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Research Article

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Evaluation of Heavy Metals Concentration in Selected Medicinal Plants (*Sterculia setigera* Del. and *Sclerocarya birrea* (A. rich.) Hochst) Collected from Bwabul Spring, Bambuka and Jalingo Low-lands, Taraba State

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Abstract

Analytical study was conducted on some selected medicinal plants (*Sterculia setigera* Del. and *Sclerocarya birrea* (A. rich.) Hochst) collected from Bwabul Spring, Bambuka, and Jalingo Low-Lands in order to determine the presence and levels of some selected heavy metals (Cd, Mn, Fe Pb and Zn) and also to compare the concentrations of these metals from the two locations. Results obtained from this study revealed that the concentration of elements Cadmium, Iron and Lead (0.03 ± 0.06, 4.84 ± 0.08 and 0.06 ± 0.02) mg/kg from Bwabul were lower compared to those from Jalingo Low-lands (0.21 ± 0.07, 6.03 ± 0.05 and 0.36 ± 0.02) mg/kg. On the other hand, the concentration of Zinc and Manganese (5.69 ± 0.08 and 1.87 ± 0.10) mg/kg are higher from Bwabul as compared to Jalingo Low-lands (4.29 ± 0.10 and 1.45 ± 0.00) mg/kg. However, despite the high concentrations of these elements from the two locations, they were found to be within the permissible limit set by WHO/FAO as at the time of determination.

Keywords: Heavy metals; *Sterculia setigera* Del; *Sclerocarya birrea* (A. rich.) Hochst; Bwabul; Jalingo; WHO/FAO

Introduction

Heavy metal is general term which applies to the group of metals and metalloids with an atomic density greater than 4 g/cm^3 [1,2]. They are defined by the United Nations Economic Commission for Europe (UNECE) as "those metals or, in some cases, metalloids which are stable and have a density greater than 4.5 g/cm^3 and their compounds" [3]. Heavy metals are elements which have an atomic density greater than 6 g/cm^3. Although it is a loosely defined term, heavy metals are widely recognized and usually apply to the widespread contaminants of terrestrial and freshwater ecosystems. Examples of heavy metals are Cadmium, Chromium, Copper, Mercury, Lead, Zinc, Arsenic, Boron and the platinum group metals which comprise of Platinum, Palladium, Rhodium, Ruthenium, Osmium and Iridium. Unlike almost all organic pollutants, such as organochlorines, heavy metals are elements which occur naturally in the earth's crust. They are therefore found naturally in soils and rocks with a subsequent range of natural background concentrations in soils, sediments, water and organisms. Anthropogenic release can give rise to higher concentrations of the metals relative to the normal background values. The most important anthropogenic releases of heavy metals to the environment come from metalliferous mining and smelting, agricultural materials (pesticides and fertilizers), irrigation and application of sewage water and sludge, fossil fuel combustion and metallurgical industries [4]. As they are elements, they cannot be broken down; therefore, heavy metals will persist in the environment. Unlike many organic pollutants, which eventually degrade to carbon dioxide and water, heavy metals will tend to accumulate in the environment, especially in lake, estuarine or marine sediments and can be transported from one environment compartment to another [1].

The aquatic environment with its water quality is considered the main factor controlling the state of health and disease in both man and animal. Nowadays, the increasing use of the waste chemical and agricultural drainage systems represents the most dangerous form of chemical pollution particularly heavy metal pollution. The most important heavy metals from the point of view of water pollution are Zinc (Zn), Copper (Cu), Lead (Pb), Cadmium (Cd), Mercury (Hg), Nickel (Ni) and Chromium (Cr). When heavy metals enter the aquatic environment, the metal ions can react with constituents of the water or settle to the bottom and react with the sediments. Heavy metals have a greater chance of remaining in solution when complexed to chelating ligands such as specific anions whose concentrations are described by the pH of the surrounding environment. Metals precipitate as oxides/hydroxides at different pH regions and the amphoteric elements return to solution at higher pH. The hydroxide concentration (or pH) is therefore of great importance for the mobility of metals. Other factors also affect the fate of the metal ions like redox conditions and the presence of adsorbent sediments [4].

This study is therefore, aimed at investigating the presence, concentration levels, and effects of heavy metals contaminants in the stem, root and leave of *Sclerocarya birrea* and *Sterculia setigera* plants found around the Bwabul spring, whose medicinal usefulness has been

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known over time, with the hope that a useful information obtained will help educate the local populace and to provide an insight to the scientific community about the levels of such contaminants in them.

Taxonomy and ethnobotanical uses of *Sclerocarya birrea* and *Sterculia setigera*

Sclerocarya birrea: It is a savannah tree, belonging to the family *Anacardiaceae* (Figure 1). On an average, the height ranged between 7 and 17 m; bark: grey, fissured, flaky and pale green foliage; leaves: compound, pinnate and flowers: greenish-white or reddish. The fruits are yellow, plum-like upto 3-4 cm in diameter with a juicy flesh resembling a mango [5]. Due to contrasting grey and pale brown patches the rough stem bark appeared mottled. The ethnobotanical uses of S. birrea have been reported by early workers, some of these revealed the potency of different parts of the plant (stems-bark, roots and leaves) in curing various human ailments such as abdominal cramps, abscesses, arthritis, backache, body pains, boils, carbuncles, constipation, cough, diabetes mellitus, diarrhea, dysentery, epilepsy, fevers, headaches, hypertension, infertility, malaria, proctitis, stomach ailments, sore eyes, schistosomiasis, sores, toothache, and certain other bacterial infections [6-12].

Figure 1: *Sclerocarya birrea* (A. rich.) Hochst.

Sterculia setigera **Del.**: It belongs to the family *Sterculiaceae* and in Nigeria (Figure 2), it has diverse common names: Hausa-“Kukuki”; Fulani-“bo’boli”; Yoruba-“Ose-awere” [13]. It is a savannah tree in tropical Africa found in open savannah woodlands and seeds have a yellow aril. Also, it has been used in traditional medicine by various indigenous communities. For instance, black soap is prepared from black powder obtained from burnt mixture of the fruits and seeds to cure dermatosis [13]. Methanol extract is used to treat jaundice and dried stems and bark is used for treating wounds [14,15]. Bark decoction is used to treat diarrhea and dysentery in Nigeria [14,16].

Figure 2: *Sterculia setigera* Del.

The bark, shoots and seeds are used to prepare traditional medicines for the treatment of nasopharyngeal affections, pulmonary disorders, arthritis, rheumatism, syphilis, leprosy, dropsy, oedema, gout, boils, whitlow, convulsion and epilepsy [17]. The leaves and bark are also used to make ethno medicines for the treatment of diarrhea, dysentery and helminthiasis.

Methodology

Study areas

The study areas comprise of a small settlement (Bambuka) in Karim Lamido local government area, and Jalingo metropolis, Jalingo local government area, both in Taraba State, Nigeria. Bambuka village is located at latitude 9°51’N and longitude 11°35’E with an altitude of 438 m above the sea level. The average annual rainfall is 959 mm [18] within the Guinea Savannah sub-humid region. The area is predominantly occupied by peasant farmers and traditionalist (people of the ‘Kyak’ ethnic group) whose major occupation is food production. This small community therefore engages in herbal and traditional remedies for diseases and illnesses. On the contrary, Jalingo is an urban settlement located at latitude 8°89’N and longitude 11°38’E, with an altitude of 351 m above sea level. In a year, the average rainfall of Jalingo is 958 mm [18].

Collection of plant materials

The leaves, stem and roots of *Sclerocarya birrea* and *Sterculia setigera* were collected between the months of Match-April, 2016 and were authenticated by a botanist (Mr. Bristone Basiri of Plant Science department, Modibbo Adamawa University of Technology, Yola). The samples were air-dried in the laboratory for 14 days at room temperature.

Preparation of plant samples for the determination of heavy metals

The air-dried samples were crushed to smaller particles and subsequently grounded into uniform powder using a mortar. About 100 g were obtained as the representative samples that were stored in a well-labeled sampling bottle.

Sample digestion: The sample digestion was carried out according to the method outlined by Quraishi [12]. 5 g of the sample was placed in a porcelain dish and was put in a muffle furnace and the temperature was raised to 450°C for complete ashing of the sample. Ash obtained from the muffle finance was cooled and the fixed amount 5 g, of ash was transferred into a 100 ml beaker and then dissolved in minimum amount of aqua regia (Concentrated Nitric acid and concentrated Hydrochloric acid, 3:1) and evaporated to dryness on heating mantle [19]. In cases where the ash did not become white, 1 ml of aqua regia was added, it was then evaporate again to dryness, and allowed to cooled, the solution was then filtered through 100 ml volumetric flask and diluted with distilled water up to mark. The obtained solution was then filtered through Whatman filter paper.

Preparation of the standard solution

Standard solutions of Fe, Mn, Zn, Cd and Pb were prepared using Iron (III) chloride, Manganese (II) chloride, Zinc nitrate, Cadmium chloride and Lead nitrate salts respectively for the calibration of the instrument. 2.8 g of $FeCl_3$, 3.60 g $MnCl_2.4H_2O$, 4.37 g of $Zn(NO_3)_2$, 4.39 g of $CdCl_2.21/2H_2O$ and 1.58 g of $Pb(NO_3)_2$ were weighed separately using analytical weighing balance and dissolved in a 1000 cm^3 volumetric flask and made up to mark with distilled water [20].

Procedure of using Atomic Absorption Spectrometer (AAS)

Determination of Fe, Mn, Zn, Cd, and Pb was made directly on each solution using the bulk scientific VGP210 AAS according to the procedure of Mendham [21].

The bulk scientific VGP210 AAS was ascertained for its good working condition. Hallow cathode lamp for each metal was selected and fixed. The instrument was switched on and allowed to warm up for 10 minutes in order to stabilize. Air and Acetylene were used as oxidant and fuel, respectively. The current and resonance line wavelength for each metal was selected and the gas control systems adjusted to give a fuel rich flame. Distilled water was used as zero reading. The prepared standard solution was aspirated in order of decreasing concentration and follow by aspiration of distilled water. The absorbance was used for the construction of calibration curves. The unknown sample solution was read for absorbance of the AAS screen after instrument adjustment for calibrations solutions. Then the sample concentration was obtained in ppm by calculation. Concentrations obtained in ppm were then converted into mg/kg for each element using the formula.

mg/kg=PPmxV/W

Where V=volume of digested sample in cm^3; W=weight of sample in grams.

Results and Discussion

Figure 3 shows the results of heavy metal concentrations in Bwabul.

- Cadmium concentration ranges from 0.00 ± 0.00 to 0.03 ± 0.07 mg/ml, the highest concentration was found in the root of *Sclerocarya birrea* and stems of *Sterculia setigera*.
- Iron concentration ranges from 2.421 ± 0.01 to 4.84 + 0.01 mg/ml, the highest concentration was found in the leaves of *Sclerocarya birrea*.
- Manganese concentration ranges from 1.09 ± 0.007 to 1.87 ± 0.10 mg/ml, the highest concentration was found in the root of *Sclerocarya birrea*.
- Lead concentration ranges from 0.00 ± 0.00 to 0.06 ± 0.03 mg/kg, the highest concentration was found in the root of *Sclerocarya birrea*.
- Zinc was the second highest in concentration after Iron. The Zinc concentration ranges from 1.56 ± 0.03 to 3.76 ± 0.08 mg/kg, the highest concentration was found in the leave of *Sterculia setigera*.

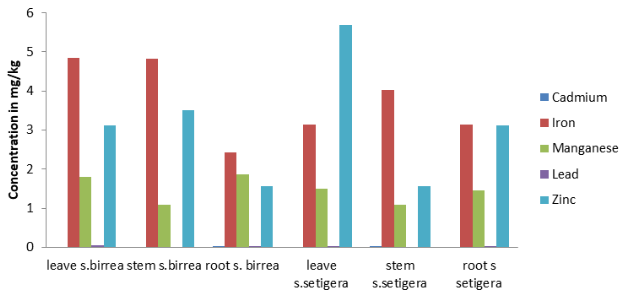

Figure 3: Heavy metals concentration in the leaf, stem and root of *Sclerocarya birrea* and *Sterculia setigera* collected from Bwabul.

In Figure 3, there is significant variation in the accumulation capacity of the plant even for the same heavy metal element, this will be due to the fact that they are different plant species the variation might also be as a result of biological character of each plant such as living form and morphology had great influence on the accumulation capacity of the element in the plant. For example, higher concentration of Iron in the leaves of *Sterculia setigera* might be due to its biological character which has broad leaves and absorbed more Iron from the surrounding environment, the differences between the concentrations of heavy metal accumulated and distributed in each part of the plant, depends on the bioavailability of the heavy metal in the soil. This work is in agreement with the previous work of Ye [22] who reported that heavy metal concentration in plants are in descending other Iron, Zinc Manganese, Lead and Cadmium, however, despite the high concentration are still within the permissible limit FAO/WHO [23].

Figure 4 showed the results of concentration of heavy metal in Jalingo. Cadmium concentration ranges from 0.00 ± 0.00 to 0.21 ± 0.07 mg/kg. The highest concentration of Cadmium was found in the stems of *Sterculia setigera*. Iron has the highest concentration at the aerial parts of the plants; the concentration ranges from 3.14 ± 0.05 to 6.03 mg/kg. Manganese concentration ranges from 0.63 ± 0.02 to 1.08 ± 0.07 mg/kg in the leaves and stem of *Sclerocarya birrea*. Lead concentration ranges from 0.02 ± 0.02 to 0.36 mg/kg, the highest concentration was found on the leave of *Sterculia setigera*. Zinc concentration ranges from 1.36 to 4.29 ± 0.010 mg/kg, the highest concentration was found in the leaves of *Sclerocarya birrea*.

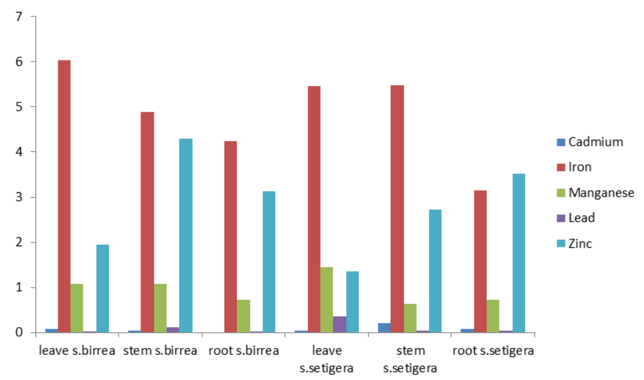

Figure 4: Heavy metals concentration in the leaf, stem and root of *Sclerocarya birrea* and *Sterculia setigera* collected from Jalingo.

There is significant difference in the heavy metal concentration in Jalingo as shown in Figure 4. This is because different plants have different accumulation capacity. The concentration of elements such as Zinc, Iron is higher in *Sclerocarya birrea*. Cadmium, Lead and Manganese are higher in *Sterculia setigera*. The difference might be due to biological character for each plant such as living form; morphology in addition climatic condition had great effect capacity on the elements in plant. It showed that even if plants were collected from the same region the uptake efficiency of the element will significantly vary [24]. This could be regarded as the effect of climatic condition as well as the nature of the element on it efficiency. However, despite the high concentration of these elements are still within the permissible limit of FAO/WHO [23].

Comparison of the result for heavy metal concentrations of *Sclerocarya birrea* and *Sterculia setigera* (leaves, stem and root) from the two locations (Bwabul and Jalingo)

From the results, Cadmium was only detected in the root of *Sclerocarya birrea* and stem of *Sterculia setigera* with a concentration of 0.03 ± 0.07 and 0.03 ± 0.06 mg/kg from Jalingo. *Sclerocarya birrea* ranges from 0.05 ± 0.02 to 0.08 ± 0.09 and in *Sterculia setigera* 0.05 ± 0.04 to 0.21 ± 0.07 mg/kg. Cadmium was not detected in the leaves of plants in Bwabul. The highest concentration of the Cadmium in all samples was 0.21 ± 0.07 found in Jalingo and the lowest concentration was found in Bwabul 0.00 ± 0.00 in the *Sclerocarya birrea*. This difference may be as a result of the environment. Also it might be due the fact that plants in Bwabul are located along a spring and rocks in which the concentration of Cadmium is less compared to those from Jalingo which is on flat land and there is much human activities. The main source of environmental Cadmium is vehicle wheel, waste mud and these increase Cadmium content in plants [25].

The study also revealed that the concentration of Iron in Bwabul ranges from 2.42 ± 0.01 to 4.84 ± 0.01 while in Jalingo ranges from 3.14 ± 0.05 to 6.02 ± 0.22, therefore the concentration of the metal from Jalingo is higher compared to those Bwabul. Most of the Iron was accumulated in the leaves, as well as the stem of the plants. In both locations, the difference in the concentration might be as a result of the geographical location, geological factors of the plants as well as industrial, human activities such as traffic in the location. The present result is in good agreement with the previous study by Manzoor [24] who reported that most Iron is accumulated on the aerial part of the plant.

Similarly, the study further revealed that the concentration of Manganese from Bwabul, ranges from 1.09 ± 0.07 to 1.87 ± 0.10 while in Jalingo, it ranges from 0.08 ± 0.07 to 1.45 ± 0.00. The concentration of Manganese is high in Bwabul as compared to Jalingo. This variation in concentration is as a result of agricultural activities that are observed in Bwabul. The differences between the concentrations of heavy metal accumulated and distributed in each part of the plant, as depends on the bioavailability of the heavy metal in the soil. Different plant species had varying abilities to take up and accumulate metals.

Lead was not detected in the stems of plants in Bwabul, the concentration of lead from Bwabul ranges from 0.0 ± 0.00 to 0.06 ± 0.03 while those from Jalingo ranges from 0.02 ± 0.02 to 0.36 ± 0.02 this showed that high concentration of the lead was found from Jalingo. Heavy metal contents were higher in plant sample collected near main roads however, this variation in concentration in both locations will be due to the addition of artificial fertilizer and pesticide causes an increase of lead levels near the main road [26,27].

And finally, the concentration of Zinc varies according to the location, from Bwabul, the concentration ranges from 1.56 ± 0.03 to 5.07 ± 0.08 while those from Jalingo ranged from 1.95 ± 0.03 to 4.29 ± 0.10 which shows that the concentration of Zinc in Bwabul is higher as compared to Jalingo. This variation might be due to the availability of Zinc in the soil, also it may be as a result of environmental factors, such as climate condition, mineral composition of the soil dust, soil water and natural elements cycling process and vegetation zone may have significant influence on uptake efficiencies of heavy metal element [28].

Conclusion

In conclusion, the elemental analysis of leaf, stem and root of *Sclerocarya birrea* and *Sterculia setigera* from the two locations studied, revealed that samples from Jalingo have higher concentration of heavy metals as compare to those from Bwabul. However, despite the high concentrations of these elements, they are still within the tolerable limit set by FAO/WHO.

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