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Assessment of Some Heavy Metals Concentration in Soil and *Moringa Oleifera* Samples from Gwarzo Town, Kano State, Nigeria.

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Abstract

The presence of heavy metals in plants is of significant concern owing to their toxicity to humans and ability to accumulate in food chains. This study was conducted to assess the levels of heavy metals in Moringa oleifera plant and soil within Gwarzo Town, Kano State, Nigeria via X-ray Fluorescence Technique. Leaf extracts from the plant, Moringa oleifera, and samples of the soil supporting the plant were collected from different parts of Gwarzo town. Six heavy metals namely: Fe, Cu, Ni, Cd, Mn, and Cr were determined. The results showed that the mean concentration of Fe, Cu, Ni, Cd, Mn, and Cr were 669.95 mg/kg and 4998.4 mg/kg, 4.63 mg/kg and 1.37 mg/kg, 194.0 mg/kg and 19.26 mg/kg, 50.85 mg/kg and 1.25 mg/kg, 1.42 mg/kg and 5.56 mg/kg, and 44.24 mg/kg and 129.7 mg/kg, for plant and soil samples respectively. The Fe and Cr concentration values for both plant and soil samples were above the acceptable values of 27 mg/kg and 100 mg/kg set by World Health Organisation. Considering the results obtained from this study, plants need proper treatment before consumption. Also, farms should not be sited near the highway and factories to avoid the accumulation of heavy metals.

Keywords: Moringa oleifera, Heavy metals, X-ray fluorescence technique, Toxicity.

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INTRODUCTION

Soil has been recognised as an indispensable natural resource vital for human existence and is commonly viewed as the primary repository for various pollutants originating from multiple sources. Industrialisation, along with various human activities such as artisanal mining, smelting, energy generation, power transmission, vehicular movement, intensive agricultural practices, and sludge disposal, can collectively lead to the build-up of metals and metalloids in agricultural soils and associated vegetation. Typically, plants uptake metals and metalloids from the soil via their roots, as well as from atmospheric deposits through their aerial structures (Koye *et al.,* 2022; Zarma *et al.,* 2023).

Moringa oleifera, also known as moringa, drumstick, horseradish, benzoil, ben oil or zogale in Northern Nigeria, is a small tree from the family of Moringaceae (Mahmud, 2019). Originally native to north-western India, but currently found in different parts of Africa, America, Europe, Oceania, and Asia, it is one of the most commonly cultivated species of the genus *Moringa* and its leaves and young seed pods are mostly used as vegetables (Brilhante, 2017). This plant has an excess amount of various nutrients and has been mentioned as a good supplement of nutrients such as protein, minerals, and fibre (Fakanku et al., 2013). Additionally, it has countless importance for the prevention of different categories of diseases such as: hyperglycaemia, malaria, syphilis, diarrhoea, pneumonia, scurvy, headaches, asthma, flu, heartburn, skin diseases, dyslipidaemia, bronchitis, ear and eye infections. It also reduces blood pressure, cholesterol and acts as an anticancer, antioxidant, and anti-atherosclerotic (Daba, 2016). The medicinal value of *Moringa oleifera* is due to the presence of essential and heavy metals (traced elements) contained in it (Ahmed *et al.,* 2018).

Heavy metals are divided into two in relation to their toxicity. Metals such as iron (Fe), manganese (Mn), molybdenum (Mo), copper (Cu), chromium (Cr), nickel (Ni), and zinc (Zn) are essential trace element for living organism at low concentration while others including arsenic (As), cadmium (Cd), mercury (Hg) and lead (Pb), are completely toxic with no known importance for living organisms. Those toxic metals even at low concentrations have been reported to have damaging effects on humans and animals since there is no good mechanism for their elimination from the body (Angon *et al.,* 2024; Zarma *et al.,* 2023). High intake of these toxic metals above the limit could lead to hypertension, heart, lung, kidney, liver vomiting, diarrhea, headache, irritability, intellectual problems, and cancer (Kusse and Tsegaye 2020).

Since plants typically absorb water and minerals directly from the soil, the uptake ability of heavy metals by this *Moringa oleifera* also occurs in the same way. These heavy metals are accumulated in different parts of the plants after absorption and are entered into biological chain after consumption by humans and animals (AA and OE 2013). A lot of research have been done on determination of heavy metals spreading in different part of *Moringa oleifera* such as: *Moringa* leaves, seeds, root, and pods (Mahmud, 2019; Faranku et al., 2018; Kusse and Tsegaye 2020 and Bojago, 2020). However, there is little or no data recorded on heavy metal concentration of *Moringa* leaves and soil in Gwarzo Local Government, Kano State, Nigeria. This study is aimed at investigating the elemental concentration of some heavy metals in *Moringa* leaves and soil sample collected from Gwarzo Local Government, Kano State, Nigeria.

METHODOLOGY

Study Area
The study area is Gwarzo Local Government, Kano State, Nigeria. Gwarzo is one of the forty-four (44) Local Government Areas in Kano State. Koya, Dan'amale, Katambawa, and Zango were the four selected towns for samples location. Gwarzo is located between latitude 11^{0}54'57.49" N and longitude 7^{0}56'1.32" E. with a total population of 183,987 in 2006 census (NPC, 2017). Gwarzo is known for the cultivation of different crops such as millet, groundnut, rice, cotton, etc. and it is also famous for the rearing of different animals such as rams, camels, and horses (Muhammad, 2020).

Sample Collection
The leaf samples of *Moringa oleifera* and their corresponding soil samples were collected from different locations and placed into into polythene bags. All the leaves and soil samples were labelled as shown in Table 1 and taken to the Chemistry Lab, Federal University Dutse, Jigawa State for preparation.

Table 1: Geographical coordinate of sampling points

Study Area	Sample ID	Latitude (N)	Longitude (E)
Zango	ZG	11^{0}54'59.1"	7^{0}56'41.9"
Dan'amale	DM	11^{0}56'51.8"	8^{0}02'08.3"
Katambawa	KTW	11^{0}54'55.1"	7^{0}56'13.2"
Koya	KY	11^{0}53'65.1"	9^{0}56'42.4"

Sample Preparation
The leaf samples were rinsed with tap water to eliminate dust and sand particles, then allowed to air-dry at room temperature. The samples were pulverized to fine granules using mortar and pestle and sieved through a 2-mm mesh sieve to obtain the finest powder. A small portion of each of the powdered leaves samples were stored in different plastic containers, labelled, and tagged for irradiation at Umaru Musa Yar'aduwa University (UMYU) using x-ray fluorescence spectroscopy. Similarly, the soil samples were also dried at room temperature to remove any moisture content. The samples were then crushed with a mortar and pestle, dried again and sieved through a 2 mm sieve to obtain a powder. A small portion of each of the soil samples were stored in plastic container and tagged with a sample ID for irradiation.

Sample Analysis
The samples were analysed and quantified using Energy Dispersive X-ray Fluorescence Spectrometer. X-ray fluorescence is a non-invasive analytical method utilized to identify the elemental composition of materials. The analysis of the elements with the x-ray fluorescence technique is based on the measurement of the characteristic x-rays emitted by the elements of interest contained in the sample when properly excited. XRF analysers identify the elements in a sample by detecting the fluorescent (or secondary) x-rays emitted when the sample is stimulated by a primary x-ray source.

RESULTS AND DISCUSSION
The concentration of Fe, Cu, Zn, Cr, Ni, Mn, and Cd in the leaves and soil samples from the four (4) selected sites are presented in Tables 2 and 3 respectively.

Table 2: Heavy metal concentration (mg/kg) in leaf samples

Study Area	Heavy metals concentration (mg/kg)					
	Fe	Cu	Zn	Ni	Cr	Mn
ZG	802.4	4.89	24.95	59	0.69	53.8
DM	857.6	5.80	113.1	55.7	3.82	54.56
KTW	303.6	5.33	27.13	42.6	0.21	29.7
KY	716.2	2.49	610.8	46.1	0.95	38.9
Mean	**669.95**	**4.63**	**194.0**	**50.85**	**1.42**	**444.24**
WHO	**27**	**10**	**50**	**1.63**	**1.5**	**200**

Table 3: Heavy metal concentration (mg/kg) for soil samples

Study Area	Heavy metals concentration (mg/kg)					
	Fe	Cu	Zn	Ni	Cr	Mn
ZG	5891	2.47	29.27	110.2	5.56	106.5
DM	4684.5	0.80	20.41	61.8	Nd	87.1
KTW	4709.1	1.12	13.67	56.5	Nd	241.9
KY	4709	1.09	13.67	56.5	Nd	83.3
Mean	**4998.4**	**1.37**	**19.26**	**71.25**	**5.56**	**12.7**
WHO	**27**	**36**	**50**	**35**	**100**	**200**

The concentration of iron (Fe) in the leaf samples of *M. oleifera* ranged between 303.6 to 857.6 mg/kg with a mean value of 670 mg/kg and 4684.5 to 5891.0 mg/kg with mean value of 4998 mg/kg for soil sample. The minimum value was obtained from KTW and DM while the maximum value was obtained from DM and ZG. All values were found to be above the maximum concentration value of 27 mg/kg as set by WHO. The high concentration of Fe in *M. leaves* may be due to the contamination of the site soil as a result of the wear of heavy-duty vehicle engine and emission Fe from the exhaust pipe when an unleaded fuel is used. Vehicular heavy metal emission, especially Fe, near highways is mostly from two sources: exhaust pipe (from using leaded fuel) and non-exhaust pipe sources (from tire wear, brake degradation, and engine wear (Wang, 2021). The presence of high quantity of iron in the soil is another possibility since it is an essential trace element in both plants and animals.

The minimum and maximum concentration value of Cu in the leaf sample are 2.49 and 5.80 mg/kg obtained from KY and DM sample location, with mean value of 4.63 mg/kg lower than the WHO set value of 10 mg/kg. Furthermore, 0.80 and 2.47 mg/kg are the lowest and highest value of Cu in soil samples, obtained from DM and AG, with mean value of 1.37 these values were far lower than the recommended value of WHO 36 mg/kg. Cupper is an essential trace element generally occurring in soil, sediments and air. However, overdoes of cupper could lead to respiratory tract diseases, fever, hair and skin decolouration WHO, 2017.

The concentration of Zn in *M. oleifera* leaf samples varied from 24.95 to 610.8 mg/kg with mean value of 194.0 mg/kg. KY is the sample location with the highest concentration and ZG is the sample location recorded the lowest value. Fifty percent of the leaf sample have exceeded the recommended value of 50 mg/kg set by WHO. This high concentration of Zn in the leaf sample may be due to the contamination of the sites as a result of high level of traffic and vehicular emission in Gwarzo, and Karaye road. Research has shown that Zn emission from vehicular sources and its accumulation in roadside soils have increased the level of Zn in leafy vegetables near the roads, posing health risks due to ingestion of such leaves (Agrawal & Vema, 2021). The Zn concentration in soil samples ranged between 13.67 to 29.27 mg/kg with mean value of 19.26 mg/kg all below permissible limit of 50 mg/kg. Zinc is an important heavy metal and plays a vital role in the development of the brain, bone formation, normal growth, and wound healing but causes vomiting, diarrhea, bleeding and abdominal cramps at high concentration (Kharazi et al., 2021).

The concentration of Ni ranges from 42.6 to 59 mg/kg and 56.5 to 110.2 mg/kg with mean value of 1.63 mg/kg and 35 mg/kg for leaf and soil samples respectively. The minimum value was obtained from KTW and KY sample location while the maximum values of both leap and soil was obtained in ZG sample location. The concentration values in leaf samples were found to be almost twenty-one times higher than the recommended value of 1.63 mg/kg. Similarly, all the values of soil samples were the accepted limit of 35 mg/kg. The high concentration of Ni in the leaf samples may be due to the emission of Nickel along the road from engine oil combustion and tires of motor vehicles from the roads of the study area, it may also be due to the soil contamination with Ni. Nickel is also an essential trace element for plants and animal health that plays a vital role in the regulation of lipid contents in tissues and help in the formation of red blood cells (Zambelli *et al.,* 2016). High concentration of Ni in the body could lead to serious diseases such as cancer, depression, heart attack, low blood pressure, skin problem, nausea, kidney dysfunction, and vomiting (Genchi *et al*., 2020).

The concentration of Cr in leaf samples obtained from DM and KTW were respectively the highest and lowest with a value of 0.21 and 3.82 mg/kg and mean value of 1.42 mg/kg, all below the recommended limit of 1.5 mg/kg. For the soil samples, Cr was only detected in the ZG sample location. The detected value is 5.56 mg/kg, ten times lower than maximum contamination level of 100 mg/kg. Some concentration of Mn was detected in the leaf and soil samples at all locations in the study area. The concentration ranges from 29.7 to 54.56 mg/kg and 83.3 to 241.9 mg/kg, with mean value of 44.24 and 129.7 mg/kg for leaf and soil samples respectively. The highest values were obtained from DM and ZG while the lowest values were obtained from KTW and KY. All the values were lower than the maximum accepted value except ZG sample location with values above the standard value of 200 mg/kg.

CONCLUSION

The concentration of heavy metals in plant and soil samples in Gwarzo town, Kano state, Nigeria was determined using x-ray fluorescence technique. It was found that, the concentration of heavy metals varied significantly in the leaves and soil samples with some samples exceeding the WHO set limit. Therefore, consumption of *Moringa* leaves sold along Dan'amale, Katambawa, Zango, Koya, should be discourage. Additionally, agricultural lands should not be sited close to highway to prevent excessive build-up of heavy metals. It is also very important to check the concentration of heavy metals of each edible plant before consumption.

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