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Heavy Metals Contamination in Medicinal Plants. A Case Study of Onigambari Forest Reserve Ibadan, Nigeria

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Abstract

Medicinal plants from time long have been playing an important role in human health. They represent a class of traditional herbal medicine needed for diseases treatment. Due to anthropogenic activities, these plants are contaminated by toxic substances including heavy metals. This study was conducted to determine the contamination of heavy metals in herbal medicinal plants. A total of 10 medical plants from Onigambari forest reserve were analyzed in this study for heavy metals (Pb, As, Zn, Ni, Mn, Cr and Cd) contamination using (ICP-OES). The samples were collected between the months of February and March, 2024. The concentrations of the heavy metals (mg/kg) were in the range of 1.58±0.33 to 5.21±0.00 mg/kg for Pb, <0.008 to 0.08±0.01 mg/kg for As, 10.22± 0.42 to 18.45 ±0.06 mg/kg for Zn, 0.88±0.44 to 1.72 ±0.12 mg/kg for Ni, 11.00± 0.30 to 88.46± 0.28 mg/kg. for Mn, 0.53 ±0.23 to 2.43± 0.40 mg/kg. for Cr, and 0.11±0.01 to 0.55±0.02 mg/kg for Cd. The results revealed that the plants under examination were unsafe for Cr in all sampled plants and Cd in Khaya ivorensis being higher than the World Health Organization (WHO) permissible limits. Due to the presence of several quarry sites around the forest reserve blasting rocks and releasing heavy metals and radionuclides which have the tendencies of causing severe health implications on humans, it is therefore recommended that there is a need for constant monitoring of plants for human consumption to ensure their safety.

Keywords: Contamination, Heavy Metals, Health Risk Medicinal Plants,

Introduction: A plant species that contain therapeutic or curative qualities of pharmacological value on human or animal body is referred to as Medicinal plant (Tilburt and Kaptchuk,2008).

The consumption of various parts of medicinal plants including the leaves, roots, barks, fruits, and even seeds for medical uses is well-known as the initial form of therapeutic method (Rufai, Olaniyi and Lawal, 2019). Approximately 80% of patients in Africa use traditional medicine for their healthcare needs (WHO,2018).

Medicinal plants due to their ability to survive even in polluted soils can absorb contaminants through their roots or by

deposition on the leaves from the air (Kohzadi, Shahmoradi, Ghaderi, Loqmani, and Maleki, 2018). Several Health Services in Africa including Nigeria and Ghana has embraced the use of herbal medicines in recognition of the essential role herbal medicines play in health care system (Traditional and Alternative Medicine Ghana,2022).

Commonly used medicinal plants in Nigeria are Chromolaena odorata (Siam weed), for stopping bleeding wounds, diarrhea, etc. Piper guineense (West African black pepper) is known to treat fevers and malaria. Lime which contains vitamin C is used to treat scurvy. Garcinia kola (locally known in Nigeria as Obi) is used as a decoction in traditional medicine for treating ailments such as cough, an erectile dysfunction) (Boadu and Asase,2017). Medicinal plants can be contaminated by Heavy metals if planted or grown in contaminated soils (Jurowski and Krosniak 2022). The heavy metals can find its way into human system if the contaminated plant is consumed, inhaled or through the dermal route (Duoris, Bentil, Osei, Akoto, Amponsah, Adu, and Bussan, 2022). This can pose a serious health implications to humans. Delayed exposure to Cd causes hypertension, lung and prostate cancer, bone and kidney diseases, and emphysema (Li, Zhou, Qin, Tian, Qi, Yan, and Han, 2019). Arsenic is known to cause teratogenic and mutagenic disorders, Copper usually causes metabolic disorders, kidney and liver damage, anemia and abdominal pain (Shahkarami, Goudarzi, Amiri-Ardekani, and Dehghani, 2021). Lead has been reported to cause cardiovascular and reproductive disorders (Saleh, Saleh, Panahande, Yousefi, Asghari, Conti, Talaee, and Mohammadi, 2019).

The occurrence of high concentrations of heavy metals including Co, As, Zn, Ni, Pb, Cr, Cd, and Fe in medicinal plants have been reported in Nigeria and several other African countries (Oladeji, Kopaopa, Mugivhisa, and Olowoyo, 2023). With almost total disregard to reports on the dangers associated with the occurrence of heavy metals in plants, the use of medicinal plants has been on the rise in all parts of Nigeria (Sulaiman, Santuraki, Gimba, Ali, and Barambu, 2022).

This study therefore determines the levels of contamination of heavy metals ((Pb, As, Zn, Ni, Mn, Cr and Cd) in selected medicinal plants from Onigambari Forest Reserve.

Materials and methods: Samples collection: A total of 10 medicinal plant samples were collected from Onigambari forest reserve, Oyo state south west Nigeria during the months of February and March, 2024. Sampling locations were selected based on areas with a high production of medicinal plants. Onigambari forest reserve was chosen particularly due to its preserved vegetation and Prescence of diverse economic tree species.

Samples digestion for Heavy Metal Analysis: All the reagents used were of analytical grade: perchloric acid ($HClO_4$) 70% 1.33 Merck, Darmstadt, Germany and nitric acid (HNO_3) 65%, 1.40 Merck, Darmstadt, Germany. The sample digestion was performed with (HNO_3:$HClO_4$) at a ratio of 1:3, as reported elsewhere (Ekere, Ihedioha, Ayogu, Ogbefi-Chima, Onoja, and Alum, 2018). In brief, the plant samples (1.0 g) were transferred into Teflon cups. About (20 mL) of HNO3 was added and stood for one hour. Approximately 70% (5 mL) of $HClO_4$ was heated for 30 min and then added to the mixture. The mixture was then heated in a fume cupboard for 15 min to

reduce the volume of the solution to 10 mL, filtered with a Whatman filter paper (no. 42) into a 50 mL volumetric flask, and marked with deionized water. Blanks were also digested in the same way as samples. The resulting filtrate was utilized to determine the concentration of heavy metals in the plant samples through Inductively Coupled Plasma-Optical Emission Spectrometry (ICP-OES).

Statistical analysis: The data obtained was subjected to simple descriptive statistics (mean and standard deviation), and the mean values obtained was separated using Duncan multiple range test (DMRT) and compared with the standard permissible limit.

Results and Discussion: Concentration (mg/kg) of Heay Metals in Medicinal Plants, Table 1 shows the mean concentrations of heavy metals in medicinal plant samples from Onigambari forest reserve south west Nigeria. The mean concentration of Pb was 2.98±0.5 mg/kg and ranges from 1.58±0.33 to 5.21±0.00 mg/kg. All the metal samples under consideration had Pb concentrations below the WHO permissible limits of 10mg/kg in medicinal plants. This agreed with Ullah, Khader, Hussain, A b d u l s a l a m , Talha, and Khan, (2012) where a similar work done in India reported Pb levels that ranged from 0.25- 2.64 mg/kg below WHO permissible limits. Exposure to lead has detrimental effects on humans with symptoms that varies from hypertension, convulsions, chronic nephritis, central nervous system disorders and anemia. Also, exposure to lead can cause learning deficits, sound effects and cognitive disorder in children (Singh, Shubharani, and Sivaram 2014).

The mean arsenic concentration recorded was 0.03±0.01 mg/kg with a range of <0.008 to 0.08±0.01 mg/kg. All the samples in this study recorded As levels below the World Health Organization maximum permissible limit of 3.0 mg/kg. Acacia *senegal* had the highest As level of 0.06 mg/kg while Parkia *biglobosa* had the lowest level of <0.008. Arsenic was not detected in medicinal crops sampled within the Accra Metropolis, Ghana (Tawiah,2018). The variation can be attributed to the different activities that took place in the locations. An As range of 0.18 to 5.44 mg/kg was recorded in selected medicinal crops from in Algeria (Begga and Messaoudi,2019). Toxic levels of As exposure In adults usually causes conditions such as lungs cancer, liver dysfunction, and respiratory syndromes (Bjorklund, Oliinyk, Lysiuk, 2020).

The mean Zn concentration in the plants was 11.20± 0.30 and ranges from 10.22± 0.42 to 18.45 ±0.06 mg/kg. These values are below the WHO permissible limit of 100 mg/kg zinc. The work is in agreement with the report of Bhavani and Vive, (2014) where a low level of zinc ranging from 0.21 to 1.07 mg/kg was reported. Conversely, Kulhari, Sheorayan, Bajar, Sarkar, Chaudhury, and Kalia, (2013) reported an elevated zinc levels ranging from 2.42 to 8.93 mg/kg. As an essential metal in human health, Zinc regulates muscles contraction and also plays the role of a co-factor for enzymes in the body. However, elevated zinc intake beyond the permissible limit can increase blood lipoprotein levels toxicity, and the immune system (Moradi, Mirzaei, Alipour, Bay, Ghaderpoori, Asadi, Fakhri, Sorooshian, and Mousavi, 2020). Increased intake can lead to reduced body weight, and internal organ damage.

The mean nickel (Ni) concentration was 1.25 ± 0.24 mg/kg with a range of 0.88±0.44 to 1.72 ±0.12 mg/kg. This are lower than the

WHO maximum permissible limit of 10.0 mg/kg for Ni. Blighia sapida had the highest concentration and Parkia biglobosa had the least nickel (Ni) concentration. The level of Ni in this study was higher than the level reported by Raouf, Hammud, Zamil, (2014) in Kenya with Ni levels ranging from 0.09 to 1.6 mg/kg. Also, Baba and Mohammed, (2021) reported levels of Ni below the WHO for medicinal plants sampled from Kano, Nigeria which agreed with the present study. High blood pressure, neurological, cardiovascular, lung cancer and developmental disease are associated with high levels of Ni in humans.

The mean manganese (Mn) concentration in this study was 60.59 ± 0.55 mg/kg with a range of 11.00± 0.30 to 88.46± 0.28 mg/kg. Elevated levels of manganese in human have been reported to result in tremors, facial muscle spasms and walking difficulty.

The mean concentration of Cr was 1.41± 0.30 mg/kg and ranges from 0.53 ± 0.23 *to* 2.43± 0.40 mg/kg. The results obtained for Cr in this study showed a higher Cr concentration in the plants examined when compared to WHO permissible of 2.0 mg/kg for Cr in plants (Onwordi, Agbo, and Ogunwande 2015). Parkia biglobosa had the highest Cr level of 2.43± 0.40 mg/kg and Jatropha curcas had the least value of 0.53 ± 0.23 mg/kg respectively. Cr levels of 0.73–4.79 mg/kg reported in a similar study by Boateng, Danso-Appiah, Turkson, and Tersbol, (2016) was approximately twice the results obtained in this study. Cr plays a vital role in nucleic acid regulation, lipoprotein and glucose metabolism, also it is important to note that increased level of Cr in human has been reported to cause gastrointestinal cancer, cardiovascular disorders, and reduces blood glucose. The mean cadmium (Cd) concentration was 0.24 ± 0.40 mg/kg with a range of 0.11±0.01 to 0.55±0.02 mg/kg. Khaya ivorensis recorded the highest Cd concentration which is higher than the WHO permissible limit while Jatropha curcas had the least concentration below the WHO Limit of 0.3 mg/kg.

This study recorded lower levels of Cd when compared to the work of Ogbonna, Nzegbule, Obasi, and Obasi (2018) that reported a mean Cd concentration of 2.00 mg/kg for medicinal crops higher than WHO permissible limit from Enyimba City, Nigeria. In a similar report, higher Cd concentrations above the values obtained in this study was reported in herbal plants in Kumasi region of Ghana (Nkansah, Hayford, Borquaye, and Ephraim, 2016). Cadmium toxicity predominantly accumulates in the kidneys, where it has been reported to inflict severe damage ranging from renal tubular destruction, vascular immune system disruption, to kidney stones (Mahajan and Kausha,2018).

Table 1: Concentration of Heavy Metals in Selected Herbal Medicinal Plants

Medicinal Plant	Pb	As	Zn	Ni	Mn	Cr	Cd
Khaya ivorensis	2.87±0.04^{c}	0.01±0.01^{c}	18.45±0.06^{a}	1.68±0.58^{a}	55.47±0.78b	1.89±0.77a	0.55±0.02a
Blighia Sapida	4.52± 0.12^{a}	0.02±0.01^{c}	10.22±0.42^{c}	1.72±0.12^{a}	56.00±0.50 b	1.27±0.08b	0.23±0.09b

Cedrela odorata 0.49±0.06a	3.21± 0.32 [b]	0.05±0.02[a]	11.19±0.40[c]	1.12±0.10[c]	38.43±0.93c	0.96±0.46c
Jatropha curcas 0.11±0.01c	2.77± 0.06[c]	0.01±0.00[c]	5.88±0.22[d]	1.33±0.18[b]	88.46±0.28a	0.53±0.23c
Mansonia altisima 0.12±0.03c	1.64±0.29[d]	0.04±0.01[b]	11.87±0.12[c]	1.12±0.26[c]	22.87±1.59d	1.65±0.32a
Milicia excelsa 0.26 ±0.02b	2.11±1.09 [d]	0.08±0.03[a]	14.97±0.18[b]	1.01±0.35[c]	11.00±0.30	1.44±0.19b
Parkia biglobosa 0.19±0.00b	1.58±0.33[d]	<0.008[d]	13.05±0.19[b]	0.88±0.44[d]	77.24±0.17a	2.43±0.40a
Terminalia superba 0.17±0.04 b	2.03±0.11[d]	0.02±0.01[c]	12.66±0.78[c]	0.35±0.07[e]	126±0.46a	1.78±0.03a
Sterculia oblonga 0.13±0.00c	5.21±0.00 [a]	0.03±0.01[b]	17.45±0.25[a]	1.63±0.19 [a]	47.26±0.14c	1.26±0.18b
Acacia Senegal 0.12±0.02c	3.87±2.11 [b]	0.06±0.01[a]	13.66±0.41[b]	1.66±0.1.4[a]	83.12±0.36a	0.88±0.25c
Mean 0.24±0.03	**2.98±0.5**	**0.033±0.01**	**11.20±0.30**	**1.25±0.24**	**60.59±0.55**	**1.41±0.30**

Mean values with same superscript along the same column are not significantly different (P>0.05)

Conclusion: The contamination of herbal plants from Onigambari forest reserve southwest, Nigeria by heavy metals was determined in this study. The results revealed that the studied heavy metals in the medicinal plants were mostly below the permissible limit for consumed herbal plants as set by the WHO, except for Cr in all the plants and Cd in Khaya ivorensis.

Recommendation: Due to the presence of several quarry sites around the forest reserve blasting rocks and releasing heavy metals and radionuclides which have the tendencies of causing severe health implications on humans, it is therefore recommended that there is a need for constant monitoring of plants for human consumption to ensure their safety.

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