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Phytoremediating Potentials of *Sida acuta and Duranta erecta* for Lead, Cadmium, Cobalt and Zinc

Anarado, C.E.[1], Anarado, C.J.O.[2], Agwuna, C.[3], Okeke, M.O.[4], Okafor, P.C.[5]

Department of Pure and Industrial Chemistry, Nnamdi Azikiwe University. P.M.B. 5025, Awka, Anambra State, Nigeria

Abstract: ***Recently pollution of the environment has gathered an increased global interest. In this respect, contamination of soils with heavy metals has always been considered a critical challenge in the scientific community . Remediation of soil contaminated by heavy metals is necessary in order to reduce the associated risks, make the land resource available for agricultural production, enhance food security, and scale down land tenure problems. Immobilization, soil washing, and phytoremediation are frequently listed among the best available technologies for cleaning up heavy metal contaminated soils but have been mostly demonstrated in developed countries. Non-edible African plants –Sida acuta and Duranta erecta were used to study the absorption of Cadmium, Lead Zinc and Cobalt from soils inoculated with the metal ions. 0.1M, 0.5M and 1M solutions of the metal ions were used in the inoculation. The Leaves, stems and roots of Sida acuta and the stems and roots of Duranta erecta were collected in the first instance at six weeks, and then, at ten weeks of planting. Atomic Absorption Spectrophotometer was used to determine the metal ion concentration in the plants' parts. Lead was more absorbed by Sida acuta than did Duranta erecta, with the highest absorption of 1.223mg/kg in the former occurring in the roots. Absorption increased as the concentration of the inoculant solution increased, and also on moving from 6 weeks' to 10 weeks' samples for concentrations less than 0.1M. Cadmium was the only absorbed by Sida acuta, with a highest value of 6.495mg/kg in the roots,. Duranta erecta was poisoned by Cd^{2+} in all concentrations. Zinc was more absorbed by Duranta erecta than did Sida acuta, with the highest absorption of 7.898mg/kg in the former occurring in stems. Absorption increased as the concentration of the inoculants solution increased. Cobalt was most absorbed by Sida acuta with the highest value of 9.354mg/kg found in the stem. Generally, Phytotoxicity was shown in the plants at inoculants concentration above 0.5M, after 6 weeks except for Duranta erecta inoculated with Zn^{2+}. The tolerance for Lead, Cadmium, and Cobalt by Sida acuta show a good promise for its phytoremediation and recovery.***

Keywords: *Phytoremediation ;Sida acuta; Duranta erecta*; Phytotoxicity; Lead; Cadmium; Cobalt, Zinc

On behalf of all authors, the corresponding author states that there if no conflict of interest

1. Introduction

One of the greatest problems that the world is facing today is that of environmental pollution, increasing with every passing year and causing grave and irreparable damage to the earth(Meagher, 2000).

Industrialization is considered vital to the nation's socio-economic development as well as its standing in the international community. Ideally, the siting of industries should achieve a balance between socio- economic and environment considerations(Mohammedand Folorunsho 2015).

In recent years, heavy metal contamination has become a serious problem all over the world as these metals persist in the soil for longer period due to their non biodegradability(Kavitha et al, 2013). Since the beginning of the industrial revolution, soil pollution by these toxic metals has accelerated dramatically and has contributed to a variety of toxic effects on living organisms. Soils as the major sink have been contaminated by heavy metals and metalloids through emissions from the rapidly expanding industrial areas, sewage sludge, pesticides, wastewater irrigation, coal combustion residues, spillage of petrochemicals, and atmospheric deposition (Raymond et al, 2011, Aremu et al, 2010). Heavy metal pollution of the soil is caused by various metals, especially Cu, Ni, Cd, Zn Cr and Pb(Singh and Kalamdhad, 2011).

Heavy metal contamination of soil may pose risks and hazards to humans and the ecosystem through: direct ingestion or contact with contaminated soil, the food chain (soil-plant-human or soil-plant-animal-human)(McLaughlin et al, 2000). Lead is a highly toxic metal whose widespread use has caused extensive environmental contamination and health problems in many parts of the world(Monisha et al, 2014). The decontamination of soil and wastes polluted with anthropogenic chemical is a global problem that has consumed considerable economic resources(Chambers et al, 1991, Watts, 1997, Baker et al, 1994).

Presently, phytoremediation has become an effective and affordable technological solution used to extract and remove heavy metal pollutants from polluted soil. Many species of plants have been successful in absorbing heavy metal pollutants such as lead, cadmium and others from the soil and water(Tangahu at al, 2011, Foluso et al, 2009, Amin et al, 2013, Otaru et al, 2013, Kavitha and Jegadeesan, 2014). The health risks posed by these metals have continued to be of global concern, and have made the European Union to place thirteen metals on the High-Risk-Monitor level. These include Arsenic, Cadmium, Cobalt, Chromium, Copper, Mercury, Manganese, Nickel, Lead, Tin, and Thallium.

Lead, Cadmium, Zinc and Cobalt have been used in this work to study the ability of two nonedible African plants – *Sida acuta and Duranta erecta* – to phytoremediate soils polluted with the metal ions in their +2 oxidation states.

2. Methods

Twenty five seedlings, each, of the two plants were grown on soils isolated in polyethylene pots. Forty eight pots were inoculated with 0.1M, 0.5M and 1.0M solutions of Pb^{2+}, Zn^{2+}, Co^{2+} and Cd^{2+}, while controls were left. The plants' parts were harvested after the sixth and eighth week of inoculation. The harvested plants were washed, dried, and ashed at 450°C. After digesting with concentrated HNO_3, Varian AA240 spectrophotometer was used to determine the metal ions concentrations absorbed in the plants' parts.

3. Results

Table 1: Concentration of Pb^{2+} absorbed by *Sida acuta* in mg/kg

Stem (Ss)	1st Harvest	2nd Harvest
Ss_1	0.397	0.496
Ss_2	0.489	0.634
Ss_3	1.108	Died

Root(SR)	1st Harvest	2nd Harvest
SR_1	0.417	0.523
SR_2	0.563	0.985
SR_3	1.223	Died

Leaf(SL)	1st Harvest	2nd Harvest
SL_1	0.358	0.405
SL_2	0.425	0.597
SL_3	0.713	Died

Table 2: Concentration of Pb^{2+} absorbed by *Duranta erecta* in mg/kg

STEM(Ds)	1st Harvest	2nd Harvest
Ds_1	0.251	Died
Ds_2	2.400	Died
Ds_3	Died	Died

Root(ER)	1st Harvest	2nd Harvest
DR_1	0.197	Died
DR_2	1.658	Died
DR_3	Died	Died

Table 3: Concentration of Cd^{2+} absorbed by *Sida acuta* in mg/kg

Stem (DS)	1st Harvest	2nd Harvest
Ss_4	1.423	2.004
Ss_5	4.001	Died
Ss_6	5.241	Died

Root(DR)	1st Harvest	2nd Harvest
SR_4	1.859	2.326
SR_5	4.510	Died
SR_6	6.495	Died

Leaf(DL)	1st Harvest	2nd Harvest
SL_4	0.921	1.675
SL_5	3.577	Died
SL_6	4.932	Died

Table 4: Concentration of Cd^{2+} absorbed by *Duranta erecta* in mg/kg

STEM(Ds)	1st Harvest	2nd Harvest
Ds_4	Died	Died
Ds_5	Died	Died
Ds_6	Died	Died

Root(DR)	1st Harvest	2nd Harvest
DR_4	Died	Died
DR_5	Died	Died
DR_6	Died	Died

Table 5: Concentration of Co^{2+} absorbed by *Sida acuta* in mg/kg

Stem (DS)	1st Harvest	2nd Harvest
Ss_7	7.421	Died
Ss_8	8.252	Died
Ss_9	9.354	Died

Root(DR)	1st Harvest	2nd Harvest
SR_7	6.089	Died
SR_8	6.595	Died
SR_9	8.074	Died

Leaf(DL)	1st Harvest	2nd Harvest
SL_7	6.853	Died
SL_8	7.532	Died
SL_9	8.901	Died

Table 6: Concentration of Co^{2+} absorbed by *Duranta erecta* in mg/kg

STEM(Ds)	1st Harvest	2nd Harvest
Ds_7	3.689	Died
Ds_8	4.725	Died
Ds_9	Died	Died

Root(DR)	1st Harvest	2nd Harvest
DR_7	2.142	Died
DR_8	3.986	Died
DR_9	Died	Died

Table 7: Concentration of Zn^{2+} absorbed by *Sida acuta* in mg/kg

Stem (Ss)	1st Harvest	2nd Harvest
Ss_{10}	2.347	2.418
Ss_{11}	2.515	2.663
Ss_{12}	4.441	Died

Root(SR)	1st Harvest	2nd Harvest
SR_{10}	2.409	2.434
SR_{11}	2.557	2.731
SR_{12}	4.520	Died

Leaf(DL)	1st Harvest	2nd Harvest
SL_{10}	1.857	2.001
SL_{11}	2.409	2.605
SL_{12}	3.713	Died

Table 8: Concentration of Zn^{2+} absorbed by *Duranta erecta* in mg/kg

STEM(Ds)	1st Harvest	2nd Harvest
Ds_0	3.252	3.970
Ds_{11}	3.754	5.078
Ds_{12}	7.571	7.898

Root(DR)	1st Harvest	2nd Harvest
DR_{10}	2.573	2.834
DR_{11}	2.975	3.422
DR_{12}	3.721	3.115

CODES: S- *Sida acuta*, D-*Duranta erecta*, s- stem, R- root, L- leaf, $_{1,4,7,10}$= 0.1M, $_{2,5,8,11}$= 0.5M, $_{3,6,9,12}$= 1.0M

4. Discussions

The result of the analysis generally showed that some African plants could be used to phytoremediate soil polluted with Pb^{2+}, Cd^{2+}, Co^{2+} and Zn^{2+}. Zinc was most absorbed by both plants. Lead was more absorbed by *Sida acuta* than did *Duranta erecta*, with the highest absorption of 1.223mg/kg in the former occurring in the roots. Absorption increased as the concentration of the inoculant solution increased, and also on moving from 6 weeks' to 10 weeks' samples for concentrations less than 0.1M. Phytotoxicity was shown in the plants at inoculants concentration above 0.5M, after 6 weeks for *Sida acuta*, and from time of planting to 10 weeks for *Duranta erecta*. Cadmium was the only absorbed by *Sida acuta*, with a highest value of 6.495mg/kg in the roots, *Sida acuta* could not tolerate Cd^{2+} as concentration of the inoculant solution increased, and also on moving from 6 weeks' to 10 weeks'. *Duranta erecta* was poisoned by Cd^{2+} in all concentrations. Zinc was more absorbed by *Duranta erecta* than did *Sida acuta*, with the highest absorption of 7.898mg/kg in the former occurring in stems. Absorption increased as the concentration of the inoculants solution increased. Cobalt was most absorbed by *Sida acuta* with the highest value of 9.354mg/kg *found in the* stem. Generally, Phytotoxicity was shown in both plants at inoculants concentration above 0.5M, after 6 weeks except for *Duranta erecta* inoculated with Zn^{2+}. The tolerance for Lead, Cadmium, and Cobalt by *Sida acuta* shows a good promise for its phytoremediation and recovery.

5. Conclusion

Soil is the fundamental foundation of our agricultural resources, food security, global economy and environmental Quality. The need to decontaminate the soils of heavy metals cannot be overemphasized. *Sida acuta and Duranta erecta* were used. It can be safely concluded that *sida acuta* has better phytoremediating potential for Pb^{2+}, Cd^{2+} and Co^{2+} than did *Duranta erecta*. *Duranta erecta* which cannot be used to phytoremediate Cd^{2+} had better phytoremediating potential for Zn^{2+}than did *Sida acuta*.

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