ASSESSMENT OF METALS POLLUTION IN SOME HERBS FROM KANO METROPOLIS

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ABSTRACT

The aim of this study was to determine the content, transfer factor (Tf) and pollution index (PI) of cadmium, chromium, manganese and magnesium in six herbs and soil samples collected from five different areas in Kano Metropolis. The samples were collected and prepared using standard analytical procedures while analytical grade reagents were used for digestion. Fast sequential Atomic absorption spectroscopy was used for the analysis of the metal content of these herbs. Mg ranged from 8.19 mg/kg to 113.87 mg/kg, Cr: 0.76 mg/kg to 32.56 mg/kg, Mn: 0.96 mg/kg to 84.56 mg/kg, Cd: 0.004 mg/kg to 1.4 mg/kg. Tf (Bompai) ranged from 0.004 (Cr) to 1.49 (Mg), Tf (Challawa) ranged from 0.02 (Mn, Cr) to 5.28 (Mg), Tf (Jakara) ranged from 0.01 (Mn) to 4.82 (Mg), Tf Sharada ranged from 0.01 (Mn) to 7.19 (Mg) and Tf (Watari) ranged from 0.02 (Cd, Cr) to 8.75 (Mg). Challawa sampling area exhibited the highest mean PI value of 7.22 and Watari, the lowest with mean PI value of 2.11.

Key words: Herbs, metals, Kano, Nigeria

INTRODUCTION

Herbal medicines refer to the use of plants for the promotion of healing and maintenance of health [1]. Medicinal herbs are sources of chemical substances that have different biological activities including those useful in the treatment of human and animal diseases [2]. The ecology of a plant community is greatly influenced by physical and chemical properties of soil, particularly presence of excess and deficiency of mineral nutrients [3]. However, environment, atmosphere, pollution, soil, harvesting and handling are some of the factors which may play important roles in the contamination of medicinal plants by metals and microbial growth [4]. The chemical elements, including metals mostly in ionic form, absorbed by plants, with the help of their roots, could be essential or non-essential elements, based on the importance in the plant's metabolism and by their quantity in the plant [5].

Apart from the pharmacological effect, herbs could be toxic because of the presence of heavy metals like Pb, Cd, and other impurities. Certain elements at elevated levels are toxic. The quantification of various elements is important to determine the effectiveness, safety and scientific validation of therapeutic use of the plants [6]. Various reports have discussed the potential health implications of trace metals in medicinal herbs, since the herbal bush is known to accumulate them [7, 8]. Over one-third of the population in developing countries lack access to essential medicines. Therefore, the provision of safe and effective herbal drug therapies could become a critical tool to increase access to health care [9]. Up to 80 % [10] or even 90% [11] of some populations depend almost entirely on traditional medicine (TM) for most of their primary healthcare needs. The irony is that among these same population, TMs, including herbal drugs, are hardly regulated by the State. Because herbal preparations are usually not evaluated for purity and consistency of active components, they often contain unintentional contaminants. Many indigenous plants are widely consumed as food or home remedies especially in the treatment or management of common diseases [12, 13].

The aim of this study was to determine the content, transfer factor and pollution index of cadmium, chromium, manganese and magnesium in six herbs collected from Bompai, Challawa, Jakara, Sharada and Watari in Kano Metropolis Nigeria.

MATERIALS AND METHOD

The Study area

The study areas were Bompai, Challawa, Sharada, Bank of river Jakara, and Watari as control area in Kano State, Nigeria (Fig. 1). The vegetation is that of tropical savannah. There are two distinct seasons, the wet and the dry seasons. The Geographic coordinates in degrees and decimal minutes are; latitude: 12º0.0072’ N, longitude: 8º31.0032’ E and elevation above sea level was 484 m.

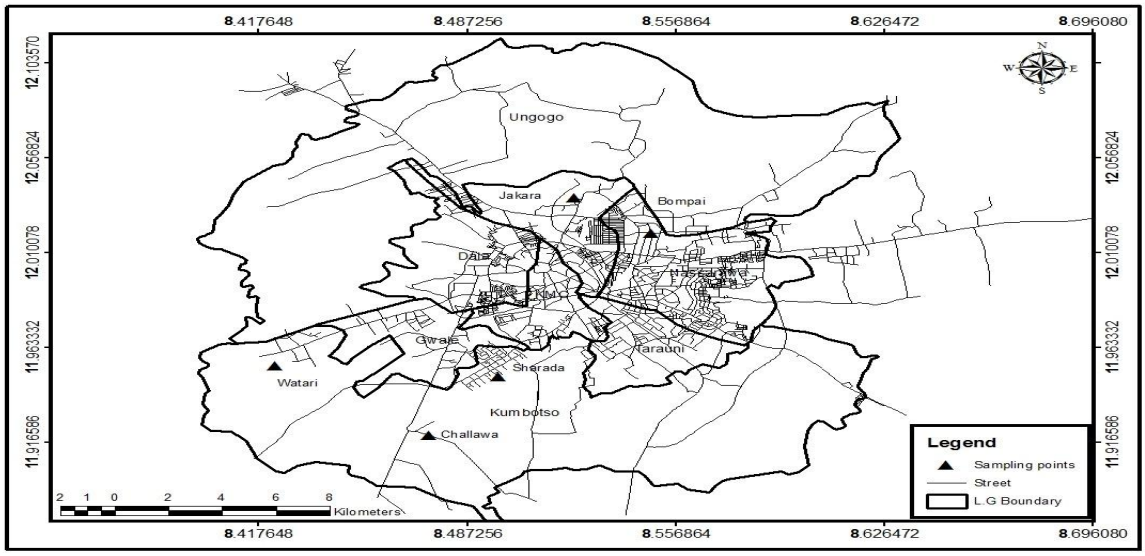

Figure 1: Map of Kano State showing Sampling Areas

SAMPLING

Plant materials

Fresh samples of the plant species studied were collected from June to August, 2015. The samples were authenticated at the Herbarium Unit, Department of Plant Biology, Bayero University, Kano, and accession numbers were given to each sample. The plants were sampled in each location randomly and for each specie. About 1-2 kg of material was obtained from all locations. The plant samples were thoroughly washed with tap water and then de-ionized water to remove dust and other particles then dried at room temperature and ground to fine powder and finally stored in airtight cleaned plastic bottles.

ASHING OF PLANT SAMPLES

About 5g of air dried, ground and sieved plant samples were weighted into porcelain crucible and ashed into a constant weight in a muffle furnace at a temperature of 550 ^{o}C. About 20 cm^3 of 0.1M HNO_3 analaR grade was added to the ashed sample in a beaker and boiled for few minutes on a hot plate. After the appearance of white fumes, the digest was allowed to cool, then filtered through No. 1 Whatman filter paper into 100 cm^3 volumetric flask and made up to the mark with the 0.1M HNO_3. Blank (without the sample) was prepared using the same procedure. Both the samples and the blank were aspirated into the flame of the AAS for the determination of the

metals. Absorbance values were recorded and the corresponding concentrations from the calibration curve plotted were determined and presented in mg/kg dry weight [14, 15].

DIGESTION OF SOIL SAMPLES

About 2 g of each soil sample was weighed into a separate, clean, dry and labeled 100cm^3 beaker. To each beaker 5cm^3 of water was added and then 5cm^3 conc. HNO_3. Each slurry was mixed with the bare glass end of a different stirring rod and each beaker was covered with a non-ribbed watchglass, placed concave up. All the samples were heated together on one hotplate until they were refluxing (that is, until vapor is condensing on the bottom of the watch glass and dripping back down into the beaker), and were kept at reflux for 10 min, while stirring a few times. The samples were removed from the hotplate and allowed to cool until they can be safely handled. Another 5cm^3 of conc. HNO_3 was added to each, the watch glasses were replaced, and refluxed for another 10 min. The samples were again allowed to cool enough to handle, then 5cm^3 of conc.HCl was added and then 10cm^3 of water. The watch glass cover was replaced and refluxed for 15 min, stirring occasionally. Finally, each solution was filtered through No 1 filter paper into a 100cm^3 volumetric flask and was made to the mark. Blank was prepared using the same procedure. Both the samples and the blank were separately aspirated into the flame of the AAS for the determination of the metals. Absorbance values were recorded and the corresponding concentrations from the calibration curve plotted were obtained by interpolation and presented in mg/kg dry weight [16, 17].

RESULTS AND DISCUSSION

The analysis of the samples was done in triplicates under the same conditions as standards and blanks. The data was subjected to a two-way analysis of variance. The validity of the method used had been ensured by incorporating various quality control (QC) checks and analysis of certified reference material (CRM).

Figure 2 shows the levels of Magnesium in the six herbs among the five sampling areas. The range in Bompai was 8.19±1.44 mg/kg in Rice flatsedge to111.54±1.06 mg/kg in Sodon apple. In Challawa, Mg ranged from 18.89±1.65 mg/kg in Morning glory to 101.42±1.71 mg/kg in Coffesenna. Jakara has lowest Mg value of 7.50±0.52 mg/kg in Rice flatsedge and highest value of 111.67±1.38 mg/kg in Coffesenna. In sharada Mg had the range of 8.19±0.33 mg/kg in

Morning glory to 113.67±1.24 mg/kg in Coffesenna. In Watari Mg ranged from 11.72 mg/kg in Sodom apple to 94.91±1.43 mg/kg in Coffesenna.Analysis of variance (ANOVA) shows that P value is <0.0001.Magnesium concentrations in this research are lower than those reported by [14,18] but higher than those reported by Hussain et al, 2013 [19]. Magnesium is an important mineral element in connection with circulatory diseases such as ischemic heart disease and calcium metabolism in bone [20]. Figure 3 shows the concentrations of chromium in the herbs. The concentration in Bompai ranged from 7.10 mg/kg in Coffesenna to 15.93±0.84 mg/kg in Sickle wild and 15.93±0.80 mg/kg in Bindii. In Challawa, Cr ranged from 6.51 - 32.52 mg/kg in Coffesenna and Sickle wild. The Cr range in Jakara was 1.18 in Sodom apple to 17.76 mg/kg in Sickle wild. In sharada Cr ranged from 2.96 mg/kg inCoffesenna to 15.95±1.45 mg/kg in Sodom apple. The range in Watari was 0.76 - 2.39 mg/kg in Coffesenna and Morning glory.

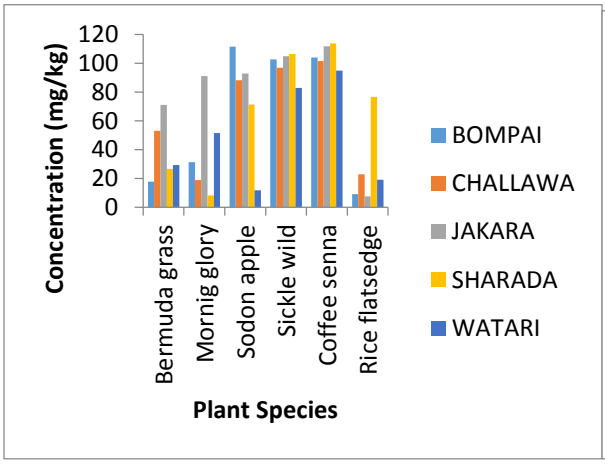

Fig. 2**:** Magnesium concentrations

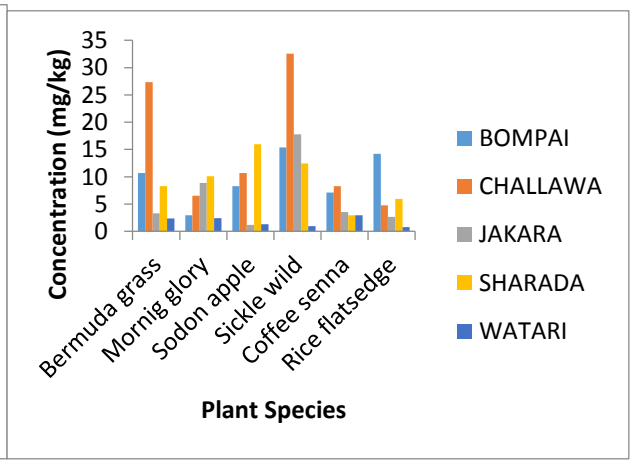

Fig. 3: Chromium concentrations

Chromium is essential in carbohydrate metabolism. It also functions in protein and cholesterol synthesis. Analysis of variance (ANOVA) shows that P value is <0.0001.

Figure 4 shows the levels of Manganese in the six herbs in the five sampling areas. Lowest level found in Bompai was 3.0 mg/kg in Coffee sennaand the highest was 42.89±1.85 mg/kg in Sodon apple. In Challawa, Mn ranged from 7.35 mg/kg in Coffee senna to 63.02±0.16 mg/kg in Sodon apple. In Jakara, Mn ranged from 4.15 mg/kg in Coffee senna to 36.24±2.04 mg/kg in Sodon apple. In Sharada, Mn ranged from 0.96±0.16 mg/kg in Coffesenna to 84.56±2.36 mg/kg in Sodon apple. Watari has Mn concentration range of 5.82±0.80 mg/kg in Sickel wild and

63.28±0.31 mg/kg in Sodon apple. Hassan and Umar [18] reported manganese value of 11.60 mg/100g, Hussain et al, [20] reported a range of 0.26 mg/kg to 3.43 mg/kg. It was reported that a variety of medicinal plants show great Mn accumulating ability [21]. The RDA for manganese is 2 to 5 mg. Manganese is a co-factor for many enzymes which take part in glucose and amino acid metabolism [22]. The result showed that the herbs are good source of manganese.

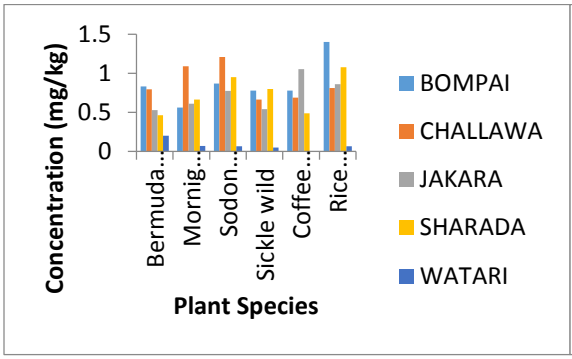

Fig. 4: Manganese concentrations

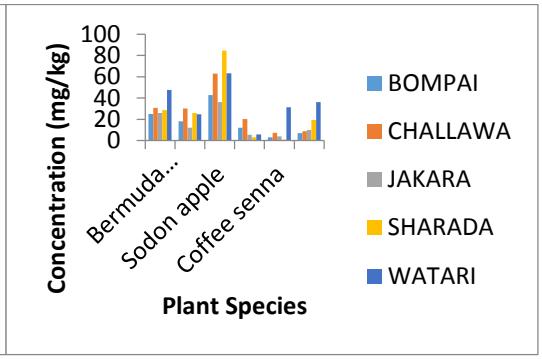

Fig. 5: Cadmium concentrationsis <0.0001.

Figure 5 shows cadmium concentration in the six herbs at the five sampling areas. Cadmium in Bompai ranged from 0.559 in Morning glory to 1.4 mg/kg in Rice flastsedge. In Challawa, it ranged from 0.66 mgkg in Sickel wild to 1.21 mg/kg in Sodom apple. The range in Jakara was from 0.569 in Bermuda grass to 1.05 mg/kg inCoffesenna. In Sharada, it ranged from 0.46 mg/kg in Bermuda grass to 1.07 mg/kg in Rice flatsedge, while in Watari, Cd ranged from 0.004 in Coffee senna to 0.20 mg/kg in Bermuda grass. Analysis of variance (ANOVA) shows that P value is <0.0001.

Figure 6 shows the lowest magnesium value of 10.84±0.78 mg/kg in Watari control area and highest value of 74.62±0.21 mg/kg in Bompai area. Manganese ranges from 140.62±6.87 to 241.77±1.37 mg/kg in Watari and Jakara respectively. Lower Manganese range of 5.51 - 9.61 µg/g was reported [26] while higher range of 200 to 5840 mg/kg was reported by Adamu et al [23]. Cr ranges from 45.89±2.09 to 939.91±7.55 mg/kg in Watari and Challawa which was higher than 50 – 200 mg/kg the maximum allowable Limits (MAL) [24]. Lower ranges of 0.5 to 30.5 mg/kg [25] and 16 to 56 mg/kg [36] were also reported. Cr is strongly associated with industrial effluents, especially the tanning industry as well as the textile and iron and steel industries at various levels [26]. This factor alone might have significantly contributed to the

excessively high concentration at Challawa and Bompai which have the highest concentration of all the aforementioned industries, particularly tanning and textile industries. The significantly low mean obtained at the control may justify the claims of both industrial and domestic waste being contributors to Cr deposits in soils. Cd ranges from 1.09±0.08 to 4.09±0.09 mg/kg in Watari and Bompai which was lower than 2 – 8 mg/kg the maximum allowable Limits (MAL) [27]. Higher ranges from 5.15 to 5.79 µg/g [28] and 68 mg/kg were also reported. Umaru [29] reported a similar range of 0.1 to 4.5 mg/kg.

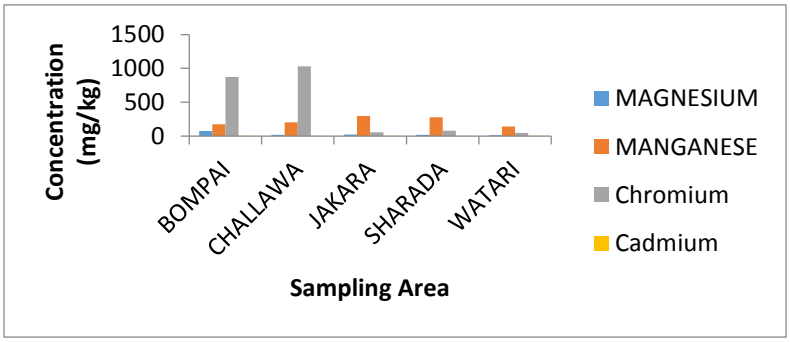

Fig.6: Metals concentrations in the soil

Mean Soil-Herbs Transfer Factor (Tf)

Transfer factor was used to understand the extent of risk and associated hazard due to transfer of heavy metals from the soil into the herbal plants and its subsequent accumulation, using the relation according to [15, 30-31].

TF= Cp/Cs

Where: Cp = concentration of metal in the herb, Cs = metal concentration in the in soil sample.

Among the different herbs studied, various transfer factors were generally observed, the maximum value for the transfer of the six metals to plant was obtained as: TF: Mg= 1.49, 5.28, 4.82, 7.197 and 8.75 at Bompai, Challawa, Jakara, Sharada and Watari sampling areas respectively, TF: Cr = 0.02, 0.06, 0.34, 0.20 and 0.06 at Bompai, Challawa, Jakara, Sharada and Watari sampling areas respectively. TF: Mn = 0.25, 0.32, 0.12, 0.31 and 0.45 at Bompai, Challawa, Jakara, Sharada and Watari sampling areas respectively.

TF: Cd = 0.45, 0.58, 0.60, 0.395 and 0.11 at Bompai, Challawa, Jakara, Sharada and Watari sampling areas respectively. At control area, transfer factor for all the metals was lower as compared to the other sampling areas. The highest TF values for Cd, was found as 0.60 in P6 Jakara, while the lowest TF values were found as 0.043 in P10 Bompai. The reason for high TF for Cd might be due to its high mobility in soil [32], and the low retention of Cd (II) in the soil than other toxic cations [33]. The TF pattern of Cd is as Jakara (0.60) >Challawa (0.58) >Bompai (0.45) >Sharada (0.39) > Watari (0.14). The results from this study indicated that the uptake of each metal differs from one site to another and from one plant to another and the TF for the herbs in all sites ranged differently. The TF value of unity, indicated that the concentration of the metal in the plant was equal to that of the soil while the TF value greater than unity indicates a higher concentration of the metal in the plants than in the soil which means plant uptake of this metal at the sites was not restricted by pH or other parameters [34].

Metal pollution index (MPI) of heavy metal in herbs

Metal pollution index (MPI) was applied to examine the overall metal contents of the different herbs from the five sampling areas in order to compare and monitor the metal pollution due to aggregate effects of all the metals in the analyzed samples. Metal pollution index was computed by calculating the geometrical mean of the concentration of all the metals in the herbs using the relation according to Ghosh et al. [35]:

$$MPI= (CF1*CF2*CF3…….*CFn)^{1/n}$$

Where CF1, CF2, CF3….CFn = concentrations of the studied metals 1, 2, 3 up to n metal in the sample. Figure 7 indicates the Metal Pollution Index (PI) of various herbs for the five sampling areas. At Bompai, PI ranged from 5.1 to 7.2 and from 6.0 to 8.7 at Challawa. Also PI ranged from 5.2 to 9.3, 4.2 to 10.0 and 1.9 to 3.7 at Jakara, Sharada and Watari respectively.

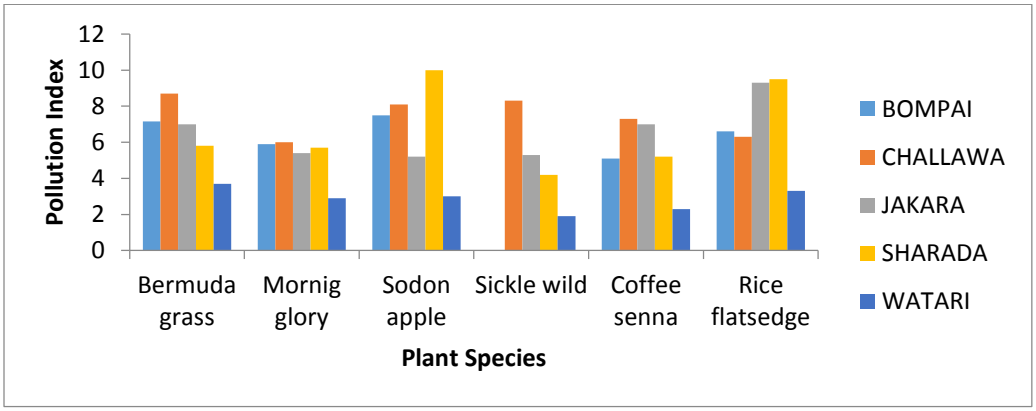

Figure 7: Metal Pollution Index of various Herbs for all Areas

The high mean pollution index obtained at Challawa indicates that herbs at this site receive accumulated loads of heavy metals more than those from other sampling areas. Hence, Challawa could be described as higher risk site compared to other areas. The mean pollution index is in order: Challawa>Bompai>Jakara>Sharada>Watari. Among the different herbs examined, Sodon apple showed the highest value of pollution index (10) while lowest PI value was observed in Sickle wild (1.9). Chris and Leo [36] reported higher pollution index value in ready-to-use herbal remedies (9H-Nal (30.3), Virgy-virgy worm expeller (26.4) and sekin powder (24)) in South Eastern Nigeria. Values of PI < 1 indicate that the plant material is not yet contaminated whereas PI > 1 indicates pollution. On the other hand, PI = 1 reveals a critical state which makes the involved plant useful for environmental monitoring [37, 38].

CONCLUSION

Medicinal plants are sources of a large number of active ingredients of herbal and modern medicine. This study confirmed that herbs analyzed contained the essential metals like chromium, magnesium e.t.c., which support the treatment of various diseases. Therefore, these herbs may be a good source of minerals to treat number of diseases that are mainly caused due to the deficiency of those minerals. However, continuous increase in environmental pollution is leading to the buildup of pollutants including heavy metals in the plant parts which eventually enter the human food chain. The present investigation clearly demonstrated the variation in metals concentration depending upon the collection sites. The need to screen medicinal plants, used in traditional medicine for their elemental composition is highly desirable due to the presence of some toxic metals like cadmium.

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