JJEES
Jordan Journal of Earth and Environmental Sciences
JJEES (2022) 13 (2): 114-121
ISSN 1995-6681

Ecotoxicological Consequences and Hyper-accumulative Potentials of Beans (Phaseolus vulgaris) Exposed to Heavy Metals Spiked in Native Soils

Doris Fovwe Ogeleka*[1] and Gloria Omorowa Omoregie[2]

[1]*Department of Chemistry, Federal University of Petroleum Resources, Effurun, Delta State, Nigeria*
[2]*Department of Environmental Management and Toxicology, Federal University of Petroleum Resources, Effurun, Delta State, Nigeria*

Received 29 March 2021; Accepted 20 January 2022

Abstract

Heavy metals from anthropogenic sources in Nigeria are daily on the increase. This research was to ascertain the adverse effects of cadmium, zinc, and lead on the morphology of beans (*Phaseolus vulgaris*) with a secondary aim to evaluate the hyper-accumulative potentials of the plant. Bean seeds were planted in cadmium, zinc, and lead spiked soil with a heavy metal concentration in the soil was 0.1 mg/kg, 1.0 mg/kg, and 10 mg/kg respectively. The control experiment consisted of beans seed grown in metal-free soil. Metals in the soil were significantly reduced in the various treatment groups indicating uptake of metals by the plant. Morphological response to this environmental stress indicated that the leaves of some of the exposed concentrations showed necrosis, chlorosis, and reduced root, length, especially in the higher concentrations. Plant height, leaf an area, leave a number, and senescence were indicators used to measure morphological response to heavy metal stress. *Phaseolus vulgaris* is capable of metal uptake, and the highest concentration from the soil was recorded in Zn (32%) while the highest metal accumulation/bioaccumulation factor (BAF) was 0.206 ± 0.042. This capacity was indicative of hyperaccumulation potential.

Keywords: *Phaseolus Vulgaris*, Heavy Metals, Hyper-Accumulative Potential, Natural Soils.

1. Introduction

In most conurbations in the world, there is a great risk of chemical contamination, especially in peri-urban settlements due to intensive anthropogenic processes and actions. Sometimes, the environmental bodies (soils, sediments, water, etc.) within the region of organizations can be contaminated with metals namely from batteries (Cd, Pb, Zn), paint (Pb), steel (Zn), wires (Cu), crude oil gas flaring (heavy metals) and waste disposal (Kacholi and Sahu, 2018).In addition, the utilization of untreated sewage and wastewater for irrigation could discharge effluents containing heavy metals which could lead to the absorption of these metals by plants (Ogeleka *et al*., 2018).

Exposure of metals to humans could occur through various pathways, including inhalation of air, and ingestion through food, water, soil, or dust. The high concentration of heavy metals in the environmental bodies is of great concern because they are recalcitrant and could bioaccumulate in organisms along the food chains with disastrous consequences on the environment and human health (Ikhajiagbe *et al*., 2014). To this end, metals in the environment above recommended levels can increase the risk of illness and death among consumers of items (food, water, etc.) as in the case of Itai-Itai disease caused by consuming rice containing excess cadmium concentrations and poisoning from other sources (Kobayashi 2006). Chronic ailments and consequences resulting from contact with heavy metals include cancer and organ (heart and kidney) malfunction, diseases, seizures, mental retardation, behavioral disorders among others (Santos *et al*., 2006). In addition, soil polluted with heavy metals can impact toxic consequences on sensitive organisms (Ogeleka *et al*., 2016).

The most common heavy metal contaminants include copper, cadmium, lead chromium, and zinc. Metals are natural components in soil; however, due to the toxicity trace metals may impact, it is important to use phytoremediation to remove the excess amount from the environment and eliminate the risk to humans/environment from the damaging consequences. Soil washing, burning, and excavation is engineering techniques used to remediate heavy metal contaminated soil; however, the techniques are cost-intensive and time-consuming with lots of damage to the soil structure and soil-dwelling organisms (Pilon-Smits and Freeman, 2006). For this reason, the development of low-cost, effective, and sustainable technologies to remediate heavy metal contaminated soils is very important and had been given considerable attention (LeDuc and Terry, 2005). The phytoremediation process can be divided into different classes namely, phytostabilisation, phytostimulation / rhizodegradation, phytovolatilization, phytodegradation, and phytoextraction (Pilon-Smits and Freeman, 2006). Several plants have been widely used for removing contaminants from environmental bodies and some have achieved success recorded (Cho-Ruk *et al*., 2006). Phytoremediative plants also suffer some level of phytotoxic impacts of the remediated heavy metal. These plants first show a significant level of

* Corresponding author e-mail: dorysafam@yahoo.com

tolerance to the accumulated metal (Ikhajiagbe, 2016). In the present study, the capacity for phytoremediation of selected metal by *Phaseolus vulgaris* is investigated vis-à-vis its morphological adaptive capacities.

2.0 Materials and Methods

2.1 Study Area

The sample location is in Ugbomro, a community in Effurun, Delta State, Nigeria. The community houses the Federal University of Petroleum Resources, Effurun (FUPRE). The surrounding towns in Effurun include Ekpan, Enerhen, Edjeba, Ogunu, Jakpa, Ovwian-Aladja, and Udu. Anthropogenic activities in this region include but are not limited to gas flaring, refinery, acid rain/precipitation, farming, fishing and burning of wood, fossil fuels, commercial, and so on. The area is characterized by a tropical equatorial climate with a mean annual temperature of 32.8°C and rainfall amount of 3000 mm. The rainfall period ranges from January to December. However, double rain maxima between the months of July and September are observed. There is a little dry spell in the month of August called — August break. Convectional type of rainfall is predominant in the city (Figure 1) (Ojeh, 2011).

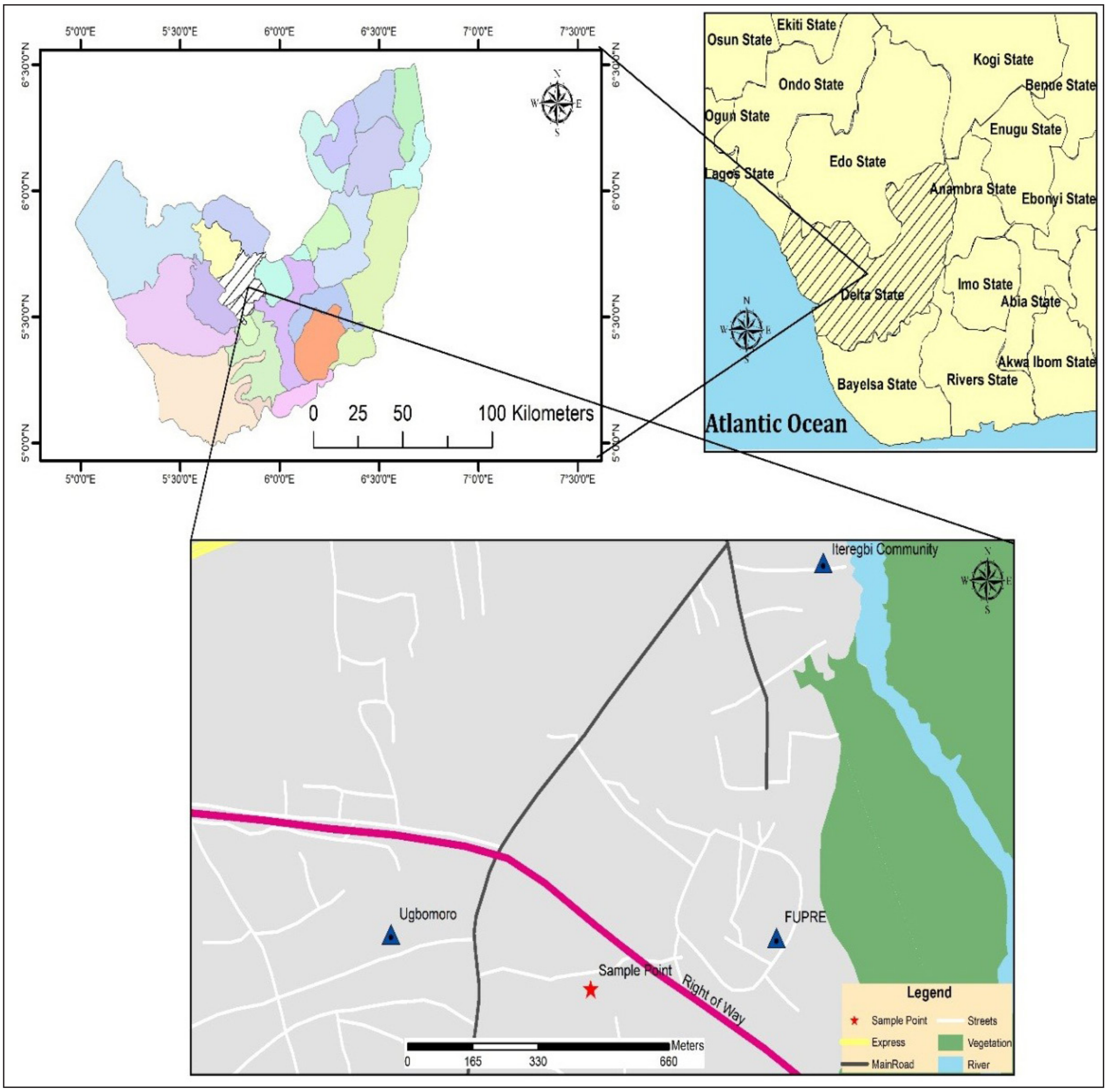

Figure 1. Map of the study area.

2.2 Soil Sampling

The native (indigenous) soil samples used for the study were randomly collected from farm sites in the Federal University of Petroleum Resources, Effurun Delta State, Nigeria. The soil samples were taken from the surface and the first sub-surface horizon (0 – 30 cm). After collection, objects such as dead weeds, stems, leaves, sticks, and stones were carefully removed, and the soil samples were transferred into labeled aluminum foils/containers in the laboratory. The uncontaminated soils were kept for planting and analysis of the different components needed for the experimental bioassay procedure and analysis.

2.3 Chemical preparation

Cadmium, lead, and zinc metals of Analar grade were used for the toxicity assessment. Pre-determined amounts of the test compounds were weighed, dissolved in a small quantity of deionized water, and the solution made up to a fixed volume by adding an appropriate volume of deionized water as diluents to achieve a stock solution of 1000 mg/L of Cd, Pb, and Zn. The resultant stocks were then serially diluted to obtain solutions of the required concentrations of the various metals used for the experiment.

2.4 Test specie -*Phaseolus vulgaris*

A healthy seedling of the test specie was obtained from the International Institute of Tropical Agriculture (IITA), Ibadan, Nigeria. Before the experiment, the seedlings were wetted approximately 24 hours before planting and three seedlings per test tank were planted.

2.5 The Physico-chemical properties of soils used for the study

The soils used in planting the test toxicants were assessed before they were used for the photo-toxicity experiment. The Physico-chemical analysis determined includes soil pH, total organic carbon (TOC), soil texture, particle size, moisture content, and heavy metals (cadmium, lead, and zinc).

Table 1. Specific soil quality parameters and methods used for the study

Parameters	Analytical Methods
pH	pH, (APHA 4500 H^+), APHA, 2017
Total organic content (%)	Walkey Black, 1937
Metals (Cd, Pb, and Zn)	Extraction and Atomic Absorption Spectrophotometer (Shimazu 6701 F model)
Soil texture	(IITA, 1984)
Soil particle size	(IITA, 1984)
Moisture content	Gravimetry
Water holding capacity	Gravimetry

2.6 Experimental bioassay procedure for the hyper-accumulation of Phaseolus vulgaris

The experimental procedure was carried out for 90 days using the Organization for Economic Co-operation and Development, (OECD) protocol #208 (OECD, 2003). From the prepared stock solutions of the test chemicals, serial dilutions were made to obtain concentrations in the range of 10 mg/L (0.001%), 1.0 mg/L (0.0001%), and 0.1 mg/L (0.00001%) of Cd, Pb, and Zn. When these concentrations were spiked with 1.0 kg of natural soil, the resultant concentrations were 10mg/kg, 1.0 mg/kg, and 0.1 mg/kg of Cd, Pb, and Zn, respectively.

Ten kg (10 kg) of uncontaminated soil samples were accurately weighed into large containers and the soil samples were spiked with 850 mL of the test toxicants. Seeds of the test plants were sown in the soils spiked with metals at 5 different concentrations of the heavy metals each treatment was replicated 5 times. The control setup was prepared in conjunction with the test metals as described above except that the seedlings were planted on a clean substrate and sprinkled with 800mL of water (i.e., without the toxicants) after being homogenized. Daily or every other day 100 mL of the toxicants were irrigated into the treatment tanks and the control was based on the water holding capacity of the soil. Observations for germination, leaves, stem, and root were taken daily / weekly depending on the parameter. Similarly, soil samples were randomly collected and analyzed for individual metal residues for the hyper-accumulative endpoint assessment and other ecological effects.

2.7 Heavy metal analyses

Two (2) g of sieved air-dried soil and plant samples (air-dried plant leaves) was digested in a mixture of 7 mL concentrated nitric acid (HNO_3) and 2 mL sulphuric acid (H_2SO_4). Digestion was done on a hot plate and continued until brown fumes of nitric acid were no longer seen. When white fumes started coming out the heat was turned off. The solution was cooled, and the filtrate was made up to the mark in a volumetric flask of 100 mL with double distilled water. The level of the metals (cadmium, lead, and zinc) was estimated with a Flame Atomic Absorption Spectrophotometer (AAS) with a Shimadzu 6701F model.

2.8 Leaf Area

By multiplying leaf length by leaf width with a correlation coefficient (r) of 0.72, the leaf area (LA) was calculated according to the methods of Hoyt and Bradfield, (1962) and Udo and Oputa, (1984).

2.9 Bioaccumulation factor (BAF)

The ability of specie to bioaccumulate toxicants from a medium can be estimated using the BAF, which is given as the ratio of metal concentration in the specie (e.g., plant) to that in the medium (soil). This can be used to determine the extent of hyperaccumulation of the plant. Bio-concentration factor of metal in the plant was calculated with the formula below:

$$BAF = \frac{\text{Metal concentration in plant}}{\text{metal concentration in soil}}$$

2.11 Statistical analysis

All experiments were conducted in triplicate and used for the calculation of the mean of the various endpoints including germination, plant height, leaves number, stem girth, and metal levels. The statistical analysis was performed to obtain the significant variation between the treated and untreated groups at a probability level of 5%. In addition, bar, line, and XY-scattered graphs were used to depict the various endpoint parameters.

3.0 Results

Tables 2–6 and Figures 2–5 described the results of *Phaseolus vulgaris* exposed to varying concentrations of cadmium, lead, and zinc spiked in natural soils for a period of 7 weeks. Plant height, leave length (area), leave number, stem girth, and senescence were assessed to monitor the morphological response of plant species. Chlorosis, necrosis, and growth retardation (inhibition) were observed daily and weekly depending on the parameter.

Table 2. Physico-chemical properties of natural soil quality used for the study

Parameter	Results
pH	5.79 ± 0.23
Total organic content (TOC), (%)	0.49 ± 0.01
Cation exchange capacity (CEC), (meq/L)	1.353
Soil texture	Sand
Sand (%)	86.24
Clay (%)	9.20
Silt (%)	4.56
Moisture content, (%)	1.29 ± 0.20
Water holding capacity, (%)	7.83 ± 0.12
Cadmium (mg/kg)	<0.001
Lead (mg/kg)	<0.001
Zinc (mg/kg)	<0.001

3.1 Growth Retardation

For the period under study, growth was more inhibited at the higher concentrations of 10 mg/kg than the lower concentrations of 1.0 and 0.1 mg/kg. Similarly, there was reduced root length at the higher concentration. Although there was measurable growth in all the concentrations, the heavy metals were reduced in the various treatment groups.

3.2 Necrosis

Morphological studies indicated that the leaves of some of the exposed concentrations showed necrosis, a condition when a biological species' cells degenerate and die. Plants affected show signs of change in coloration (green to yellow to brown) as was observed at the higher concentrations of heavy metals exposure in this assessment (Figure 2).

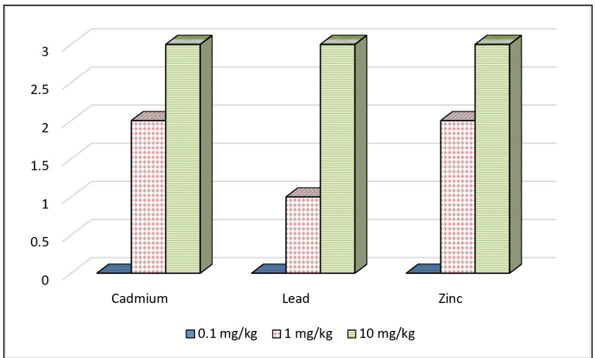

Figure 2. Mean results of the effect of heavy metals on necrosis of *Phaseolus vulgaris*

3.3 Chlorosis

The results also indicate that the leaves of some of the exposed concentrations showed chlorosis. Chlorosis, is a condition involving the yellowing of the leaf tissue due to a lack of chlorophyll. Chlorophyll is responsible for the green coloration of the leaves. Some of the chlorotic leaves observed in this research were pale, yellow, or yellow white. There was yellowing in the highest heavy metal exposures (Figure 3).

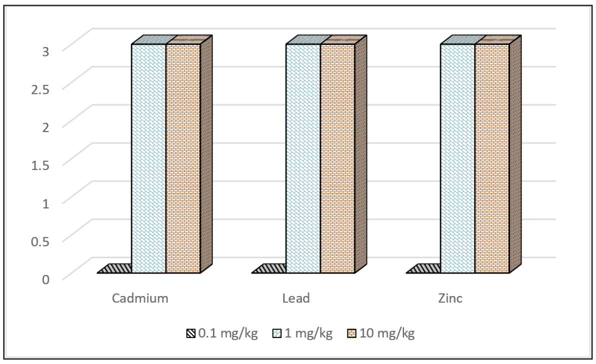

Figure 3. Mean results of the effect of heavy metals on chlorosis of *Phaseolus vulgaris*

3.4 Plant Height

The plant height is a measure from the soil level to the terminal leaf. At the end of the experiment, the mean results for control were 89.4 ± 5.6 cm, Cd in soil was52.6 ± 4.9 cm, 33.2 ± 4.2 cm, 13.5 ± 2.9 cm for the control, 0.1, 1, and 10 mg/kg respectively. Also, the mean value of Pb was57.6 ± 2.4 cm, 37.1 ± 7.2 cm, and 19.0 ± 3.2 cm in the respective concentrations. Furthermore, Zn was62.4 ± 4.1 cm, 38.0 ± 0.9 cm, 19.0 ± 3.2cm in the respective order (Table 3). These results showed that the plant height of *Phaseolus vulgaris* was greatly affected by metal concentration (the higher concentration of heavy metal resulted in a decrease in plant height).

3.5 Leaf Area

The results for the leaf area for *Phaseolus vulgaris* seedling revealed 51.3 ± 6.4 cm^2 in the control, while the average concentration of Cd in soil was 41.6 ± 7.6 cm^2, 13.5 ± 2.9 cm^2, 16.4 ± 3.9 cm^2 for 0.1, 1 and 10 mg/kg respectively. Also, Pb values was44.2 ± 3.4 cm^2, 28.3 ± 8.1 cm^2, 17.0 ± 4.6 cm^{2}while Zn in soil had47.0 ± 0.9 cm^2, 25.1 ± 4.2 cm^2, 15.6 ± 0.1 cm^{2}in the order mentioned above (Table 4). These results showed a reduction when compared to the control.

Table 3. Mean weekly results of the effect of heavy metals on plant height of *Phaseolus vulgaris*

TIME (Days)		7	14	21	28	35	42	49
CONTROL		14.2 ± 0.4	20.3± 1.5	23.2± 3.5	31.4 ± 2.1	38.1 ± 4.3	42.3 ± 4.5	89.4 ± 5.6
Cd	0.1 mg/kg	11.5 ± 3.8	16.9 ± 3.2	19.3 ± 3.0	26.9 ± 4.4	34.9 ± 5.4	46.3 ± 3.5	52.6 ± 4.9
	1 mg/kg	10.8 ± 0.3	13.9 ± 6.2	17.6 ± 1.5	18.4 ± 2.4	23.9 ± 5.0	32.1 ± 2.4	33.2 ± 4.2
	10 mg/kg	7.2 ± 1.3	10.3 ± 2.1	12.1 ± 1.4	12.4 ± 1.6	12.7 ± 1.4	13.2 ± 3.0	13.5 ± 2.9
Pb	0.1 mg/kg	13.9± 2.0	16.7 ± 2.1	18.9± 3.2	23.1± 1.5	26.8± 1.7	44.0± 1.3	57.6± 2.4
	1 mg/kg	11.6 ± 2.1	14.0 ± 3.0	17.3 ± 2.8	18.7 ± 3.4	23.9 ± 6.5	32.5 ± 6.2	37.1 ± 7.2
	10 mg/kg	7.6 ± 1.7	11.2 ± 1.1	11.9 ± 1.9	12.3 ± 1.8	13.2 ± 1.3	13.9 ± 1.3	14.0 ± 1.3
Zn	0.1 mg/kg	11.2 ± 1.3	17.3 ± 3.8	21.3± 4.2	28.9 ± 4.0	41.8± 3.8	56.3± 3.3	62.4± 4.1
	1 mg/kg	9.4± 0.7	13.5 ± 1.8	16.0 ± 1.7	17.1 ± 3.1	26.6 ± 3.8	33.9 ± 3.1	38.0 ± 0.9
	10 mg/kg	8.4 ± 1.3	10.4 ± 0.3	12.8 ± 1.9	14.2 ± 2.7	15.4 ± 2.8	16.3 ± 2.4	19.0 ± 3.2

Table 4. Mean weekly results of the effect of heavy metals on leaf area of *Phaseolus vulgaris*

TIME (Days)		7	14	21	28	35	42	49
Control		14.2 ± 2.1	19.2 ± 3.0	22.0 ± 3.0	26.5 ± 2.4	36.0 ± 3.6	43.6 ± 2.4	51.3 ± 3.4
Cd	0.1 mg/kg	10.6 ± 2.1	16.0 ± 3.0	18.3 ± 3.8	22.3 ± 2.4	28.3 ± 2.6	40.5 ± 3.2	41.6 ± 2.6
	1 mg/kg	8.7 ± 0.8	12.2 ± 2.2	15.9 ± 2.8	17.1 ± 1.8	17.6 ± 3.3	18.2 ± 0.2	20.6 ± 3.6
	10 mg/kg	7.6 ± 0.3	9.6 ± 1.7	11.8 ± 1.4	13.7 ± 3.7	15.4 ± 3.2	15.9 ± 2.4	16.4 ± 3.9
Pb	0.1mg/kg	11.2 ± 3.1	17.3 ± 3.0	19.5 ± 2.8	21.3 ± 4.1	28.4 ± 3.3	40.6 ± 4.4	44.2 ± 3.4
	1 mg/kg	10.3 ± 0.9	14.7 ± 3.9	16.7 ± 3.0	17.5 ± 2.8	20.3 ± 3.1	22.4 ± 2.3	28.3 ± 3.1
	10 mg/kg	10.3 ± 0.7	10.9 ± 2.4	12.7 ± 1.3	13.7 ± 2.5	15.0 ± 1.9	15.3 ± 3.2	17.0 ± 2.6
Zn	0.1mg/kg	12.6 ± 1.7	18.1 ± 5.4	20.8 ± 2.8	23.0 ± 2.7	26.6 ± 2.8	44.9 ± 0.2	47.0 ± 0.9
	1 mg/kg	11.8 ± 0.3	15.5 ± 2.8	17.0 ± 2.7	20.0 ± 2.2	22.1 ± 1.2	22.5 ± 2.7	25.1 ± 4.2
	10 mg/kg	8.6 ± 1.5	12.4 ± 2.1	13.0 ± 2.4	14.1 ± 1.6	14.6 ± 1.1	14.8 ± 3.7	15.6 ± 0.1

3.6 Leaf Number

The number of leaves was determined by visual counting of the number of leaves per seedling per treatment. The results at day 7 for each treatment was 2 ± 0.0, 2 ± 0.0, 2 ± 0.0, 0.0 ± 0.0 for the 0.1, 1 and 10 mg/kg respectively except for the control which showed 5 ± 0.0. These results showed the emergence of the first leaf at the same interval, however, as the days progressed there was variation amongst treatments. At the end of the experiment, the results varied for the different concentrations - control was 26 ± 1.4, Cdwas20 ± 2.1, 17± 2.5, 15 ± 0.7 respectively, While Pb was20 ± 4.3, 18 ± 0.9, 16 ± 3.2, Zn was20 ± 4.6, 19 ± 1.0, 17 ± 2.1in the above-mentioned order, the results could be due to the likely effect of the metals on the plants (Figure 4).

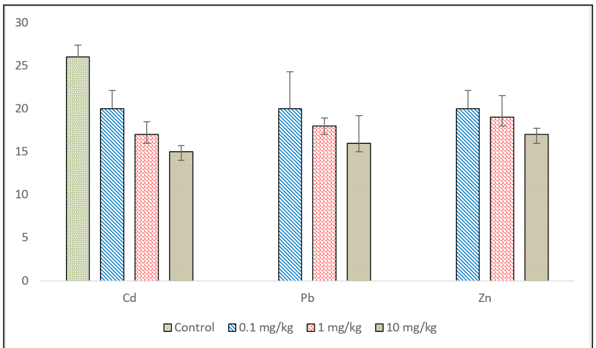

Figure 4. Effect of heavy metals on leaf number of *Phaseolus vulgaris* at 49 days

3.7 Senescence

The number of senescence leaves was determined by visual counting of the number of dead leaves per seedling per treatment. At the end of the experiment (49 days), the results varied for the different concentrations. The control was 0.0 ± 0.0, Cd was 7.3 ± 2.1, 8.0 ± 0.0, 12 ± 1.2, Pb was 3.7 ± 2.9, 8.5 ± 0.7, 8.8 ± 1.4 while Zn was 3.5 ± 0.1, 7.0 ± 4.2, 7.4 ± 1.3 for 0.1, 1 and 10 mg/kg respectively (Figure 5).

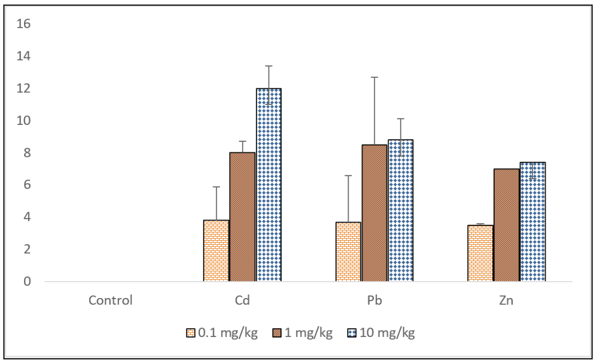

Figure 5. Effect of heavy metals on senescence of *Phaseolus vulgaris* at test termination

3.8 Residual concentration in soil and uptake in plant

The exposed plants' accumulated metals from the soil for the period under study as indicated in Table 5.

3.9 Bioaccumulation factors (BAFs) of heavy metals in the plant

Significant differences were found in the BAF of heavy metals in the exposed plants. The order of the heavy metal (Zn, Pb, Cd) for BAF was similar to that obtained for the metal concentrations in plants (Figure 6). There was a significant difference at a probability value of 5% between the control samples and the exposed samples.

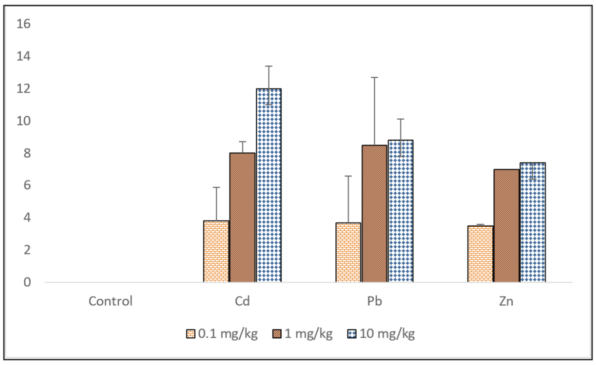

Figure 6. Bioaccumulation factors (BAFs) of heavy metals in different accessions. Error bars indicate the standard error of five replicates.

Table 5. Mean results of heavy metal in soil and plant at test termination

	Residual concentration in soil (mg/kg)			Uptake in plant leaves (mg/kg)			Removal of heavy metal (%)		
Test concentration (mg/kg)	Cd	Pb	Zn	Cd	Pb	Zn	Cd	Pb	Zn
0.1	0.079 ± 0.001	0.072 ± 0.001	0.068 ± 0.003	0.0108	0.012	0.014	21	28	32
1.0	0.837± 0.06	0.79 ± 0.04	0.73 ± 0.02	0.065	0.079	0.083	16	21	27
10	8.85 ± 0.60	8.55 ± 1.2	8.4± 0.51	0.59	0.62	0.71	11.5	14.5	16

4. Discussion

The growth of plants and their life cycles are associated with survival, and this is used to assess the potential of plants to grow in contaminated soil (Spiares *et al.,* 2001). The survival of plants on contaminated soils may be ascribed to several factors that either help to reduce the effects of the contaminants by rendering them immobile (Ikhajiagbe *et al.,* 2017) or directly by accumulating the contaminants and stirring them in harvestable plant parts. The presence of microbes in the rhizosphere confers such capabilities (Nwoko *et al.,* 2007).

Heavy metals are among the environmental pollutants. Aside from natural activities, practically all human activities have the potential to produce heavy metals as byproducts. The migration of these contaminants into noncontaminated areas as dust or leachates through the soil, as well as the spread of heavy metals containing sewage sludge, are only a few instances of occurrences that contribute to ecosystem contamination.

Heavy metals are a type of pollutant that can be found in the environment. Aside from natural activities, practically every human activity has the potential to produce heavy metals as a byproduct. The spread of heavy metals containing sewage sludge and the migration of these contaminants into non-contaminated areas as dust or leachates through the soil are two examples of occurrences that contribute to ecosystem contamination.

Plants can endure relatively high concentrations of organic and inorganic chemicals without toxic effects, and they can take up and convert these contaminates swiftly to less toxic metabolites in some cases by rhizodegradation (Nwoko *et al.,* 2007). Like other plants, Phaseolus *vulgaris* have been previously reported to have the ability to accumulate metals in their roots and stem tissues with remarkably high tolerance to heavy metals (Malairajan *et al.,* 2015; Ohanmu et al., 2018). Elevated amounts of essential and non-essential heavy metals present in soils can result in toxic symptoms including growth retardation in most plants.

Transfer, translocation, and accumulation of toxicants (heavy metals) by plants can reduce the quality and quantity of viable species, which can lead to serious health hazards for humans who consume contaminated food along the food chain (Axtell *et al.,* 2003; Sathawara *et al.,* 2004).

During the last three decades, environmental degradation has gotten increasingly severe because of fast economic expansion. Soil degradation from hazardous organic chemicals and heavy metals would put enormous strain on an already fragile planet.

Because of its importance to humanity's sustainability and well-being, food security and safety have been designated as one of the most important sustainable goals. From the point of view of plant-based food security, a significant reduction would lead to a concomitant decrease in food availability. The capability of the *P. Vulgaris* to take up heavy metals reflects their tolerance capacities. Whereas some plants accumulate metals and do not show any phytotoxic symptoms; others are highly sensitive. Soil matrices naturally contain heavy metals; however, some anthropogenic, geologic, industrial, and agricultural practices increase the levels to the extent that they could cause deleterious effects on humans, flora, and fauna (Bonnail *et al.,* 2016). Sometimes, even when soils are naturally high in a certain metal, the plant may adapt over time to these elevated levels but with a limited amount of growth and other metabolic processes. Toxicity because of metal exposure usually occurs from repeated anthropogenic alterations and perturbation (Ata et al., 2009).

Plants need both essential macronutrients (N, P, K, S, Ca, and Mg) and essential micronutrients (Fe, Zn, Mn, Ni, Cu, and Mo) to grow and function. Plants have a specific capability to take up, translocate and store these required nutrients. The ability of a plant to remove metals from environmental matrices is limited by the plant's ability to take up and tolerate such an exposed amount. Trace metals can exact toxic effects (cytotoxic) at relatively low concentrations, even though only very few are needed for metabolic processes (Kabata-Pendias and Pendias, 2001). According to Linger *et al*., (2005) and Khan *et al*., 2015), metal toxicity reduces plant functions and growth, which could cause the death of the plant in extreme cases. Reduced growth due to exposure to heavy metals was reported in the study.

Although the report from the study showed a significant reduction in plant morphological parameters, most plants still show tolerance capacities. Heavy metal contaminated settings, according to Levitt (1980), act as stress factors on plants, causing physiological response changes that diminish or limit plant vigor and growth. A plant that has been injured or died as a result of metal stress is said to be sensitive to its surroundings. Resistant plants, on the other hand, can survive and reproduce in metal-stressed environments (Ernst *et al.,* 2008). Plants can withstand heavy metals in general by avoiding or tolerating them.

Plants use a variety of techniques to prevent metals from entering root tissue, which is known as avoidance. Plants can avoid metal uptake in circumstances where soil metal pollution is unevenly distributed by exploring less contaminated soil. Mycorrhizal fungi, which may stretch their hyphae up to many tens of meters outside the plant's rooting zone and transmit the necessary materials to the plant, are another avoidance method.

It becomes clear that different mechanisms of metal accumulation, exclusion, and compartmentation exist in various plant species; this may have accounted for the survival of *P. vulgaris* even when the exogenous elevation of soil Zn led to stunted growth presentation. In *T. caerulescens*, Zn is sequestered preferentially in vacuoles of epidermal cells in a soluble form (Frey *et al.,* 2000).

Most metals are too insoluble to flow freely in the vascular system once within the plant, thus they precipitate as carbonate, sulfate, or phosphate, which immobilizes them in apoplastic (extracellular) and symplastic (intracellular) compartments (Raskin *et al.,* 1997). The high cation exchange capacity of cell walls further limits apoplastic transport unless the metal ion is carried as a non-cationic metal chelate (Raskin *et al.,* 1997; 2000).

Non-essential heavy metals may compete efficiently for the same transmembrane transporters employed by necessary heavy metals, causing chlorotic and necrotic signs. Toxic heavy metals like cadmium may effectively compete with micronutrient heavy metals for the same transmembrane carrier. This lack of selectivity in transmembrane ion transport could help explain why non-essential heavy metals can still enter cells despite a concentration gradient. Kinetic studies, for example, show that necessary Cu2+ and Zn2+ fight for the same transmembrane carrier as non-essential Cd^{2+} (Crowley et al., 1991). Metal chelate complexes can also be transported across the plasma membrane using specific carriers, as Fe–phytosiderophore transport in graminaceous species is (Cunningham and Berti, 1993).

5. Conclusion

The study corroborates previous reports on the phytotoxic impact of heavy metals growth and development of *Phaseolus vulgaris*. The study also suggested the ability of *P. vulgaris* to survive in the metal-contained media. This implies the need to ensure extreme care during crop husbandry.

References

American Public Health Association/American Water Works Association/Water Environment Federation. 2017. Standard methods for the examination of water and wastewater. 23rd edn, Washington DC, USA.

Ata S., Farid M., and Soroush M. (2009). Heavy metal contamination and distribution in the Shiraz industrial complex zone soil, South Shiraz, Iran. World Applied Sciences Journal. 6(3): 413-425.

Axtell, N. R., Sternberg, S. P. K., Claussen, K., (2003). Lead and nickel removal using Microspora and Lemna minor, Bioresour. Technol. 89: 41-48.

Bonnail E., Sarmiento A.M., Del Valls T.A., Nieto J.M., Riba I (2016). Assessment of metal contamination, bioavailability, toxicity, and bioaccumulation in extreme metallic environments (Iberian Pyrite Belt) using Corbicula fluminea. Sci. Total. Environ. 544: 1031-1044,

Cho-Ruk K., Kurukote J., Supprung P., and Vetayasuporn S. (2006) "Perennial plants in the phytoremediation of lead-contaminated soils," Biotechnology. 5(1):1–4

Crowley, D.E., Wang, Y.C., Reid, C.P.P., and Szansiszlo, P.J. (1991). Mechanism of iron acquisition from siderophores by microorganisms and plants. Plant and Soil, 130: 179-198. Cunningham, S.C. and Berti, W.R. (2000). Phytoextraction and Phytostabilization: Technical, Economic, and Regulatory Considerations of the Soil-Lead Issue. In: Terry, N. and Banuelos, G. (eds.) Phytoremediation of Contaminated Soil and Water. Boca Raton, Florida, USA: Lewis Publishers; 2000. pp. 359–376.

Frey, B., Keller, C. and Zierold, K. (2000). Distribution of Zn in functionally different leaf epidermal cells of the hyperaccumulator Thlaspi caerulescens. Plant Cell Environment, 23: 675–687.

Hoyt, P. and Bradfield, R. (1962). Effect of the varying leaf by defoliation and plant density on dry matter production on corn. Agronomy Journal. 54: 523 – 525.

Ikhajiagbe. B. (2016). Possible adaptive growth responses of Chromolaenaodorata during heavy metal remediation. Ife Journal of Science 18(2): 403 – 411.

Ikhajiagbe, B., Oshomoh, E.O., and Esangbedo, O. (2014). Studies of bioconcentration of heavy metals on roadside plants used in local herbal medicine preparations in Edo State. Journal of Laboratory Science, 2(1): 54 – 61.

International Institute of Tropical Agriculture (IITA). (1984). Selected methods for soil and plant analysis. IITA press, Ibadan, Nigeria. Manual Series. 1: 10-50.

Kabata-Pendias, A. and Pendias H. (2001). Trace elements in soils and plants. 3rd Edn., CRC Press, Boca Raton, Florida, USA., pp 1-413.

Kacholi D.S and Minati Sahu M. (2018). Levels and health risk assessment of heavy metals in soil, water, and vegetables of Dar es Salaam, Tanzania. Journal of Chemistry. 2018. 1402674: 1-9.

Khan A., Khan S., Khan M., Qamar Z and Waqas M. (2015). The uptake and bioaccumulation of heavy metals by food plants, their effects on plants nutrients, and associated health risk: A review. Environmental Science and Pollution Research International. 22(18): 13772–13799.

Kobayashi I., Fujiwara S., Saegusa H., Inouhe M., Matsumoto H. and Tsuzuki M. (2006). Relief of arsenate toxicity by Cd-stimulated phytochelatin synthesis in the green alga Chlamydomonas reinhardtii. Mar. Biotechnol. (NY). 8: 94 – 101.

LeDuc D.L. and Terry N. (2005). Phytoremediation of toxic trace elements in soil and water. J Ind Microbiol Biotechnol. 32(11-12): 514-20.

Linger P., Ostwald A. and Haensel J. (2005). Cannabis sativa L. growing on heavy metal contaminated soil: growth, cadmium uptake and photosynthesis. Biol Plant. 49: 567–576.

Malairajan S., Tesso M. and Wondimu L. (2015). The use of plants for detoxification of heavy metals in polluted soils. Environmental Science an Idian Journal 10(7):254-259.

Nwoko C. O., Okeke P. N., Agwu O. O. and Akpan I. E. (2007). Performance of Phaseolus vulgaris L. in a soil contaminated with spent-engine oil African Journal of Biotechnology. 6(16): 1922-1925

Ogeleka D.F., Ugwueze V.I., OkieimenF.E. (2016). Ecotoxicological Assessment of Cadmium and Lead Exposure to Terrestrial Sentinels - Snails (Archachatina marginata). International Journal of Research in Chemistry and Environment. 6(4): 1-16.

Ogeleka D.F., Edjere O., Nmai O.O., Ezeogu P. and Okieimen F.E. (2018). Consideration of contamination status of soils within the vicinity of automobile workshops in Warri, Delta State, Nigeria. Science Journal of Chemistry. 6(4): 56-65.

Ohanmu, EO, Ikhajiagbe, B, and Anoliefo, GO (2018). Growth and yield respponses of African yam bean on cadmium contaminated growth medium. 2nd Annual Conf. and stakeholder forum of the Society for Underutilized Legumes, at Covenant University, Ota. 11-12 July 2018

Ojeh, V.N. (2011). Thermal Comfort Characteristics in Warri and Environs, Delta State, Nigeria, an unpublished M.Sc Dissertation in the Department of Geography and Regional Planning, Delta State University, Abraka.

Organization for Economic Co-operation and Development, (OECD). (2003). Environment, Health and Safety Publications Series on Pesticides Persistent, Bioaccumulative, and Toxic Pesticides in OECD Member Countries Results of Survey on Data Requirements and Risk Assessment Approaches., No. 15: p 1 – 67.

Pilon-Smits E.A.H. and Freeman J.L. (2006). Environmental cleanup using plants: biotechnological advances and ecological considerations. A review. Front Ecol Environ. 4(4): 203–210.

Raskin, I. and Ensley, B. D. (2000). Recent developments for in situ treatment of metal contaminated soils. In: Phytoremediation of Toxic Metals: Using Plants to Clean up the Environment. John Wiley and Sons incorporated, New York. Available at: http//clu – n. org/techfocus.

Raskin, I., Smith, R. D. and Salt, D. E. (1997). Phytoremediation of metals: Using plants to remove pollutants from the environment. Current Opinion in Biotechnology 8: 221 – 226.

Santos E.E., Lauri D.C. and Silveira P.C.L., (2006). Assessment of daily intake of trace elements due to consumption of food stuffs by adult inhabitants of Rio de Janeiro city. Science of the Total Environment. 327: 69–79.

Sathawara N.G., Parikh D.J. and Agarwal Y.K., (2004). Essential heavy metals in environmental samples from western India. Bulletin of Environmental Contamination and Toxicology. 73: 756–761.

Spiares J.D., Kenworthy K.E., Rhykerd R.L. (2001). Emergence and height of plants seeded in crude oil contaminated soil. Tex. J. Agric. Nat. Res. 14: 37-46.

Udo, E.J. and CO. Oputa (1984). Some studies on the effect of crude oil pollution of soil on plant growth. West African Journal of Biological and Applied Chemistry.26: 3-14.