Original Article

Assessment of Heavy Metals in Soil from Selected Farmlands in Nasarawa West, Nasarawa State, Nigeria

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ABSTRACT

We refer to heavy metals as metallic element of relatively high-density when compared with its sizes and could be very toxic even at low concentration. Furthermore, these metals are among the major environmental pollutants based on their contribution on the quality of ecosystem. This work is to study heavy metals in soil from selected farmlands in Nasarawa West, Nasarawa State. Various samples of soil were obtained from various farmlands and spread to dry under normal temperature, later which standard methods was used to digest them with acid. Atomic Absorption Spectrophometer (AAS) was utilized to obtain the concentration of these metals in mg/kg (Zn, Fe, Cu, Cd, Ni, and Cr). The mean levels obtained in the soil samples were (mg/kg) 94.90 + 0.013 for Fe, 18.36+5.679 for Zn, 2.296+0.604 for Cu, 1.710+0.430 for Ni, 0.472+0.264 for Cr, 1.140+ 0.068 for Cd, and 0.067+0.013 for Pb. The outcome of this work depicts that the concentration of these metals in the samples of soil differs based on the manner with Fe > Zn > Cu > Ni > Cr > Cd > Pb across the four locations including these control site. The metals were noticed in the samples of soil and values obtained were within the acceptable international standard for soil. The results show that there would not be risk associated with consumption of food crops and vegetation in the study area by human and animal populations, because of the hazardous nature of Cd, Pb with no known health benefits.

Introduction

We referred to heavy metals as metallic element of relatively high-density when compared with its sizes and could be very toxic even at low concentration. Furthermore, these metals are among the major environmental pollutants based on their contribution on the quality of ecosystem [1]. The problem of ecosystem in soil due to metals that are toxic plays a very vital role in the current events. Soil contamination by these metals may arise in a number of ways for instance dumping of refuse; the refuse may consist of used batteries, cans of soft drinks, animal waste, and so on. Contamination of

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these metals in crops in the farmlands and soil used for agriculture has been regarded as a major environmental concern [2]. Metals like copper, manganese, and iron are occurring naturally in environment, depending on their content; they may serve as nutrient to plant while other groups like lead, cadmium, and extra which are not distributed directly due to activities of humans may be highly toxic even on least concentrations [3]. It was reported that the existence of these heavy metals in soil utilized for agriculture heavenly increase the availability of the rest of the nutrients for the growth of plants, out of these, manganese is a micro-nutrient while lead, nickel, mercury, and chromium are dangerous and can pose complication in the use of extra (micro) nutrients [4]. It has been widely distributed that the heavy metals contaminated food crops consumed may result to severe health issue on the body system of the persons affected. Even though few of these heavy metals such as Fe, Cu, Zn, and Ni are vital nutrients needed in trace amount for plants and animals, they are dangerous at superior levels. Nonetheless, some metals which include Cr, Cd, Co, and Pb have no (physiological) functions and are dangerous at certain levels according to Flora *et al.* (2018) [5], Khlifi and Hamza-Chaffai (2020) [6] and Jaishankar *et al.* (2019) [7].

One of the major problems of these metals is that exposure to Cd in particular can pose both acute and chronic health issues in living organisms [8]. The chronic issues include skeletal damage, itai-itai (ouch-ouch) diseases, and kidney damage [9]. Experimental data in both animals and humans showed that Cd may pose cancer in humans, hair loss, diarrhoea, depression, and Acrodermatitis enteropathica (dermatitis) [10].

Lead and its compounds have been accumulating in the environment, including water, soil, and air, due to human activities which include manufacturing, burning fossil fuels, and mining (Abdu, et al., 2022) [11]. Batteries, cosmetics, and metal products including solder, bullets, and pipes are all made with lead [12,13]. Since lead is dangerous (extremely), its use in so many items, like gasoline, paints, and the rest, has decreased significantly in modern times (Mundi et al., 2019) [14].

This work aimed to assess the level of these metals in soil from selected farmlands in Nasarawa West Senatorial District, Nasarawa State. This work will help to create awareness as to the status of the examined farmlands in terms of heavy metals concentrations. The map of the study area is displayed in **Figure 1**.

To sum up, this study contributes valuable insights into the levels of heavy metals in soil within Nasarawa West, Nasarawa State, Nigeria. It not only assesses environmental conditions, but also addresses potential health risks associated with heavy metal contamination. By adhering to international standards and emphasizing the absence of known health benefits for certain metals, this work underscores the importance of responsible environmental stewardship in the region.

Experimental

Materials and methods

This study considered Nasarawa west located at the western part of Nasarawa State. Four (4) separate farmlands were chosen for the work, which include Nagari Farm (Gauta Keffi Local Government), Sharna farm (Abuja Road Karu Local Government), Gyunkas integrated farm (Kokona Local Government), and Gunduma farm (Kaduna Road, Karu Local Government) [15].

A portion of the sample of soil (20 g) was obtained from each of the chosen farm-lands earlier mentioned. These samples were obtained from the surface of the soil with only about 0-15 cm depth with the aid of a hand-held auger from the four separate sites. The samples of the soil were gotten from the alternate points of particular location and reassigned into a bag (polyethylene) and tight with clips (plastic), properly labelled with codes based on the date and the location of site, and then taken to the laboratory. A control sample were further collected from Nasarawa State University

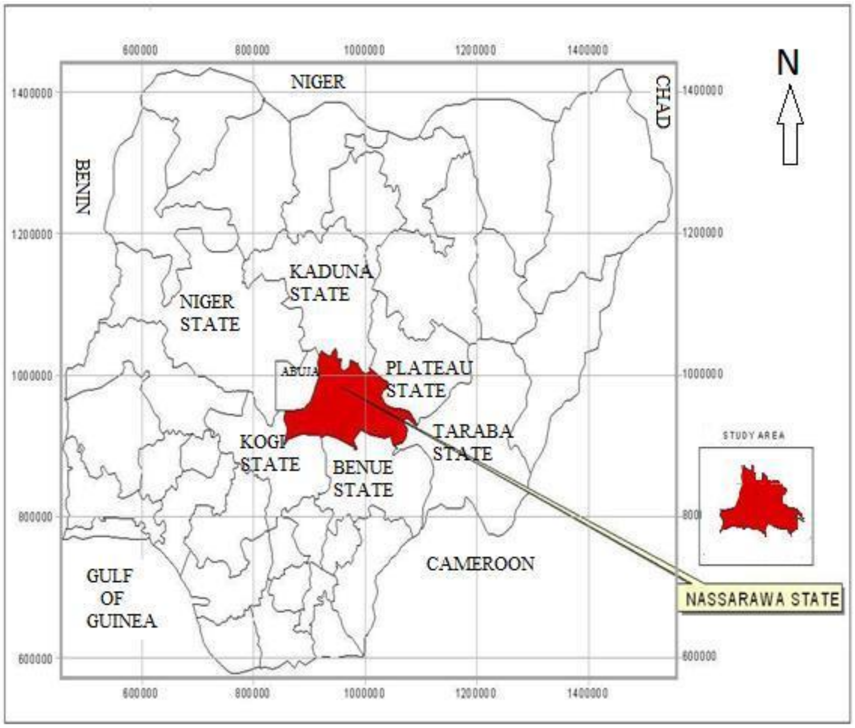

Figure 1. Map of Nasarawa West

football field where farming activities is known to be absent.

The samples of soil obtained from various locations were properly blended to make sure homogeneity is attained. These samples were later heated for 12 hours in a 32L DIN-12880-Class-3.1 oven certified for temperature safety, setting a temperature of 80 °C to get rid of the moisture. With the aid of molar, pestle, and 2 mm sieve, the resulting dried samples were made fine particles.

One gram (1 g) of these fine particulate soils were laid into a Pyrex flask and a 25 cm^3 of nitric acid (concentrated ,70% High Purity HNO_3) (with specific gravity of 1.42 g/mL) against 75 cm^3 of hydrochloric acid (35% Hcl concentrated) (with specific gravity of 1.18 g/mL) been in the ratio of 1:3, was then added to dissolve the metals. After that, the resulting mixture was laid on a VM-300S hot-plate (with the maximum loading capacity of 50 mL and speed range of 300 rmp) and left to be cool. The obtained solution was later filtered via Whatman filter paper no. 42 and filled up to a 50 mL mark with water (distilled). This was taken to Perkin Elmer Atomic Absorption Spectrophotometer AAnalyst 400 for metal ion content analysis.

The AAS Aanalyst 400 model was utilized for the determination of heavy metal content in previously digested soil samples. The setup process involved fixing the nitrous oxide, acetylene gas, and compressor. The compressor was then activated, and the liquid trap was purged to eliminate any trapped liquid. Following this, both the Extractor and the AAS control were switched on.

To ensure the analysis precision, meticulous cleaning procedures were performed. The slender tube and nebulizer piece were thoroughly cleansed using a purifying wire, and the burner's opening was cleaned using an arrangement card. Subsequently, the AAS programming worksheet on the connected PC was opened, and the empty cathode light was inserted into the light holder. The light source was turned on, and the cathode beam was carefully adjusted to precisely target the arrangement card, ensuring optimal light throughput. Once this was achieved, the machine was ignited.

In preparation for analysis, a fine amount of the sample was placed in a 10 ml graduated cylinder containing deionized water, and the aspiration rate was measured. An analytical blank was meticulously prepared, followed by the creation of a series of calibration solutions with known quantities of the analyte element (standards). These standards, along with the blank, were atomized sequentially, and their respective responses were recorded. Calibration curves were constructed for each standard solution, enabling the subsequent atomization and measurement of the sample solutions.

Finally, the concentrations of various metals within the sample solution were determined by referencing the absorbance values obtained for the unknown sample against the calibration curves. This methodology allowed for the accurate quantification of heavy metal concentrations in the soil samples.

Results and Discussion

The outcome of the heavy metal's concentration in the samples of soil is presented on **Table 1**. The data presented in **Table 1** were used to plot the charts for comparison and presented in **Figures 2** to **Figures 8**.

Table 1. Metals content in samples of soil (mg/kg)

Sample No.	Zn	Cu	Cd	Pb	Fe	Ni	Cr
1	27.40	2.303	0.061	0.092	94.30	1.520	0.431
2	17.30	2.332	0.103	0.063	121.4	1.822	0.824
3	21.20	2.624	0.094	0.081	83.20	2.153	0.430
4	15.40	3.020	0.210	0.060	104.2	2.153	0.430
5	10.51	1.203	0.233	0.042	71.40	0.973	0.033
Mean	18.36	2.296	0.140	0.067	94.90	1.710	0.470
SD	5.68	0.64	0.068	0.013	17.19	0.43	0.26
CV%	30.93	26.30	48.57	19.40	18.11	25.14	55.93

A = Nagari Farm, B = Sharna Farm, C = Gyunka's Integrated Farm, D = Gunduma Farm, and E = Nasarawa state university football field (control site).

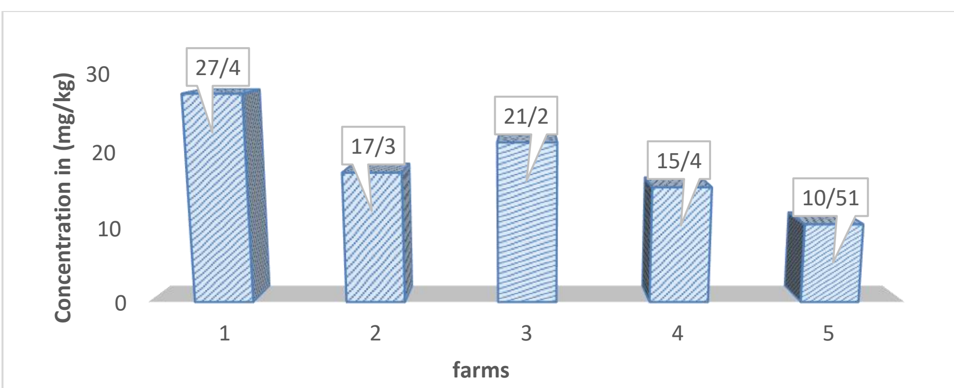

Figure 2. Concentration of Zinc in (mg/kg)

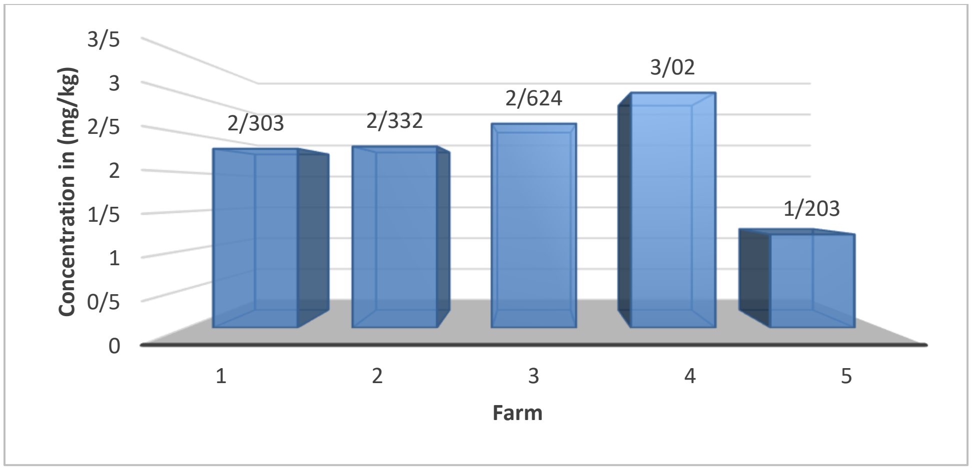

Figure 3. Concentration of Copper in (mg/kg)

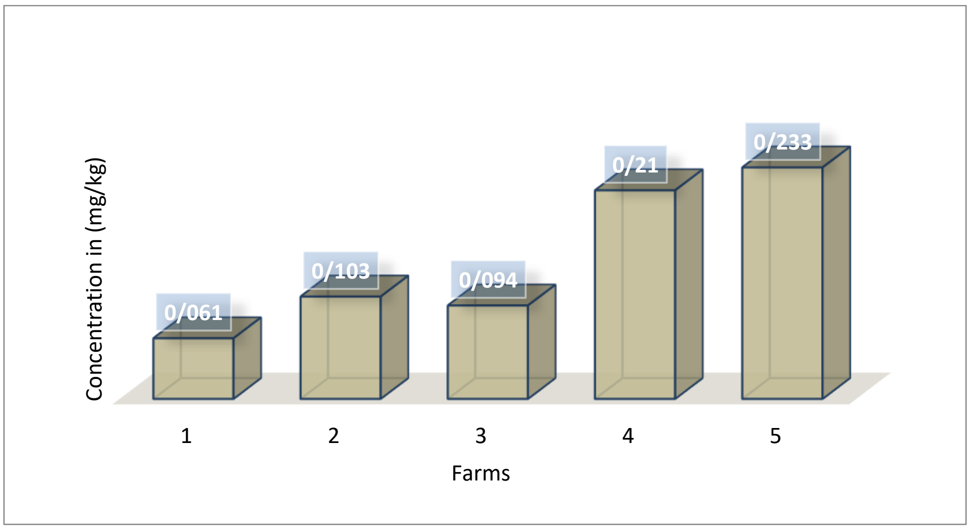

Figure 4. Concentration of Cadmium in (mg/kg)

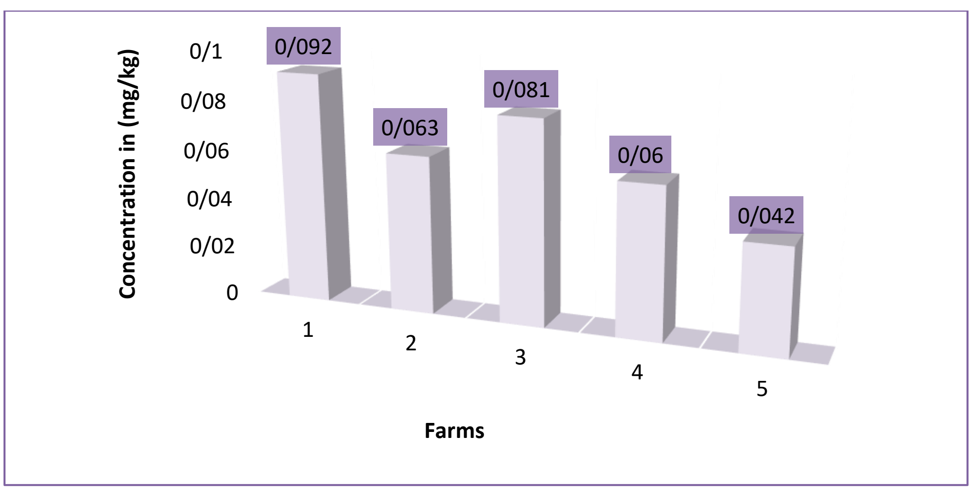

Figure 5. Concentration of Lead in (mg/kg)

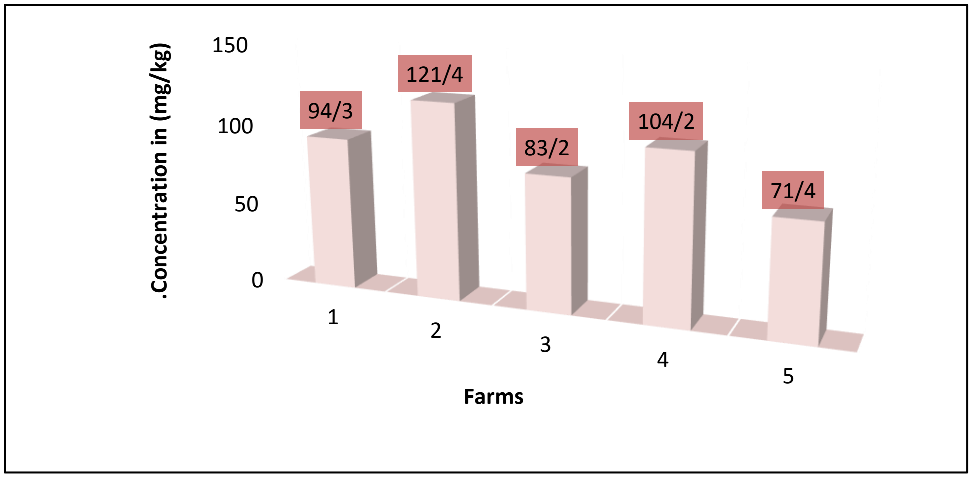

Figure 6. Concentration of Iron in (mg/kg)

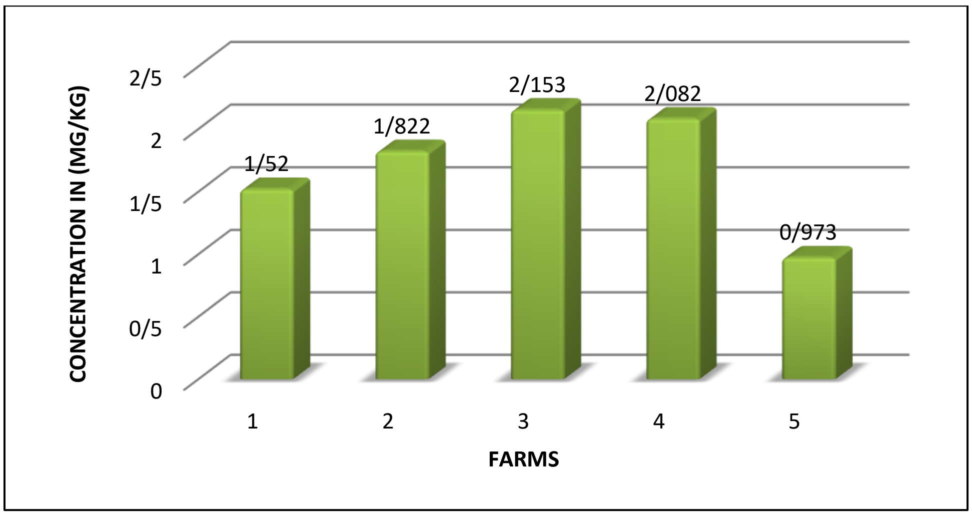

Figure 7. Concentration of Nickel in (mg/kg)

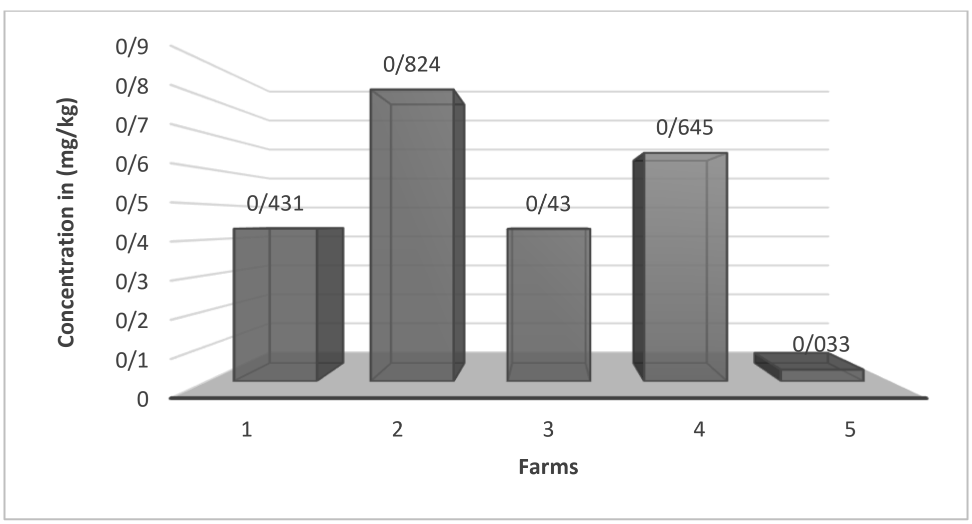

Figure 8. Concentration of Chromium in (mg/kg)

In **Table 1** and **Figure 2**, it is evident that the zinc content, measured in milligrams per kilogram (mg/kg), exhibited variability within the range of 15.40 to 27.40, with an average value of 18.36 ± 5.679 mg/kg and a coefficient of variation (CV %) of 30.93. In contrast, the control sample showed a lower zinc concentration of 10.51 mg/kg. This disparity can be attributed to the absence of human activities, the limited use of agrochemicals, and minimal vehicular emissions in the control area. However, it is important to note that atmospheric dust from industrial sources, fertilizers, sludge, and sewage can contribute to the accumulation of zinc in soil, serving as an anthropogenic source.

Comparing these findings to prior research in Delta state (mg/kg) by Zhao (2019) [16], the zinc content in the present study appears relatively lower, with a range of 30.34 to 105.78 mg/kg and a mean value of 59.34 ± 25.21. While zinc is essential for both plant and animal health, excessive levels can be toxic [17,18]. Therefore, it is imperative to manage zinc levels in soil, especially for agricultural purposes. The average zinc content observed in this study falls lower than the standard limit set by FAO/WHO for zinc in soil, which is 50 mg/kg.

Moving on to copper, this metal has recognized health benefits but can become hazardous in excess, leading to liver damage, immune system impairment, and reproductive issues. As indicated in **Table 1** and **Figure 3**, copper content ranged from 2.304 mg/kg in Nagari farm to 3.020 mg/kg in Gunduma farm, with an average of 2.296 ± 0.604 mg/kg and a CV% of 26.30. In contrast, the control sample contained only 1.203 mg/kg of copper, which is lower than the levels found in the four study locations.

Copper's importance in seed production, disease resistance, and water regulation underscores its significance in agriculture. However, excessive copper can be harmful. Notably, copper in soil tends to strongly bind to organic matter and minerals, limiting its mobility after release [19,20]. The relatively higher copper content observed in some study locations (ranging from 0.688 to 0.396 mg/kg) may be attributed to increased agrochemical use and the other anthropogenic activities. Nevertheless, the average copper content in this investigation is lower than the WHO/FAO standard limit of 36 mg/kg for soil samples.

The cadmium content, as presented in **Table 1** and **Figure 4**, ranged from 0.061 to 0.233 mg/kg, with an average of 0.140 ± 0.086 mg/kg and a CV% of 48.57%. Interestingly, the control sample exhibited a higher cadmium concentration compared to all four study locations, possibly due to human activities and vehicular emissions. Importantly, the average cadmium content in this study falls significantly lower than the standard limit established by WHO/FAO for soil (0.8 mg/kg). This suggests that there is no apparent risk associated with the consumption of food crops and vegetation in the study area by human and animal populations, as cadmium is known to have no health benefits [21].

Analyzing lead content, it varied from 0.060 to 0.092 mg/kg, with an average of 0.067 ± 0.013 mg/kg and a CV% of 19.40% (**Table 1** and **Figure 5**). The control site exhibited a lead concentration of 0.042 mg/kg, which was lower than what has been reported in some studies, possibly due to the sources of lead pollution such as vehicle exhaust gases, food chain exposure, and dust and soil ingestion [22,23].

In contrast, iron content stood out prominently among the metals studied, ranging from 83.20 to 121.4 mg/kg, with an average of 94.90 ± 17.19 mg/kg (**Table 1** and **Figure 6**). The control sample had a lower iron content of 71.40 mg/kg, likely due to the absence of intense human activities and commercial fertilizer application. The high iron concentrations in the soil samples may also be influenced by natural lithogenic and pedogenic processes, as well as anthropogenic factors contributing to the environmental pollution [24,25]. It is worth noting that iron concentrations in this study were significantly higher compared to the other elements.

Regarding nickel content, as seen in **Table 1** and **Figure 7**, Gyunkas integrated farm exhibited the highest concentration at 2.153 mg/kg, while Nagari farm had the lowest concentration at 1.520 mg/kg, with an average of 1.710 ± 0.430 mg/kg and a CV% of 25.14%. The control site showed the minimal traces of nickel in the soil, lower than 100 mg/kg. Nickel is considered as a vital trace element for human and animal health, but excess amounts can have adverse effects on the immune and reproductive systems [26-30]. The average nickel content observed in this study falls below the standard limit of 35 mg/kg for soil samples.

Lastly, chromium content ranged from 0.430 mg/kg in Gyunkas integrated farm to 0.824 mg/kg in Nagari farm, with an average of 0.472 ± 0.264 mg/kg and a CV% of 55.93 (**Table 1** and **Figure 8**). The control site had the lowest chromium content at 0.033 mg/kg, likely due to the absence of significant human activities leading to the bioaccumulation of these metals in the soil. Chromium exposure can lead to respiratory organ cancer due to its carcinogenicity, particularly when workers are exposed to dust containing chromium [31-35].

Finally, the results obtained from this comprehensive analysis highlight the variability in the concentrations of these metals in the study area. While some metals are present within acceptable limits, others may require further investigation and monitoring. It is important to note that the levels observed generally meet or fall lower than the established standards, suggesting limited risk associated with the consumption of food crops and vegetation in the area. Nevertheless, ongoing vigilance is necessary to ensure environmental and public health standards are maintained.

Conclusion

Heavy metals accumulation in soil depends on the nature of human activities such as application of inorganic fertilizers, vehicular emissions, animal waste, industrial waste, and pesticides.

To sum up, this research contributes valuable insights into the levels of heavy metals in soil within Nasarawa West, Nasarawa State, Nigeria. It not only assesses environmental conditions, but also addresses potential health risks associated with heavy metal contamination. By adhering to the international standards and emphasizing the absence of known health benefits for certain metals, this work underscores the importance of responsible environmental stewardship in the region.

The proposed study presented results on the concentration of metals (heavy metals) in soil from selected farmlands in Nasarawa West, Nasarawa State. The analysis of results indicate iron to have the superior content out of the entire seven metals detected in the whole five locations. While the lead content was gotten as the inferior in the current work. Moreover, the practice of agricultural activities affects the closer and farther environment from the farm. Therefore, it is good to examine some of these impacts that might occur in the environment like change of land use, pollutions by chemicals and global warming as a result of agricultural activities. As some of these metals' bio accumulates in human organs and tissues, they create a problem to the health of those who consumes food products from polluted farmlands. The overall results revealed that the concentration of metals found in this study were within the FAO/WHO standards. Based on these findings, it is concluding that plants are safe from the hazardous effect of heavy metals in the study areas.

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