Studies on Efficiencies of Heavy Metal Hyper-Accumulation Plants as Potential Land Remediators for Heavy Metal Polluted Soils

Abstract

The purpose of this study was to determine which hyper accumulator plant is more efficient for phytoremediation of heavy metals in a heavy metal polluted soil. The plants used were Sunflower, Asiatic dayflower, Guinea grass, Bahama grass, and Vertiver grass. Heavy metals such as Pb, Zn, Cu, Cd, Ag and Hg were impregnated in the soil samples. The plants were planted in the heavy metal polluted soil and harvested after 75 days to determine the percentage concentration of the heavy metals in the root and shoot of the plants. The result showed that heavy metals were hyper-accumulated in the roots and shoots of the plants at the end of the investigation. The heavy metals with a percentage concentration above 50 % can be used as a phytoremediator of that particular metal in a polluted soil. It was discovered that the best hyperaccumulator plants for Pb is the Sunflower, for Zn and Cd is the Bahama grass, for Cu and Ag is the Vertiver grass whilst, for Hg is the Guinea grass.

Keywords: Heavy metals, Pollution, Soil, Hyperaccumulation, Phytoremediation

1 Introduction

In recent years, public concerns relating to ecological threats caused by heavy metal have led to intensive research of new economical plants-based remediation technologies. Conventional methods used for reclamation of contaminated soils, namely chemical, physical and microbiological methods, are costly to install and operate [1]. The rapid increase in population coupled with fast industrialization growth causes serious environmental problems, including the production and release of considerable amounts of toxic waste materials into environment [2]. In ecological research, any metal or metalloid that causes environmental problem which cannot be biologically degraded should be considered as a heavy metal. Heavy metals (HMs) are natural components of the Earth's crust, but in many ecosystems the concentration of several HMs has reached toxic levels due to consequence of anthropogenic activities. The adaptative responses of plants to heavy metals contaminated environments are efficient processes that include many physiological, molecular, genetic and ecological traits. These traits give certain species the ability to survive or hyperaccumulate the toxic metals. Soil pollution caused by metals is somewhat different from air or water pollution, because HMs persist in soil much longer periods of time than in other compartments of the biosphere [3]. The hyperaccumulation of HMs in some plants has been recorded by many researchers during last few decades [4] and, this has emphasized the importance of further advanced research in molecular basis of phytoremediation technology. The hyperaccumulation of heavy metals is depends on the plant species, soil condition (pH, organic matter content, cation exchange capacity et cetra) and types of heavy metal [5], [6].

In metal biology, it has been experimentally proven that even some metals that are essential for the normal plants' growth (such as iron and copper) may become toxic, depending on the oxidation state, complex form, dose and mode of exposure [7]. Remediation of metal-contaminated soils became a goal for many research laboratories in the world. The use of plants in designing low-cost treatment system is still a challenge in environmental managements. Phytoremediation, a new green technology has been inventoried, in which some metal hyperaccumulator plants were utilized to decontaminate soil, water and ambient environment [8] and, it is growing without symptoms of toxicity.

Hyperaccumulator plants represent a resource for remediation of metal polluted site, as they are able to extract wide range of metals and to concentrate them in their upper parts with the character of metal tolerance. In some plant species, the concentrations accumulated in aboveground biomass of metals or metalloids are more than one and up to four, orders of magnitude higher than in other adjacent plants [9]. HMs contamination at river or soil has become worst. One of the reasons because of the industrial sector or agricultural was in huge development [10]. Therefore, it causes the heavy metals been released into the environment without proper treatment which poses bad impact to the environment. To solve the problem, several methods have been used. One of the methods is phytoremediation technique. It is however, important to determine the efficiency of extraction of heavy metals using some hyperaccumulator plants.

2 Area of Study

Soil samples was obtained behind Shagari phase 2, Yola town, Yola South local government area of Adamawa State, Nigeria. The town lies along River Benue with coordinates of 9^o 16’ 45’N 12^o 6’ 45’’E.

3 Experimental procedures

3.1 Reagents and materials

The following materials were used, a hoe, bucket, a sieve, plastic container, 100 mL volumetric flask, 10 mL measuring cylinder and filter. The entire standard was of analytical grade. Reagents used include, distilled water, $Ni(NO_3)_2.6H_2O$ (98.5 w/w %); copper(II) nitrate pentahydrate $(Cu(NO_3)_2).10H_2O$ (99.0 w/w %); zinc nitrate hexahydrate $Zn(NO_3)_2.6H_2O$ (99.0 w/w %); mercury nitrate $Hg(NO_3)_2$ cadmium nitrate tetrahydrate, $Cd(NO_3)_2.4H_2O$ (99.0 %) and lead nitrate, $Pb(NO_3)_2$ (99.0 w/w %), arsenic nitrate $As(NO_3)_5$, trioxonitrate (v) acid, HNO_3 and hydrogen peroxide (H_2O_2) plants used were Asiatic dayflower (*Commelina communis*), Vertiver grass (*Chrysopogon zizanioides*), Sunflower (*Helianthus annuus*), Guinea grass (*Megathyrsus maximus*) and Bahama grass (*Cynodon dactylon*).

3.2 Soil Sampling

The soil samples were collected using a hoe from the mapped-out site, top and sub soil samples collection was done within the sampling site, using a clean stainless trowel from 0-15 cm depth [11]. Soil sample which served as control was also collected. The soil samples were manually sorted to remove coarse materials and air-dried under ambient conditions in the laboratory for 72 hours. The samples were thoroughly mixed in a clean plastic bucket to obtain composite samples [12].

3.3 Impregnation of soil samples with heavy metals

The thoroughly mixed soil sample was divided into six parts, each weighing 20 kg of the dried soil. The dried soil was impregnated with heavy metals, each of the samples were impregnated with the same quantity of compounds containing heavy metals in them except for one pot which was served as control. The trioxonitrate (v) of the metals were employed due to their solubility. The compounds were ground to help enhance proper mixing during formulation of the samples with heavy metals. The chemicals were weighed using electronic compact scale, a filter paper was placed on the scale and the weight of the filter paper was measured and noted after which the chemical to be measured was added and the desired weight was taken by subtracting the weight of the paper from the sum weight of the paper and the chemical measured [2]. The soil sample were impregnated with 15g each of the following compounds in dry/solid state without adding water; Nickel (II) nitrate hexahydrate (98.5 w/w %); copper (II) nitrate pentahydrate (99.0 w/w %); zinc nitrate hexahydrate (99.0 w/w %); cadmium nitrate tetrahydrate (99.0 %), arsenic nitrate $As(NO_3)_5$, mercury nitrate $Pb(NO_3)_2$ and lead nitrate (99.0 w/w %) were used to spike soil sub-samples to simulate artificial contamination with Ni, Cu, Zn, Cd, As Hg and Pb, respectively [2], [13].

Five pots were made and filled with the soil samples (20 kg) which was placed in plastic pots (15 cm diameter x 25 cm height). The moisture level of the soil was maintained to near field water capacity (35.6 %) and equilibrated for two weeks [14].

3.4 Harvesting of the hyper-accumulator plant samples on impregnated soils

Five different hyper-accumulators were planted and harvested on the same type of prepared soil which was polluted with some heavy metals; the plants were monitored with the same chemical composition and physical conditions. The plants were harvested after 75 days and the level which they hyper-accumulate certain heavy metals in their system from the soil were determined [15].

The hyperaccumulator plants selected for cultivation were those mostly seen on waste and dump site. There were some factors that were considered before selecting the hyperaccumulators for cultivation [9]. The hyperaccumulators were resistant to drought and can hyperaccumulate the heavy metals without being affected by the heavy metals. These hyperaccumulators were also selected base on the fact that they were not consumable but can be used for checking erosion and maintenance of the soil organism and moisture of the soil [9].

3.5 Preparations of soil samples for analysis

The soil samples polluted with the heavy metals before planting and the soil after planting were collected and prepared for heavy metals concentrate on them. Sampling technique employed was bases on [16] where the soil samples polluted with the heavy metals were properly mixed and sampling was based on coning and quartering sample preparation techniques where the samples were divided in to four equal parts and one of the for samples were taken as a representative sample. The samples were then ground with a mortar and pestle to pass through a 2 mm sieve and homogenized. The dried, sieved, and homogenized soil samples were finally stored in polyethylene bags and kept in desiccators until digestion and analysis.

Each of the soil left after harvesting was removed from the pot and allowed to dry. The sample was pounded in a ceramic mortar to break the lumps of the soil in to powdered form for easy sampling. Sampling was done using the same sampling method as established earlier by [17] using coning and quartering.

3.6 Digestion of soil samples for AAS analysis

For the digestion of the soil samples for analysis by AAS, the method employed by [18], [19] was employed where 10mL of 1:1 HNO_3 was added and mixed with the slurry and covered with a watch glass. The sample was heated to 95°C ± 5°C and refluxed for 10 to 15minutes without boiling. The sample was cooled and 5mL of concentrated HNO_3 was added to it and the cover was replaced and allowed to reflux for 30 minutes. Brown fumes were generated; indicating oxidation of the sample by HNO_3, this step was repeated (addition of 5mL of conc. HNO_3) over and over until no brown fumes were given off by the sample indicating the complete reaction with HNO_3. A ribbed watch glass/vapor recovery system was used to allow the solution to evaporate to approximately 5mL without boiling or heat at 95°C ± 5°C without boiling for two hours. Covering of solution was obtained over the bottom of the vessel at all times. After the previous step has been completed and the sample was cooled and 2mL of water and 3mL of 30 % H_2O_2 were added. The vessel was covered with a watch glass or vapor recovery device and the covered vessel was returned to the heat source for warming and for to start the peroxide reaction. Care was taken to ensure that losses do not occur due to excessively vigorous effervescence. It was heat until effervescence subsides and cool the vessel was cooled and 30 % H_2O_2 was added in 1mL aliquots with warming until the effervescence was minimal [19].

The sample was covered with a ribbed watch glass and heating continued with the acid- peroxide digestion until the volume was reduced to approximately 5 mL or heat at 95°C ± 5°C without boiling for two hours. Covering of solution over the bottom of the vessel was maintained at all times. After cooling, it was diluted to 50mL with water. Particulates in the digestate were then removed by filtration by allowing the sample to settle. The sample was now ready to be analysis by AAS.

3.7 Plant Sampling

The seeds of the plants were grown in the polluted soil for sunflower and *Commelina Erecta*, the seeds were not placed too deep into the ground so that they can germinate properly, the seeds were placed 2-3 cm deep in to the soil. The pot was watered daily to 60 % of the field water capacity while the seedlings of vetiver grass, Guinea grass and Bermuda grass were transported into the polluted port and place under a shade for proper adaptation in a flower garden before been exposed directly to the sun [1].

The plants were allowed to grow in a good atmosphere where they received adequate water and sunlight for at least 9-10 hours a day. The pot was carefully monitored such that there will be no foreign substances will not be added to the pots, the pots were free from weed. The plants were allowed to grow for 75 days. The water for irrigating the hyperaccumulators was gotten from a well which was analyzed to free from heavy metals [20].

The plant samples grow well on the polluted soil, almost in the same way as the control. Fertilizer was not added to the plant samples as they were allowed to grow under natural conditions.

After the 75 days, plant samples were harvested for the analysis to test the effectiveness of the plants in removal of heavy metals. The plants pots were watered to ensure that the soil is soft such that during uprooting the root from the ground the root will be completely removed from the soil.
First, the plants were washed with tap water then rinsed with distilled water. After that, each grass and its soil were weighted before placed it in the oven for 3 days at 70 ℃ [21].
After 3 days the grasses and the soil were weight again to get the moisture content of the soil and dry weight of grasses. The plants were cut into small particles and pounded into small particles using a ceramic pestle mortar. Each plant was divided into two samples consisting of; root and shoot. The powdered samples were carefully sieved such the bigger particle were pounded again to obtain a uniform size of the plant sample. Only 1 gram was taken for each sample for the root and shoot sample, for digestion. After all samples were weighed and prepared, the digestion process takes place. For the digestion process, nitric acid (HNO_3), hydrogen peroxide (H_2O_2) and distilled water with ratio 6:2:2 were used as solution [22]. During the digestion process, the sample will be heated on hot plate inside the fume chamber for 2 hours and each hour 10 mL of the solution were added because the sample will have dried out. After digestion process finished, samples will be cooled down before mixed with 25 mL of distilled water.
In filtering process, all samples were filtered 2 times for each. The first filtration was done using filter paper to remove large particles or foreign objects whereas the second filter by using syringe filter which size at 0.25 micrometers to remove fines and smaller particles. Before samples will be analyzed using AAS, all samples must be stored in cold room to prevent damage of the samples. The sample been prepared and analyzed using Atomic Absorption Spectrophotometer. The technique for this AAS is using flaming method. Before starting the analysis, a set of standard solution for Ni, Zn, Cd and Pb must be prepared first which consist of 0.2 ppm, 0.4 ppm, 0.6 ppm, 0.8 ppm and 1.0 ppm. The result from this experiment will be to see the translocation factor of various plants can act as hyper-accumulator plant or not.

3.8 Water sampling

The water used for irrigating the plants was obtained from a well and collected in sample bottle and taken to the laboratory for the analysis of heavy metals in the water

3.9 Analytical Studies of the Samples

3.9.1 Concentration of heavy metals

The concentration of heavy metals in the soil was analyzed before planting to know the initial concentration of the heavy metals in the polluted soil. The plants were also analyzed and the concentrations of the heavy metals in the plants were determined. The water used for the irrigation of the plants was also analyzed to check if there was external source of the heavy metals in the controlled experiment.

4 Results and discussion

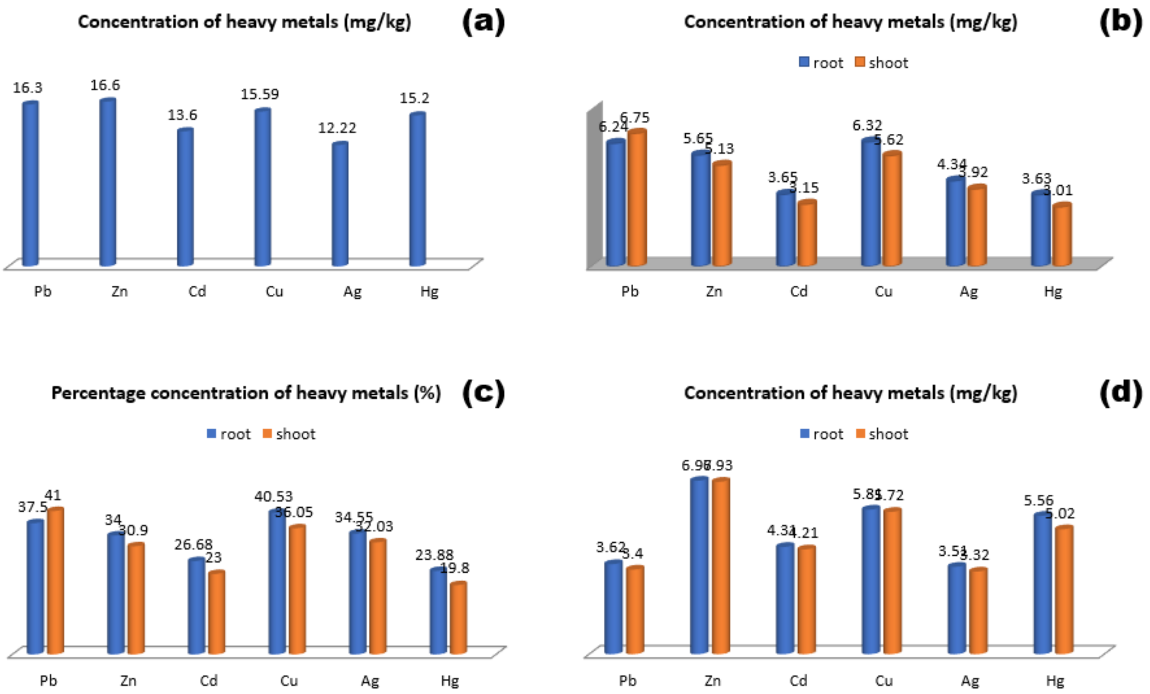

Figure 1 Concentration of heavy metals in the polluted soil **(a)**, Heavy metals Composition in root and shoot of sunflower (mg/kg) **(b)**, Percentage of heavy metals in root and shoot of sunflower **(c)**, Concentrations of heavy metals in root and shoot of *Commelina Erecta* **(d)**.

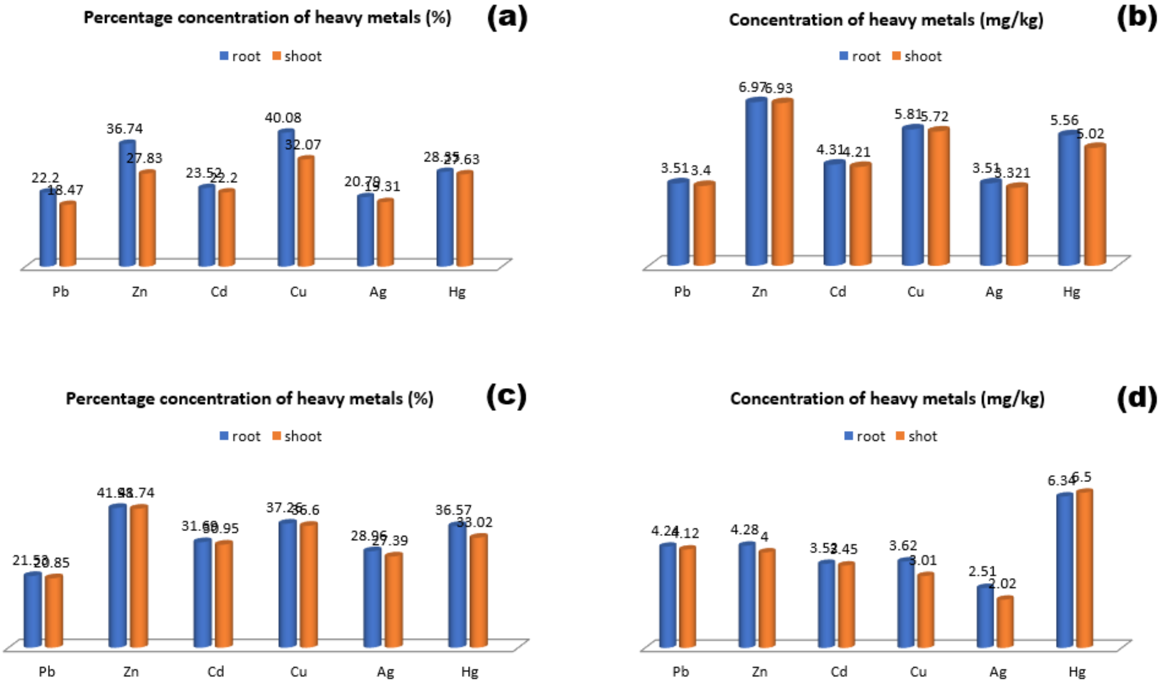

Figure 2 Percentages of extracted heavy metals in root and shoot of *Commelina Erecta* **(a)**, Heavy metals Composition in root and shoot of Bahama grass (mg/kg) **(b)**, Percentage of heavy metals in root and shoot of Bahama grass (mg/kg) **(c)**, Heavy metals Composition in root and shoot of Guinea grass (mg/kg) **(d)**.

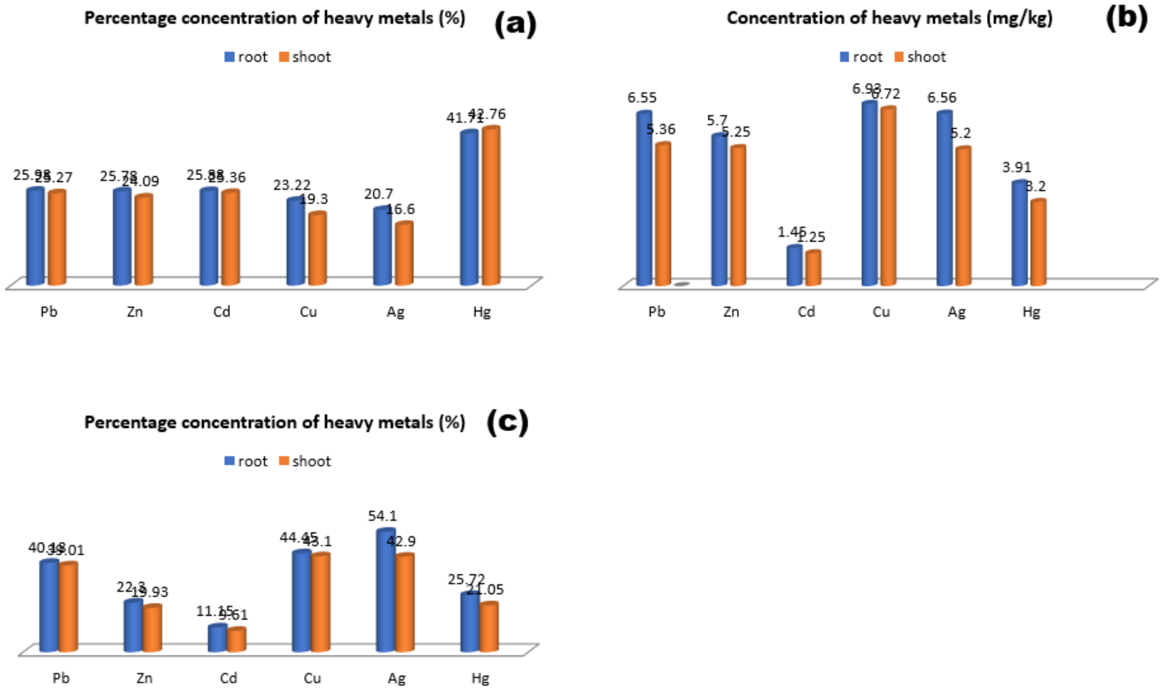

Figure 3 Percentage concentrations of heavy metals in root and shoot of Guinea grass (mg/kg) **(a)**, Heavy metals Composition in root and shoot of vetiver grass (mg/kg) **(b)**, The percentage concentration of heavy metals in vetiver grass **(c)**.

Table 1 Concentration of heavy metals in soil before planting, removed by the plant parts and the concentration left after harvesting in sunflower.

Sample	Pb	Zn	Cd	Cu		Hg
Initial conc. in soil (mg/kg)	16.30±0.16	16.60±0.10	13.60±0.11	15.59±0.05	12.12±0.05	15.20±0.61
Conc. removed by plant (mg/kg)	12.91±0.14	10.78±0.12	6.80±0.16	11.94±0.13	8.15±0.04	6.64±0.21
Conc. left in soil after (mg/kg)	3.31±0.21	5.82±0.31	6.80±0.31	3.65±0.31	3.97±0.03	8.56±0.09

Table 2 Concentration of heavy metals in soil before planting, removed by the plant parts and the concentration left after harvesting in *Commelina Erecta*.

Sample	Pb	Zn	Cd	Cu	Ag	Hg

Initial conc. in soil (mg/kg)	16.30±0.16	16.60±0.10	13.60±0.11	15.59±0.05	12.12±0.05	15.20±0.61
Conc. removed by plant (mg/kg)	6.63±0.23	10.72±0.34	6.22±0.15	11.25±0.45	4.86±0.25	8.31±0.11
Conc. left in soil after (mg/kg)	9.72±0.05	5.88±0.13	7.38±0.05	4.34±0.34	7.26±0.13	6.69±0.09

Table 3 Concentration of heavy metals in soil before planting, removed by the plant parts and the concentration left after harvesting in Bahama grass.

Sample	Pb	Zn	Cd	Cu	Ag	Hg
Initial conc. in soil (mg/kg)	16.30±0.16	16.60±0.10	13.60±0.11	15.59±0.05	12.12±0.05	15.20±0.61
Conc. removed by plant (mg/kg)	6.91±0.01	13.60±0.17	8.52±0.16	10.53±0.12	6.83±0.27	10.58±0.21
Conc. left in soil after (mg/kg)	9.39±0.32	3.00±0.16	5.08±0.21	5.06±0.04	5.29±0.18	4.62±0.02

Table 4 Concentration of heavy metals in soil before planting, removed by the plant parts and the concentration left after harvesting in Guinea grass.

Sample	Pb	Zn	Cd	Cu	Ag	Hg
Initial conc. in soil (mg/kg)	16.30±0.16	16.60±0.10	13.60±0.11	15.59±0.05	12.12±0.05	15.20±0.61
Conc. removed by plant (mg/kg)	8.35±0.20	8.28±0.06	6.97±0.16	6.63±0.23	4.53±0.03	12.84±0.32
Conc. left in soil after (mg/kg)	7.95±0.27	8.32±0.10	6.63±0.11	8.56±0.08	7.59±0.02	2.32±0.25

Table 5 Concentration of heavy metals in soil before planting, removed by the plant parts and the concentration left after harvesting in Vetiver grass.

Sample	Pb	Zn	Cd	Cu	Ag	Hg
Initial conc. in soil (mg/kg)	16.30±0.16	16.60±0.1	13.60±0.11	15.59±0.05	12.12±0.05	15.20±0.61
Conc. removed by plant (mg/kg)	11.91±0.01	6.95±0.12	2.70±0.33	13.65±0.12	11.76±0.08	7.11±0.14
Conc. left in soil after (mg/kg)	4.39±0.23	9.35±0.32	10.90±0.13	1.94±0.22	0.36±0.24	8.09±0.12

Physically, the plants grew healthy in the polluted soils and showed no effect of the heavy metals on the plants. The plants were harvested and the concentration of the heavy metals in the plants and the polluted soil were analyzed. The HMs concentrations in the polluted soil samples were analyzed and presented in Figure 1a, the trend in the HMs concentration in mg/kg was established as follows; Zn > Pb > Cu > Hg > Cd > Ag. The concentration of the heavy metals in the polluted soil was used to calculate the percentage of the various heavy metals in each plant. Plants that have a concentration greater than 50 % can be used for phytoremediation while those that have a concentration of less than 50 % cannot be used for hyper-accumulation of heavy metals in such plants [23]. Toxic metals in soil are usually not entirely accessible by the hyper-accumulative plants.

Consequently, only part of the total amount of metals in soil is removed by hyperaccumulation, especially from soils rich in organic matter or clay. Potential toxic metals left in soil after remediation are likely to be present in chemically stable mineral forms and bound to non-labile soil fractions. As such, they are less mobile and bioavailable, and therefore less toxic in comparison with the original conditions before remediation. The concentration of the heavy metals left in the soil after harvesting the plants has been shown in Tables 1-5 in the results section. The water used for the irrigation of the plants was also analyzed and the metals were below detection level except for copper which had 0.0108 mg/kg. The *p*H of both the water and soil were found to be 7.2 and 6.9 respectively.

The HMs concentrations and percentages in the root and shoot of the sunflower plant as seen from Figures 1b and 1c highlighted a trend as follows; Pb > Cu > Ag > Zn > Cd > Hg. From the result, it can be seen that sunflower can be used for hyperaccumulation of Pb, Cu, Zn, and Ag (Figure 1c) because the sum of their percentage concentrations (root and shoot) of these heavy metals in the plant was above 50%. Sunflower cannot be used for the hyper-accumulation of Hg and Cd because, they had a percentage concentration is less than 50% of the heavy metals in the plant [23]. The initial concentrations of the HMs in the polluted soil, concentration of HMs absorbed by Sunflower plant and HMs concentration left in the soil has been enumerated in Table 1; the efficiency of HMs removal by the Sunflower for Pb, Cu, Zn, and Ag was more evident with 3.31±0.21, 3.65±0.31, 5.82±0.31 and 3.97±0.03 (mg/kg) HMs concentrations left in the soil. These observed concentration values shows that the Sunflower was more efficient in the removal of Pb ions from the polluted soil samples.

The HMs concentrations and percentages in the root and shoot of the Asiatic dayflower as seen from Figures 1d and 2a highlighted a trend as follows; Zn > Cu > Hg > Cd > Pb > Ag. From the result, it can also be observed that the Asiatic dayflower can be used for hyperaccumulation of Zn, Cu, and Hg only (Figure 2a) and as such, the Asiatic dayflower cannot be used for the hyper-accumulation of Pb, Cd and Ag respectively [23]. It has been presented in Table 2, the initial concentrations of the HMs in the polluted soil, concentration of HMs absorbed by Asiatic dayflower plant and HMs concentration left in the soil, it was observed that the concentrations of the HMs left in the soil after removal by the Asiatic dayflower plant was more efficient for Zn, Pb and Cu with concentrations 5.88±0.13, 6.63±0.23 and 4.34±0.34 (mg/kg) respectively.

It was established that the HMs concentrations and percentages in the root and shoot of the Bahama grass as seen from Figures 2b and 2c also shows a similar trend; Zn > Cu > Hg > Cd > Pb > Ag as observed from the Asiatic dayflower plant. From the result, it can also be observed that the Bahama grass can be used for hyperaccumulation of Zn, Cd, Cu, Ag and Hg only (Figure 2c) [23] because, their concentration was high in the plant parts above 50%, and it is on this regard, the Bahama grass cannot be used for the hyper-accumulation of Pb. Table 3 enumerates the initial concentrations of the HMs in the polluted soil, concentration of HMs absorbed by Bahama grass and HMs concentration left in the soil, it was identified that the concentrations of the HMs left in the soil after removal by the Bahama grass plant was more efficient for Zn, Hg, Cd and Cu with concentrations 3.00±0.16, 4.62±0.02, 5.08±0.21 and 5.06±0.04 (mg/kg) respectively.

The information derived from figures 2d and 3a shows the absorbing strength of the Guinea grass plant on various HMs studied (initial concentrations of the HMs in the polluted soil and concentrations of HMs absorbed). A trend of Hg > Zn > Pb > Cu > Cd > Ag was identified. From this investigation, it can be seen that the Guinea grass can be employed for the hyperaccumulation of Hg, Cd, Zn and Pb only whose total percentage concentration in the shoot and root were found to be above 50 % [23] (Figure 3a) and not for Ag and Cu. From Table 4, the initial concentrations of the HMs in the polluted soil, concentration of HMs absorbed by Guinea grass plant and HMs concentration left in the soil was shown. It was observed that the removal of the heavy metals from the polluted soils was more evident for Hg and Cd than it was for Zn and Pb, with Pb having the highest unabsorbed concentration of 7.95±0.27 mg/kg.

The HMs concentrations and percentages in the root and shoot of the Vetiver grass as seen from Figures 3b and 3c highlighted a trend as follows; Cu > Ag > Pb > Zn > Hg > Cd. From this result, it can be deduced that the Vetiver grass can be used for hyperaccumulation of Ag, Cu and Pb only (Figure 3c). Therefore, cannot be used for the hyperaccumulation of Zn, Cd, and Hg because, they had a total percentage concentration is less than 50% of the heavy metals in the plant [23]. The initial concentrations of the HMs in the polluted soil, concentration of HMs absorbed Vertiver grass and HMs concentration left in the soil has been enumerated in Table 5; the efficiency of HMs removal by the plant for Ag, Cu and Pb was more evident with concentrations 0.36±0.24, 1.94±0.22 and 4.39±0.23 (mg/kg) left in the soil. These observed concentration values shows that the Vertiver grass was more efficient in the removal of Ag and Cu ions from the polluted soil samples with 0.36±0.24 mg/kg and 1.94±0.22 mg/kg left in the soil.

From these results above, it means the use of bioaccumulation and percentage concentration has proven to be suitable tools for identifying the ability of the plants to hyperaccumulate heavy metals in their tissues and remediate a polluted soil. From this investigation, it can be deduced that the best plant for the hyperaccumulation of Pb follows the trend Sunflower > Vertiver grass > Guinea grass > Bahama grass > Asiatic dayflower, for Zn; Bahama grass > Sunflower > Asiatic dayflower > Guinea grass > Vertiver grass, for Cd; Bahama grass > Guinea grass > Sunflower > Asiatic dayflower > Vertiver grass, for Cu; Vertiver grass > Sunflower > Asiatic dayflower > Bahama grass > Guinea grass, for Ag; Vertiver grass > Sunflower > Bahama grass > Asiatic dayflower > Guinea grass, for Hg; Guinea grass > Bahama grass > Asiatic dayflower > Vertiver grass > Sunflower respectively. It can be suggested that the best hyperaccumulator plants for Pb is the Sunflower, for Zn and Cd is the Bahama grass, for Cu and Ag is the Vertiver grass whilst, for Hg is the Guinea grass.

Conclusion

The study on the efficiencies of hyperaccumulator plants; Sunflower, Asiatic dayflower, Guinea grass, Bahama grass and Vertiver grass on soils impregnated with selected heavy metals revealed that bioaccumulation can serve as a means to establish the concentrations and aid in the removal or absorption of heavy metals from polluted soils thus, serving as a means of phytoremediation in a polluted matrix. It can be concluded that the best hyperaccumulator plants for Pb is the Sunflower, for Zn and Cd is the Bahama grass, for Cu and Ag is the Vertiver grass whilst, for Hg is the Guinea grass.

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