



# The Effect of Ripe Plantain Peels Waste on the Phytoextraction of Pb and Cd by *Echinochloa colona* (L.) Link

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**Abstract:** This research work was to investigate the effect of plantain peels of various concentrations to induce the bioaccumulation of Pb and Cd in *Echinochloa colona* planted in heavy metal contaminated soil. Two (2) kilograms of homogenous heavy metal contaminated soil composite was weighed into polythene bags arranged in 4 batches (1, 2, 3, 4) alongside uncontaminated soil (batch 5) of 12 replications each. Then 100g, 200g and 300g of the powdered ripe plantain peels (waste) was added as amendment into batches 1, 2, 3, respectively, and batches 4 and 5 were without plantain peel (0g) addition designated as control and double control respectively. Two seedlings of *Echinochloa colona* was transplanted from the nursery into all the batches. The plant and soil samples were analyzed at two month interval for Cd and Pb contents using anatomical absorption spectrophotometry (AAS). The accumulation of Pb was higher in plants than in soil with Bioaccumulation factor > 1 in 200g and 300g plantain peel treated soil. Also 300g plantain peels treated soil had greater Cd concentration in shoot than root with (translocation factor (TF) > 1) at month 2 and 4, while the Bioaccumulation factor > 1 was observed in all treatments at 2 and 4 month for Cd. Therefore, 300g plantain peels treatment is effective in enhancing the availability, mobility and uptake of Cd. This indicated that 300g plantain peel (waste) is effective in the remediation of Cd polluted soil using *Echinochloa colona* as a remediating agent.

**Keywords:** Phytoextraction, *Echinochloa colona*, Plantain Peels, Contamination, Metals

## 1. Introduction

Rapid industrialization and increasing human population have been spotted as the main cause of environmental degradation on a global scale. Contaminations from areas such as mining and smelting of metalliferous ores, scrap metal dump, electroplating, gas exhaust, fuel production and waste generated from municipal waste contain heavy metals. The various sources of heavy metal pose a threat in the environment. Metals from various minor sources increase in concentration over- time [1]. Increase in soil metals is detrimental to plants, animals and humans [2]. Metals are non-degradable but are only transfer from one oxidative state to another. Due to scarcity of available land for agricultural purposes, there is absolute need for remediation of every

polluted soil.

The conventional/physicochemical methods for metal remediation are expensive and render the soil unfit for agricultural purposes [3]. The biological metal remediation approaches has proven more feasible, since it renders the soils suitable for agricultural activities by improving soil structure, texture and fertility [4]. Phytoremediation which involve the use of plants to remove metal and other contaminants from the environment is available option for heavy metal pollution remediation. Among the various processes of phytoremediation methods available and practiced; phytoextraction is the most suitable because it involves plant roots removing metals from contaminated soils and transporting them to leaves and stems for harvest and disposal without destroying the soil structure and

fertility. Phytoextraction can be natural (hyperaccumulator plants) or induced (use of substances such as chelators to increase metal availability and mobility in plant). Hyperaccumulating plant species has the natural ability to accumulate high amounts of heavy metals from the polluted environment and subsequently translocate them from roots to their above ground biomass. The tolerance of increasing metals concentration observable in hyperaccumulators is a function of the plants internal metals detoxification mechanisms. Plant species with shoot accumulating rate greater 1000 mg/kg of Ni have been a bench mark to the definition of hyperaccumulator [5]. Some plants have been observed to extract very high concentration of toxic metals to a level far greater than soil metal concentrations [6] [7]. Certain plants have been singled out for their phytoextraction potentials. For instances, Kashe metal. [8] and; Tanee and Amadi [9] reported the suitability of *Colocasia antiquorum* and *Moringa oleifera* respectively, in the remediation of Cd polluted soil. Reeves *et al.* [10] and Ma *et al.* [11] also found that *Thlaspi caerulescens* and *Pteris vittata* were effective in the remediation of Cd and As contaminated environment, respectively. Certain plants that are not naturally hyperaccumulators can be induced to be hyperaccumulating plant by the addition of inducement agents (chelators). The use of inorganic and organic substances to induce the phytoextraction potential of plants has been widely studied [12]. For instance, substances such as EDTA, citric acid, acetic acid, malic acid, NPK and elemental sulphur have been reported to induce hyperaccumulation in plants [13] [14] [15]. The use of local organic waste materials to induce bioaccumulation of metals in plant has not been extensively done in Nigeria. Hence, the aim of this study is to investigate the use of ripe plantain peel (waste) of various concentrations to induce phytoextraction of Pb and Cd in *Echinochloa colona*. In Nigeria and other Africa nations, plantain (*Musa paradisiaca*) serves as a major food crop [16]. It can be consumed in the unripe, ripe and over ripe stages. The major waste of plantain consumption in Nigeria is the peels which are generated as a result of mechanical removal of outer coverings of the plantain fruits. These peels are indiscriminately discarded in the environment hence constitute nuisance and menace. The effective use of this waste in this direction will provide alternative way of managing this waste.

## 2. Materials and Methods

Soil collected from an abandoned metal scraps dumpsite at Ikoku metals scrap site in Port Harcourt, River State, Nigeria. The soil was analyzed (baseline analysis) and confirmed to contain high Pb and Cd concentrations was used for the experiment. The soil was collected in bulk at 0-20 cm depth with a spade. It was then transported to Centre for Ecological Studies, University of Port Harcourt, Rivers State, Nigeria which was the experimental site.

A Completely Randomized Design (CRD) was used for the experiment. The total (bulk) soil was mixed thoroughly,

dried and sieved through a 2mm wire mesh to obtain a homogenous 'fine fraction' of soil composites. Two (2) kilograms of the homogenous soil composite was weighed with a weighing balance (Setra480S, USA) into 60 polythene bags of height 18cm, diameter 14cm and surface area 0.095m<sup>2</sup>. The polythene bags were arranged in 4 batches (1, 2, 3, 4) of 12 replications each. The unpolluted soil obtained from fallow land (also analyzed for cadmium and lead) was filled into batch 5 of 12 replicates too.

The ripe plantain peels (waste) used as the amendment were obtained from Kaiama, Kolokuma/Opukuma, Local Government Area, Bayelsa). This was dried and processed in powder form. The analysis of the powder show the following result: pH 9.08, phosphorus 36.84mg/kg, sodium 137.45 mg/kg, potassium 26,743 mg/kg, magnesium 1614 and calcium 4,400mg/kg, Pb and Cd (Not Detected). Then 100g, 200g and 300g of plantain peels (waste) powder was added into each of batch 1,2,3, respectively, while batch 4 and 5 had no (0g) plantain peel addition. That is, batches 4 and 5 acted as control and double control (polluted and unpolluted without amendment), respectively. The soil with the plantain peel powder was thoroughly mixed in the bags to enhance the harmonization of the treatments with the soil. The bags were allowed to stand for 3 weeks before two seedlings of *Echinochloa colona* was transplanted from the nursery into batches 1, 2, 3, 4 and 5. The summary of the design areas follows;

Batch1: contaminated soil + 100g plantain peel (waste) + *Echinochloa colona*.

Batch 2: contaminated soil + 200g plantain peel (waste) + *Echinochloa colona*.

Batch 3: contaminated soil + 300g plantain peel (waste) + *Echinochloa colona*.

Batch 4: contaminated soil + 0 g plantain peel (waste) + *Echinochloa colona*, (control).

Batch5: Uncontaminated soil + 0g plantain peel (waste) + *Echinochloa colona*.

It was also ensured that the plants used were of the same sizes and vigour. The experimental site was devoid of natural rain by shedding it with transparent roofing sheets. Watering (50cl/bag) was done three times a week. The experimental set was monitored for 4 month but analyzes were done at two month interval.

At every two month interval, the soil from all the batches and replicates were collected, air-dried for 3 days. The *Echinochloa colona* plant from each batch was carefully harvested by uprooting them from the bag. This was achieved by shaking and destroying the bags so that the soil will loose grip of the plant. The shoots and roots of the plant samples were washed; separated and air dried. The soil samples were ground and sieved (500µm sieve) and then dried in an oven at 65°C for 16 hrs, and kept in clean polythene bags for further analysis. One gram (1g) of each of the soil and plant samples was digested separately with 10cm<sup>3</sup> of aqua regia (a mixture of 3 parts concentrated HCl to 1 part concentrated HNO<sub>3</sub>) on a hot plate in a fume cup board. The samples (plant and soil) were then analyzed for cadmium (Cd) and lead (Pb) using

Atomic Absorption Spectrophotometer (AAS) (BUCK scientific 200A model).

The bioaccumulation quotient (BQ) and the translocation factor (TF) were calculated to determine the degree of metal accumulation in the *Echinochloa colona*.

### 2.1. Bioaccumulation Quotient

Bioaccumulation quotient was calculated with the formula Baker [17] as

$$BQ = \frac{\text{Concentration of metal in plant}}{\text{Concentration of metal in soil}}$$

### 2.2. Translocation Factor

This is given as the ratio of concentration of metal in the shoot to that in the roots. It was evaluated using the formula Cui, [18]:

$$TF = \frac{\text{Concentration of metal in plant shoot}}{\text{Concentration of metal in plant root}}$$

### 2.3. Data Analysis

The data generated were subjected to statistical analysis of variance (ANOVA) using Statistical Analysis System [19]. Further validity of differences among treatment means was estimated using Least Significance Difference (LSD) method.

## 3. Results

Figure 1 showed the effect of plantain treatments on the accumulation of lead (Pb) in shoot and root of *Echinochloa colona*. The plantain peel treatment inhibited the accumulation of Pb in shoot at 2 months. The highest increase in Pb accumulation was recorded at the control (contaminated soil + 0g plantain peel waste) and 100g plantain peel treated soil (batch 1) at 2 and 4 month, respectively (Figure 1). There was significant increase in accumulation of Pb in the root at 2 and 4 months ( $p=0.05$ ). The highest lead accumulation in root was observed in 300g plantain peels soil treatment (batch 3) at 2 and 4 month (Figure 2). Low accumulation of Pb in root was recorded at the double control soil.

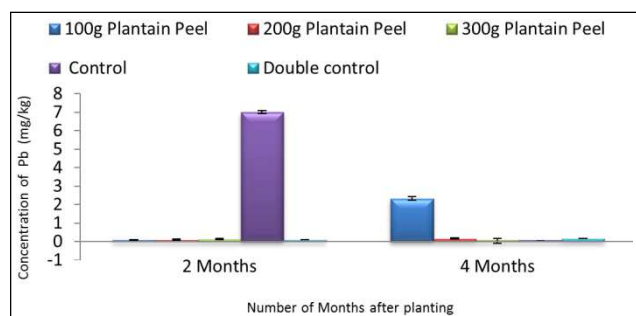


Figure 1. Effect treatment of concentration of Pb in *Echinochloa colona* shoot.

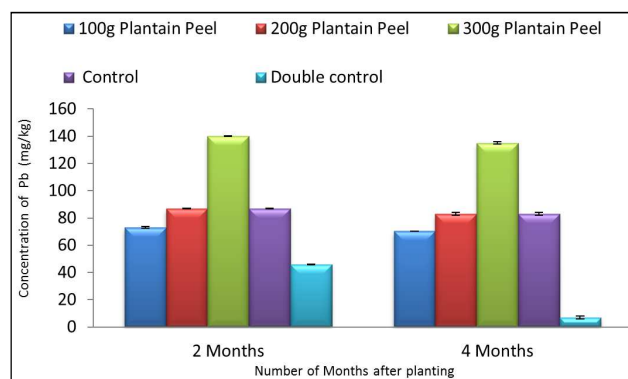


Figure 2. Effect of treatment on the concentration of Pb in *Echinochloa colona* root.

Plantain peel treatment influenced cadmium accumulation in root and shoot of *Echinochloa colona* at 2 and 4 month. The highest cadmium content in shoot was observed in 300g plantain peels treated soil, while low value was recorded at the double control @  $p=0.05$  (Figure 3). Highest root cadmium concentration was recorded in 100g plantain peels treated soil (batch1) at 2 and 4 month while plant in the double control showed the least Cd content in root (Figure 4). The height of the test plant was also affected by the various application levels of the plantain peels (waste). Highest plant height was observed in 300g and 200g of plantain peels treated soil at 2 and 4 month, respectively (Figure 5).

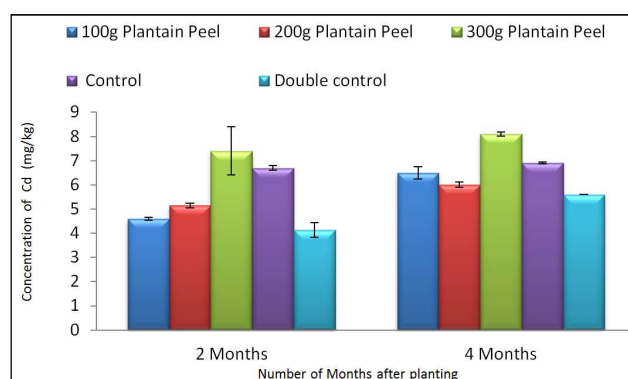


Figure 3. Effect of treatment on the concentration of Cd in *Echinochloa colona* shoot.

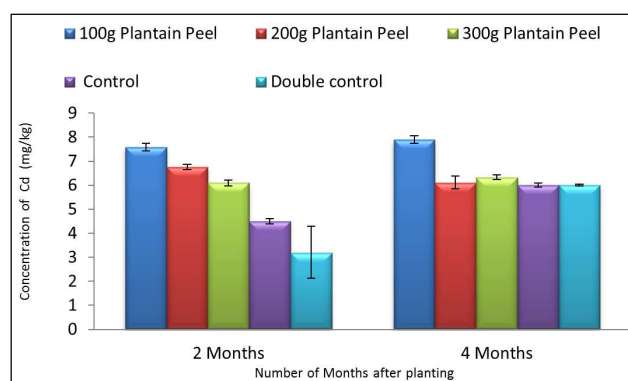


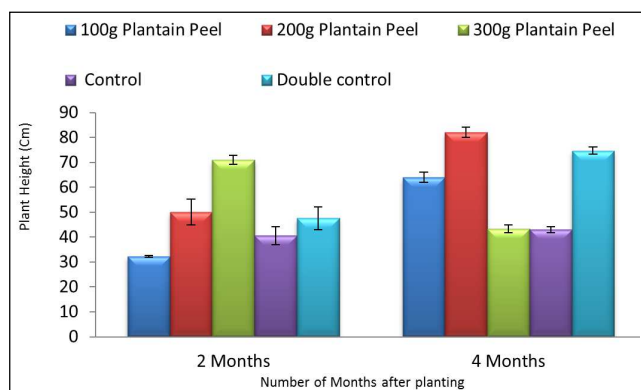
Figure 4. Effect of treatment on the concentration of Cd in *Echinochloa colona* root.

**Table 1.** The concentration of Pb in soil phytoextracted with *Echinochloa colona*.

	Initial unpolluted	Initial polluted	100grams	200grams	300grams	Control	Doublecontrol	LSD
2 Month	130.5±1.0 <sup>b</sup>	167.3±1.01 <sup>a</sup>	116.7±3.0 <sup>c</sup>	81.7±2.0 <sup>c</sup>	76.6±0.032 <sup>f</sup>	91.0±0.11 <sup>d</sup>	34.23±0.01 <sup>e</sup>	0.04
4 Month	130.5±1.0 <sup>b</sup>	16.73±1.01 <sup>a</sup>	100±1.4 <sup>c</sup>	75±0.061 <sup>c</sup>	71±0.01 <sup>c</sup>	85±0.04 <sup>d</sup>	16.3±1.3 <sup>f</sup>	0.44

**Table 2.** The concentration of Cd in soil phytoextracted with *Echinochloa colona*.

	Initial unpolluted	Initial polluted	100grams	200grams	300grams	Control	Double control	LSD
2 Months	0.80±2.0 <sup>b</sup>	15.3±0.01 <sup>a</sup>	0.03±0.001 <sup>c</sup>	0.05±0.01 <sup>c</sup>	0.03±0.002 <sup>c</sup>	0.04±0.001 <sup>c</sup>	0.03±0.001 <sup>c</sup>	0.02
4 Months	0.80±2.0 <sup>b</sup>	15.3±0.01 <sup>a</sup>	0.01±0.4 <sup>c</sup>	0.03±0.03 <sup>c</sup>	0.04±0.01 <sup>c</sup>	0.05±0.1 <sup>c</sup>	0.02±0.003 <sup>c</sup>	0.01

**Figure 5.** Effect of treatment on the height of *Echinochloa colona*.

There was decrease in cadmium concentration in soil phytoextracted with *Echinochloa colona* at 2 and 4 month with or without plantain waste treatment. The least was observed at 100g and 300 g was treatment and double control soils at 2 month and 100g treated soil at 4 month (Table 2).

Translocation factor < 1 was observed for lead (Pb), while 200g and 300g plantain peels soil treatment effectively increased metal bioaccumulation factor at 2 and 4 month (Table 3). The translocation factor > 1 for cadmium was observed at 300g plantain peels treated soil at 2 and 4 month while the bioaccumulation factor >1 for cadmium was observed in all the plantain peel treatment concentrations at 2 and 4 month.

**Table 3.** The translocation and bioaccumulation factor of Pb in *Echinochloa colona*.

Treatment	2 Months		4 Months	
	TF	BQ	TF	BQ
100g plantain peel	0.001	0.62	0.03	0.72
200g plantain peel	0.1	1.06	0.002	1.10
300g plantain peel	0.001	1.83	0.002	1.90
Control	0.008	0.03	0.003	0.98
Double control	0.002	0.9	0.02	0.43

**Table 4.** The translocation and bioaccumulation factor of Cd in *Echinochloa colona*.

Treatment	2 Months		4 Months	
	TF	BQ	TF	BQ
100g plantain peel	0.61	406	0.82	1440
200g plantain peel	0.76	238	0.98	404
300g plantain peel	1.21	450	1.27	360.7
Control	0.89	280	0.8	258
Double control	0.72	244	0.93	6580

## 4. Discussion

This study showed that plants can accumulate a wide range of metals from soil. The uptake of metals from the soil is a function of the metal concentration and availability in the soil. The rate of absorption/uptake is also influenced by the bioavailability of the metals which is in turn determined by both external (soil associated) and internal (plant-associated) factors. Result revealed that plantain peel (waste) influenced the availability of Pb in soil. This is in agreement with Ross [20] and; McGrath *et al.* [21] that organic matter content of a soil is an important factor influencing the mobility of metals. An ideal plant for phytoextraction of metal should have a high biomass production with the ability to concentrate the metal in the above-ground part [22] [23]. So the high growth rate of the plant observed in plantain peels treated soil may have contributed to the bioaccumulation of metal especially in the 300g peel. The increase in Pb accumulation in root than shoot may be attributed to the inhibitory nature of the amendment material in translocation of metals from root to shoot. This assertion is justifiable since the amendment material is high in pH because alkaline substance has inhibitory property on metal bioavailability in plants [12]. The phytoavailability of the metal is the most important step for a successful metal bioaccumulation [24]. Result also revealed that plantain peel treatment of various concentration increase the uptake of Cd than Pb in root of the plant. This suggests that plants have different abilities in the bioaccumulation of metals. This corroborates Salt *et al.* [25] who had earlier reported that the uptake and bioaccumulation of metals by plants and plant parts was plant species dependent. It was observed that treatment increased the availability of mobility of Pb and Cd. This observation is true since the increase in Pb and Cd availability was observed at 100g plantain peels treatment. The result indicates that translocation factor of Pb was <1 while 300g plantain peels treatment effectively enhanced the translocation of cadmium from root to shoot, showing that metal movement in plant is plant species dependent because the plant must possess the capability to mobilize the metal from the soil in solution before translocation to the above ground part [26]. Yashim *et al.* [27] classified plants on the basis of their bioaccumulation quotient. According to them, a plant can be classified as hyperaccumulator when the bioaccumulation quotient > 10; when >1<10, the plant is an accumulator while <1 is an excluder. Since the bioaccumulation factor of the both

metals was >10 suggests that the amendment possess the capacity to induce hyperaccumulating characteristics in *Echinochloa colona*.

## 5. Conclusion

Results from the study revealed that the application of plantain peel (waste) significantly improved the soil fertility leading to improve growth (biomass) of the plant and hence increase accumulation of Pb and Cd in *Echinochloa colona*. The study therefore recommends that 300g ripe plantain peels amendment can enhance the growth performance of the plants.

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