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Heavy Metal Profiles of Medicinal Plants Found within the Vicinity of Quarry Site in Demsa, Adamawa State, Nigeria

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Authors' contributions

This work was carried out in collaboration between all authors. All authors read and approved the final manuscript.

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ABSTRACT

Heavy metals profile of ethanolic leaves extracts of some medicinal plants was carried out so as to ascertain the levels of Chromium (Cr), Cadmium (Cd), Lead (Pb), Manganese (Mn) and Nickel (Ni) in *Anogeissus leiocarpus, Bauhinia reticulata, Prosopis oblonga, Sterculia tomentosa* and *Tamarindus indica,* because leaves of these plants are used for treatment of some ailments by the people residing in that community were quarry factory was situated. The leaves of the plants were dried, grinded to powder and digested. The digests were analyzed for the trace metals using Atomic Absorption Spectrophotometer (AAS) model 210VGP and the result was interpreted using statistical analysis. The highest value for Manganese (Mn) was obtained from *Anogeissus leiocarpus* sample with 5.31 mg/l from the Quarry site, followed by *Sterculia tomentosa* with 1.6 mg/l, *Tamarindus indica* with 1.56 mg/l, *Prosopis oblonga* with 1.46 mg/l and least is *Bauhinia reticulata* with 1.22 mg/l. Chromium (Cr) has value of <0.04, Cadmium (Cd) with <0.01 and Nickel (Ni) having <0.05 in all the samples. The samples away from the Quarry site has 0.68 mg/l of Mn in *Bauhinia reticulata* while both *Anogeissus leiocarpus* and *Tamarindus indica* has values of 0.03 mg/l. Lead (Pb) was detected in only one of the control sample site with value of 0.08 mg/l in

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Bauhinia reticulata and in three plant samples from the Quarry site which include *Anoggeissus leiocarpus* with 0.06 mg/l and 0.07 mg/l for *Bauhinia reticulata* and 0.07 mg/l for *Prosopis oblonga* respectively. Other trace metals results obtained away from the quarry site include (Cr) with value of <0.04, (Cd) with <0.01 and (Ni) with <0.05 in all the samples. Some plants in the quarry site contain Mn and Pb above their threshold levels, therefore these plants are not recommended for consumption by animals to avoid bioaccumulation which will in further bring about health hazard.

Keywords: Heavy metals; Sterculia tomentosa; sample; manganese; quarry.

1. INTRODUCTION

Any toxic metal may be called heavy metal, irrespective of their atomic mass or density [1]. Heavy metals are a member of an ill-defined subset of elements that exhibit metallic properties. These include the transition metals, some metalloids, lanthanides, and actinides. One source defines heavy metal as one of the common transition metals, such as copper, lead, and zinc. These metals are a cause of environmental pollution from sources such as leaded petrol, industrial effluents, and leaching of metal ions from the soil into lakes and rivers by acid rain [2].

Any metal (or metalloid) species may be considered a “contaminant” if it occurs where it is unwanted, or in a form or concentration that causes a detrimental human or environmental effect. Heavy Metals/metalloids include lead (Pb), cadmium (Cd), mercury (Hg), arsenic (As), chromium (Cr), copper (Cu), selenium (Se), nickel (Ni), silver (Ag), and zinc (Zn). Other less common metallic contaminants include aluminium (Al), cesium (Cs), cobalt (Co), manganese (Mn), molybdenum (Mo), strontium (Sr), and uranium (U) [3].

Living organisms require varying amounts of heavy metals. Iron, cobalt, copper, manganese, molybdenum, and zinc are required by humans [4]. All metals are toxic at higher concentrations [5]. Excessive levels can be damaging to the organism. Other heavy metals such as mercury, plutonium, and lead are toxic metals that have no known vital or beneficial effect on living organisms, and their accumulation over time in the bodies of animals can cause serious illness. Certain elements that are normally toxic are for certain organisms or under certain conditions, beneficial. Examples include vanadium, tungsten, and even cadmium [1].

Metal concentration in soil typically ranges from less than one to as high as 100,000 mg/kg [6]. Heavy metals are the main group of inorganic contaminants and a considerable large area on land it contaminated with them due to use of sludge or municipal compost, pesticides, fertilizers, and emissions from municipal wastes incinerates, exudates, residues from metalliferous mines and smelting industries. Irrespective of the origin of the metals in the soil, excessive levels of many metals can result in soil quality degradation, crop yield reduction, and poor quality of agricultural products, posing significant hazards to human, animal, and ecosystem health [7].

Heavy metal contaminations of land resources continue to be the focus of numerous environmental studies and attract a great deal of attention worldwide. This is attributed to non--biodegradability and persistence of heavy metals in soils. In order to identify spatial relationship of heavy metals in soil-rice system at a regional scale, 96 pairs of rice and soil samples were collected from Wenling in Zhejiang province, China, which is one of the well-known electronic and electric waste recycling centers. The results indicated some studied areas had potential contaminations by heavy metals, especially by Cd. The spatial distribution of Cd, Cu, Pb, and Zn illustrated that the highest concentrations were located in the northwest areas and the accumulation of these metals may be due to the industrialization, agricultural chemicals and other human activities [8].

Human health has become threatened due to exposure to hazardous and toxic substances, such as industrial effluents and emissions, sewage sludge, fertilizers and agrochemicals [9]. The possibility of their movement along the food chain cannot be over ruled out, Cd, Pb and Hg are major contaminants of food and may be considered an important problem to our environment while others like Fe, Zn and Cu are essential for biochemical reactions in the body [10].

Medicinal plants represent a rich source from which powerful drugs are produced [11]. Herbal medicine has shown to be effective and about 60percent of the rural population depends on it for their primary health care [12,13]. The interest in the scientific investigation of medicinal plants from Nigeria is based on the claims of their effective use for the treatment of many diseases, therefore research into the effects of these local medicinal plants is expected to enhance the use of these plants against diseases caused by the test pathogens, however most of these plants used in herbal medicine have not been screened for their toxicity effects. Traditional medical herbs are used for strengthening the body immune system and nutritional elements. According to Sofowora [14], many plants have been documented to have the efficacy to treat many diseases in Nigeria. In order to control and prevent the inevitable progression of the immune system destruction that these stresses causes, therapy must be diverse, involving all levels of health, diet, use of mineral supplements and life style. It has been revealed that, elements in biological sources are more efficient than pure elemental status, because of presence of element as well as presence of vitamins and other physiological active compounds [15]. A research report by Rajurkar and Damame [16] shows correlation between elemental content of medicinal plants and their curative ability, so the quantitative estimation of various micro element concentrations is important for determining the effectiveness of the medicinal plants in treating various disease, as sources of supplement and also to understand their pharmacological action. Moreover macro and micro elemental analysis of medicinal plants can be used to decide the dosage the herbal drugs prepared from these plant materials and also the concentration of toxic element like Pb, Cd and Hg [16]. Studies conducted by [17,18] have demonstrated that the relative high levels of essential elements such as Fe, Mn, Zn and Ca influence the retention of toxic elements in animals and human beings.

Therefore, the main aim of the research is to carry out the heavy metal analysis of some medicinal plants found in the vicinity of quarry site.

2. MATERIALS AND METHODS

2.1 Study Area

The study area is quarry site situated in Demsa Local Government Area of Adamawa State, Nigeria. Fig. 1 shows the map of the study area. Demsa is a Local Government Area of Adamawa State, Nigeria. Demsa lies on the Benue River. Coordinates: 9°25'N 12°8'E with population of 180,251. The state spans two vegetation zones namely Sudan and Sahel savannah. Effective rains start in late June and end in late October. They dry seasons start in October and end in June. The occupation of the rural community of Demsa LGA has always been agrarian. The local government communities of these areas have been using these medicinal plants under investigation to cure various diseases for a long time.

2.2 Sample Collection

Leave samples of *Bauhinia reticulata, Prosopis oblonga*, *Sterculia tomentosa*, *Tamarindus indica* and *Anogeissus leiocarpus* were collected from the Quarry site (N R C) along Numan road in Demsa L.G.A and transported to Modibbo Adama University of Technology, Yola, where they were identified and authenticated by Dr A. Jauro from forestry department. Voucher specimens of these plants were deposited at the University Herbarium.

2.3 Sample Preparation

The plant samples were washed thoroughly with tap water to remove the soil particles from the leaves. The samples were then cut into smaller pieces and air dried for some days. The dried samples were ground into powder and stored in labeled polythene bags. Each powdered sample was digested as reported by Barminas et al. [19]. 2 gm of each sample was weighed into separate beakers and treated with 20 cm^3 of HNO_3 acid. It was then digested on an electric hot plate at 70°-90° for 60 minutes. Blank was prepared similarly by digesting 20 cm^3 of HNO_3 acid in an empty beaker. It was cooled and the content filtered through Whatman No. 42 filter paper into a volumetric flask and made up to 100 cm^3 with deionised water. The digests were analyzed for the trace metal contents using Buck scientific model 210VGP Atomic Absorption Spectrophotometer. A calibration curve was constructed using standard stock solution for each element. The unknown sample absorbance is read off on the spectrophotometer and the concentration in ppm is obtained by extrapolation on the curve.

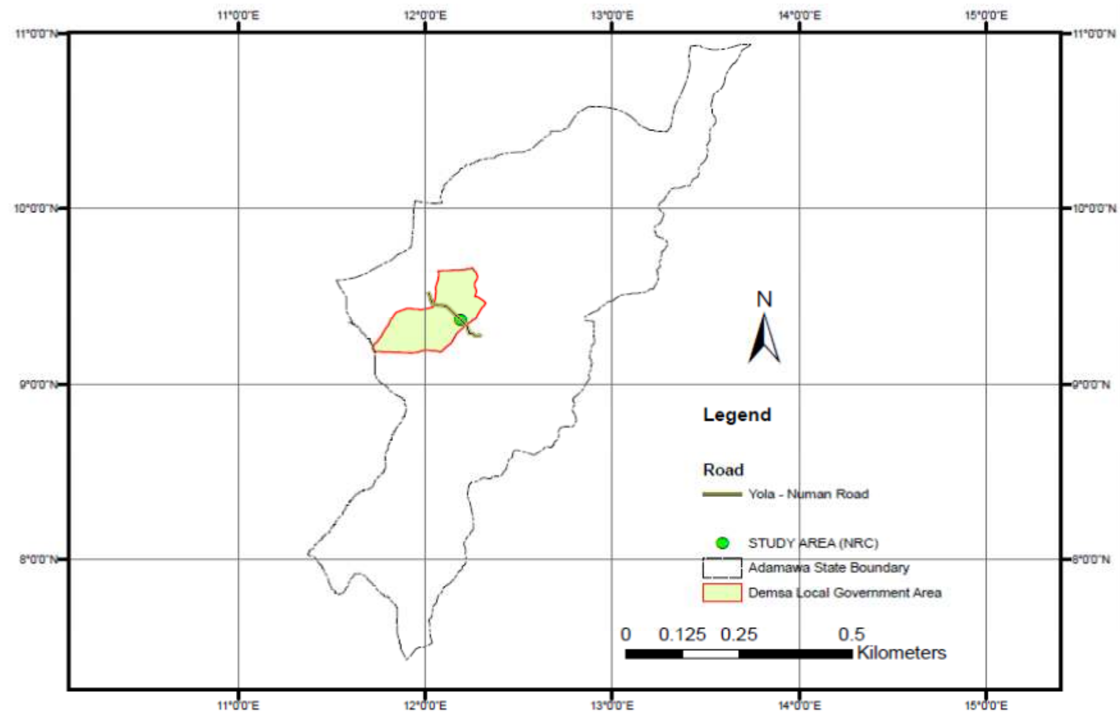

Fig. 1. Map of Adamawa State showing Demsa LGA and the study area

2.4 Determination of Essential and Heavy Elements in the Sample

This was achieved by means of absorbance measurements of the dilute solutions using the advantage of the sensitivity of the AAS spectrophotometer. The instrument was calibrated by allowing some warm up time for the AAS machine and the control knob adjusted until the meter reads 0% transmittance. Three glass cuvettes were obtained and blotted with tissue paper. One of them was used for the solvent blank which is distilled water while the others were used for the analyte samples. The absorbance reading was measured for each metal serial dilution of the various samples. Calibration curve for each metal was prepared from which unknown concentration in the samples was extrapolated. A plot of the absorbance (A) versus concentration gives a straight line graph.

3. RESULTS AND DISCUSSION

Table 1 and 2 shows the summaries of the mean concentrations of the heavy metals that are found on the leaves of each plant sample. Most of heavy metals analyzed were below detection limit of Atomic Absorption Spectrophotometer AAS Buck 210VGP used. However, Manganese (Mn) and Lead (Pb) were significantly present in both samples from Quarry site and away from the quarry site.

Pb concentration in the plants species studied was above 0.05 mg/l permissible limit given by Barminal et al. [19] and WHO [20]. Levels for Mn accumulation during the present study as contained in Table 1 and 2 revealed *Anogeissus leiocarpus* sample collected from the quarry site had the highest Mn content of 5.31 mg/l while the sample of *Anogeissus leiocarpus* collected away from the quarry site had the least Mn content of 0.03 mg/l. The permissible limit for Mn set by WHO [20] is 0.01 mg/l while the permissible limit of FEPA [9] is 0.05 mg/l. Hence Mn does appear to present a hazard to both human and animal that ingest the plants extract as medicine.

Most of the heavy metals analyzed were not detected except in few plants where Mn and Pb were noted. High values for both Mn and Pb were found in plant samples collected within the vicinity of the quarry site. The levels recorded for Mn and Pb were observed to exceed the permissible limit of FEPA [9] and Barminas et al. [19].

Table 1. Mean levels of some heavy metal (mg/l) in the plants in quarry site

Element	*Anogeissus leiocarpus*	*Bauhinia reticulate*	*Prosopis oblonga*	*Sterculia tomentosa*	*Tamarindus indica*	WHO standard limit
Cr	<0.04	<0.04	<0.04	<0.04	<0.04	0.05
Cd	<0.01	<0.01	<0.01	<0.01	<0.01	0.005
Pb	0.060±0.01	0.07±0.01	0.07±0.01	<0.04	<0.04	0.05
Mn	5.31±0.01	1.22±0.01	1.46±0.01	1.61±0.01	1.56±0.0 1	0.1
Ni	<0.005	<0.005	<0.005	<0.005	<0.005	0.02

Table 2. Mean levels of some heavy metal (mg/l) in the plants away from quarry site

Element	*Anogeissus leiocarpus*	*Bauhinia recticulata*	*Prosopis oblonga*	*Sterculia tomentosa*	*Tamarindus indica*	WHO standard limit
Cr	<0.04	<0.04	<0.04	<0.04	<0.04	0.05
Cd	<0.01	<0.01	<0.01	<0.01	<0.01	0.005
Pb	<0.04	0.08±0.01	<0.04	<0.04	<0.04	0.05
Mn	0.03±0.01	0.68±0.01	<0.03	<0.03	<0.03	0.1
Ni	<0.005	<0.005	<0.005	<0.005	<0.005	0.02

Table 1 represents the mean levels of some heavy metals (mg/l) in some medicinal plants found within the vicinity of quarry site. The values determined from the samples were compared with the international standard set by WHO [20]. The values for Cr and Cd in *Anogeissus leiocarpus, Bauhinia reticulata, Prosopis oblonga, Sterculia tomentosa* and *Tamarindus indica* were all within the international standard set by WHO [20]. The values for Pb in *Anogeissus leiocarpus, Bauhinia reticulata, Prosopis oblonga* and *Sterculia tomentosa* were above the permissible level set by WHO [20] with the exception of *Sterculia tomentosa* and *Tamarindus indica* whose values were within the acceptable limit set by WHO [20]. The values for Mn in all the samples were extremely high and as a result can accumulate and biomagnified. Lastly, Ni values obtained from the plants were all within the permissible limit set by WHO [20].

Table 2 represents the mean levels of some metals (mg/l) in the plants sample away from the quarry site (control area). The values detected for Cr and Cd for all the samples were within the acceptable limit when compared with the values set by WHO [20]. Pb values for *Anogeissus leiocarpus, Prosopis oblonga, Sterculia tomentosa* and *Tamarindus indica* were within the range of the acceptable level set by WHO [20] with the exception of *Bauhinia reticulata* whose value was very high. Mn values for *Anogeissus leiocarpus* and *Bauhinia reticulata* were above the permissible limit set by WHO [20], while *Prosopis oblonga, Sterculia tomentosa* and *Tamarindus indica* were within the acceptable limit set by WHO [20]. The Ni values of all samples were within the permissible limit set by WHO [20]. The plants in the quarry site that contains Mn and Pb above their permissible limit are not recommended for consumption by animals to avoid bioaccumulation which will in further bring about health hazard. Therefore, the plants should not be used for medicinal purposes due to their suspected toxicity to the consumers because of the presence of high level of Mn and Pb.

4. CONCLUSION AND RECOMMENDATION

The medicinal plants within the vicinity of the quarry site contain elevated levels of lead and manganese above their threshold levels and therefore the plants are not recommended for consumption by animals in order to avoid bioaccumulation in their body systems which could lead to health hazards. It is recommended that another study should be carried out on other edible plants that are cultivated around the quarry site in order to know if they are safe to be consumed or not.

COMPETING INTERESTS

Authors have declared that no competing interests exist.

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