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DETERMINATION AND HEAVY METALS POLLUTION INDEX OF SOME NIGERIAN MEDICINAL PLANTS

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ABSTRACT
This current study aimed to determine the content of arsenic (As), cadmium (Cd), copper (Cu), chromium (Cr), manganese (Mn), nickel (Ni) and lead (Pb) and assessed the pollution index of these heavy metals in 10 medicinal plants samples. The samples were digested using HNO_3: $HClO_4$in the ratio of (2:1) and heavy metals analysis were carried out using Atomic Absorption spectrophotometer (AAS). The results of metals contentranged forAs (0.00-0.095ppm), Cd(0.00-0.24ppm), Cr(0.061-1.995ppm),Cu(0.875-2.98ppm), Mn(0.765-2.075ppm),Ni(0.00-1.089ppm) and Pb(0.116-8.295ppm).The mean concentrations of the metals were compared with World Health Organization (WHO) and FAO/WHOstandards; the levels of metals were below the permissible limits in all 10 medicinalplants analyzed except Mn in two samples. The heavy metal pollution index (HMPI) analysis in the10samplesindicated atrend in the order of: AC >ES >KT >FT >AL >CT >CK >CS >GS >SL.The HMPIanalysis revealed that AChasthe highest pollution index and is more likely to cause an adverse health effect than the other studied samples.
Keywords: Determination, Heavy metal, Medicinal plant, Pollution index

INTRODUCTION

Medicinal plantis an important class of traditional medicine systems and is the oldest form of healthcare known to humans and has found extensive use in disease prevention, treatment, and management (Kofi *et al.*, 2013). The expansion of consumption of herbal plants has seen a significant increase in the use of herbal medicine due to their minimal side effects, availability and acceptability to the majority of the population, so medicinal plants play avital role in traditional medicine and are widely consumed as a home remedy (Haci *et al.*, 2016). According to the world health organization (WHO), About 70 - 85% of the world's population mainly in developing countries today still rely on traditional medicine as their primary form of healthcare (WHO, 2000; Inamdar *et al.*, 2008;Nwachukwu*et al.,* 2018).

The general public perception that herbal medicine is safer and harmless because they are natural plant-based material is untrue (Nwachukwu*et al.*, 2018). This is because there is the tendency that plants may be contaminated with hazardous substances such as pathogenic microorganisms, agrochemicals and toxic heavy metals (WHO, 2004). These medicinal plants can present health risks due to the presence of toxic metals such as Pb, Cd, Al, and Hg, which are hazardous to humans. Several researches have been reported on the phyto-chemical and biological activities of medicinal plants, although there is a little report, with regards to the heavy metal contents of these plants (Yap *et al.*, 2010). Heavy metals may be toxic if consumed beyond their estimated required daily intake. The toxicity of heavy metals on human health and the environment has attracted considerable attention in recent years (Rania *et al.*, 2015), and there is a clear need to monitor its status to avoid health hazards (Shadi *et al.*, 2018).

Agencies like World Health Organization (WHO) and the Food and Agricultural Organization (FAO) have highlighted these critical issues and strongly recommended toxic heavy metal analysis in herbal medicines and medicinal plants (Nwachukwu *et al.*, 2018). Hence, the assessment of these toxic metals in medicinal plant and finished products must be undertaken to evaluate the safety of and quality of such plant materials and finished products (Kishan *et al.*, 2014). However, this current study aimed at determining the contents of As, Cd, Cu, Cr, Mn, Ni, and Pb, and assesses the pollution index of these heavy metals by comparison with the established standards with the view of determining the safety or otherwise from consumption of these medicinal plants.

MATERIALS AND METHODS

Sample Collection

Medicinal plants that are frequently consumed and mostly purchased in the market were chosen for the analysis of toxic metal concentration. The samples of ten raw medicinal plant materials were procured from the Market. The plant materials were authenticated at the Department of Biological Sciences, Gombe State University, Nigeria. The plant materials were washed with deionized water and shade dried.

Sample Preparation and Digestion

An acid digest of each plant sample was prepared by oxidizing 0.2 g of the powdered plant sample with nitric/perchloric acid (2:1) mixture (10 ml). The digests (2.5 ml) of each sample was further diluted to 50 ml. The blank and working standards were run first followed by the samples.

Determination of Heavy Metals

Determination of Cd, Mn, Cr, Ni, Cu, and Pb was performed using Atomic Adsorption spectroscopy (AAS: Germany) under an optimized measurement condition. All analyses were performed in triplicates, and the mean values were presented as the results.

Heavy Metal Pollution Index (HMPI)

To evaluate the overall content of heavy metal in the medicinal plant's samples, the heavy metal pollution index (HMPI) was used. HMPI for each sampled was determined as the total metals content in the different samples. The heavy metal pollution index (HMPI) is calculated using the following equation (Usero *et al*., 1997; Nwachukwu *et al*., 2018, Sonu *et al,* 2019).

$$HMPI = (Cf_1 \times Cf_2 \times Cf_3 \ldots\ldots\ldots\ldots x\ Cf_n)^{1/n}$$

Where: HMPI is the metal pollution index, Cf_1 is the concentration of the metal in the sample, n is the number of metals studied.

Statistical Analysis

All the data obtained from the study were statistically analysed using the two-way analysis of variance (ANOVA). The data were expressed as mean ± standard error. Pearson correlation of different metals in samples was calculated to identify the correlation of different metal types.

RESULTS AND DISCUSSION

The heavy metals content of the medicinal plant's samples (Table 1) indicate that, the load of the heavy metals studied isin the following order: Pb > Cu > Mn > Cr > Ni > Cd > As. The As recorded lowest content of all the studied samples with values ranged from (0.00 to 0.095ppm). The highest contents of Pb (8.295 ppm), followed by Cu (2.98 ppm), Mn (2.075 ppm), Cr (1.995 ppm), Ni (1.089 ppm) and Cd (0.24 ppm) were recorded respectively. The lowest contents of Pb (0.116 ppm), Cu (0.875 ppm), Mn (0.765 ppm) and Cr (0.061 ppm), while below detectable limits of As in *jathropha curcas* and *ficus thonningii*, Cd in *ficus thonningii* and Ni in *commiphora kerstingii* and *athropha curcas.*Arsenic is a toxic and non-essential element, widely known for its adverse effects on human health (Santuraki *et al*., 2019). Chronic toxicity results in multisystem diseases including carcinogenesis affecting almost all organs (Ratnaike, 2003). Arsenic exerts its toxicity by inactivating up to 200 enzymes, especially those involved in cellular energy pathways, DNA synthesis, and repair (Kishan *et al*., 2014). The values of As obtained in this study were below values earlier reported in a similar study, (0.43 ppm) in some Indian medicinal plants, Bengal, India (Kishan *et al*., 2014), but above that of the study by Kopi *et al.* (2013), which was below the detectable limit. However, the arsenic was below the detectable limit in two medicinal plant samples collected. Cadmium causes both acute and chronic poisoning, which may result in adverse effects on the liver, kidney, immune system and vascular tissue (Jabeen *et al*., 2010).Cadmium is frequently discharged from anthropogenic sources (Sulaiman *et al*., 2019). The levels of Cd recorded in this study were lower compared to similar studies earlier reported, (1.66 ppm) in ten important folk therapeutic plants, Peshawar, Pakistan (Jabeen *et al*., 2010), (14.05 µg/g) in some selected medicinal plants, Kumasi, Ghana (Kofi *et al*., 2013) and (0.36 ppm)in some selected medicinal plants, Ibadan, Nigeria (Rufai *et al*., 2019), but in line with values reported by Kishan *et al*., (2014). Chromium is important in carbohydrate metabolism and also functions in cholesterol and protein synthesis (Kishan *et al.,* 2014), but chronic exposure of chromium may result in nose irritations, skinrash, stomach upset, bleeds, kidney, liver and lung damage (Zayed and Terry, 2003; Baye and Hymete, 2013). The values of Cr obtained from this study were higher than values reported in earlier studies, (0.69 mg/kg) in some medicinal plants, Riyadh, Saudi Arabia (Hatem *et al*., 2019), but lower than the value of (4.79ppm) reported by (Rufai *et al*., 2019). Copper is an essential element to the human body, it forms component in several enzymes, includes; lysyloxidase, cytochrome oxidase and an iron-oxidizing enzyme in the blood (Adamu *et al*., 2016), but could be toxic if taken above their commended dose and long duration (Obi*et al*., 2006).

The Cu levels in the present study werehigher than (0.34 ppm) reported for grewia mollis plant parts from Borno, Nigeria (Adamu *et al.*,2016). However, thelevel of Cuin this study was lower than (15.62 ppm) and (35.50 mg/kg) reported for medicinal plants from Pakistan (Jabeen *et al.*, 2010) and Serbia (Danijela *et al.*, 2011) respectively. Manganese is an essential element for bone development, metabolism of lipids, amino acids and carbohydrates, reproduction and its helps in the central nervous system function (Adamu *et al.*, 2016). The levels of Mn obtained from this study were lower than the similar studies as earlier reported, (49.39 mg/kg) in medicinal plants and their extracts, Serbia (Danijela *et al.*, 2011), (105.56 ppm) in Pakistan (Jabeen *et al.*, 2010), but in line with values reported by (Adamu *et al.*, 2016). Nickel is required in the body in small quantities as it is present in the pancreas where it plays an important role in insulin production (Rufai *et al.*, 2019). Similarly, it has been confirmed that the deficiency of nickel in the human body results in liver disorder (Khan *et al.*, 2008). The levels of Ni in this present study were higher than (0.88 mg/kg) and (0.113 ppm) reported in medicinal plants from India (Kishan *et al.*, 2014), Borno, Nigeria (Adamu *et al.*, 2016), and below detectable limit from Ibadan, Nigeria (Rufai *et al.*, 2019) respectively. Lead is a non-essential element, exposure of lead beyond the permissible limits or long term use of contaminated plants may result in chronic nephritis, headache, colic, anemia, convulsions, brain damage and central nervous system (CNS) disorders (Tong *et al.*, 2000; Klaassen, 2001; Kishan *et al.*, 2014). The recorded value of Pb in this study was lower than values reported in an earlier study, (9.7 mg/kg) in some medicinal plants, Riyadh, Saudi Arabia (Hatem *et al.*, 2019) and (9.25 ppm) reported by (Kofi *et al.*, 2013). The mean metals contents (As, Cd, Cr, Cu, Mn, Ni and Pb) in medicinal plants samples were below the WHO and FAO/WHO target limit of (As = 0.2, Cd = 0.3, Cr = 2, Cu = 3, Mn = 2, Ni = 1.63 and Pb = 10 ppm). However, the mean content of Mn in *ficus thonningii* and *cassia singueana* samples studied was above 2ppm limit set by WHO, (2007).

Table 1: Heavy metal mean content (ppm) in some medicinal plants from Nigeria [mean ± SE]

S/N	Plants name	Treatment	Part use	As	Cd	Cr	Cu	Mn	Ni	Pb
1	*Commiphora kerstingii*	Antibiotic	Stem bark	0.002±0.0	0.034±0.00	1.570±0.0	2.090±0.0	0.765±0.01	BDL	4.500±0.0
2	*Guiera senegalensis*	File	Leaves	0.001±0.0	0.097±0.00	1.995±0.0	1.995±0.0	1.830±0.04	0.362±0.00	1.575±0.0
3	*Jathropha curcas*	Stomachache	Leaves	BDL	0.155±0.00	0.061±0.0	2.980±0.0	1.965±0.12	BDL	8.295±0.0
4	*Securidaca*	Antibiotic	Whole	0.025±0.0	0.240±0.01	0.940±0.0	1.400±0.0	0.965±0.08	0.016±0.00	0.116±0.0
5	*Erythrina senegalensis*	Yellow fever	Leaves	0.014±0.0	0.035±0.00	1.670±0.1	0.875±0.0	1.885±0.00	0.875±0.01	7.870±0.0
6	*Cochlospermum*	Yellow fever	Stem bark	0.016±0.0	0.009±0.00	1.990±0.0	2.865±0.0	1.950±0.06	0.985±0.00	0.572±0.0
7	*Khaya senegalensis*	Stomachache	Stem bark	0.053±0.0	0.008±0.00	1.070±0.0	0.990±0.0	0.936±0.04	1.000±0.00	7.890±0.0
8	*Ficus thonningii*	Yellow fever	Leaves	BDL	BDL	0.880±0.0	2.935±0.0	2.020±0.01	0.005±0.00	5.716±0.0
9	*Anogeissus leiocarpus*	Cool and	Stem bark	0.095±0.0	0.141±0.00	1.470±0.0	1.290±0.0	1.275±0.01	1.051±0.00	2.402±0.0
10	*Cassia singueana*	Antibiotic	Leaves	0.160±0.0	0.050±0.04	0.194±0.0	0.925±0.0	2.075±0.02	1.089±0.01	3.871±0.0

BDL= Below detectable limit

Heavy metal pollution index (HMPI)

The heavy metal pollution index (HMPI) is a useful tool used for effective monitoring of heavy metal pollution in a study samples. The HMPI in this study revealed that HMPI values are in the following order: AC > ES > KT > FT > AL > CT > CK > CS > GS > SL. This indicated that AC sample is having the highest pollution index and is more likely to cause an adverb heath effect than the other studied samples.

Table 2: Heavy metal pollution index in the medicinal plant's samples

S/No	Plants samples	ID	Heavy metal pollution Index
1	*Commiphora kerstingii*	CK	1.368
2	*Guiera senegalensis*	GS	1.338
3	*Jathropha curcas*	AC	1.454
4	*Securidaca longepedunculata*	SL	1.205
5	*Erythrina senegalensis*	ES	1.446
6	*Cochlospermum tinctorium*	CT	1.355
7	*Khaya senegalensis*	KT	1.425
8	*Ficus thonningii*	FT	1.418
9	*Anogeissus leiocarpus*	AL	1.339
10	*Cassia singueana*	CS	1.354

Pearson correlation analysis

Pearson correlation analysis was performed for metal contents in the medicinal plant's samples at levels of significance ($p < 0.05$ and $p<0.01$) and the results are presented in Table 3. The results indicated that metal pairs have a week and negative correlations ($r>-0.2$) except Mn and Ni with positive correlations $r > 0.3$. Most metal pairs showed negative significant ($p< 0.05$ and $p<0.01$) indicating no simultaneous release of the metals from the same sources.

Table 3: Pearson correlation matrix for the heavy metals in some medicinal plants from Nigeria

Metals	As	Cd	Cr	Cu	Mn	Ni	Pb
As	1	-.043	-.353	-.565**	.062	.639**	-.108
Cd		1	-.254	-.099	-.240	-.341	-.354
Cr			1	-.041	-.181	.199	-.411
Cu				1	.331	-.555*	-.036
Mn					1	.153	.113
Ni						1	-.026
Pb							1

**. Correlation is significant at the 0.01 level (2-tailed).

*. Correlation is significant at the 0.05 level (2-tailed).

CONCLUSIONS

The results of the study showed the presence of As, Cd, Cr, Cu, Mn, Ni and Pb. The results also showed that except for Mn, all other metals were below the target limits set for medicinal plants (WHO and FAO/WHO)of (As = 0.2, Cd = 0.3, Cr = 2, Cu = 3, Mn = 2, Ni = 1.63 and Pb = 10 ppm) in the samples. The HMPI analysis revealed that AC has the highest pollution index and is more likely to cause an adverse health effect than the other studied samples.

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Conflict of interest:

Author(s) have not declared any conflict of interest

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