

# Assessment of Heavy Metals Pollution in Soil Samples at Modoji Quarters, Katsina, Katsina State, Nigeria

Samaila, A.\*, Sani, J., Abdullahi, I. and Isah, M. R.

Department of Physics, Al-Qalam University Katsina.

\*Corresponding author: aminusamaila64@gmail.com; +2347063506864

## Abstract

Heavy metals are essential for plant growth and living organism but can harm environment and human health when accumulated through human activities like waste disposal (for example: animal waste, tyres, and oil). This buildup can lead to environmental pollution and indirect exposure to heavy metals, posing a risk to human health. The investigation of background concentration analysis of heavy metals in soil samples taken from Modoji Quarters, Katsina, Nigeria, which is situated at latitude 13° 0' 8.352" N and longitude 7° 38' 25.548" E, was conducted. Using a digging hoe and at 5 m depth, ten (10) soil samples were taken from the study region and given place-specific names (B1-B10). The five heavy metals under investigation (Cd, Pb, Hg, Cr, and Co) concentration were measured using a flame atomic absorption spectrophotometer (FAAS). The average concentration of heavy metals at the location is 0.029, 0.371, 0.239, 0.564, and 0.014 parts per million, respectively. By comparing the target areas' mean concentration of heavy metals with the World Health Organization's (WHO) threshold limit and related research, differences were observed. It was concluded that the samples were free of heavy metal contamination. However, the presence of the metals does not need immediate action or corrective actions from the authorities. It was advised that in order to minimize human activity and create a stable, pollution-free environment, factories, gas stations, and manufacturing businesses should not be situated in or close to the area.

**Keywords:** *Flame atomic absorption spectrophotometer, Environmental threat, Heavy metals, Pollution, Threshold limit.*

## 1. Introduction

Heavy metals are defined as metallic chemical elements that have a relatively high density and are toxic or poisonous at low concentrations (Samaila et al., 2022). They also include a large group of elements that are important for both industry and biology and have an atomic density of more than 6g/cm<sup>3</sup>. Heavy metals are harmful due to their long biological half-lives, non-biodegradable nature, and ability to accumulate in different body parts (Kankara et al., 2021). More than 20 heavy metals, including aluminum, arsenic, cadmium, chromium, cobalt, lead, manganese, mercury, nickel, selenium, tin, vanadium, zinc, and platinum, have been identified (Sultana et al., 2017). They can be found in various forms, such as minerals attached to airborne particles, encased in organic or inorganic compounds, and present in soil, rocks, and sand (Ibrahim et al., 2024). Anthropogenic activities cause heavy metals to accumulate in the environment, leading to pollution (Samaila et al., 2023). Humans primarily ingest heavy metals through food, especially vegetables. Assessing the level of heavy metal contamination in food items is one of the most important aspects of food quality assurance (Gurukiran et al., 2017). There is global concern as the build-up of these metals poses both direct and indirect risks to human health (Lokeshappa et al., 2012; Yusuf and Nuraddeen, 2020).

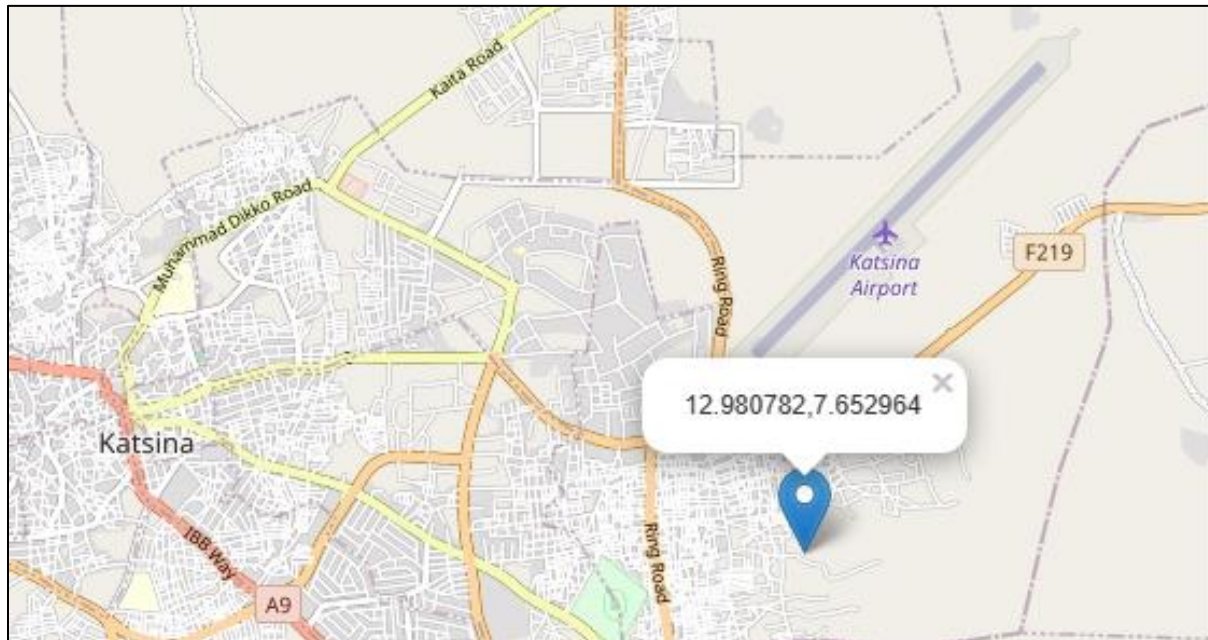
For an unspecified period, humans have been exposed to heavy metals. The presence of this waste poses a significant risk to local residents, including children, scavengers, and others who may come into contact with toxic metals. Contamination of groundwater, which is widely used in Katsina town for various purposes, is also a concern. Additionally, rainwater may transport the waste into water channels, further contaminating soil and water bodies (Uba et al., 2020). Factors such as rapid population growth, mining, agriculture, urbanization, and industrial

development have contributed to an alarming accumulation of waste and pollutants, harming water sources like dams, streams, and lakes, as noted by Shamsuddin et al. (2018).

In addition to supporting strategic planning and environmental monitoring and protection, identifying toxic metals will allow for the assessment of hazard indices, thereby safeguarding human health (Idris *et al.*, 2019; Uba *et al.*, 2021). Furthermore, this study will provide baseline data on the concentration levels of hazardous and elemental metals in developing areas, such as heavy metals in soil, including Cr, Cu, Cd, Pb, and Co. This information may be used by the government in future efforts to prevent environmental contamination and mitigate potential health risks from heavy metals like radon. As a result, this study will provide valuable insights into the safety of settling in the vicinity if the concentrations of hazardous heavy metals exceed permissible levels. The primary objective of this study is to determine the concentrations of heavy metals, including Cr, Cu, Cd, Pb, and Co, in soil samples collected from the Modoji Quarter of Katsina, Nigeria

## 2. Study Area

The study region was part of Katsina metropolis and was set apart from the main township to allow for area expansion. However, due to a rapid increase in population, the study area has since been merged with the main town of Katsina. The area is now surrounded by schools, hospitals, business centers, filling stations, minor highways, and other settlements. Due to human activity, it is anticipated that the soil in these locations contains traces of heavy metals. The area has become heavily populated and is littered with a various waste material, including leaking gasoline and motor oil, animal feces, rusted iron objects, rubbish dumps, kerosene, diesel, and more all of which could introduce trace amounts of heavy metals. Modoji Quarters is located at latitude 13° 0' 8.352" N and a longitude of 7° 38' 25.548" E in Katsina State Nigeria (Figure 1).



**Figure 1:** Map of Katsina Metropolis Showing Modoji Quarters coordinates (Extracted from Google Earth in Sept, 2023)

### 3. Materials and Method

Polythene bag, meter rule, tape, hand auger, hand gloves, drilling machine, permanent marker, masking tape, plastic container, sieve, hydraulic pressure, sulphuric acid (concentrated), nitric acid (concentrated), perchloric acid (concentrated), hydrochloric acid (concentrated), distilled water, sieve, filter paper, spatula, funnel, 100 mL volumetric flask, boiling tube, GPS and flame atomic absorption spectrophotometer (Samaila *et al.*, 2023).

#### 3.1 Sample Collection

The sampling strategy employed in this research was random sampling where 10 areas were randomly selected at all cardinal points of the quarters and labelled B1-B10 (Table 1). Soil samples were collected from each area using a digging hoe at a depth of 5 meters.

**Table 1.** Selected sample locations and their codes.

S/N	Locations	Sample Code
1	Qauran Rafi	B1
2	Tsohuwar Modoji	B2
3	Unguwar Musa	B3
4	Safda Estate	B4
5	Unguwar Gabas	B5
6	Sabuwar Modoji	B6
7	Usman Danfodiyo Mosque	B7
8	Nasarawa Magajin Gari	B8
9	Iman Plaza	B9
10	Maternity – Child Health Care	B10

#### 3.2 Sample Preparation and Analysis

The soil samples were sieved, air-dried at the customary laboratory temperature, and then crushed with a mortar and pestle before being stored for chemical analysis. A spatula and a weighing scale were used to extract 0.5g of each sample. The samples were then taken to a fume-cup board for digestion after being placed in a Teflon beaker. Concentrated nitric acid and concentrated perchloric acid were used for digestion in a 2:1 ratio, after which the mixture was transferred to an oven and kept at 200°C. After allowing the mixture to cool, the residue was diluted with 5 mL of 20% HNO<sub>3</sub>. After being digested, the samples were then filtered and deionized water was added to make up a total volume of 100 mL. A blank determination, without a sample was performed using an atomic absorption spectrometer. After that, the samples were then dissolved and aspirated into a Unicam Solar A.A.S 969 model atomic absorption spectrometer for metals analysis. In a manner identical to that described above, a blank determination was also performed, but without a sample. The measured absorbance of each element and its corresponding concentration were used to plot a calibration graph. The calibration curve was used to calculate the metal concentration, as reported in our previous research (Samaila *et al.*, 2023).

### 4. Results and Discussion

Table 2 presents a comparison between the current study's results (in ppm) and those of other comparable studies. Comparing the findings of this study with those of other investigations revealed a considerable drop in the quantities of cadmium (Cd) 0.029, lead (Pb) 0.371, mercury (Hg) 0.239, chromium (Cr) 0.564, and cobalt (Co) 0.014. It is important to note that the values reported in this study, as well as in Samaila *et al.* (2022) and Samaila *et al.* (2023), were significantly lower than those published in Ahmad *et al.* (2015) and Rahib *et al.* (2015). These differences could be attributed to various factors such as different sampling sites, analytical techniques, or environmental changes over time. To fully understand the observed variations, it is essential to consider the specific context and methodology used in each study.

**Table 2.** The Concentration of this study in (ppm) Compare with the results of related research.

Cd (ppm)	Pb (ppm)	Hg(ppm)	Cr (ppm)	Co (ppm)	Reference
1.000	205.00	-	475.5	-	Ahmad <i>et al.</i> , (2015)
8.800	152.00	-	301.6	32.50	Rahib <i>et al.</i> , (2015)
0.023	0.0032	-	0.554	0.160	Samaila <i>et al.</i> , (2022)
0.002	0.0930	-	0.110	0.240	Samaila <i>et al.</i> , (2023)
0.029	0.3710	0.239	0.564	0.014	This research results

The Table 3 provides information on the concentration levels of different heavy metals, specifically cadmium (Cd), lead (Pb), mercury (Hg), chromium (Cr), and cobalt (Co) measured in parts per million (ppm). The mean values are 0.0290, 0.371, 0.239, 0.564 and 0.014 ppm, respectively. The minimum values are: 0.0210, 0.020, 0.115, 0.368 and 0.005 ppm, while the maximum values are: 0.0360, 0.790, 0.345, 0.727 and 0.037 ppm. The standard deviation values are: 0.0047, 0.225, 0.9710, 0.118 and 0.009 ppm, respectively.

**Table 3.** Concentration of heavy metals collected from Modoji quarters, Katsina state.

S/N	Parameters	Cd (ppm)	Pb (ppm)	Hg (ppm)	Cr (ppm)	Co (ppm)
1.	Mean	0.0290	0.371	0.239	0.564	0.014
2.	Minimum	0.0210	0.020	0.115	0.368	0.005
3.	Maximum	0.0360	0.790	0.345	0.727	0.037
4.	Standard deviation	0.0047	0.225	9.710	0.118	0.009

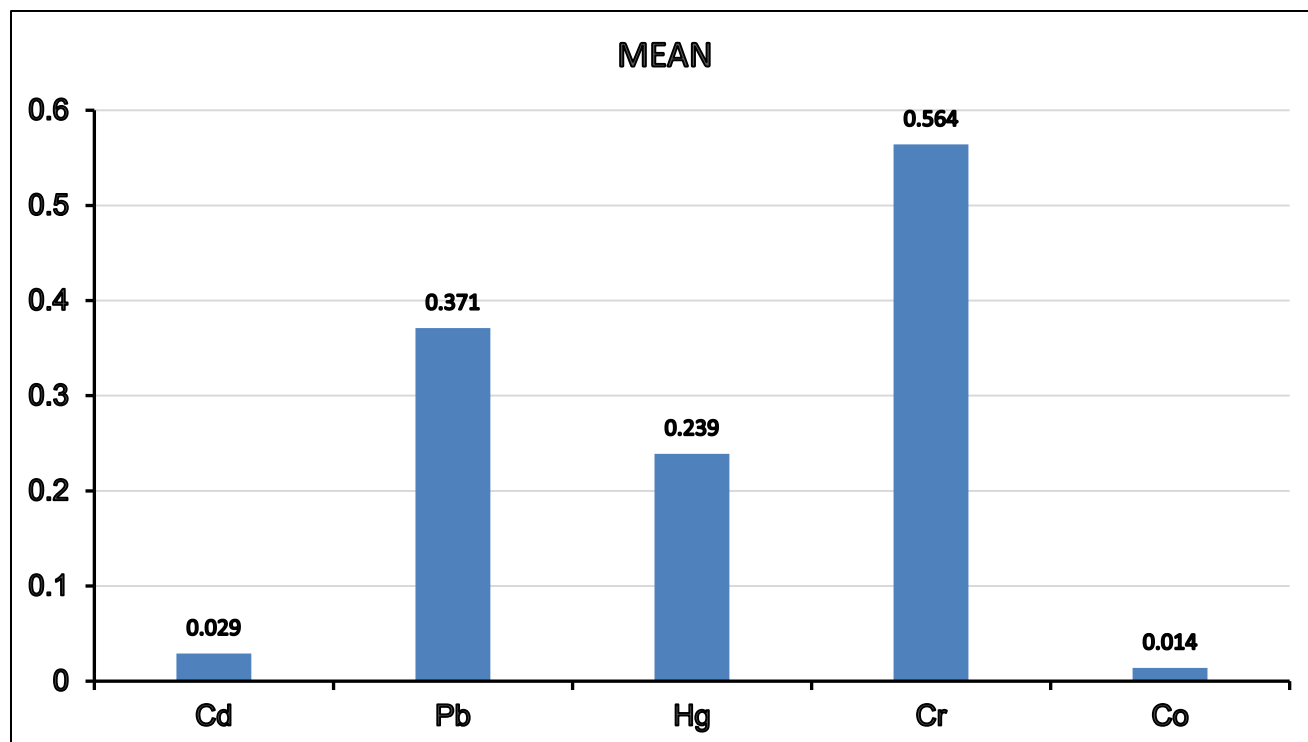
Additionally, the mean concentration of cadmium is 0.029 ppm, with a range from 0.021 ppm to 0.036 ppm. The standard deviation is relatively low at 0.0047 ppm, indicating that the values are close to the mean. Lead has a higher mean concentration at 0.371 ppm, with a broader range from 0.02 ppm to 0.79 ppm. The standard deviation of 0.225 ppm, suggests greater variability in lead concentrations. Mercury shows a mean concentration of 0.239 ppm, with a considerable standard deviation of 9.710 ppm. The range is from 0.115 ppm to 0.345 ppm, indicating some variability but not as much as reflected in the standard deviation. Chromium has a mean concentration of 0.564 ppm, with a relatively narrow range from 0.368 ppm to 0.727 ppm. The standard deviation is 0.118 ppm, suggesting that the values are relatively close to the mean. Cobalt has the lowest mean concentration at 0.014 ppm, with a range from 0.005 ppm to 0.037 ppm. The standard deviation is 0.009 ppm, indicating low variability in cobalt concentrations.

The current research's concentration levels are found to be within the permissible range when compared to the WHO threshold limits, as shown in Table 4. Figure 2 illustrates the mean concentrations of the five elements.

**Table 4.** Comparison of the heavy metals and the World Health Organization (WHO) recommended Threshold limit (ppm) threshold limit for the study

Heavy metals	Pb (ppm)	Zn (ppm)	Cu (ppm)	Cd (ppm)
This study	0.371	-	-	0.0290
WHO (ppm)	100	200	30	3.00

Source- WHO (1996b)



**Figure 2:** The mean concentration levels of the five elements.

## 5. Conclusion

Soil samples from Modoji Quarters were collected, and the concentration of heavy metals (Cd, Pb, Hg, Cr, and Co) were measured using a flame atomic absorption spectrophotometer. The obtained results (Cd 0.02 ppm, Pb 0.371 ppm, Hg 0.239 ppm, Cr 0.564 ppm, and Co 0.014 ppm) were compared with findings from similar studies as well as the WHO threshold limits. It is evident that all the measured heavy metals were found at concentrations within the legally permissible concentration limits. The concentration levels of these heavy metals in the research region did not exceed national or WHO threshold levels (international requirements). Consequently, there have been no reports of heavy metal contamination in the region. In light of these findings, it is strongly advised against establishing industries and companies in this area to maintain ecosystem stability.

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