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Evaluation of Some Trace Metals from the Leaves of Some Economic Trees Grown in Kudenda Industrial Area of Kaduna State-Nigeria

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Authors' contributions

This work was carried out in collaboration between all authors. All authors read and approved the final manuscript.

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ABSTRACT

Chromium, zinc and cadmium were quantitatively estimated from the leaves of mango, guava and cashew trees cultivated in Kudenda Industrial Area of Kaduna using Atomic Absorption Spectrometry. The results of the analysis indicated higher concentration of chromium in guava and mango leaves (0.087 and 0.083 mg/kg) respectively, with lower level in that of cashew (0.033 mg/kg). Zinc was found to be low at 0.54 and cadmium just at the maximum permissible mark of 0.05 mg/kg in cashew leaves and very low values of 0.024 and 0.003mg/kg, respectively in mango and guava. The chromium levels in guava, cashew and mango leaves were above the allowable limits in the range of 0.05-0.18 mg/kg whereas zinc concentration in the cashew leaves was also below the Food and Agriculture Organization/ World Health Organization (FAO/WHO) set limits of 0.05 mg/kg and 60 mg/kg, respectively. The results revealed that, with continuous industrial activities, pollution due to the studied heavy metals is likely accumulate to dangerous levels if appropriate measures are not taken.

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1. INTRODUCTION

Heavy metals which are usually considered trace elements are those metallic elements with high relative atomic masses. The term is usually applied to common transition metals such as copper lead, zinc etc. These metals are a cause of environmental pollution (heavy metal pollution) which emanates from a number of sources such as lead (Pb) in petrol, industrial effluents and leaching of metal ions from the soil into lakes and rivers by acid rain. Heavy metals are natural components of the environment but they are a cause for concern because they are being added to soil, water and air in increasing amounts as a result of growth in population and expansion of industrial activities etc. [1]. Most heavy metals are essential to living organisms, but their excessive concentration is generally harmful to plants and animals. The poison of heavy metals depends largely on their chemical forms, concentration, residence time, etc. [2-4].

Nowadays, heavy metal pollution poses a serious threat to the earth's atmosphere. Traffic emission on roads constitutes one of the main causes of heavy metals in the environment and planet species [5-8]. Heavy metals released during industrial activities form the major portion of the contamination that accumulates in air, soil and water bodies. Chromium in particular, being highly soluble and bioavailable, exerts toxic effect on biological systems arising from the possibility of free diffusion across cell membranes and has strong oxidative potentials [9]. Zinc induces damage to living systems, essential enzymes involved in metabolism [7]. Photosynthesis is one of the major physiological processes known to be severely affected by heavy metals. Heavy metals induce damage to the photosynthetic apparatus which induces changes in photosynthetic electron transport and carbon fixation capacity [10-12]. Cadmium, for example, enters air from mining industries and burning of coal as well as household waste [13]. Cadmium particles in air can travel long distances before falling to the ground or into water bodies. The toxicity of cadmium, chromium and zinc ions and their binding capacity have been studied at varying test levels using duckweed as the test organism. Excessive accumulation of chromium causes cancer and stomach ulcer. Cadmium causes severe lung damage among others while zinc causes ataxia and lethargy.

These metals were selected for investigation in Kudenda industrial area based on the likelihood of being released into the surrounding environment as a result of the industrial activities and effluent discharge. The research was also intended to reveal the potential risk posed to the health of the inhabitants of the area and by implication, the nation as a whole.

2. EXPERIMENTATION

2.1 The Study Area

Kudenda is an industrial area located in the southern part of Kaduna (i.e., along the Western by-pass). The area is a host to international beer and beverages production sites, flour mills, foam companies, sun glass company and a lot of other industries.

2.2 Sampling

Three leaf samples from each tree type were collected at random within the study area and packaged separately. The samples were air-dried for five weeks. The dried leaves were then ground into fine powder and sieved using a 1x1mm plastic sieve in preparation for analysis.

2.3 Digestion

The sample (1 g) was placed in a 50 mL Crucible before the addition of 10 mL concentrated HNO_3. The mixture was placed on a hot plate for 30–45 min to allow for oxidation. After cooling, 5 mL $HClO_4$ (70%) was added, and the mixture was reheated on a hot plate until the digest became clear and semi-dried. Then, the sample was cooled and filtered through Whatman No. 42 filter paper before being quantitatively transferred to a 50 mL volumetric flask by adding deionized distilled water. The digests were run on an atomic absorption spectrophotometer (Cole UV-750) [14].

3. RESULTS

Tables 1-3 below display the dry-weight trace metal contents (mg/kg) in the leaves of mango, guava and cashew of the study area.

Table 1. The dry weight trace metal contents (mg/kg) in mango leaves in Kudenda industrial area of Kaduna

	Trace metals (mg/kg)		
Leaf sample	**Cr**	**Zn**	**Cd**
M1	0.05	-0.011	0.001
M2	0.18	-0.040	0.007
M3	0.02s	-0.020	0.002

Table 2. The dry weight trace metal contents (mg/kg) in guava leaves in Kudenda industrial area of Kaduna

	Trace metals (mg/kg)		
Leaf sample	**Cr**	**Zn**	**Cd**
G1	0.110	-0.030	0.003
G2	0.050	0.080	0.006
G3	0.100	-0.040	0.000

Table 3. The dry weight trace metal contents (mg/kg) in cashew leave in Kudenda industrial area of Kaduna

	Trace metals (mg/kg)		
Leaf sample	**Cr**	**Zn**	**Cd**
C1	0.010	0.600	0.010
C2	0.050	0.490	0.050
C3	0.040	0.530	0.0920

Chromium is present in appreciable amounts in all samples. The profile of the average chromium content in the leaves were found to be in the order guava>mango>cashew, with the average chromium values as 0.086, 0.083, and 0.03 mg/kg respectively. The values obtained for guava and mango were higher than the recommended FAO/WHO limit of 0.05 mg/kg allowed in plants. Cashew leaves however had a lower value compared with the FAO/WHO standard. Descriptive statistics (Table 4) shows the concentration of chromium in the samples.

The 95% confidence band for the mango leaves lies between -0.128 and 0.295. From the ANOVA (Table 5), since p=0.447>0.05, we accept the null hypothesis and conclude that chromium is equally present in mango, guava and cashew leaves (Fig.1). The descriptive statistics for the other plants are also displayed (Tables 6 and 7). Chromium concentrations found in tomatoes in a study carried out in Delta State Nigeria were below the FAO limits contrary to the findings of this research [16]. This may largely be as a result of difference in location and types of activities taking place in the areas.

Zinc is not present in mango leaves, less available in guava leaves but present in appreciable amount in cashew leaves. The profile were found to be in the order cashew>guava>mango with average zinc values as 0.54, 0.003 and -0.024 mg/kg respectively and these values are much below 60 mg/kg recommended for plants [15]. The 95% confidence band for the zinc concentration in mango leaves lies between -0.061 and 0.013 (Table 6). From the ANOVA for zinc, Since p=0.000<0.05, we reject the null hypothesis and conclude that zinc is not present in all the leaves (Table 8).

Table 4. Descriptive Statistics for chromium

Sample locations	Leaves	N	Mean	SD	Std. error	95% Confidence interval	
						Lower bound	**Upper bound**
Nasarawa/ Kudenda	Mango	3	0.083	0.085	0.049	-0.128	0.295
	Guava	3	0.087	0.032	0.019	0.007	0.167
	Cashew	3	0.033	0.021	0.012	-0.018	0.085
	Total	9	0.068	0.053	0.018	0.027	0.109

Table 5. ANOVA for chromium

Sample locations	Sources of variation	Sum of squares	Df	Mean square	F	Sig.
Nasarawa/ Kudenda	Between Groups	0.005	2	0.003	0.923	0.447
	Within Groups	0.017	6	0.003		
	Total	0.023	8			

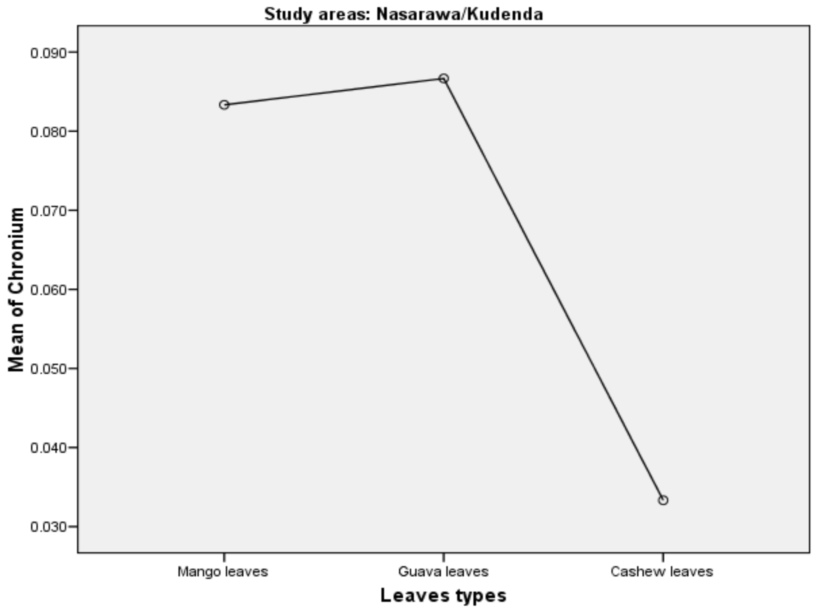

Fig 1. Mean chromium concentration (mg/kg) in the leaf samples from plants of Kudenda industrial area

Table 6. Descriptive statistics for zinc

Sample locations	Leaves	N	Mean	SD	Std. error	95% Confidence interval	
						Lower bound	Upper bound
Nasarawa/ Kudenda	Mango	3	-0.024	0.015	0.009	-0.061	0.013
	Guava	3	0.003	0.067	0.038	-0.162	0.169
	Cashew	3	0.540	0.056	0.032	0.402	0.678
	Total	9	0.173	0.279	0.093	-0.041	0.388

Table 7. Descriptive statistics for cadmium

Sample locations	Leaves	N	Mean	SD	Std. error	95% Confidence interval	
						Lower bound	Upper bound
Nasarawa/ Kudenda	Mango	3	0.003	0.003	0.002	-0.005	0.011
	Guava	3	0.003	0.003	0.002	-0.004	0.010
	Cashew	3	0.008	0.003	0.002	0.001	0.015
	Total	9	0.005	0.004	0.001	0.002	0.007

Table 8. ANOVA for zinc by sample locations

Sample locations	Sources of variation	Sum of squares	Df	Mean square	F	Sig.
Nasarawa/ Kudenda	Between Groups	0.606	2	0.303	117.32	0.000
	Within Groups	0.016	6	0.003		
	Total	0.622	8			

The descriptive statistics for cadmium revealed a 95% confidence band for the mango leaves which was between -0.005 and 0.011. Since p=0.148>0.05 from the ANOVA for cadmium (Table 9), we accept the null hypothesis and conclude that cadmium is present in all the leaves. The profile for average cadmium content varied in the order cashew>mango> guava with values of 0.007, 0.003, and 0.001 mg/Kg respectively. The values for cadmium concentrations obtained in this research were below the FAO/WHO limits of 0.20 mg/Kg [15]. A similar study involving Zn and Cd in vegetation within metropolitan sites of Kaduna state obtained Zn concentrations to be within acceptable limits with Cd levels being higher than the acceptable FAO limits [16]. See table 10 for FAO/WHO standards.

The variation in concentration in all the leaves analyzed for trace metals chromium, zinc, and cadmium are as graphically displayed in Figs. 1, 2 and 3 respectively.

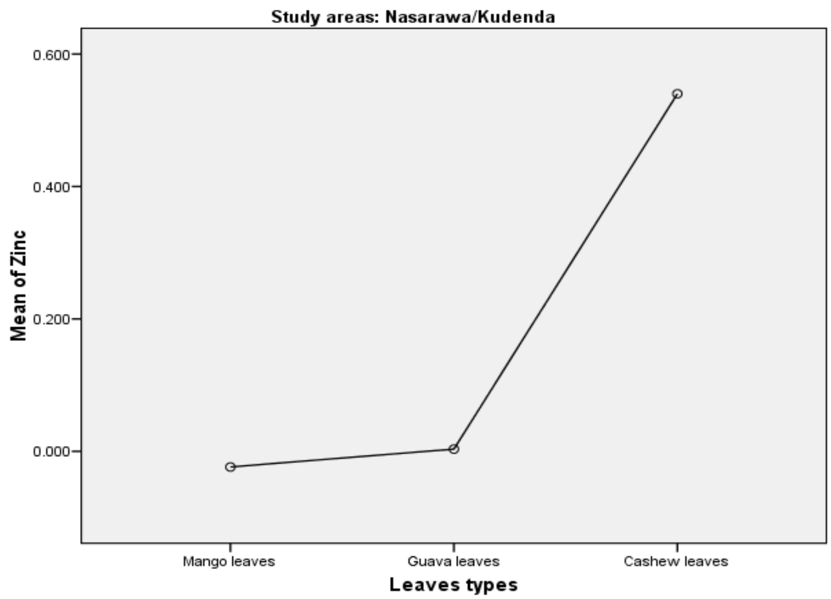

Fig. 2. Mean zinc concentration (mg/kg) in the leaf samples from plants of Kudenda industrial area

Fig. 3. Mean cadmium concentration (mg/kg) in the leaf samples from plants of Kudenda industrial area

Table 9. ANOVA for cadmium by sample locations

Sample locations	Sources of variation	Sum of squares	Df	Mean square	F	Sig.
Nasarawa/ Kudenda	Between Groups	0.000	2	0.000	2.671	0.148
	Within Groups	0.000	6	0.000		
	Total	0.000	8			

Table 10. FAO/WHO guidelines for metals in foods and vegetables

Metals mg/kg)	WHO/FAO	Normal range in plants
Cd	1	<2.4
Cu	30	2.5
Pb	2	0.50-30
Zn	60	20-100
Fe	48	400-500
Ni	-	0.02-50
Cr	0.05	

4. CONCLUSION

The results of this study indicated that the leaves analyzed contained varying concentrations of heavy metals which could pose threat to the health of humans who depend on them for sustenance. The Zinc concentration of cashew leaves was found to be above the limit set by FAO/WHO. For the guava and mango leaves, the Zinc concentration was below the set limit. The Chromium content for the mango and guava leaves was found to be above the FAO/WHO limit. Generally, the results showed that, with continuous industrial activities, pollution resulting from the studied heavy metals is likely to have severe but localized effect on human health if appropriate measures are not taken.

5. RECOMMENDATION

Bio or phyto remediative measures should be embarked upon by the companies whose activities have resulted in the pollution of some sites; proper waste management and disposal techniques should be adopted so as to avoid future accumulation of heavy metals which may be detrimental to the health of humans who use the fruits of the trees for consumption purposes.

COMPETING INTERESTS

Authors have declared that no competing interests exist.

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