

# EVALUATION OF CERTAIN HEAVY METALS IN SOIL SAMPLES WITHIN SELECTED SOUTHERN PART OF KADUNA STATE, NIGERIA

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## ABSTRACT

This research paper investigated the presence of heavy metals in Soil samples from three selected sites within the southern part of Kaduna State, Nigeria. The aim of the study to analysis the level of heavy metals concentration within selected southern part of Kaduna State, Nigeria. Twelve (12) samples were analysed at the Federal Ministry of Agriculture and Rural Development, Kaduna using Atomic Absorption Spectrophotometer (AAS). From the result, it was found that Mn has the highest mean concentration 83.3 mg/kg and Cd, Cr, Ni, Cu, Zn and Pb have moderate concentration with mean level of 11.37 mg/kg, 36.53 mg/kg, 41.17 mg/kg, 7.30 mg/kg, 24.57 and 40.13 mg/kg respectively. Other Samples with low mean concentration levels are; Ca, Fe, K, Mg and Na with 0.05 mg/kg, 0.04 mg/kg, 0.01 mg/kg, 0.01 mg/kg and 0.38 mg/kg respectively, which is far less than the maximum permissible level recommended by WHO of 1.2 to 1.5 mg/kg. Hence, the result shows that there were heavy elements within the sampled area. The need for health agency to create awareness on the poor level of basic nutritional elements within the area and also, provide alternative source of the nutritional elements in their dietary. These lack of the basic nutritional elements can leads to the Retard growth, Kwashiorkor, Rickets and Anaemia.

**Keywords:** Soil, Heavy Metals, Atomic Absorption Spectrometer, Kaduna.

## INTRODUCTION

Soil is a vital component of the biosphere and its degradation has a negative impacts on the quality of human life (Ihedioha *et al.*, 2017). Soils constitute part of vital environmental, ecological and agricultural resource that has to be protected. The determination of elemental status of cultivated lands is necessary to identify yield limiting deficiencies of essential micronutrients and polluted soils (Alloway, 1990). The heavy reliance on land application as a mean of municipal waste disposal, Mining Sites and wastes from industries has generated concern in recent years. Recent studies have shown that the problem of environmental contamination is one of the main concerns of scientific researchers around Nigeria and the entire globe. Fast industrial development and the uncontrolled growth of the urban population could result in the production of toxic wastes (Mathew *et al.*, 2023). Man's activity with his environment has led to the pollution of soil mainly by chemical contaminants. Presently studies in developing countries like Nigeria have shown that high level of illiteracy in the country and inadequate awareness on how to mitigate the problems associated with soil pollution contributed to contamination of its soils (Sylvester *et al.*, 2017). The presence of heavy metals in soil can affect the

quality of food, groundwater, micro-organisms activity and plant growth (Mathew *et al.*, 2023). When contaminated soils are used for agricultural purposes such as farming and animal husbandry, the heavy metals are non-biodegradable and bio-accumulated via biological chains, plants take in the heavy metals via the soil in the process, which can adversely affect soil ecology, agricultural product quality, groundwater quality, which directly harm the living organisms by food chain. Thus, these heavy metals in the soil have toxic effect on human beings when permissible concentration levels are exceeded. Therefore, it is important to determine the free metal ion concentrations in soil solutions. The free metal ion concentration depends not only on the total metal ion content in soils, but also on the metal species that exist in the soils (Ene *et al.*, 2009). Thus, this research is aim at evaluating the level of some heavy metal concentrations within the Southern part of Kaduna State, Nigeria, using the AAS.

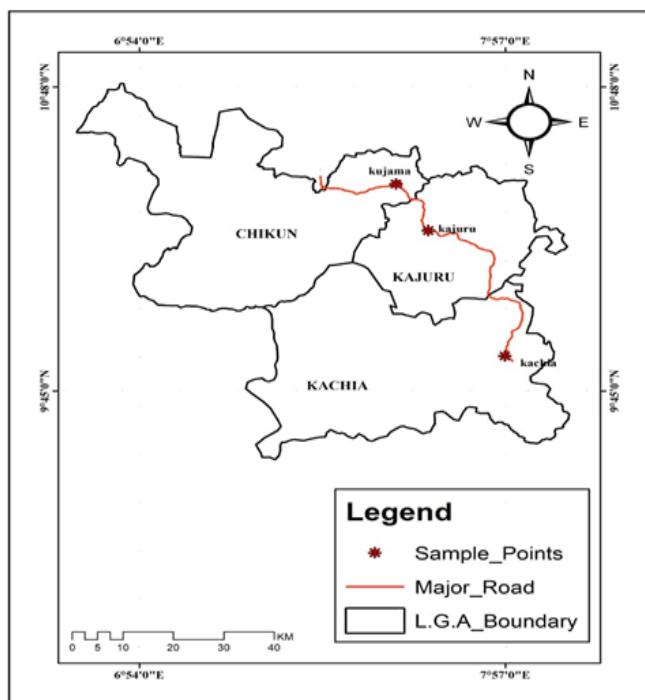
## METHODOLOGY

### Study Area

This research project was carried out within three Southern part of Kaduna State, Nigeria. The study Area is bounded to Zangon Kataf Local Government toward the North, Kaduna South Local Government toward the East Local Government, Kaduna North Local Government to the West and Kagarko Local Government to the South. These area experiences, wet and dry season weather with an average annual rainfall of six to seven months. The occupation of most people there are peasant farmers, who are into fruits and vegetable farming. The geographical map of the study area is shown in Figure 1.0.

### Sample Collection

Soil samples were collected randomly in Kachia, Kajuru and Kujama Local Government Area within Southern Part of Kaduna State, Nigeria. The research area location is shown in Figure 1. Samples of Soil were kept in a clean container and labelled accordingly. Samples were stored in a refrigerator at prior to analysis to inactivate bacteria and prevent any change in volume that may be caused due to evaporation (Mathew *et al.*, 2023).



**Figure 1:** The Geographical Map of the Research Area (GIS Lab, KASU).

#### Digestion of Water Sample

The vigorous digestion method described by Gregg (1989) was adopted. 100 mL of each of the representative water samples were transferred into Pyrex beakers containing 10 mL of concentrated HNO<sub>3</sub>. Place the beaker and content on a hot plate and digest till when brown fumes of HNO<sub>3</sub> have escaped. Continue heating till when content have reduced to 10 ml volume. The filtrates were transferred to 100 mL volumetric flasks and diluted to the mark with distilled water. These solutions were then used for the elemental analysis using the AAS.

#### Metal Analysis

A total of twelve (12) metallic elements were determined in the pre-treated samples of water using AAS as described by Gregg (1989). These include Zn, Cu, Mn, Fe, Ni, Cr, Cd, Pb, Ca, Mg, Na and K.

#### RESULTS AND DISCUSSION

The research was conducted in order to assess the heavy metal contamination of soil samples collected from some selected areas within the Southern part of Kaduna State, Nigeria. Table 1, shows the heavy metals concentration of soil sample collected randomly at various locations on the earth surface within the Southern part of Kaduna State, Nigeria.

**Table 1:** Showing Results of Mean Concentration Value of Soil Samples

S/No	Parameters	Kachia	Kajuru	Kujama	Mean Concentration Value
1	Zn (mg/kg)	23.7	10.2	39.8	24.57
2	Cu (mg/kg)	2.40	19.3	0.19	7.30
3	Mn (mg/kg)	80.9	69.7	99.3	83.30
4	Fe (mg/kg)	0.04	0.00	0.09	0.04
5	Ni (mg/kg)	48.8	22.9	51.8	41.17
6	Cr (mg/kg)	49.6	29.0	31.0	36.53
7	Cd (mg/kg)	5.9	10.7	17.5	11.37
8	Pb (mg/kg)	13.0	61.5	45.9	40.13
9	Ca (mg/kg)	0.03	0.09	0.03	0.05
10	Mg (mg/kg)	0.01	0.01	0.01	0.01
11	Na (mg/kg)	0.05	0.05	1.05	0.38
12	K (mg/kg)	0.00	0.02	0.01	0.01

#### Nutritional Value

##### Cadmium (Cd)

This is a heavy metal of major environmental concern because of its high mobility and at small concentration can adversely affect plants and animal metabolism. Toxicity of cadmium results from cadmium substitution for Zn in enzymes or Ca in bones (Mathew *et al.* 2023). Cadmium intoxication can lead to kidney, bone and pulmonary damages. From Table 1 above, the mean concentration value of Cd is 11.37 mg/kg, which is above the WHO/NIH maximum mean value level of 0.3 mg/kg.

##### Lead (Pb)

Lead is the most immobile of all the common heavy metals. It is strongly absorbed by soils under neutral to basic conditions, being particularly attracted to sulphur groups in humans. The common symptom of lead poisoning is anaemia because lead interferes with the formation of haemoglobin. It prevents iron uptake (Stoessel, 2004). High levels of lead may produce permanent brain damage and kidney dysfunction. Over time lead will substitute Ca in bone which acts to store the lead. Then in old age the lead is reactivated by slow dissolution of the bone (Mason, 1966; Mathew *et al.*, 2023). The mean concentration level of Pb in the sampled areas is 40.13 mg/kg and is above the WHO/NIH maximum mean level 0.3 mg/kg.

##### Nickel (Ni)

Agricultural soils contain Ni at levels of 8.5 – 15 mg/kg. The major source of nickel for humans is food where nickel can be present from normal intake from the soil. Nickel is considered likely to be an essential micronutrient (Calabrese *et al.*, 1985). Exposure to nickel toxicity produces a specific form of dermatitis and may include the lining and nasal cavity cancer. From the result obtained, the Ni mean concentration level is 41.17 mg/kg which is within the WHO/NIH maximum permissible level of 50 mg/kg.

##### Zinc (Zn)

Zinc is an essential trace element for both animals and humans. Zinc participates in the synthesis and degradation of carbohydrates, lipids, proteins and nucleic acids. A deficiency of zinc is marked by Retarded growth, Muscular stiffness, loss appetite, Nausea and Sterility (Mason, 1966; Mathew *et al.*, 2023). The Zn mean concentration level is 24.57 mg/kg, which is within the WHO/NIH maximum permissible level of 99.4 mg/kg.

**Copper (Cu)**

Cu concentration in soils is generally from mineralization. Cu is very mobile in weathering environment (Mason, 1966). This is the reason why it can hardly be found in excess in soils. What is generally experienced is Cu deficiency in soils. Copper has been found in all forms of animal and plant life and in every part of human body. It is an essential part of several enzymes and is essential for the synthesis of haemoglobin. Cu deficiency in humans may cause anaemia, poor growth, degeneration of the nervous system and bone demineralisation (Mason, 1966). The Zn mean concentration level is 7.30 mg/kg, which is below the maximum permissible level of WHO/NIH of 73.3 mg/kg.

**Magnesium (Mg)**

Magnesium is a nutrient that the body needs to stay healthy. Magnesium is important for many processes in the body, including regulating muscle and nerve function, blood sugar levels, and blood pressure and making protein, bone, and DNA. A nutritional deficiency of magnesium giving rise to clinical symptoms included high blood pressure, heart disease, type 2 diabetes and osteoporosis (NIH 2023). The Mg mean concentration level is 0.01 mg/kg, which is below the maximum permissible level of WHO of 2 – 2.6 mg/kg.

**Chromium (Cr)**

Chromium is an essential nutrient that potentiates insulin action and thus influences carbohydrate, lipid and protein metabolism (WHO 1996). Chromium deficiency signs impaired growth, elevated serum cholesterol and triglycerides, increased incidence of aortic plaques, decreased fertility and sperm count. The Cr mean concentration level is 36.53 mg/kg, which is above the WHO maximum permissible level of 2 mg/kg (WHO 1996).

**Manganese (Mn)**

Manganese is both an activator and a constituent of several enzymes. Manganese deficiency includes impaired growth, skeletal abnormalities, disturbed or depressed reproductive function, defects in lipid and carbohydrate metabolism (WHO 1996). The Mn mean concentration level is 83.53 mg/kg, which is lower than the WHO permissible level of 2 – 2.6 mg/kg.

**Iron (Fe)**

Iron is a mineral that the body needs for growth and development. Human body uses iron to make haemoglobin, a protein in red blood cells that carries oxygen from the lungs to all parts of the body, and myoglobin, a protein that provides oxygen to muscles (WHO 1996). The body also needs iron to make some hormones. Symptoms of iron deficiency include Anaemia, Weakness, Lack of energy, and problems with concentration and memory (National Institutes of Health, 2023). The Fe mean concentration level is 0.04 mg/kg, which is lower than the WHO maximum permissible limit of 425.5 mg/kg.

**Potassium (K)**

Potassium is a mineral that helps regulate fluid in the body and helps muscles and nerves to work properly. It is found inside cells and is essential for good health (WHO 1996). Deficiency in potassium (hypokalaemia) can lead to symptoms including weakness, tiredness, muscle cramps, constipation and abnormal heart rhythms (National Health and Medical Research Council). From Table 1, the mean concentration level is 0.01 mg/kg which is

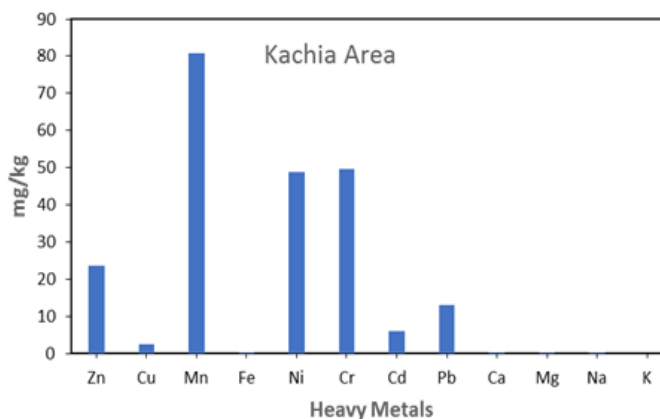
below the WHO maximum permissible limits of 400 - 3510 mg/kg.

**Calcium (Ca)**

Calcium is a mineral your body needs to build and maintain strong bones and to carry out many important functions (WHO 1996). Calcium is the most abundant mineral in the body. Symptoms of calcium deficiency are Fatigue, Rickets, Seizures, Abnormal heart rhythm and Cognitive issues (WHO 1996). The Ca mean concentration level is 0.05 mg/kg, which is lower than the WHO maximum permissible level of 200 - 1300 mg/kg.

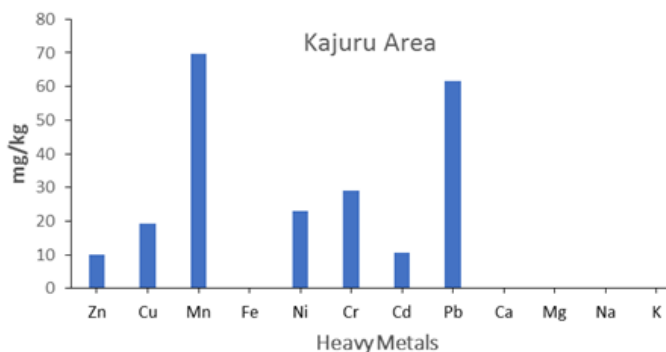
**Sodium (Na)**

The human body requires a small amount of sodium to conduct nerve impulses, contract and relax muscles, and maintain the proper balance of water and minerals (WHO 1996). Sodium deficiency symptoms may include feelings of weakness, apathy, and nausea as well as cramps in the muscles of the extremities. The Na mean concentration level is 0.38 mg/kg, which is within the WHO maximum permissible level of 0.3 – 0.7 mg/kg.



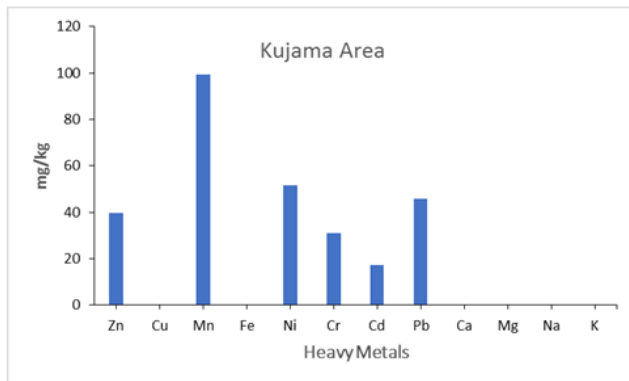
**Figure 2(a):** The Mean Concentration Level of Heavy Metal in soil sample from Kachia Area.

From the figure 2 (a) – (c) above, shows the graphical representation of the mean concentration level of heavy metal in the soil samples within the southern part of Kaduna State, Nigeria. Figure 2(a) shows the Kachia area elementary compositions at different levels with Mn, Zn, Ni, Cr, Pb and Cd with high concentration levels while Cu, Fe, Ca, Mg, Na and K with low concentration levels.



**Figure 2(b):** The Mean Concentration Level of Heavy Metal in soil sample from Kajuru Area

Figure 2(b) shows the Kajuru area elementary compositions at different levels with Mn, Pb, Ni, Cr, Cu, Zn and Cd with high concentration levels while Fe, Ca, Mg, Na and K with low concentration levels. Figure 2(c) shows the Kujama area elementary compositions at different levels with Mn, Zn, Ni, Cr, Pb and Cd with high concentration levels while Cu, Fe, Ca, Mg, Na and K with low concentration levels.



**Figure 2(c):** The Mean Concentration Level of Heavy Metal in soil sample from Kujama Area

### Conclusion

The research study has shown that heavy metals pollution of soil is an issue of environmental concern. The results from this research study revealed the presence of significant concentrations of Cd, Cr, Zn, Mn, Ni and Pb in the sampled area. The low concentration levels of FE, Ca, Mg, Na and K in the sampled area could lead to serious malnutrition health challenges to the area populace such as Retard growth, Anaemia, Rickets and Infertility. Thus, the need for alternative sources for nutritional elements deficiency in their dietary. Education and legislation management of contaminants in villages should be intensified to forestall the effects of heavy metals contaminated related problems.

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