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Phytoremediation Potential of *Eleusine Indica* for Zinc, Copper, Lead, Nickel, Cadmium and Cobalt

*[1]Gudusu, M., [2]Tukur, A. and [1]Adam, S.
[1]Department of SLT, Ramat Polytechnic, Maiduguri, Borno State. Nigeria.
[2]Cereals Research Department, Lake Chad Research Institute, Maiduguri, Borno State, Nigeria.
Corresponding Author: gudusu.mohammed@gmail.com

ABSTRACT

This study was undertaken to evaluate the phytoremediation potentials of *Eleusine indica* L. for the metals: Zn, Co, Cd, Pb, Cu and Ni. Viable seeds of the grass was planted into 2 kg soil spiked with the salts of the heavy metals: Ni as $Ni(NO_3)_2.6H_2O$, Pb as $Pb(NO_3)_2$, Zn as $Zn(SO_4).6H_2O$, Cu as $CuSO_4.5H_2O$, Co as $CoCl_2.6H_2O$ and Cd as $Cd(NO_3)_2$ at concentrations. A separate pot with untreated soil was used as a control. Irrigation was done with 500 ml of water after every five days in the evening hours for eight weeks. Samples of the grass and soil were collected at the end of the experiment; the grass was washed with tap water and carefully separated into roots and shoots, dried along with the soil, ground and sieved. The sieved soil, roots, shoots of the experimental grass as well as that of the control were analyzed for the levels of heavy metals: Zn, Cu, Pb, Ni, Cd and Co following digestion with aqua-regia using AAS. The Bioconcentration Factor (BCF), the Enrichment factor (EF) and the Translocation Factor (TF) were evaluated for the different metals. For Zn, the highest BCF value 7.55, EF = 3.14 and TF value 0.82. Cobalt had the highest BCF value of 5.40, EF = 10.75, and the TF value of 3.59. Copper had BCF value of 8.27, EF = 2.38; and the TF of 0.79. Cadmium had BCF value of 0.97, EF of 1.00, and TF of 1.10 Nickel had the highest BCF = 1.74, EF = 1.12, and the TF of 1.38., whereas Pb had the highest BCF of 4.71, EF of 1.84, and TF of 0.56. *E. indica* L. may serve as phytostabilizer of Zn, Cu, Pb and Co in the soil for having higher values of BCF and EF than TF. *E. indica* may also serve as a phytoextractor for Cd and Ni having high values of BCF and TF than EF. BCF indicates high degree of absorption; EF indicates high retention in the root and TF is the ability to translocate absorbed elements to the shoots. The results of this study demonstrated that the elevated concentrations of the metals (Cu, Co, Pb, Zn, Cd and Ni) in roots and translocation to the aerial parts of the grasses suggest the suitability of *Eleusine indica* for phytoremediation.

KEY WORDS: Accumulation, heavy metal, hyperaccumulation, phytoremediation, soil

INTRODUCTION

There has been an increasing concern with regard to the accumulation of toxic heavy metals in the environment and their impact on both public health and the natural environment [1]. The accumulation of heavy metals in soil is becoming a serious problem as a result of industrial and agricultural practices to name but a few of the causes of pollution today. Fertilizers from sewage sludge, mining waste and paper mills all contribute to the continuous deposition of heavy metals into soils. Another point of concern is the effect of leaching on these contaminated sites which in turn contaminate water tables [2]. Large quantities of untreated municipal sewage and industrial effluents are emptied directly to surface water causing rigorous pollution mainly due to heavy metals. The potential cost and environmental issues have attracted increasing attentions [3]. "Phytoremediation", represents a harmless and low cost technique, lacking of distinctive side effects [4]. Most of the studies on phytoremediation have mainly focused on metal hyperaccumulating plants [5]. Hyperaccumulators can accumulate several hundred-folds certain metals comparing normal plant species, with no adverse effects on their growth [6].

There are a number of conventional remediation technologies which are employed to remediate heavy metal contaminated soil such as solidification/stabilization, soil flushing, soi1 washing, and excavation, retrieval and offsite disposal. They include, mechanical, thermal or biological processes such as: - (1) Restricting the use of the contaminated land and leaving the contaminants as they are. (2) Encapsulation of the contaminated land (complete or partial). (3). Land filling: carried out after excavation of the contaminated soil. (4). In-situ or ex-situ treatment of contaminated soil. Based on the four processes listed above, different remediation methods have been developed in the last three decades due to the risk of contaminants to groundwater and air.

Majority of these technologies are costly to implement and cause further disturbance to the already damaged environment [7]. The global emphasis at present is to use natural methods to curb pollution and reclaim polluted soils. Bioremediation is based on the potentials of living organisms, mainly micro organisms and plants, to detoxify the environment [8]. Several studies have demonstrated that some plants have the capacity to tolerate high levels of heavy metals without causing any remarkable toxic effects on its metabolic functions. Plant based bioremediation technologies have been collectively termed as phytoremediation; this technology can be applied to both organic and inorganic pollutants present in soil (solid substrate), water (liquid substrate) and the air [9].

The use of plants for remediation of soils and waters polluted with heavy metals, has gained acceptance in the past two decades as a cost effective and non-invasive method [10]. This approach is emerging as an innovative tool with great potential that is most useful when pollutants are within the root zone of the plants (top three to six feet). The method of phytoremediation exploits the use of either naturally occurring metal hyper accumulator plants or genetically engineered plants [11]. A variety of polluted waters can be phytoremediated, counting sewage and municipal wastewater, agricultural runoff/drainage water, industrial wastewater, coal pile runoff, landfill leachate, mine drainage, and groundwater plumes [12]. Plants play a vital role in metal [removal through absorption, cation exchange, filtration, and chemical changes through the root. There is evidence that wetland plants such as *Typhalatifolia*, *Cyperus malaccensis* etc. can accumulate heavy metals in their tissues [13].

Phytoremediation is a broad term that incorporates all the different processes that plants use to remove, transform or stabilize pollutants in soil, water or atmosphere. It is a plant based remediation technology that is applied to both inorganic and organic contaminants in soil, water and sediments globally [14]. Natural processes by which plants and their associated microbes degrade and/or sequester inorganic and organic pollutants are incorporated in this technology which makes it a cheaper and environmentally sustainable option to mechanical and chemical methods of removing contaminants from soil [14].

The aims of this study are: i) determine some physicochemical properties such as pH, soil texture, electric conductivity, cation exchange capacity, organic matter of the soil that supports the growth of goose grass (*Eleusine indica L. Gaerth*). ii) conduct a laboratory pot experiment by spiking three different set of 2 kg soil in a pot experiment with 150, 250, 400 ppm of the metal $Cd(NO_3)_2$, $CoCl_2.6H_2O$, $CuSO_4.5H_2O$ with additional, 500 and 1000 ppm of the metals; $Ni(NO_3)_2$, $Pb(NO_3)_2$, and 500, 2000, 4000 ppm for $Zn(SO_4).6H_2O$. iii) harvest and analyze the soil, root and the shoot of the experimental grass as well as the control for the level of heavy metals (Pb, Cd, Co, Zn, Cu and Ni) and asses the phytoremediation potential of the native grass through the Bioconcentration (BCF), Translocation (TF) and Enrichment Factor (EF) from the level of the same metals.

MATERIALS AND M ETHODS

Sampling and Study Area

The seeds samples of *Eleusine indica L.Gaerth* along with the soil that support the growth of the grass was collected from Lake Chad Research Institute, Maiduguri, Borno state, Nigeria. The grass heads of *Eleusine indica L.Gaerth* was collected and air dried in the laboratory for two days. The seed was then removed from the head husks and stored in glass bottles for subsequent laboratory pot experiments.

Experimental pots containing 2 kg soil was conducted according to method described by Ahalya *et al.* [15] which was carried out in Lake Chad Research Institute Commercial Nursery. The soil was spiked with the salt of following heavy metals at various concentration; Ni as $Ni(NO_3)_2.6H_2O$, Pb as $Pb(NO_3)_2$, $Zn(SO_4).6H_2O$, Cu as $CuSO_4.5H_2O$, Co as $CoCl_2.6H_2O$ and Cd as $Cd(NO_3)_2$ at a concentration of 150, 250, and 400ppm for Cd, Cu and Co; 150, 500, and 1000ppm for Pb and Ni; 1000, 2000 and 4000 ppm for Zn. Viable seeds of the goose grass was planted into the pots. A separate pot with untreated soil was used to serve as a control. Experiments were exposed to natural day and night temperatures, since humidity is one of the factors ensuring the growth of plants and the necessary physiological processes. Irrigation of the pots was done with 500 ml of water after every five days in the evening hours. Plastics trays were placed under each pot and the leached was collected and put back in their respective pots in order to prevent loss of nutrients and trace element from the samples [16]. Four replicates of each experimental pot of the grasses were planted for statistical analysis. The samples of the grass and the soil were collected at the end of the experiment. The grass was washed thoroughly in the laboratory with distilled water, carefully separated into roots and shoots, air dried at room temperature to a constant weight, ground and sieved through a 2mm nylon sieve according to Lombi [17]. The soil samples collected were homogenized, dried at $105^{\circ}C$ to a constant weight, ground and then sieved through a 2mm mesh ready for further analysis. The dried soil sample of the control pots was characterized for some physicochemical properties [17].

One gram of each of the soil and plant samples was digested separately with 10 cm^3 of aqua regia (a mixture of 3 parts concentrated HCl to 1 part concentrated HNO_3) on a hot plate in a fume cupboard, until a clear solution was obtained. Water was added periodically to avoid drying up of the digest. To the hot solution, 30 cm^3 of water was then added and filtered through a Whatman No. 42 filter paper into a 50 cm^3 standard volumetric flask and then made up to the mark [18]. Analysis of the digested samples was done using atomic absorption spectroscopy (AAS).

RESULTS AND DISCUSSION

Physicochemical properties of the experimental soil

The results of the physicochemical properties of the experimental soil is shown in Table 1. The taxonomy classification of the soil was found to be sandy loam with pH of 6.94. The less acidic nature of the soil is generally within the range for soil in the region; soil pH play an important role in the sorption of heavy metals, it control the solubility and hydrolysis of metal hydroxide, carbonate and phosphates [19]. A very low Electric Conductivity was observed in experimental soil 0.27 ms/cm for *E. indica*. Low organic matter content of 0.64 was also observed in the experimental soil as well as very low Cation Exchange Capacity (4.89 mol/100g of soil) for *E. indica*. CEC measures the ability of soil to allow for mobility of electron within the soils. The low level of clay and CEC indicate the permeability and leach ability of metals in the soil [20].

TABLE 1: Physicochemical Properties of the experimental soil

Parameters	*Soil of Eleusine indica*
P^H	6.94±0.01
EC (dsm^{-1})	0.27±0.01
CEC (cmol/100kg soil)	4.89±0.02
Organic carbon (%)	0.37±0.02
Organic Matter (%)	0.64±0.04
Silt (%)	28.20±0.10
Clay (%)	14.70±0.01
Sand (%)	57.10±0.10
Textural Class	Sandy Loamy

HEAVY METAL ACCUMULATION IN THE ROOT AND SHOOT OF *ELEUSINE INDICA*

This research work shows the uptake and accumulation by *Eleusine indica* at different concentrations, 500, 2000 and 4000 ppm of Zn, spiked in to the experimental pots. The results showed that most of the metals absorbed are retained in the root including the control. The experimental pot spiked with 2000 ppm has the highest level of Zn in the root at 2553.5±0.10 ppm whereas the experimental pot spiked with 500 ppm has the lower level of Zn accumulated in the root (1816.6±0.03 ppm Zn). In *E. indica*, high levels of Zn was found in the root (Table 2). This report agrees with the observation reported by Garba *et al* [19] that high level of Zn was naturally retained in the root of *E. indica*

Table 2: Concentration (mg/kg^{-1}) of Zn in the Soil, Shoot and Root of *Eleusine indica L, Gaerth* and the Translocation (TF), Enrichment (EF) and Bioconcentration Factor (BCF)

Amount Spike	*Soil*	*Root*	*Shoot*	*BCF*	*TF*	*EF*
500	250.5±0.05	1816.6±0.03	713.5±0.04	7.25	0.39	2.85
2000	338 ± 0.03	2553.5±0.10	1060± 0.02	7.55	0.42	3.14
4000	1304.5±0.04	1979± 0.07	1631.7±0.04	1.52	0.82	1.25
Control	356.5± 0.13	1216.5±0.05	505.5 ± 0.10	3.41	0.42	1.42

Data are presented as Mean ±SD. No significant difference was observed at $P<0.05$ using ANOVA Analysis and Multiple Comparison according to Tukey test, SD=Standard Deviation

Plate 1: *E.indica L* spiked with Zn

Table 3 shows the uptake and distribution of Cu in the parts of *Eleusine indica* spiked at different concentrations with 150, 250 and 400 ppm in the experimental pots. The grass accumulated high level of Cu in the root at all the three different concentrations. There was a translocation to the shoot at the control pot with 180±0.01ppm in the shoot and 62±0.01 in the root. This result agrees with Garba *et al* [19], who reported that high level of Cu was also found in the root of *E. indica* (236.00±3.72µg/g), but in contrary, Wang *et al* [21], observed that high level of , Cu, was translocated to the shoot with the leaves having the highest percentage.

Table 3: Concentration (mg/kg^{-1}) of Cu in the Soil, Shoot and Root of *Eleusine indica L ,Gaerth* and the Translocation, Enrichment and Bioconcentration Factors

Amount Spiked	*Soil*	*Root*	*Shoot*	*BCF*	*TF*	*EF*
150	48.5 ± 0.02	401 ± 0.02	85.5 ± 0.02	8.27	0.21	1.76
250	91 ± 0.00	203± 0.01	121.5± 0.01	2.23	0.60	1.34
400	116 ± 0.01	348 ± 0.04	276.5 ±0.08	3.00	0.79	2.38
Control	65 ± 0.00	62 ± 0.01	180 ± 0.01	0.95	0.34	2.77

Data are presented as Mean ±SD. No significantly different was observed at $P<0.05$ using ANOVA Analysis and Multiple Comparison according to Tukey Test, SD=Standard Deviation

Plate 2 : *E.indica L* spiked with Cu

Table 4 shows the uptake and accumulation of Pb by *Eleusine indica*. It shows that the level of Pb in the root increases as the concentration spiked in the experimental pot increases whereas the level in the shoot decreases as the concentration spiked in the experimental pot increases. For instance, at 150 ppm the level of Pb in the root of the grass was 627.5±0.03 ppm and at 1000 ppm the level of Pb in the root increases to 1356±0.04 ppm. The level of Pb in the shoot of the grass at 150 ppm was 329±0.02 ppm and at 1000 ppm the level was observed to decrease (225.5±0.02 ppm). The result indicated that most of the element was absorbed and accumulated in the root. This agrees with the report by Subhashini and Swamy [22]. who observed that Pb and Ni were highly accumulated by the root than the stem and leaves of *Catharanthus roseous* (67.34 and 20.63 mg/kg), but contrary to the report by Garba *et al*. [23], who observed high level of the metal in the shoot of *E. indica* (326.00±4.26 μg/g). Despite the high level of Pb in the plant, no visible sign of toxicity was observed compared with control experiment (Figures 3 and 7) both plants also shows a uniform growth.

Table 4: Concentration (mg/kg^{-1}) of Pb in the Soil, Shoot and Root of *Eleusine indica L. Gaerth* and the Translocation, Enrichment and Bioconcentration factors

Amount Spiked	*Soil*	*Root*	*Shoot*	*BCF*	*TF*	*EF*
150	346.5±0.01	627.5±0.03	329±0.02	1.81	0.52	0.95
500	258.5±0.02	1216.5±0.01	312± 0.06	4.71	0.56	1.20
1000	396±0.07	1356 ± 0.04	644.6±0.03	3.42	0.47	1.62
Control	139 ± 0.00	796.5±0.03	225.5±0.02	5.73	0.32	1.84

Data are presented as Mean ±SD. No significantly different was observed at P<0.05 using ANOVA Analysis and Multiple Comparison according to Tukey test, SD=Standard Deviation

Plate 3 : *E.indica L* spiked with Pb

Table 5 shows the absorption and distribution of Ni in the root, shoot and soil of *Eleusine indica*. The grass accumulated high level of the metal Ni in the root although there was a small translocation of the element to the shoot at 500 ppm, but at 150 and 1000 ppm, higher level of the metal Ni was observed to be retained in the root. For instance, at 500 ppm in the experimental pots the shoot had 332±0.07 ppm and at both 150 and1000 ppm, the roots absorbed 546±0.06 and 451±0.03 ppm respectively. For the control, the root had 255.5±0.06 ppm whereas the shoot had 73±0.05 ppm. For *E. indica,* the accumulation was found to fluctuate because at 150 and 1000 ppm, the grass accumulated high level of Ni in the root whereas at 500 ppm, the grass absorbed and translocated the metal to the shoot as shown in Table 5. This agrees with the report of Subhashini and Swamy [22], that Pb and Ni were highly accumulated by the root than the stem and leaves of *Catharanthus roseous* (67.34 and 20.63mg/kg), but disagrees with Wang *et al.* [21], who observed higher Ni in the shoot than the root of wheat. It has been extensively reported that, higher concentration of Ni was found in the above-ground parts of plants rather than in the roots [24].

Table 5: Concentration (mg/kg^{-1}) of Ni in the Soil, Shoot and Root of *Eleusine indica L,Gaerth* and the Translocation, Enrichment and Bioconcentration factor

Amount Spiked	*Soil*	*Root*	*Shoot*	*BCF*	*TF*	*EF*
150	316 ± 0.07	549 ± 0.06	353.5±0.02	1.74	0.64	1.12
500	332 ±0.01	240±0.03	332 ±0.07	0.72	1.38	1.00
1000	618.5±0.03	451± 0.03	342.5 ±0.04	0.73	0.62	0.55
Control	380 ± 0.06	255.5 ±0.06	73 ± 0.05	0.67	0.29	0.19

Data are presented as Mean ±SD. No significantly different was observed at $P<0.05$ using ANOVA Analysis and Multiple Comparison according to Tukey Test, SD=Standard Deviation

Plate 4 : *E.indica L* spiked with Ni

Table 6 shows the uptake and translocation of Cd in the soil, root and shoot of Eleusine *indica*. The control experiment accumulated high levels of Cd in the shoot (156.5±0.07ppm). This level was lower than what was observed when the experimental pots were spiked with Cd at different concentrations: 150, 250 and 400 ppm. At all the three concentrations, high level of Cd was absorbed and translocated to the shoot of the grass. For instance, when the experimental pot was spiked with 150 ppm Cd, the level of the metal in the root was 176±0.06 ppm and the shoot had 193±0.04 ppm. The same trend was observed when the level in the experimental pot was increased to 250 and 400 ppm. The result indicated that the level of the metal accumulated in the shoot decreases as the concentration in the soil increases. High level of cadmium was observed in the shoot of the plant as shown in Table 6. This observation agrees with the report of Wang *et al*. [21] that high level of Cd was found in the shoot of wheat plant especially the leaves (52%). Hartel *et al*. [25] also observed high shoot Cd accumulation in bread wheat cultivar. Translocation of Cd from root to shoot has been studies in several species plant including rye grass, *secale cereal*, [26] tomato, lycopersicon esculentum, [27], maize [28]. Movement of Cd from shoot is likely to occur via xylem and to be driven by transpiration pool from the leaves.

Table 6: Concentration (mg/kg^{-1}) of Cd in the Soil, Shoot and Root of *Eleusine indica L,Gaerth* and the Translocation, Enrichment and Bioconcentration factor

Amount Spiked	*Soil*	*Root*	*Shoot*	*BCF*	*TF*	*EF*
150	230 ± 0.01	176 ± 0.06	193 ± 0.04	0.77	1.10	0.84
250	191.5± 0.02	186 ± 0.01	191.5± 0.02	0.97	1.02	1.00
400	231 ± 0.01	217± 0.00	223.5± 0.01	0.93	1.03	0.97
Control	195 ± 0.00	104± 0.07	156.5 ±0.05	0.53	1.50	0.80

Data are presented as Mean ±SD. No significantly different was observed at $P<0.05$ using ANOVA Analysis and Multiple Comparison according to Tukey Test, SD=Standard Deviation

Plate 5: *E.indica L* spiked with Cd

Table 7 shows the concentration of the metal Co in the soil, root and shoot of *Eleusine indica.* The result showed that at lower concentration, such as the control and 150 ppm, most of the metal was retained in the root but at 250 and 400 ppm, the metal was translocated to the shoot due to the high level of the metal concentration in the soil. For 250 ppm the root had 23.5±0.07ppm which was less than what was translocated to the shoot (63±0.02 ppm), when the level was increased to 400 ppm, absorption increased as well as translocation to the shoot. *E. indica* was found to accumulate high level of the metal Co in the shoot at 400 ppm level in the soil. The rate of absorption and translocation of metals in plants depend on the concentration of the metals in the soil (Table 7). This result agrees with Nadia *et al.* [29], who reported that as regards to Co and Ni accumulation in plants, they are believed to remain highly accumulated in root tissues of *Cyperus laevigatus* and *Phragmite australis.* The growth of *E. indica* at the three different concentrations of 150, 250 and 400 ppm in this study shows no sign of toxicity or morphologic changes compared to the control (Plates 6 and 7).

Table 7: Concentration (mg/kg^{-1}) of Co in the Soil, Shoot and Root of *Eleusine indica L,Gaerth* and the Translocation,Enrichment and Bioconcentration factor

Amount Spiked	*Soil*	*Root*	*Shoot*	*BCF*	*TF*	*EF*
150	62 ± 0.01	312.6± 0.03	62 ± 0.03	5.04	0.20	1.00
250	50.5 ± 0.02	23.5 ± 0.07	63 ± 0.02	0.47	2.68	1.25
400	29.5 ± 0.03	88.2 ± 0.05	317 ± 0.09	2.99	3.59	10.75
Control	20 ± 0.06	10.5 ± 0.01	2.5 ± 0.08	0.53	0.23	0.13

Data are presented as Mean ±SD. No significantly different was observed at $P<0.05$ using ANOVA Analysis and Multiple Comparison according to Tukey Test, SD=Standard Deviation

Plate 6: *E.indica L* spiked with Co

Plate 7: Control of *E. indica*

Phytoremediation Potentials of E. *indica*

All plants can absorb and accumulate heavy metals at different concentrations; however, there exist differences in the metals accumulation between plants and within plants species. According to Chaney *et al.* [30], for a plant to be considered for phytoremediation, it should possess the following characteristics: (i) Tolerance to high concentration of the contaminant (ii) Ability to extract, degrade or stabilize the contaminant in the soil and (iii) Rapid growth rate and high biomass production. For grasses, other added advantages are their long and fibrous root system. 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 [31].

Bioconcentration Factor

The Bioconcentration Factor of metals was used to determine the quantity of heavy metals that is absorbed by the plant from the soil. This is an index of the ability of the plant to accumulate a particular metal with respect to its concentration in the soil [16].

BCF is calculated by the relation: ratio of the metal concentration in the root to the concentration in the soil. The higher the BCF value the more suitable is the plant for phytoextraction [32]. BCF values > 1 were regarded as high values.

BCF=metal concentration in the root/ metal concentration in the soil

Translocation Factor

To evaluate the potential of plants for phytoextraction the translocation factor was used. This ratio is an indication of the ability of the plant to translocate metals from the roots to the aerial parts of the plant [33].

TF is calculated by the relation: ratio of concentration of metal in the shoot to the concentration of metal in the roots [34]. Metals that are accumulated by plants and largely stored in the roots of plants are indicated by TF values < 1 with values > 1 indicating that the metals are stored in the stems and leaves (shoot).

Enrichment Factor Retention of the Metals in the Root

To evaluate the potential of plants for phytostabilization the enrichment factor was used. This ratio is an indication of the ability of the plant to retain metal in the root of the plant. EF is given by the relation: - The ratio of the concentration of metal in the shoots to the concentration of metal in the soil [34].

In this study, the BCF, EF and TF values for the metals; Zn, Cu, Ni, Cd, Pb and Co are presented in the Tables 2, 3, 4, 5,6 and 7 at different level of the metals in the experimental pots.

For Zn in *Eleusine indica* the TF values are 0.39, 0.42, 0.82 at 500, 2000 and 4000 ppm whereas in control the TF value is 0.42 and the EF values are 2.85, 3.14, and 1.25 whereas in the control the EF value is 1.42 as shown in Table 2. This also shows that E. indica can absorb and retain high level of metal Zn in the root without translocating it to the shoot. The BCF values are all greater than 1 which also indicates the ability of the grass to absorb Zn as shown in Table 2. The study shows that experimental grass may serve as phytostabilizer or metal excluder of Zn contaminated soil

Copper (Cu)

The BCF values of all the concentrations of Cu spiked are greater than 1 while at control the BCF value is less than 1. Having the BCF values of greater than 1 in all the three concentration spiked suggest that the grass has the ability to absorb the metal from the soil. Result of this study showed that *E. indica* may serve as phytostabilizers or metal excluders of Cu contaminated soil while Eleusine indica may serve as phytoextractor of Cu.

Lead (Pb)

This indicates that *E.indica* can absorb and accumulate Pb in the root (Table 4). The BCF values of all the concentrations spiked in the experimental pots were greater than 1 which suggests that the degree of the metal absorption is high. According to this study *E.indica* may serve as Pb phytostabilizers or metal excluders.

Nickel (Ni)

This shows that the grass of *E.indica* can only absorb and retain Ni in the root, although at 500 ppm the TF value was found to be 1.38 which is higher than 1, but it is still greater than EF value (1.00). These indicate the ability of the grass to accumulate and translocate the metal Ni in the shoot. The BCF values are all less than 1 except at 150 ppm which is 1.74 which indicates the degree of metal absorption from the soil. *E.indica* may serve as Ni phytoextractor or metal indicator.

Cadmiun (Cd)

This indicates that the grass has the ability to absorb and translocate Cd to the shoot. The BCF values of the three different concentrations are all less than 1 as shown in Table 6. These suggest that the grass has low ability to absorb metal from the soil. Based on this research *E. indica L, Gaerth* may serve as Cd phytoextractor or metal indicator (Hyperaccumulator).

Cobalt (Co)

This shows that the grass *E. indica* can absorb and translocate the metal Co to shoot but at low concentration it can only retain the metal in the root. The BCF values at 150 and 400 ppm are greater than 1 whereas at 250 ppm and control is less than 1 (Table 7). Therefore the study shows that *E. indica* may serve as phytoextractor or metal indicator (Hyperaccumulator) of Co.

CONCLUSION

Phytoremediation is an innovative technology that uses plants to remove and/or degrade environmental contaminants such as heavy metals and organic compounds. In this study an assessment of remediation of contaminated soil was done using native Goose grass (*Eleusine indica*) without the need for soil excavation. Goose grass demonstrated their ability to absorb and accumulate heavy metals (Ni, Co, Pb, Cu, Zn, and Cd) in either their roots or shoots with no noticeable symptoms of toxicity. From the result obtained and the Translocation, Bioconcentration and Enrichment Factors calculated, *E. indica L, Gaerth* may serve as phytostabilizers or metal excluders of Zn, Cu, and Co in the soil for having higher values of BCF and EF than TF. *E. indica* may serve as phytostabilizer or metal excluders for Pb in the soil for having high values of BCF and EF than TF. It may also serve as a phytoextractor or metal indicator for Ni and Cd (hyperaccumulator) for having high values of BCF and TF than EF. The results of this study demonstrated that the elevated concentration of the metals (Cu, Co, Pb, Zn, Cd and Ni) in roots and translocation to the aerial parts of the grass suggest the suitability of *Eleusine indica* for phytoremediation.

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