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ASSESSMENT OF HEAVY METALS CONTENT OF SOME PLANT BASED MEDICINES IN PARTS OF SOUTHERN NIGERIA, WEST AFRICA

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ABSTRACT: The concentration levels and human health risk of iron, cadmium, zinc, nickel, copper and lead were determined in 25 popularly consumed types of commercially available herbal drugs in Southern Nigeria. In each type, three brands were selected and analysed. The study area was divided into five sampling zones (A - E) and the herbal drugs were categorized into five clusters based on their advertised usage. The samples were digested using HNO_3: $HClO_4$ mixture in the ratio of (4:1) and metals analysis were carried out using Atomic Absorption spectrophotometer. The results showed the concentration of the metals in the ranges: Fe = 4.524 ± 0.011 to 70. 121 ± 0.002 µg/g; Cd = 0.012 ± to 0.620 ± 0.002 µg/g; Zn = 0.03 ± 0.01 to 42.010 ± 3.40 µg/g; Cu = 0.160 ± 0.000 to 66.21 ± 2.11 µg/g and Pb = BDL to 22.011 ± 0.850 µg/g. The provisional weekly intake (PWI) of the metals did not exceed the recommended provisional weekly tolerable intake (PTWI) except nickel in 5 samples. The heavy metal pollution index (HMPI) in the five sampling locations indicated a trend: D > C > E > B > A. Seventeen brands of the studied herbal drugs had Fe, Cd, Ni, Cu and Pb levels higher than the WHO/FAO limits. Consumption of these studied herbal drugs ought to be monitored regularly to prevent toxic metals poisoning due to elevated levels of these metals.

INTRODUCTION: The use of herbs as medicine is the oldest form of healthcare known to humanity and has been used in all cultures throughout history. About 70 - 85% of the world's population mainly in developing countries today still banks on non-conventional medicine in their primary health care as reported by World Health Organization (WHO) [1]. The general public perception that herbal drugs are safer and harmless because they are natural plant-based material is untrue.

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Research results have shown that plants not only contain toxic secondary metabolites but are often contaminated with environmental pollutants especially heavy toxic metals which are hazardous to all living organisms on exposure [2, 3]. Heavy metals contamination of herbal preparations is common place in earlier reports [4 - 8]. The heavy metals contamination in traditional medicines may occur due to polluted environment in which the herbal plants grow [9]; the polluted conditions in which the plants are dried and processed, the storage conditions and / or even adulterated purposefully by the manufacturer of the products in the final dosage form [10].

Heavy metals presence in the environment as a result of agricultural, industrial, commercial and domestic activities lead to their bioaccumulation in

the food chain. Increasing concern and fear have also been expressed on the unsupervised use, efficacy, toxicity and quality of these natural products as well as the legal responsibilities of their practitioners. Rigorous qualitative and quantitative assessment of these products is necessary to minimize the risks to humans and other animals due to unintentional or intentional metal exposure at above tolerable limits resulting from herbal drugs ingestion or usage [10]. Agencies such as Food and Agricultural Organisation (FAO) and World Health Organisation have highlighted these critical issues and strongly recommended toxic heavy metal analysis in the herbal medicines along with other necessary biological, chemical and environmental analysis in their guidelines and also documented the dietary allowances, absorption, elimination and toxic profiles of heavy metals [11].

In Nigeria, most trado-medicine producers and dealers sell their products in local markets, along busy highways, in buses and motor parks where they display them openly. Few of these drugs are also displayed in pharmaceutical shops and patent medicine stores. Some of these drugs are listed by National Food and Drug Administration and Control (NAFDAC), the statutory body vested with power to regulate food and drugs in Nigeria. The mode of production either machine or manually blended, storage containers and distribution channels are some of the routes by which heavy metals taint local herbal drugs [11].

The objectives of this study were to: (a) determine the concentrations of Fe, Cd, Ni, Zn and Pb in selected types / brands of ready-to-use and commonly available herbal drugs in South Eastern Nigerian markets (b) assess the potential human risk associated with consumption of these drugs due to their studied metals contamination (c) determine the heavy metals pollution index of the metals and (d) by comparison with set standards establish the safety or otherwise arising from consumption of these herbal preparations.

MATERIALS AND METHODS:

Samples and Sampling Technique: A total of 75 samples of liquid herbal drugs prepared for in-vitro oral administration were selected randomly from herbal medicine vendors and pharmaceutical shops in five randomly selected cities across the southern region of Nigeria namely Owerri Enugu, Lagos metropolis, Aba and Uyo. The samples were selected from 25 types of herbal drugs with different curative agents. The drugs were divided into five clusters (C_1 – C_5) indicating their advertised therapeutic effects thus: C_1 – antimalaria / thypoid drugs; C_2 – Antibiotics; C_3 – Analgesics; C_4 – immune booster and C_5 – power/energy drinks. A total of 65 sampled drugs were listed by the government agency authorized to do so which in National Food and Drug Administration and Control (NAFDAC) of Nigeria but some were not. A total of 5 brands were selected from each cluster and sampled three times at monthly intervals.

Chemicals and Reagents: All chemicals and reagents used in this study were of analytical grade: Nitric acid 65% (1.40, Merck, Darmstadt, Germany), Perchloric acid 70% (1.33, Merck, Darnsadt, Germany) were used as supplied without further purification. Deionised water was used as diluents and for washings.

Sample Preparation and Analysis: All glassware were soaked in 5% nitric acid for 2 hours and then washed with de-ionized water prior to use. All the samples were digested using acid mixture of HNO_3 and $HClO_4$ in 4: 1 ratio. Each of the herbal drug samples (1.0 g) was precisely weighed in a previously cleaned and weighed beaker on an electronic balance (Bosch D.7455). Concentrated HNO_3 (20 ml) was added and allowed to stand overnight. The solution was heated carefully in water bath until the production of red nitrous fumes had ceased and allowed to cool at room temperature and 70% $HClO_4$ (5 ml) was heated first in a water bath for 30 minutes and added to the mixture. The acids/drug mixture was heated with an electric heater confined in a fume cupboard for 15 minutes which reduced the volume of the solution to 10 ml. It was diluted with de-ionized water to 30 ml and filtered with a whatmann filter paper (no. 42) into a 50 ml volumetric flask and made up to mark using de-ionized water. Blanks were also prepared and digested just as the samples. A standard GFS Fisher's AAS reference standard stock solutions of the studied metals containing 1000 ppm were diluted serially with HCl: HNO_3 (3:1) ratio to achieve solutions of 0.5, 1, 2, 5, 10 and 20 ppm concentrations.

The standards were used to generate calibration curves for the metals before analysis of the sample. Calibration curves of the metals showed linearity and the R^2 values for all the metals were above 0.980. Atomic Absorption Spectrophotometer (model AA320N, Wincom Coy Ltd., China) was used and the standard operating conditions of the Spectrophotometer is shown in **Table 1**. Analysis of the different samples of each brand was done in triplicates (n = 3) and mean and standard deviation of the concentration of each metal in each sample were calculated and recorded as the amount of the metal in the sample.

TABLE 1: OPERATION CONDITIONS OF AAS FOR ANALYSIS OF THE HEAVY TOXIC METALS

Working parameter	Fe	Cd	Ni	Zn	Cu	Pb
Wavelength (nm)	248.3	228.8	232.0	213.9	324.7	217.0
Cathode lamp current (mA)	10	10	10	10	10	10
Flame type	Air -acetylene	Air -acetylene	Air -acetylene	Air- acetylene	Air- acetylene	Air- acetylene
Integration time (s)	10	10	10	10	10	10
Air flow (L min^{-1})	17	17	17	17	17	17
Acetylene flow (L min^{-1})	2.0	2.0	2.0	2.0	2.0	2.0
LOD		0.004		0.007		0.010
LOQ		0.011		0.020		0.040

Health Risk Assessment: The health risk of ingesting the heavy metals *via* consumption of the each sampled herbal drugs was assessed by calculating the daily intake (DI) and provision for weekly intake (PWI) of the metals from the drugs considered in the light of the manufacturers' maximum recommended dosages. Hence by multiplying the daily drug intake dosage by the mean concentration of each metal in the sample gave the amount of metal ingested by the users per day while the PWI was got by multiplying the daily ingested metal concentration by seven. These values of PWI got were compared with the provisional tolerable weekly intake (PTWI) of the metals as recommended by World Health Organisation (WHO) and other authorities for an average adult of 60 kg body weight [11]. Also, the heavy metal pollution index (HMPI) for each sampled station was determined to compare the total heavy metals content in the herbal medicines at different sampling locations. Using the equation given by users Usero and Co - workers [12].

$$HMPI = (Cf_1 \times CF_2 \times CF_3 \ldots\ldots\ldots\ldots \times CF_n)^{1/n}$$

Where Cf_1 is the concentration of the heavy metal in the Sample drug 1 and n in the number of different samples from the location.

Applying the equation to here, HMPI for sampling station A is given as

$$HMPI = (Fe_A \times Cd_A \times Ni_A \times Zn_A \times Cu_A \times Pb_A)^{1/6}$$

Where Fe_A is the mean concentration of Iron in location A and so on.

RESULTS AND DISCUSSION: The result obtained from the metals analysis is presented in **Table 2**. The percentage concentrations of Fe in the clusters were 22.14, 19.50, 12.92, 25.01 and 20.40 in antimalaria (C_1), Antibiotics (C_2), Analgesics (C_3), Immune boosters (C_4) and Power/energy drinks (C_5) respectively. The Cd distribution in the studied drug clusters were 44.52%, 3.13%, 17.91%, 13.57% and 20.87% in C_1, C_2, C_3, C_4 and C_5 respectively. The levels of Ni in the drug clusters were in the order of 21.22, 15.53, 19.47, 28.57 and 15.11% in C_1 to C_5 while Zn has the following percentages in same order: 14.75, 18.88, 18.06, 24.25 and 24.10. Also, percentage levels of Cu in the drugs were 12.61, 10.97, 15.37, 21.43 and 39.62 in C_1 to C_5 respectively while that of Pb were 7.67, 15.64, 11.84, 30.37 and 34.48 in similar order.

The Fe mean concentration in the sampled herbal drugs are of the ranged between 4.524 - 70.121 µg/g in and Cd contents of the samples were of the ranges 0.012 ± 0.011 to 0.620 ± 0.002 µg/g. The concentrations of Ni in the samples range from below detection level (bdl) 22.44 ± 3.01 µ g/g while Zn concentration ranged from as low as 0.03 ± 0.01 µg/g to as high as 42.01 ± 3.40 µg/g in the samples. The levels of Pb in the samples are of the range BDL to 18.92 µg/g in the content levels of Cu in the samples were of the range 0.16 ± 0.00 - 66.21 ± 2.11 µg/g in the sampled herbal drugs. The health risk assessment results are presented in **Table 3** and **4**.

TABLE 2: HEAVY METALS CONTENTS (µg/g ± SD) OF HERBAL DRUGS

S. no.	Cluster	Sample	Fe	Cd	Ni	Zn	Cu	Pb
1	C_1	C_{1A}	30.235±0.001	0.044±0.000	2.620±0.048	1.050±0.001	0.500±0.001	BDL
	Anti- malaria	C_{1B}	44.805±0.012	0.012±0.011	0.851±0.01	10.236±0.012	4.001±0.75	1.022±0.01
		C_{1C}	30.752±0.112	0.620±0.002	11.212±0.31	0.801±0.001	12.101±1.02	2.621±0.05
		C_{1D}	70.121±0.002	0.374±0.102	18.750±1.85	21.65±0.013	12.450±0.11	5.400±0.09
		C_{1E}	40.932±0.014	0.232±0.002	7.162±0.91	10.25±0.001	11.013±0.03	0.451±0.031
2	C_2	C_{2A}	20.0161±0.001	0.020±0.000	BDL	20.025±0.00	1.201±1.02	0.652±0.08
	Antibiotics	C_{2B}	40.035±0.011	0.016±0.002	2.650±0.14	22.124±1.011	6.020±0.14	6.122±0.05
		C_{2C}	30.135±0.023	0.016±0.000	6.000±0.11	12.850±0.000	11.153±0.11	2.630±0.03
		C_{2D}	60.350±0.011	0.024±0.002	14.221±1.19	30.014±3.121	10.021±2.11	8.511±0.10
		C_{2E}	40.163±0.021	0.014±0.011	6.901±0.92	4.235±0.011	6.452±0.65	1.622±0.04
3	C_3	C_{3A}	20.133±0.011	0.027±0.000	1.637±0.11	0.061±0.001	0.160±0.00	0.100±0.000
	Analgestics	C_{2B}	30.450±0.012	0.121±0.001	4.440±0.65	2.754±0.310	8.150±0.45	4.321±0.06
		C_{3C}	4.524±0.011	0.024±0.002	14.011±1.50	15.130±0.134	14.321±1.45	2.742±0.03
		C_{3D}	30.850±0.112	0.304±0.002	12.450±2.10	28.550±2.150	12.033±4.21	4.233±0.21
		C_{3E}	40.454±0.102	0.040±0.011	4.752±0.90	7.400±0.511	14.152±1.11	3.420±0.05
4	C_4	C_{4A}	60.096±0.001	0.020±0.000	3.201±0.00	0.029±0.01	17.141±0.45	BDL
	immune boosters	C_{4B}	30.654±0.011	0.016±0.000	8.113±1.10	11.012±1.012	6.204±0.22	12.051±0.01
		C_{4C}	40.840±0.201	0.021±0.002	12.652±0.95	15.300±0.035	21.602±1.50	18.922±0.11
		C_{4D}	61.102±0.341	0.311±0.012	22.440±3.01	42.010±3.400	10.021±3.21	6.422±0.45
		C_{4E}	51.984±0.001	0.024±0.001	8.34±0.11	4.000±0.018	13.110±0.85	0.550±0.04
5	C_5	C_{5A}	30.144±0.000	0.027±0.000	0.627±0.001	10.064±0.00	0.300±0.012	0.200±0.011
	power/Energy	C_{5B}	40.230±0.001	0.015±0.001	2.190±0.45	4.650±0.001	14.042±1.20	22.011±0.85
	Drinks	C_{5C}	20.444±0.001	0.207±0.001	1.011±0.002	12.761±0.850	66.214±2.11	10.452±0.23
		C_{5D}	64.131±0.501	0.331±0.014	18.601±2.01	35.902±1.200	28.451±3.45	6.401±2.13
		C_{5E}	44.631±0.021	0.018±0.001	6.503±1.15	8.410±0.911	16.808±1.50	4.022±0.23
	WHO/FAO Standard (µg/g) (2002) *FDA (1999)		60	0.3	0.1*	60	3.0	5.0

BDL = below detection level

TABLE 3: WEEKLY INTAKE OF METALS (µg / WEEK) ACCORDING TO MANUFACTURER'S DOSES FOR A 60kg BODY WEIGHT

Sample	Fe	Cd	Ni	Zn	Cu	Pb
C_{1A}	63	0.924	55.02	22.05	10.50	BDC
C_{1B}	940.91	0.252	17.85	214.956	84.021	21.42
C_{1C}	643.70	13.020	235.41	16.821	254.10	55.02
C_{1D}	147.54	7.854	393.75	454.65	261.45	113.40
C_{1E}	859.59	4.872	150.36	215.25	231.21	9.45
C_{2A}	420.40	0.420	BDL	420.525	25.20	13.65
C_{2B}	840.765	0.336	53.76	464.604	126.42	128.52
C_{2C}	632.833	0.336	126.00	269.85	234.15	55.23
C_{2D}	1267.350	0.504	298.620	630.294	210.42	178.71
C_{2E}	843.430	0.294	144.900	88.935	135.45	34.02
C_{3A}	422.790	0.567	34.377	1.281	3.36	2.10
C_{3B}	639.450	2.541	93.24	57.834	171.15	90.72
C_{3C}	95.004	0.504	294.21	317.73	300.72	57.54
C_{3D}	647.850	6.384	261.45	599.55	252.63	88.83
C_{3E}	849.534	0.840	99.75	155.40	297.15	71.82
C_{4A}	1262.016	0.42	67.41	0.63	359.94	BDC
C_{4B}	643.734	0.336	170.31	231.25	130.20	253.05
C_{4C}	857.640	0.441	265.65	321.30	453.60	397.32
C_{4D}	1283.142	0.531	471.24	882.21	210.42	134.82
C_{4E}	1091.664	0.504	175.14	84.00	275.31	11.55
C_{5A}	633.024	0.567	13.251	211.34	6.30	4.20
C_{5B}	844.830	0.315	45.99	97.65	294.84	462.21
C_{5C}	429.324	4.347	21.21	267.96	1390.41	219.45
C_{5D}	1346.751	6.951	390.60	754.32	597.45	134.40
C_{5E}	937.211	0.378	136.50	176.61	354.48	84.42
PTWI	56000 [40]	150 [40]	245 [41]	13001 – 19000 [41]	6300 [41]	1500 [40]

TABLE 4: HMPI OF THE METALS IN SAMPLE LOCATIONS

Locations	Total Metal Content (µg)						
	Fe	Cd	Ni	Zn	Cu	Pb	MPI
A	160.62	0.14	8.08	31.23	19.30	0.95	6.86
B	186.18	0.19	18.59	40.76	38.41	45.52	18.97
C	122.69	0.87	44.88	66.84	46.84	37.36	28.71
D	286.55	1.33	86.46	158.14	52.97	30.96	45.22
E	218.15	0.31	33.55	34.30	70.90	10.06	19.53

The provisional weekly intake of the drugs were of the ranges 63.00 - 1346.31 µg/week; 0.232 - 13.00 µg/week, 17.35 - 431.24 µg/week; 0.63 - 883.21 µg/week; 3.36 - 1390.41 µg/week and 2.10 - 462.21 µg/week for Fe, Cd, Ni, Zn, Cu and Pb respectively. The heavy metal pollution indices of the studied area were 6.86 in Owerri; 18.97 in Enugu, 28.71 in Lagos; 45.22 in Aba and 19.53 in Uyo.

Fe was in excess of the WHO / FAO maximum permissible limit in 5 studied samples and was found highest in Anti malaria drugs but least in analgesics. Cd was found in excess in 40% of the drugs and these include four samples of antimalarias, three of analgesics, two of energy drinks and one sample of immune boosters. Also Ni was above the FDA maximum permissible limit in 96% of the studied samples but Zn was below the set limit in herbal drugs in all the samples.

However, Cu was above the set limit in 84% of the samples. The levels of Pb were higher than the permissible limit in seven samples amounting to 28% of the whole samples studied. The calculated provisional weekly intake (PWI) for all the metals did not exceed the recommended tolerable limit except that of Ni in seven samples. Hence, at the present rate of drug ingestion in the studied area, only Ni pose potential health risk. The HMPI was highest in location D (Aba) and least in location A (Owerri). The WHO / FAO recommended maximum allowable level is 60 µg/g.

The results of this study show a wide variation of Fe content in different herb samples. The result is comparable to values of Fe found in Egyptian spices and medicinal plants which ranged between 26.96 and 1046.25 $mgkg^{-1}$ [13]. Fe plays many crucial roles in the human body including oxygen supply, energy production, and immunity. It facilitates the oxidation of carbohydrates, proteins and fats to control body weight, which is a very important factor is diabetes management. Iron is necessary for the formation of haemoglobin and also plays an important role in oxygen and electron transfer in the human body.

Low iron content causes gastrointestinal infection, nose bleeding and myocardial infection [14] Iron toxicity has an adverse effect on various metabolic functions and cardiovascular system [15]. Iron salts have astringent action which causes irritation of the gastrointestinal mucosa which gives rise to gastric discomfort, nausea, vomiting and diarrhea or constipation [16]. When there is a high oral dose of iron, the astringent action of iron salts damages the mucosal cells. Severe damage may cause bleeding in the stomach or haematemesis and necrosis of mucosal cells may cause perforation of the gut wall [16]. Location, D showed higher Cd contents in the anti malaria, analgesics, immune booster and power / energy drink samples.

There is the likelihood that sources of Cd pollution exist in location D which led to contamination of the herbal products. Cd is a toxicant and has been implicated in many disorders and its contamination of drugs may lead to cough, headache, cancer of the lungs, *etc.* [17, 18]. The, concentration of Cd in these samples is low compared to the concentration of Cd in herbal drugs used as anti-malarial in Zaria [19] and as reported in 25 other herbal products sampled from eastern and western Nigeria [20] with Cd concentration ranging from 0.55 to 4.75 mg. The Cd levels found in some samples in the study were lower than those obtained by Hina *et al*., [21]; Uddin *et al*., [22] and Nwoko and co – workers [23]. However, Ekeanyanwu and co workers [24] did not detect Cd and Ni in the herbal drugs examined in their study but found other metals to be within the permissible limit recommended by regulatory agencies. Cadmium is among the most toxic natural elements.

The WHO maximum permissible limit (MPL) of Cd in medicinal herbs is 0.3 mg/kg [25] Chronic exposure to Cd causes kidneys and lungs failure,

affect bones and stomach. The toxic effects of Cd on humans are same in both adults and children even though the experimental data showed that younger animals absorb more than adults [26]. The high levels of cadmium possess a serious health risk on human health. Kidney is mostly the critical target organ in the exposed population. Excretion of Cd usually is very slow and it accumulates in human kidney for a relatively long time which may result in an irreversible impairment of the renal tract [27, 28]. Also, at high concentrations, Cd produces serious effects on the liver and vascular and immune system [29].

Severe toxic symptoms as a result of Cd ingestion are reported between 10 - 326 mg and fatal ingestions of Cd, producing shock and acute renal failure do occur from ingestions exceeding 350 mg [30]. An indication of cadmium nephrotoxicity, aminoaciduria, glycosuria and tubular necrosis has been detected at renal cadmium concentration of less than 50 µg/g tissue [31].

The values of Ni in all locations except for C_2D location were higher than the FDA recommended limit of 0.1 µ g/g [32]. However, WHO/FAO has not set permissible limit for Ni in 2005 [32]. Ni is widely distributed in the environment as a result of natural and anthropogenic activities. Despite the elevated amount of Ni in the drugs, toxicity of Ni in human body is rare due to its low absorption by the body [33, 34, 35]. For example, in humans, the average nickel absorption is 27 ± 17% of the dose ingested in water and 0.7 ± 0.4% of the dose ingested in food [36]. However, if Ni is taken orally in doses greater than 0.5 g some forms if nickel may be acutely toxic to humans affecting cardiovascular system, immune system and blood which may lead to kidney and liver damage [35, 36].

Coogan and co- workers [35] reported that many harmful effects of nickel ingestion are due to its interference with the metabolism of essential metals such as Fe (II), Mn(II), Ca(II), Zn(II), Cu(II), or Mg(II). Toxicity of nickel probably results from its ability to replace other metal ions in enzymes and proteins or to bind to cellular compounds containing oxygen, sulphur and nitrogen atoms thereby inhibiting their actions [35, 36]. Overall, Zn concentrations were below the maximum permissible limit by WHO / FAD of 60 µg/g and consumption of the herbal drugs pose no immediate health risk [37]. WHO in 2005 recommendation did not set new limit for Zn in herbal preparation [22].

Except for C_1A, C_2A, C_3A and C_5A samples, the rest had higher than permissible amount of Cu in them [38]. This can be compared to medicinal herbs and herbal products analysed in Zagreb, China with the concentration of Cu ranging from 0.05 mg/kg to 0.5 mg/kg which is below permissible limit [39]. Copper contamination of herbal drugs results from many sources such as utensils, polluted soil and fumigants used to preserve the herbal plant from destruction. Copper is an essential element for the human metabolic system which regulates various biological processes inside the body like oxidation-reduction reactions, energy production, connective tissues formation, iron metabolism, synthesis of neurotransmitter *etc.* [40, 41].

However, chronic exposure to high concentration of copper causes irritation of nasal mucosa, vomiting, nausea, diarrhoea, damaging kidney and liver [42]. In humans, acute copper poisoning is rare and usually results from contamination of foodstuffs or beverages by copper containers or from the accidental or deliberate ingestion of large quantities of copper salt [43]. Symptoms of acute copper poisoning include salivation, epigastric pain, nausea, vomiting and diarrhoea, all of which are probably due to the irritant effect of copper on the gastrointestinal mucosa [43].

Lead is one of the highly toxic environmental pollutants and it can complex with various biomolecules which adversely affect their functions. Lead exposure may have an adverse effect on the blood, nervous, immune, renal, skeletal, muscular, reproductive, and cardiovascular systems causing poor muscle coordination, gastrointestinal symptoms, brain and kidneys damage, hearing and vision impairments, and reproductive defects [44, 45]. Exposures to lead at early childhood and prenatally leads slowed cognitive development, learning deficits, and many other effects [44]. The Food and Agricultural Organization / World Health Organization FAO / WHO has established a "provisional tolerable weekly intake" (PTWI) of 25 µg lead/kg body weight for humans.

Individually, the levels of Pb in sample clusters C_1D, C_2B, C_2D, C_4B, C_4C, C_4D, C_5B, and C_5D were above the WHO/FAO permissible limit for Pb in herbal drugs of 5.0 µg/g [46] while the rest were below the limit. The result was lower than earlier report In Pakistan where Mohammed and co-workers [7] found Pb to be 70.1 ± 0.00 µg/g and 49.528µg/g in branded herbal drugs. Also Edebi and Alade [46] found Pb in malarial and black herbal tea to be 102.22 µg/g in similar work. However, the result of this study was comparable to the Pb levels found in herbal tea and similar products [21]. The Pb levels found in this study are lower than an earlier report conducted in some parts of the same study area [23]. In the report, Nwoko and co - author [22] found the levels of Pb up to 4.8 µg/g in some locations.

Elevated levels of Pb in food and drug pose health risk to humans because Pb is a toxicant. At low levels Pb has been implicated in pregnancy miscarriages and low birth weight of babies, low sperm count and mortality in men [47]; damage and reduction of antibody production and immuglobin forming cells and decrease in the performance of nervous system and renal clearance [48, 49].

The weekly intake of Fe, Cd, Zn, Cu and Pb form ingesting the herbal drugs did not exceed the provisional tolerable weekly drugs as, recommended by various bodies [11]. However, the intake of Nickel (Ni) from seven samples (C_1D, C_2D, C_3C, C_3D, C_4C, C_4D and C_5D) exceeded the allowed PTWI. Ingestion of these drugs may pose health hazard to consumers. The heavy metal pollution index of sampling locations indicated the trend: D > C > E > B > A. Hence location D with an HMPI of 45.22 showed highest pollution load of heavy metals studied while location A showed the lowest metal pollution load.

The presence of heavy metal may be the result of accidental contamination during manufacture, for instance, from grinding weights or lead-releasing containers or other manufacturing utensils Medicinal herbs may contain heavy metals when grown in seriously polluted soil. The use of agrochemical products on agricultural lands and some organic solvents used during the extraction and preparation of these herbal medicines can be a great source of physicochemical contaminants.

CONCLUSION: The results of the study showed that except for Zn, all other metals were in excess of the MRL in at least four samples of the drugs. Ni for instance was in excess in more than 80% of all the samples. The trend of the metals levels in the clusters were: Fe = $C_4 > C_1 > C_5 > C_2 > C_3$; Cd = $C_1 > C_5 > C_4 > C_3 > C_2$; Ni = $C_4 > C_1 > C_3 > C_2 > C_5$; Zn = $C_4 > C_5 > C_2 > C_3 > C_1$; Cu = $C_5 > C_4 > C_3 > C_1 > C_2$ and Pb = $C_5 > C_4 > C_2 > C_3 > C_1$. Ni was of potential risk in the drugs. The HMPI was highest in samples from location D which was Aba in Abia state. Although, most of the selected herbal drugs used for this analysis are listed by the National Food and Drug Administration and Control (NAFDAC) in Nigeria, the fact that some of the herbal drugs are sold in the open market is very discouraging.

Herbal medicines have been used in clinical practice for ages but the toxicity of these herbal medicines has been of great concern. The presence of toxicants especially heavy metals results from many sources ranging from bioavailability in herbs grown in contaminated soils to the herbal drug manufacture processes. This reported work showed that some of the commercially available herbal drugs are tainted by the studied heavy metals and pose health risk when consumed by humans.

There is need for continuous monitoring of herbal drugs sold in the market to make sure wholesome and safe drugs are sold for human consumption.

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