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Full Length Research Paper

Effectiveness of neem, cashew and mango trees in the uptake of heavy metals in mechanic village, Nigeria

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The concentrations of heavy metals were determined from the soil of the mechanic village, in Abeokuta and a control farmland located at Federal University of Agriculture, Abeokuta (FUNAAB). The soil sample collected at the base of different species of tree showed that the heavy metals were below permissible levels (FAO/WHO and EC/CODEX standard) and show no significant difference in the range of mean. Absorption of heavy metals by the bark of the trees in the mechanic village was evident when compared relatively to the presence and uptake of the heavy metals from the soil by tree in the farmland. The mean concentrations of the heavy metals in the soil of the farmland are in this order of magnitude Cd>Cu>Pb, while the mean concentration of the heavy metals in the soil of the mechanic village are in the order of magnitude Pb>Cu>Cd. Lead has the least concentration in the farmland, while in the mechanic village, it is the predominant heavy metal detected which also shows greater significant different at $p<0.05$ with a value of 24.34 mg/kg indicating area of high mechanic activities. The concentration values of heavy metals in the barks in comparison to the standard shows that the concentration of the heavy metals in those vicinities is within the permissible range for cadmium and copper, while lead present was above the WHO/FAO standard at 0.299 mg/kg and close to the EC/CODEX standard. It can also be concluded that the uptake efficiency of heavy metal under study of the three species are in the order magnitude Mango>Cashew>Neem.

Key words: Absorption, concentration, farmland, magnitude, phytoremediation.

INTRODUCTION

Mechanic Villages or workshop engage in the finishing processes of oil, paints, fuels and other Heavy metals which are inevitably discharge into the soil and render the soil derelict and infertile for live except if proper remediation is done to revert the already damage soil to fertility. Phytoremediation takes the advantage of the unique and selective uptake capabilities of plant root systems, together with the translocation, bioaccumulation, and contaminant degradation abilities of the entire plant body (Hinchman et al., 1995). Many species of plants have been successful in absorbing contaminants such as lead, cadmium, chromium, arsenic, and various radionuclides from soil (Bieby et al., 2011).

Heavy metals are the most dangerous contaminants since they are persistent and accumulate in water, sediments and in tissues of the living organisms, through

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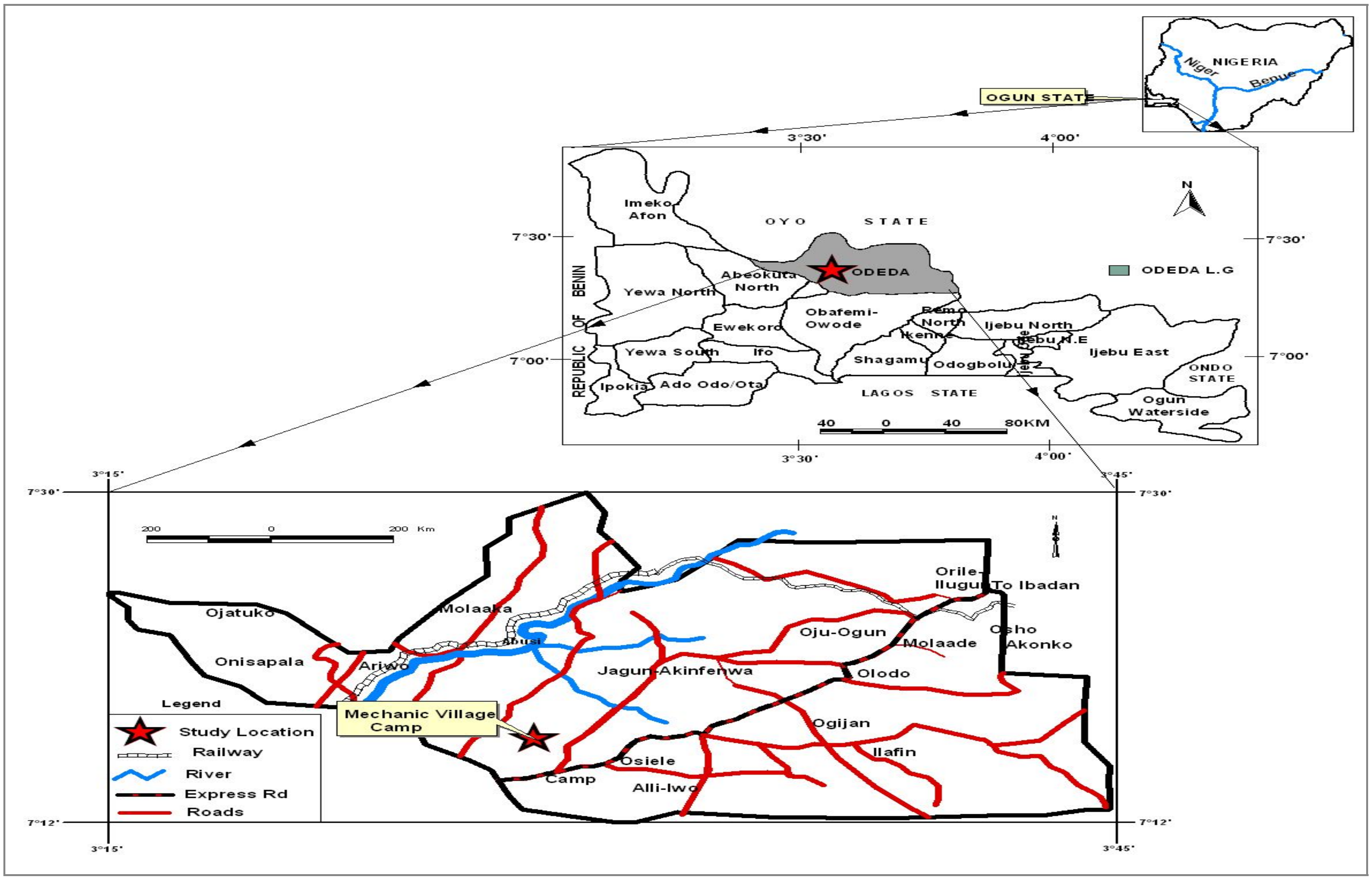

Figure 1. Map of Odeda local government, indicating the mechanic village. Source: GIS laboratory, Federal University of Agriculture Abeokuta, 2014.

two mechanisms, namely "bioconcentration" (uptake from the ambient environment) and "biomagnification" (uptake through the food chain) (Chaphekar, 1991). Hyperaccumulators are plants that can absorb high levels of contaminants concentrated either in their roots, shoots and/or leaves (Penkala, 2005). Baker and Brooks have defined metal hyperaccumulator as plants that contain more than or up to 0.1% that is more than (1000 mg/g) of copper, cadmium, chromium, lead, nickel cobalt or 1% (> 10,000 mg/g) of zinc or manganese in the dry matter.

Various plants have been used as bioindicators to assess the impact of a pollution source on the vicinity which is due to high metal accumulation of plants (Onder and Dursun, 2006). Devendra et al. (2013), have investigated in their study of the bioindicators: A comparative study on uptake and accumulation of heavy metals in some plant's leaves in India. Majolagbe et al. (2010), had investigated 10 different species of trees from 42 sampling locations taken in Oyo town, southwest, Nigeria using Corn (Zea Mays) Grown on Contaminated Soil in Heavy Metal Uptake with comparable results of that of Akhionbare et al. (2010). Lawal et al. (2011) carried out an estimation of heavy metals in Neem tree leaves along Katsina – Dutsinma – Funtua Highway in Katsina State of Nigeria. Bieby et al. (2011) conducted a review on heavy metals (As, Pb, and Hg) uptake by plants through phytoremediation. Raskin et al. (1997) understudied phytoremediation of metals using plants to remove pollutants from the environment. Thus establishing the importance for the study of Neem (*Azadirachta indica*), cashew (*Anacardium occidentale*), and mango (*Manifera indica*) trees as possible bioindicators of heavy metals in the environment.

The mechanic village studied is located along the Abeokuta – Ibadan expressway, Odeda local government, Ogun state, Nigeria. It covers a large span of land and serves as the major mechanic workshop for the Abeokuta metropolis and other neighboring states as shown in Figure 1. The landscape is covered with the presence of cover trees such as Neem ((*Azadirachta indica*), cashew (*Anacardium occidentale*), and mango (*Manifera indica*) trees in the land area, and it serve as shades to the mechanics and raw material for the production of herbal medicine.

But due to the activities in the mechanic village which majorly produces non-biodegradable waste that contains heavy metals such as Lead (Pb), Cadmium (Cd) and Chromium (Cr), trees now becomes one of the major avenue of absorbing these substances from the soil and because they are not bio-degradable it posses adverse effect on the plants development (Garba et al., 2013). The objectives of this research was to determine the effectiveness of Neem, Cashew, and Mango trees in uptake of heavy metals in mechanic village as well as evaluate the concentration of heavy metals by the barks of the trees in comparison to a control and WHO guidelines for assessing quality of herbal medicines with reference to contaminants and residue and finally to examine the effectiveness of the uptake of heavy metals as a prospect of phytoremediation in the study area.

MATERIALS AND METHODS

Soil samples was collected 10 m from the base of each species of trees to be sampled, at a depth of 0–15 cm (top soil) and 15-30 cm (subsoil) of the soil, using a soil auger and collected in polythene bags, then transported to the laboratory where it is air dried. The same procedure was repeated for FUNAAB farmland which is act as the controlled to the experiment.

Tree barks was also collected by cutting from the top, middle and bottom of the trunk of the tree with the aid of pre-washed stainless knife, and further washed after each sampling with 10% nitric acid to avoid cross contamination. The bark sample was wrapped with paper, and kept in a polythene material and thereafter transported to the laboratory.

Physical and chemical properties of the soil samples such as pH, electrical conductivity, temperature using pH metre, and total dissolved solid was first analyzed, followed by the determination of total content of Copper (cu), Lead (Pb), and Cadmium (Cd) using spectrophotometric method. Same parameters were analyzed for the bark of the different species of trees.

A composite samples of the tree bark of the trees analyzed which includes Neem, Cashew, and Mango tree were collected by cutting from the top, middle and bottom of the trunk of the tree with the aid of pre-washed stainless knife, and further washed after each sampling with 10% nitric acid to avoid cross contamination. The bark sample was wrapped with paper, and kept in a polythene material and thereafter transported to the laboratory. Random samples are carefully chosen to reflect the areas of high mechanic activities in the mechanic village.

Soil physical parameters analysis

5 grams of air dried and 2 mm sieved soil sample was weighted into 100 ml sampling bottles and 100 ml of distilled water was added. The sampling bottles where then arranged on an Edmund Bühler KS-A SWIP Orbital shaker and allowed to shake for 30 min. The mixture was poured into distilled water rinsed beaker, then the temperature, electrical conductivity and pH, where determined using HANNA combo pH and EC meter.

Soil digestion and heavy metal determination

Two (2) grams of air dried and 2 mm sieved soil was weighted of each soil sample into a BÜCHI k-424 digestion unit. 2 ml of concentrated sulphuric acid/selenium spec solution and 4 ml of concentrated hydrogen peroxide was dosed into each sample. The sample was allowed to digest at 300-400°C until content changes from black to colourless or light golden yellow in the digestion tubes. Digestion was complete when the solution became clear with appearance of white fumes (Audu and Lawal, 2005). The digest was allowed to cool to room temperature and carefully made-up to 100 ml with deionized water in a standard flask. The digest was stored in a 100 ml sample bottle. Heavy metals where determined by aspirating samples into a calibrated Thermo S4 Atomic Absorption spectrometer (AAS) with a digital read out system. Calibration curves were prepared separately for all the metals by running different concentrations of standard solutions. The instrument was set to zero by running the respective reagent blanks. The digested solutions were aspirated individually and atomized in an air-acetylene flame. All samples were run in triplicates and average values taken for each determination.

Bark analysis

One (1) g of each of the samples collected and oven dried at a temperature of 105°C for about 3 h (Majolagbe et al., 2010), was measured into BÜCHI k-424 digestion unit. 2 ml of concentrated sulphuric acid, 4 ml of perchloric acid and 25 ml of concentrated nitric acid was dosed into the sample in the digestion tube. The sample was allowed to digest at 300-400°C until brown fumes of nitric acid disappear and digest becomes colourless or light golden yellow. Digest was allowed to cool to room temperature and made-up to 100ml with deionized water in a standard flask. The digest was stored in a 100 ml sample bottle. Heavy metals where determined by aspirating samples into a calibrated Thermo S4 Atomic Absorption spectrometer (AAS) with a digital read out system. Calibration curves were prepared separately for all the metals by running different concentrations of standard solutions. The instrument was set to zero by running the respective reagent blanks. The digested solutions were aspirated individually and atomized in an air-acetylene flame. All samples were run in triplicates and average values taken for each determination.

Data were reported as mean value and descriptive analysis and graphs were used to analyze the data using SPSS version 17.0.

RESULTS AND DISCUSSION

The mean pH and the temperature of the soils samples collected from both the farmland and the mechanic village was 7.14 and 7.17, respectively, which is neutral and the mean temperature of 27.9°C was found for both the farm land and the mechanic village.

The variation in the mean electrical conductivity between the farmland and the mechanic village were 94.83 μS/cm at 25°C and 136.94 μS/cm at 25°C shows significant difference in their mean at 0.05 level of significant (Figure 2). It indicates that the mineral salts present in the mechanic village, is higher in comparison to the average farmland, hence higher conductivity.

Table 1 results indicates that there is an increase in the mean level of the concentration of cadmium, lead and copper in the soil due to the mechanic activities going on in the mechanic village.

The mean concentrations of the heavy metals in the

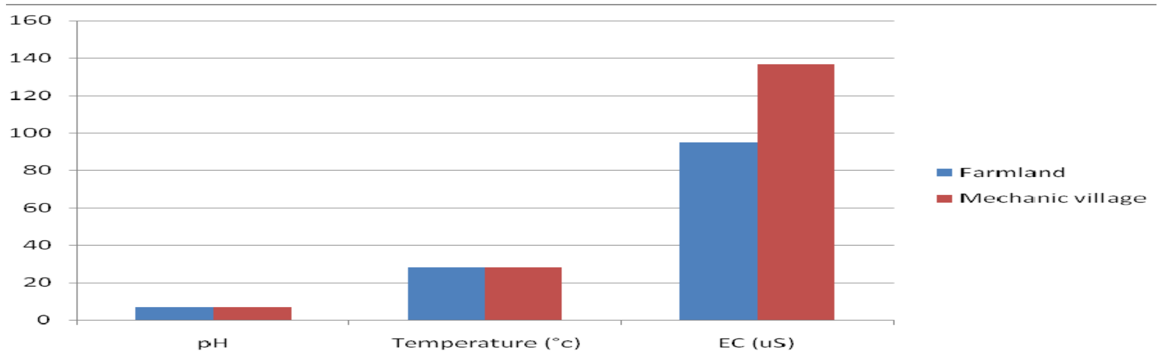

Figure 2. Comparison of the physiochemical parameters of soils from the farmland and mechanic village.

Table 1. The variation of some heavy metals in soil between the control and the mechanic village.

Parameter	Cd (mg/kg)	Pb (mg/kg)	Cu (mg/kg)
Allowable Limit	100	600	100
Farmland (Control)	0.062	0.000	0.018
Mechanic Village	0.069	2.959	0.137

Table 2. Soil concentration range and regulatory guidelines for some heavy metals.

Metal (mg/kg)	Soil concentration range (mg/kg)	Regulatory limits(mg/kg)
Pb	0.00 - 24.34	600
Cd	0.06 - 0.08	100
Cu	0.00 - 1.20	100

soil of the farmland are in this order of magnitude Cd>Cu>Pb, while the mean concentration of the heavy metals in the soil of the mechanic village are in the order of magnitude Pb>Cu>Cd (Table 2). Lead has the least concentration in the farmland, while in the mechanic village, it is the predominant heavy metal detected which also shows greater significant different at $p<0.05$ concuring with the work of Lawal et al. (2011). Also, the maximum statistical value for the concentration of lead in the soil at a point in the mechanic village, which is at 24.34 mg/kg as shown in Figure 3 indicates area of high mechanic activity. Opaluwa et al. (2012) noted that the spread of these metals over a large span of land and the continuous usage of these farmlands for growing crops could lead to bioaccumulation, hence the need for reduction in the concentration of the metals.

In comparison to international standard for permissible level of heavy metals in soil as recommended by World Health Organization (WHO) (2010), the concentration of lead, copper, and cadmium is below the permissible level. Hence, the level of pollution of the area is still minimal.

Table 3 shows the uptake of heavy metal in the bark of the trees. Mean concentration values of heavy metals in the barks in comparison to the FAO/WHO and EC/CODEX standard for these heavy metals shows that the concentration of the heavy metals in those vicinities is within the normal range for cadmium and copper, but the lead present is above the WHO/FAO standard at 0.299 mg/kg and close to the EC/CODEX standard.

The percentage uptake of the heavy metal in the bark of the plant was calculated using the Lawal et al. (2011) formula:

% Conc. of uptake = Conc. of bark ÷ (Conc. of bark + Conc. of soil) × 100

The determination ensured the level of bioaccumulation of the heavy metals by each tree.

The percentage uptake of the three heavy metals as shown is, lead and copper by Neem, Mango and Cashew were (36.63, 0.77, 33.67%), (38.37, 13.63, 75.32%) and cashew was (34.37, 33.70, 44.24%) (Table 4) respectively also showing alliance with the work of Lawal

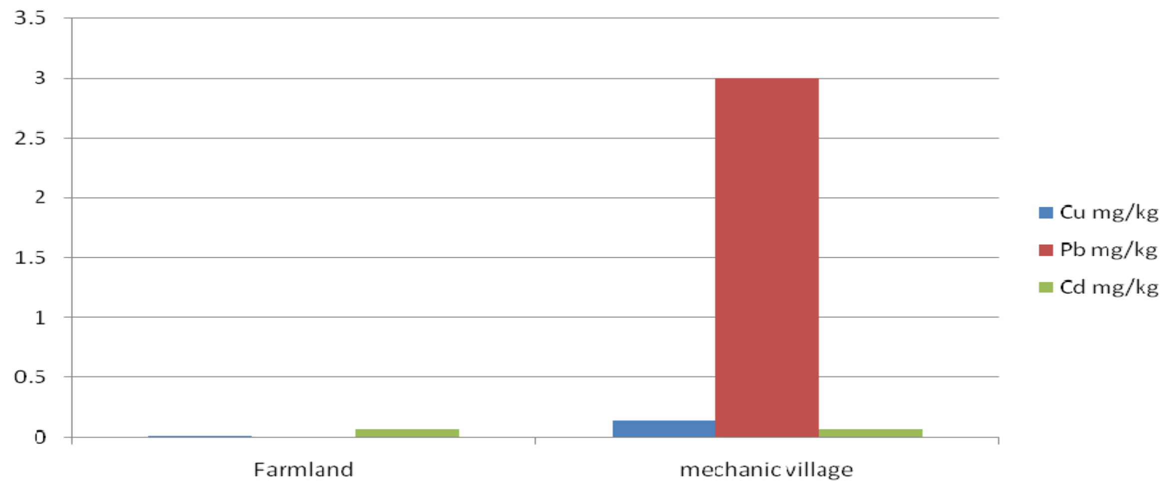

Figure 3. Comparison of the concentration of heavy metals in soils.

Table 3. Comparing the Values of Heavy Metals in Bark of the Trees Under Study with Standards.

Metals	WHO/FAO (mg/kg)	EC/CODEX (mg/kg)	MEAN concentration in plant bark (mg/kg)
Cd	0.05-0.10	0.200	0.042
Cu	0.10	0.300	0.052
Pb	0.10	0.300	0.299

Source: Authors Field Work 2014 and FAO/WHO (2011) Standard.

Table 4. The percentage uptake efficiency of neem, mango and cashew.

Plant	Percentage Uptake Efficiency (%)		
	Cadmium	Lead	Copper
Neem	36.63	0.77	33.67
Mango	38.37	13.63	75.32
Cashew	34.37	33.70	44.24

et al. (2011). These results indicate that different tree species have different uptake efficient capacity with respect to different metals. The three species has almost between 30-40% uptake capacity efficiency for cadmium with no significant difference but the uptake of lead and copper show large significant difference with respect to the mean values which range between 0.77- 33.67% and 33.70-75.32% respectively. These percentages indicate that Mango have greater uptake efficiency with respect to copper follow by Cashew. It can also be concluded that the uptake efficiency of heavy metal under study of the three species are in the order of magnitude of Mango>Cashew>Neem (Figure 4). We can also deduce that for economy importance and uptake or phytoremediation it will be better to plant Mango for steady rate of uptake then Neem could be of great importance.

Conclusion

The concentrations of heavy metals determined from the soil of the mechanic village collected at the base of different species of tree showed that the heavy metals were below permissible levels (FAO/WHO standard) but increased deposition of waste generated from mechanic activity will increase the presence of the heavy metal as areas characterized by high activities showed high concentration of metals especially lead but abandoned or unused areas showed lower concentration relatively.

Absorption of heavy metals by the bark of the trees in the mechanic village was evident when compared relatively to the presence and uptake of the heavy metals from the soil by tree in the average farmland (FUNAAB, COLANIM Farm). The presence of lead in the soil is recorded in high quantity even though it is still within the

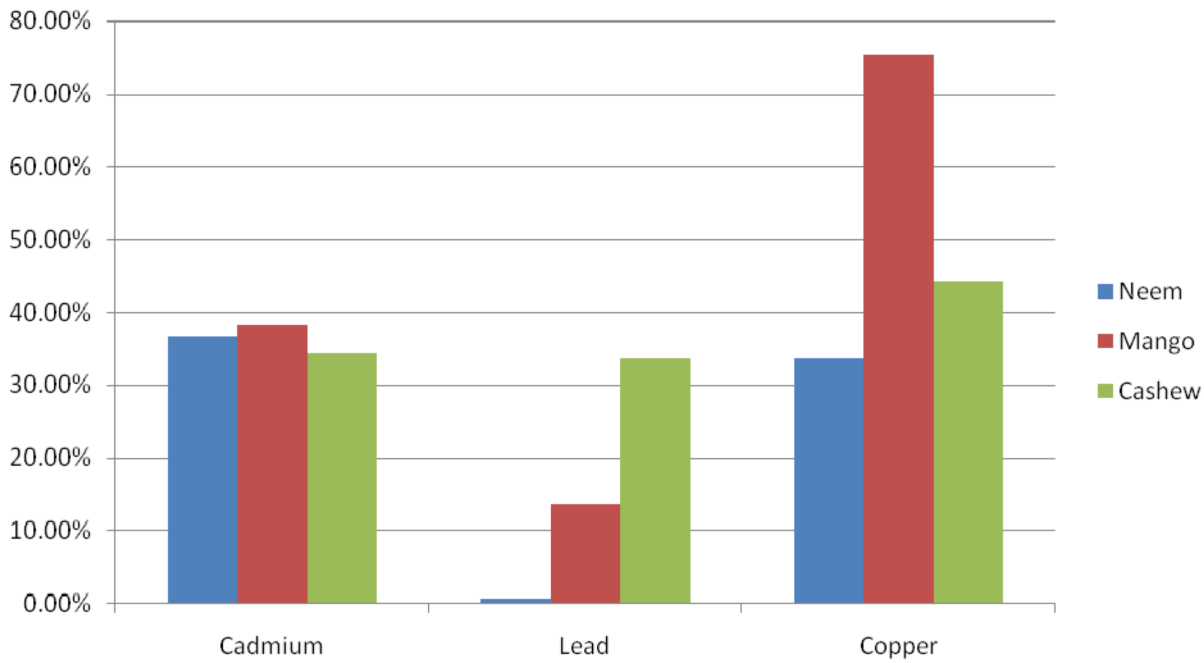

Figure 4. Comparison of the percentage of the uptake of heavy metals by the bark of trees from the soil.

permissible limit while the concentration values of heavy metals in the barks in comparison to set standards for these heavy metals shows that the concentration of the heavy metals in those vicinities is within the normal range for cadmium and copper, but the lead present is above the WHO/FAO standard at 0.299 mg/kg and close to the EC/CODEX standard.

It can also be concluded that the uptake efficiency of heavy metal under study of the three species are in the order of magnitude of Mango>Cashew>Neem. We can also recommend that for better efficient cleanup especially where an area is polluted with copper, mango is best bet for the uptake of such metal while if an equal proportion of many heavy metals is evident then it will be better to use Neem as a phytoremediation plant.

Conflict of interests

The authors did not declare any conflict of interest.

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