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CHRONIC KIDNEY DISEASE OF UNKNOWN ETIOLOGY (CKDu) IN HADEJIA VALLEY, NIGERIA: ASSESSMENT OF HEAVY METALS IN SOILS FROM DIFFERENT LOCATIONS ALONG THE VALLEY

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ABSTRACT

Chronic kidney disease of unknown etiology (CKDu), a major life-threatening disease is becoming rampant in Nigeria and notable in Hadejia Valley. Continuous exposure to heavy metals and environmental toxins soil directly or indirectly contributes to diseases like CKDu. This research is conducted in Hadejia Valley covering part of Yobe State, (Gashua and Nguru) Jigawa State, (Birniwa, Kirikasamma, Hadejia, Auyo, Gujungu, Taura, and Ringim), and Kano State (Zakirai), to determine the effects of environmental toxins and gene polymorphism on CKDu. The study intends to find out the presence, and concentration of Fluorine (F), Cadmium, (Cd) Lead (Pb) Arsenic (As), from randomly selected soils including riverbed soil, soil collected from refuse damps, farm lands and barren lands. Collected soils were digested and analyzed using an Atomic Absorption Spectrophotometer (AAS model Agilent-AA55). Findings from the research suggest some levels of contamination of the soils in Hadejia Valley, particularly with lead and cadmium, both of which are nephrotoxic heavy metals linked to chronic kidney disease. Results indicated soil type shows a highly significant effect on concentration and location. Dump site soil was significantly higher in fluorine concentrations than River Bed soil, Farm Land soil and Barren Land soil, indicating that the heavy metal is not transported to the area by the river rather than deposited in dump sites. Dump Site soil have higher Cadmium than River Bed soil, Farm Land and Barren Land soils. Lead was higher in Barren Land and Farm Land soils, more than River Bed soil and Dump Site soil has highest cadmium suggesting that refuse deposited in Dump Site are high in lead and naturally will find its way in to the food chain and hence to consume by human and other animal in Hadejia Valley. Arsenic was higher in Farm Land soil than in River Bed soil and Barren Land soil significantly different and lower than Farm Land soil. Farm Land soil was higher significantly than River Bed soil. Though all measured means in the results have values less than the standard CCME soil guideline, and are well within safe ranges, the appreciable levels in the different soil sampled naturally will accumulate along the food chain and can leach toxicity level over time. Immediate intervention is needed to ensure safer soils to mitigate CKDu risks. Other measures including urgent monitoring of soils are required to prevent or at least reduce CKDu outbreaks. Monitoring and rapid intervention are needed to manage the contamination and safeguard the local population and ecosystem.

Key words: Kidney, Soil, Hadejia Valley, Heavy Metals, Concentration and Contamination

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INTRODUCTION

Chronic kidney disease of unknown etiology (CKDu) is a term used to describe a form of chronic kidney disease that is not attributable to any traditional risk factors, such as diabetes or hypertension and no specific single agent has yet been identified (Lunyera et al., 2015). Kidney disease is one of the major life-threatening health problems (Ahmed, et al., 2017). There is documented evidence of CKDu in Nigeria notable in some communities of the Hadejia Area of Kano, Jigawa, and Yobe States (Ahmed et al., 2017).

Exposure to heavy metals and environmental toxins occurs in soil, water, foods and air over some time (Hassan et al., 2015). The protective role of metallothionein proteins against nephrotoxic heavy metals toxicity has been established (McNeill et al., 2019). Genetic polymorphisms of the Metallothionein gene in humans can lead to low expression of MT or the production of an abnormal form of the metallothionein protein leading to low expression of MT and possibly CKDu. Considering the rampant cases within the study area and the fact that CKDu affects the life and socio-economic development of the population, the study becomes indispensable.

Reports of kidney-related diseases of unknown causes have been rampant in Kano, Jigawa, and Yobe States for over 10- 20 years with findings from this area indicating the highest prevalence of 35% when compared to many other parts of the country with a record of only 20 to 25% prevalence (Nuraddeen et al., 2018).

The level of toxins exposure by humans is linked to chronic kidney diseases in humans (Chen et al., 2019), similarly, environmental factors and genetic variations contribute to disparities in the disease risk. Low MT expression theoretically predisposes an individual to heavy metals and differences in MT could alter the susceptibility of an individual's kidney to disease due to toxicity by nephrotoxic heavy metals (Klaassen, et al., 2009).

An important feature that may influence soil quality in any given area is the anthropogenic activities and geology of an area. The geology of the Hadejia valley in Jigawa State, Nigeria, is characterized by a mix of sedimentary and basement complex formations and the valley is underlain by the Chad formation in the northeast and a basement complex of igneous origin in the south while the subsurface lithology includes various rock types such as sandstones, shales, limestone, silt, and clay. Muhammad et al., (2023). The area also was reported to contain weathered layer and a fresh basement (bedrock) and the northern part of the valley is covered by the Chad formation, a sedimentary deposit. The southern portion of the valley is underlain by a basement complex, consisting of solid igneous rocks with a weathered mantle on top.

The subsurface of Hadejia Valley is composed of various layers, including topsoil, weathered basement, fractured basement, and fresh basement. Resistivity surveys reveal varying electrical resistivity values for different layers, indicating the presence of different rock types and their relative water-bearing potential. Implications for Water Resources showed aquifer potential. The geological formations, including the weathered layer and fractured basement, play a role in groundwater recharge and storage, (Idris, 2023).

Exposure to high Pb concentrations brings about health problems including skeletal, circulatory, nervous, enzymatic, endocrine, and immune systems disorders in human body (Zhou and Guo, 2015; Esmaeilzadeh et al., 2019; Vasseghian et al., 2020), Heavy industrialization in many countries has led to serious environmental pollution (Sadeghi et al.,

2020). Human activities undoubtedly create many environmental issues, which considerably affect the surrounding soil and water resources (Miri et al., 2017). According to Karimi et al. (2020), using treated and untreated wastewater for irrigation may result in the accumulation of heavy metals in soils and consequently in plants and foodstuffs. Soil pollution occurs due to many human activities including industrial activities and agro-chemical applications (Esmaeilzadeh et al., 2019). Soil is generally regarded as the ultimate sink for heavy metals released into the environment (Qingjie et al., 2008). Soil pollution by industries is one of the greatest environmental issues, posing major issues to the environment, organisms, and humans (Mohammadi et al., 2019a). Therefore, human health risks as a result of exposing the soil to heavy metals should not be ignored (Mohammadi et al., 2019a).

The behaviors of heavy metals such as As, Cd, Pb andFl have become a growing concern in ecological research because of their capability of ecotoxicity, persistence, bioaccumulation and biomagnification properties, making them a threat to the water and soil resources' health (Kamani et al., 2018; Jafarzadeh et al., 2021). Heavy metals due to their non-biodegradability and long resistance properties are among the critical contaminants in the environment (Mohammadi et al., 2019a). Their increased concentrations in soil can damage the fertility and productivity of the farmlands (Sadeghi et al., 2020), and are potentially toxic to most living organisms at a high level of exposure (Rezaei et al., 2019).

Several studies have been conducted on heavy metals. For example, the assessment of the human health risk of heavy metals in agricultural soils irrigated by effluents of stabilization ponds by Karimi et al. (2020), the levels of heavy metal contamination of surface water, groundwater and soils by Sadeghi et al. (2020), the concentrations of heavy metals in surface sediment samples and pollution status by Seifi et al. (2019), the pollution status of heavy metals in soils by Mohammadi et al. (2019a) and the human health risk indices of arsenic (As), chromium (Cr), lead (Pb) and zinc (Zn) due to drinking water consumption using chronic daily intake, hazard quotient, hazard index and cancer risk by Sajjadi et al. (2022). Heavy metals exist in water, air, soil and consequently also in foods, eventually can cause adverse health effects such as carcinogenic and non-carcinogenic human health risks (Shams et al., 2020). Association between heavy metals in soil and human health risks (Adimalla, 2020) and between food contamination of heavy metals and the incidence and spatial distribution of stomach cancer (Fei et al., 2018), and the involvement of heavy metals in the development of colorectal cancer (Sohrabi et al., 2018) were established. Long-term exposure to even low concentrations of As, for example, can increase the risk of skin and lung cancer (Shams et al., 2020). Cd is a 'lethal' metal due to its severe health effects, causing bone fracture, cancer, kidney dysfunction and hypertension, human respiratory cancers, also causing infertility in humans, and developmental disorders in children at higher concentrations (Shams et al., 2020). Moghaddam et al. (2022) also studied the concentrations of heavy metals such as Pb, Cu, Fe, Ni, and Zn in water, soil, and vegetables in Iran and assessed the investigation of the extent of contamination health risks in consumers.

In developing countries, agricultural land is contaminated by heavy metals, which is a serious environmental problem due to heavy metal toxicity (Agca and Ozdel, 2014). Irrigation water contaminated by industrial effluents has led to severe heavy metal contamination in soil and plants. Due to the use of wastewater for soil irrigation, the concentration of heavy metals in the edible parts of growing plants is increasing (Arora et al., 2008).

The major sources of heavy metal contamination in the environment are human activities such as industrial waste generation, eventually resulting in the serious contamination of the surrounding water resources on local, regional, and global scales and causing significantly serious health problems in humans and animals (Radfard et al., 2019; Kamani et al., 2018).

Report indicated that soil in the Hadejia Valley is significantly impacted by heavy metal contamination, particularly from Chromium (Cr), Lead (Pb), Zinc (Zn), and Arsenic (As), with concentrations often exceeding safe environmental and health limits. The primary sources are a combination of industrial effluents, agricultural runoffs, and the area's natural geology. Key Pollutants and Contamination Levels

Multiple studies in the region have found concerning levels of various heavy metals. For example Chromium (Cr) was found in the Hadejia River system sediments at extremely high levels, with mean concentrations significantly above the permissible limits set by the WHO and Lead (Pb) and Zinc (Zn) in Wetland soils in the Hadejia/Jama'are river basin have high-risk levels of toxic effects from Pb and Zn contamination. Aliyu, (2020). The pollution is a result of both human activities (anthropogenic) and natural geological factors. Industries located upstream in urban centers like Kano City discharge untreated effluents into the river system, which then flow downstream into the Hadejia Valley.Intensive agricultural practices in the region involve the use of agrochemicals, pesticides, and chemical fertilizers and runoff from these farms carries trace elements and contaminants into the rivers and soils, Mohammad, (2025).The improper disposal of industrial and municipal wastes into river sources contributes to the overall contaminant load.The natural composition of the local soil and parent rock materials also contributes to the baseline levels of some heavy metals.

The soil pollution in the Hadejia Valley has several serious consequences. High levels of heavy metals disrupt the ecological equilibrium, negatively affecting soil fauna (like earthworms and beetles) and microbial communities that are vital for soil health.Contaminated soil and water pose direct human health risks. Exposure has been linked to potential carcinogenic risks (especially from Chromium) and the prevalence of chronic kidney disease in the local population.The high levels of heavy metals in the soil and water lead to their accumulation in farm produce, such as rice grains and vegetables,introducing them into the human food chain.Siltation and Degradation: Sedimentation and the invasion of problem weeds like Typha grass, partly due to altered water flow and land use, further degrade the wetland environment and impact agricultural productivity.

RESEARCH METHODOLOGY

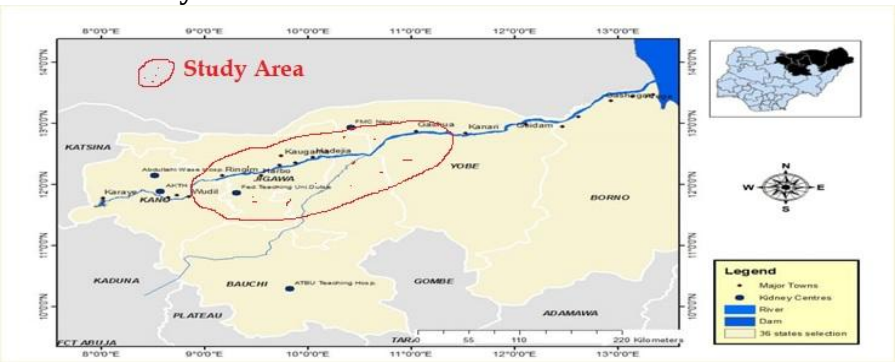
The research currently is been conducted in some parts of Yobe State, (Gashua and Nguru) Jigawa State, (Birniwa, Kirikasamma, Hadejia, Auyo, Gujungu, Taura, and Ringim), and Kano State (Zakirai). All the sites lie midway along the Hadejia Valley. In each of the 10 sites concentrations of nephrotoxic heavy metals and residual herbicides and pesticides in soil water and plant materials from different sources of water and soil were collected from and analyzed using an atomic absorption spectrophotometer (AAS). The samples were analyzed using two research centres and the data was derived after validation of the AAS analysis of the sample.

All Statistical analyses involve SPSS Version 23 computer software (SPSS Chicago, IL, USA), and data were recorded as mean± standard deviation. All statistical tests was considered significant at $p \leq 0.05$.

Samples Collection

All samples were collected on the indicated GPS points and within 3km to the nearest indicated named towns.

Study Area



Source: Cartography Unit, Bayero University Kano, Nigeria (2022)

Sampling Points

S/No	Collection Area	Collection Points
1	Gashua	12’52’01N 11’01’10’E
2	Nguru	12’52’12’N 10’26’07’E
3	Birniwa	12’47’30’N 10’14’36’E
4	Kiri Kasamma	12’41’04’N 10’15’09’E
5	Hadejia	12’26’26’N 10’01’47’E
6	Auyo	12’21’54’N 09’55’21’E
7	Gujungu	12’21’29’N 09’34’51’E
8	Taura	12’13’20’N 09’17’26’E
9	Ringim	12’08’12’N 09’09’46’E
10	Zakirai	12’05’39’N 08’52’51’E

Collection Techniques

a. River Bed Sand (SRS)

-Labelled Sampling Bottles were used for the soil sampling using the following procedure:

-The location (GPS) of the site for collection of the river bed soil accurately identified and recorded

- In-situ parameters including the colour, pH, Temperatue of the soil should determined and recorded before the sample was collected

-Soil samples were collected from 0-15 cm from the surface and 15-30cm down below on three sites, mid river and towards the banks of the river

-The soil samples collected were mixed thoroughly and 10mg finally collected from such, in a labelled specimen bottle.

- The samples collected were transported to the laboratory for storage and analysis.

- All bottles used were sterilized and sample collectors wore hand globes

b. Farm Land Soil (SFS)

Labelled Sampling Bottles were used for the soil sampling using the following procedure:

-The location (GPS) of the site for collection of the farm land was accurately identified and recorded

- In-situ parameters including the colour, pH, Temperatue of the soil determined and recorded before the sample was collected

-Soil sample were collected from 0-15 cm from the surface and 15-30cm down below in five locations including northen, easten, southen, westen and central part of the farm.

-Each of the soil collected was mixed thoroughly and 10mg collected from such was placed in a sterilized specimen bottle and labelled and transported to the laboratory for storage and analysis.

c. Dump Site Soil (SDS)

Labelled and sterilized Sampling Bottles were used for the soil sampling using the following procedure:

-The location (GPS) of the site for collection of the dump site soil accurately identified and recorded

- In-situ parameters including the colour, pH, Temperatue of the soil were determined and recorded before the sample was collected

-Soil samples were collected from 0-15 cm from the surface and 15-30cm down below in five locations including northen, easten, southen, westen and central part of the dump site.

-The soil collected was mixed thoroughly and 10mg finally collected from such, in a labelled specimen bottle.

- The samples collected were transported to the laboratory for storage and analysis.

d. Barren Land Soil (SBS)

Labelled sterilized Sampling Bottles were be used for the soil sampling using the following procedure:
-The location (GPS) of the site for collection of the baren land soil were accurately identified and recorded
- In-situ parameters including the colour, pH, Temperatue of the soil determined and recorded before the sample collected
-Soil samples collected from 0-15 cm from the surface and 15-30cm down below five locations including northen, easten, southen, westen and central part of the barren land.
-The sample collected were mixed thoroughly and 10mg placed in the labelled specimen bottle and transported to the laboratory for storage and analysis.

Sample Preparation:

The soil samples were dried, and ground into a fine powder. A representative sub-sample was taken from each powdered sample and digested using an acid mixture to ensure complete dissolution of the heavy metals into solution.

Digestion Protocol:

The acid digestion was carried out using a mixture of nitric acid and perchloric acid under controlled heating conditions. This step ensured that any organic constituents were decomposed, and the metals were released into the solution for analysis.

Measurement of Heavy Metals:

The digested samples were then analyzed using AAS. Calibration curves were generated using certified standard solutions for each metal to ensure quantitative accuracy. The heavy metals targeted in this analysis included lead (Pb), cadmium (Cd), arsenic (As), and Fuorine (Fl)

Quality Control:

To validate the results, quality control measures such as the use of blanks, duplicate samples, and standard reference materials were incorporated throughout the analysis. This helped to reduce procedural errors and ensured that the data obtained were robust and reproducible.

Safety Standards for Comparison

For the purpose of risk assessment, the measured heavy metal concentrations were compared against internationally recognized guidelines. Specifically, the FAO/WHO maximum permissible limits for heavy metals in soils were used. These guidelines include:Arsenic (As) 20 mg/kg, Cadmium (Cd): 3 mg/kg, Fluorine (F): 150-400 mg/kg and Lead (Pb): 60-85 mg/kg

Determination of Metal Concentrations

All the samples were subjected to Flourine (F), Cadmium, (Cd), Lead (Pb) and Arsenic (As) using Atomic Absorption Spectrophotometer (AAS model AgilentAA55) after selecting the various wavelengths at which the heavy metals were determined. An analytical blank was

prepared in a similar manner. The obtained results were expressed as mg/kg wet weight. According to WHO the maximum permitted concentrations of heavy metals naturally present in beverages are as follows: arsenic 0.14 ppm, cadmium 0.10ppm, Fluorine mercury 5.0 ppm respectively (WHO, 2023) The maximum allowable concentrations of non-nutrient metals shall not exceed: arsenic, 10 parts per million (ppm); cadmium, 20 ppm; and lead, 10 ppm.

RESULTS

The results of the soil analyses for heavy metals including Fluorine, Cadmium, Lead and Arsenic from 10 locations along Hadejia Valley, from different locations river bed, dump site, farm land and barren land in the valley; River Hadejia, are presented in Table 1 below. The heavey metals from the locations; Gashua, Nguru, Birniwa, Kiri-Kasamma, Hadejia, Auyo, Gujungu, Taura, Ringim and Zakirai revealed out come that clearly indicated the effect of environment and socio-cultural practices of people living in each study area.

All heavy metals exceed WHO safe limits (except some Fluorine values). Pond and well water have the highest Fluorine risk. Lead and Arsenic contamination is widespread and severe. Cadmium is a hidden problem—though present in very small amounts, it's above safe limits. Hadejia, Nguru, Birniwa show worse contamination.

2. SOIL SAMPLES

The results of the soil types analyses for heavy metals including Fluorine, Cadmium, Lead and Arsenic from 10 locations along Hadejia Valley, from different sources including the river bed from main river flowing through the valley; River Hadejia, dump sites, cultivated lands and barren lands in each location, are presented in Table 2 below. The heavey metals from the soil collection points in each locations; Gashua, Nguru, Birniwa, Kiri-Kasamma, Hadejia, Auyo, Gujungu, Taura, Ringim and Zakirai revealed the level of pollution and demonstrates the effect of environment and socio-cultural practices of people in these study areas.

From the result Fluorine in soil indicated $F = 35.12$, $p = 1.83e\text{-}09$, a strong evidence soil means differ. Location: $F = 10.22$, $p = 1.17e\text{-}06$, location effect also was found to be significant. Cadmium has $F = 53.26$, $p = 1.81e\text{-}11$. Location has $F = 12.79$, $p = 1.23e\text{-}07$. Lead in soil has $F = 51.41$, $p = 2.72e\text{-}11$. Location HAS $F = 3.19$, $p = 0.0093$. Arsenic relation to soil has $F = 15.43$, $p = 4.84e\text{-}06$, Location: $F = 3.84$, $p = 0.0031$

For all four metals, Soil type shows a highly significant effect on concentration. Location is also significant for every metal though some less strongly, meaning concentration varies by sampling site as well.

Fluorine statistically has SDS significantly higher than SRS (diff ≈ 0.2333, $p \approx 0.0001$), SDS significantly higher than SFS (diff ≈ 0.1449, $p \approx 0.0150$), SDS significantly higher than SBS (diff ≈ 0.2092, $p \approx 0.0003$), SDS> (SRS, SFS, SBS)

Cadmium has SDS significantly higher than SRS (diff ≈ 0.0018, $p \approx 0.0017$), SDS significantly higher than SBS (diff ≈ 0.0019, $p \approx 0.0009$), SDS> (SRS, SBS); note differences are numerically very small because Cd concentrations are tiny.

Lead has SDS significantly higher than SBS (diff ≈ 0.2346, $p < 0.0001$), SFS significantly higher than SRS (diff ≈ 0.0931, $p \approx 0.0031$), SDS highest; SFS > SRS for lead.

Arsenic has SFS significantly higher than SRS (diff ≈ 0.8725, p ≈ 0.0002), SBS significantly different from SFS (diff ≈ 0.5893, p ≈ 0.0169), SFS > SRS (and SFS > SBS).Tukey HSD — significant soil pairwise differences (α=0.05)

Fluoride (soil) — CCME agricultural guideline: 200 mg/kg. ccme.ca

Cadmium (Cd) — CCME agricultural guideline: 1.4 mg/kg (SQG for agricultural land use). ccme.ca

Lead (Pb) — CCME provisional agricultural guideline values are in the range ~61–113 mg/kg depending on endpoint; agricultural/residential values often cited ~61–113 mg/kg. ccme.ca

Arsenic (As) — CCME agricultural soil guideline: 12 mg/kg. ccme.ca+1

In comparison with CCME limit all measured means and all individual measurements in observed have different levels of magnitude below these CCME soil guideline values:

Fluorine: measured ~1.3–1.85 mg/kg vs guideline 200 mg/kg → far below. ccme.ca, Cadmium: measured ~0.002–0.008 mg/kg vs guideline 1.4 mg/kg → far below. ccme.ca, Lead: measured ~0.21–0.63 mg/kg vs guideline ~61+ mg/kg → far below. ccme.ca and Arsenic: measured ~2.1–4.3 mg/kg vs guideline 12 mg/kg → below. ccme.ca+1.

Level of heavy metals in soil were found to be within safe/expected ranges.

Heavy Metals in Soil Samples

The result of the analysis of the heavy metals in the soil samples collected is shown in Table 2 below.

Table 1: Mean Concentrations of Flourine (F), Cadmium, (Cd), Lead (Pb) and Arsenic (As) (mg/kg) in Soil (i)River Bed Sand = **SRS** (ii) Farm Land Soil = **SFS** (iii) Dump Site Soil = **SDS** (iv) Barren Land Soil= **SBS**from Hadejia Valley, July, 2022

		Locations									
Heavy Metals (mg/kg)	**Food Type**	**Gashua** 12'52'01 N 11'01'10 'E	**Nguru** 12'52'12' N 10'26'07' E	**Birniwa** 12'47'30'N 10'14'36'E	**K/Kasamma** 12'41'04'N 10'15'09'E	**Hadejia** 12'26'26' N 10'01'47' E	**Auyo** 12'21'54' N 09'55'21' E	**Gujungu** 12'21'29'N 09'34'51'E	**Taura** 12'13'20'N 09'17'26'E	**Ringim** 12'08'12'N 09'09'46'E	**Zakirai** 12'05'39'N 08'52'51'E
Flourine (F),	**River Bed Sand (SRS)**	1.511	1.433	1.411	1.500	1.560	1.333	1.300	1.322	1.393	1.222
	Farm Land Soil (SFS)	1.522	1.510	1.498	1.415	1.606	1.611	1.388	1.490	1.520	1.309
	Dump Site Soil (SDS)	1.650	1.550	1.614	1.606	1.850	1.750	1.611	1.588	1.650	1.449
	Barren Land Soil (SBS)	1.583	1.401	1.429	1.399	1.555	1.489	1.301	1.322	1.433	1.314
Cadmium, (Cd)	**River Bed Sand (SRS)**	0.005	0.005	0.004	0.004	0.006	0.005	0.004	0.004	0.003	0.003
	Farm Land Soil (SFS)	0.005	0.004	0.003	0.003	0.006	0.005	0.003	0.004	0.005	0.004
	Dump Site Soil (SDS)	0.007	0.006	0.005	0.005	0.008	0.008	0.005	0.006	0.006	0.005
	Barren Land Soil (SBS)	0.004	0.003	0.003	0.003	0.005	0.004	0.002	0.003	0.003	0.003
Lead (Pb)	**River Bed Sand (SRS)**	0.318	0.207	0.218	0.314	0.440	0.351	0.333	0.302	0.316	0.301
	Farm Land Soil (SFS)	0.408	0.403	0.422	0.385	0.425	0.428	0.302	0.445	0.413	0.400
	Dump Site Soil (SDS)	0.567	0.510	0.565	0.491	0.630	0.599	0.591	0.502	0.540	0.451
	Barren Land Soil (SBS)	0.407	0.350	0.311	0.302	0.435	0.428	0.301	0.355	0.433	0.317
Arsenic (As)	**River Bed Sand (SRS)**	2.111	2.124	2.124	3.120	3.130	2.988	2.120	2.128	2.114	2.133
	Farm Land Soil (SFS)	3.545	3.202	3.202	3.211	3.675	3.232	3.211	3.044	3.273	3.222
	Dump Site Soil (SDS)	3.325	2.436	2.436	2.422	4.304	2.565	2.422	2.522	2.278	2.214
	Barren Land Soil (SBS)	2.448	2.555	2.502	2.400	2.834	2.731	2.400	2.411	2.209	2.202

Table 2: Mean concentrations (mg/kg) for each heavy metal across the four soil/food types

Metal	River Bed Sand (SRS)	Farm Land Soil (SFS)	Dump Site Soil (SDS)	Barren Land Soil (SBS)
Fluorine (F)	1.394	1.497	1.662	1.422
Cadmium (Cd)	0.0043	0.0042	0.0061	0.0033
Lead (Pb)	0.310	0.403	0.545	0.374
Arsenic (As)	2.309	3.262	2.649	2.469

DISCUSSION

As observed from the results mean concentration of the heavy metals showed strong evidence that they differ. For all four metals, Soil type shows a highly significant effect on concentration. Location is also significant for every metal (some less strongly), meaning concentration varies by sampling site as well.

Dump site soil was found have generally significantly higher Fluorine concentrations than River Bed soil, Farm Land soil and Barren Land soil, indicating that the heavy metal is not transported to the area by the river rather than deposited in dump sites.

In a similar manner Dump Site soil was found have generally significantly higher Cadmium concentrations than River Bed soil, Farm Land soil and Barren Land soil, equally indicating that the heavy metal is not transported to the area by the river rather than deposited in dump sites around the study area.

Lead concentration was found to be significantly higher than Barren Land soil and Farm Land soil was found to be significantly higher than River Bed soil and Dump Site soil has highest cadmium. A similar observation was made by Aliyu, (2020). He observed soils in Hadejia Wet Land was contaminated by As, Pb and Cd. This suggest that refuse deposited in Dump Site are high in lead and naturally will find its way in to the food chain and hence to consume by human and other animal in Hadejia Valley.

Arsenic was significantly higher in Farm Land soil than in River Bed soil and Barren Land soil significantly different and lower than Farm Land soil. Farm Land soil was higher significantly than River Bed soil.

The pollution is most likely as a result of both human activities (anthropogenic) and natural geological factors as observed by Mohammad (2025a) that Industries located upstream the Valley in urban centers like Kano City discharge untreated effluents into the river system, which then flow downstream into the Hadejia Valley. Intensive agricultural practices in the region involve the use of agrochemicals, pesticides, and chemical fertilizers and runoff from these farms carries trace elements and contaminants into the rivers and soils, Mohammad, (2025b).

Though all measured means and all individual measurements in the results have values less than the standard CCME soil guideline, and are well within safe ranges, the appreciable levels in the different soil sampled naturally will accumulate along the food chain and can leach toxicity level over time.

It is recommended that immediate intervention is needed to ensure safer soils to help in mitigating CKDu and other health risks. Other measures including urgent monitoring of soils

are required to prevent or at least reduce CKDu outbreaks. Monitoring and rapid intervention are needed to manage the contamination and safeguard the local population and ecosystem.

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