

EVALUATION OF CHEMICAL REMEDIATION TECHNIQUES OF Pb-CONTAMINATED SOILS USING KINETIC APPROACH

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ABSTRACT

This study investigated the effect of rock phosphate (RP), polyvinyl acetate butyl acrylate emulsion 50% active material w/w (PVAc) and Humic acid (HA) as natural and synthetic materials applied in remediation, and time of soil incubation on rates of lead (Pb) desorption from three Egyptian soils, alluvial clay soil (*Typic torrets*), calcareous soil (*Typic calcids*) and Sandy soil (*Typic psammets*), using electrical stirred flow technique (ESFU). Lead fractionations in the studied soils were also investigated after 2 and 16 weeks.

The obtained results showed that in all soil treatments, the applied materials were significantly reduced the extractable fraction of Pb as in following order: HA > RP > PVAc. In addition to that, the percentages of Pb extracted from the studied soils by (NH₄HCO₃) DTPA generally decreased with increasing time of soil incubation in both amended and non-amended soil samples. Data of Pb distribution in different fractions showed that reducing of Pb extracted from different soils may be attributed to precipitation/ adsorption of Pb, rendering Pb less available. The different mechanisms of remediation effects of the used materials from kinetic study and Pb distribution in different soils were discussed.

Keywords: chemical remediation, Pb, kinetic models, Pb fractionation.

INTRODUCTION

Lead contamination in soils is increasingly recognized as a public health hazard due to its toxicity to humans and animals, especially to children. Lead concentration in uncontaminated soils ranges from 2 to 200 mg kg⁻¹ (Lindsay, 1979). However, elevated Pb concentrations have been reported in many soils resulting from anthropogenic activities. A soil is generally considered contaminated with Pb when its total Pb concentration exceeds 300 mg kg⁻¹ (EPA, 1993), and remediation is required when total Pb concentrations is above 400 mg kg⁻¹ (Oswar, 1994). The remediation of metal contaminated soils is of growing importance, due to governmental effect of potential toxic metals. Technologies to remediate Pb contaminated soils include chemical, physical and biological treatments. However, most current treatment technologies are either very costly or only partially effective.

At present, the most usual way of remediating metal contaminated sites is either to cap the site or to excavate and dispose of the contaminated soil elsewhere. These approaches are designed to reduce the risks of metal exposure to vulnerable receptors on a site-specific basis by erecting some forms of barrier between the contaminated soil and the biosphere. Although the metals are effectively isolated from the biosphere, they remain trapped within the barrier and still pose potential pollution threat.

Recently, there has been considerable interest focused on the use of natural or organic materials to react with heavy metals in soil and concentrate them in the easily complicated form as an alternative remediation technology. Lead is used in a variety of industrial and manufacturing processes and is

one of the most common contaminants found at hazardous waste sites (Reed *et al.*, 1996; Gunneriusson *et al.*, 1994 and Strawn *et al.*, 1998).

Another chemical/mineralogical method of rendering metals immobile and non-bioavailability in situ has been suggested by Ma *et al.* 1993; Cotter-Howells, 1996. These methods focus on converting the metals present in the soil into metal phosphates. However, many of these technologies are costly (e.g. excavation of contaminated material and chemical/physical treatment) or do not achieve a permanent or aesthetic solution (e.g. encapsulation, verification). An alternative approach is to form insoluble heavy metal compounds thereby immobilizing the metal and reducing their ecological bioavailability. The prediction of the fate and transport of contaminants such as Pb in the environment, is commonly rely on distribution coefficients and maximum adsorption levels that are obtained from experiments in which it is assumed that the reaction is at equilibrium. However, reactions in the environment are rarely at equilibrium, but instead are in a state of a continuous change because of occurring the dynamic processes occurring (Sparks, 1995 and 1998).

The primary objectives of this research were: (i) To investigate the effectiveness of different materials e.g. Rock phosphate (RP), Humic Acid (HA) and polyvinyleacetat (PVAc) in immobilizing aqueous Pb from Pb contaminated soils, and (ii). To accomplish these objectives using ESFU (Zaghloul and Abou Seeda, 2003) technique with different soil texture. Such soils also varied in their physical and chemical properties.

The obtained results will give insights that may improve remediation strategies, disposal practices and risk assessments.

MATERIALS AND METHODS

Soils

Three cultivated soil samples representing A horizons (0–30 cm) are used namely; clay alluvial soil from El-Sharkia Governorate (*Typic torrerts*), A calcareous soil from Mariot (*Typic Calcids*) and sandy soil from Wadi El-Natron (*Typic Psammets*). The physical and chemical properties analyzed according to Cottenie, *et al.* (1982). are presented in table (1)

Table 1: Some physical and chemical characteristics of the studied soils.

Soil	Type	Dep. (cm)	Avail Pb ppm	pH	Org. Matter (%)	Clay content %	Total CaCO ₃ %	Active CaCO ₃ %	Text
Typic torr.		0-15	54.0	7.68	1.73	42.0	3.06	2.95	Clay
Typic Calcids		0-15	14.0	8.24	0.98	35.5	24.64	17.90	Clay loam
Typic psam.		0-15	5.5	8.00	0.81	2.5	3.00	-	Sandy

Incubation study:

In a pot experiment, three sets of pots were filled with three types of the investigated soil samples. In each set, the soils were pretreated with 500-ppm of Pb as PbNO₃, the polluted soils were left for 48h. After equilibrium, except control (polluted soils), the three sets were treated with RP, HA and PVAc as follows:

- 500 mg/kg rock phosphate (RP)
- 1.00% humic acid (HA) / pot
- poly vinyl acetate butylacrylate emulsion (PVAc)
50% active material w/w

The amended soils were well mixed and each set was divided into two segments to keep the time of soil incubation to two and sixteen weeks. Each treatment was triplicate for each set of soil samples. After each time of incubation the soil samples were air dried and kept for analyses.

Kinetic study for Pb release from different amended soils

Release experiments were carried out using Electrical stirred flow unit (ESFU) method for all soil samples submitted to different incubation times i.e. 2, 8 and 16 weeks. A Diagram of Electrical stirred flow unit used in this paper with the modification of the new set up and mechanism of kinetic procedure was previously mentioned in more details (Zaghloul and Abou-Seeda, 2003). The Pb release data were fitted, using regression analysis of four kinetic equations as follows:

- Modified Freundlich equation which can be expressed as:
$$\text{Log } q = \log b^1 + k_d \log t$$
- The Elovich equation in the form:
$$q_t = 1/\beta \ln \alpha\beta + 1/\beta \ln t$$
- The apparent first-order equation form (Spark, 1989):
$$\text{Log } (1 - k_t/k_0) = -k t$$
- The parabolic diffusion model from (Sparks, 1998) was also used to determine if transport was rate limiting:
$$q_t = b + R t^{0.5}$$

where:

- q = the amount of Pb desorption in time t
- k_d = desorption rate coefficient in $\text{mg kg}^{-1} \text{soil min}^{-1}$
- b^1 = intensity constant in $\text{mg Pb kg}^{-1} \text{soil}$
- α = a constant related to the initial rate of Pb release in $\text{mg Pb kg}^{-1} \text{min}^{-1}$
- β = a constant in $\text{mg kg}^{-1} \text{soil}$
- b = intensity constant in $\text{mg Pb kg}^{-1} \text{soil}$
- R = the apparent diffusion rate coefficient in $\text{mg Pb kg}^{-1} \text{soil min}^{-1}$
- q_0 = the maximum amount of P release $\text{mg P kg}^{-1} \text{soil}$
- k_1 = the rate constant of the reaction in sec^{-1}

The higher the coefficient of determination R^2 and the lower the SE values, the best-fitted equation(s) to describe the kinetic data.

Kinetic parameters in the four tested equations k_d , b^1 of modified Freundlich, α and β of Elovich, R of the parabolic diffusion and k of the first-order equations were calculated for the studied soils under different treatments, compared and discussed. There are many instances in the soil and environmental science literature where mechanistic meanings have been given to rate data slowly on the fit of the data to one of these equations Aharoni and Ungarish, (1976) and Aharoni, *et al.* (1991).

Lead distribution as affected by time of soil incubation and remediation materials in Pb contaminated soils.

After two and sixteen weeks of soil incubation, 1.0 g of each soil were reacted with 15 ml deionized water for 2h in a 40-ml centrifuge tube at room temperature, and the following fractions were obtained: the water soluble, exchangeable, carbonate, Fe-Mn oxides, organic, and residual, using the procedure of Tessier *et al.* (1979), and Zaghloul and Abou Seeda (2003).

- A. Water-soluble:** soil soluble, soil sample extracted with 15 ml of deionized water for 2 h.
- B. Exchangeable:** The residue from water-soluble fraction is extracted with 8 ml of 1M $MgCl_2$ (pH7.0) for 1h.
- C. Carbonate-Form:** The residue from exchangeable fraction is extracted with 8 ml of 1 M NaOAc (adjusted to pH 5.0 with HOAc) for 5h.
- D. Fe-Mn Oxides-Form:** The residue from carbonate fraction is extracted with 0.04M $NH_2OH.HCL$ in 25% (v/v) HOAc at 96°C with occasional agitation for 6h.
- E. Organically form:** The residue from Fe-Mn oxide fraction is extracted with 3 ml of 0.02M HNO_3 and 5ml of 30% H_2O_2 (adjusted to pH 2 with HNO_3). The mixture is heated to 85°C for 2h, with occasional agitation. A second 3-ml aliquot of 30% H_2O_2 (pH 2 with HNO_3) is added and the mixture heated again to 85°C for 3h with intermittent agitation. After cooling, 5 ml of 3.2M NH_4OAc in 20% (v/v) HNO_3 is added and the samples diluted to 20 ml and agitated continuously for 30 min.
- F. Residual Fraction:** The residues from organic fraction are digested using a HF-HCl/ HNO_3 .

After each successive extraction, centrifuging for 30 min did separation. The supernatants were removed with a pipette, filtered and analyzed for metals. The residue was washed with 8.0 ml of deionized water followed by vigorous hand shaking, and then followed by 30 min of centrifugation before the next extraction.

Statistical analysis

The regression analysis and standard division analysis were applied to test the significance of the applied materials in remediation of Pb contaminated soil and to evaluate the conformity of Pb release to the used models. Also, testing the significant differences in rate coefficients and cumulative quantity of Pb desorbed was done using SAS software (SAS, 1985).

RESULTS AND DISCUSSION

Fig 1 illustrates the effects of the incubation periods and type of remediation materials on Pb release from the studied soil samples. According to standard deviation analysis, data show that RP and PVAc materials significantly decreased Pb released from the studied soil samples. However, addition of HA material showed higher decreasing order as compared with either RP, PVAc materials or control treatments. Increasing of the incubation periods from two to eight and sixteen weeks led to decrease Pb release from the contaminated soils used with various degrees according to the properties of the studied soils.

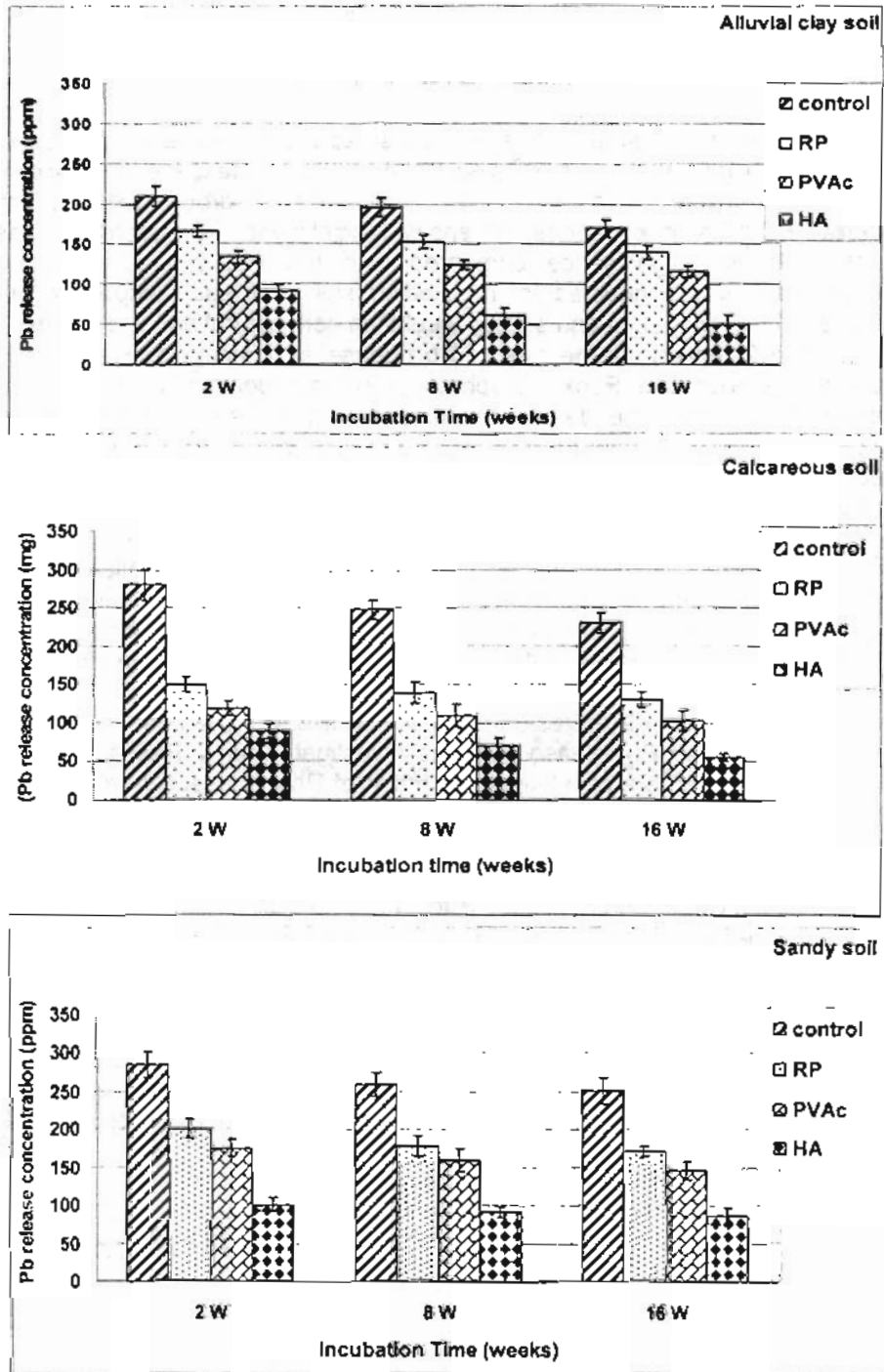


Fig. 1: Effect of Remediation materials and Time of soil incubation on Pb release from the studied soil samples

Kinetics of Pb release from the studied soils as affected by amended materials and time of soil incubation.

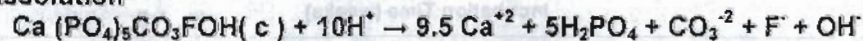
Prior to running complete kinetics of Pb desorption experiment, a preliminary study was conducted to represent the conformity of kinetic models used to the kinetic data. The obtained results indicate that modified Freundlich model was the best fitted equation used to describe the rate of Pb release from the studied soils. The Elovich, the 1st order model and the parabolic diffusion equations, all showed significance to describe release data with low significance compared with the first model. Desorption experiment was conducted in the studied soil after each incubation time achieved (i.e. two, eight and sixteen weeks) in both control and treatments.

Fig 2 represents the rate of Pb release as affected by HA, polyvinyl acetate (PVAc) and Rock phosphate (RP) from contaminated soils. The amended and non-amended soil samples were incubated to eight weeks. The obtained results show that the releasable fraction of Pb from the investigated soil was affected by the type of remediation materials as compared with control one. It was observed that application of humic acid (HA) was more effective than other materials adopted herein for minimizing the mobilization of Pb from the contaminated soils. It was noticed that desorption patterns were characterized by two desorption parts, fast one occurred during the first 360 min particularly for sandy soil followed by calcareous soil after 500 min and finally alluvial soil at 1440 min. and steady state of the desorption characteristic occurred throughout the rest time of the kinetic study.

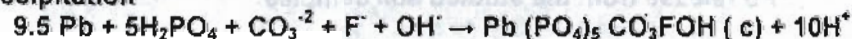
Data in Table 2 represents the rate constant of the best fitting kinetic models described Pb release from the investigated soils. Results indicated that the apparent rate of releasable fraction of Pb expressed by K_d constant of modified Freundlich equation is decreased in all treated soils as compared with control particularly after two weeks of incubation. Higher values were observed in case of PVAc whereas the lowest were noticed in HA treated soil. The beneficial effect of the RP for minimizing the Pb released from the contaminated soil was noticed. The primary mechanism of Pb immobilization in these systems is through dissolution of hydroxyapatite or RP, and subsequent precipitation of a pyromorphite like mineral (Ma *et al.* 1993, 1995). Our hypothesis was supported by that of Ruby *et al.* (1994), who demonstrated that Pb was converted from galena to insoluble lead phosphate in a contaminated soil containing both P and Pb. They further demonstrated that formation of pyromorphite-like mineral significantly reduced Pb bioavailability.

Dissolution of RP and subsequent precipitation of a carbonate fluoropyromorphite-like mineral can be described by the following simplified equation (assuming equal molar concentrations of F^- , OH^- and CO_3^{2-} as an example):

Dissolution



Precipitation



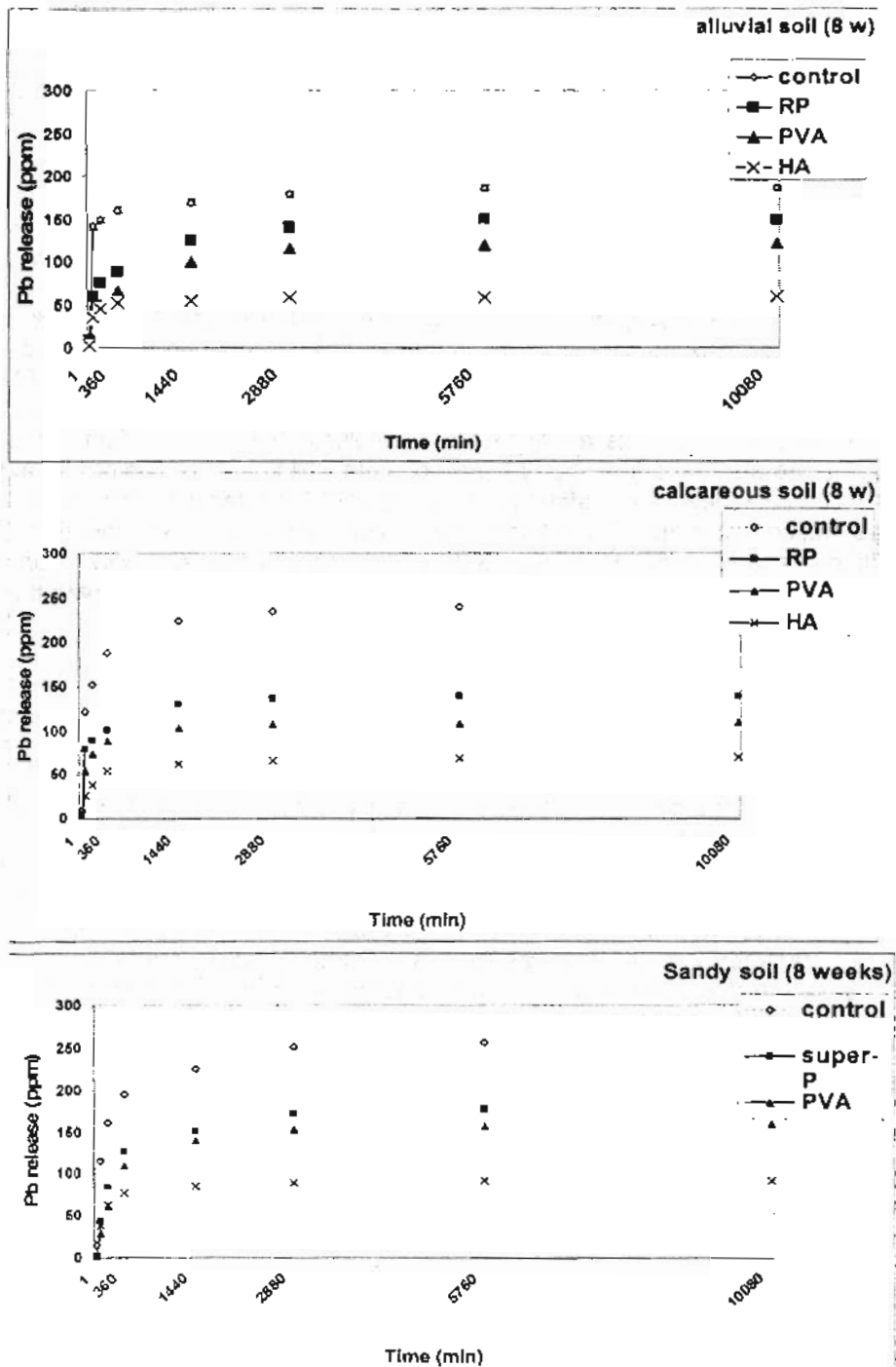


Fig. 2: Kinetics of Pb release from the studied soil samples as affected by remediation materials(8 weeks incubation time)

Results also show that in alluvial clay soil increasing the time of incubation can stimulate the reduction of the mobilization fraction of Pb. It was noticed that averages of decrease were about 41%, -38% and 48% as compared with two weeks of incubation for RP, PVAc and HA respectively. Similar trends were revealed in both calcareous and sandy soils. Results observe that application of RP's was more pronounced effect on the immobilization of Pb from contaminated soil particularly in alluvial soil as compared with other soils. Increasing time of incubation may increase the dissolution of RP creating Ca^{++} , P^- and OH^- concentration, whereas fluoropyromorphite precipitation reduces P and OH^- concentration. Theoretically, the higher the solubility of RP, the more effective the material should be in reducing aqueous Pb concentration. Ma *et al.* (1993), reported that the more soluble the hydroxyapatite, the more effective it is in reducing aqueous Pb. The effectiveness of RP in immobilizing Pb from contaminated soil thus primarily depends on its ability to provide soluble P in soil solution. Other factors are also important such as reaction time and the properties of RP and soil, because they directly affect the solubility of RP reacted with Pb in soils. It was noticed that HA showed the least value followed by RP and PVAc. Martinez and McBride (1999) reported that Pb can strongly react with organic matter, due to its high affinity toward Pb. Li and Shuman (1996) showed that due to high content of the organic matter particularly in the topsoils, Pb can be binded with nonleachable forms reducing the mobility of Pb.

The β value of Elovich equation was shown by Elkhatib and Hern, (1988) to be inversely proportional to the soil supplying power of the studied element to plant. Data in Table 2 represents the β constant values of Pb release from the studied soil samples. The obtained results show that β values influenced by the remediation materials.. After 2 weeks of incubation time, the decreasing order of β values ranged from 42 to 58% in RP treatments regardless the soil type, the respective values were 20-35 % and 59-62 % in PVAc and HA treatments. In all cases, however, the HA treatments showed the higher decreasing order as compared with RP and PVAc treatments. Increasing the incubation time to sixteen weeks led to increase the rate of Pb release in all treatments especially in PVAc treatment. Concerning the soil type, data show that the higher decreasing order was noticed in alluvial clay soil treated with HA, the best treatment in decreasing the rate of Pb release. This result indicates that presence of clay content, organic matter and amorphous materials in alluvial clay soil work as a sunk for Pb in soil.

In calcareous soil high pH and carbonate content are common chemical characteristics of North costal Egyptian soils. In this condition the heavy metals tend to occur in insoluble forms (Neilsen, et.al, 1988). Mainly precipitates in carbonates (Elkhatib, 1990; Andreu and Garcia, 1996, Brown and Elliott, 1992) or oxides. Also, carbonate minerals are the major components of calcareous soils of Egypt and may have a high potential of surface adsorption of heavy metals. This result is supported by McBride, *et al.* (1994) and can have a great effect on Pb mobility and reactivity through their surface interaction with Pb and their effect on soil pH

Table 2: Rate constants of Lead release from the studied soil samples as affected by remediation materials after 2 and 16 weeks of incubation.

Fraction	Incubation Time											
	2 Weeks					16 Weeks						
	Control	Rock P	PVAc	HA	Control	Rock P	PVAc	HA	Control	Rock P	PVAc	HA
Alluvial Clay soil												
K_d	12.75	6.37	8.75	3.91	6.58	3.76	5.41	2.02				
β	0.31	0.18	0.25	0.12	0.29	0.16	0.20	0.09				
k	0.10	0.05	0.07	0.03	0.06	0.30	0.05	0.02				
R	0.17	0.13	0.14	0.10	0.11	0.10	0.11	0.04				
Calcareous soil												
K_d	14.99	7.49	9.25	4.51	8.77	4.72	6.3	2.49				
β	0.76	0.32	0.51	0.29	0.54	0.25	0.43	0.22				
k	0.13	0.10	0.11	0.08	0.08	0.06	0.05	0.02				
R	0.12	0.09	0.11	0.08	0.07	0.08	0.06	0.06				
Sandy Soil												
K_d	19.52	6.25	11.75	2.50	17.32	6.22	9.12	1.79				
β	1.73	0.97	1.13	0.71	1.70	0.91	1.11	0.57				
k	0.22	0.13	0.12	0.11	0.20	0.12	0.11	0.11				
R	0.08	0.05	0.06	0.04	0.06	0.04	0.05	0.04				

The β values of the studied sandy soil were decreased from 1.73 mg kg⁻¹soil in control treatment to 1.0, 1.13 and 0.71 mg kg⁻¹soil by treated the contaminated soil, with RP, PVAc and HA and incubated two weeks of incubation, respectively. After sixteen weeks of incubation time, the respective values of remediation treatments were 0.91, 1.11 and 0.57 mg kg⁻¹soil.

Chien and Clayton (1979) also mentioned that the decreasing of β values enhanced the rate of reaction. Sikora *et al.* (1991) reported that β constant is an important parameter to define the desorption rate of ions (I) or dl/dt throughout the whole dissolution period of added ion.

Although the k and R rate constants of the first-order and parabolic diffusion equations took the same trend of the best fitted equations i.e. modified Freundlich and Elovich equation in the case of alluvial soil, such these constant values in calcareous and sandy soils showed a little or no difference for different incubation periods studied.

Lead distribution as affected by time of soil incubation and remediation materials in Pb contaminated soils.

Lead distribution among the extractant solution e.g.; water soluble (a), exchangeable (b), Carbonate-Bound (c), Fe-Mn Oxide-bound (d), Organic Bound (E) and residual (F) in alluvial, calcareous and sandy soils as affected by chemical remediation and times of incubation are illustrated in figs. 3 and 4. After two weeks of incubation in control treatment of polluted alluvial soil, data indicate that lead was primarily associated with Fe-Mn oxide fraction in control treatment (41 % of sum of all fractions), followed by carbonate bound (26.5 %), exchangeable (20 %), organic (7.5%) and water soluble (5.5 %). In calcareous soil data show that carbonate fraction is the predominant fraction associated with Pb followed by Fe-Mn fraction, organically bound, exchangeable and soluble fractions. In sandy soil, however, lead distribution in control treatment showed that exchangeable and soluble fractions are the predominant fractions as compared to other fractions (~76 %), the other fractions distribution being as follow: carbonate, Fe-Mn and organically bound fraction. Lead associated with Fe-Mn oxides were observed by Andersson, A. 1979; Scokart, *et al.*, 1983; and Ramos *et al.* (1994).

Results also indicated that type of soil and remediation materials were varied in their effect on Pb immobilizing order in different fractions. It was noticed that all remediation materials used in current study reduced soluble and exchangeable fractions of Pb particularly in alluvial soil specially after two weeks of incubation. Results also showed that HA reduced the extractable Pb associated with Fe-MN fraction relatively to other fractions by about \approx 37% comparing with control. Similar trends were noticed after 16 weeks of incubation. It was also noticed that application of HA decreased the mobilizable fraction of Pb by about 81%. However, PVAc treated soil resulted in a reduction of Pb fraction associated in carbonate form by about 43% and 39% particularly after 2 and 16 weeks of incubation as compared with control one. Application of RP in alluvial soil reduced the mobilizable fraction of Pb bounded with organic form \approx 64% followed by carbonate and Fe-Mn fraction (40-47%) and (34-36%) after two and sixteen weeks of incubation, respectively.

Ma *et al.* (1995) have shown that phosphate rock (primarily $\text{Ca}_{10}\text{PO}_4\text{F}_2$) effectively immobilized Pb from aqueous solutions. The primary mechanism of Pb immobilization is via dissolution of phosphate rock and subsequent precipitation of a fluoropyromorphite-like mineral ($\text{Ca}_{10}\text{PO}_4\text{F}_2$) although precipitation of Pb as hydrocerussite also occurred in some instances.

In calcareous soil, results indicate that remediation technique of HA material dose not depend on specific fraction regardless the incubation time. After two weeks data show that percentage of decrease of Pb bound to carbonate was about 70% of control, the Pb organically bound and the Fe-Mn oxide values were ranged between 59-60 %. The same trend was almost detected in sixteen weeks of incubation. In this soil type data showed that PVAc material mainly reduced the carbonate bound Pb over the other fractions. The respective values of the fraction were about 50 and 76 % as compared with control after two and sixteen weeks respectively. The RP treatment indicates that the remediation working varied with time of soil incubation, results show that after two weeks of soil incubation the reduced order was observed in carbonate fraction. After sixteen weeks the higher value was noticed in Fe-Mn oxide and organically bound Pb.

Results also revealed that chemical remediation of the studied sandy soil, just water soluble and exchangeable fractions of Pb were the most predominant fractions affected by the remediation materials added. Moreover, the effectiveness of these materials was observed after 2 weeks of incubation as compared with other soil types. This result may be due to the structureless and less colloidable compounds in the soil type which led to distribute most of Pb added only in both two fractions regardless the long period of soil incubation.

Table 3 represents the conclusion of this study in both control (untreated soil) and remediated soil samples through Pb distribution in different forms as affected by the remediation material and time of soil incubation in different soil samples. From this Table, it could be concluded that HA material is the best material which could be used since the residual form was the highest value as compared with other used material and regardless the incubation time followed by RP and PVAc respectively. In addition, the remediation technique of the studied soil samples is mainly depending on the soil type which influencing the Pb distribution in different fractions Martinez and McBride (1999), McBride, *et al.*, (1999) and Zaghloul and Yousry (2002) reported that soil surface area generally influenced the binding energy of the associated ions and subsequently the release of these ions. The residence time of interaction between remediation material and the studied soils was influencing the Pb distribution and subsequently Pb release from the studied soil samples.

From the stirred-flow experiment five important conclusions can be driven: (i) Pb release consists of fast and a slow reaction, (ii) Pb desorption decreases with addition of soil organic matter (SOM), (iii) desorption is not reversible within the time frame of these experiment, (iv) long incubation times have significant impact on the amount of Pb that can be desorbed, and

(v) apparent hysteresis increases as the percentage of SOM in the soil increases.

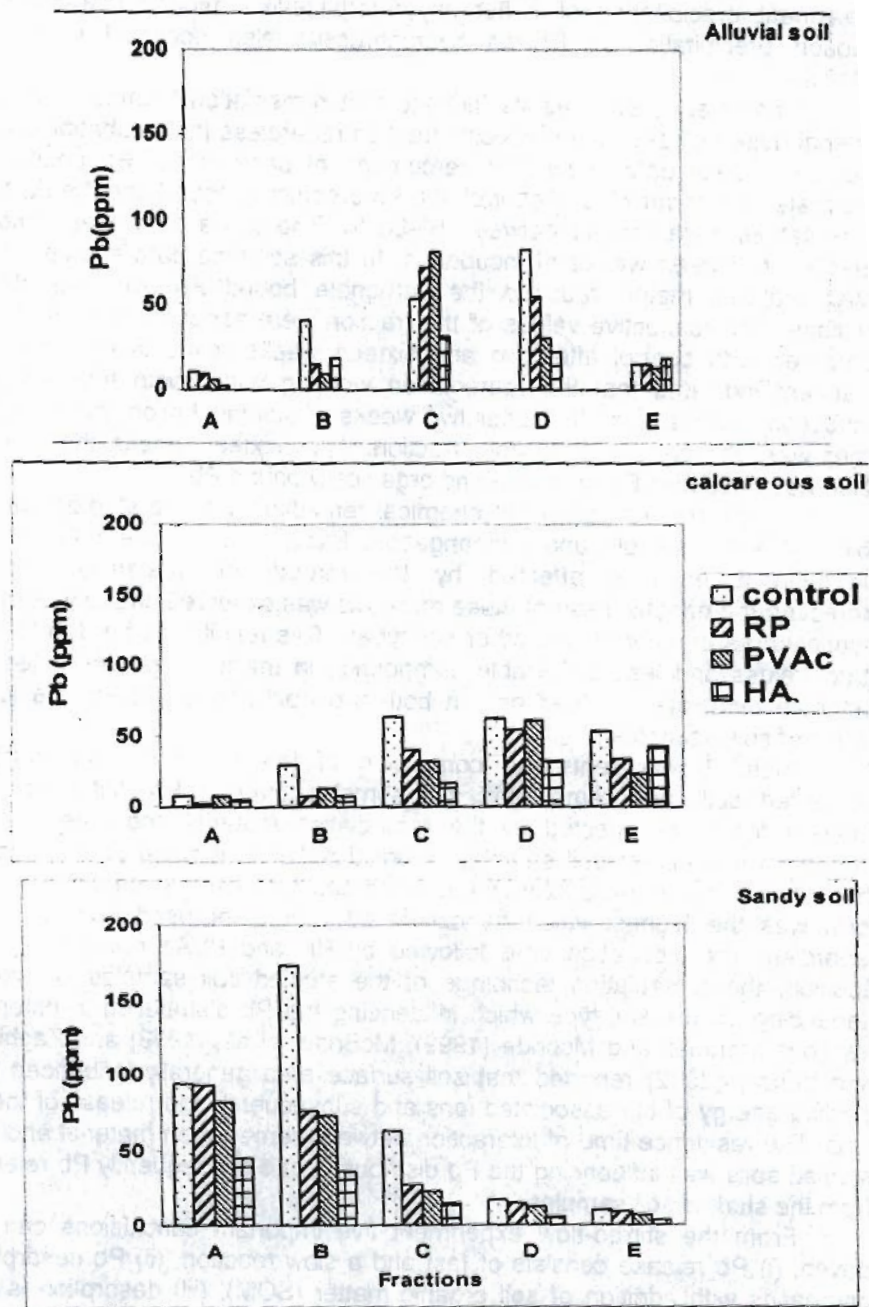


Fig.3 : Lead distribution in different fractions in the studied soils as affected by Remediation and time of incubation (2weeks).

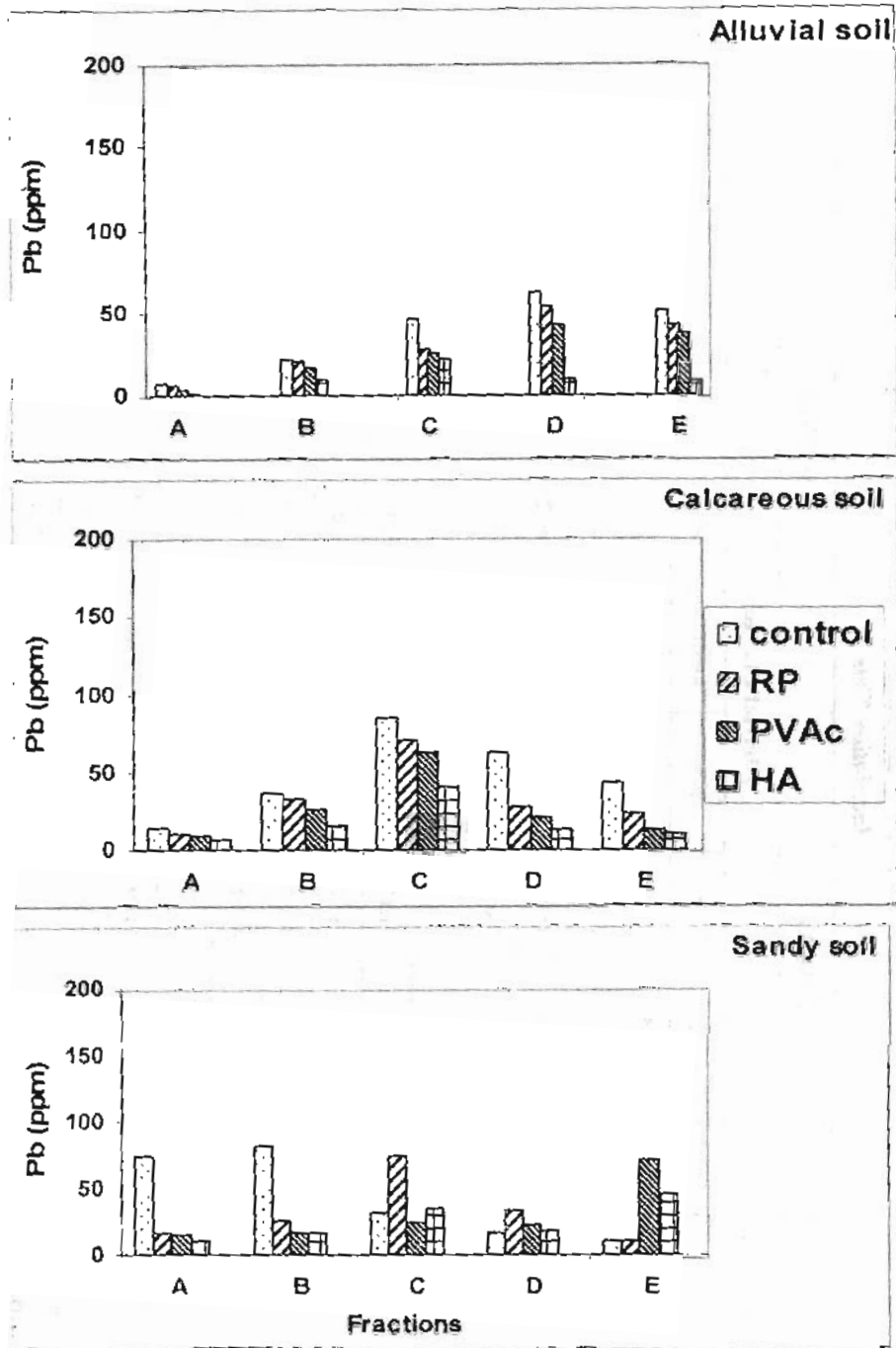


Fig. 4 : Lead distribution in different fractions in the studied soils as affected by Remediation and time of incubation (16 weeks).

Table 3: Lead distribution in different fractions in the studied soils as affected by remediation materials after 2 and 16 weeks of incubation.

Fraction	Incubation Time											
	2 Weeks					16 Weeks						
	Alluvial Clay soil											
	Control	Rock P	PVAc	HA	Control	Rock P	PVAc	HA	Control	Rock P	PVAc	HA
Residual Pb %	59.62	67.5	72.36	81.6	62.88	70.13	74.86	89.42				
N. residual (NR) Pb %	40.38	32.5	27.64	18.5	37.12	29.87	25.14	10.58				
Decrease in NR Pb %	19.24	35.0	44.72	63.1	25.76	40.26	49.72	78.84				
Sum of all fraction	499.9	502	500.0	499.9	508.9	499.8	501.0	503.2				
Calcareous soil												
Residual Pb %	56.54	71.82	71.87	78.66	63.65	68.0	73.9	83.2				
N. residual Pb %	43.46	28.18	28.13	21.34	46.35	32.0	26.13	16.8				
Decrease in NR Pb %	13.08	43.64	43.74	57.32	17.3	36.0	47.77	66.4				
Sum of all fraction	499.8	490.1	493.9	494.5	521.9	514.7	501.0	511.0				
Sandy Soil												
Residual Pb %	29.66	55.83	61.09	78.67	56.84	68.0	25.8	75.3				
N. residual Pb %	70.34	44.17	38.9	21.33	43.16	32.03	74.2	24.7				
Decrease in NR Pb %	-40.68	11.66	22.19	57.34	13.68	35.97	48.4	50.6				
Sum of all fraction	505.7	501.5	507.4	493.2	499.8	500.2	498.0	511.3				

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تقييم كفاءة استخدام بعض المواد كـمعالجات كيميائية في اصلاح الاراضى الملوثة
بعنصر الرصاص وذلك من خلال استخدام تـكنيك الطاقة الحركية
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تهدف هذه الدراسة الى التعرف على كفاءة بعض المواد الكيميائية (الصخر الفوسفاتى-PR- بولى فينيل اسيتات PVAc - وحمض الهيوميك HA) على علاج وتقليل تلوث الاراضى بعنصر الرصاص .
اجريت الدراسة على ثلاث انواع مختلفة من الاراضى المصرية ذات خواص طبيعية وكيميائية مختلفة تشمل الاراضى الرملية Sandy soil الاراضى الرسوبية Alluvial clay soil والاراضى الجيرية Calcareous soil ، كما تشمل الدراسة ايضا تأثير فترات التحضين المختلفة على معدل انطلاق (تيسر) عنصر الرصاص من خلال دراسة صور تلك العنصر العنيدة والمختلفة التالية:

Water soluble, exchangeable, carbonate, Fe.Mn oxides, organically forms and residual fractions.

حيث تشير النتائج الى الاتى:

- ادت اضافة المواد (الصخر الفوسفاتى ، بولى فينيل اسيتات ، حمض الهيوميك) للاراضى الملوثة بعنصر الرصاص الى انخفاض معدل تيسر انطلاق العنصر حيث تشير النتائج الى ان حمض الهيوميك (HA) كان افضلهم فى عملية تقليل التلوث واقلهم هو البولى فينيل اسيتات (PVAc) وعزى ذلك الى قدرة حمض الهيوميك على خلب العناصر الثقيلة لاسيما الرصاص وبذلك تكون ميكانيكية المعالجة كيميائية بحتة فى حين ان ميكانيكية معالجة البولى فينيل اسيتات تعتمد على تقليل اسطح العنصرة لعنصر الرصاص والمعرضة لمحاليل الاستخلاص وبذلك تكون نوعية المعالجة طبيعية وعلية يكون ترتيب المواد المستخدمة من حيث كفاءة المعالجة هى كالتالى:



- اظهرت النتائج المتحصل عليها ايضا الى ان استخلاص عنصر الرصاص بواسطة مادة DTPA و NH_4HCO_3 ادى الى انخفاض تركيز عنصر الرصاص تحت ظروف التحضين المختلفة مما يؤكد كفاءة استخدام المواد الكيميائية فى تقليل صور التلوث كما تلعب الخواص الطبيعية والكيميائية للاراضى تحت الدراسة تيسر وانطلاق عنصر الرصاص.