



Phytoremediation Potential of Selected Plant Species on Lead Contaminated Soil

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ABSTRACT

Contamination of the environment by heavy metals is one of the major threats to water and soil as well as human health and phytoremediation has been used to remediate metal-contaminated sites. This study evaluated the remediation potential of *Panicum virgatum*, *Ocimum basilicum* and *Luffa cylindrica* growing on lead irrigated soil. The experiment consists of five levels of lead (0, 200, 400, 600 and 800 mg/L) and the three plants species laid out in Randomized Complete Design with four replicate. Plant root, stem, leaf and the soil samples were analyzed for lead content. Bioconcentration Factor (BCF), Biological Accumulation Coefficient (BAC) and Biological Transfer Coefficient (BTC) were calculated. The results obtained revealed that *O. basilicum* and *L. cylindrica* had BTC, BAC and BC > 1 but *P. virgatum* had BTC < 1 which means that *O. basilicum* and *L. cylindrica* have the ability to accumulate and translocate lead in their tissues and *P. virgatum* had limited ability to translocate the metal. The results revealed that lead content in plant tissues is differ significantly ($p < 0.05$) with concentration, species and plant parts. Turkey simultaneous test showed that *L. cylindrica* was significantly different with *O. basilicum* and *P. virgatum* ($p < 0.05$), and *O. basilicum* was significantly different with *P. virgatum* ($p < 0.05$). The lead content in leave is significantly different as compared with stem and root including growing media ($p < 0.05$). Root length is also significantly different with soil and stem. The study recommends the use of all plants in phytoremediation of lead contaminated soil and considered *L. cylindrica* and *O. basilicum* as hyperaccumulators.

Keywords: Phytoremediation, Bioconcentration Factor (BCF), Biological Accumulation Coefficient (BAC) and Biological Transfer Coefficient (BTC)

INTRODUCTION

Environmental pollution has been known to cause severe illness and sudden death in humans, which is largely attributed from mining, automobile exhaust, agricultural and industrial activities. Heavy metals have been classified among major causes of pollution (Adedokun *et al.*, 1989; Galadima *et al.*, 2011). Phytoremediation could be the cheapest and simplest options among the available soil clean up strategies (Susarla *et al.*, 2002). The use of Plants for contaminant degradation or extraction of xenobiotic from water or soil substrate has been reported (Bouwman *et al.*, 2005). It is remediation without excavation of contaminated site, often referred as botanical bioremediation (Chaney *et al.*, 1997), which involve the use of green plants to decontaminate soils, water or air. It's an emerging technology that can be applied to both organic and inorganic pollutants present in the soil, water or air (Salt *et al.*, 1998). However, the ability to accumulate heavy metals differ significantly between species and among cultivars within species due to different mechanism of ion uptake that are operative in each species, based on their genetics, morphological, physiological and anatomical characteristics. There are different categories of phytoremediation including phytoextraction, Phytofiltration, phytostabilization and phytovolatilization and phytodegradation, depending on mechanism of the remediation which is based on problem on ground (Garbisu and Alkorta, 2001).

Lead has been listed as a potential carcinogen by United State Environmental Protection Agency (2000) and causes many problems in both plant and animals. It accumulates in the body's organs such as brain, which

may lead to poisoning (plumbism) or even death. The gastrointestinal tract, kidney and central nervous system are also affected by the presence of lead. Children exposed to lead are at the risk for impaired development, lower Intelligent quantum, shortened attention span, hyperactivity and mental deterioration (Env.writer; 2000). According to report by humanitarian aid groups, Doctors without Borders (2012) lead poisoning claimed the lives of over four hundred (400) children between 2010 to 2011 and left over 2000 others at risk in Zamfara state, Nigeria. This phenomenon, indeed poses a clear and present danger to Nigerian children.

Although, many metals are essential to plant growth but most metals are toxic at higher concentration thereby causing oxidative stress by formation of free radicals, they replace essential metals in the pigment or enzymes disrupting their function (Henry, 2000). Heavy metals render the land unsuitable for plant growth and destroy biodiversity. Despite the extreme toxicity of heavy metals, some plants have the ability to adapt to metal rich soil through natural selection (Antonovics *et al.*, 1971). This research aimed at evaluating the phytoremediation potentials of selected plants species on lead contaminated soil; with a view to determine total concentration of lead metals in plant biomass growing in contaminated sites.

MATERIALS AND METHODS

Study area: This research was conducted in Botanical Garden of the Usmanu Danfodiyo University, Sokoto, Nigeria which lies between (latitudes 13°06' 28"N and 0° longitudes 51°2' 46"E) and has average annual

temperature of 28.3 °C and mean annual rain fall ranging from 500 mm to 1300 mm and in terms of vegetation Sokoto falls within the Sudan savanna zone.

Collection of Plant and Soil Samples

Three plant species namely: *Panicum virgatum*, *Luffa cylindrica* and *Ocimum basilicum* used in this study were obtained from different source. *P. virgatum* (Switch grass) was collected from Sokoto Energy Research Center (SERC) in the Usmanu Danfodiyo University Sokoto. The seeds of *L. cylindrica* (Vietnamese gourd) were obtained from Department of Biological Sciences, Usmanu Danfodiyo University, Sokoto, while, the seeds of *O. basilicum* (Sweet basil) were collected from Gandhi town in Rabah Local Government area of Sokoto State. The plants were planted in nursery for two weeks and healthy seedlings of the same height were selected for the experiment. Selected seedlings were transplanted and grown in pots under greenhouse condition. Soil sample was collected from the Botanical Garden of the Biological Sciences Department Usmanu Danfodiyo University, Sokoto. At a depth 20cm homogenized and air dried for 24 hours. Air dried soil 300g was filled into plastic pots and moistened with water and one stand of a test plants were transplanted.

Experimental Design and Treatment

The experiment was designed to investigate the effects of three different factors namely plant species, plant parts and concentration of lead. The plant species was taken at three level viz *P. virgatum*, *L. cylindrica* and *O. basilicum* using 4x5 factorial, while plant parts was taken at three level also viz root, stem and leaves. Lead concentration [Pb (NO₃)₂], on the other hand was taken at five levels: 0, 200, 400, 600 and 800 mg/L. Each plant species was irrigated daily with 20 ml of a given concentration of Pb²⁺ solution for six (6) weeks. Experiments were conducted with four replicates. Random sampling was applied to both the experimental media and test plants.

Data Collection

After 14 days of pretreatment, each of the given plant grown in its corresponding concentration in a pot containing 300g garden soil (media). On each treatment, Plant height and number of leaves were measured weekly throughout the test period. Plant heights were measured in centimeter using a ruler while leaf numbers were counted manually. After harvesting, root length and fresh weight were measured. Fresh biomass was measured using weighing balance and oven dried at 80 °C until constant mass was obtained (Mangkoedihardjo, 2006). The weight of the dry mass was also measured. The oven dried plant sample were divided into leaves, stem and roots which were later pulverized using motor and pestle, and the grinded powder were used for digestion and lead analysis.

Determination of Lead in Plants and Soil

Lead content was determined in the soil sample before and after phytoremediation. From each pot, 0.5g of soil was taken. Soil sample of the same treatment were homogenized and analytical sample was taken from each mixture for heavy metal analysis. One gram (1g) of the analytical sample was digested with a mixture of perchloric acid and nitric acid. Lead was analyzed using Atomic absorption spectrophotometer (Standard Methods, 1995).

To estimate the total lead in plants, one gram (1g) of powdered sample (leaf, stem or root) was digested in 20ml concentrated nitric acid (65%). The solution was boiled on a hot plate until white fumes were given off. The digested sample was allowed to cool down and then diluted to 100ml with deionize water and left over night to allow the remaining particle to settle before it was filtered. Finally, 30ml of each sample solution was used to determine heavy metal concentration using Atomic Absorption Spectroscopy (AAS) (Varian 240FS, promochem GmbH, Germany. Certified concentration (Pb=58.5) was used as a reference material.

Evaluation of Hyper accumulating Activity

In evaluating hyperaccumulation potential of given plant species, not only the metals concentration in the above ground biomass are considered but also metal concentration in the soil has to be considered. Biological accumulation coefficient (BAC), biological transfer coefficient (BTC) and Bioconcentration factor (BCF): Biological Accumulation Coefficient was defined as the concentration of heavy metals in plant shoots divided by the heavy metal concentration in soil (Zu *et al.*, 2005) and is given in equation 1.

$$BAC = [\text{Metal}] \text{ shoot} / [\text{Metal}] \text{ soil} \text{ ----- Eq. 1}$$

Biological Transfer Coefficient was described as the ratio of heavy metal concentration in plant shoot to that in plant root (Zu *et al.*, 2005) and is given in equation 2.

$$BTC = [\text{Metal}] \text{ shoot} / [\text{Metal}] \text{ root} \text{ ----- Eq. 2}$$

Bioconcentration Factor was calculated as ratio of concentration of heavy metal in plant roots to that of soil (Yoon *et al.*, 2006) and is given in equation 3.

$$BCF = [\text{Metal}] \text{ root} / [\text{Metal}] \text{ soil} \text{ ----- Eq. 3}$$

Data Analysis: Data obtained was analyzed using ANOVA with SPSS

RESULTS AND DISCUSSION

The results of phytoremediation potential of *L. cylindrica*, *O. basilicum* and *P. virgatum* in varying lead concentration are presented in Table 1. There is a significant difference (p<0.05) in content of lead in various tissues of the plant and soil studied. It revealed that *P. virgatum* had the highest concentration of lead in the root and leaf followed by *O. basilicum* and *L. cylindrica* respectively. Two of the three plant species have concentration greater in shoots than roots. *O. basilicum* and *P. virgatum* accumulated Pb above 1000 mg kg⁻¹ in the shoots, the criteria for a hyperaccumulator as given by Baker & Brooks (1989).

The greater concentration of Pb in shoots was found in *P. virgatum* and *O. basilicum*. In all plant samples, only *O. basilicum* and *L. cylindrica* had Pb concentrations in shoot (leave +stem) greater than those in roots, indicating high mobility of Pb from roots to the shoots and mobilization of heavy metals in roots. The lowest Pb concentration was observed in the stems of *L. cylindrica*, *O. basilicum* and *P. virgatum* respectively, and *O. basilicum* had the highest Pb content in the leaves.

From the result obtained the lead content in the studied plant species (mg/kg) indicated that different species have it corresponding effects on different concentration tested (mg/L), plants parts and absorption level (mg/kg) comparisons of the means shows that Pb content (mg/kg) is significantly different ($p < 0.05$) with concentration (mg/L), species and plant parts. Interaction between concentration (mg/L) with species, concentration (mg/L) with species parts and species with their parts are also significant ($p < 0.05$) where $R^2 = 90.51\%$. Turkey simultaneous test for Pb content in the plants (mg/kg) at 0 concentrations (control) shows significant difference ($p < 0.05$) among all the treatment in all the plant species. At 200 mg/L, comparison of the means shows significant differences with all the treatment except in control, but at 400mg/L comparison shows significant difference with 600 and 800 mg/L while at 600mg/L means comparison are insignificant with 800mg/L ($p < 0.05$) in Table 1.

Comparisons of Pb content among the species shows that *L. cylindrica* was significantly different from *O. basilicum* and *P. virgatum* ($p < 0.05$), and *O. basilicum* was significantly different with *P. virgatum* ($p < 0.05$). Further comparison of Pb content (mg/kg) in different plant parts shows that leaf is significantly different with stem and root including growing media(soil) ($p < 0.05$). Roots are also significantly different from soil and stem but the Pb content (mg/kg) in soil was insignificantly different ($p < 0.05$) from that in the stems of the plant

(Table 1). The results of this study revealed that accumulated concentration of Pb content (mg/kg) fluctuate with increasing concentration (mg/L) in *P. virgatum*. The distribution of lead in different plants parts decreased in the order shoot > root. In the leaf of *L. cylindrica*, Pb content (mg/kg) increases with the Pb concentration (mg/L) for the first two levels then decreases and then rise again. In the stem and root, absorption values fluctuate with concentration. Metals are generally unevenly distributed throughout a given plant, although in hyperaccumulators the metal content of the leaves is often greater than other portions of the plant; for example, the greatest proportion of nickel in *Alyssum heldreichii* was found in the leaves (Brooks, 1998b). The distribution of lead content in different parts of *L. cylindrica* decrease in this order stem < leaf < root. Similar observation was made by Li *et al.* (2005) for absorption of Cd and Zn by *Sedum alfredii* (Li *et al.*, 2005; Xiong *et al.*, 2004). The data show that the concentrations of Cd and Zn in leaves and stems increase with increasing Cd and Zn levels. The distribution of the metals in different plants parts decreased in the order; stem > leaf > root for Zn and leaf > stem > root for Cd. In *O. basilicum* leave, lead accumulation is high at high level of concentration. In it stem and root, lead content mg/kg increase with increasing levels of concentration then decrease at 800mg/L. indicate that *O. basilicum* can absorb and hyperaccumulate lead metal up to 733.26 ± 696 , 513.95 ± 5.77 and 1019.64 ± 5.80 mg/kg in leaf, stem and root respectively. The distribution of lead in its parts decrease in the order: stem > leaf > root. The absorption fall down at high level (800mg/L), it may be that at this level plants can no longer secrete phytosidophores or exude into the rhizosphere to chelate and solubilize metals that bound with soil (Kinnerseely, 1993). Similarly, microorganism that released enzyme whose break and convert lead in different forms cannot function well at this level such enzymes are usually dehalogenase, oxygenase and reductalase (Black, 1995).

Table 1: Concentration of Lead Metal in studied Plant tissues and Soil.

Plant part	Concentration (mgL ⁻¹)	<i>L. cylindrica</i>	<i>O. basilicum</i>	<i>P. virgatum</i>
Leaf	0	140.03 ^b ±0.41	372.11 ^b ±5.71	734.40 ^b ±0.06
	200	464.32 ^a ±5.83	636.23 ^b ±5.83	436.32 ^b ±0.01
	400	556.63 ^a ±5.73	588.69 ^b ±5.74	1477.57 ^a ±0.01
	600	329.23 ^b ±9.99	723.65 ^a ±6.96	520.80 ^b ±0.01
	800	335.34 ^b ±6.11	733.26 ^a ±5.52	745.98 ^b ±0.01
Stem	0	79.80 ^b ±5.77	248.84 ^b ±5.80	734.40 ^b ±0.06
	200	122.84 ^b ±6.32	382.03 ^b ±5.77	436.32 ^b ±0.01
	400	84.91 ^b ±5.83	436.49 ^b ±5.96	1477.57 ^a ±0.01
	600	154.88 ^a ±5.80	513.97 ^a ±5.77	520.80 ^b ±0.01
	800	109.66 ^b ±5.61	448.25 ^b ±5.03	745.98 ^b ±0.01
Root	0	1115.15 ^b ±3.98	327.58 ^b ±5.83	1548.90 ^b ±0.00
	200	420.69 ^b ±5.83	830.11 ^b ±5.83	1812.75 ^b ±0.01
	400	1142.45 ^a ±5.48	922.15 ^b ±6.35	2825.55 ^a ±0.01
	600	349.07 ^b ±5.81	1019.64 ^a ±5.80	746.62 ^b ±0.00
	800	497.35 ^b ±5.64	825.24 ^b ±5.55	850.80 ^b ±0.00
Soil	0	85.09 ^b ±0.59	120.59 ^b ±5.83	21.714 ^b ±0.58
	200	682.59 ^b ±5.49	162.05 ^b ±5.59	120.12 ^b ±0.33
	400	77.51 ^a ±6.01	172.35 ^a ±5.49	477.12 ^b ±0.06
	600	±0.39 59.21 ^b ±6.03	112.48 ^b ±3.33	483.54 ^b ±0.33
	800		180.01 ^a ±5.77	652.11 ^a ±1.53

*Values are means of three replicate determinations and values with different superscript in the same column are significantly different ($P < 0.05$).

Although, the standard for assessing hyperaccumulator has not been defined scientifically however, different authors proposed different criteria which include four rules i.e., the concentration of heavy metals in plant shoots reach hyperaccumulating level (Pb and Cu > 1000 mg/kg, Zn > 10,000 mg/kg) (Baker *et al.*, 1994; Brown *et al.*, 1994 and Wei *et al.*, 2002; Kakar *et al.*, 2011). In this study, two of the plant species had metal concentrations > 1000 mg/kg in shoots, i.e. they are hyperaccumulators (*O. basilicum* and *P. virgatum*). The concentration of heavy metals in its above ground part is 10-500 times more than in plants from non polluted environments (Shen and Liu, 1998). From the above principle, none of the studied plants species was metal hyperaccumulator, the metal concentrations in shoots are invariably greater than that in roots and enrichment coefficient > 1, showing a special ability of the plant to absorb from soils and transport metals and store in their above-ground parts (Baker *et al.*, 1994; Brown *et al.*, 1994; Wei *et al.*, 2002). It is difficult to judge whether a plant species is hyperaccumulator or not if the plant species must accord with above four rules simultaneously. Currently Biological Accumulation Coefficient (BAC), Biological Transfer Coefficient (BTC) and Bioconcentration Factor (BCF) had been in used to estimate a potential for phytoremediation purposes.

The results of BAC, BTC and BCF values for the studied plant species are presented in Table 2. Among the plant species evaluated, BAC for number of treatment in plant samples were greater than 1, *P.*

virgatum had the highest BAC value of 33.80 followed by *L. cylindrica* with 15 and then *O. basilicum* with maximum value of 11.35 at 600mg/L. BTC values ranges from 0.56 to 1.87 in *L. cylindrical* and *P. virgatum* had lowest values. *O. basilicum* had the highest BTC values of 1.50. BTC values of *O. basilicum* and *L. cylindrica* were greater than 1.while that of *P. virgatum* is less than one for all treatment. *P. virgatum* had the highest BCF value of followed by *L. cylindrical* and *O. basilicum*. Considering BAC, all of the 3 plant species evaluated possess the characteristic of hyperaccumulator. *L. cylindrical* and *O. basilicum* had the BTC values greater than 1. These species possessed the characteristic of hyperaccumulator. The BCF values of Pb range from 0.16-14.73, 2.71 - 5.35 and 0.47 - 0.87 in *L. cylindrical*, *O. basilicum* and *P. virgatum* respectively. These values were lower than that found by Kim *et al.* (2003) in *P. redundant* (BCF= 58) and higher than those (BCF=0.004-0.45) reported by Stoltz and Greger (2002). Shu *et al.* (2002) reported a BCF of 0.1 for Pb in *P. distichum*. Plants exhibiting BTC and BCF value less than one are unsuitable for phytoextraction (Fitz and Wenzel, 2002). All the three plant species used in this research were capable of accumulating heavy metals in the roots and shoots, but *P. virgatum* had highest BAC and BCF values and lowest BTC values, which means passable ability of heavy metal accumulation by the plant and limited translocation within the plants. Among the plant species evaluated none of them satisfied all for criteria set at the earlier (were identified as metal hyperaccumulator) However, all but *P. virgatum* had BCFs and BACs

greater than 1. *O. basilicum* and *L. cylindrica* were most effective in terms of these values. These plant species were considered suitable for growing in industrially polluted regions, as they accumulate considerable quantities of heavy metals from the soil with their root system but in term of accumulated concentration in the shoot *P. virgatum* was the best. Therefore all the plant species studied can be used as potential aspirant for restoring heavy metals contaminated site. Similarly, hyperaccumulators are species of plant that accumulate appreciable quantities of a metal in their tissues regardless of their concentration in the soil (Parad and Freitas, 2003). Based on this criterion, all the tested plant species are hyperaccumulators and could therefore be suitable for lead phytoremediation, because they all accumulate appreciate concentration their biomass. According to Istvan and Benton (1997) the toxic concentration of lead metal was at 300 mgL⁻¹, than all plant (*L. cylindrica*, *O. basilicum* and *P. virgatum*) were considered being hyperaccumulant because they did best at concentration greater than toxic level.

For *P. virgatum* that was able to absorb reasonable amount of lead in both shoot or root which may be as a result of a process called Rhizodegradation due to it hardy deep rooted system that enhancement the naturally-occurring biodegradation in soil and ideally will lead to destruction or detoxification of contaminant. Other terms have been used by some authors as synonyms for rhizodegradation, such as enhanced rhizosphere biodegradation. Contaminants in soil can often be broken down into simpler products or completely mineralized to inorganic products such as carbon dioxide and water by naturally occurring bacteria, fungi, and actinomycetes. The nature of the plant roots will often increase the size and variety of microbial populations in the soil surrounding roots (the rhizosphere) or in mycorrhizae (associations of fungi and plant roots). Similar assertion was made by Jordahl *et al.* (1997) that significantly higher populations of total heterotrophs, denitrifiers, pseudomonads, degraders, and atrazine degraders were found in rhizosphere soil around hybrid poplar trees in a field plot (*Populus deltoides* × *nigra* DN-34, Imperial Carolina) than in non-rhizosphere soil (Jordahl *et al.*, 1997). The increased microbial populations are due to stimulation by plant exudates. Such as sugars, amino acids, organic acids, fatty acids, sterols, growth factors, nucleotides, flavanones, enzymes, and other compounds (Shimp *et al.*, 1993). The increased microbial populations and activity in the rhizosphere can result in increased contaminant biodegradation in the soil, and degradation of the exudates can stimulate metabolism of contaminants in the plant rhizosphere. *P. virgatum* is may be regarded as lead hyperaccumulator though Biological Transfer Coefficient was less than one at all level but Biological Accumulation coefficient and Bioconcentration factor was up to 33.80 and 15.09 respectively. Henderson *et al.* (2007) reported that compound atrazine and its metabolites were found in

both root and above-ground tissue of *P. virgatum* which was 0.5% and 7% of applied atrazine, respectively. Recently *P. virgatum* was founded to contain degradation products of atrazine, of which 94.3% of the applied amount were found as metabolites (Lin *et al.*, 2008).

According to Rowell *et al.* (2002) the structure of *L. cylindrica* is cellulose based and the surface in contact with media is negatively charged, Pb²⁺ compound use was to dissolve to give cationic metal which will undergo attraction on approaching the anionic *Luffa cylindrica* structure (Ho, *et al* 2002) on this basis, it is expected that metal cation such as Cu²⁺ and Pb²⁺ will have strong sorption affinity for *L. cylindrica* hence it absorb as high as 556.63±5.73, 154.88± 5.80 and 1142.45±5.48 mg/kg in leaf, stem and root respectively. The biological accumulation coefficient or enrichment factor was 15.71 at 600 levels treatment which is far greater than phytoextraction factor of 1.7 for *B. juncea* which was use as indicator that was grown on lead concentration of 500mg/L (Henry, 2000). Considering the BTC or Translocating factor of 1.37 which qualified the plant to satisfied the criteria for a plant to be Hyperaccumulator as proposed by Yanqun *et al.* (2005) that BTC must be greater than one.

The effects of Pb on morphological characteristic of the studied plants species are presented in Table 3. The results show that plant height increase with concentration with the highest means value in *L. cylindrica* comparisons of indicate that there is significantly different between the species and within the concentration level as well as their interaction (p<0.05) when R²=91.36%. Leaf number also increases with increasing concentration with exception of 600mg/L which decrease analysis of variance indicate that leaf number is significantly different with concentration, species and their interaction (p<0.05). R²=66.25%. Root length generally decrease with increasing concentration with exception of 400 treatments which increase with the means values of 24 cm in *L. cylindrica* only and shows that root length (cm) and concentration of lead content mg/kg are insignificantly different (p<0.05). But significantly different with species and their interaction (p<0.05) where R²=76.72%. Concentration can decrease root penetration, leading to some portions of the soil never being contacted by roots. Perhaps the most serious impediment to successful rhizodegradation is its limitation to the depth of the root zone. Many plants have relatively shallow root zones, and the depth of root penetration can also be limited by soil moisture conditions or by soil structures such as hard pans or clay pans that are impenetrable by roots. However, in some cases roots may extend relatively deep (e.g., 110 cm) and extend into soil with high contaminant concentrations (Olson and Fletcher, 2000). Plant height and number of leaves in *O. basilicum* increase with increasing concentration with the exception of 600 mgL⁻¹ (treatment) which shown

decrease. The highest plant height and leaf number was obtained at 800 mgL⁻¹ while control had the lowest values for plant height and number of leaves which reveals that lead has significant positive effect on plant height and number of leaf. The root length of *O. basilicum* increased with concentration at the low levels and decrease at height levels which confirms the work of Olson and Fletcher (2000) that concentrations can decrease root penetration. *O. basilicum* dry matter increased with concentration then decreased and then increased again with the highest value recorded at 400 mgL⁻¹ and the lowest at 600 mgL⁻¹. this mean that at 600 and 800mg/L lead concentration significantly reduce the production of biomass and 400mg/L is the concentration at which *O. basilicum* was at peak. Plant height in *L. cylindrica* increase with increasing concentration and leaves number follow the same trend with increasing concentration with the highest value at the highest treatment and lowest at the control,

increases in lead concentration significantly affect the number and plant height in concentration dependent manner. Root length of *L. cylindrica* does not follow any usual pattern.

Biomass produces at the end the experiment, shows an increase significantly with concentration and then decrease at the highest treatment, *L. cylindrica* produced the highest biomass with average mean value of 8.33g against *O. basilicum* with 6.27g though accumulated lead content in *O. basilicum* is higher than that of *L. cylindrica* which against the point of McGranthy (1998).that the greater biomass of plant, the greater the mass of metals it would be remove from the soil. Even though the concentration within the plant might be lower than in hyperaccumulators. He also point out that however, the much higher metal concentration achievable in hyperaccumulators more than compensate for their low biomass.

Table 2: The biological transfer coefficient (BTC), Biological Accumulating Coefficient (BAC), and Bioconcentration Factor (BCF) in selected plants.

	Biological Translocating coefficient			Biological Accumulating Coefficient			Bioconcentration factor		
Conc. (mgL ⁻¹)	<i>L. cylindrica</i>	<i>O. basilicum</i>	<i>P. virgatum</i>	<i>L. cylindrica</i>	<i>O. basilicum</i>	<i>P. virgatum</i>	<i>L. cylindrica</i>	<i>O. basilicum</i>	<i>P. virgatum</i>
0	1.87	0.92	0.47	2.59	3.01	33.85	1.35	2.71	71.33
200	1.39	1.23	0.54	0.85	5.92	3.63	0.61	5.12	15.09
400	0.56	1.12	0.52	0.73	6.00	3.10	14.74	5.35	5.92
600	1.09	1.50	0.69	15.71	11.35	1.08	13.95	9.0	1.07
800	0.90	1.43	0.87	7.50	6.53	1.14	8.39	4.58	1.14

*Values are means of Triplicate Determination. * Species with values greater than 1 possess hyperaccumulators property

Table 3: Effect of lead on morphological characteristics of the studied plants.

Species	Conc.(mgL ⁻¹)	Plant height(cm)	Leaf no.(cm)	Root length(cm)	Biomass(g)
<i>O. basilicum</i>	0	25.33 ^a ±2.03	39.00 ^a ±10.6	13.33 ^a ±1.45	4.30 ^b ±06
	200	29.33 ^a ±1.20	43.00 ^a ± 4.41	13.33 ^a ±1.67	5.17 ^b ±03
	400	30.33 ^a ±1.45	59.00 ^b ±8.21	9.00 ^b ±00	10.30 ^a ±06
	600	21.00 ^b ±1.00	26.00 ^b ±2.08	9.00 ^b ±58	4.23 ^b ±09
	800	30.33 ^a ±9.10	57.00 ^a ±12.01	9.00 ^b ±00	7.33 ^b ±09
<i>L. cylindrica</i>	0	73.33 ^b ±8.04 ^b	12.00 ^b ±0.58	20.33 ^a ±1.20	4.00 ^b ±35
	200	138.33 ^a ±8.10	17.00 ^a ±0.58	17.33 ^a ±4.05	8.43 ^b ±0.59
	400	130.67 ^a ±6.20	20.00 ^a ±2.33	24.67 ^a ±1.45	9.70 ^b ±1.29
	600	145.67 ^a ±10.3	22.00 ^a ±2.84	18.00 ^a ±3.61	13.77 ^a ±1.13
	800	116.00 ^a ±23.26	24.00 ^a ±4.51	18.00 ^a ±1.00	5.77 ^a ±0.9

*The values are means of tree replicate determination.

*Values with different superscript in the same column are significantly different (p<0.05).

Based on the findings of this result, the following plant could be introduced as Heavy metals accumulators; *L. cylindrica* and *O. basilicum* although some differences occur between them regarding the amount and accumulating organ (leaf, stem and root). In general, *O. basilicum* is considered the best hyperaccumulator among the studied plants species followed by *L. cylindrica* because they satisfied most of the proposed criteria for a plant to be hyperaccumulator. In conclusion, based on the findings of this study, all the studied plants possess the potentials to be used in phytoremediation of lead contaminated soil. *L. cylindrica* and *O. basilicum* were regarded as

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- hyperaccumulators for their potential in accumulation and translocation of higher amount of lead content in their tissues. The study recommend the use of *O. basilicum*, *L. cylindrica* and *P.virgatum* in remediating lead contaminated sites and considered *O. basilicum* and *L. cylindrica* as hyperaccumulators.
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