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PHYTOREMEDIATION OF POTENTIALLY TOXIC ELEMENTS IN INDUSTRIAL SOIL USING HILDEGARDIA BARTERI (MAST.) KOSTERM

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ABSTRACT
Potentially toxic elements (PTEs) contamination has become a sombre environmental risk. This study selected *Hildegardia barteri* as remediation specie for reduction of PTEs concentrations in industrial soil (IS). Pots experiment consisting of five treatments: T1 (2kg control soil (CS)), T2 (1.5 kg CS + 0.5kg IS), T3 (1kg CS+1kg IS), T4 (0.5kg CS+1.5kg IS) and T5 (2kg IS) were replicated six times in a completely randomized design. The experiment was done for a period of 12 weeks after transplanting (WAT). Soil samples before and at the end of experiments, the roots and shoots of *Hildegardia* barteri were analysed for Zn, Cu, Pb, Co and Cr using Atomic Absorption Spectrophotometer (AAS). Data were assessed using bioaccumulation factor (BAF) and translocation factor (TF). The concentrations of PTEs in soil before the experiment in the treatments were Zn (40.11-58.21), Cu (28.91-43.29), Pb (18.05-28.11), Co (8.21-15.85) and Cr (5.78-14.11) in mg/kg. Also, the concentrations of PTEs in soil at the end of the experiment were Zn (15.35-20.51), Cu (15.62-18.73), Pb (10.48-20.37), Co (3.62-6.26) and Cr (2.94-6.21) in mg/kg. Concentrations of PTEs (mg/kg) in shoots were significantly higher at P≤0.05 than those in the roots of Hildegardia *barteri*. The values of BAF were between 0.68 and 1.23 while TF values ranged from 1.01 to 1.48. Bioaccumulation and translocation factors indicated that *Hildegardia barteri* can effectively accumulate PTEs (*Zn*, Cu, Pb, Co and Cr) into the roots and transfer them into their shoot. This study has shown that *Hildegardia barteri* can reduce the toxicity of the elements in soils. Thus, planting of *Hildegardia barteri* is recommended for urban forestry in the study area.

KEY WORDS
Bioaccumulation, toxicity, translocation, phytoextraction, urban forestry.

Environmental dilapidation and contamination are unsurprising due haphazard discarding of wastes, emissions of toxic and dodgy gases containing potentially hazardous elements that can be of risk to human health through food chain (Huang*et al.,* 2020). Some of these elements are noxious, cancer-inducing agents and have latent to accrue in soils and biota (Tchounwon *et al.,* 2012). The unremitting liberate of toxic elements (heavy metals) in the soil has enormous and stern impact on terrestrial ecosystem and humans. Consequently, there is need to clean up the contaminated soils through green planting technology for environmental management and sustainability (Lovett *et al.,* 2007). The use of plants for the cleaning up of contaminants from the environment is called phytoremediation. Phytoremediation is a promising and useful green technology method that is practically economical with least brunt on the environment (Liu wt al, 2019; Akintola *et al.,* 2022). This method has been proven by several researchers for cleaning up of contaminants from soil and other environmental systems (Olowoyo *et al.,* 2012; Akintola *et al.,* 2022). Hildegardia barteri is fast growing tree up to a height of 24 - 30m. The tree is upheld with a clear bole of 9 - 12 m tall and a girth of up to 3.5 m. The tree is harvested from the wild, grown sometimes as living fence and serves as source of timber and fiber. This study thus investigated the potential of *Hildegardia barteri* for remediation of potentially toxic elements (Zn, Cu, Pb, Cu and Co, Cr) in industrial soil (IS).

The experiment was carried out at Federal College of Forestry in Ibadan, Oyo State. The area lies between Latitude (7^o26'N - 7^o28'N) and Longitude (3^o51'E- 3^o54'E). The climate pattern of the area is tropically dominated by annual rainfall pattern ranging from 1,300mm to 1,500mm. It has an average relative humidity of about 65 percent with mean temperature of about 26^o C. The area has two seasons: dry seasons usually commencing from November to March and rainy season from April to October (FRIN, 2021).

MATERIALS AND METHODS OF RESEARCH

Sixty (60) healthy *Hildegardia barteri* seedlings of equal length were collected from Nursery A of Forestry Technology Department, Federal College of Forestry, Ibadan, Oyo state. The industrial soils were collected from the different sampling sites within the Oluyole industrial estate in Ibadan, Oyo State. The soils were mixed together as composite samples. Soil used as control in this study was also collected from where there is little or no human disturbance.

Experimental Design. Two (2) kg of top soil were filled into polythene pots with the topsoil from industrial area (IS) and top soil for control (CS) as follows:

- T1 (2kg control soil (CS);
- T2 (1.5 kg CS + 0.5kg IS);
- T3 (1kg CS+1kg IS);
- T4 (0.5kg CS+1.5kg IS);
- T5 (2kg IS).

Two seedlings were planted in each of the pots and replicated six times in a completely randomized design. The experiment was done for a period of 12 weeks after transplanting (WAT) under natural conditions. Soil before and after the experiments were analysed for Zn, Cu, Pb, Co and Cr. Roots and shoots of plants were collected analysed for aforementioned metals analysis using Atomic Absorption Spectrophotometer (AAS).

Data were assessed using bioaccumulation factor (BAF) and translocation factor (TF) as given by Yadav *et al*., (2009) as indicated in equation 1 and 2.

$$BAF = CHMIP/CHMIS \quad (1)$$

Where: BAF - Bioaccumulation factor; CHMIP - Concentraion of heavy metals in plant; CHMIS - heavy metal concentration in soil;

$$TF = CHMISh/CHMIR \quad (2)$$

Where: TF – Translocation factor; CHMISh – Concentration of heavy metals in shoot; CHMIR - Concentration of heavy metals in root.

RESULTS AND DISCUSSION

The concentrations of PTEs in soil before the experiment in the treatments were Zn (40.11-58.21), Cu (28.91-43.29), Pb (18.05-28.11), Co (8.21-15.85) and Cr (5.78-14.11) in mg/kg. Also, the concentrations of PTEs in soil at the end of the experiment were Zn (15.35-20.51), Cu (15.62-18.73), Pb (10.48-20.37), Co (3.62-6.26) and Cr (2.94-6.21) in mg/kg. The concentrations of the determined elements in the soils before the experiment were higher than those determined after the experiment, indicating the accumulation potential of *Hildegardia barteri.* it was also noticed that the concentrations of the heavy metals in the soils increases with the treatment levels. This indicates the impact of the industrial activitties in the study area.

Results of PTEs concentrations in roots and shoots of the seedlings are showed in Table 2. The PTEs concentrations in shoots were Zn (9.27-14.69), Cu (6.84-8.92), Pb (4.17-7.27), Co (1.24-2.15) and Cr (1.02- 2.12) while their concentrations in roots were Zn (6.39-14.69), Cu (5.66 -7.25), Pb (4.01-6.99), Co (1.22-2.11) and Cr (1.01-2.10) in mg/kg. The results showed that the concentrations of PTEs in shoots were higher than their concentrations in roots. This is an indication

that *Hildegardia barteri* seedlings have the potential to uptake the metals from the soil through the roots into the shoots. The higher concentrations of heavy metals observed in shoots of *Hildegardia barteri* seedlings than the roots agreed with the findings of Akintola et al (2021).

Table 1 – Concentration of PTEs in growing media before and after the experiment

Treatments	Experiment	PTEs in mg/kg				
		Zn	Cu	Pb	Co	Cr
T1: 2kg CS	Before	40.11	28.91	18.05	8.21	5.78
	After	15.35	15.62	10.48	3.62	2.94
T2: 1.5 kg CS +0.5kg IS	Before	43.75	30.01	20.26	9.99	7.66
	After	16.79	15.22	11.14	3.99	3.49
T3: 1.0kg CS +1.0 kg IS	Before	46.42	33.99	23.78	11.01	9.02
	After	18.82	17.97	14.07	5.52	5.09
T4: 0.5 kg CS +1.5kg IS	Before	48.29	37.11	26.24	12.66	11.81
	After	18.42	18.85	17.29	5.87	5.30
T5: 2kg IS	Before	58.21	43.29	28.11	15.85	14.11
	After	20.51	18.73	20.37	6.26	6.21
Recommended values in soils (Kabata-Pendias, 2000)		300	100	100	50	50

Note: CS - control topsoil; IS top soil collected from Industrial area.

Table 2 – PTEs concentration in roots and shoots of the seedlings

Treatments	Seedling'sparts	PTEs in mg/kg				
		Zn	Cu	Pb	Co	Cr
T1: 2kg CS	Roots	6.39b	5.66b	4..01b	1.22b	1.01b
	Shoots	9.27a	6.84a	4.17a	1.24a	1.02a
T2: 1.5 kg CS +0.5kg IS	Roots	7.01b	6.11b	4.21b	1.35b	1.I8b
	Shoots	9..95a	7.29a	4.37a	1.36a	1.19a
T3: 1.0kg CS +1.0 kg IS	Roots	8.56b	7.01b	4.89b	1.89b	1.71b
	Shoots	12.33a	8.27a	5.10a	1.92a	1.75a
T4: 0.5 kg CS +1.5kg IS	Roots	9.25b	7.22b	6.02	1.98	1.81
	Shoots	13.41a	8.81a	6.08	2.01	1.85
T5: 2kg IS	Roots	10.13b	7.25b	6.99	2.11	2.10
	Shoots	14.69a	8.92a	7.27	2.15	2.12

Note: Values of shoots and roots with different letters re significantly differ from each other at P≤0.05.

Table 3 – Bioaccumulations (BAF) and Translocation factors (TF) of PTEs in *Hildegardia barteri* seedlings

Treatments	Factors	PTEs in mg/kg				
		Zn	Cu	Pb	Co	Cr
T1: 2kg CS	BAF	1.02	0.80	0.78	0.68	0.69
	TF	1.45	1.21	1.01	1.02	1.01
T2: 1.5 kg CS +0.5kg IS	BAF	1.01	0.88	0.77	0.68	0.68
	TF	1.42	1.19	1.03	1.01	1.01
T3: 1.0kg CS +1.0 kg IS	BAF	1.11	0.85	0.71	0.69	0.68
	TF	1.44	1.18	1.04	1.01	1.01
T4: 0.5 kg CS +1.5kg IS	BAF	1.23	0.85	0.70	0.68	0.69
	TF	1.45	1.22	1.01	1.01	1.01
T5: 2kg IS	BAF	1.21	0.89	0.70	0.68	0.69
	TF	1.45	1.23	1.04	1.01	1.01

The bioaccumulation factor (BAF) and translocation factor (TF) of PTEs in *Hildegardia barteri* seedlings were shown in Table 3. The values of BAF were between 0.68 and 1.23 while TF values ranged from 1.01 to 1.48.). Plants with TF values > 1 are classified as high-potential, plants with TF< 1 are classified as low-potential plants for transfer of metal from the roots to shoots (Madanan *et al*, 2021). Also plants with BAF greater than I are classified as accumulators, while those with BAF values less than 1 are excluders (Akintola *et al*., 2021). Thus, BAF and TF showed that *Hildegardia barteri* seedlings can uptake the metals into their roots and transfer them into the shoot. The results have shown that heavy metals removal in soils depend on the capacity of the plants to take up the metals and transfers it into their shoots thus defend the soils and sustain the environment.

CONCLUSION

This study assessed the potential of *Hildegardia barteri* to accumulate toxic elements from the soil within the industrialized area. Reductions in the PTEs concentration in soils after the experiment indicate the accumulation of the metals by *Hildegardia barteri*. Bioaccumulation and Translocation factors of Zn, Cu, Pb, Cr and Co classified *Hildegardia barteri* as accumulator and high efficiency phytoextractor plants. This study has shown that *Hildegardia barteri* can accumulate substantial amount of the studied PTEs into their root and transfers it into their shoots. Thus, the planting of trees should be encouraged in the urban area particularly where there is contamination to reduce their impact on the environment.

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