HEALTH RISKS OF HEAVY METALS VIA CONSUMPTION OF HERBS COLLECTED AROUND SHARADA AND CHALLAWA INDUSTRIAL AREAS IN KANO STATE, NIGERIA

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ABSTRACT

The study investigated the concentrations of Co, Ni, Pb, Cd and Cr in five herbal plants collected in the vicinity Sharada and Challawa Industrial areas in Kano State, Nigeria. The samples were collected and prepared using standard analytical procedures and analytical grade reagents were used for digestion. Agilent 240 FS AA model of fast sequential Atomic absorption spectroscopy (AAS) was used for the analysis of five heavy metal content of these samples. The result of the analysis showed that Cr ranged from 4.74±0.84 to 15.93±1.45, Co rangeg from 1.08±0.06 to 8.33±0.06, Ni ranged from 1.73±0.16 to 7.59±0.16, Cd ranged from 0.10±0.02 to 0.84±0.03 and Pb ranged from 6.89±0.37 to 13.30±0.37. The target hazard quotients (THQs) values of the metals for the investigated samples did not exceed one (1) indicating that there was no health risk from consuming these herbs. The THQs of Heavy Metals from consumption of herbs being less than 1.0 suggested that health risk was insignificant.

Keywords: Challawa, herbs, metals, Sharada, Challawa.

INTRODUCTION

Plants have been one of the important sources of medicine ever since the dawn of human civilization. Traditional medicine (including herbal drugs) comprises of therapeutic practices that have been in existence, often for hundreds of years, before the development and spread of modern medicine [30]. The importance of plants in medicine remains even of greater relevance with the current global shift to obtain drugs from plant sources. As a result of which, attention has been given to the medicinal value of herbal remedies for safety, efficacy and economy [11, 17]. However, environment, atmosphere, pollution, soil, harvesting and handling are some of the factors which may play important roles in contamination of medicinal plants by metals and microbial growth [1]. It is therefore of major interest to evaluate the composition of some metallic elements in herbal plants, because at elevated levels, these metals can be dangerous and toxic [24, 23]. The World Health Organization (WHO) has revealed that 70 to 80% of world's population uses alternative remedies, especially medicinal herbs as their first step treatment and the tendency to use herbal products has recently grown [19]. Up to 80 % [34] or even 90% [6] of some populations depend almost entirely on Traditional Medicine (TM) for most of their primary healthcare needs. The irony is that TMs, including herbal drugs, are hardly regulated by the State. Over one-third of the population in developing countries lack access to essential medicines. The provision of safe and effective herbal drug therapies could become a critical tool to increase access to health care [33].

Various reports have discussed the potential health implications of trace metals in medicinal herbs, since the herbal bush is known to accumulate them [4, 12]. The World Health Organization in a number of resolutions emphasized the need to ensure the quality control of plant products by using modern techniques and applying suitable standards [31].

Several methods have been proposed to estimate the potential health risks of pollutants, categorized mainly into carcinogenic and noncarcinogenic effects.

Current noncancer risk assessment methods are typically based on the target hazard quotient (THQ), which is a ratio of determined dose of a pollutant to the dose level (a Reference Dose or RfD). If the ratio is less than 1, there will not be any obvious risk. An exposed population will experience health risks if the dose is equal to or greater than the RfD [27].

THQ provides an indication of the risk level due to pollutant exposure. This risk estimation method has recently been used by Chien et al [7] and proved to be valid and useful.

This non cancer risk assessment method was also applied in this study.

The aim of the research is to determine the levels of Pb, Cd, Co, Ni and Cr in five medicinal plants samples (Morning glory, Sennatora, Senna occidentalis, Leptadenia hastate, Momordicabalsamina) collected in the vicinity of Sharada and Challawa Indusrial areas and ascertain their target hazard quotient.

MATERIALS AND METHOD

The Study Area

The study areas were Sharada and Challawa Industrial areas in Kano State, Nigeria. The vegetation is that of tropical savana. There are two distinct seasons, the wet and the dry seasons.

The Geographic coordinates in degrees and decimal minutes are: latitude, 12^{o}0.0072' N, longitude, 8^{o}31.0032' E and 484 m elevation above sea level.

SAMPLE COLLECTION

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 species, 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. These dry raw materials will later be used for digestion.

ASHING OF PLANTS SAMPLES

About 5 g of air dried ground and sieved plant samples were ashed in a muffle furnace at a temperature of 550 ^oC. About 20 cm^3 of 0.1M HNO_3 analaR grade was added to the ash sample in a beaker and boiled for few minutes on a hot plate. After the appearance of white fumes, the digest (usually colourless or pink) 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 was prepared using the same procedure without the sample. Both the samples and the blank were aspirated into the AAS for the determination of Cd, Pd, Co, Ni and Cr. Absorbance values were recorded and the corresponding concentrations from the calibration curve plotted were determined and presented in mg/kg dry weight [2, 13].

The analysis of the samples was done in triplicates under the same conditions as standards and blank. Agilent 240FS AA model of fast sequential Atomic absorption spectroscopy was used for this study. The validity of the method used has been ensured by incorporating various quality control (QC) checks and analysis of certified reference material (CRM). The agreement between the certified values and the measured values were excellent, which demonstrated the accuracy of the generated calibration as well as the overall accuracy of the method.

Table 1: Certified and Measured values of reference material (LGC7162) (mg/kg).

Element	Certified value.	Measured value	% recovery
Chromium (Cr)	2.15	1.85	86.05%
Cadmium (Cd)	0.17	0.165	97.05%
Lead (Pb)	1.8	1.721	95.61%
Nickel (Ni)	2.60	2.521	96.96%
Cobalt (Co)	0.47	0.432	91.92%

RESULTS AND DISCUSSION

Table 2: Concentrations of heavy metals (mg/kg) in herbs at Challawa sampling area

Herb	Cr	Co	Ni	Cd	Pb
Mornig glory	10.07±0.83	1.25±0.06	3.37±0.29	0.713±0.03	6.89±0.37
Sennatora	12.43±1.45	8.33±0.06	1.73±0.16	0.448±0.02	7.96±0.43
Senna occidentalis	10.06±0.84	5.96±0.11	2.97±0.25	0.559±0.03	13.01±0.43
Leptadenia	5.92±0.84	7.25±0.21	6.30±0.43	0.717±0.04	11.22±0.13
Balsam apple	9.47±0.83	6.82±0.44	7.59±0.16	0.101±0.02	13.31±0.75

Table 3: Concentrations of heavy metals (mg/kg) in herbs at Sharada sampling area

Herb	Cr	Co	Ni	Cd	Pb
Morning glory	11.84±0.83	1.08±0.06	3.37±0.04	0.619±0.06	7.96±0.22
Sennatora	15.95±1.45	3.37±0.11	2.94±0.32	0.841±0.031	0.78±0.15
Senna occidentalis	4.74±0.84	5.53±0.37	3.33±0.32	0.273±0.041	1.02±0.37
Leptadenia	10.66±1.45	5.57±0.18	4.79±0.21	0.282±0.02	7.65±1.15
Balsam apple	11.84±0.84	7.47±0.23	5.83±0.25	0.172±0.20	13.30±0.37

At Challawa sampling area, Cr concentration (mg/kg) in the herbs analyzed ranged from 5.92±0.84 in Leptadenia to 12.43±1.45 in Sennatora, while at Sharada sampling area Cr ranged from 4.74±0.84 in Senna occidentalis to 15.95±0.84 in Sennatora. Umoru [25] reported Cr concentration range of 1.0 mg/kg to 8.0 mg/kg, Naser et al [20] reported range of 4.81 mg/kg to 6.23 mg/kg and Diaconu et al [8] reported Cr range of 2.28 mg/kg to 36.12 mg/kg.

Chromium is found in the pancreas, which produces insulin [3]. Deficiency of chromium decreases the efficiency of insulin and increases sugar and cholesterol in the blood. [18]. The daily intake of 50-200 μg Cr has been recommended for adults by US National Academy of Sciences [29].

Co value (mg/kg) at Challawa ranged from 1.25±0.06 in Morning glory to 8.33±0.06 in Sennatora and at Sharada, Co ranged from 1.08±0.06 in Morning glory to 7.47±0.23 in Balsam apple. Kékedy-Nagy and Ionescu [15] reported Cobalt value range of 0.025 to 0.124 mg/kg while Ibrahim and Jimoh [13] reported value of 0.75u g/g in tomato and 1.02ug/g in moringa oleifera. Estimated daily intake of Cobalt from food and water worldwide is 5 mcg - 40 mcg / day. Cobalt deficiency may lead to pernicious anemia, severe fatigue, shortness of breath, low thyroid.

At Challawa, Ni (mg/kg) ranged from 1.37±0.16 in Sennatora to 7.59±0.16 in Balsam apple, while at Sharada, Ni ranged from 2.94±0.32 in Sennatora to 5.83±0.25 in Balsam apple. Khan et al [16] reported Nickel value of 0.203 mg/kg and Baranowski et al [5] reported 6.21 mg/kg. Nickel causes allergic dermatitis known as nickel itch and is a suspected carcinogen. Although Nickel is required in minute quantity for body as it is mostly present in the pancreas and hence plays an important role in the production of insulin, its deficiency results in the disorder of liver [22]. EPA has recommended daily intake of Ni should be less than 1 mg beyond which is toxic [18].

At Challawa, Cd (mg/kg) ranged from 0.101±0.02 in Balsam apple to 0.717±0.04 in Leptadenia, while at Sharada, Cd ranged from 0.172±0.02 in Balsam apple to 0.841±0.03 in Sennatora. Umoru [25] recorded cadmium value of 0.64±0.34 mg/kg while Diaconu et al [8] reported Cd value of 3.67 mg/kg in *Menthapiperita* and 1.84mg/kg in *Matricariacamomilla*. Cadmium is a nonessential trace element with uncertain direct functions in both plants and humans. It is responsible for several cases of poisoning through food. Cadmium is highly toxic for the body as it causes several health hazards, including cell death and cell proliferation [9, 10]. Jabeen et al [14] reported that for medicinal herbs the permissible limits for Cadmium set by WHO [34] was 0.3mg/kg. Similarly, permissible limits set by Canada were 0.3mg/kg in raw medicinal plant material and 0.006 mg/day in finished herbal products [32].

Pb (mg/kg) at Challawa sampling area ranged from 6.89±0.37 in Morning glory to 13.31±0.75 in Senna 0ccidentalis. At Sharada, Pb ranged from 7.65±0.22 in Leptadenia to 13.30±0.37 in Balsam apple. Naser et al [20] reported lead level range of 2.7 -11.0 mg/kg) and Diaconu et al [8] reported Pb value of 22.52 mg/kg. Lead is toxic and non essential element for human body as it causes rise of blood pressure, kidney damage, mis-carriage, subtle abortion, brain damage, decline fertility of men through sperm damage and diminishes learning abilities due to neuron damaging actions [9]. The WHO [34] prescribed limit for lead contents in herbal medicine is 10 ppm while the dietary intake limit for lead is 3 mg/week.

Target hazard quotient (THQ)

Target hazard quotient is a noncancerous risk assessment method which is the ratio of determined dose of a pollutant to the Reference Dose (RFD). THQ was determined based on the formula given by Chien et al [7]:

$$THQ= 10^{-3} (EF*ED*BIR*C/ RFD*WAB*TA)$$

where, EF is exposure frequency (365 days year^{-1}); ED - Exposure duration = 55 years, equivalent to average life time of a Nigerian adult [21]; BIR is the basic ingestion rate (g person^{-1}day^{-1}); RFD is the oral reference dose (mg kg^{-1} day^{-1}), which does not cause deleterious effects during a lifetime, generally used in EPA's noncancer health assessments [26].

Values of RFD for Cd (0.001 mg kg$^{–1}$ per day), Ni (0.02 mg kg$^{–1}$ per day) and Cr (1.5 mg kg$^{–1}$ per day) were taken from Integrated Risk Information System [28]. The value of RFD for Pb (0.0035 mg kg–1 per day) was taken from WHO [29]. There is no consensus about the RFD for Co, and then the oral reference dose for Co was estimated at 0.043 mg kg$^{–1}$ per day. WAB is the average body weight and TA is the average exposure time for noncarcinogens (365 days year^{-1} x number of exposure years). The average body weight was taken as 70 kg for adults [33].

Daily intake was calculated by the following equation:

$$DIR= (C_{metal} \times D_{herb\ intake})/ B_{average\ weight}$$

where, C_{metal}, $D_{herb\ intake}$ and $B_{average\ weight}$ are the heavy metal concentrations in plants (mg kg^{-1}), daily intake of herbs (kg person-1) and average body weight (kg person^{-1}), respectively.

To evaluate the potential risk to human health through more than one Heavy Metal, the hazard index (HI) has been developed [27]. The hazard index is the sum of the hazard quotients, as described in equation below. It assumes that the magnitude of the adverse effect will be proportional to the sum of multiple metal exposures. It also assumes similar working mechanisms that linearly affect the target organ.

$$HI = \Sigma HQ = HQCd + HQNi + HQPb + HQCo + HQCr$$

Table 4: Target hazard quotient for different heavy metals due to consumption of herbs collected from Challawa Area

Herb	Cd	Cr	Pb	Ni	Co	HI
Mornig G	0.0173	0.0004	0.2105	0.0083	0.0005	0.2370
Senna T.	0.0064	0.0103	0.3359	0.0034	0.0169	0.3729
Senna O.	0.0069	0.0007	0.4706	0.0052	0.0104	0.4938
Leptad.	0.0084	0.0002	0.5672	0.0251	0.0196	0.6205
Balsam A.	0.0008	0.0006	0.3277	0.0455	0.0121	0.3867

Table 5: Target hazard quotient for different heavy metals due to consumption of herbs collected from Sharada Area.

Herb	Cd	Cr	Pb	Ni	Co	HI
Mornig G	0.0064	0.00098	0.27596	0.01610	0.00025	0.29969
Senna T.	0.0093	0.00150	0.46973	0.00723	0.00386	0.49162
Senna O.	0.0035	8.51E-05	0.50304	0.00808	0.01040	0.52511
Leptad.	0.0023	0.00110	0.13342	0.02335	0.00898	0.16915
Balsam A.	0.0004	0.00110	0.42486	0.03400	0.01898	0.47934

Table 4 shows the THQ of the toxic metals at Challawa. The THQs values of metals for the investigated samples did not exceed one indicating that there was no health risk from consuming these herbs. HI ranged from 0.2370 to 0.6205. The THQs for toxic metals were below 1 in table 5 for samples collected from Sharada and the HI ranged from 0.16915 to 0.52511. The THQs and HI values of the metals for the investigated samples at Sharada sampling areas did not exceed one indicating that there was no health risk from consuming these herbs.

CONCLUSION

Medicinal plants are sources of a large number of active ingredients of herbal and modern medicine. However, continuous increase in environmental pollution is leading to the buildup of pollutants including heavy metals in the plant parts which eventually enter human food chain. The present investigation clearly demonstrated the variation in heavy metal concentration depending upon the collection sites. The need to screen medicinal plants, used in traditional medicine for their elemental composition is highly desirable. Target hazard quotients for individual herbs were all below 1.0 for all heavy metals, regardless of the sampling area, The THQs of heavy metals from consumption of herbs being less than 1.0 suggested that health risk was insignificant. From the human health point of view, heavy metals THQ values (<1) show a situation of no risk for the consumer.

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