Global Journal of Researches in Engineering: E
Civil And Structural Engineering
Volume 14 Issue 6 Version 1.0 Year 2014
Type: Double Blind Peer Reviewed International Research Journal
Publisher: Global Journals Inc. (USA)
Online ISSN: 2249-4596 & Print ISSN: 0975-5861

A Sediment Phytoattenuation Evaluation by Four Sessions of Vetiver Planting and Harvesting

By T. Y. Yeh & C. L. Lin
National University of Kaohsiung, Taiwan

Abstract- Phytoattenuation is a novel green remediation approach which can be employed in both a sediment and a soil decomination. Pot experiments have been conducted to evaluation two pollution levels of a sediments consisted of high pollution from swine industries and low contamination from campus wetland. EDTA demonstrated satisfactory metal uptake and mobility enhancement has been achieved. Pb is less mobile which induced low vetiver translocation while Zn is the most mobile which possesses high bioavailability. Four sessions of planting and harvesting gradually decreasing Cu and Zn levels the constrictions decreasing to achieve local a sediment criteria which can be used for agricultural a soil conditioning. The results of this study is prominent with gradually mitigating a sediment contamination is less detriment to a sediment properties relative to commonly used a soil washing.

Keywords: phytoattenuation, Cu, Zn, vetiver, heavy metal.

GJRE-E Classification : FOR Code: 820699

ASEDIMENTPHYTOATTENUATIONEVALUATIONBYFOURSESSIONSOFVETIVERPLANTINGANDHARVESTING

Strictly as per the compliance and regulations of :

A Sediment Phytoattenuation Evaluation by Four Sessions of Vetiver Planting and Harvesting

T. Y. Yeh [α] & C. L. Lin [σ]

Abstract- Phytoattenuation is a novel green remediation approach which can be employed in both a sediment and a soil decomination. Pot experiments have been conducted to evaluation two pollution levels of a sediments consisted of high pollution from swine industries and low contamination from campus wetland. EDTA demonstrated satisfactory metal uptake and mobility enhancement has been achieved. Pb is less mobile which induced low vetiver translocation while Zn is the most mobile which possesses high bioavailability. Four sessions of planting and harvesting gradually decreasing Cu and Zn levels the constrictions decreasing to achieve local a sediment criteria which can be used for agricultural a soil conditioning. The results of this study is prominent with gradually mitigating a sediment contamination is less detriment to a sediment properties relative to commonly used a soil washing.

Keywords: phytoattenuation, Cu, Zn, vetiver, heavy metal.

I. Introduction

In Taiwan the brand new a sediment reused and management Act has been in progress. The lingering a sediment illeagle dumping expected to be solved after the enacted of a sediment mangagement regulatory standard. The main contaminant management was risk based control while in situ capping phytoremediation and exsitu a sediment pressured Chelator pretreated following by phytoextraction has been proposed. Phytoattentuation is a novel concept to denominated a sediment metal contents without abrasively destroys a sediment properties rendering for agricultural a soil fertilizing.

Vetiver is known for its effectiveness in a sediment erosion control due to its unique morphological and physiological characteristics. Vetiver is also a high biomass plant with remarkable photosynthetic efficiency which renders it tolerant against various harsh environmental conditions. Vetiver with deep-rooted and higher water-use can effectively stabilize soluble metals in a sediments (Chen et al., 2004). These properties enable vetiver to be an ideal candidate for phytoextraction.

EDTA, a synthetic chelator, is poorly biodegraded in the a soils though its effectiveness at completing metals. Excess amounts of EDTA may leach to groundwater and cause in subsurface water contamination. However, due to its high chelation ability, potential leaching to groundwater should be into serious concern.

A novel green remediation approach intends to convey in this paper by employing plant to gradually reduce a soil metal contamination through several rounds of planting and harvesting. Unlike phytoextraction, phytoattenuation aims to reduce a soil metal pollution in a gradually and less aggressive approach such as chelator assisted remediation (Meers et al., 2010). The initial pollution level generally is lower than most a soil contamination sites. Therefore, plant is easier to propagate to increase biomass inducing reliable metal uptake. The conceptual model is shown in Fig. 1.

Attenuation is borrowing from the concept "natural attenuation" which has been commonly proposed as a remediation approach for organic pollutants such as DNAPL (dense non-aqueous liquid) solvent TCE (tri-chloro ethylene) and PCE (tetra-chloro ethylene) or LNAPL (light non-aqueous liquid) petroleum product BTEX (benzene, toluene, ethyl benzene, and xylene. Natural attenuation mainly used natural pollution mitigation mechanism including microbial degradation, adsorption, volatilization, etc. This approach is targeted to pollutant which is not degraded in a reasonable time using conventional remediation techniques, technical imperfectability, or the cost beyond the affordable monetary amounts, economical imperfectability.

Cu and Zn are used as the fodder additives for preventing swine diarrhea and skin abrasion (Yeh and Wu, 2009). Cu has been reported the toxicity to phytoplankton and been employed as algaecide for serious eutrophication mitigation. The careless management of Cu and Zn wastewater from swine industries could damage the water and a soil environment. Previous studies regarding (Bioconcentration factor) BCF and (Translocation factor) TF are summarized in Table. EDTA, DTPA, EDDS, citric acid, and

The objectives of this study were to research the phytoattenuation to gradually mitigate the a sediment Cu and Zn pollution via employing EDTA chelator enhancement. Possible a sediment metal fraction and vetiver uptake evaluation also be conducted. The recent reference is listed in Table 2.

Author α σ: Department of Civil and Environmental Engineering, National University of Kaohsiung, Taiwan. e-mail: tyyeh@nuk.edu.tw

II. Materials and Methods

a) Plant, biostimulators, and a sediment preparation

Vetiver and sunflower were collected from the University of Kaohsiung campus wetlands (22°73'N, 120°28'E) precultured for 5 days and carefully washed with distilled water. Plant samples were dried at 103°C in an oven until completely dried.

b) Total metal content, a sediment retained fractionation and plant metal uptake analysis

Plant after last session of operation was harvested, careful washed, and air dried for metal analysis. Plant samples were dried at 103°C in an oven until completely dried. Dried plant samples were divided into root and shoot for metal accumulation assessment. These pretreated plants were digested in a solution containing 11:1 HNO_3: HCl solution via a microwave digestion apparatus (Mars 230/60, CEM Corporation) and diluted to 100 mL with deionized water. 0.2 g of dried a sediment adding *aqua regia* rending for microwave digestion and 2.5 g of dried for sequential extraction experiments. Metals analyses were conducted via an atomic absorption spectrophotometry (AAS, Perkin Elmer).

c) Harvested Plant tissue and final a sediment metal content analysis

Plant was harvested, careful washed, and air dried for metal analysis. Plant samples were dried at 103°C in an oven until completely dried. Dried plant samples were divided into root and shoot for metal accumulation assessment. These pretreated plants were digested in a solution containing 11:1 HNO_3: HCl solution via a microwave digestion apparatus and diluted to 100 mL with deionized water. 0.2 g of dried a sediment was added *aqua regia* rending for microwave digestion. Metals analyses were conducted via an atomic absorption spectrophotometry (AAS, Perkin Elmer).

d) Data and Statistical Analysis

Data were evaluated relative to the control to understand their statistical variation. Metal concentration of plants was recorded as mg of metal per kilogram of dry biomass. A triplicate of water and a sediment samples from each treatment were recorded and used for statistical analyses. Plant metal concentration was recorded as mg of metal per kilogram of dry biomass. Bioaccumulation coefficient (BCF; Croots/Ca soil or water) calculated as the metal concentration in plant divided by the heavy metal concentration in the solution or a soil for hydroponic and pot experiments, respectively. TF (shoots/Croots) was depicted as the ratio of concentration of metal in shoot to its concentration in root. It was calculated by dividing the metal concentration in shoot by the metal concentration in root. Schematic diagram of pot experiment and BCF and TF are shown in Fig. 1. Statistical significance was assessed using mean comparison test. Differences between treatment concentration means of parameters were determined by Student's t test. A level of $p < 0.05$ considered statistically significant was used in all comparisons. Means are reported ± standard deviation. One-way ANOVA wee employed to inference the difference among treatments. All statistical analyses were performed with Microsoft Office EXCEL 2007.

III. Results and Discussion

a) Pot Experiment Results

The conceptual setup of the pot experiment is shown in Fig. 1

i. *The background and metal fraction results*

The background propert8es of a sediment was pH, organic matter were 6.58 ± 0.44, 3.43 ± 0.13 %, respectively. The background Cu, Zn, and Pb a sediment concentrations were 3.26 ± 4.72, 121.55 ± 6.34, and 76.55 ±12.68 mg/kg, respectively. Total metal leaves were 898.35 ±15.70, 5933.96 ±5 91.09, and 3109.26 ± 60.37 mg/kg，respectively which was around 1.5 to 3 folds (Cu：400 mg/kg, Zn：2000 mg/kg, Pb：2000 mg/kg). The a sediment particle size of sand, silt, and clay were 5.7%, 82.2%, and 12.1% which is common for most farmland a soil properties.

ii. *Sequential Fraction Results*

Sequential extraction was performed to illumine the adsorption fraction; namely exchangeable, ionic adsorp organic bound, Fe-Mn bound, and sulfide bound portions were in the descending order.

a. Cu uptake enhancement results

For Cu, sequential extraction results are depicted in Fig, Exchangeable fraction was 44 folds while adsroped fraction increased 1.98 folds relative to control while the organic bound and carbonated bound fraction were decreasing. The results indicated whicht EDTA significant enhanced Cu mobility which transfersed from stable to loosely bound fractions from 1.49 to 23.47% which might facilitate future plant uptake.

iii. *Zn Fractionation Results*

Zn fraction results are depicted in Fig. Initial exchangeable, adsorped bound, organic bound, carbonate bound, and sulfide bound fraction of Zn concentration 519.25 ±29.80 mg/kg, 1.08 ± 1.27 mg/kg, 1.08 ± 1.27 mg/kg, 1091.41 ±1 3.78 mg/, 2587.85 ± 84.80mg/kg, 294.84 ± 24.17 mg/kg, respectively. After addition EDTA the fractions were exchange able, adsorped bound, organic bound, carbonate bound and sulfide bound fraction of Zn concentrate on771.07 ± 37.20 mg/kg mg/kg, 21.38 ± 3.33 mg/kg, 1.08 ± 1.27 mg/kg, 1651.88 ± 19.49 mg/kg, 2968.19 ± 9.09 mg/kg, 208.16 ± 41.97 mg/kg respectively. Stable adsorp factions increased 19.80 as EDTA addition which depicted whicht EDTA enhanced metal transfer to loosely bound from 11.57% to 14.1% which will further increase vetiver uptake.

Global Journal of Researches in Engineering (E) Volume XIV Issue VI Version I 22 Year 2014

iv. *Pb Fractionation Results*

The results shown in Fig 2. Exchangeable, adsorbed, organic bound, carbonated bound and sulfide bound were 676.88 ± 32.21 mg/kg, 31.69 ± 1.70 mg/kg, 692.08 ±22.97 mg/kg, 207.41 ± 58.67 mg/kg, and 207.41 ± 58.67 mg/kg, respectively. Zn+ EDTA wars moving 33.43% from stable to loosely bound fraction. EDTA mobility enhancement was increasing in upgrading sequence Pb> Cu > Zn due to Pb in a sediment generally was demonstrated more stable bound.

b) *Growth observation metal accumulation in different parts of vetiver*

The vetiver growth observation is shown in Fig. The results form left to right were Cu, Cu+EDTA, Zn, Zn+EDTA, Pb, Pb+EDTA, respectively. The observation time period was 15 days. Vetiver yields leaf yellowing and abrasion. Zn performed the worst propagation among all experiments while Pb and Pb+ EDTA without significant adverse impact.

Zn demonstrated the worst growth which is rapid to wilt. Cu+EDTA was 1.26 + 0.80 which was 21 folds relative to Zn only. For BCF Zn performed the best for with or without EDTA were 2.84 and 1.41 folds, respectively. The vetiver root: stem: leaf weight was 2:1.5:1 Cu and Pb with addition were 3.62 and 3.55 folds relative to control. EDTA demonstrated prominent Cu and Zn vetiver uptake and translocation. No EDTA toxic effects had been observed.

- *2nd stage a sediment and a soil analysis*

c) *The growth and toxicity symptoms of vetiver in pot experiments*

The increased heights of vetiver for three chelators of pot experiment are shown in Table 5. The growth of vetiver was observed for 24 days to study the toxic effect of chelators. The initial average length and weight of vetiver was approximately 30cm and 18 g, respectively. For Cu, the increased height of vetiver for control, EDDS, citric acid, and EDTA were 14.4, 1.2, 9.0 and 0.7 cm, respectively. For Zn, the increased height of vetiver for control, EDDS, citric acid, and EDTA were 0.3, 0.2, 0.5 and 0.2 cm, respectively. For Pb, the increased height of vetiver for control, EDDS, citric acid, and EDTA were 1.3, 2.0, 2.3 and 0.8 cm, respectively. The results of Zn did not present significant growth in chelator amended a sediments.

Cu+EDDS and Cu+EDTA both presented yellowing and chlorosis of leaves at the 12th day. The control and citric acid presented less toxic symptom. For Zn, the control, Zn+EDDS, Zn+citric acid, Zn+EDTA all showed the yellowing at the 8th day of treatment. All Zn treated vetiver were presented serious chlorosis and wilt symptom at the 14th day. For Pb, all treatments presented yellowing at 10th day and the toxic effect was the in the order of EDTA> citric acid> EDDS. According to the aforementioned results, the toxic effect of EDTA was more significant than whicht of other two chelators.

d) *The impact of chelator on the uptake and translocation of metals in pot tests*

The results of the uptake and translocation of metals are shown in Table 6 For Cu, total metal accumulation concentrations of EDDS, citric acid, and EDTA were 14, 4, and 12 folds ($p = 0.002$, 0.02, and 3.5×10^{-6}) increase compared to the control, respectively. The translocation to aerial parts were significant for EDDS, citric acid, and EDTA showing in shoot Cu concentrations raised 151, 6 and 84 folds ($p = 0.004$, 4.76×10^{-5}, and 0.002) compared to control, respectively. The results demonstrated whicht EDDS and EDTA statistically significant increased total metal concentration and metal in aerial parts of vetiver. In particular, the shoot concentration of Cu+EDDS was 936±274 mg/kg which was around the hyperaccumulator level (1,000 mg/kg). For Zn, the whole plant accumulation concentrations of EDDS, citric acid, and EDTA were 1.2, 1.1, and 1.1 folds compared to control, respectively. The statistical analysis compared with the control did not present significant difference ($p = 0.52$, 0.88, and 0.77) for three chelators. However, the aerial parts Zn concentration all achieved hyperaccumulator levels for three chelator treatment (10,000 mg/kg). For Pb, the whole plant accumulation concentrations of EDDS, citric acid, and EDTA were 1.1, 1.3, and 1.6 folds ($p = 0.55$, 0.128, and 0.045) increase relative to control plants, respectively. EDTA presented significant difference ($p<0.05$) with respect to the control. The other two chelators did not show clear uptake enhancement. EDTA also improved Pb uptake in aerial parts to reach the hyperaccumulator levels (1,000 mg/kg). The prominent uptake of Pb by EDTA can be explained by the stability constant ($\log Ks = 17.88$) with Pb while the constants for biodegradable chelators EDDS and citric acid with were $\log Ks = 18.4$ and $\log Ks = 6.5$, respectively. The critical results of our current research were the achievement of vetiver as a hyperaccumulator.

Another similar research showed whicht prominent metal uptake and translocation of Pb with EDTA. They explained by its effect on enhancing the solubility of Pb and absorption of the Pb-EDTA complex by the plant *Brassica napus* (Zaier et al., 2010). In Lin's study, a sediment was applied with EDTA by using sunflower. Pb concentration in the shoot of plants was found directly proportional to the amount of EDTA added to a sediment. The a sediment concentration of soluble Pb was correlated with the Pb concentration in plants grown on the a sediment (Lin et al., 2009). Another investigation also demonstrated whicht EDTA bound Pb was less toxic to free Pb ions and might induce less stress on plants. Pb complexes with phytochelatins were the possible Pb tolerance mechanisms. The results showed whicht vetiver accumulated 19,800 and 3350 mg/kg in root and shot tissues, respectively (Andra et al., 2009). A discrepancy study demonstrated whicht EDDS caused in 2.54, 2.74, and 4.3 fold increase in Cd, Zn, and Pb shoot metal concentration, respectively as compared to control plants. In their study also reported whicht EDTA induced 1.77, 1.11, and 1.87 fold increase in Cd, Zn, and Pb shoot metal concentration, respectively, as compared to control plants. Their results demonstrated whicht EDDS was more effective than EDTA in stimulation the translocation of metals from roots to shoots (Santos et al., 2006).

Research has reported whicht he treatment with 5 mmole/kg EDDS, a sediment resulted in accumulation of 157, 129, and 122 mg/kg of Cu, Zn, and Pb in whole plant, respectively. The concentration in *Brassica carinata* shoots with 2 to 4 fold increase compared to control. Comparing to NTA, the results showed whicht EDDS in a sediment degraded rapidly, reducing the risks associated with the leaching of metals to the groundwater (Quartacci et al., 2007). Other research studied the EDDS enhancement phytoextration of Cu, Zn, and Pb by maize. The results indicated whicht a sediment treated with EDDS significantly increased the concentration of metal in maize shoots (increments of 66%, 169%, and 23% for Cu, Zn, and Pb with respect to the control (Salati et al., 2010). Wang et al. (2009) suggested whicht phytoremediation of high Pb a sediment, EDDS would be better at concentration of 5 mmole in a single dosage. Citric acid showed less obvious effect might be related to its easy biodegraded in the a sediment in their study. Rescarach demonstrated whicht he accumulation of metals in the plant fractions was in descending sequence Cr>Zn>Cu>Pb. The presence of either compost or *B. licheniformis* BLMB1 strain enhanced metal by B. *napus* accumulation, Cr in particular, in the experimental conditions used (Brunetti, et al, 2011).

Our results for EDTA addition revealed the concentration of Cu, Zn, and Pb of 521, 11233, and 1125 mg/kg in shoot, respectively. The discrepancy compared to other studies might be due to the variation of plant species, initial total metal concentration, and metal bound fraction in a sediment. In particular, the metal concentration in a sediment was higher than most of research reported in our study.

e) BCF, TF, and PEF factors in pot-cultural experiments

BCF, TF and PEF in pot experiments of different treatment conditions are depicted in Fig. 5. BCF values in the pot experiment can be referenced to evaluate vetiver accumulation and adsorption at its root rhizosphere. For Cu, the values EDDS, citric acid, and EDTA were 1.97, 0.88, and 2.22 equivalent to 9, 4, 10 times of control, respectively. Based on t test analysis, the variation between control and three chelators presented significant difference ($p = 0.00084$, 0.022, and 8×10^{-7}). Three chelators all showed the significant enhancement of root Cu uptake. For Zn, the BCF values of control, EDDS, citric acid, EDTA were 2.24, 1.95, 1.67, and 1.50, respectively. Three chelators did not presented statistical difference compared to control ($p = 0.48$, 0.22, and 0.09). For Pb, the BCF values of control, EDDS, citric acid, EDTA were 0.51, 0.63, 0.67, and 0.58, respectively. Similar to Cu results, Pb with three chelators treatment also did not presented statistical difference compared with control ($p = 0.296$, 0.1, and 0.29). Three tested chelator only has significant effect on Cu. The variation might be due to the metal complex property with chelators and total metal concentration in a sediment.

TF ratio can be used to evaluate the translocation effects in vetiver. High TF can be explained as prominent transfer from root to aerial parts of plant. For Cu, TF of the control, EDDS, citric acid, EDTA were 0.03, 0.51, 0.04, and 0.2. EDDS, citric acid, and EDTA treatments were equivalent to 17, 1.3, 8 folds ($p = 0.0003$, 0.18, and 0.0022) TF increase relative to the control treatment, respectively. For Zn, TF values of the control, EDDS, citric acid, and EDTA were 0.64, 0.74, 0.82, and 0.86 which indicated the TF of EDDS, citric acid, EDTS equivalent to 1.2, 1.3, 1.3 times of control ($p = 0.027$, 0.034, and 0.05), respectively. EDDS, citric acid, and EDTA all revealed statistical difference relative to control ($p<0.05$). For Pb, the TF values of the control, EDDS, citric acid, and EDTA were 0.02, 0.06, 0.05, and 0.24. These TF values of EDDS, citric acid, and EDTA were equivalent to 3, 2.5, 12 folds ($p = 0.08$, 0.1, and 5×10^{-5}) increase to the control, respectively. Only EDTA revealed statistical difference when compared with the control. PEF was calculated by the concentrations and weights of a sediment and shoot. The p values of EDDS, citric acid, and EDAT compared to the control were Cu: 0.004, 4×10^{-5}, and 0.001, for Zn: 0.17, o.19, and 0.39, and for Pb: 0.025, 0.04, and 0.0007, respectively. Our results compared with preious are depicted in Table which demonstrated whicht our results were conformed with those researches.

In our study, the critical finding is whicht vetiver has been demonstrated as a hyperaccumultor for treatment of EDDS with Cu; EDDS, citric acid, and EDTA with Zn; and EDTA with Pb. The other important message is using PEF value to predict the required duration for a sediment remediation. The remediation time required for phytoextraction reference to PEF can be predicted by the following formula. Phytoextation time (yr) = (metal concentration (mg/kg) in a sediment needed to decrease × a sediment mass (kg))/(metal concentration in plant shoot (mg/kg) × plant shoot biomass × the frequency of harvested (number of harvest/yr)). This information is paramount crucial for a project engineer to design an in-situ phytoremediation. In this study, EDTA has been showed to be an effective chelator though its toxic effect and possible leaching to subsurface to induce groundwater contamination. EDDS has the comparable effect with EDTA, but it might be more pricy than EDTA. The alternative might chose biodegradable EDDS if groundwater leaching was a major concern. Future study should be focused on the synergistic effect of muti-metal contamination which is more realistic for the real word application.

IV. Conclusion

EDTA significantly increased a sediment mobility and further enhance vetiver plant uptake, Pb performed the best among four metals while and underground and aboveground were increased 6.9 and 2.86 folds with addition chelator EDTA. High concentration from Ho-Jin river due to contaminated by improperly treated of swine wastewater the Cu, Zn, and Pb reveal rate I 6 monthswere29.51% 、56.59% 及 49.05%, respectively. Low concentrayuon from University campus wetland Cu, Zn, and Pb reveal rate of two consecutive months were first month 29.51 %, 6.59 %, and 49.05%, respectively, and second 9.97 %, 41.69%, and 45.12%, respectively. Four sessions EDTA enhancement a sediment experiments demonstrated satisfactory results. A sediment phytoattenuation can be referenced to future operation to employ this green remediation approach.

References Références Referencias

1. Andra SS, Datta R, Sarkar D, Saminathan SKM, Mullens CP, Bach SBH. Analysis of phytochelatin complexes in the lead tolerant vetiver grass [*Vetiveria zizanioides* (L.)] using liquid chromatography and mass spectrometry. Environ Pollut 2009;157:2173-2183.
2. Chen Y, Shen Z, Li X. The use of vetiver grass (*Vetiveria zizanioides*) in the phytoremediation of a sediments contaminated with heavy metals. Appl Geochem 2004;19:1553-1565.
3. Doumett S, Lamperi L, Checchini L, Azzarello E, Mugnai S, Mancuso S, Petruzzelli G, Bubba MD. Heavy metal distribution between contaminated a sediment and *Paulownia tomentosa,* in a pilot-scale assisted phytoremediation study: Influence of different complexing agents. Chemosphere 2008; 72:1481-1490.
4. Eriberto Vagner Freitas, Clístenes Williams Nascimento, Adailson Souza, Fernando Bruno SilvaCitric acid-assisted phytoextraction of lead: A field experiment Chemosphere, Volume 92, Issue 2, June 2013, Pages 213-217.
5. E. Meers, S. Van Slycken, K. Adriaensen, A. Ruttens, J. Vangronsveld, G. Du Laing, N. Witters, T. Thewys, F.M.G. TackThe use of bio-energy crops (Zea mays) for 'phytoattenuation' of heavy metals on moderately contaminated soils: A field experiment Original Research Article Chemosphere, Volume 78, Issue 1, January 2010, Pages 35-41.
6. Evangelou MWH, Bauer U, Ebel M, Schaeffer A. The influence of EDDS and EDTA on the uptake of heavy metals of Cd and Cu from a sediment with tobacco *Nicotiana tabacum*. Chemosphere 2007; 68:345-353.
7. Epelde L, Hernández-Allica J, Becerril JM, Blanco F, Garbisu C. Effects of chelates on plants and a sediment microbial community: Comparison of EDTA and EDDS for lead phytoextraction. Sci Total Environ 2008; 401:21-28.
8. Freitas EVdS, Nascimento CWAd. The use of NTA for lead phytoextraction from a sediment from a battery recycling site. J Hazard Mater 2009;171: 833-837.
9. Jean L, Bordas F, Gautier-Moussard C, Vernay P, Hitmi A, Bollinger JC. Effect of citric acid and EDTA on chromium and nickel uptake and translocation by *Datura innoxia*. Environ Pollut 2008;153:555-563.
10. Kim IS, Kang KH, Johnson-Green P, L EJ. Investigation of heavy metal accumulation in *Polygonum thunbergii* for phytoextraction. Environ Pollut 2003;126:235-243.
11. Kos B, Lestan D. Chelator induced phytoextraction and in situ a sediment washing of Cu. Environ Pollut 2004;132:333-339.
12. Komárek M, Tlustoš P, Száková J, Chrastný V, Ettler V. The use of maize and poplar in chelant-enhanced phytoextraction of lead from contaminated agricultural a sediments. Chemosphere 2007;67:640-651.
13. Komárek M, Van ě k A, Mrnka L, Sudová R, Száková J, Tejnecký V, Chrastný V. Potential and drawbacks of EDDS-enhanced phytoextraction of copper from contaminated a sediments. Environ Pollut 2010;158:2428-2438.
14. Leštan D, Luo CL, Li XD. The use of chelating agents in the remediation of metal-contaminated a sediments: A review. Environ Pollut 2008;153:3-13.
15. Lin C, Liu J, Liu L, Zhu T, Sheng L, Wang D. A sediment HYPERLINK "http://www.science-direct.com/science?_ob=ArticleURL&_udi=B6T66-4V47CFB-2&_user=1579755&_coverDate=03%2-F31%2F2009&_alid=1654101047&_rdoc=1&_fmt=high&_orig=search&_origin=search&_zone=rslt_list_item&_cdi=5022&_st=13&_docanchor=&view=c&_ct=2&_acct=C000053860&_version=1&_urlVersion=0&_userid=1579755&md5=c26339ea96205a48cfec6058563bf14c&searchtype=a" amendment application frequency contributes to phytoextraction of lead by sunflower at different nutrient levels. Environ Exp Bot 2009; 65:410-416.

16. Quartacci MF, Irtelli B, Baker AJM., Navari-Izzo F. Theuse of NTA and EDDS for enhanced phytoextraction of metals from a multiply contaminated a sediment by *Brassica carinata*. Chemosphere 2007;68:1920-1928.
17. Santos FS, Hernandez-Allica J, Becerril JM, Amaral-Sobrinho N, Mazur N, Garbisu C. Chelate-induced phytoextraction of metal polluted a sediments with *Brachiaria decumbens*. Chemosphere 2006; 65: 43-50.
18. Sun YB, QX, An J, Liu WT, Liu R. Chelator-enhanced phytoextraction of heavy metals from contaminated a sediment irrigated by industrial wastewater with the hyperaccumulator plant (*Sedum alfredii* Hance). Geoderma 2009; 150:106-112.
19. Salati S, Quadri G, Tambone F, Adani F. Fresh organic matter of municipal solid waste enhances phytoextraction of heavy metals from contaminated a sediment. Environ Pollut 2010; 158:1899-1906.
20. Saifullah, Zia MH, Meers E, Ghafoor A, Murtaza G, Sabir M, Zia-ur-Rehman M, Tack FMG. Chemically enhanced phytoextration of Pb by wheat in texturally different a sediment. Chemosphere 2010; 79: 652-658.
21. Tandy S, Schulin R, Nowack B. The influence of EDDS on the uptake of heavy metals in hydroponically grown sunflowers. Chemosphere 2006; 62: 1454-1463.
22. Tanhan P, Kruatrachue M, Pokethitiyook P, Chaiyarat R. Uptake and accumulation of cadmium, lead and zinc by Siam weed [*Chromolaena odorata* (L.) King & Robinson]. Chemosphere 2007; 68: 323-329.
23. Tessier A, Campbell PGC, Bisson M, Sequential extraction procedure for the speciation of particulate trace metals, Anal. Chemosphere 1979; 51:844-851.
24. Turgut C, Pepe MK, Cutright TJ. The effect of EDTA on *HYPERLINK "http://www.sciencedirect.com.-libsw.nuk.edu.tw:81/science?_ob=ArticleURL&_udi=B6V74-4DTTB2P-8&_user=1579755&_cover-Date=02%2F28%2F2005&_alid=1655027625&_rdoc=1&_fmt=high&_orig=search&_origin=search&_zone=rslt_list_item&_cdi=5832&_sort=r&_st=13&_docanchor=&_ct=2&_acct=C000053860&_version=1&_urlVersion=0&_userid=1579755&md5=49fca6c3b7de0bafada0202175a2a85e&searchtype=a"Helianthus annuus* HYPERLINK "http://www.science-direct.com.libsw.nuk.edu.tw:81/science?_ob=ArticleURL&_udi=B6V74-4DTTB2P-8&_user=1579755-&_coverDate=02%2F28%2F2005&_alid=1655027625&_rdoc=1&_fmt=high&_orig=search&_origin=search&_zone=rslt_list_item&_cdi=5832&_sort=r&_st=13&_docanchor=&_ct=2&_acct=C000053860&_version=1&_urlVersion=0&_userid=1579755&md5=49fca6c3b7de0bafada0202175a2a85e&searchtype=a" uptake, selectivity, and translocation of heavy metals when grown in Ohio, New Mexico and Colombia HYPERLINK "http://www.sciencedirect.-com.libsw.nuk.edu.tw:81/science?_ob=ArticleURL&_udi=B6V74-4DTTB2P-8&_user=1579755&_cover-Date=02%2F28%2F2005&_alid=1655027625&_rdoc=1&_fmt=high&_orig=search&_origin=search&_zone=rslt_list_item&_cdi=5832&_sort=r&_st=13&_docanchor=&_ct=2&_acct=C000053860&_version=1&_urlVersion=0&_userid=1579755&md5=49fca6c3b7de0bafada0202175a2a85e&searchtype=a"a sediment HYPERLINK "http://www.sciencedirect.-com.libsw.nuk.edu.tw:81/science?_ob=ArticleURL&_udi=B6V74-4DTTB2P-8&_user=1579755&_cover-Date=02%2F28%2F2005&_alid=1655027625&_rdoc=1&_fmt=high&_orig=search&_origin=search&_zone=rslt_list_item&_cdi=5832&_sort=r&_st=13&_docanchor=&_ct=2&_acct=C000053860&_version=1&_urlVersion=0&_userid=1579755&md5=49fca6c3b7de0bafada0202175a2a85e&searchtype=a"s. Chemosphere 2005; 58:1087-1095.
25. Valipour, M., Mousavi, S.M., Valipour, R., Rezaei, E., 2013. Deal with Environmental Challenges in Civil and Energy Engineering Projects Using a New Technology. Journal of Civil & Environmental Engineering. 3 (1), 127. http://valipour.webs.com/-48.pdf
26. Valipour, M., Mousavi, S.M., Valipour, R., Rezaei, E., 2013. A New Approach for Environmental Crises and its Solutions by Computer Modeling. In: The 1st International Conference on Environmental Crises and its Solutions, Kish Island, Iran. http://www.civilica.com/EnPaper-ICECS01_005.html
27. Valipour, M., Mousavi, S.M., Valipour, R., Rezaei, E., 2012. Air, Water, and Soil Pollution Study in Industrial Units Using Environmental Flow Diagram. Journal of Basic and Applied Scientific Research. 2 (12), 12365-12372. http://vali-pour.webs.com/18.pd
28. Wang X, Wang Y, Mahmood Q, Islam E, Jin X, Li T, Yang X, Liu D. The effect of EDDS addition on the phytoextraction efficiency from Pb contaminated a sediment by *Sedum alfredii* Hance. J Hazard Mater 2009; 168:530-535.
29. Ye-Tao TANG, Teng-Hao-Bo DENG, Qi-Hang WU, Shi-Zhong WANG, Rong-Liang QIU, Ze-Bin WEI, Xiao-Fang GUO, Qi-Tang WU, Mei LEI, Tong-Bin CHEN, G. ECHEVARRIA, T. STERCKEMAN, M.O. SIMONNOT, J.L. MOREL Designing Cropping Systems for Metal-Contaminated Sites: A Review Original Research Article Pedosphere, Volume 22, Issue 4, August 2012, Pages 470-488
30. Zaier H, Ghnaya T, Rejeb KB, Lakhdar A, Rejeb S, Jemal F. Effects of EDTA on phytoextraction of heavy metals (Zn, Mn and Pb) from sludge-amended a sediment with *Brassica napus*. Bioresour Technol 2010; 101: 3978-3983.

Table Captions

- Table 1 Plant uptake and transportation in recent study.

Figure Captions

- Fig. 1 Schematic diagram of pot experiment
- Fig. 2 Chemical bond distribution results of (a) Cu, (b) Zn and (c) Pb of a sediment in sequential extraction experiment

Table 1 : BCF and TF summery list from previous studies

Reference	Plant	Chelator	Metal content	BCF	TF
Nascimento et al. (2004)	*Brassica juncea*	EDTA 10 mmol/kg	A soil: Pb 12.1 mg/kg Zn 85.3 mg/kg Cu 17.4 mg/kg Ni 16.3 mg/kg Root part： Cd 9.3 mg/kg Pb 645.3 mg/kg Zn 454.8 mg/kg Cu 296.8 mg/kg Ni 204.2 mg/kg Aerial part： Cd 127.3 mg/kg Pb 1013.4 mg/kg Zn 1239.9 mg/kg Cu 476.9 mg/kg Ni 252.7 mg/kg	Pb:53.30 Zn:5.33 Cu :17.05 Ni:12.53	Cd:13.68 Pb:1.57 Zn:2.73 Cu:1.61 Ni:1.24
		DTPA 10 mmol/kg	A soil: Pb 12.1 mg/kg Zn 85.3 mg/kg Cu 17.4 mg/kg Ni 16.3 mg/kg Root part ： Cd 32.4 mg/kg Pb 453.8 mg/kg Zn 355.2 mg/kg Cu 264.5 mg/kg Ni 183.3 mg/kg Aerial part： Cd 147.1 mg/kg Pb 280.4 mg/kg Zn 765.3 mg/kg Cu 283.7 mg/kg Ni 168.3 mg/kg	Pb:37.50 Zn:4.16 Cu:15.20 Ni:11.25	Cd:4.15 Pb:0.62 Zn:2.15 Cu:1.07 Ni:0.92
		Oxlic10 mmol/kg	A soil: Pb 12.1 mg/kg Zn 85.3 mg/kg Cu 17.4 mg/kg Ni 16.3 mg/kg Root part： Cd 103.9 mg/kg Pb 484.9 mg/kg Zn828.8 mg/kg Cu 256.4 mg/kg Ni 191.4 mg/kg Aerial part： Cd 87.9 mg/kg Pb 43.7 mg/kg Zn 783.1 mg/kg Cu Cu 125.8 mg/kg Ni 226.1 mg/kg	Pb:40.07 Zn:9.72 Cu:14.74 Ni:11.74	Cd:0.85 Pb:0.09 Zn:0.94 Cu:0.49 Ni:1.18

		Citric acid 10 mmol/kg	A soil: Pb 12.1 mg/kg Zn 85.3 mg/kg Cu 17.4 mg/kg Ni 16.3 mg/kg Root part： Cd 105.3 mg/kg Pb 512.1 mg/kg Zn 799.3 mg/kg Cu 246.6 mg/kg Ni 211.5 mg/kg Aerial part： Cd 138.0 mg/kg Pb 112.5 mg/kg Zn 649.1 mg/kg Cu 329.2 mg/kg Ni 276.4 mg/kg	Pb:42.32 Zn:9.37 Cu:14.17 Ni:12.98	Cd:1.31 Pb:0.22 Zn:0.81 Cu:1.34 Ni 1.31
		Vanillic acid 10mmol/kg	A soil: Pb 12.1 mg/kg Zn 85.3 mg/kg Cu 17.4 mg/kg Ni 16.3 mg/kg Root part： Cd 96.2 mg/kg Pb 442.9 mg/kg Zn 701.8 mg/kg Cu156.9 mg/kg Ni 158.9 mg/kg Aerial part： Cd 141.1 mg/kg Pb 41.5 mg/kg Zn 699.3 mg/kg Cu 43.0 mg/kg Ni 98.3 mg/kg	Pb:36.60 Zn:8.23 Cu:9.01 Ni :9.75	Cd:1.47 Pb:0.09 Zn:1.00 Cu:0.27 Ni:0.62
		Gallic acid 10mmol/kg	A soil: Pb 12.1 mg/kg Zn 85.3 mg/kg Cu 17.4 mg/kg Ni 16.3 mg/kg A soil： Cd 275.2 mg/kg Pb 572.4 mg/kg Zn 829.3 mg/kg Cu 324.5 mg/kg Ni 373.9 mg/kg Aerial part： Cd 125.2 mg/kg Pb 25.0 mg/kg Zn 748.4 mg/kg Cu 58.5 mg/kg Ni 183.8 mg/kg	Pb:47.31 Zn:9.72 Cu:18.65 Ni:22.94	Cd:0.45 Pb:0.05 Zn:0.90 Cu:0.18 Ni:0.49
Sudova et al. (2007)	*Glomus intraradices*	EDDS 2.5 mmol/kg	Root part： Pb 462 mg/kg Aerial part： Pb 145 mg/kg		Pb 0.31
		EDDS 5.0 mmol/kg	Root part： Pb 558 mg/kg Aerial part： Pb 351mg/kg		Pb 0.63
Lim et al. (2004)	*Brassica juncea*	EDTA 2 mmol/kg	Root part： Pb 350 mg/kg Aerial part：		Pb 1.11

Global Journal of Researches in Engineering (E) Volume XIV Issue VI Version I Year 2014

			Pb 390mg/kg		
		EDTA 5 mmol/kg	Root part： Pb 420 mg/kg Aerial part： Pb 690mg/kg		Pb 1.64
Chen and Cutright (2001)	Sunflower *Helianthus annuus*	EDTA 0.5 g/kg	Root part： Cd 900 mg/kg Ni 590 mg/kg Aerial part： Cd 910 mg/kg Ni 700 mg/kg		Cd 1.01 Ni 1.19
		EDTA 1.0 g/kg	Cd shoot:115 mg/kg Root : 68 mg/kg Ni shoot :150 mg/kg Root:50 mg/kg		Cd 1.69
Madrid et al. (2003)	*Hordeum vulgare*	EDTA 0.5 g/kg	Root part： Cu 15.0 mg/kg Zn 15.3 mg/kg Fe 1077.5 mg/kg Mn 53.1 mg/kg Aerial part： Cu 11.7 mg/kg Zn 25.0 mg/kg Fe 210 mg/kg Mn 86.3 mg/kg		Cu 0.78 Fe 0.19 Mn 1.63 Pb 1.63
Turgut et al. (2004)	Sunflower *(Helianthus annuus)*	Citric acid 1 g/kg	Root part： Cd0.09 mg/g Ni 0.01mg/g Cr 0.06 mg/g Aerial part： Cd 0.02 mg/g Ni 0.01 mg/g Cr 0.09 mg/g		Cr 1.50 Ni 1.00 Cd 0.22
		Citric acid 3 g/kg	Root part： Cd 0.05 mg/g Ni 0.01 mg/g Cr 0.09 mg/g Aerial part： Cd 0.0025 mg/g Ni 0.03 mg/g Cr 0.07 mg/g		Cr 0.78 Ni 3.00 Cd 0.05
		EDTA 0.1 g/kg	Root part： Cd 0.09 mg/g Ni 0.01 mg/g Cr 0.06 mg/g Aerial part： Cd 0.125 mg/g Ni 0.01 mg/g Cr 0.07 mg/g		Cr 1.17 Ni 1.00 Cd 1.39
		EDTA 0.3 g/kg	Root part： Cd 0.22 mg/g Cd 0.01 mg/g Cr 0.11 mg/g Aerial part： Cd 0.015 mg/g Ni 0.17 mg/g		Cr 1.55 Ni 3.50 Cd 0.09

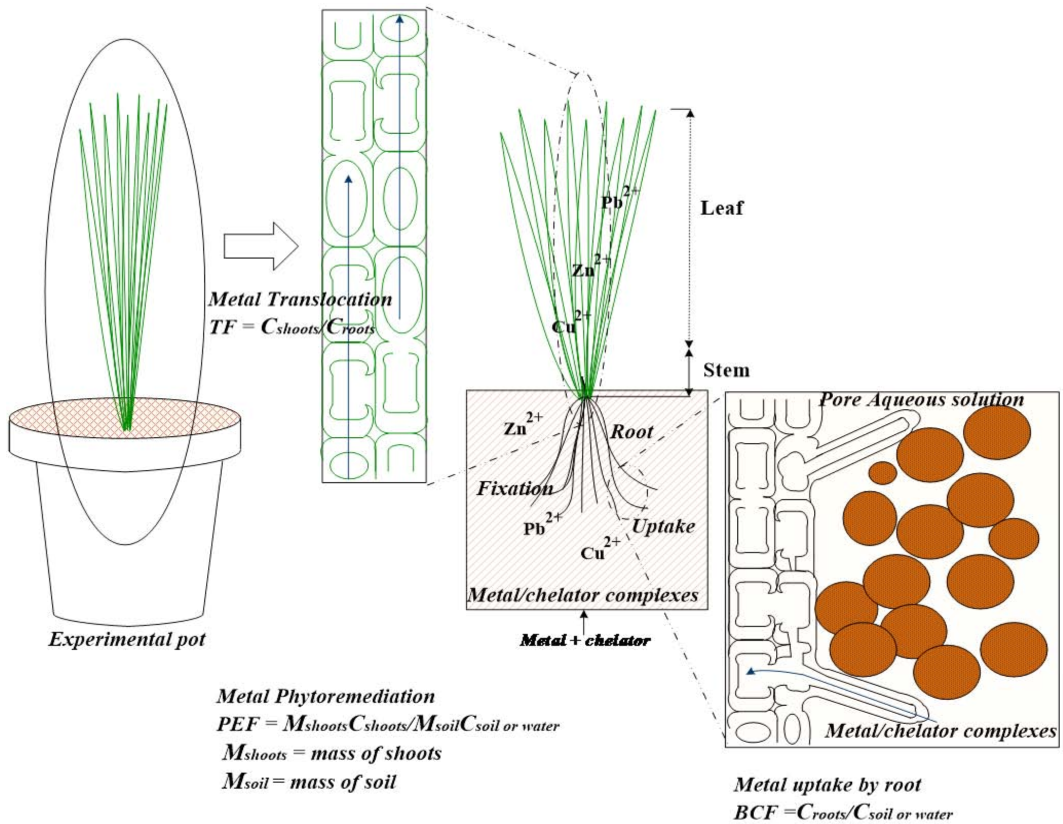

Figure 1 : Schematic diagram of pot experiment

1st day

4th day

15th day

Fig. 2 : Vetiver groth observation via EDTA application

This page is intentionally left blank