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RESEARCH ARTICLE

Assessment of selected heavy metals concentration in twenty standard hotels in Kaduna metropolis, Kaduna state, Nigeria

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ABSTRACT

The rise in contamination of raw foods by heavy metals has become an unavoidable problem nowadays. The episodes of accumulation of heavy metals in the biotic environment result from rapid increase in industrial activities, advancement in agricultural methods, or the activities of humans in the urban settings. These activities have prompted metal distribution in the environment and, subsequently, resulting to impairment in health of the populace by the ingestion of food contaminated by harmful metals components. The aim of this study was to assess the heavy metals concentrations and characterize the heavy metals found in raw food samples collected from selected standard hotels in Kaduna State and compare with the Food Agriculture and Organization (FAO)/World Health Organization (WHO) guidelines so as to assess the potential health hazard**.** Twenty samples of rice and nine samples beans were obtained from 20 hotels within three-, four-, and five-star ratings with their purchase sources coded from hotel 1 to 20 for confidentiality. The powdered samples were digested with nitric acid. Extract from the digest was analyzed for Copper (Cu), Lead (Pb), and Cadmium (Cd) using Buck Scientific AAS. The results of this research indicated levels of HMs were within safe limit, when compared with FAO/WHO standard and concentrations are significantly low, as the heavy metals are the same across the samples at *P*-value set at 0.05. The results of this study indicated presence of the heavy metals (Copper, Cadmium, and Lead) in the samples but they were at safe levels when compared with the WHO standard. Despite these, one should not neglect the fact that the two metals (Cd and Pb) accumulate in the body over time because of consumption frequency of beans and rice. Bioaccumulation rate can pose serious health risk to consumers. Implementation of hazard analysis critical control point for routine assessment of heavy metals in food products to help eliminate of not exceed global standard for food safety should be practice.

Keywords: Beans, Hazard analysis critical control point, Heavy metals, Hotels, Kaduna state, Rice

INTRODUCTION

Numerous researchers in Nigeria have reported on adverse effects on human health due to exposure to some of these heavy metal's concentration in drinking water and food.[1-21] Even though these heavy metal's concentrations are toxic to humans, there exposure cases and the rise in contamination of raw foods by heavy metals have become an unavoidable problem nowadays.[6,12,16,22-24] The episodes of accumulation of heavy metals in the biotic environment result from rapid increase in industrial activities, advancement in agricultural methods, or the activities of humans in the urban settings.[25-47] These activities have prompted metal distribution in the environment and, subsequently, resulting to impairment in health of the populace by the ingestion of food contaminated by harmful metal components.[1-5,7,14,17,22-24,46-48] A heavy metal is denoted as any metallic chemical element that has a generally high density and is poisonous or lethal at low levels. These metals have a

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moderately high density and are lethal at low levels,[1-5,7,14,17,49] and usually do not disintegrate into less toxic constituents and they accumulate where they are discharged.[50,51] Examples of heavy metals include mercury (Hg), cadmium (Cd), arsenic (As), chromium (Cr), thallium (TI), and lead (Pb) which can be of serious risk to animals and humans due to their vey toxic nature and affinity to bioaccumulate in the food chain at low concentrations.[1-5,7,14,17,52] Heavy metals, the presence in very low concentrations in raw foods, have the ability to cause human health problems. Information about the dietary intake of such metals is essential to measure the threats to consumers. Consumption of these metals in food could account for little amount of the toxic metals found in the blood and urine of many people.[1-5,7,14,17,53-56] The contamination of raw food with heavy metals may cause a serious health effects depending on concentration exposed to. Some of these metals, such as cadmium and mercury, affect the kidney and cause symptoms of chronic toxicity, including impaired kidney function, poor reproductive capacity, hypertension, tumors, and hepatic dysfunction.[1-5,7,14,17,57] Furthermore, lead causes renal failure and liver damage.[46,47,57] Thus, there is a need to determine heavy metals concentrations found in raw food samples, to assess the heavy metals concentrations found in raw food samples collected from selected standard hotels in Kaduna State and to compare them with the World Health Organization (WHO) guidelines so as to assess potential health hazard.

MATERIALS AND METHODS

Study area

The study was conducted in Kaduna State. Kaduna is the state capital of Kaduna state in North-west Nigeria, on the Kaduna River [Figure 1]. It is a trade center and a major transportation hub for the surrounding agricultural areas, with its rail and road junction. The population of Kaduna was at 760,084 as of the 2006 Nigerian census. Rapid urbanization since 2005 has created an increasingly large population, now estimated to be around 1.3 million. It has a density of about 5800 km^2.

Study design

The research involved cross-sectional study design with laboratory analysis to determine the concentration of heavy metals in raw foods.

Sample size

Field survey was conducted using purposive sampling; hotels were picked based on their star ratings, and three-, four-, and five-star hotels were considered for the study. The hotel was rated using the Nigeria Tourism Development Corporation[58] classification, it was possible to obtain representative samples from the 20 hotels visited were 20 samples were collected for analysis.

Method of data collection

The samples were collected from different hotels into sterile polythene bags. All the samples were labeled appropriately and taken to Central Laboratory at Ladoke Akintola University of Technology, Ogbomosho, Oyo State.

Sample preparation

Samples were carefully collected to avoid contamination. Glass wares used were washed clean with distilled water after soaking for 24 h in 1% HNO_3, and analytical grade reagents purchased from Aldrich Chemical Company Limited, England were used. Reagent blank determinations were used to correct errors.

Metal determination

The samples were oven dried at 105°C to constant weight for 90 min, cooled to room temperature of 28 ± 1°C and ground to fine powder in a porcelain mortar and exactly 1 g of the ground sample was quantitatively transferred into a well-glazed porcelain crucible, placed in a muffle furnace and ashed at 450°C for 12 h. The resultant ash was cooled to room temperature and digested to a clear solution with 5 ml of 5M HNO_3. The residue was then filtered into a calibrated 50 ml volumetric flask

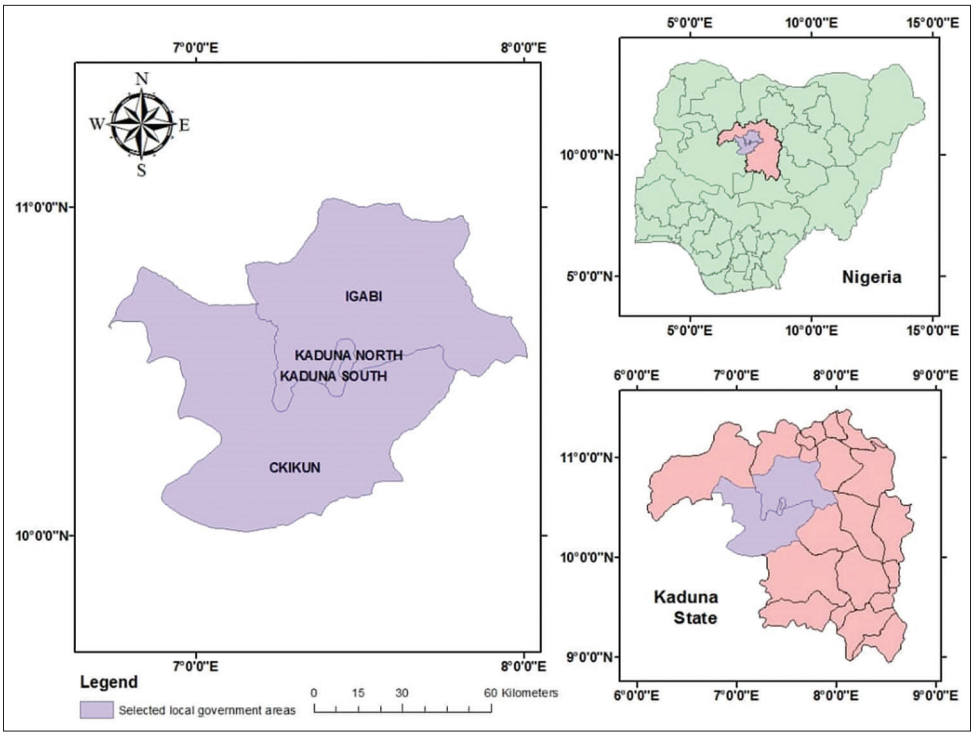


Figure 1: Map of the study area Source: Author Field Survey, (2019)

using Whatman No. 41 filter paper, and the solution was made up to mark with deionized water. The total concentrations of the metals in the digests were determined by aspirating the solution into Buck Model 210A atomic absorption spectrophotometer after the necessary standardization procedures and the respective spectral lines (nm) were 283.3, 324.7, and 228.8, for Pb, Cu, and Cd, respectively, from hollow cathode lamps.

Data management

SPSS, version 23 (Stanford, California, USA), was used for the statistical analysis. Data were subjected using analysis of variance for descriptive statistics. Statistical data were presented in charts and tables. Significant difference was set at 5%.

Scope of the study

The study was limited to analysis of the amount of heavy metals found in raw food samples collected from three-, four-, and five-star hotels in Kaduna, with the objectives of determining heavy metal concentrations found in raw food samples, estimation of heavy metal dietary intakes by citizen, and compare them with the (WHO) guidelines so as to assess potential health hazard and the characterization of the heavy metal found in raw food samples collected from selected three-, four-, and five-star hotels in Kaduna State.

RESULTS AND DISCUSSION

Concentrations of Copper (Cu), Cadmium (Cd), and Lead (Pb) in Rice

Figure 2 shows the concentrations of copper, cadmium, and lead in rice, which involved 20 samples (Sample 01, Sample 02, Sample 03, Sample 04, Sample 05, Sample 07, Sample 013, Sample 014, Sample 015, Sample 016, Sample 017, Sample 018, Sample 019, Sample 021, Sample 022, Sample 023, Sample 024, Sample 025, Sample 026, and Sample 027, respectively) with concentrations ranging from 0.0012 to 0.0072 mg/kg. Figure 2, also points out that all the concentrations of Cu in the rice samples are below the permissible limits of Food Agriculture and Organization (FAO)/WHO[59,60] maximum contaminant level, (30.0 mg/kg). The result was similar to the study by Changping and Frederick,[61] on human health risks of heavy metals in paddy

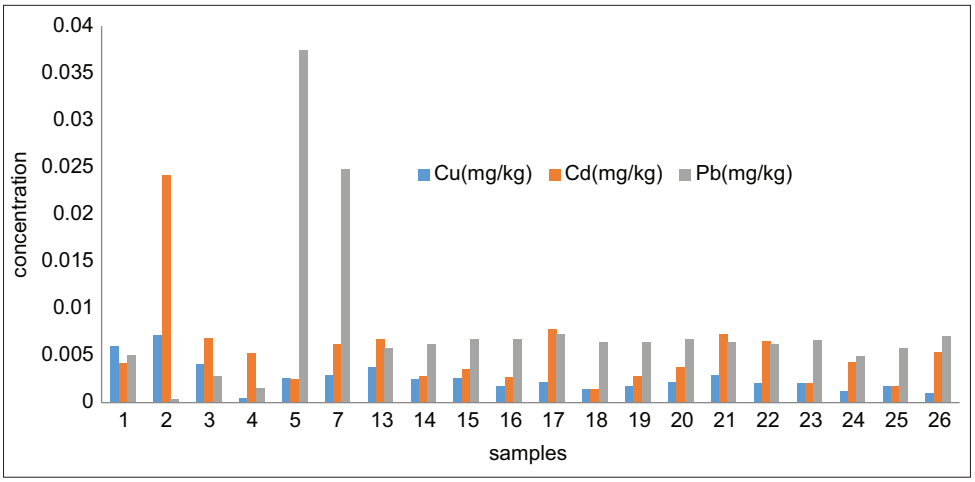


Figure 2: Concentrations of Copper (Cu), Cadmium (Cd), and Lead (Pb) in Rice

rice based on transfer characteristics of HMs from soil to rice which revealed that the heavy metals concentrations (Cadmium, Zinc, Chromium, Copper, Lead, Arsenic, Iron, Mercury. and Manganese) were in the low levels and this is below the maximum allowable limit. Copper is regarded as important and may come in contact with the food chain from soil through mineralization by crops or environmental pollution with pesticides containing heavy metals.[27-35] Excessive intake of copper has been reported to be toxic.[1-5,7,14,17,62-64] The excessive concentration of Cu in the rice may be due to exhaust from burnt vehicles along the major roads since copper is mostly seen in electrical wirings.

For the concentrations of cadmium in rice, which involved 20 samples (Sample 01, Sample 02, Sample 03, Sample 4, Sample 5, Sample 7, Sample 013, Sample 014, Sample 015, Sample 016, Sample 017, Sample 018, Sample 019, Sample 021, Sample 022, Sample 023, Sample 024, Sample 025, Sample 026, and Sample 027, respectively) with the frequency of in a decreasing order of the identified metal, which include: 0.0242>0.0078>0.0073>0.0069>0.0068>0.0065>0.0062>0.0054>0.0052>0.0043>0.0042>0.0038>0.0036>0.0028>0.0028>0.0027>0.0025>0.0021>0.0017>0.0014. These results agree with a study on occurrence and partitioning of cadmium, arsenic, and lead in mine impacted paddy rice: Hunan, China conducted by Paul *et al*.,[65] where the outcomes of the results revealed the presence of cadmium in the sample analyzed. The results also disagree with the study by Simmons *et al*.,[66] on Elevated levels of cadmium and zinc in paddy soils and elevated levels of cadmium in rice grain downstream of a zinc mineralized area in Thailand conducted where he reported that the concentration of cadmium in the samples was within the range 0.5–284 (mg/Kg). According to Zhang *et al*.,[67] the Cd available in rice cannot be washed away totally during washing and it can be dissolved during cooking due to its acidity. This can establish a major health effect to humans as cadmium will be filtered in kidney and can retain for 10–35 years in its active form due to its long biological half-life. It shows that all the concentrations of Cu in the rice samples are below the permissible limits of WHO[60] maximum contaminant level, (1.0 mg/kg).

Similarly, Figure 2 shows the concentrations of lead in rice, which involved 20 Samples 1, 2, 3, 4, 5, 7, 13, 14, 15, 16, 17, 18, 19, 21, 22, 23, 24, 25, and 26) with concentrations ranging from 0.0015 to 0.0375 mg/kg. Figure 2 also shows that all the concentrations of Pb in the rice samples are below the permissible limits of FAO/WHO[59] maximum contaminant level, (2 mg/kg). The concentration in this study remains much lower than the concentrations observed by Mirlohi *et al.* and[68] Zazoli *et al*.,[69] for rice samples planted in different areas. Lead as a toxic significant metal gotten into the environment by man in enormous quantities, in spite of its low geochemical portability and has been diffused around the world.[59] Food might be contaminated with lead through its take-up from air, water, and soil.[70] The

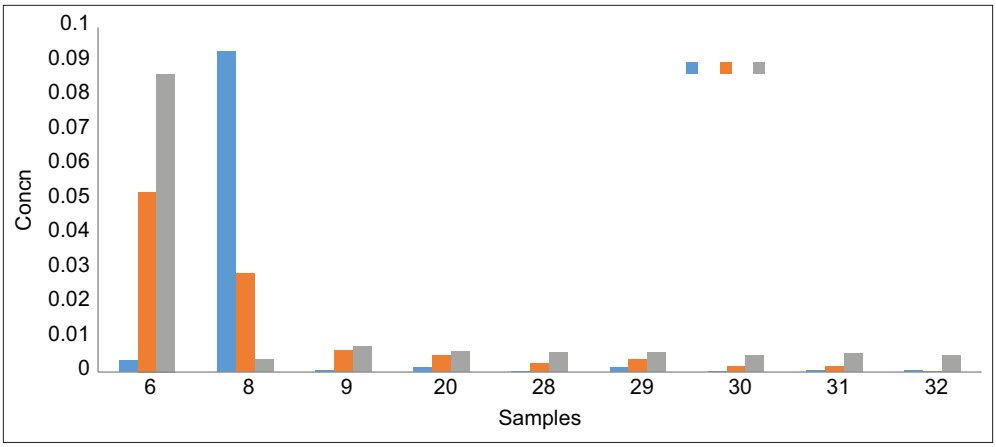


Figure 3: Concentrations of Copper (Cu), Cadmium (Cd), and Lead (Pb) in Beans

previous studies have reported extreme amount of heavy metals, especially for cadmium, chromium, and lead in rice grains from various countries.[71,72] These studies have indicated that anthropogenic activities such as industrial production, mining, and transportation discharge a high measure of heavy metals to the water and soil sources utilized in the rice growth. Rice harvested even from non-contaminated zones might be contaminated as a result of the application fertilizers, pesticides, and sewage that are used in farming,[25-41] containing cadmium, lead, and other heavy metals.[70,73] HMs and trace elements in rice grain can be reduced to an acceptable limit by washing and soaking as demonstrated by Al Saleh *et al*.[74] As a result of the above, the hotel management should adopt hazard analysis critical control point (HACCP) system which assesses the different risks associated with food being purchased and prepared for their consumers to reduce or eliminate the risk/hazards present in them.

From Table 1, it shows significant value of (0.466) with *P*-value set at (0.05), meaning that the result is accepted at H_0: The average concentration of heavy metals across the sample is the same.

Figure 3 shows the concentrations of copper in beans, which involved nine samples (Sample 6, Sample 8, Sample 9, Sample 20, Sample 28, Sample 29, Sample 30, Sample 31, and Sample 32, respectively) with concentrations ranging from 0.0001 to 0.093 mg/kg. From Figure 3, it also shows that all the concentrations of Cu in the beans samples are below the permissible limits of FAO/WHO[59,60] maximum contaminant level, (10 mg/kg). The result from this study is consistent with a study on elevation of heavy metals in beans in some selected markets in Katsina State Nigeria conducted by Yaradua *et al*.[75] revealed that concentration of copper, chromium, cadmium, iron, nickel, manganese, and zinc in the samples analyzed were lower than the FAO/WHO maximum permissible limits but lead was not detected in all the samples. Furthermore, Figure 3 shows the concentrations of cadmium in beans), which involved nine samples (Sample 6, Sample 8, Sample 9, Sample 20, Sample 28, Sample 29, Sample 30, Sample 031, and Sample 032, respectively) with concentrations ranging from 0.0001 to 00.0180 mg/kg. This Figure 3 also shows that all the concentrations of Cd in the beans samples are below the permissible limits of FAO/WHO[59,60] maximum contaminant level, (0.02 mg/kg). This result is in conformity to the study on HM levels in beans (*Vigna unguiculata*) in selected markets in Ibadan, Nigeria conducted by Adepoju *et al*.[76] which reported that the concentration of Cd and Pb in

Table 1: Analysis of Variance of Cu, Cd, and Pb across the rice samples

Dependent Variable: Conc				
Source	**df**	**Mean Square**	**F**	**Sig.**
Intercept				
Hypothesis	1	0.001	8.881	0.096
Error	2.002	0.000[a]		
Sample				
Hypothesis	19	2.630E-5	1.016	0.466
Error	38	2.588E-5[b]		

Table 2: Analysis of variance of Cu, Cd, and Pb across the beans samples

Source	df	Mean Square	F	Sig.(Beans)
Intercept				
Hypothesis	1	0.004	7.340	0.105
Error	2.155	0.001[a]		
Sample				
Hypothesis	8	0.001	2.076	0.102
Error	16	0.000[b]		

the samples was in the low level when compared with FAO/WHO standard. This also agrees with a study by Sulyman *et al*.[77] which indicated that the Cd levels in the cereal were below the safe limit. In any case, one should not neglect the fact that these heavy metals accumulate in the body with time because of the frequency of beans containing them in minute quantities. If these metals are not eliminated or reduced at the rate at which they bioaccumulate, they present serious health risk to their consumers. Furthermore, concentrations of lead in beans in Figure 3 involved nine samples (Sample 6, Sample 8, Sample 9, Sample 20, Sample 28, Sample 29, Sample 30, Sample 31, and Sample 32, respectively) with concentrations ranging from 0.0037 to 0.0864 mg/kg. It shows that all the concentrations of Cd in the beans samples are below the permissible limits of FAO/WHO[59,60] maximum contaminant level (2 mg/kg). This study is in accordance with a study reported for market sold beans in Eastern Nigeria and a study conducted in Vadodara India.[78,79] The amount of HMs estimated may likely to have been contributed by plant take-up at where the beans were grown as well as discharge from vehicle while transporting them to the markets for sale.

From Table 2, it shows significant value of (0.102) with *P*-value set at (0.05), meaning that the result accepted at H0: The average concentration of heavy metals across the sample is the same.

CONCLUSION

The results of this study indicated the presence of heavy metals (Copper, Cadmium, and Lead) in the samples but they were at safe levels compare with the FAO/WHO standard and analyzes of the data by ANOVA to correlate the HMs concentrations in beans and rice samples showed that the heavy metals concentrations are the same across the samples and have significantly lower *P*-value level ($P < 0.05$). In any case, one should not neglect the fact that the HMs accumulate in the body with time because of the frequency of beans and rice containing them in minute quantities. If that these metals are not eliminated or reduced at the rate at which they bioaccumulate, they present serious health risk to their consumers. Hence, it is necessary for agricultural activities and other human activities that increase heavy metal contamination of raw foods to be monitored.

RECOMMENDATIONS

- Regular assessment of heavy metal concentration in food stuffs bought by the hotels with the implementation of HACCP system to ensure that heavy metals are eliminated from the food or do not exceed the global standard for food safety
- Safe waste disposal methods should be encouraged to reduce environmental contamination because industrial wastes are major sources pollution by heavy metals
- Hotels should affiliate with farms directly for the purchase of food stuffs as to ascertain safety or traceability if hazards are detected in the foods.

CONFLICT OF INTEREST

The authors in this study have declared that no conflicting interests exist.

ETHICS APPROVAL

Ethical approval was granted from the Kwara State University Ethical Review Committee. Informed consent was obtained from each respondent.

DATA AVAILABILITY

Data used to support the findings of this study are included within the article.

FUNDING

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