REMEDIATION OF LEAD AND ZINC POLLUTED SOIL USING ARACHIS HYPOGAEA AND GLYCINE MAX L

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REMEDIATION OF LEAD AND ZINC POLLUTED SOIL USING *ARACHIS HYPOGAEA* AND *GLYCINE MAX* L

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Abstract

Remediation of lead and zinc polluted soil using Arachis hypogaea and Glycinemax. L was investigated in this study. Lead and zinc were added into soil as $Pb(NO_3)_2$ *and* ($ZnSO_4$)*. Five viable seeds were planted in 30 bowls containing 5kg of soil. The concentrations of lead used were 50 mg and 250 mg while 300mg and 700mg of zinc was used. The presence of lead and zinc in A. hypogaea and G. max. L seeds was determined using AASafter 0, 4, 8 and 12 weeks, 27.47 mg and 201.49 mg of lead were obtained in A. hypogaea at week 4 when 50 mg and 250 mg of leadwas treated with the soil. At week 8, A. hypogaea had lead concentration of 201.02 mg when soil was treated with 250 mg of lead. The highest concentration of zinc (402.42 mg) was recorded in A. hypogaea when soil was treated with 700 mg of zinc and lowest concentration (141.25 mg) was obtained at week 8. The leaf of A. hypogaea had least concentration (0.15 mg) of lead out of all the treatments. The highest concentration of zinc (4.05 mg) was found in leaf of G. max L when the soil was treated with 700 mg of zinc while the least concentration (1.10 mg) was found in seeds when the soil was treated with 300 mg. The results of this study revealed that A. hypogaea and G. max. L were able to uptake various concentrations of lead and zinc.*

Keywords: *Arachis hypogaea, Glycine max*. L, remediation, biosorption, zinc, lead

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1. INTRODUCTION

Heavy metals in the soil include some significant metals of biological toxicity such as mercury (Hg), cadmium (Cd), lead (Pb), chromium (Cr) and arsenic (As). They also include other heavy metals of certain biological toxicity, such as Zinc (Zn), copper (Cu), nickel (Ni), stannum (Sn) and vanadium (V). In recent years, with the development of the global economy, both type and content of heavy metals in the soil caused by human activities have gradually increased, resulting in the deterioration of the environment (Han and Banin, 2002; Sayyed and Sayadi, 2011; Raju *et al*., 2013; Prajapati and Meravi, 2014; Sayadi and Rezae, 2014; Zojaji *et al*., 2014). Contamination of soil by heavy metals occurs as a result of different anthropogenic activities, such as mining, irrigation with waste water, disposal of solid wastes including sewage sludge, application of metal containing pesticides and the use of fertilizers. However, the degree of concentration depends on the type of heavy metals and the activities taking place in a particular area (Ayodele and Abubakkar, 2010; Ibeto and Okoye, 2010).

Toxicities of heavy metals can range from severe illness to death of both plants and animals (Paudyal *et al*., 2007; Wani*et al*., 2008; Khan *et al* 2008), leading consequently to losses in soil fertility. As a result of the direct or indirect metal effect, the health of plants including legumes like soya beans and groundnut growing in metal enriched soil is adversely affected due to nutrient deficiency or due to direct effects of toxicants. For instance, higher concentrations of metals have shown toxicity to various physiological processes like synthesis of chlorophyll pigments in various plants including legumes, inactivated protein synthesis and consequently led to severe reduction in crop yields (Wani *et al*., 2008).

Phytoremediation often referred as botanical bioremediation or green remediation is defined as the use of plants to remove pollutants from the environment or to render them harmless, is being considered as a new highly promising technology for the remediation of polluted sites (Chaney *et al.,* 1997).This technology can be applied to both organic and inorganic pollutants present in soil (solid substrate), water (liquid substrate) or the air (Salt and Kramer, 1999). In this respect, plants can be compared to solar driven pumps that can extract and concentrate certain elements from their environment (Salt *et al.*, 1995). However, the ability to accumulate heavy metals varies significantly between species and between cultivars within a species.

Phytoremediation is currently divided into the following areas: Phytoextraction; the use of pollutant-accumulating plants to remove metals or organics from soil by concentrating them in the harvestable parts (Kumar *et al.*, 1995). Rhizofiltration; the use of plant roots to absorb and adsorb pollutants, mainly metals from water and aqueous waste streams (Dushenkov *et al.,* 1995). Lead is accumulated in roots due to some physiological barriers against metal transport to aerial parts, while other metal such as cadmium is easily transported in plants (Arshad *et al.,* 2008). Phytostabilization: the use of plants to reduce the bioavailability of pollutants in the environment. Plants stabilize pollutants in soils, thus rendering them harmless and reducing the risk of further environmental degradation by leaching of pollutants into the ground water or by airborne spread (Smith and Bradshaw, 1972). Phytovolatilization: the use of plants to volatilize pollutants; and the use of plants to remove pollutants from air (Burken and Schnoor, 1999). Phytodegradation: the use of plants and associated microorganisms (plant assisted bioremediation) to degrade organic pollutants. Plant roots in conjunction with their rhizospheric microorganisms are utilized to remediate soils contaminated with organics; the air purifying also uses some plants (Burken and Schnoor, 1997).This research therefore, aimed at the remediation of lead (Pb) and zinc (Zn) polluted soil using *Arachis hypogaea* and *Glycine max* L.

2. MATERIALS AND METHODS

Collection and processing of samples

The soil samples used for this study was collected from Biology Garden, Bosso Campus, Federal University of Technology, Minna, Nigeria from a depth of 25 cm and transported to the garden for experimental set up. The soil sample was air-dried and sieved by using 2mm diameter mesh. Mature *A. hypogaea* and *G. max* L seeds were purchased from Kure New Market, Minna, Nigeria. The seeds were tested for their viability. This was done by soaking them inside water to select those that would sink from those that would float. Sinking of seeds confirms its viability while floating shows that the seeds are not viable. Viable seeds were used for this study.

Experimental design and treatment

Lead and zinc were added in form of their soluble salts as lead nitrate $Pb(NO_3)_2$ and zinc sulphate ($ZnSO_4$) respectively. Fifteen plastic bowls, each containing 5kg of sieved soil samples was set up. Zinc (300 mg) and Zinc (700 mg) was each dissolved inside 1000 ml of deionized water and sprinkled on 5 kg of sieved soil samples in triplicate. This was followed by mixing for even distribution. Fifty 50 mg and 250 mg of lead was also dissolved inside 1000 ml of deionized water and sprinkled on 5 kg each of sieved soil sample and mixed for even distribution in triplicate. The remaining three bowls contained unpolluted but sieved soil. These served as control (Association of Official Analytical Chemist, AOAC, 2005).

Five *G. max* L. seeds were planted inside a set of three bowls containing soils polluted with 300 mg and 700 mg of Zn while the remaining set of three bowls were used to plant five *A. hypogaea* seeds. Five *G. max* L. seeds were planted inside each of another set of three bowls containing soils polluted with 50 mg and 250 mg of lead, while the remaining set of three bowls were used to plant 5 *A. hypogea* seeds each. The control also comprised 5 of the two plants each in three different bowls of uncontaminated soil. The total number of seeds planted were 150 (75 *G. max* L and 75 *A. hypogaea*).

Analysis of lead and zinc in *A. hypogaea* and *G. max.* L

The presence of lead and zinc in the *A. hypogaea* and *G. max*. L was determined on 0, 4, 8 and 12 weeks of the experiment using methods described by AOAC (2005).

Statistical analysis of data

Statistical analysis was performed by using the Special Package for Social Sciences (SPSS) version 20. Differences in concentrations and all parameters measured were detected by using One-way Analysis of Variance (ANOVA). A significance level of ($p<0.05$) was used throughout the study.

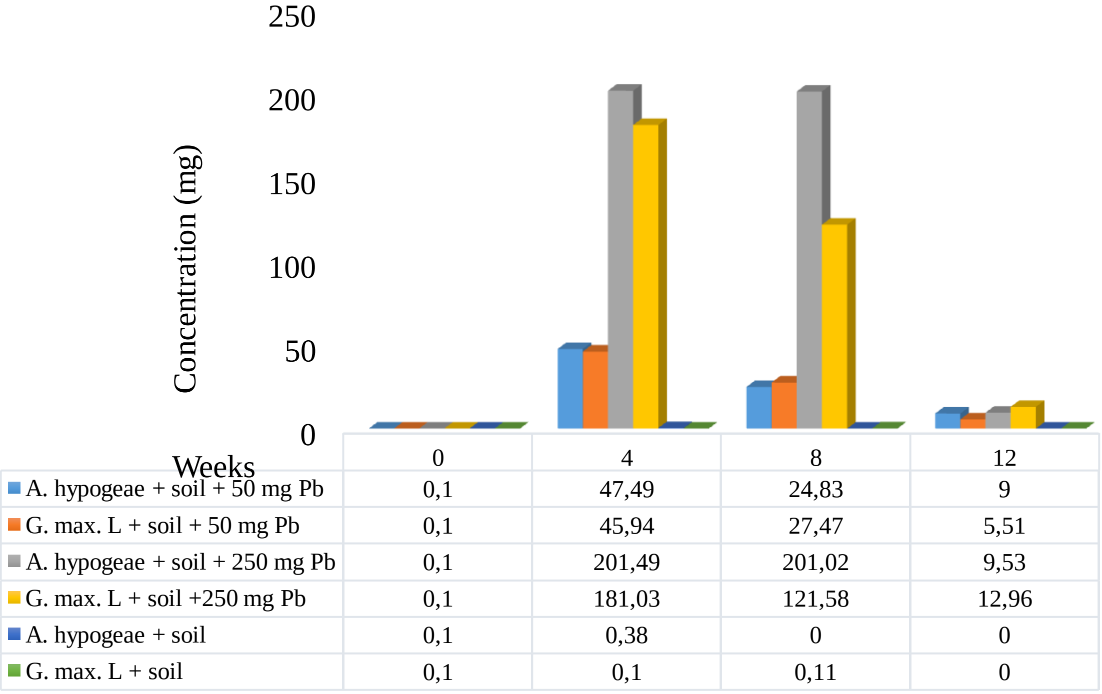
3. RESULTS AND DISCUSSION

The concentration of lead in *A. hypogaea* and *G. max* L. seeds when the soil was polluted with lead is shown in Figure 1. The concentration of Pb remained constant (0.1 mg) in *A. hypogaea*, *G. max. L* and control at week 0. This suggests that the biosorption capacity of lead by *A. hypogaea* and *G. max* L. at the initial week of growth was the same and may be due to slow biosorption potential of lead by the plants. The 27.47 mg of Pb was biosorped by *A. hypogaea* at week 4 when 300 mg of Pb was treated with the soil, 201.49 mg of Pb was obtained in *A. hypogaea* when the soil was treated with 700 mg of Pb while the control had Pb concentration value of 0.10 mg. At week 8, *A. hypogaea* had Pb concentration of 201.02 mg when soil was treated with 700 mg of Pb while the control had 0.00 mg of Pb. The concentration of Pb in all the samples was low at week 12, with the highest Pb uptake by G. max. L (12.96 mg).

The increase in the concentration of heavy metals between week zero and four may be due to the heavy metals added to the experimental soil. This was observed at all concentrations for all the metals and for both plants (*Glycine max* L. and *Arachis hypogaea*). Therefore, higher concentration was detected in soils to which high concentration of heavy metals were added. Figures 1 and 2 showed the concentration of heavy metals against soil samples. The eighth and twelfth week recorded significant reduction in concentration of heavy metals. This is due to the leguminous plants sowed in the soil containing heavy metals. The reliability of the result of this study is evident by the result of the control set up (*Glycine max* L+ soil and *Arachis hypogaea* + soil). It was also observed that the reduction in heavy metal concentrations was at an increasing rate from the fourth to the twelfth week (Figure 1 and 2).

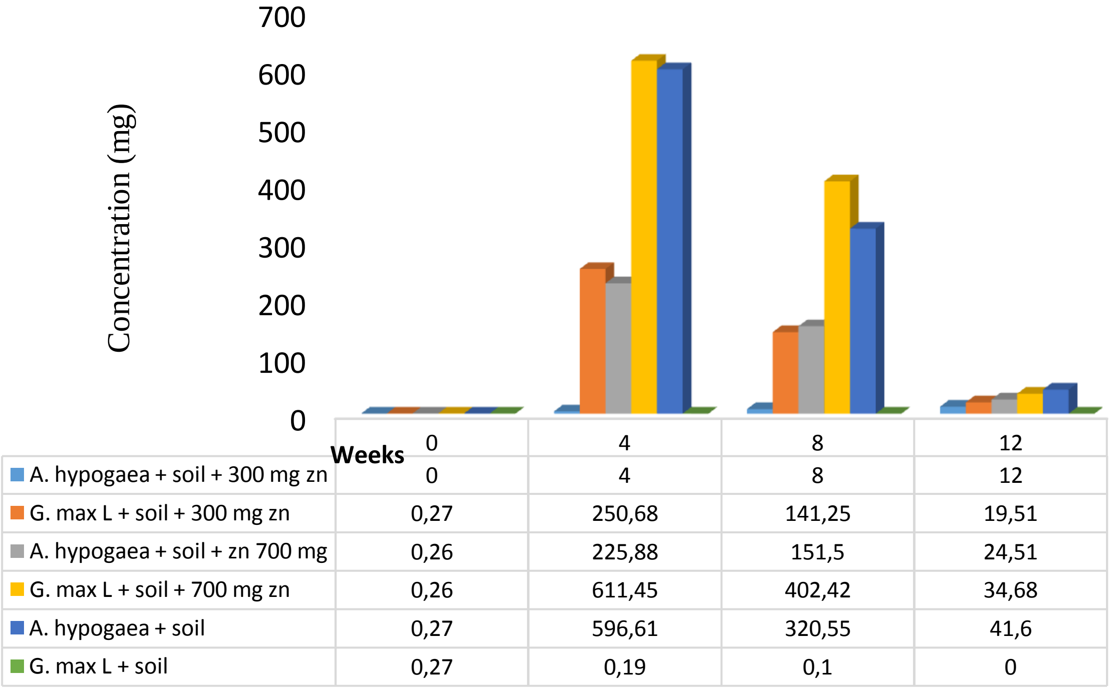
The concentration of zinc in *A. hypogaea* and *G. max* L. seeds when the soil was polluted with zinc is shown in Figure 2. At week 4, the highest concentration of zinc (611.45 mg) was recorded in *A. hypogaea* when the soil was mixed with 700 mg of zinc and the lowest (225.88 mg) was found in G. max L when the soil was treated with 300 mg of zinc. At week 8, the highest concentration (402.42 mg) was found in *G. max*L while the lowest was found in *G. max* L. At week 12, there was low recorded value of zinc in all the treatment with *G. max* L having the highest biosorped value 41.68 mg.

The concentration of Zn and Pb in the seed, root, stem and leaf of the experimental plants*A. hypogaea* and *G. max* L is shown in Figure 3 and Figure 4. Leaf of *G. max. L.* had the highest value of concentration (1.30 mg) in the treatment of soil with 300 mg of Pb. The concentration of zinc in the different parts of *G. max* L and *A. hypogaea* is shown in Figure 4, the highest concentration of zinc (4.05 mg) is found in leaf of *G. max* L when the soil was treated with 700 mg of zinc while the least concentration (1.10 mg) was found in seeds when the soil was treated with 300 mg of zinc.The leaf of *A. hypogaea* biosorped least concentration (0.15 mg) of Pb out of all the treatment. The presence of significant concentration of heavy metals in the shoot shows that the plant was able to accumulate substantial amount of heavy metals.This is similar to the findings of Ijah *et al.* (2015) when *A. hypogaea* was used in restoration of lead contaminated soil. The plants acted as solar-driven pumping and filtering systems based on their ability to take up contaminants (mainly water soluble) through their roots and transport them through various part of their tissues where they can be sequestered, metabolized, or volatilized (Moosavi and Seghatoleslami, 2013).



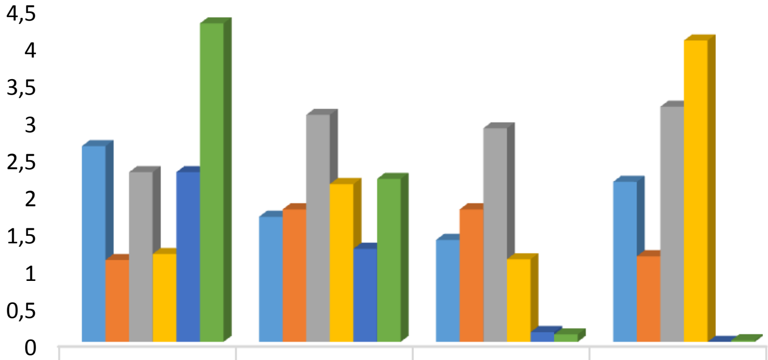
Weeks	0	4	8	12
■ A. hypogeae + soil + 50 mg Pb	0,1	47,49	24,83	9
■ G. max. L + soil + 50 mg Pb	0,1	45,94	27,47	5,51
■ A. hypogeae + soil + 250 mg Pb	0,1	201,49	201,02	9,53
■ G. max. L + soil +250 mg Pb	0,1	181,03	121,58	12,96
■ A. hypogeae + soil	0,1	0,38	0	0
■ G. max. L + soil	0,1	0,1	0,11	0

Fig. 1. Concentration (mg) of Lead in the lead polluted soil of *A. hypogeae* and *G. max* L



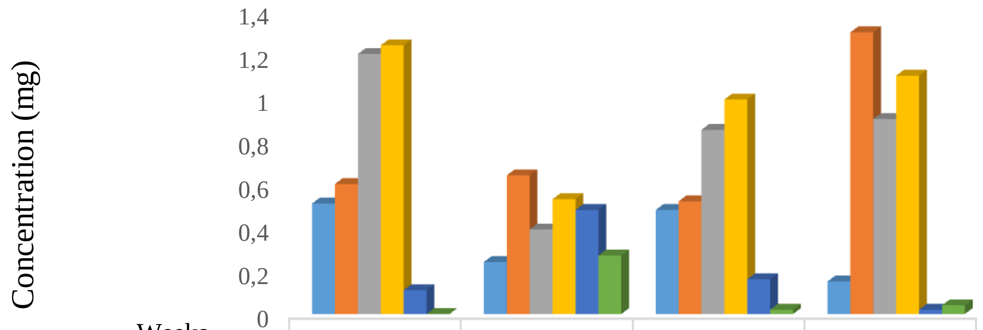
Weeks	0	4	8	12
■ A. hypogaea + soil + 300 mg zn	0	4	8	12
■ G. max L + soil + 300 mg zn	0,27	250,68	141,25	19,51
■ A. hypogaea + soil + zn 700 mg	0,26	225,88	151,5	24,51
■ G. max L + soil + 700 mg zn	0,26	611,45	402,42	34,68
■ A. hypogaea + soil	0,27	596,61	320,55	41,6
■ G. max L + soil	0,27	0,19	0,1	0

Fig. 2. Concentration (mg) of zinc in *A. hypogaea* and *G. max* L in zinc polluted soil



	Seed	Root	Stem	Leaf
A. hypogaea + soil + 300mg zn	2,63	1,68	1,37	2,15
G. max L + soil + 300 mg zn	1,1	1,78	1,78	1,15
A. hypogaea + soil + 700 mg zn	2,28	3,05	2,87	3,16
G. max L + soil + 700 mg zn	1,18	2,12	1,11	4,05
A. hypogaea + soil	2,28	1,25	0,13	0
G. max L + soil	4,28	2,19	0,1	0,02

Fig. 3. Concentration (mg) of Zinc in the different parts of *G. max* L and *A. hypogaea*



Weeks	Seed	Root	Stem	Leaf
🟦 A. hypogaea + soil + 50 mg Pb	0,51	0,24	0,48	0,15
🟧 G. max L + soil + 50 mg Pb	0,6	0,64	0,52	1,3
■ A. hypogaea + soil + 250 mg Pb	1,2	0,39	0,85	0,9
🟨 G. max L + 250 mg Pb	1,24	0,53	0,99	1,1
🟦 A. hypogaea + soil	0,11	0,48	0,16	0,02
🟩 G. max L + soil	0	0,27	0,02	0,04

Fig. 4. Concentration of Lead in the different parts of *G. max* L and *A. hypogaea*

The appearance of *G. max* L. showed response to different concentrations of lead. No plant death was recorded in all treatments of soil with the heavy metal. However, some of the plants showed signs of phytotoxicity such as yellowing of leaves and stunted growth compared with the control after 12 weeks. These signs of phytotoxicity might be as a result of the heavy metals' (Pb and Zn) stress (Azmat *et al.*, 2005) on the plant. Stunted growth and chlorosis was observed in *A. hypogaea,* both in Zinc and lead polluted soils. These results show that *A. hypogaea* and *Glycine max* L. could tolerate some degree of exposure to heavy metals. These observations are similar to that of the findings of Heale *et al.*(1985) who stated that heavy metal could interfere with biochemical reactions of plant and induce physiological disorders like reduction in leaf chlorophyll. In addition, Vassilev *et al*. (1998) who stated that plants when grown on heavy metal polluted soil are susceptible to stunted growth. Similarly, Farooqi *et al*.(2009) reported that lead and cadmium toxicities affected seed germination, root and shoot seedling length, root-shoot ratio and dry biomass of *Albizia lebbeck* L and reduction of biomass through inhibition of chlorophyll synthesis and photosynthesis respectively.

4. CONCLUSIONS

Arachis hypogaea and *Glycine max*. L were able to uptake various concentrations of lead and zinc in this study and could be used to remediate soil and groundwater polluted by lead and zinc.

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