	0.07	9.63	0.58	90.4
10.0	7.85	0.11	5.25	7.22	77.2	7.70	0.10	7.88	7.01	86.8	7.60	0.10	7.88	1.68	90.4	7.35	0.08	9.63	0.30	90.4
20.0	7.85	0.13	4.38	6.29	65.5	7.60	0.10	7.00	6.58	86.8	7.60	0.10	7.88	1.46	90.4	7.35	0.09	8.75	0.15	91.4
Mean	7.89	0.11	6.13	7.74	76.7	7.73	0.09	8.40	7.38	90.1	7.67	0.09	8.93	3.03	92.0	7.44	0.07	9.98	1.40	92.9
Nile alluvial soil																				
0	8.05	1.85	38.70	12.91	225.3	7.95	1.74	31.90	9.96	206.4	7.90	1.62	31.90	9.96	181.8	7.85	1.55	25.00	7.37	181.8
2.5	8.05	1.91	34.10	10.68	218.3	7.95	1.76	29.30	9.96	205.7	7.90	1.70	27.30	9.74	175.5	7.85	1.58	22.80	7.15	174.1
5.0	8.05	1.91	31.90	10.46	212.0	7.95	1.78	26.00	9.67	195.2	7.90	1.74	22.80	9.02	174.1	7.60	1.60	20.50	7.08	169.2
10.0	8.00	1.94	29.60	9.60	209.9	7.95	1.78	25.00	9.38	191.7	7.85	1.76	20.50	7.08	172.7	7.80	1.62	20.50	7.01	163.7
20.0	7.95	1.98	27.30	9.17	209.2	7.95	1.80	22.80	8.66	189.5	7.85	1.76	20.50	6.86	172.0	7.75	1.76	20.50	6.50	134.8
Mean	8.02	1.92	32.32	10.56	214.9	7.95	1.77	27.00	9.53	197.7	7.88	1.72	24.60	8.53	175.2	7.77	1.62	21.86	7.02	164.7
Calcareous soil																				
0	8.10	0.68	16.80	4.61	184.2	8.10	0.65	15.60	4.46	181.8	8.00	0.63	14.70	2.88	179.8	8.00	0.62	12.60	2.45	161.4
2.5	8.10	0.73	15.80	3.24	179.0	8.05	0.67	13.70	2.81	176.9	8.00	0.67	13.70	1.37	171.6	7.90	0.62	12.60	1.22	152.7
5.0	8.10	0.73	14.70	2.74	173.2	8.00	0.70	13.70	1.30	172.4	7.95	0.67	12.60	1.15	164.2	7.90	0.64	11.60	1.08	148.6
10.0	8.10	0.74	14.70	2.59	170.4	8.00	0.71	11.60	1.01	164.2	7.90	0.69	10.50	0.86	163.8	7.90	0.64	9.50	0.72	145.4
20.0	8.05	0.81	13.70	1.87	166.7	7.95	0.71	11.60	0.72	160.1	7.90	0.69	9.50	0.65	151.1	7.85	0.65	7.40	0.22	143.7
Mean	8.09	0.74	15.14	3.01	174.7	8.02	0.69	13.24	2.06	171.1	7.95	0.67	12.20	1.38	166.1	7.91	0.63	10.74	1.34	150.4

(1985) reported that high soil pH may precipitate Pb as hydroxide, phosphate or carbonate as well as it promotes the formation of Pb-organic complex.

Table (4): Statistical relationships between some soil parameters and available Cd (mg kg^{-1}) in the investigated soil

Soil parameter	Regression coefficient (r)		
	Sandy soil	The Nile alluvial soil	Calcareous soil
PH (1:2.5)	N.S.	N.S.	N.S.
Organic matter (%)	0.664**	0.547*	0.578**
Available N (mg kg^{-1})	-0.646**	N.S.	-0.537*
Available P (mg kg^{-1})	N.S.	N.S.	-0.529*
Available K (mg kg^{-1})	N.S.	N.S.	-0.469*

* Significant at 5%
** Significant at 1%

Table (5): Effect of applied lead treatments on the available Pb (mg kg^{-1}) in the investigated soils at different incubation periods.

Pb treatment (mg kg^{-1})	Incubation periods (day)			
	0	7	14	45
		Sandy soil		
0	0.92	0.42	0.34	0.40
50	39.92	33.52	28.92	16.66
100	97.25	66.80	53.75	44.15
200	194.40	118.60	98.40	70.40
400	317.20	208.00	201.80	176.60
Means	129.94	85.47	76.64	61.64
L.S.D. $_{0.05}$	Pb = 18.71	periods = 16.73	Pb × periods =	37.42
		The Nile alluvial soil		
0	5.44	3.65	3.71	1.02
50	36.28	31.44	22.40	19.78
100	82.95	53.50	49.30	39.35
200	137.60	113.60	106.40	68.10
400	258.00	192.60	156.20	139.80
Means	104.05	78.96	67.60	53.61
L.S.D. $_{0.05}$	Pb = 15.10	periods = 13.50	Pb × periods =	30.21
		Calcareous soil		
0	4.13	2.73	2.41	1.73
50	31.82	27.58	24.84	23.38
100	96.80	70.85	70.35	58.60
200	188.60	125.20	116.30	103.90
400	341.80	270.00	242.90	221.00
Means	132.63	99.27	91.36	81.72
L.S.D. $_{0.05}$	Pb = 21.38	periods = 19.12	Pb × periods =	42.76

Table (6): The content of macro nutrients, pH and O.M. under different levels of Pb in the investigated soils at different incubation periods.

Pb treat. mg kg⁻¹	Incubation periods (day)																			
	0					7					14					45				
	PH 1:2.5	O.M. %	N mg kg⁻¹	P mg kg⁻¹	K mg kg⁻¹	pH 1:2.5	O.M. %	N mg kg⁻¹	P mg kg⁻¹	K mg kg⁻¹	pH 1:2.5	O.M. %	N mg kg⁻¹	P mg kg⁻¹	K mg kg⁻¹	pH 1:2.5	O.M. %	N mg kg⁻¹	P mg kg⁻¹	K mg kg⁻¹
Sandy soil																				
0	7.75	0.06	10.50	9.80	93.6	7.75	0.05	10.63	10.40	96.0	7.50	0.05	11.38	11.50	107.6	7.50	0.03	11.38	12.50	112.4
50	7.75	0.06	8.75	6.70	60.8	7.75	0.06	10.50	8.90	60.8	7.80	0.05	10.50	10.40	84.2	7.80	0.04	11.38	10.40	89.0
100	7.55	0.07	7.00	6.50	53.8	7.65	0.07	7.88	8.60	60.8	7.75	0.06	9.63	10.20	77.2	7.75	0.04	10.50	10.20	82.0
200	7.50	0.07	7.00	6.10	53.8	7.65	0.07	7.88	8.50	53.8	7.70	0.06	8.75	9.70	77.2	7.75	0.05	9.63	10.10	77.2
400	7.25	0.08	7.00	5.20	42.2	7.65	0.07	7.00	7.00	42.2	7.70	0.07	7.88	7.10	46.8	7.75	0.07	11.25	9.40	70.2
Mean	7.56	0.07	8.05	6.86	60.8	7.69	0.06	8.78	8.68	62.7	7.69	0.06	9.63	9.78	78.6	7.71	0.05	10.83	10.52	86.2
Nile alluvial soil																				
0	7.90	1.79	39.20	13.30	212.9	7.95	1.75	39.20	14.80	156.0	8.00	1.72	40.00	15.70	249.0	8.05	1.50	47.60	16.40	344.8
50	7.90	1.80	33.60	8.30	210.5	7.90	1.78	36.00	9.60	212.1	7.95	1.76	39.20	9.80	218.7	8.00	1.73	47.60	10.20	223.6
100	7.85	1.92	28.00	8.60	205.6	7.90	1.81	33.60	8.60	209.7	7.95	1.78	39.20	9.40	212.1	7.95	1.77	42.00	9.50	216.2
200	7.80	2.07	28.00	6.70	201.5	7.80	1.81	33.60	8.50	207.2	7.85	1.78	36.00	8.90	208.0	7.95	1.77	39.20	9.30	208.0
400	7.70	2.14	22.40	6.40	189.2	7.75	1.82	30.80	8.10	195.0	7.80	1.82	33.60	8.20	197.3	7.80	1.78	33.60	9.20	202.3
Mean	7.83	1.94	30.24	8.66	203.9	7.86	1.79	34.64	9.92	196.0	7.91	1.77	37.60	10.40	217.0	7.95	1.71	42.00	10.92	239.0
Calcareous soil																				
0	8.00	0.67	15.93	4.00	190.0	8.00	0.65	18.38	4.70	209.7	8.10	0.65	19.60	6.10	212.5	8.90	0.64	20.82	7.60	223.0
50	7.95	0.71	14.70	4.00	189.1	8.00	0.69	15.93	4.20	204.5	8.05	0.67	15.93	4.40	206.6	8.05	0.67	15.93	6.50	221.4
100	7.95	0.72	12.25	1.30	187.2	8.00	0.71	14.70	3.50	197.5	8.00	0.67	14.70	3.90	201.2	8.05	0.67	15.93	4.30	212.5
200	7.95	0.81	11.03	1.10	176.9	7.95	0.73	12.25	3.50	183.0	8.00	0.69	12.25	3.80	196.1	8.00	0.68	14.70	3.90	197.0
400	7.95	0.83	9.80	0.70	139.9	7.95	0.75	11.03	3.40	162.9	7.95	0.71	12.25	3.70	177.4	8.00	0.69	13.48	3.70	193.8
Mean	7.96	0.75	12.74	2.22	176.6	7.98	0.71	14.46	3.86	191.5	8.02	0.68	14.95	4.38	198.8	8.20	0.67	16.17	5.20	209.5

Table (7): Statistical relationships between some soil parameters and available Pb (mg kg^{-1}) in the investigated soils

Soil parameter	Regression coefficient (r)		
	Sandy Soil	The Nile alluvial soil	Calcareous Soil
pH (1:2.5)	-0.806**	-0.905**	-0.738**
Organic matter (%)	0.760**	0.705**	0.804**
Available N (mg kg^{-1})	-0.825**	-0.767**	-0.839**
Available P (mg kg^{-1})	-0.674**	-0.717**	-0.668**
Available K (mg kg^{-1})	-0.794**	-0.521*	-0.876**

* Significant at 5%

** Significant at 1%

Also, a significantly negative correlations were obtained between each of N, P and K and available Pb. Where, the regression coefficients (r) were -0.825**, -0.767** and -0.839** for N; -0.674**, -0.717** and -0.668** for P and -0.794**, -0.521* and -0.876** for K in sandy, the Nile alluvial and calcareous soils, respectively.

3. Behaviour of nickel in soils:

The effect of different concentrations of applied Ni to the tested soils, which were incubated for 45 days on the availability of Ni are shown in Table (8). Data also show that increasing levels of applied Ni to the different studied soils was associated with a progressive significant increase in the availability of Ni in all the studied soils at all incubation periods. Data also show a significant decline in the available Ni in the different soils treated by $NiSO_4$ with increasing periods of incubation. This decline was pronounced through the duration periods up to 45 days in all the studied soils. Thisdecline in different soils may be due to the complexity and nature of the chemical interactions between applied Ni and the soil constituents. Similar results were obtained by Pelzer (1987) for organic matter and clay minerals; Kabata-Pendias and Pendias (1992) for pH; Miller *et al.* (1992) for CEC. and Abd El-Hamied *et al.* (1996) and Robinson *et al.* (2000) for $CaCO_3$.

Statistical relationships between soil parameter (Table, 9) and available Ni (Table, 8) in the different studied soils are given in Table (10). The linear regression analysis indicated a significant negative correlation between soil pH values and available Ni in the studied soils, where the regression coefficients (r) were -0.613**, -0.597** and -0.686** for sandy, the Nile alluvial and calcareous soils, respectively. In this concern, Kabata-Pendias and Pendias (1992) reported that the solubility of Ni in soil is inversely related to the soil pH. This may be due to Ni in soil formed a ligand with OH and precipitated as Ni hydroxides at alkaline soil pH. Also, the same trend was found between each of N, P & K and available Ni in the studied soils, where the regression coefficients (r) were -0.507**, -0.572** and -0.586** for N, -0.456*, -0.649** and -0.674** for P and -0.657**, -0.726** and -0.827** for K in sandy, the Nile alluvial and calcareous soils, respectively. On the other hand, significant positive correlations were found between organic matter content and available Ni, where the regression coefficients (r) were 0.660**, 0.437* and 0.724** for sandy, the Nile alluvial and calcareous soils, respectively. Pelzer (1987) reported that organic matter increases the solubility of Ni in the soil.

Table (8): Effect of applied nickel treatments on the available Ni ($mg\ kg^{-1}$) in the investigated soils at different incubation periods.

Ni treatment ($mg\ kg^{-1}$)	Incubation periods (day) 0	7	14	45
		Sandy soil		
0	0.62	0.53	0.39	0.32
5	4.76	4.43	3.48	2.37
10	6.51	5.43	4.50	3.26
20	8.74	7.25	5.64	4.73
40	14.70	13.16	11.23	6.49
Means	7.07	6.16	5.05	3.43
L.S.D. $_{0.05}$	Ni = 0.96	periods = 0.86	Ni × periods = 1.92	
		The Nile alluvial soil		
0	1.91	1.62	1.59	1.35
5	4.12	3.79	3.87	2.91
10	5.42	5.02	4.76	3.42
20	8.90	7.17	6.61	5.07
40	15.20	14.00	7.74	5.91
Means	7.11	6.32	4.91	3.73
L.S.D. $_{0.05}$	Ni = 0.88	periods = 0.78	Ni × periods = 1.76	
		Calcareous soil		
0	2.21	2.04	1.27	1.06
5	4.54	3.81	3.83	3.96
10	5.58	5.08	5.27	4.55
20	7.76	6.30	5.77	5.82
40	13.80	8.05	6.52	6.02
Means	6.78	5.06	4.53	4.28
L.S.D. $_{0.05}$	Ni = 0.60	periods = 0.35	Ni × periods = 1.20	

Table (9): The content of macro nutrients, pH and O.M. under different levels of Ni in the investigated soils at different incubation periods.

Ni Treat. mg kg^{-1}	Incubation periods (day)																			
	0					7					14					45				
	pH 1:2.5	O.M. %	N mg kg^{-1}	P mg kg^{-1}	K mg kg^{-1}	pH 1:2.5	O.M. %	N mg kg^{-1}	P mg kg^{-1}	K Mg kg^{-1}	pH 1:2.5	O.M. %	N mg kg^{-1}	P mg kg^{-1}	K mg kg^{-1}	pH 1:2.5	O.M. %	N mg kg^{-1}	P Mg kg^{-1}	K mg kg^{-1}
Sandy soil																				
0	7.65	0.08	12.60	10.95	78.5	7.95	0.06	14.70	8.58	78.5	8.05	0.05	15.75	9.65	78.5	8.05	0.04	15.75	10.49	92.6
5	7.55	0.08	9.45	7.79	64.6	7.90	0.06	13.65	8.58	78.5	8.00	0.05	15.75	9.43	78.5	8.05	0.05	16.80	10.37	92.6
10	7.50	0.08	8.40	7.72	64.6	7.65	0.06	12.60	8.30	73.0	7.95	0.06	15.75	9.29	73.0	8.05	0.05	16.80	9.72	78.5
20	7.45	0.10	8.40	7.52	56.2	7.65	0.07	11.55	8.30	73.0	7.85	0.06	14.70	9.22	73.0	8.05	0.05	16.80	9.58	73.0
40	7.40	0.13	7.35	7.36	50.6	7.45	0.08	9.45	8.15	70.3	7.75	0.07	13.65	9.07	70.3	7.95	0.07	18.90	9.32	73.0
Mean	7.51	0.09	9.24	8.27	62.9	7.72	0.07	12.39	8.38	74.6	7.92	0.06	15.12	9.33	74.6	8.03	0.05	17.01	9.90	81.9
Nile alluvial soil																				
0	7.75	1.67	36.75	12.52	207.6	7.80	1.72	63.70	13.96	224.4	7.85	1.71	71.1	14.18	230.4	7.90	1.52	73.5	16.16	249.8
5	7.70	1.68	31.85	5.87	205.3	7.80	1.74	44.10	7.46	211.5	7.85	1.76	63.70	8.03	226.7	7.90	1.76	68.60	9.30	231.9
10	7.65	1.74	29.40	5.37	190.1	7.80	1.75	44.10	6.66	209.9	7.85	1.77	58.80	7.89	221.3	7.85	1.77	65.80	8.32	255.3
20	7.60	1.76	26.95	5.01	176.4	7.75	1.77	39.20	6.59	209.9	7.80	1.78	58.80	7.17	220.5	7.85	1.78	63.70	7.96	222.0
40	7.60	1.76	24.50	5.01	176.4	7.75	1.78	36.75	5.80	194.7	7.80	1.79	56.40	7.17	212.2	7.80	1.90	58.80	7.30	222.0
Mean	7.66	1.72	29.89	6.76	191.2	7.78	1.75	45.57	8.09	210.1	7.83	1.76	61.75	8.89	222.2	7.86	1.75	66.08	9.81	236.2
Calcareous soil																				
0	7.95	0.66	17.50	4.52	176.1	8.05	0.65	26.25	4.59	192.9	8.05	0.58	26.25	5.33	192.9	8.15	0.52	31.50	6.97	200.7
5	7.90	0.69	15.75	1.15	171.6	8.05	0.67	24.50	2.50	185.9	8.05	0.67	26.25	3.31	189.6	8.15	0.64	28.00	3.74	193.7
10	7.90	0.69	14.00	0.58	167.1	8.05	0.68	22.75	2.18	180.2	8.05	0.67	24.50	3.24	183.5	8.15	0.65	28.00	3.70	187.6
20	7.85	0.71	14.00	0.58	159.7	8.00	0.69	19.25	2.09	171.2	8.05	0.68	24.50	2.45	177.3	8.10	0.67	28.00	3.50	185.9
40	7.65	0.72	14.00	0.36	149.9	8.00	0.69	15.75	1.97	169.5	8.05	0.69	22.75	2.09	177.3	8.05	0.69	25.00	2.77	181.8
Mean	7.85	0.69	15.05	1.44	164.9	8.03	0.68	21.70	2.67	179.9	8.05	0.66	24.85	3.28	184.1	8.12	0.63	28.10	4.14	189.9

Table (10): Statistical relationships between some soil parameters and available Ni (mg kg^{-1}) in the investigated

Soil parameter	Regression coefficient (r)		
	Sandy Soil	The Nile alluvial soil	Calcareous soil
pH (1:2.5)	-0.613*	-0.597*	-0.686**
Organic matter (%)	0.660**	0.437*	0.724**
Available N (mg kg^{-1})	-0.507*	-0.572**	-0.586**
Available P (mg kg^{-1})	-0.456*	-0.649**	-0.674**
Available K (mg kg^{-1})	-0.657**	-0.726**	-0.827**

* Significant at 5%

** Significant at 1%

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تأثير فترات التحضين على سلوك بعض العناصر الثقيلة فى بعض الأراضي المصرية

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أجريت مجموعة من تجارب الأصص لدراسة تأثير فترات التحضين المختلفة على سلوك بعض العناصر الثقيلة (الكادميوم، الرصاص، النيكل) فى الأراضي الرملية والرسوبية والجيرية ، وكانت المعاملات صفر ، ٢,٥ ، ٥ ، ١٠ ، ٢٠ ملجم/كجم تربة للكادميوم ، صفر ، ٥٠ ، ١٠٠ ، ٢٠٠ ، ٤٠٠ ملجم/كجم تربة رصاص ، صفر ، ٥ ، ١٠ ، ٢٠ ، ٤٠ ملجم/كجم تربة نيكل فى صورة كبريتات كادميوم ، نترات رصاص ، كبريتات نيكل على التوالي. وقد حضنت الأراضي المعاملة لفترات مختلفة هى صفر ، ٧ ، ١٤ ، ٤٥ يوم ، ثم استخلصت عناصر الكادميوم والرصاص والنيكل.

وقد أوضحت النتائج المتحصل عليها أن زيادة مستويات الكادميوم والرصاص والنيكل المضافة إلي الأراضي تحت الدراسة كانت مصحوبة بزيادة معنوية فى كمياتها الميسرة فى الأراضي ، بينما زيادة فترة التحضين فكانت مصحوبة بنقص معنوى فى كمياتها الميسرة ، وقد أظهرت نتائج التحليل الإحصائي للعلاقة المتعددة بين تلك العناصر ومكونات التربة المختلفة أهمية المادة العضوية ورقم الحموضة والقلوية كعوامل مؤثرة على تيسر تلك العناصر فى الأراضي تحت الدراسة