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Evaluation of Accumulation Ability for Pb, Cr, Ni, and Mn in Native Plants Growing on a Contaminated Air Force Shooting Range, Kaduna

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Abstract- The concentrations of Pb, Cr, Ni and Mn were determined in *Sida veronicifolia, Chrystanthelum americanum, Cassia rotundifolia* and *Borreria filifolia* samples using Atomic Absorption spectrophotometry at the Air Force shooting range, Kaduna. The heavy metals (Pb, Cr, Ni and Mn) concentrations in *Borreria filifolia* shoot were found to be (229.29 ± 0.03, 33.26 ± 0.00, 200 ± 0.01, and 142.51 ± 0.01 mg/kg respectively while those of *Sida veronicifolia* samples in shoot are 189.27 ± 0.04, 170.56 ± 0.03, 111.9 ± 0.04 and 158.71 ± 0.01 mg/kg respectively for Pb, Cr, Ni and Mn. In *chrystanthelum americanum* samples in shoot are found 112.31 for Pb, 41.14 ± 0.01 mg/kg for Cr, 176.64 ± 0.00 mg/kg of Ni and 228.80 ± 0.02 mg/kg of Mn. *Cassia rotundifolia* gave 112.23 ± 0.00 mg/kg for Pb, 41.09 ± 0.01 mg/kg for Cr, 176.56 ± 0.05 mg/kg for Ni while 228.71 ± 0.03 mg/kg in Mn. The translocation factor (TF) indicates that the plants accumulated these metals (Cr, Ni and Mn) more in the shoots than in the roots. *S. veronicifolia and B. filifolia* can be used to decontaminate soil contaminated with (Cr and Mn) studied because TF is greater than one (TF > 1) while other plants can only be used for decontamination of soil polluted with selected metals where (TF>1).

Keypoint: heavy metals, shooting range, translocation factor and native plants.

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Evaluation of Accumulation Ability for Pb, Cr, Ni, and Mn in Native Plants Growing on a Contaminated Air Force Shooting Range, Kaduna

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I. Introduction

Heavy metals are currently of much environmental concern globally. They are harmful to humans, animals and plants. The threat that heavy metals pose to human and animal health is aggravated by their long-term persistence in the environment. They are introduced into the environment through mining and smelting of metal ores, industrial emissions and applications of insecticides and fertilizers (Alloway, 1994). Pb has been found to be responsible for quite a number of ailments in human such as chronic neurological problems (Awofolu, 2005) and mental retardation in children (Huge *et al*., 1980). Pb, Sb, As and Ni are common contaminants in areas adjacent to the impact bern of military shooting ranges (Robinson *et al*., 2007). High exposure to chromium can cause spinal joints degeneration, depressed immune system and lymphatic swelling (Roth, 2009). Long term exposure to Ni can cause decreased body weight, liver damage, lungs and nasal sinus cancers and skin irritation. Manganese effect occurs in the respiratory track and in brain. Symptoms of Mn poisoning are hallucination, forgetfulness and nerve damage (Abdullahi, 2006).

The persistence of heavy metals in soils is a big environmental problem. This could have long-term implications for the biological, chemical and physical properties of agricultural and forest soil and its fertility as well as productivity (Nicholson *et al*., 2003). The heavy metals Cr, Cd, Pb, Ni, Cu and Zn take part in the biological turnover and their excess or lack of disturbance of the metabolism and inhibited vegetation (Adomaitis *et al.,*2000; Jaakkola, 1994). Metals may bioaccumulate in living organisms and be transferred into the food chain (Bogaert *et al*., 2000).

It is a confirmed fact that the major parts (75-80%) of heavy metals get into human organisms with vegetable diet when plants take it from the soil (Willaert *et al*., 1985).

Several technologies are available to remediate soils that are contaminated by heavy metals. However, many of these technologies are costly (e.g excavation of contaminated material and chemical/physical treatment) (Lorestani, *et al.,* 2011). The development of phytoremediation technologies for plant based cleanup of contaminated soil is therefore of significant interest (USEP, 2001). Phytoremediation is the use of plant to remove, detoxify or immobilize environmental contaminant in a growth matrix (soil, water or sediment) through the natural biological or chemical processes of plants (Curia *et al*., 2005). Several plants have been identified in the last two decades as highly effectively in absorbing and accumulating various toxic heavy metals. High heavy metal accumulating ability has been reported for cereal crops such as maize, sorghum and alfafa (*Medicago saliva L*) (Vijayarengan, 2005). Plants like Indian mustard, tobacco and spinach show high tolerance to heavy metals and are therefore used in phytoremediation studies (Schmidt, 2003, Tang *et al*., 2003).

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Military grounds are territories of specific purpose. Such areas have special stationary structures necessary for exercises, defence infrastructure; moreover exercises involving shooting real cartridges are held and heavy military war materials such as ammunitions and explosives are used there. Therefore soil in military grounds is very often polluted with heavy metals from spent bullets. These contaminations can create environmental and occupational health problems during range operation and maintenance.

Military training exercises lead to the release of heavy metals in the environment (Sanderson *et al.*, 2010, Johnson *et al*., 2005 and Robinson *et al*., 2008). It was reported that Air Force shooting range in Kaduna is contaminated with heavy metals as a result of shooting exercise (Nwaedozie *et al*., 2015). In this work therefore, some local plants (*Sida veronicifolia, Chrystanthalum americanum, Cassia rotundifolia and Borreria filifolia*) found growing in the shooting range were evaluated for their accumulation ability with a bid of using them as phytoremediators.

II. Materials and Method

a) Sampling

The plant samples used in this study were collected from the Nigerian Air Force shooting range located in Kaduna, Northern Western Nigeria. The entire area was divided into five (5) sections.

For sampling, four (4) different plants of each species, namely *S.veronicifolia, C. americanum*, *C. rotundifolia and B. filifolia* and three (3) samples of each plant species were collected at different points in a given section. Each plant sample was uprooted to include the roots and soil samples were also collected from the point of sampling. The samples were sorted according to species, collection points and labeled accordingly.

b) Plant Analysis

The plant samples were first separated into roots, stems and leaves, then washed with distilled water and oven dried at 70°C for 2hrs (Larry and Morgan, 1986). They were ground into fine powder sieved and stored in a labeled bottle until analysis. 0.5g of prepared plant samples were digested with 5.0cm^3 of concentrated $HN0_3$ and 5.0cm^3 of 70% $HCl0_3$ and placed on a hot plate for 5 minutes after which 20cm^3 of deionised water was added on cooling, the digest was filtered into 100.0cm^3 volumetric flask and made up to the mark with deionised water (Horwitz, 1980). Total concentrations of Pb, Cr, Ni and Mn in the prepared samples were determined by Shimadzu model Atomic Absorption spectrophotometer (AAS).

III. Results and Discussions

The Table 3.1 shows the mean total metal concentrations in plants in Air Force shooting range, Kaduna.

Table 3.1 : Heavy Metal Concentrations (mg/kg) in Plant Parts Collected at the Shooting Range of Air Force, Kaduna

Plant Species	Pb	Cr	Ni	Mn
S. veronicifolia$_{shoot}$	189.226±0.04	170.56±0.03	119.906±0.04	158.706±0.01
S. veronicifolia$_{root}$	52.422±0.04	137.358±0.04	129.692±0.04	57.818±0.04
C.rotundifolia$_{soot}$	112.226±0.00	41.086±0.01	176.562±0.05	228.71±0.03
C.rotundifolia$_{root}$	172.432±0.04	18.522±0.00	129.294±0.04	27.968±0.04
C.americanum$_{shoot}$	112.306±0.04	41.14±0.01	129.344±0.00	228.80±0.02
C.americanum$_{root}$	172.476±0.04	18.572±0.04	129.344±0.02	28.01±0.00
B. filifolia$_{shoot}$	229.29±0.03	33.26±0.00	200.00±0.01	142.51±0.01
B. filifolia$_{root}$	241.47±0.00	12.878±0.01	65.262±0.03	61.292±0.04
H. annus$_{shoot}$	500.31±0.06	25.11±0.01	41.28±0.03	423.12±0.02
H. annus$_{root}$	2213.85±0.04	21.01±0.04	16.15±0.00	103.385±0.04

Key: *SV = S. veronicifolia, CR = C. rotundifolia, CA = C. americanum, HA = H. annus*

The Table 3.1 showed that SV accumulated Pb, Cr and Mn more in the shoot than in the root while BF contained Cr, Ni and Mn higher in the shoot than in the root. The same pattern was observed in the case of CR and CA with more Ni and Mn in the shoot than in the root. This may imply that these metals absorbed by the plants are not stored in the root but fairly distributed to all parts of the plants. CA, CR and BF showed deviation in the accumulation of Pb where it is accumulated more in the roots than in the shoot. This implied that most of the Pb absorbed by CR, CA and BF from soil is stored in the roots and lesser percentage is transported to the shoot. This is same for absorbed Ni by SV. *H. annus* the control plant accumulated Pb, Cr, Ni and Mn more in the shoot than in the root. In 95% of the plant samples, the root Pb concentration were much greater than those of shoot Pb contents, indicating low mobility of Pb from the roots to the shoots and immobilization of heavy metals in the roots. This pattern was in agreement with observation of Yoon *et al*., 2006.

The results of translocation factor (TF) for all the heavy metals are reported in Table 3.2 below.

Table 3.2 : Translocation factor of SV, CR, CA and BF for Heavy Metals (Pb, Cr, Ni and Mn) in the native plants

Plant Species	Pb	Cr	Ni	Mn
S. veronicifolia	3.610	1.242	0.863	2.745
C. americanum	0.651	2.238	1.366	8.169
C. rotundifolia	0.651	2.218	1.365	9.178
B. filifolia	1.951	2.215	0.410	2.325
H.annus (Control)	1.678	1.195	2.500	4.077

The translocation factor values for heavy metals are presented on Table 3.2. The TF values for metals within the plants were calculated as the concentration of the metals in the shoot divided by the concentration in the root (Baker and Brooks, 1989). The TF highest for Pb was 3.61 for SV and lowest 0.651 for CA and CV. The TF values were greater than one for Pb in SV and BF; SV, CA, CR and BF for Mn. The control result (*H.annus*) shows TF greater than one for all the plants. A plants ability to translocate metals from the roots to the shoots is measured using the TF. TF greater than one represents that translocation of metals effectively was made to the shoot from the root (Baker and Brooks, 1989). The data presented indicate that metals (Cr and Mn) accumulated by plants species (SV, CA, and CR) were largely transported to the shoots from the roots as shown by general TF values which is greater than one (Table 3.2). Exceptions occurred in SV for Ni (TF<1), CA for Pb (TF<1) and BF for Ni (TF<1).

All the four plants studied have both TF greater than one for Cr and Mn. Therefore these plants can be used to remove these metals from the environment.

IV. Conclusion

Based on the results obtained in this study, it can be concluded that:

- All the plants studied (*S, veronicifolia, C. rotundifolia, C. amricanum and B. filifolia)* can be suitable phytoremediator for Cr and Mn.

References Références Referencias

1. Abdullahi, A. D., (2006). Heavy metals determination in soil samplesin Nigeria Defence Academy, Kaduna, Nigeria. Upublished NDA, BSc Project.
2. Adomaitis, T, Mazvilla, J and Eitminavicius, L (2000). A comparative study of heavy metals in the soiols of cities and arable lands. Ekologija, Vilnius, 3, 12.
3. Alloway, B., J (1994). Toxic metals in soil plant systems. John Wiley and Sons, Chichester,UK.
4. Ciura, J., Poniedzialek, M, Sekara, A. and Jedrszezyk, E., (2005). The possibility of using crops as metal phytoremediators. Polish Journal of Environmental Studies, 14 (1): 17-22.
5. Baker, A.J.M and Brooks, R..R (1989). "Terrestrial higher plants which hyperaccumulate metallic elements". A review of their distribution, ecology and photochemistry. *Biorecovery* 1:81 – 126.
6. Bogaert, N, Du Laing, G, Tack, F, Verloo, M.G, Hendrickx, F, Maelfait, J.P and Mertens, J (2000). Heavy metal transfer in terrestrial ecosystems. Nriagu, Jerome 11th Annual International Conference on Heavy Metals in the Environment Contribution 1392. Ann Arbor, MI, University of Michigan, School of Public Health.
7. Huges, M. K., Lepp, N. W. and Phips, D. A (1980). Arial heavy metal pollution and terrestrial ecosystem. Advance Ecol. Research 11: 217-225.
8. Horwitz, Z. W. (1980). Official Methods of Analysis (13thEd). *Association of Analytical Chemists*, Washington D.C. pp871-878.International Potash Institute, Bern.
9. Jaakkola, A (1994). Importance of Various Trace Elements in crop Growth and Crop quality. In: Trace, Elements in Soils and Plants Research Methodology, Agriculture Research Centre of Finland, Jokioionem, p1-6.
10. Larry, R. W., and Morgan, J. T., (1986). Determination of Plant Iron, Manganese, and Zinc by wet digestion procedures. *J. Food Agric*., 37: 839-844.
11. Lorestani, B., Cheraghi., M and Yousefi, N (2011). Accumulation of Pb, Fe, Mn, Cu and Zn in choice of hyperaccumulator plants in industrial town of Vian, Iran. Arch. Biol Sci., Belgrade, 63 (3), 739-745.
12. Nicholson, F.A, Smith, S.R, Alloway, B.J, Carlton-Smith, C Chambers, B.J (2003). An inventory of heavy metals input to Agricultural Soils in England and Wales. The Science of the Total Environment, 311(1-3), 205.
13. Nwaedozie, G. C., Mohammed, Y., and Faruruwa, M.D., (2015). Evaluation of Some Heavy Metals (Pb, Zn, Cu and Sb) in soil and plants collected in Air Force shooting range in Kaduna, Nigeria. International Journal of Engineering and Innovation and Research, volume4, Issue 4, ISSN: 2277-5668.
14. Robinson, B, R., Bischofberge, S., Stoll, A., Schroer, D., Furrer, G. J., Roulier, S., Gruenwald, A., Attinger, W., and Schulin, R. (2008). Plant uptake of trace elements on a Swiss Military Shooting Range. Uptake pathways and land management implications. *Environmental Pollution* 153, 668- 676.
15. Robinson, B, R., Bischofberge, S., Stoll, A., Schroer, D., Furrer, G. J., Roulier, S., Gruenwald, A., Attinger, W., and Schulin, R. (2007). Elsevier Ltd. All rights reserved.

16. Roth, R., (2009). Acu-cell nutrition: Copper and Chromium. Ryan, T. A. and Scheckel, K, G (2004). Peer Reviewed: Reducing Children'Risk from soil. *Environmental Science and Technology 38,* 18A-24A.
17. Sanderson, P, Bolan, N., Bowman, M., and Naidu, R. (2010). Distribution and availability of metal contaminant in shooting range soil around Australia. 19th World Congress of Soil Science, Soil Solution for a Changing World Brisbane, Australia. Accumulation and leaching of heavy metals. J. Environ. Qual, 32, 1939-1954.
18. Schmidth, U. (2003). Enhancing phytoremediation: The effects of chemical soil manipulation on mobility, plant
19. Tang, S., Xi, L., Zhang, J and Li, H (2003). Response to elevated CO_2 of India Mustard and sun flower growing on copper contaminated soil. Bull. Environ Contam Toxicol 71: 988-997.
20. USEPA, (2001). A Citizen's guide to phytoremediation. Washington DC, USA: EPA 542-F.01002.
21. Vijayarengan, P. (2005). Nitrogen and Potassium Status of green gram (Viana radiate) cultivar under nickel stress. Nature environ. Pollut. Tech. 4: 65-69.
22. Willaert, G, Verloo, M, and Cottenie, A (1985). Effect of soil characteristics and the chemical form of heavy metals on their uptake by plants. SCOPE Belgium- Proceedings "Metal cycling in the environment", Brussels pp 229-244.
23. Yoon, J., Cao, X., Zhou, Q, and Ma, L., O (2006). Accumulation of native plants growing on a contaminated Florida site. Sci of Total Environment 368: 456-464.