Lafia Journal of Scientific & Industrial Research (LJSIR), Vol. 3(1), 2025
p-ISSN: 3026 – 9288 e-ISSN: 3027 – 1800 pages: 118 – 122
https://lafiascijournals.org.ng/index.php/ljsir/index ⇒ Published by the Faculty of Science,
Federal University of Lafia, Nasarawa State, Nigeria

Assessment of Heavy Metals Concentration in Soil, Plants and Grains in Nasarawa North

Ahmed Sule Abdullahi[1], Umar Ibrahim[1]*, Daniel Obaje Opaluwa[2] & Yahaya Khalid Kaika[1]
[1]Department of Physics, Nasarawa State University, Keffi, Nigeria
[2]Department of Chemistry, Nasarawa State University, Keffi, Nigeria

Abstract

In this study, heavy metals concentration in soil, plants and grains were determined for Chromium, Lead, copper, Zinc and Nickel from some selected areas in Kokona and Nasarawa local government area of Nasarawa state, Nigeria. Twelve samples (soil, plants and grain) were collected. The x-ray fluorescence spectrometry analysis result revealed the mean concentration of Cr (0.075, 0.075 and 0.046 mg/kg), Pb (0.026, 0.026 and 0.052 mg/kg), Cu (0.199, 0.199 and 0.252 mg/kg), Zn (0.079, 0.079 and 0.252 mg/kg) and Ni (0.014, 0.014 and 0.032 mg/kg) in soil, plants and grain respectively. The values of heavy metal concentration in soil, plant and grain are found to be below the world average of 5 g/cm^3. Thus, the public are free from significant health risk due to consumption of heavy metals in plants and grains from Nasarawa West, Nigeria.

Keywords: Heavy metals, toxicity, spectrometry analysis, Nasarawa State

History
Submitted
December 20, 2023
Revised
April 25, 2025
First Published Online
April 29, 2025

***Corresponding author**
U. Ibrahim ✉
ibrahimumaru@nsuk.edu.ng

doi.org/10.62050/ljsir2025.v3n1.261

Introduction

In recent years, the global recognition of the health implications associated with heavy metals has prompted concerted efforts by international organizations such as the Food and Agriculture Organization (FAO) and the World Health Organization (WHO) to reassess permissible levels of these elements in plants and soils. As reported by Ukpong *et al*. [1], heavy metals, characterized by their specific gravity equal to or exceeding 5 g/cm^3, have emerged as subjects of paramount importance due to their inherent toxicity and density.

While certain heavy metals, including iron and nickel, play essential roles in sustaining life at low concentrations, the same elements become perilous in higher concentrations. Notably, heavy metals such as lead, cadmium, and mercury, even in trace amounts beyond permissible limits, exhibit toxic properties, posing severe health complications to living organisms, as expounded by Leah and Johny [2] and Khan *et al*. [2]. This dichotomy underscores the intricate balance between the essential role of certain heavy metals in physiological development and the hazardous consequences of their excess.

The realm of heavy metal research extends to an array of elements, with lead, cadmium, chromium, nickel, copper, cobalt, mercury, and arsenic emerging as focal points of extensive investigation. The deleterious effects of these heavy metals on living organisms have been meticulously studied, with documented consequences ranging from decreased mental and neurological capacity to blood and bone disorders, and kidney damage [4].

The non-biodegradable nature and prolonged half-life of heavy metals exacerbate the challenge of their degradation within biological organisms, resulting in their accumulation in the environment and subsequent toxicity [5]. This persistence of heavy metals in the environment forms the backdrop for the critical environmental challenge arising from soil contamination. Activities such as industrial processes contribute to the discharge of metals into the environment, where they bind with particulate matter and infiltrate soils and sediments, posing threats to both terrestrial and aquatic ecosystems [6].

This contamination of the soil ecosystem by heavy metals is exacerbated by their persistent nature, as highlighted by Babatunde *et al*. [6]. The consequences of heavy metal pollution are not confined to the soil but extend to the entire food web. Forstner and Wittmann [7] emphasized the link between human exposure to toxic metals and the chain transfer from soil to crops.

In the intricate web of ecological dynamics, the rise in soil heavy metal content is attributed to diverse human activities, including the application of fertilizers, pesticides, compost manures, and the use of polluted water for irrigation. Plants, acting as bioaccumulators, absorb and accumulate these toxic metals in significant quantities, compromising the quality and safety of the food they yield [7].

Ra *et al*. [8] highlighted the substantial impact of inorganic fertilizers and organic manures on heavy metal uptake in crops. Consequently, the imperative for monitoring heavy metals in agricultural soils, irrigation water, and food crops has become paramount [9]. Of particular concern are vegetables, recognized for their nutritional advantages and integral role in human diets. Leafy greens, despite their protective food value, contribute to heavy metal ingestion through the food chain [8]. In this comprehensive exploration, we delve into the multifaceted dimensions of heavy metal contamination, its far-reaching implications, and the urgency of sustained vigilance in safeguarding both environmental integrity and public health. The aim of this research is to assess heavy metals concentration in soil, plants and grain in Nasarawa north.

Materials and Methods

Sample location

This research work centered on Kokona and Nasarawa Local Government, in Nasarawa State, Nigeria. The sample points are abbreviated as KMS, KMP, KMG, for Kokona soil, plant and grains sample while, WMS, WMP and WMG for soil, plant and grains samples respectively. These points are located at 08°40.0296'N and 08°33.5212'E, 08°40.0452'N and 08°33.4772'E, 08°40.0296'N and 08°33.5212'E and 08°40.0452'N and 08°33.4772'E for Nasarawa Eggon, while 08°56.2436'N and 08°31.6741'E, 08°56.2703'N and 08°31.6853'E, 08°56.2436'N and 08°31.6741'E and 08°56.2703'N and 08°31.6853'E for Wamba.

Sample collection and preparation

Pretreatment of samples

The soil samples were air dried for at least seventy-two hours, ground in a mortar and passed through a 2 and 0.005 mm sieve and stored in clean polyethylene bags. Plant samples were washed with deionized water, air dried and dried to constant weight at about 105˚C in an oven. Samples were ground into powder, passed through a 0.02 mm sieve, mixed to homogenize and stored in acid treated polyethylene bags.

Sample preparation

Plants-Method of 4:1 mixture of HNO_3 and $HClO_4$ was used for plant digestion, the ground sample was redried at about 105˚C for about 2 h in the oven before each weighing and mixed to homogenize. 50 ml of 4:1 mixture of HNO3 and HClO4 was added into 1 g of sample and left to predigest for 24 h. The sample was heated at about 100^{o}C in a fume cupboard until the sample appeared a pale yellow or water white. The sample was transferred into 50 ml volumetric flask and diluted with de-ionized water to mark and filtered into clean plastic sample bottle ready for AAS analysis. Reagent blank was prepared in similar manner. Soil-Tessier *et al.* total metal content procedure was used to determine the studied metals. Total metal analysis procedure was carried out by digesting 1 g (<0.05 mm) of soil sample with a mixture of 10 ml HF and 2 ml $HClO_4$ to near dryness; a second addition of 10 ml HF and 1 ml $HClO_4$ was made and again the mixture was evaporated to near dryness. Finally, 1 ml $HClO_4$ alone was added and the soil sample evaporated until the appearance of white fumes. The resulting solution was filtered into a plastic bottle ready for AAS. Blank samples were extracted as above.

Water-Method of USEPA of evaporating with conc. HNO_3 was used to digest water samples. 6 ml of conc. HNO3 was added to100ml sample volume and the sample was evaporated to near dryness, making certain the sample did not boil. The beaker was cooled and another 6 ml of conc. HNO3 was added. The temperature of the hot plate was increased for a gentle reflux. The sample was evaporated to near dryness and the beaker cooled. 5 ml of 1:1 HCL was added. The beaker was warmed and the sample pH adjusted to a pH of 4 with about 4.5-5M NaOH solution. The sample was then transferred to a volumetric flask and the volume diluted to 25 ml with deionized water. The extract was analysed using AAS. Same procedure was carried out on blank sample.

Results and Discussion

Heavy metals distribution: Chromium (Cr), Lead (Pb), Copper (Cu), Zinc (Zn), and Nickel (Ni) in soil, plants and grains of Nasarawa north was analyzed and presented in Table 1. Figs 1- 3 show the concentration of heavy element in all the twelve samples collected from sample locations, from each sample location (KMS, KMP, KMG, WMS, WMP and WMG) and the WHO standard limits. The results indicate that the level of heavy metals in soil, plant and grain of Nasarawa North are below the WHO permissible limits.

Chromium (Cr)

Chromium mean concentration level, finding of this study has revealed that the chromium mean concentration level for soil, plants and grain samples were 0.049, 0.049 and 0.045 mg/kg. This implies that the mean concentration level of chromium in those areas is not significant compared to WHO (1998) who's mean concentration level for chromium was 100, 1.30 and 1.30 mg/Kg, and may not cause radiological hazard to the populace unless when accumulated over a long period of time.

Table 1: Heavy metal concentration in soil, plant and grain of Nasarawa North

Code	Heavy Metal Concentration (mg/Kg)				
	Cr	Pb	Cu	Zn	Ni
			Soil Sample		
WMS	0.016	0.024	0.044	0.019	0.162
WGS	0.042	0.013	0.134	0.059	0.003
NEMS	0.105	0.031	0.068	0.043	0.063
NEGS	0.033	0.018	0.16	0.066	0.003
Mean	**0.049**	**0.022**	**0.102**	**0.047**	**0.058**
WHO	**100**	**85**	**36**	**50**	**35**
			Plants Sample		
WMP	0.016	0.024	0.044	0.019	0.162
WGP	0.042	0.013	0.134	0.059	0.003
NEMP	0.105	0.031	0.068	0.043	0.063
NEGP	0.033	0.018	0.16	0.066	0.003
Mean	**0.049**	**0.022**	**0.102**	**0.047**	**0.058**
WHO	**1.30**	**2**	**10**	**0.60**	**10**
			Grain Sample		
WMG	0.047	0.044	0.306	0.261	0.02
WGG	0.056	0.043	0.552	0.249	0.04
NEMG	0.033	0.018	0.16	0.066	0.003
NEGG	0.044	0.05	0.578	0.305	0.037
Mean	**0.045**	**0.039**	**0.399**	**0.220**	**0.025**
WHO	1.30	2	10	0.60	10

Lead (Pb)

Lead mean concentration level, finding of this study has revealed that the Lead mean concentration level for soil, plants and grain samples were 0.022, 0.022 and 0.039 mg/kg. This implies that the mean concentration level of Lead in those areas is not significant compared to WHO (1998) who's mean concentration level for Lead was 85, 2, and 2 mg/kg, and may not cause radiological hazard to the populace unless when accumulated over a long period of time.

Copper (Cu)

Copper mean concentration level, finding of this study has revealed that the Copper mean concentration level for soil, plants and grain samples were 0.102, 0.102 and 0.399 mg/kg. This implies that the mean concentration level of Copper in those areas is not significant compared to WHO (1998) who's mean concentration level for Copper was 36, 10 and 10 mg/kg, and may not cause radiological hazard to the populace unless when accumulated over a long period of time.

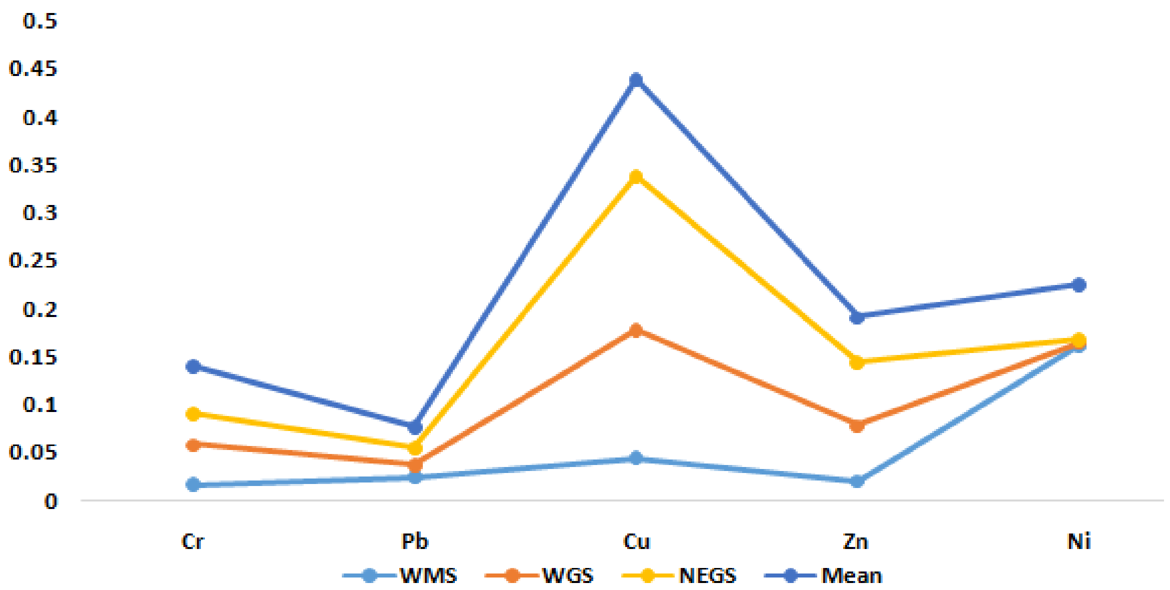

Figure 1: Heavy metal concentration on soil sample

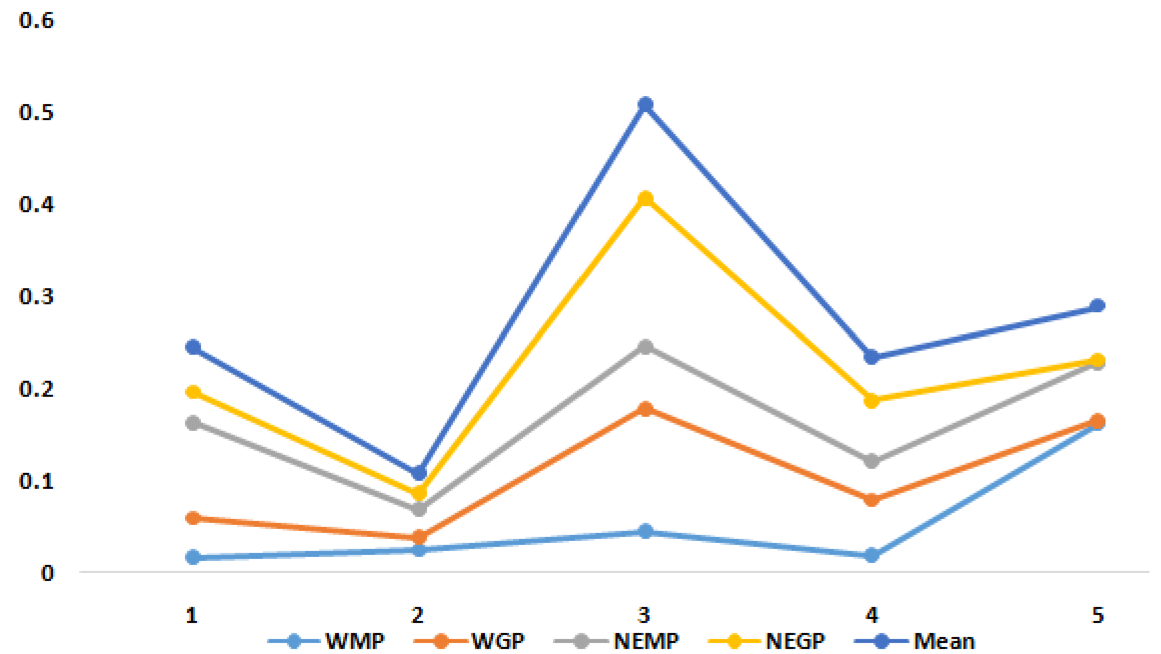

Figure 2: Heavy metal concentration on plant sample

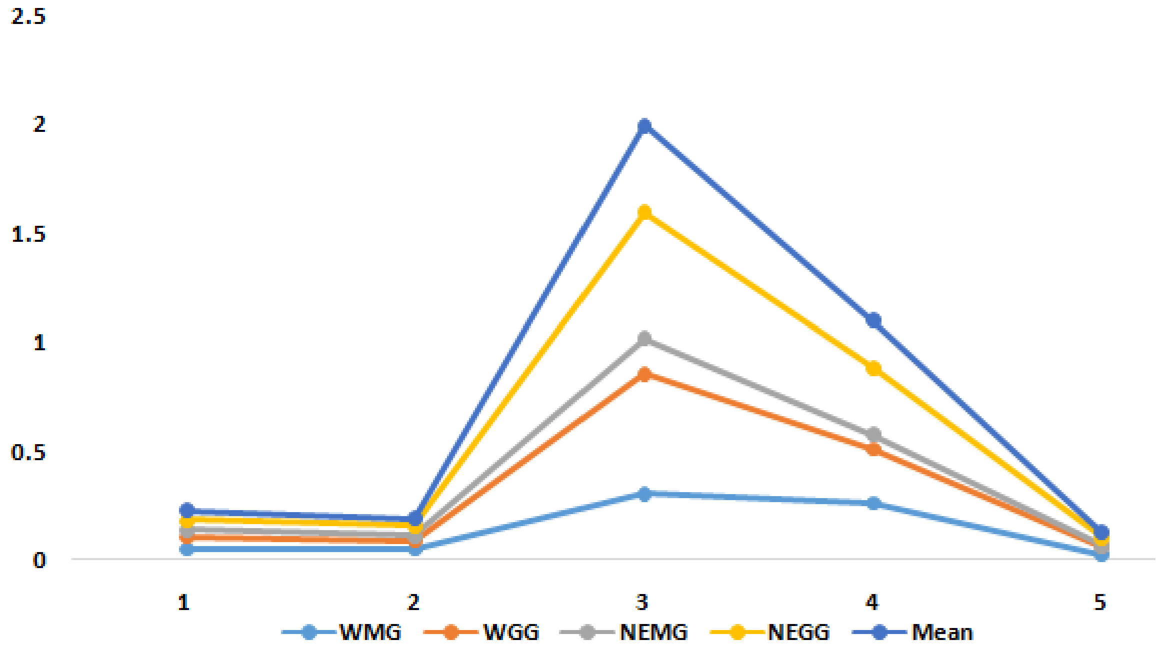

Figure 3: Heavy metal concentration on grain sample

Zinc

Zinc mean concentration level, finding of this study has revealed that the zinc mean concentration level for soil, plant and grain samples are 0.047, 0.047 and 0.220 mg/kg. This implies that the mean concentration level of zinc in those areas is not significant compared to WHO (1998) who's mean concentration level for zinc was 50, 0.60 and 0.60 mg/kg, and may not cause radiological hazard to the populace unless when accumulated over a long period of time.

Nickel (Ni)

On Nickel mean concentration level, finding of this study has revealed that the nickel mean concentration level for soil, plant and grain samples are 0.058, 0.058 and 0.025 mg/kg. This implies that the mean concentration level of nickel in those areas is not significant compared to WHO (1998) who's mean concentration level for nickel was 35, 10 and 10 mg/kg, and may not cause radiological hazard to the populace unless when accumulated over a long period of time.

Conclusion

The heavy metal contamination levels of soil, plants and grain in Nasarawa North (Wamba and Nasarawa Eggon) were analyzed and determined. Results indicate that the soil, plants and grain of Nasarawa North contained considerable low levels of heavy metals (Cr, Pb, Cu, Zn and Ni). The assessment of heavy metals concentration is important for soil management, plants growth and the safety of the populace. These study gives information about the level of the soil, plants and grains contamination, the level of Cr, Pb, Cu, Zn and Ni were below the WHO standards. Despite, the low level of heavy metals measured. Heavy metals analysis of soil, plants and grains samples of agricultural farmlands should be carried out regularly in order to maintain the quality of crops grown on farms.

Competing of interest: Authors have declared that no competing interests exist.

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Citing this Article

Ahmed Sule Abdullahi, Umar Ibrahim, Daniel Obaje Opaluwa & Yahaya Khalid Kaika (2025). Assessment of heavy metals concentration in soil, plants and grains in Nasarawa North. *Lafia Journal of Scientific and Industrial Research, 3*(1), 118 – 122. https://doi.org/10.62050/ljsir2025.v3n1.261