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Determination of trace heavy metals content of various herbal drinks marketed in Ilorin Metropolis, Nigeria

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Abstract

The study encompasses an evaluation of the health risk and hazard profiles of heavy metals contents in various herbal drinks (AGBO) products marketed in Ilorin metropolis, Nigeria. Twenty herbal drinks samples from four (4) different study (saw-mil, Osere, Oja-oba and Oke-odo) areas were collected randomly, digested and analyzed. Zinc, Lead, Copper, Iron, Manganese, Cadmium, Chromium and Nickel were analyzed using Atomic Absorption Spectrometer. The results of this study indicated that most of the heavy metals (Zn, Pb, Cu and Mn) in the herbal drinks were below the WHO recommended permissible limits. Chromium (Cr) and Cadmium (Cd) are not detected in all of the herbal drinks analyzed. However, sample C2 and D2 among other analyzed herbal samples contained unsafe concentrations of iron (Fe) and nickel (Ni) that exceeded the WHO recommended permissible limits. From the health point of view, the EDIs value of all the herbal drinks are below the daily reference dose. The non-cancerous (HQ) and hazard index (HI) value of all the herbal samples are less than one (1). Based on the results obtained in this study, there would be a non-carcinogenic health risk and hazard effects to the people taking and consuming the herbal drinks marketed in all the study areas.

Keywords: Herbal product, heavy metals, estimated daily intakes EDIs, non-cancerous HQ, hazard index

1. Introduction

The use of Herbal remedies or consumptions is presently prevalent all over the world. They are widely used as an active part in the prevention, management as well as treatment of various ailments and illnesses such as fever, pain, headache, diabetes, hypertension, rheumatism, and many others [1]. According to World Health Organization (WHO), approximately 70–80% of the global population still primarily rely on traditional medications, from herbal based products to orthodox for basic health care. The utilization of many herbal medicines for improving well-being is gaining popularity around the world due to its low cost, availability, lesser side effects, affordability and enhanced effectiveness. Also, because of poverty and limited access to modern medicine among other reasons [2]. The safety and quality of herbal medicinal plants during germination and growth are determined by several factors which include climatic conditions, seed selection, fertilizers application, harvesting and storage. Factors such as industrialization, the use of fertilizers, ineffective pollution control and pesticide residues and inconsiderate extraction method and handling are some of the factors which largely contribute to contamination of herbal products with pollutants such as heavy metals which can significantly affect and alter properties, efficacy and the quality of the herbal medicinal plants and their formulations [3,4]. The bio-accumulation of Heavy metals by the herbal plants from the soil can be highly toxic to human health and may cause serious health hazards such as decrease in immunological defenses, renal failure, gastrointestinal cancer, impaired psychological, cardiac dysfunction, fetal malformation and neurological behavior [5]. In many Africa countries such as Nigeria, most herbal traders sell their products along busy traffic urban centers [6]. These Herbal drinks are displayed outside their shops and stores exposing them to air-borne heavy metals contamination [7]. The precise knowledge of amount of Heavy metals concentration present in herbal product is important for the estimation of whether the ingested heavy metal concentration will be within the WHO PL values or not [8]. The WHO has formulated guidelines for quality assurance and control of herbal medicine, but most traditional practitioners lack this information. There are

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many research papers dealing with heavy metals content in herbal product to determine their safe daily intake, but few of them are reported [9]. Recently, a lot of cases of health risk from heavy metals such as manganese, lead, iron, cadmium and mercury remain underreported while some are not recorded due to poor bookkeeping in the developing countries [10].

The accurate determination of heavy metals using analytical method in herbal plants is vital as they have a narrow range of quality and safety between adequate levels and excessive intake of the herbal products. Among the various analytical methods used for heavy metals analysis in herbal plants, Atomic Absorption Spectrometry (AAS) is one of the most frequently used because of its simplicity, low detection limits, low volume requirements [11]. Therefore, there's a need for more studies in examining the safety and quality of the herbal products. Therefore, this research study focused on determination of Heavy metals contents in various herbal drinks products marketed within Ilorin metropolis, Nigeria. The objectives of the study were: (1) to determine the concentrations of Heavy metals in selected herbal drinks products in various locations in Ilorin, (2) to calculate the average estimated daily intake of heavy metals in herbal drinks samples and (3) to assess the non-cancerous risk and potential health hazard of the consumption of these herbal drinks products based on the World Health Organization (WHO) standard limit.

2. Materials and methods

2.1. Sample collection

The samples were collected in four different areas which includes; Saw mill, Osere, Oja-oba area and Oke-odo area and as label as sample areas A, B, C, D respectively. The herbal drinks that were gotten from this study areas are; malaria herb (Iba), All-purpose herb (gbogbo leshe), Deidra herb (jedi-jedi), Typhoid herb, Back pain herb (opa-eyin), Manhood power (Ale). The samples collected are used in the treatment of typhoid, fever, back pain, headache, body pain, malaria. The herbal drinks samples were collected into a clean bottles and labeled accordingly so as to avoid error or confusion among the samples. The experimental work for the determination of heavy metals in herbal drinks was conducted at the Chemistry Department Laboratory of the University of Ilorin, Ilorin, Nigeria. The samples collection areas, locations coordinates, sample code and their traditional use are presented in Table 1. The samples were then kept in a dry place of 10°C before being taken for analysis.

2.1.1. Sample preparation and digestion

All reagents and solvents, including nitric acid, hydrochloric acid and deionized water, were of the analytical reagent grade and was purchased from Sigma Aldrich. The digestion procedure employed for the elements (except Hg) was as described by [12] with little modification. The project was carried out using an Aqua-regia method in ratio (3:1) of HCl and HNO_3 respectively. 2.0 g of the herbal drinks (Agbo) was accurately measured into a conical flask, 15 mL concentrated nitric acid was added followed by 5 mL concentrated hydrochloric acid. The flask was closed and left for 15 minutes to ensure complete reaction. The mixture was heated for about 150°C until no browner fumes were produced. The samples solution was then cooled, and 50 mL of deionized water were added. The solution was filtered through whatmann filter paper No. 1 into a 100 mL volumetric flask and diluted to a volume with deionized water and pour into a sample bottles before taken for analysis.

2.1.2. Sample Analysis

Digest samples were analyzed for Zn, Pb, Cu, Fe, Cd, Mn, Cr and Ni using BUCK Scientific (ACCUSYS 211) atomic Absorption spectrophotometer (AAS). The 1000 ppm standard solutions of elements were diluted in five different concentrations to obtain calibration curve for quantitative analysis. All the measurements were run in triplicate for the sample and standard solutions.

2.2. Data analyses and evaluation methods

Statistical and data analysis was carried out on the results obtained in order to enhance data interpretation. The statistical data were analyzed using Microsoft Excel 2019. The concentration results of heavy metals were calculated as mean ± standard deviation (µg/L) of triplicate analysis.

2.3. Health risk and hazard evaluation of heavy metals.

In order to fully assess the health risk and Hazard of heavy metals in the herbal products, various evaluation methods are employed such as Estimated Daily Intake (EDI) of metal, Hazard Quotient (HQ), and Hazard Index (HI) [13].

2.3.1. The estimated daily intake dose (EDI)

The EDI of Zn, Pb, Cu, Fe, Mn, and Ni were calculated to estimate the average daily intake or consumption of heavy metals to a specified bodyweight, according to the mean concentrations of each heavy metal in the herbal products and the consumption rate as described by [13–15], in the Equation 1:

$$EDI = \frac{C_{H.M} \times A_{IR}}{BW_{average}} \quad (1)$$

Table 1. Study locations coordinates, samples code and traditional use

Collection area	Latitude	Longitude	Sample Code	Traditional use
Saw-mill (Ilorin west) area	8.4707° N	4.52620° E	A1	Malaria (Iba)
			A2	All-Purpose Herbs (Gbogbo Leshe)
			A3	Pile (Jedi-jedi)
			A4	Typhoid
			A5	Back Pain Herbs (Opa-eyin)
			A6	Manhood Power (Ale)
Osere (Ilorin West) area	8.09142° N	4.63767° E	B1	Malaria (Iba)
			B2	All-Purpose Herbs (Gbogbo Leshe)
			B3	Pile (Jedi-jedi)
			B4	Typhoid
			B5	Back Pain Herbs (Opa-eyin)
			B6	Manhood Power (Ale)
Oja-oba (Ilorin West) area	8.4760° N	4.4560° E	C1	Malaria (Iba)
			C2	Pile (Jedi-jedi)
			C3	Typhoid
			C4	Back Pain Herbs (Opa-eyin)
			C5	Manhood Power (Ale)
Oke-odo (Ilorin south) area	8.4799° N	4.5418°E	D1	Malaria (Iba)
			D2	Pile (Jedi-jedi)
			D3	Typhoid

Where: $C_{H.M}$ = the concentration of heavy metals in the herbal products in mg/L. $A_{I.R}$ = the average ingestion rate or daily intake of herbal products in kg., An average daily consumption or ingestion rate of 0.01 kg of herbal products was assumed in this study. $BW_{average}$ = average body weight in kg per person. The average body weight of an adult was considered to be 60 kg. This method was used because herbal products are widely consumed as a major part of the diet.

2.3.2. Hazard quotient (HQ)

Hazard Quotient was used to evaluate the non-carcinogenic risks to humans from long-term consumption of heavy metals from herbal products, according to [16]. The HQ is the ratio of the calculated dose to the oral reference dose as described by [16], in the Equation 2:

$$HQ = \frac{EDI}{Rf_{Do}} \quad (2)$$

where EDI = average estimated daily intake or consumption of herbal products in (mg/L day^{-1}) and Rf_{Do} = reference dose of each heavy metal in (mg/kg day^{-1}), which is an average daily tolerable consumption or intake to which a person is expected to have without any significant health risk effects for a long period of time. The following reference doses of heavy metals used and WHO recommended permissible limits in this study are presented in (Table 2). HQs of heavy metals in herbal products were evaluated according to the procedure described by the Environmental Protection Agency (EPA) [17]. If HQ is < 1 indicate no potential health risks effects due to herbal product consumption, while HQ is > 1 indicate that there are potential health risks and hazard due to consumption or intake of herbal product.

Table 2. LOD, Reference dose used in this study & WHO recommended PL [18–20]

Heavy metal	LOD (µg/L)	LOQ (µg/L)	RfDo (µg/L)	WHO PL (µg/L)
Zn	0.008	0.079	300.00	5000.00
Pb	0.060	0.57	40.00	10.00
Cu	0.02	0.15	700.00	2000.00
Fe	0.045	0.45	140.00	100.00
Mn	0.03	0.28	20.00	40.00
Cd	—	—	3.50	30.00
Cr	—	—	5.00	50.00
Ni	0.006	0.058	3.00	20.00

2.3.3. Hazard index (HI)

Hazard Index (HI) was used to calculate the total value of non-carcinogenic risks to human health causing by all heavy metal in herbal product. It is also the summation of the hazardous quotient (HQ) of each heavy metal detected in the herbal product as described in the Equation 3: [16, 21].

$$HI = \sum_{n=1}^{m=8} THQ_i \quad (3)$$

HQ < 1, indicate there is no possibility of adverse health risk effects on human [22,23].

2.4. Quality control

The % recovery evaluation was carried out using the Equation 4.

$$\%\ recovery = \frac{spiked - unspiked}{spiked} \times 100 \quad (4)$$

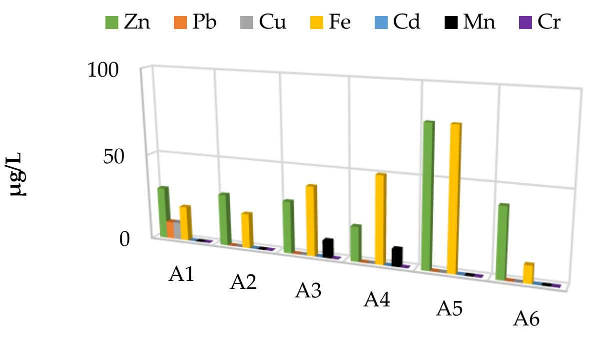

Figure 1. concentration of heavy metals in Saw-mill (A) study area

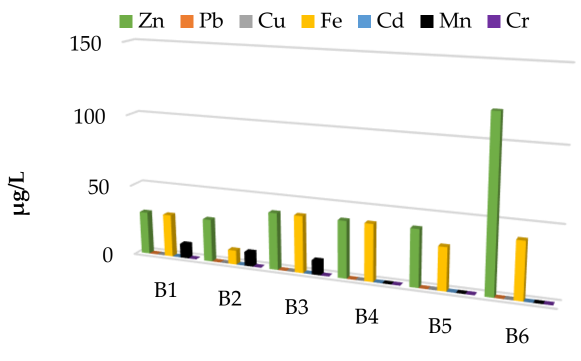

Figure 2. concentration of heavy metals in Osere (B) study area

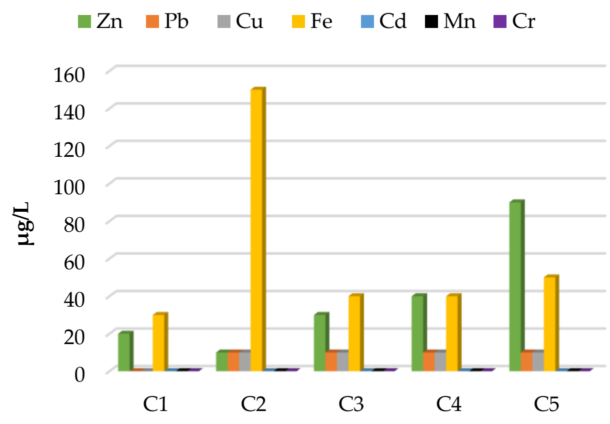

Figure 3. Concentration of heavy metals in Oja-oba (C) study area

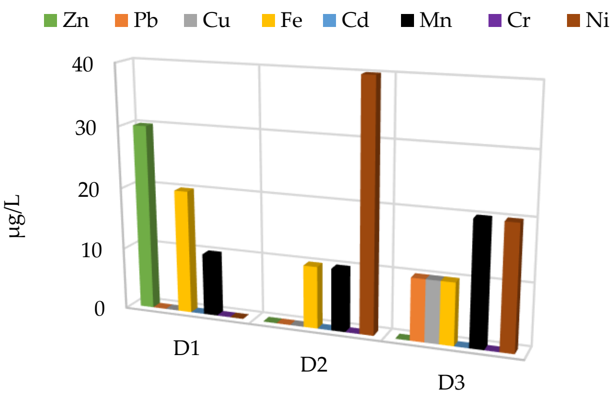

Figure 4. concentration of heavy metals in Oke-odo (D) study area

This was performed by calculating the concentration levels of the heavy metals in herbal drink of spiked and un-spiked samples, and the mean % recovery of the heavy metals ranging from 87 to 103 % were obtained.

2.4.1. Limits of detection (LOD) and quantification (LOQ)

The limit of detection was evaluated by using Perkin Elmer method. A sample solution of 10 µg/L of all the study heavy metals were aspired and the intensities for these metals and blank are calculated and their LOD were recorded (Table 2). The limit of quantification was considered as an acceptable level of accuracy. In order to calculate the LOQ, the standard sample solution of 0.1 µg/L of all the study metals were prepared and aspired in the AAS system. LOQ is considered to be approximately ten times the minimum of LOD.

3. Result and discussions

3.1. Determination of heavy metals in various herbal samples

The results of the heavy metals (Zn, Cu, Pb, Fe, Cd, Mn, Cr and Ni) concentration in the six (6) common herbal products in various locations in Ilorin metropolis are presented in the (Table 3 and Fig.1– Fig.4). The minimum and maximum mean concentration of heavy metals in the herbal product samples are; Zn (10.00 – 120.00 µg/L), Pb (0.00 - 10.00 µg/L), Cu (0.00 - 10.00 µg/L), Fe (10.00 – 150.00 µg/L), Mn (10.00 – 20.00 µg/L) and Ni (20.00 – 40.00 µg/L). The results showed that the concentration of all metals detected in the herbal samples are below the WHO recommended permissible limits, except iron (Fe) and nickel (Ni) in C2 and D2 herbal samples respectively. However, the concentration levels of all the study heavy metals were slightly comparable to the data reported by [24], which revealed the heavy metal concentration levels of commonly consumed herbal bitters in Ilorin, Nigeria. His research showed that majority of the herbal samples contained heavy metals concentrations significantly lower than the permissible limits. The concentration of nickel (Ni) was 20.00 µg/L and it's WHO permissible limits was (20.00 µg/L). Iron metal (Fe) has the highest concentration value in C2 sample product its average value was of 150.00 µg/L, this shows an indication that the herbal product was a little bit contaminated with iron (Fe) above WHO permissible limits of (10.00 µg/L). Zinc (Zn) has the highest concentration in B2 herbal sample, its mean concentration value was 120.00 µg/L. Both zinc (Zn) and iron (Fe) have the highest concentrations in A5 herbal sample, their mean concentrations were 80.00 µg/L in A5 herbal sample. The results of this study however show lower concentrations of zinc (Zn) and iron (Fe) when compared with the work of [25], after they assessed the heavy metals (Fe, Zn, Pb, Cd, Cr, Cu, Mn, and As) hazard from Nigerian spices and the concentrations of zinc and

Table 3. Concentration of heavy metals in herbal samples in different study area

Sample Code	Zn (µg/L)	Pb (µg/L)	Cu (µg/L)	Fe (µg/L)	Cd (µg/L)	Mn (µg/L)	Cr (µg/L)	Ni (µg/L)
A1	30.00 ± 0.002	10.00 ± 0.02	10.00 ± 0.002	20.00 ± 0.06	ND	ND	ND	ND
A2	30.00 ± 0.001	0.00 ± 0.00	ND	20.00 ± 0.06	ND	ND	ND	ND
A3	30.00 ± 0.001	ND	ND	40.00 ± 0.08	ND	10.00 ± 0.02	ND	ND
A4	20.00 ± 0.001	ND	0.00 ± 0.00	50.00 ± 0.10	ND	10.00 ± 0.01	ND	ND
A5	80.00 ± 0.004	ND	ND	80.00 ± 0.10	ND	ND	ND	ND
A6	40.00 ± 0.008	ND	ND	10.00 ± 0.05	ND	ND	ND	ND
B1	30.00 ± 0.002	ND	ND	30.00 ± 0.02	ND	10.00 ± 0.02	ND	ND
B2	30.00 ± 0.001	ND	ND	10.00 ± 0.03	ND	10.00 ± 0.01	ND	ND
B3	40.00 ± 0.002	ND	ND	40.00 ± 0.08	ND	10.00 ± 0.01	ND	ND
B4	40.00 ± 0.01	ND	ND	40.00 ± 0.02	ND	ND	ND	ND
B5	40.00 ± 0.01	ND	ND	30.00 ± 0.06	ND	ND	ND	ND
B6	120.00 ± 0.08	ND	ND	40.00 ± 0.04	ND	ND	ND	ND
C1	20.00 ± 0.02	ND	ND	30.00 ± 0.09	ND	ND	ND	ND
C2	10.00 ± 0.01	10.00 ± 0.06	10.00 ± 0.01	150.00 ± 0.012	ND	ND	ND	ND
C3	30.00 ± 0.01	10.00 ± 0.01	10.00 ± 0.04	40.00 ± 0.004	ND	ND	ND	ND
C4	40.00 ± 0.01	10.00 ± 0.01	10.00 ± 0.02	40.00 ± 0.008	ND	ND	ND	ND
C5	90.00 ± 0.15	10.00 ± 0.03	10.00 ± 0.01	50.00 ± 0.006	ND	ND	ND	ND
D1	30.00 ± 0.02	ND	ND	20.00 ± 0.001	ND	10.00 ± 0.01	ND	ND
D2	ND	ND	ND	10.00 ± 0.001	ND	10.00 ± 0.01	ND	40.00 ± 0.002
D3	ND	10.00 ± 0.01	10.00 ± 0.002	10.00 ± 0.004	ND	20.00 ± 0.002	ND	20.00 ± 0.001

ND = not detected; Values: means ± S.E.M (n=3)

iron in all the spices samples was relatively high when compared with other heavy metals present in different samples. Lead (Pb), copper (Cu) and Manganese (Mn) have the lowest concentrations in the samples, their average mean concentrations were within 10.00–20.00 µg/L. Hence, all the herbal samples characterized were below WHO recommended permissible limit which was comparable to the results of [26] research report of different samples of herbal products marketed in Saudi Arabia, with the concentration levels of study heavy metals within the WHO recommended permissible limit [25]. Except for iron (Fe) and nickel (Ni), they may be contaminated due to anthropogenic activities during drying or preparation processes, which are considered a health risk if they are consumes and may causes damage to lung and blood circulation. Recent studies have revealed that when people take above the permissible safe limit of nickel and iron, either from orthodox or traditional herbal products, untoward reactions may occur [24]. Lead (Pb) and copper (Cu) are not detected in all Osere (B1, B2, B3, B4, B5, B6) herbal samples, manganese (Mn) is not detected in all Oja-oba (C1, C2, C3, C4, C5) herbal samples and nickel is only detected in Oke-odo (D2 & D3) herbal samples. Meanwhile, cadmium (Cd) and chromium (Cr) where not detected in all the herbal product samples in the study areas.

Table 4. The estimated daily intake (EDI) for heavy metals in herbal samples

Sample Code	Estimate Daily intake *(EDI)*					
	Zn	Pb	Cu	Fe	Mn	Ni
A1	0.000005	1.66667×10^{-06}	1.67×10^{-06}	6.67×10^{-06}	0	0
A2	0.000005	0	0	3.33×10^{-06}	0	0
A3	0.000005	0	0	6.67×10^{-06}	1.67×10^{-06}	0
A4	3.33×10^{-06}	0	0	8.33×10^{-06}	1.67×10^{-06}	0
A5	1.33×10^{-05}	0	0	1.33×10^{-05}	0	0
A6	6.67×10^{-06}	0	0	1.67×10^{-06}	0	0
B1	0.000005	0	0	0.000005	1.66667×10^{-06}	0
B2	0.000005	0	0	1.6667×10^{-06}	1.66667×10^{-06}	0
B3	6.67×10^{-06}	0	0	6.6667×10^{-06}	1.66667×10^{-06}	0
B4	6.67×10^{-06}	0	0	6.6667×10^{-06}	0	0
B5	6.67×10^{-06}	0	0	0.000005	0	0
B6	0.00002	0	0	6.6667×10^{-06}	0	0
C1	3.33×10^{-06}	0	0	0.000005	0	0
C2	1.67×10^{-06}	1.66667×10^{-06}	1.67×10^{-06}	0.000025	0	0
C3	0.000005	1.66667×10^{-06}	1.67×10^{-06}	6.6667×10^{-06}	0	0
C4	6.67×10^{-06}	1.66667×10^{-06}	1.67×10^{-06}	6.6667×10^{-06}	0	0
C5	0.000015	1.66667×10^{-06}	1.67×10^{-06}	8.3333×10^{-06}	0	0
D1	0.000005	0	0	3.3333×10^{-06}	1.66667×10^{-06}	0
D2	0	0	0	1.6667×10^{-06}	1.66667×10^{-06}	6.66667×10^{-06}
D3	0	1.66667×10^{-06}	1.67×10^{-06}	1.6667×10^{-06}	3.33333×10^{-06}	3.33333×10^{-06}

Table 5. The non-carcinogenic hazard quotient (HQ) and hazard index (HI) of heavy metals in the herbal samples.

Sample Code	Target Hazard Quotient (THQ)						Hazard Index (HI)
	Zn	Pb	Cu	Fe	Mn	Ni	
A1	1.67×10^{-05}	0.00047619	4.17×10^{-05}	9.5238×10^{-06}	0	0	0.000544048
A2	1.67×10^{-05}	0	0	4.7619×10^{-06}	0	0	2.14286×10^{-05}
A3	1.67×10^{-05}	0	0	9.5238×10^{-06}	1.19048×10^{-05}	0	3.80952×10^{-05}
A4	1.11×10^{-05}	0	0	1.1905×10^{-05}	1.19048×10^{-05}	0	3.49206×10^{-05}
A5	4.44×10^{-05}	0	0	1.9048×10^{-05}	0	0	6.34921×10^{-05}
A6	2.22×10^{-05}	0	0	2.381×10^{-06}	0	0	2.46032×10^{-05}
B1	1.67×10^{-05}	0	0	7.1429×10^{-06}	1.19048×10^{-05}	0	3.57143×10^{-05}
B2	1.67×10^{-05}	0	0	2.381×10^{-06}	1.19048×10^{-05}	0	3.09524×10^{-05}
B3	2.22×10^{-05}	0	0	9.5238×10^{-06}	1.19048×10^{-05}	0	4.36508×10^{-05}
B4	2.22×10^{-05}	0	0	9.5238×10^{-06}	0	0	3.1746×10^{-05}
B5	2.22×10^{-05}	0	0	7.1429×10^{-06}	0	0	2.93651×10^{-05}
B6	6.67×10^{-05}	0	0	9.5238×10^{-06}	0	0	7.61905×10^{-05}
C1	1.11×10^{-05}	0	0	7.1429×10^{-06}	0	0	1.8254×10^{-05}
C2	5.56×10^{-06}	0.00047619	4.17×10^{-05}	3.5714×10^{-05}	0	0	0.000559127
C3	1.67×10^{-05}	0.00047619	4.17×10^{-05}	9.5238×10^{-06}	0	0	0.000544048
C4	2.22×10^{-05}	0.00047619	4.17×10^{-05}	9.5238×10^{-06}	0	0	0.000549603
C5	0.00005	0.00047619	4.17×10^{-05}	1.1905×10^{-05}	0	0	0.000579762
D1	1.67×10^{-05}	0	0	4.7619×10^{-06}	1.19048×10^{-05}	0	3.33333×10^{-05}
D2	0	0	0	2.381×10^{-06}	1.19048×10^{-05}	0.000333333	0.000347619
D3	0	0.00047619	4.17×10^{-05}	2.381×10^{-06}	2.38095×10^{-05}	0.000166667	0.000710714

3.2. Estimated daily intakes of heavy metals.

The daily intakes of Zn, Cu, Pb, Fe, Mn and Ni, from herbal samples were estimated according to the concentrations of each specific heavy metal in the herbal samples and the daily ingestion rate for adults with 60 kg average body weight.

The findings show that all the herbal samples had lower values of EIDs as presented in (Table 4). The EDI values of all the heavy metals in the herbals samples were below the tolerable daily intake reference dose (RfD) of individual heavy metals. These levels were below the WHO allowable daily dose of 0.01 kg/day for adults weighing 60 kg [18]. The EDIs increasing according to this trend: Pb < Cu < Ni < Zn < Fe. The iron (Fe) and zinc (Zn) contributions are the highest among the daily intake of heavy metals form the herbal products in the study locations.

3.3. Evaluation of non-carcinogenic hazard quotient (HQ) and hazard index (HI)

In order to evaluate the health risk effect of exposure to heavy metals through the daily intake of herbal product, the non-carcinogenic hazard quotient (HQ) and hazard index (HI) are calculated, and the obtained results are presented in (Table 5). As shown in (Table 5), the non-carcinogenic (HQ) values of all the study heavy metals (Zn, Cu, Pb, Fe, Mn and Ni) through the daily intake of herbal products were all below 1 (HQ < 1). The estimated values show an indication that the daily intake of heavy metals via the ingestion of herbal products would be unlikely to have adverse health risk effects on consumer, which is in agreement with [24]. The results of the health hazard index (HI) for all herbal samples in different locations in Ilorin metropolis were below 1 (HI < 1), (Table 5). The findings of this study reveal that there are no health risks for consumption and ingestion of herbal products from all the four (4) study locations. According to the hazard index (HI) results, daily intake or consumption of the herbal products do not pose any health risk effects to humans. The results of the study are similar compared to [5] who reported the non-carcinogenic hazard quotient (HQ) and hazard index (HI) of study heavy metals investigated in 14 different herbal plants obtained from the three regions in Central Serbia, Zlatar, Sokobanja, and Kopaonik were below 1. The hazard index findings suggest that more attention should be paid to determining the amount of daily intakes of Heavy Metals from herbal products consumption and their potentially negative effects according to [27].

4. Conclusion

The research study aimed to determine the level of trace heavy metals (Zn, Pb, Cu, Fe, Mn, Cd, Cr, and Ni) contents of various herbal drinks (AGBO) marketed in Ilorin metropolis, Nigeria. The results of this study indicated that most of the heavy metals in the herbal drinks (Zn, Pb, Cu and Mn) were below the WHO recommended permissible limits. Chromium and Cadmium are not detected in all of the herbal drinks analyzed. However, sample C2 and D2 of all of the analyzed herbal samples contained unsafe concentrations of iron (Fe) and nickel (Ni) that exceeded the WHO recommended permissible limits. From the health point of view, the EDIs value of all the herbal drinks are below the daily reference dose. The non-cancerous (HQ) and hazard index (HI) value of all the herbal samples are less than 1, suggesting no potential health risk effects. Based on the results obtained in this study, there would be non-carcinogenic health risk effects to the people taking the herbal drinks marketed in all the study areas.

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References

[1] R. Dghaim, S. Khatib, H. Rasool, M. Khan, Determination of heavy metals concentration in traditional herbs commonly consumed in the United Arab Emirates, J Environ Health Sci Eng, 2015, 236-257.

[2] C.T. Onwordi, N. Agbo, I.A. Ogunwande, Levels of potentially toxic metals in selected herbal medicines in Lagos, Nigeria, J Environ Health Sci Eng, 2015, 3186, 148-157.

[3] T. Quds, M. Ahmed, S. Shakeel, N. Jalbani, I. Azhar, Determination of the heavy metal contents of frequently used herbal products in Pakistan, Trop J Pharm Res, 2021, 377-382.

[4] D. Eskinazi, M. Blumenthal, N. Farnsworth, C. Riggins, Botanical Medicine: Efficacy, Quality, Assurance, and Regulation, 1999, New York: Mary Ann Liebert.

[5] I. Kandić, M. Kragović, J. Petrović, P. Janaćković, M. Gavrilović, M. Momčilović, M. Stojmenović, Heavy metals content in selected medicinal plants produced and consumed in Serbia and their daily intake in herbal infusions, Toxics, 2023, 11, 198.

[6] M. Idu, O. Oghale, A. Jimoh, Heavy metals contamination of some polyherbal products from Lagos state, Nigeria, J Ayurveda Holist Med, 2015, 1(2), 45-50.

[7] C.O. Nwoko, L. Mgbeahuruike, Heavy metal contamination of ready-to-use herbal remedies in South Eastern Nigeria, Pak J Nutr, 2011, 10, 959-964.

[8] N.S. Mokgalaka, R.I. McCrindle, B.M. Botha, Multielement analysis of tea leaves by inductively coupled plasma optical emission spectrometry using slurry nebulisation, J Anal At Spectrom, 2004, 19, 1375-1378.

[9] World Health Organization, Guideline for Good Manufacturing Practices for Herbal Medicine, Geneva, 2007.

[10] S.I. Korfali, T. Hawi, M. Mroueh, Evaluation of heavy metals content in dietary supplements in Lebanon, Chem Cent J, 2013, 7, 10.

[11] A.M. Bobaker, I. Alakili, S.B. Sarmani, N. Al-ansari, Determination and assessment of the toxic heavy metal elements abstracted from the traditional plant cosmetics and medical remedies, Int J Environ Res Public Health, 2019, 16, 1957.

[12] A.A. Adu, O.J. Aderinola, V. Kusemiju, Heavy metals concentration in garden lettuce grown along Badagry Expressway, Lagos, Nigeria, Transnatl J Sci Technol, 2012, 2, 115-130.

[13] L. Zheng, Q. Zhang, Z. Li, R. Sun, S. Zhong, Exposure risk assessment of nine metal elements in Chongqing hotpot seasoning, RSC Adv, 2020, 10(4), 1971-1980.

[14] F. Adusei-Mensah, D. Essumang, R. Agjei, J. Kauhanen, C. Tikkanen-Kaukanen, M. Ekor, Heavy metal content and health risk assessment of commonly patronized herbal medicinal preparations from the Kumasi metropolis of Ghana, J Environ Health Sci Eng, 2019, 17(2), 609-618.

[15] M. Aschale, Y. Sileshi, M. Kelly-Quinn, Health risk assessment of potentially toxic elements via consumption of vegetables irrigated with polluted river water in Addis Ababa, Ethiopia, Environ Syst Res, 2019, 8(1), 29.

[16] T. Adefa, M. Tefera, Heavy metal accumulation and health risk assessment in Moringa oleifera from Awi zone, Ethiopia, Chem Afr, 2020, 3, 1073-1079.

[17] United States Environmental Protection Agency, MidAtlantic Risk Assessment: Human Health Risk Assessment, 2014.

[18] H.R. Gebeyehu, L.D. Bayissa, Levels of heavy metals in soil and vegetables and associated health risks in Mojo area, Ethiopia, PLoS One, 2020, 15(1), e0227883.

[19] WHO, Guidelines for Drinking-water Quality, 3rd ed., Chapter 8, DRAFT, Geneva, 2023.

[20] World Health Organization. Guideline for Good Manufacturing Practices for Herbal Medicine, Geneva. 2007.

[21] M. Aschale, Y. Sileshi, M. Kelly-Quinn, Health risk assessment of potentially toxic elements via consumption of vegetables irrigated with polluted river water in Addis Ababa, Ethiopia, Environ Syst Res, 2019, 8(1), 29.

[22] USEPA, Guidelines for the health risk assessment of chemical mixtures, Fed Regist, 1986, 51, 34014-34025.

[23] C. Meng, P. Wang, Z. Hao, Z. Gao, Q. Li, H. Gao, F. Feng, Ecological and health risk assessment of heavy metals in soil and Chinese herbal medicines, Environ Geochem Health, 2022, 44(3), 817-828.

[24] R.O. Ayanniyi, S.O. Folami, H.A. Olumoh-Abdul, S.A. Atunwa, I.A. Oreagba, Heavy metal content of commonly consumed herbal bitters in Ilorin, West Afr J Pharm, 2017, 28(1), 147.

[25] R.N. Asomugha, N.A. Udowelle, S.J. Offor, C.J. Njoku, I.V. Ofoma, C.C. Chukwuogo, O.E. Orisakwe, Heavy metals hazards from Nigerian spices, Rocz Panstw Zakl Hig, 2016, 67(3), 309-314.

[26] I.A. Maghrabi, Determination of some mineral and heavy metals in Saudi Arabia popular herbal drugs using modern techniques, Afr J Pharm Pharmacol, 2014, 8(36), 893-898.

[27] J. Zhang, R. Yang, R. Chen, Y. Peng, X. Wen, L. Gao, Accumulation of heavy metals in tea leaves and potential health risk assessment: A case study from Puan County, Guizhou Province, China, Int J Environ Res Public Health, 2018, 15, 133.