Comparative Assessment of Heavy Metals Loads in the Shoot of Selected Tree Plants and their Accumulation Potential in Kazaure, Jigawa Nigeria

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Abstract: The environment is often beautified by the presence of tree plants which consist of the shoot and the root. These plants contain organs often referred to as above ground organs (shoot) and below ground organ (root). In this study, the plant organs of five different plants including Adansoniadigitata, Anacardiumoccidentale, Azadirachtaindica, Eucalyptus globulus, and Parkiabiglobosa were sampled to investigate the levels of cobalt (Co), chromium (Cr), copper (Cu), iron (Fe), manganese (Mn), nickel (Ni), lead (Pb) and zinc (Zn). The sampled parts were transported in polythene bags to the laboratory where they were sorted, pretreated, stored and digestedwith10 cm^3 of 6M nitric acid. The digested samples were subjected to analysis using atomic absorption spectrophotometry to determine the heavy metals (HMs). The results revealed that all the above ground organs of these plants accumulated HMs at varying levels. The leaf samples of the all tree plants accumulated higher concentrations of the HMs than the bark samples except in P. big lobosa (7.07 ± 0.42 mg/Kg, Co [leaf]; 14.10 ± 0.62 mg/Kg, Co [bark]). The results revealed that the leaves portion contained more of the essential heavy metals (EHMs) than the bark samples of the tree plants. A. indica has the highest bio-indication potential while E. globulus exhibited the least potential based on the above ground organs analysis. The translocation factors of the NHMs (Cr and Pb) were below unity. The translocation factors well above unity suggest better phytoextraction capability of the tree plants. All the plants potentially accumulated the metals at varying levels irrespective of the different geographical locations, morphological and biomass variations of the tree plants.

Keywords: Tree plants, Heavy metals, Bio-accumulation, Arid region, Environment

I. Introduction

In the recent years, the use of higher plant organs above ground such as leaves, barks of stem, seed, fruits as biomonitors for atmospheric heavy metal pollution has been on the rise most especially in urban and suburban areas (Adesuyi*et al*, 2018). Heavy metals (HMs) may be classified as essential and non-essential heavy metals (NHMs). Essential heavy metals (EHMs) are micronutrients necessary for the growth of the plants. Examples of EHMs include Co, Cu, Mn, Mo, Fe, Se and Zn. Non-essential heavy metals (NEHMs) such as (Pb, and Cr) possess unknown viable biological feature but rather exercise their toxic nature by competing with EHMs over active enzyme sites. In contrast, EHMs may pose devastating effect to the environment if the level of exposure is significantly high (Bonanno*et al.*, 2017). The indiscriminate discharge of these metals and other particulates into the environment constitute air pollution thereby changing the natural composition of the environment, the resultant of which disturb the ecosystem. (Zhian and Farhad, 2018) Some of the sources of HMs or activities that led to the release of these metals into the environment include anthropogenic activities like steel and iron industry, mining, smelting procedures, traffic, and agricultural activities (Zhian and Farhad, 2018), urban development, generation of electricity (Bonanno*et al.*, 2017). On the other hand, the natural sources of HMs, often emanate from rocks, ore minerals, volcanoes, and release of metals during weathering leading to soil formation (Bonanno*et al.*, 2017).

Heavy metals (HMs) have had a direct or indirect negative effect on the environment at large. Researchers have reported that excessively high levels of HMs can pose severe threat to biodiversity by degrading air and water quality in many ecosystems (Harun*et al.*, 2021). Plants role in pollution studies cannot be overemphasized. Ordinarily, plants filter these toxic HMs that constitute air pollution from whatever sources of their production. On discharging these HMs into the environment, the plants uptake them via their above ground tissues (bark of stem and leaves) by sorb and metabolize the accumulative and non-biodegradable HMs. The uptake of these hazardous HMs by plants paves way for heavy metal infection in the life cycle of the plant, especially when present in largely excess levels that may threaten the existence of the plants (Zhian and Farhad, 2018). Among all the above ground tissues available in plants, the leaf is gravely affected by atmospheric heavy metals load for being the most sensitive portion and the site for major physiological processes (Naima*et al.*, 2010). Biomonitoring is an approach that enables the utilization of living things to be deployed in monitoring and evaluation of the aftermath of various contaminants in a given area. Usually, findings about loads of life threatening HMs in the environment can be ascertained by analyzing different parts of plant tissues including the root, bark of stem, leaf, flower, seed and shell. Monitoring of environmental contaminants via this route is no doubt easy and cheap to accomplish (Harun*et al.*, 2021). Restoration, monitoring and management of any undulating ecosystem may be enhanced if the spread of HMs levels in plant tissues in arid regions are known.

Unveiling the relationship between a particular plant species and a given heavy metal could aid the implementation of planned environmental engineering applications targeted at reclaiming the natural functions of affected plants in the arid ecosystems. This will in turn enhance afforestation of arid habitats (Bonanno*et al.*, 2017). However, works comparing the distribution of HMs among tree plants in arid regions are largely scarce. The capacity of tree plants to accumulate HMs differs from one species to another and carrying out comparative studies among different species available in Kazaure LGA may assist in identifying general and specific patterns in tree plant species from the same ecological region. Some of the tree plants used in the present study include *Adansoniadigitata, Anacardiumoccidentale, Azadirachtaindica, Eucalyptus globulus,* and *Parkiabiglobosa.*

*Adansoniadigitata*a curious shaped medium sized, deciduous tree belongs to Bombacaceae family. African baobab as is popularly called. It is also referred to as dead rat tree, lemonade tree, monkey tamarind and upside down tree. Eight species constitute *Adansonia*genus and is native to tropical Africa. The tree is usually massive, with a cylindrical and abruptly bottle-shaped and buttressed trunk measuring about 10m in diameter. Baobab generally produces leaves during the rainy season and shed their foliage during the dry season to reduce moisture loss (Sundarambal*et al.*, 2015; DonatienKaboré, *et al.*, 2011). This plant is multi-purpose in its applications. Various parts of the plant can serve as domestic usage and source of earning income. The bark of baobab is usually smooth, reddish brown to grey, soft and fibrous. It is locally called “Kuka” (Donatien Kaboré, *et al.*, 2011).

Anacardiumoccidentale L., the cashew tree, is a member of the Anacardiaceae plant family, with height reaching 15m. There are 76 genera in the Anacardiaceae family, grouped into five tribes, with over 600 species. The cashew tree is native to Brazil and could also be found in tropical countries like Nigeria. The tree can resist a variety of harsh conditions, but not cold frost. The nuts which are the true fruits are employed in confectionaries, with high nutritional values and containing minerals such as sodium, magnesium, phosphorus, potassium, copper, zinc, iron and calcium. The bark, leaves, and nuts of cashew tree offers a long range of therapeutic properties (Doniya and Ashoka2022).

Azadirachtaindica often referred to as neem tree (Imam *et al.,* 2012), is regarded as drugs store due to its therapeutic activities. Neem is native to India and can equally be found in tropical and sub-tropical regions across the globe. It is a member of *maliceae* family (Innocent *et al.*, 2021). Numerous biological activities do occur in different non-woody parts of neem plant like fruits, seed, flower, leaf, bark and root (Oscar *et al.*, 2019). The tree is about 40-50 feet or more, bearing a straight trunk and long spreading branches forming a broad round crown. The bark of neem plant is rough dark brown bark with wide longitudinal fissures separated by flat ridges. The leaves of neem plant are compound in nature and they alternate with one another (Imam *et al.,* 2012). Neem plant is locally known as “dogonyaro” (Innocent *et al.,* 2021).

Parkiabiglobosa tree is known as African locust bean. It is a wild legume that contains numerous nutritional components. The fermented form of the locust bean is named iru by the Yorubas of south western Nigeria and dawadawa by the Hausas of northern Nigeria. (Omolara and Ibrahim, 2014). The matured fruits from this tree are highly valuable. Pulp and grains obtained from the matured fruits are rich in minerals and can be processed into edible foodstuffs. It also has a large range of medical related features (Touré*et al, 2022*). *Eucalyptus globulus belongs to the* family-My rtaceae and are known as blue gum in English. Their breakthrough is from Australia. They are one the tallest trees on earth and often grow into large sizes in their natural ecosystem. Blue gum eucalyptus found a number of uses in landscaping, pulping, production of electric poles, fuel, wind brakes, while the leaves and stem bark are highly medicinal (Ekhuemelo*et al.,* 2017). The five plants used in the present study may not possess the same accumulating potential for the HMs in the kazaure environment. This study may unveil this differential among the selected five tree plants. Also, according to Shrrog, 2019, the selection of plants is very pertinent in environmental pollution treatment programs in affected areas because some plants, tree plants inclusive have the ability to accumulate HMs in different plant tissues or organs more than others.

The specific object of the present work is to analyze the levels of Co, Cr, Cu, Fe, Ni, Mn, Pb and Zn in the above ground organs of five tree plants *A. digitata, A. occidentale, A. indica, P. biglobosa, E. globulus* found in kazaure LGA Jigawa State. This study also aimed at x-raying the role of ecology, anthropogenic activities in influencing the levels of HMs in arid tree plants, and to assess the biomonitoring potential of the targeted tree plants.

II. Materials and Methods

Reagents and equipment

Chromium (III) trioxonit rate (V) (60.5%), cobalt chloride (98%), lead chloride (99%), manganese tetraoxosulphate (VI) (97%) and zinc trioxonit rate (V) (≥99%) employed in the production of standard solutions were all obtained from Sigma-Aldrich (St. Louis, USA). Copper (II) tetraoxosulphate (VI), nickel chloride and iron (III) trioxonitrate (V) nonahydrate used for the preparation of standard solutions were purchased from Fluka (Durban, South Africa). Trioxonitrate (V) acid (95-97%) bought from Friendemann Schmidt (Parkwood, Australia) was used for digesting the samples. The drying of the leaves and bark samples was conducted in an oven (Asturias, Spain). Desiccator (Enigma Business Park, UK) is employed to provide temporary air-tight storage for the prepared samples prior to digestion. Furnace (Waltham, USA) aided the ashing of the samples. Elemental determination was performed using atomic absorption spectrophotometer, AAS (model Perkin Elmer 3110) (Massachusetts, USA). The grinding of the leaves and barks samples were accomplished with the aid of pestle and mortar (Oregon, USA). Other chemicals are of qualitative analytical grade. Deionized water was used to prepare the aqueous solutions.

Study Areas

Two locations were used as sampling sites in Kazaure (Nigeria) for the purpose of this present study. These sites are tagged site A and B. Site A is a botanical garden housed in the department of Science Laboratory Technology, School of Science and Technology, Hussaini Adamu Federal Polytechnic, (HAFED POLY) Kazaure (Fig. 1). The botanical garden has a vast array of tree plants. On the other hand, site B is also a garden in the premises of Federal Government Girls College, (FGGC) Kazaure, with a collection of varieties of tree plants (Fig.2). These sites are characterized with varying degrees of human impact as a function of anthropogenic activities, such as vehicular emissions, pollution from street frying of potatoes, beans cake and yam, roasting of fish, chicken, maize and meat and farming. The natural impact is also evident like blowing of winds on the tree plants and rainfall. Anthropogenic activities are more pronounced in site A over site B. the reverse is the case for the impact of natural events. The coordinates of Site A and site B is ($12^0 38'04.8''$ N, $8^0 25'17.2''$ E) and (N, E) respectively.

Fig. 1 Site A: HussainiAdamu Federal Polytechnic, (HAFED POLY) Kazaure

Fig. 2 Site B: Federal Government Girls College, (FGGC) Kazaure

Sample collection and treatment

Samples of leaves and barks wereobtained during the months of July, August and September 2023 from different locations in Kazaure local government area of Jigawa State. Ten samples of each tree plant leaves and barks were gathered for analysis. Samples of leaves and barks from each tree plant were collected at varying distances from one another by hand clipping at breast height and above to a maximum height of 2 metres from the ground. These sampled portions of various plants were placed in plastic bags, labeled and transported to the biological laboratory of the department of Science Laboratory Technology, HussainiAdamu Federal Polytechnic, Kazaure where they were authenticated by a botanist, Rabi RabiuAbubakar. The samples were then sorted and dregs discarded. The sorted samples were air dried in the open, ground into powder and sieved to obtain fine powder of what particle size (d >250µm). Each powdered samples (23g) were weighedinto $100cm^3$ beaker of known weight and oven dried at a temperature of 105^0C until a constant weight was reached. Each sample (20g) was stored in an air tight container. Sample solution was prepared by digesting 10g of each sample which has been ashed at 550^0C using $10cm^3$ of 6M nitric acid. The mixture was filtered into $50cm^3$ volumetric flasks and de-ionized water was added up to the mark (Fowotade, 2005). The solutions were analyzed for Mn, Zn, Pb, Cr, Co, Ni, Cu and Fe, using atomic absorption spectrophotometer at 2000^0C (Model Perkin Elmer 3110). A procedural blank and a set of standard for each element were determined each time a series of samples were run. Average readings of the samples were corrected with the blank reading and a calibration curve was constructed for each standard solution. The concentrations of each element under investigation in parts per million (PPM) were determined from the curve of its standard by interpolation.

Statistical Procedure

The analysis employs values of concentration of HMs to determine translocation factors (TF) which aided the assessment of elemental mobility in the studied tree plants.

Translocation factors (TF):

$$C_{leaf}/C_{bark}$$

$$C_{bark}/\ C_{leaf}$$

Where C_{leaf} and C_{bark} are, respectively, concentration (mg/kg) of a given HMs in leaves and stem barks of the tree plant species. All plant species studied possess both leaves and bark. TF expresses the mobility of a given element within the plant species, where higher TF values result in a greater translocation capability.

III. Results and Discussion

All the tree plants revealed varying loads of heavy metals present in their locations (Table 1). However, the leaves of *A. indica* and *A. occidentale*, followed by *A. digitata* and *E. globulus* indicated higher bio-accumulation potential. In contrast, the accumulation potential of *P. biglobosa* was restricted to Fe, Co, Mn and Zn in the leaf samples. The accumulation potential was more prominent in the bark samples of *A. occidentale* and *A. indica,* trailed by *P. biglobosa* and *A. digitata.* The accumulation capacity of *E. globulus* bark samples was limited to Co, Fe and Mn. Across the arid region of Kazaure Local Government Area (LGA), the load of Fe is the highest while Cu is the least considering the leaves and bark samples of all assayed tree plants.

The results for translocation of HMs within plants (TF) indicated significant differences in metallic loads between different tree plant species and for different elements (Tables 2 and 3).

Table 1 Concentration (mean values ±SD) of heavy metals (mg/kg) in above ground organs

Tree plant	Organs	Co	Cr	Cu	Fe	Mn	Ni	Pb	Zn
A. digitata	Leaf	12.03 ± 0.20	12.57 ± 0.60	5.03 ± 0.12	82.57 ± 0.60	46.10 ± 0.26	2.03 ± 0.21	2.07 ± 0.15	23.63 ± 0.15
	Bark	21.30 ± 1.10	0.85 ± 0.01	12.50 ± 0.30	37.30 ± 0.90	25.20 ± 0.75	6.30 ± 0.95	4.20 ± 0.92	20.20 ± 1.06
A. occidentale	Leaf	10.10 ± 0.26	4.07 ± 0.15	0.50 ± 0.03	125.07 ± 1.90	49.10 ± 0.85	4.01 ± 0.12	2.03 ± 0.31	20.10 ± 1.51
	Bark	14.30 ± 0.96	12.53 ± 0.95	0.45 ± 0.10	150.20 ± 1.11	31.10 ± 1.10	4.20 ± 0.80	10.20 ± 0.92	1.52 ± 0.09
A. indica	Leaf	9.50 ± 0.17	0.80 ± 0.12	2.00 ± 0.10	200.13 ± 1.03	8.07 ± 0.51	0.70 ± 0.13	5.03 ± 0.90	16.50 ± 0.14
	Bark	10.20 ± 0.92	12.51 ± 1.00	0.25 ± 0.10	138.20 ± 0.85	44.20 ± 0.85	2.20 ± 0.95	4.13 ± 1.03	2.65 ± 0.10
E. globulus	Leaf	16.07 ± 0.32	6.50 ± 0.17	2.50 ± 0.09	57.03 ± 0.21	43.07 ± 0.51	2.03 ± 0.40	3.02 ± 0.82	22.50 ± 0.14
	Bark	7.10 ± 0.82	0.80 ± 0.05	3.07 ± 0.61	40.07 ± 0.91	16.03 ± 0.80	5.07 ± 0.51	5.07 ± 0.32	5.10 ± 0.53
P. biglobosa	Leaf	7.07 ± 0.42	2.03 ± 0.29	1.07 ± 0.15	67.50 ± 0.06	8.07 ± 0.81	0.30 ± 0.15	4.07 ± 0.51	11.10 ± 0.62
	Bark	14.10 ± 0.62	6.07 ± 0.71	0.50 ± 0.30	100.10 ± 0.85	40.10 ± 0.53	5.07 ± 0.91	2.03 ± 0.31	4.07 ± 0.61

The translocation factor expresses the mobility of HMs within for the different elements as well as within the different tree plants. The results revealed the values of mobility in both the leaf region and bark region of the tree plants. The mobility values for specific HM in the leaf region varied appreciably for the different elements (minimum of 0.410 for Ni and maximum of 5.550 for Zn). On the contrary, the translocation factors in the leaf region for different tree plants were within a relatively narrow range (minimum value of 1.078 in *P. biglobosa* and maximum value of 2.590 in *E. globulus*) (Table 2). On the other hand, the values of mobility in the bark $(Cbark/Cleaf)$ were largely varied with respect to specific HM (least amount of 0.338 in Zn, highest amount of 5.296 in Ni) (Table 3). The implication of translocation is to get the HMs especially the EHMs to the locations where they will be useful or converted to useful end products for the growth and well-being of the tree plants. The restricted TF thus observed in the leaves samples compared to the bark samples suggest that the leaves are centers for photosynthetic activities in the shoot part of the tree plants.

Table 2 Leaf/bark translocation factor (C_{leaf}/C_{bark}) for the tree species

HMs	*A. digitata*	*A. occidentale*	*A. indica*	*E. globulus*	*P. biglobosa*	Mean
Co	0.56	0.71	0.93	2.26	0.50	0.992
Cr	14.79	0.32	0.06	8.13	0.33	4.726
Cu	0.40	1.11	8.00	0.81	2.14	2.492
Fe	2.21	0.83	1.45	1.42	0.67	1.316

Mn	1.83	1.58	0.18	2.69	0.20	1.296
Ni	0.32	0.95	0.32	0.40	0.06	0.410
Pb	0.49	0.20	1.21	0.60	2.00	0.900
Zn	1.17	13.22	6.23	4.41	2.72	5.550
Mean	2.721	2.365	2.298	2.590	1.078	

Table 3 Bark/leaf translocation factor (C_{bark}/C_{leaf}) for the tree species

HMs	*A. digitata*	*A. occidentale*	*A. indica*	*E. globulus*	*P. biglobosa*	Mean
Co	1.79	1.41	1.08	0.44	2.00	1.344
Cr	0.07	3.13	16.67	0.12	3.03	4.604
Cu	2.5	0.90	0.13	1.23	0.47	1.046
Fe	0.45	1.20	0.69	0.70	1.49	0.906
Mn	0.55	0.63	5.56	0.37	5.00	2.422
Ni	3.13	1.05	3.13	2.50	16.67	5.296
Pb	2.04	5.00	0.83	1.67	0.50	2.008
Zn	0.85	0.08	0.16	0.23	0.37	0.338
Mean	1.423	1.675	3.531	0.908	3.691	

The significance of calculating the mean translocation of different tree plants is to show the disparity of TF within a specific plant and across the different plant species (Table 2 and 3).

One of the criteria for selecting the tree plants species as bio-accumulator for HMs is their ability to differentiate soil borne HMs from airborne HMs and the present study keyed into that proposition (Miri*et al.*, 2017). Usually the above ground organs in tree plants are capable of dual source of accumulating HMs such as air borne (particulate matters, PMs in the atmosphere) and soil borne (root uptake) (Harun*et al*., 2021). Majority of HMs are soil borne, while few HMs are air borne. The criterion for such distinction is their concentration, which is a function of their translocation factor or mobility factor. The present study reveals that *A. digitata* leaves sample accumulated HMs in the following order, Fe >Mn> Zn > Cr > Co > Cu >Pb> Ni. The load of Pb and Ni in the leaves of *A. digitata*is approximately 2.0 mg/kg each, while that of Cr and Co were approximately in the range 13.0 – 12.0 mg/kg (Table 1). Also, *A. digitata* bark accumulated HMs as follows Fe >Mn> Zn > Co > Cu > Ni >Pb> Cr. The least concentrated HMs in *A. digitata* bark is Cr (0.85 mg/kg). Considering these outcomes, *A. digitata* leaves and bark unveiled the same trend for HMs, Fe, Mn and Zn but different trend for the remaining five HMs. The loads of Co, Cu, Ni and Pb are more in *A. digitata* bark than the leaves. The reverse is the case for Cr, Fe, Mn and Zn in which the leaves concentrated more of these HMs over the barks. The outcome of the present findings on the organs of *A. occidentale* relays the following order of HMs accumulation; Fe >Mn> Zn > Co > Cr > Ni >Pb> Cu (leaves) and Fe >Mn> Co > Cr >Pb> Ni > Zn > Cu (barks). The load of Cr and Ni in *A. occidentale* is approximately 4.00 mg/kg. Cu is the least concentrated metal in both organs of *A. occidentale*(Table 1). The leaf of *A. occidentale* can be said to have high bio-accumulation potential for Fe, Mn and Zn, while the bark exhibited high bio-accumulation potential for Fe, Mn and Co. Both organs in *A. occidentale* revealed low bio-accumulation potential towards Cu. On the part of *A. indica*the loads of the specific HMs is as follows; Fe > Zn > Co >Mn>Pb> Cu > Cr > Ni (leaves) and Fe >Mn> Cr > Co >Pb> Zn > Ni > Cu (bark) (Table 1). The load of Cr and Ni in *A. indica* leaves approximates to unity (1.00 mg/kg), while both metals recorded least levels in the leaves. The bark of *A. indica* accumulated divergent values for Cr (12.51 mg/kg) and Ni (2.20 mg/kg) with Cu having the lowest load. The present findings also indicate the order of HMs' levels in *E. globulus* as Fe >Mn> Zn > Co > Cr >Pb> Cu > Ni (leaves) and Fe >Mn> Co > Zn > Ni = Pb> Cu > Cr (bark). The levels of Ni, Pb and Zn in *E. globulus* bark is approximately 5.00 mg/kg, while there is no such semblance in *E. globulus* leaves, though the difference between the levels of Ni and Pb in the leaves is unity. The results equally unveil the following order of HMs accumulation in *P. biglobosa* as follows; Fe > Zn >Mn> Co >Pb> Cr > Cu > Ni (leaves) and Fe >Mn> Co > Cr > Ni > Zn >Pb> Cu (bark) (Table 1). The Cu load in the leaves and bark of *P. biglobosa* is approximately unity (1.00mg/kg). The order of accumulation of HMs is similar in the organs of both *A. digitata* and *E. globulus*. This is due to the location of the two tree plants, the premises of Federal Government Girls College (FGGC) Kazaure. Also the organs of *A. occidentale, A. indica*and *P. biglobosa*revealed almost the same order of HMs accumulation due to their location in Kazaure LGA (HussainiAdamu Federal Polytechnic, Kazaure). Cr is a toxic NHMs usually present in agricultural soils due to anthropogenic or natural activities. Chromium may exist in the form of Cr (III) or Cr (VI) in the soil with latter being the most hazardous form to the living component of the ecosystem (Ali *et al.*, 2023). This implies that Cr is more of soil borne than air borne. However, the prevalent mechanism for the uptake of Cr is dependent on carriers of essential anions like sulphate. Competition over carrier binding with Cr is equally observed from iron, sulphur and phosphorus

(Shanker*et al.*, 2005). The results of the present study agreed with the submission of Shanker*et al.*, (2005) as the accumulation of Fe is proportional to that of Cr in the all the organs of the tree plants with the exception of organs of *A. indica*. Additionally, the load of Cr reported in this finding is very low compared to the estimated permissible limit of 64 mg/kg in soiland 1.60 mg/Kg in plants (Ali *et al.*, 2023). As for the other toxic NHM (Pb), its movement in plant is highly limited thus a meager quantity may be available for root uptake. This implies that the tree plants are accessible to air borne Pb (Harun*et al.*, 2021). This foregoing fact is corroborated in the present study as both organs across all sampled tree plants bio-accumulated Pb at almost the same level. The difference in the amount of loads of Pb reported for both locations under study is as a result of high trafficking of automobiles along Kazaure-Kano highways where HAFED polytechnic was located as compared to the low traffic in the vicinity of FGGC. According to Farouk and Muhammad (2018), lead and its derivatives can be obtained through leaded gasoline from automobiles, printing press and leaded paint. All these occupations are characterized of the location of HAFED poly thus resulting to the elevated loads of Pb in this area over the FGGC counterpart. The results of the present study show that the loads of Pb in all the organs of the tree plants are within the normal range of 5 – 10mg/kg as reported by Kabata-Pendias (2011). The EHMs are well bio-accumulated with the exception of Cu and Ni while in some rare instances Zn. The source of these micro-nutrients is predominantly soil. These EHMs are present and accessible to the tree plants in the following forms in the soil such as: copper as Cu^{2+}, iron as Fe^{2+} and Fe^{3+}, manganese as Mn^{2+} and Mn^{3+}, zinc as Zn^{2+} (Godwin, 2019). The bioaccumulation and biomagnification of the EHMs as revealed in the above ground organs of the tree plants in the present study buttresses the fact that they are much important in the various activities taking place in the plants which include photosynthesis, pigment formation, respiration, synthesis of chlorophyll, protein synthesis and plant metabolism (Godwin, 2019). The loads of Fe, Mn and Zn is higher irrespective the location or plant species. This may be due to the local geochemistry of the soil and other anthropogenic activities in areas of study (Miri.*et al.*,2016). The observed trend of HMs reported in the present study is similar to the findings from other studies (such as Pavlíková*et al.*, 2021; Fowotade and Jimoh, 2013; Jimoh and Fowotade, 2013; Fowotade*et al*. 2021). Another findings from this study is the same order of accumulation of three EHMs (Fe>Mn> Zn) in *A. digitata* (leaf and bark), *A. occidentale* (leaf), *E. globulus* (leaf) and *P. biglobosa* (leaf). The first three most accumulated metals in all the above ground organs in the tree plants studied are EHMs with the exception of *A. digitata* bark sample with NHMs (Cr) as the third most accumulated metal. Based on the foregoing intra-organ analysis, the leaves of *A. digitata* recorded higher loads of EHMs (Fe, Mn. Zn) and NHMs (Cr) over the bark of the same tree.In contrast, the bark shows a combined prominence for bioaccumulation of NHMs (Pb) and EHMs (Co, Cu, Ni). Since both organs are above the ground level, though one is closer to the ground than the other, they are capable of dual access to HMs accumulation. The two options as earlier mentioned are soil borne and air borne pathways. Additionally, both organs regenerate periodically, thus are termed temporary organs and could be considered for short-term periods (Llagostera*et al*., 2011). However, the leaves are more temporary organ than the bark. The distribution of both forms of HMs is uniform in the above ground organs of *A. digitata.* On total HMs analysis the leaf samples (186.03 mg/kg) accumulated more metals than the bark samples (127.85 mg/kg).The leaf sample of *A. occidentale* gave higher loads of three EHMs (Fe, Mn, Zn) over the bark counterpart. The bark samples displayed higher bio-indication towards two NHMs (Cr, Pb) and one EHM (Co) over the leaf samples. Both organs displayed almost similar bio-indicator potential towards two EHMs (Cu, Ni). On the basis of total metal concept, the bark samples (224.50 mg/kg) displayed greater affinity to HMs indication than the leaf sample (214.98 mg/kg). The leaf sample of *A. indica* concentrated more of essential metals like Cu, Fe, Zn and Pb a non-essential metal over the bark samples. However, EHMs such as Co, Mn, Ni and NHM like Cr exhibited more prominence in the bark sample than the leaf counterpart. On the overall, the leaf sample (242.73 mg/kg) is a better bio-indicator than the bark sample (214.34 mg/kg) (Table 1). The spread of the EHMs and NHMs is the same as obtained in *A. digitata*. The leaf samples of *E. globulus* show higher loads for EHMs like Co, Fe, Mn, Zn and NHMs in Cr over the bark samples. In other words, the bark samples present higher loads of EHMs such as Cu, Ni and NHMs in Pb over the leaf samples. Based on total HMs analysis, the leaf samples (152.72 mg/kg) accumulated more HMs than the bark samples (82.31 mg/kg). The leaf samples of *P. biglobosa* accumulated two EHMs (Cu, Zn) and one NHM (Pb) more than the bark samples, whereas the bark samples accumulated four EHMs (Co, Fe, Mn, Ni) and one NHM (Cr) more than the leaf samples. Total HMs accumulation analysis shows that the bark sample (172.04 mg/kg) is a better bio-accumulator than the leaf sample (101.21 mg/kg). Therefore loads of HMs in the above ground organs of the tree plants differed according general trend: leaf > bark (*A. digitata* , *A. indica* , *E. globulus*) and bark > leaf (*A. occidentale* , *P. biglobosa*). These results affirm that leaves and bark alternate the maximum load of HMs. The observed competition between these two above ground organs for the HMs bio-accumulation suggests that the tree plants may adopt a tolerance strategy known as removal strategy that favours accumulation of HMs in temporary organs like leaves and bark. Even though, the latter is less temporary than the former. This removal method may be as a result of active mobilization of toxic metals from stem bark to leaves, which aids elemental loss during periodical leaf regeneration (Malea and Haritonidis, 1999; Llagostera*et al*., 2011). The internal mobility of HMs in the above ground organs is referred to as translocation factor, TF (Bonnano*et al.*,2017). The translocation factor or internal mobility factor can be greater than one (TF > 1) or less than unity (TF < 1). When TF >1, it implies that the plant successfully translocate HMs from roots to the shoots, considering the fact that majority of the metals are in their dissolved forms and accessible to plants via the roots in the soil (Rezvani and Zaefarian, 2011). The present study only considered the organs in the shoot of the tree plants, thus the translocation factor is restricted to leaves and barks (stem bark). The internal mobility of HMs from barks to leaves is therefore expressed as the ratio of the load of an element in the leaves to its load in the barks for a particular tree plant $(C_{leaf}/C_{bark}$. The reverse is the case for the internal mobility of HMs from tree plant barks to leaves designated as $(C_{bark}/C_{leaf}$. The present findings uncover that on tree plant species basis, HMs such as Co, Cu, Ni& Pb were more in the barks than in the leaves of *A. digitata* (TF < 1). Conversely, the TF > 1 for the likes of Cr, Fe, Mn& Zn, indicating that these HMs are easily mobilized into leaf region from the bark region of the plant (Table 2). In the case of other tree plant species with TF > 1, *A. occidentale*, had three HMs (Cu, Mn& Zn); *A. indica* had four HMs (Cu, Fe, Pb& Zn); *E. globulus* had five HMs (Co, Cr, Fe, Mn& Zn) and *P. biglobosa* had two HMs (Cu & Zn). It is only in *A. occidentale* that the TF < 1 for the NHMs (Cr &Pb). On the overall, based on the tree plant species findings the mean translocation factor is more than unity (TF > 1) for all the plants with highest ratio in *A. digitata* (2.721) and lowest ratio in *P. biglobosa* (1.078) (Table 2). On the element basis approach, the reported translocation factor when TF > 1 for Co is only observed in *E. globulus*. Other results are as follow; Cr (*A. digitata, E. globulus*); Cu (*A. occidentale, A. indica, P. biglobosa*); Fe (*A. digitata,A. indica , E. globulus*); Mn (*A. digitata , A. occidentale, E. globulus*); Ni (none); Pb (*A. indica, P. biglobosa*) and Zn (all species maximum (13.22) in *A. occidentale* and minimum (1.17) in *A. digitata*). Based on this foregoing, the mean translocation factor is less than unity only for Co and Pb (Table 2). All the remaining HMs are readily internally mobilized by all the tree plant species. The antithesis of the above observations is reported in Table 3, where HMs were mobilized into the bark region of the tree plant species from the leaves. Plant phenology, robustness, metal speciation, soil and water chemistry are determinant factors of metal tolerance in plant (Yang and Ye, 2009). Another finding from the present study is that all the tree plants possess higher potential for phytoextraction due to the above unity value of their mean translocation factors for elements. The internal mobilization of the elements within the above ground organs in all the species are well pronounced and agree to the findings of Bonanom et al., 2017. The internal mobility of elements varies among the tree plants studied and a function of the above ground organs as mentioned earlier. The finding of the present study observes a possible removal strategy for Cr by *A. digitata* and *E. globulus*, while same approach is adopted by *P. biglobosa*for Pb. The removal strategy may be related to active mobilization of toxic HMs from roots to shoots thereby aiding element loss during leaf regeneration in plants (Llagostera*et al*., 2011). In a nut shell, uptake of HMs by plants depends on a number of factors which may involve the biotic and abiotic components of the ecosystem, alongside their interactions (Yang and Ye, 2009). Notwithstanding, the avalanche of variables militating against the loads of HMs accumulation or bio-indication in the environment, the present study reveals that all the studied tree plant species responded differently to the availability of HMs and the potential to bio-accumulate or bio-indicate HMs is more a function of particular tree plant species than location and morphological traits.

IV. Conclusions

The findings of the present work unveiled that, for HMs the bio-accumulation potential, translocation between organs and total levels present within plant organ are specific to tree plant species. Additionally, all the HMs analyzed were all detected. Irrespective of the location and biomass of the tree plant species, iron (Fe) an EHM has the highest load, while another EHM Cu has the least load in the above ground organs examined. The order of bio-accumulation of HMs in the above ground organs is quite similar across all studied tree plants, the most unique is order is found in the *A. digitata* bark sample (Fe >Mn> Zn > Co > Cu > Ni >Pb> Cr). However, the trio of Fe, Mn and Zn revealed all the order in the leaf samples of the entire tree plants. Also, the duo of Fe and Mn revealed almost the same order in all the tree plants' above ground organs. Furthermore, for all the selected HMs in the present study, all the tree plant species shared some general common trends like relatively high loads in the above ground organs, similar internal mobility, high loads and bio-accumulation potential for EHMs. In particular, the outcome of this study uncovers two sub-classifications with most indistinguishable trends for HMs loads: (i) *A. digitata , A. indica , E. globulus* (ii) *A. occidentale , P. biglobosa*. The recognition of these sub-classes could implies that tree plant species in the same ecosystem but different localities and near morphological features tend to possess almost the same mechanisms and modus operandi to deal with HMs in their above ground organs, though this may not be a generalized stand as tree plants in the same location do possess different patterns of HMs loads as observed in *A. indica* when compared to *A. occidentale*and *P. biglobosa*. In contrast, tree plants with different morphological traits display similar pattern of HMs loads as noted for *A. digitata , A. indica*and *E. globulus*. In a nutshell, the mean translocation factor is well above unity (TF > 1) for all the studied tree plants suggesting that every tree plants are capable of internal mobility mechanization. Nonetheless, element based translocation factor outcomes displayed divergent values suggesting the varying mobility potential of tree plants toward specific HM. However, Ni and Zn unveiled a uniquely opposite outcomes. All the tree plants successfully mobilized Zn into the leaves region while none of them mobilize Ni. Another pertinent finding from the present work is that all the tree plants species possess higher potential for phytoextraction due to the above unity value of their mean translocation factors for all the HMs considered. Regardless of the indisputably countless factors influencing HMs loads in Kazaure environment, the present results opine that the considered tree plants react to HMs presence in varying patterns and these may seem to be more on the particular tree plant species capacity to accumulate and deactivate the HMs rather than on morphological and biomass traits.

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