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Assessment of Groundwater Pollution of Parts of Ilorin Metropolis North Central Nigeria: An Insight from Heavy Metals Indices

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ABSTRACT **Original Research Article**

This study examined groundwater pollution in parts of Ilorin metropolis, North Central Nigeria using heavy metal indices. The research is considered inevitable as a result of the need to providing detailed information on the current state of groundwater potability within the study area. Water samples from 30 locations across the city were analyzed for heavy metal concentrations using standard methods and procedures. The results revealed that iron (Fe) and lead (Pb) exceeded that of World Health Organization (WHO) and Nigerian Standard for Drinking Water Quality (NSDWQ) permissible limits in some sampled locations, indicating potential health risks to consumers. Conversely, copper (Cu), chromium (Cr), zinc (Zn), and cadmium (Cd) levels were within or below permissible limits, suggesting that these metals may not pose significant health risks in the study area. The study revealed the potential health risks associated with Fe and Pb contamination due to anthropogenic activities such as industrial influence, poorly managed waste disposal sites, and other human-related activities. The findings of this study underscore the need for regular monitoring and treatment of water to ensure safe drinking water for the inhabitants of Ilorin. The results of the study shows significant implications for water resource management and public health policy in the region, emphasizing the importance of proper waste management practices, routine water quality assessments and effective mitigation strategies to reduce the risks associated with heavy metal contamination.

Keywords: Heavy Metals, Indices, Environmental, Assessment, Groundwater.

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1. Introduction

The adage that water is life is consistently and practically a fulfilled phenomenon in our days. Demand for water is increasingly becoming uncontrollable due to population increase, industrialization, improved technological know-how facilitating over-abstraction of groundwater. Sustenance of life both for plants and animals depend on regular water supply. Water is the first most essential food for plants and animal. Sadly, this resource is under undue threat and depletion due to geogenic and anthropogenic activities. Wild population growth engendering increased waste generation which are indiscriminately disposed, adverse effects of climate change and primitive agricultural practices resulting in releasing of some trace metals have put this non-renewable natural resource under threat for its potability. Prolong draught as witnessed in arid and semi-arid region constitute another major challenge to water resources both surface and underground. The foregoing constitutes the need for sustained routine assessment of water conditions in order to enlighten the public on the likely danger inherent in the consumption of groundwater both in rural and urban areas.

Monitoring the groundwater chemical composition and identifying the presence of pollutants is an integral part of any comprehensive groundwater management strategy. Trace metals occur naturally in the environment, and their presence in groundwater is generally not desired as many have toxic effects even at low concentrations. This is problematic especially in the urban and rural areas where groundwater serves as a major source for drinking water supply (Brindha, *et al.*, 2020). Groundwater resource all over the world is under threat due to contaminant load introduced into it through urbanization, industrialization, agriculture and exploitation of natural resources. Heavy metals in groundwater are sourced from atmospheric precipitation, agricultural wastes, discharge of industrial wastewater, agro-pesticides leaching, and urban sewage, mineral mining, and infiltration of surface runoff. Groundwater is exposed to these pollutants due to it being a component of the water cycle, which includes the atmosphere, ground surface, rocks and surface water (Kana, 2022). The availability of potable water is essential for safeguarding public health and ensuring the well-being of all living organisms. Due to its easy access, groundwater is considered a readily available source of fresh water, thus making it essential for several aspects of human life, including the economy, industry, and food production. Regrettably, the rapid expansion of urban areas and industrial sectors, along with the increased discharge of hazardous materials, has led to a decline in groundwater quality (Kumar and Singh 2024). Water is an essential component for all living beings, and it is indispensable. It forms a vital ground water resource recognized for its supreme importance. Groundwater is essential as it forms the primary drinking water source in several parts (Saddam and Gufran 2024).

2. Methodology

Groundwater samples were collected from hand-dug wells across Ilorin metropolisas shown in Figure 1, using a systematic sampling technique. This method ensured that samples were representative of the entire study area while capturing variations in pollution levels across different zones. Sampling sites were chosen based on proximity to potential pollution sources such as industrial facilities, agricultural fields, and waste dumps. A total of 30 groundwater samples were collected using 2.5 liters pet bottles. Samples were preserved by adding nitric acid to stabilize heavy metals before laboratory analysis. Samples were stored in coolers with ice packs to maintain a consistent temperature during transport to the laboratory.

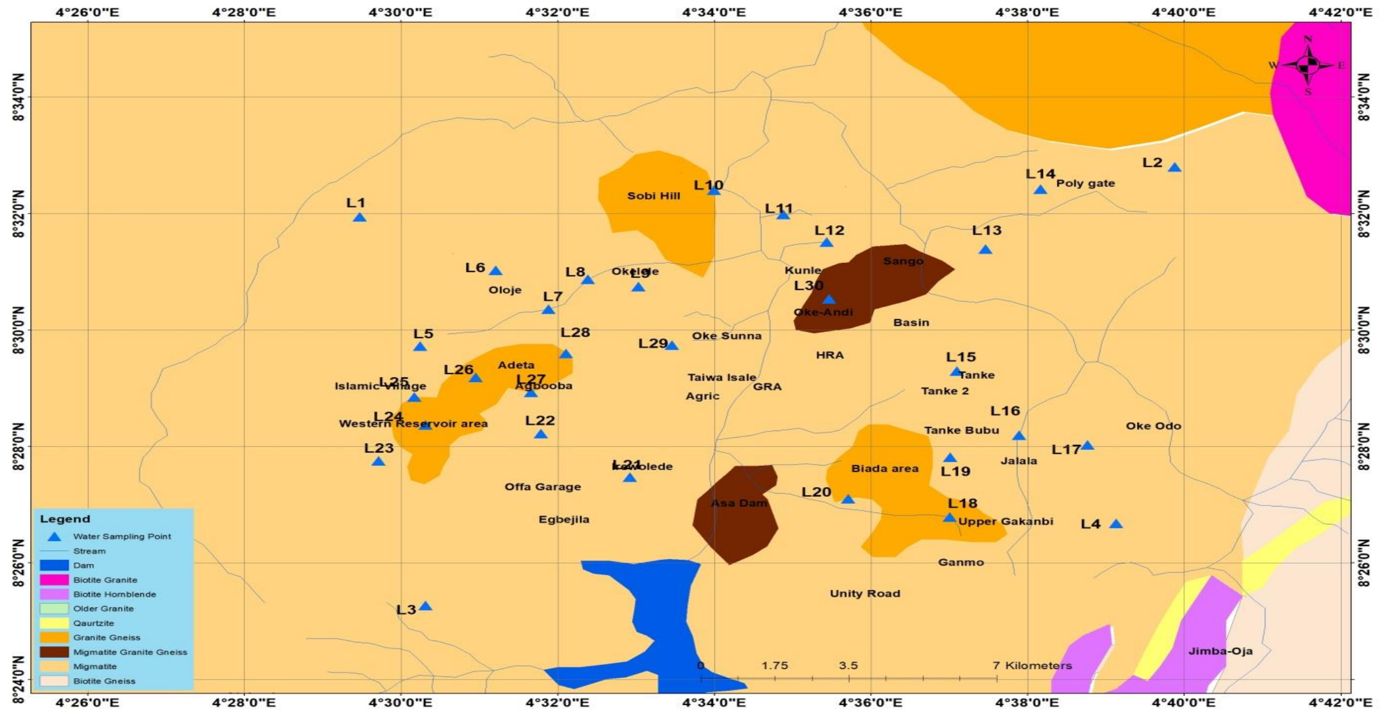


Figure 1: Geological Map of the Study Area showing Water Sampling Points (modified after NGSA, 2007)

2.1 Laboratory Analysis

Laboratory analysis was conducted on groundwater samples collected from various hand-dug wells to determine their heavy metal concentration. Parameters analyzed were; Pb, Cd, Zn, Co, Ni, Mn, Fe, Cr, Cu. Atomic absorption spectrophotometers (AAS) technique was employed following protocols established by the American Public Health Association (APHA) and other recognized bodies. Quality control procedures including the use of blanks, duplicates, and calibration standards were rigorously applied throughout the analysis process. The data generated provided critical insights into the groundwater quality status across Ilorin metropolis enabling comparison with national and international water quality standards and facilitating health risk assessments. Samples were filtered using Whatman filter paper to remove suspended particles before analysis. AAS method is a sensitive and widely used technique for detecting and quantifying of heavy metals in water samples. It works by measuring the absorption of light by free metal atoms vaporized in a flame or graphite furnace. Each metal absorbs light at a specific wavelength, allowing for precise determination of its concentration in the sample.

3. Result and Discussion

3.1 Hydrochemical Laboratory Result

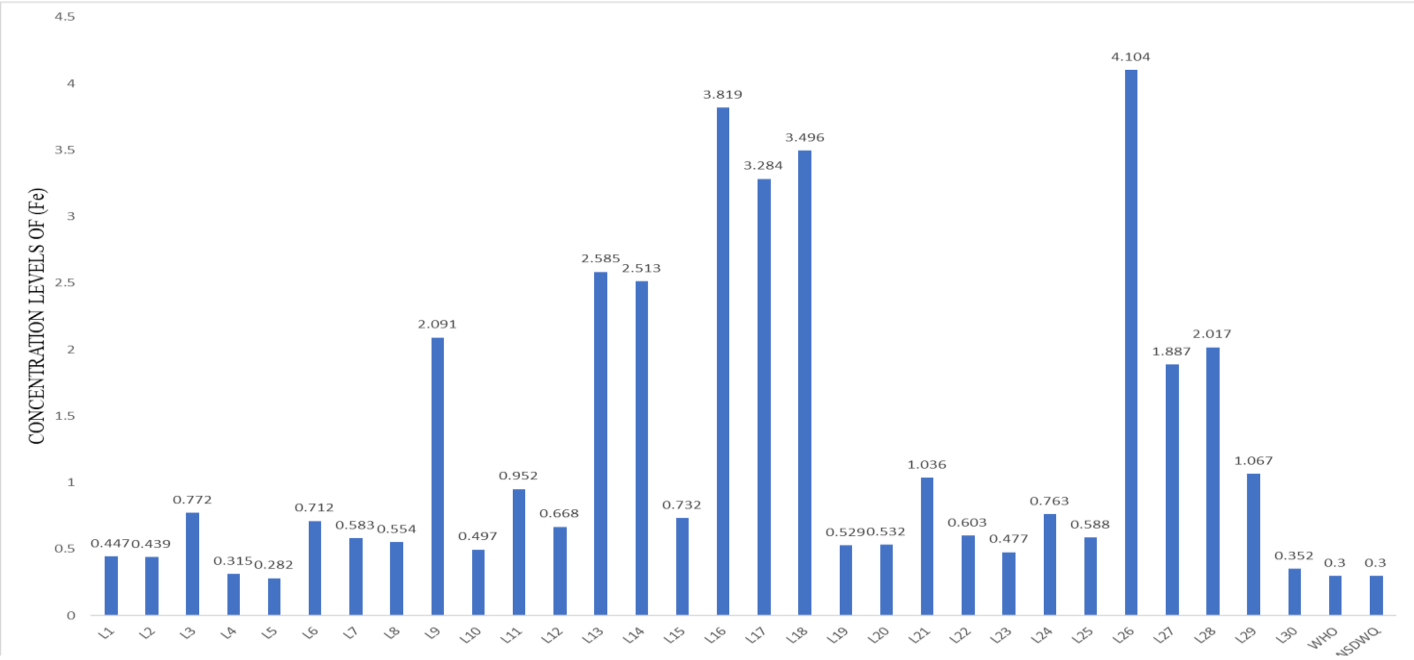
The hydrochemical result of the study area is presented in table 1.

Table 1. Hydrochemical Result of Heavy Metal within the Study Area

LOCATION	Fe	Pb	Cu	Cr	Mn	Zn	Ni	Co	Cd
L1	0.447	0.056	0.042	0.039	0.107	0.028	0.003	0.003	0.002
L2	0.439	0.054	0.034	0.033	0.102	0.021	0.003	0.003	0.002
L3	0.772	0.076	0.052	0.048	0.159	0.038	0.003	0.003	0.002
L4	0.315	0.046	0.035	0.028	0.102	0.026	0.003	0.003	0.002
L5	0.282	0.043	0.034	0.026	0.127	0.023	0.003	0.003	0.002
L6	0.712	0.062	0.042	0.037	0.153	0.032	0.003	0.003	0.002
L7	0.583	0.047	0.032	0.024	0.129	0.032	0.003	0.003	0.002
L8	0.554	0.049	0.034	0.028	0.132	0.028	0.003	0.003	0.002
L9	2.091	0.087	0.036	0.043	0.227	0.033	0.003	0.004	0.002
L10	0.497	0.048	0.027	0.023	0.108	0.023	0.003	0.003	0.002
L11	0.952	0.067	0.053	0.041	0.164	0.034	0.004	0.004	0.002
L12	0.668	0.044	0.038	0.036	0.116	0.031	0.003	0.003	0.002
L13	2.585	0.084	0.049	0.047	0.222	0.037	0.003	0.004	0.002
L14	2.513	0.097	0.05	0.048	0.216	0.036	0.003	0.004	0.002
L15	0.732	0.048	0.036	0.024	0.103	0.022	0.003	0.003	0.002
L16	3.819	0.097	0.068	0.052	0.261	0.041	0.006	0.004	0.003
L17	3.284	0.082	0.067	0.049	0.232	0.039	0.005	0.003	0.002
L18	3.496	0.086	0.072	0.046	0.227	0.042	0.005	0.004	0.003
L19	0.529	0.044	0.037	0.034	0.123	0.029	0.003	0.003	0.002
L20	0.532	0.042	0.036	0.032	0.128	0.031	0.003	0.003	0.002
L21	1.036	0.033	0.025	0.027	0.069	0.049	0.003	0.003	0.002
L22	0.603	0.039	0.028	0.021	0.086	0.034	0.003	0.003	0.002
L23	0.477	0.031	0.036	0.028	0.067	0.038	0.003	0.003	0.002
L24	0.763	0.042	0.044	0.037	0.082	0.045	0.003	0.003	0.002
L25	0.588	0.046	0.048	0.035	0.069	0.038	0.003	0.003	0.002
L26	4.104	0.081	0.061	0.058	0.164	0.056	0.005	0.004	0.003
L27	1.887	0.062	0.055	0.054	0.158	0.054	0.004	0.003	0.002
L28	2.017	0.091	0.063	0.056	0.173	0.048	0.003	0.003	0.002
L29	1.067	0.077	0.059	0.043	0.143	0.045	0.003	0.003	0.002
L30	0.352	0.031	0.024	0.023	0.057	0.034	0.003	0.003	0.002
WHO	0.3	0.01	1.0	0.05	0.4	3.0	0.07		0.003
NSDWQ	0.3	0.01	1.0	0.05	0.2	3.0	0.07		0.003

3.1.1 Iron (Fe)

The value of iron recorded in the study ranged from 0.282 to 4.104 mg/L. Sample location 16 and 26 had the highest mean value, which was above the permissible value of 0.3 mg/L. Values obtained in other sampled locations were below the recommended limits. Hence, water of this area is considered to be safe for drinking. Figure 2 showing the bar chat illustrating the variations of Fe concentration within the study area. Some location values obtained exceeded that of WHO standard limit of 0.3 mg/l making the water unsafe for drinking. Concentration of (Fe) greater than 0.3 mg/l can damage fabric paper, and corrode the inner walls of high pressure boilers (Hussen, 2020).

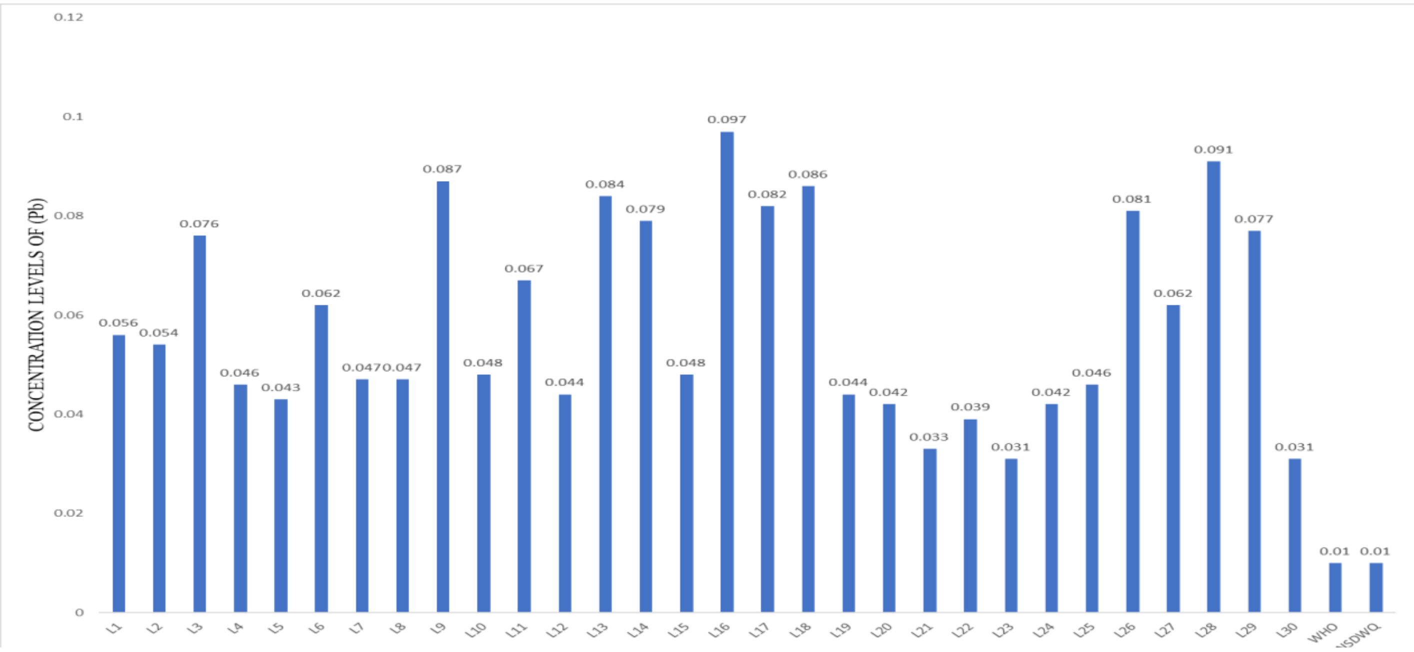


Locations

Figure 2: Spatial Distribution of Iron (Fe) Concentration within the Study Area

3.1.2 Lead (Pb)

Lead (Pb) was detected in all the sampled locations with concentrations level above the WHO limit for drinking water of 0.01 mg/l. Figure 3 shows that the values of Pb exceeded the WHO standard limit of 0.01 mg/l. This observation corroborates the findings that (Pb) concentrations were found in groundwater and could be released into the environment from anthropogenic sources related to handling of petroleum products or mechanic.



Locations

Figure 3: Spatial Distribution of Lead (Pb) Concentration within the Study Area

3.1.3 Copper (Cu)

Copper (Cu) concentrations ranged from 0.024 to 0.072 mg/las shown in figure 4. The levels of Cu in every source of water that were sampled are all below the WHO approved permitted limits. The minimum and maximum concentrations that were found where < 0.024 and 0.072 mg/l respectively.

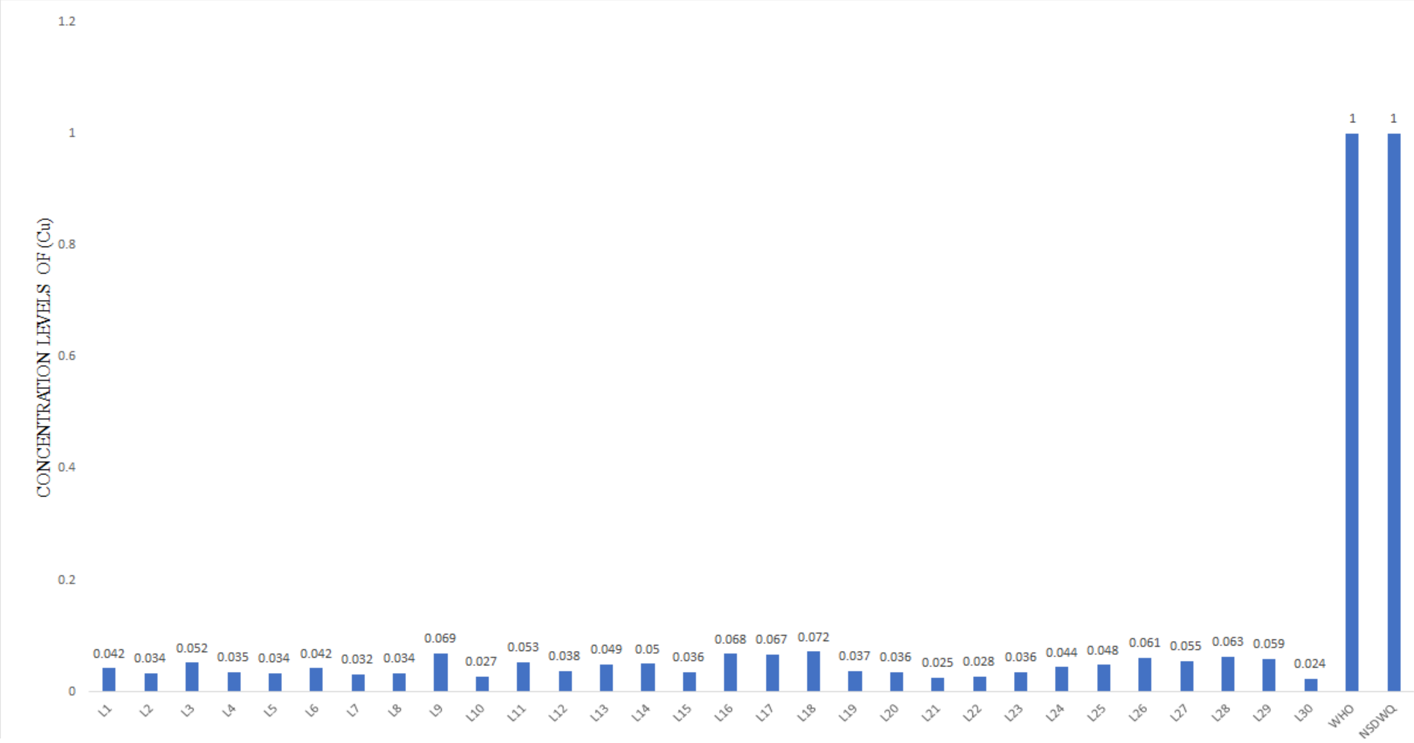
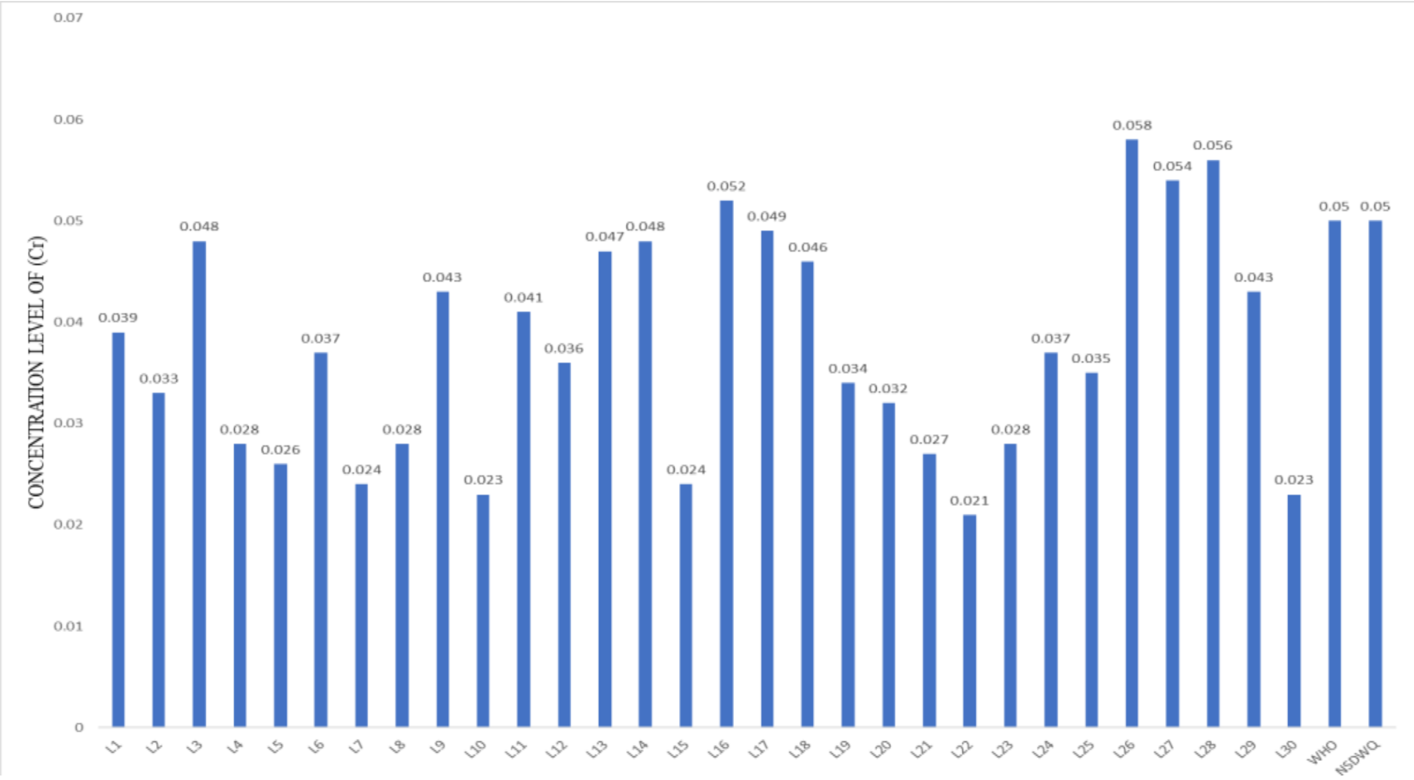


Figure 4: Spatial Distribution of Copper (Cu) Concentration within the Study Area

3.1.4 Chromium (Cr)

With a mean concentration of 0.020–0.05 mg/l. The values for the (Cr) determination ranged from 0.021 to 0.058 mg/l. The minimum and maximum concentrations of Cr were found between 0.021 and 0.058 mg/l respectively as shown in Figure 5.



Locations

Figure 5 Special Distribution of Chromium (Cr) Concentration within the Study Area

3.1.5 Manganese (Mn)

Level of concentration ranged from 0.261 to 0.057 mg/L, with sample location 16 having the highest mean value and sample location 30 having the lowest mean value. Values obtained were within the acceptable WHO limit, as shown in Figure 6.

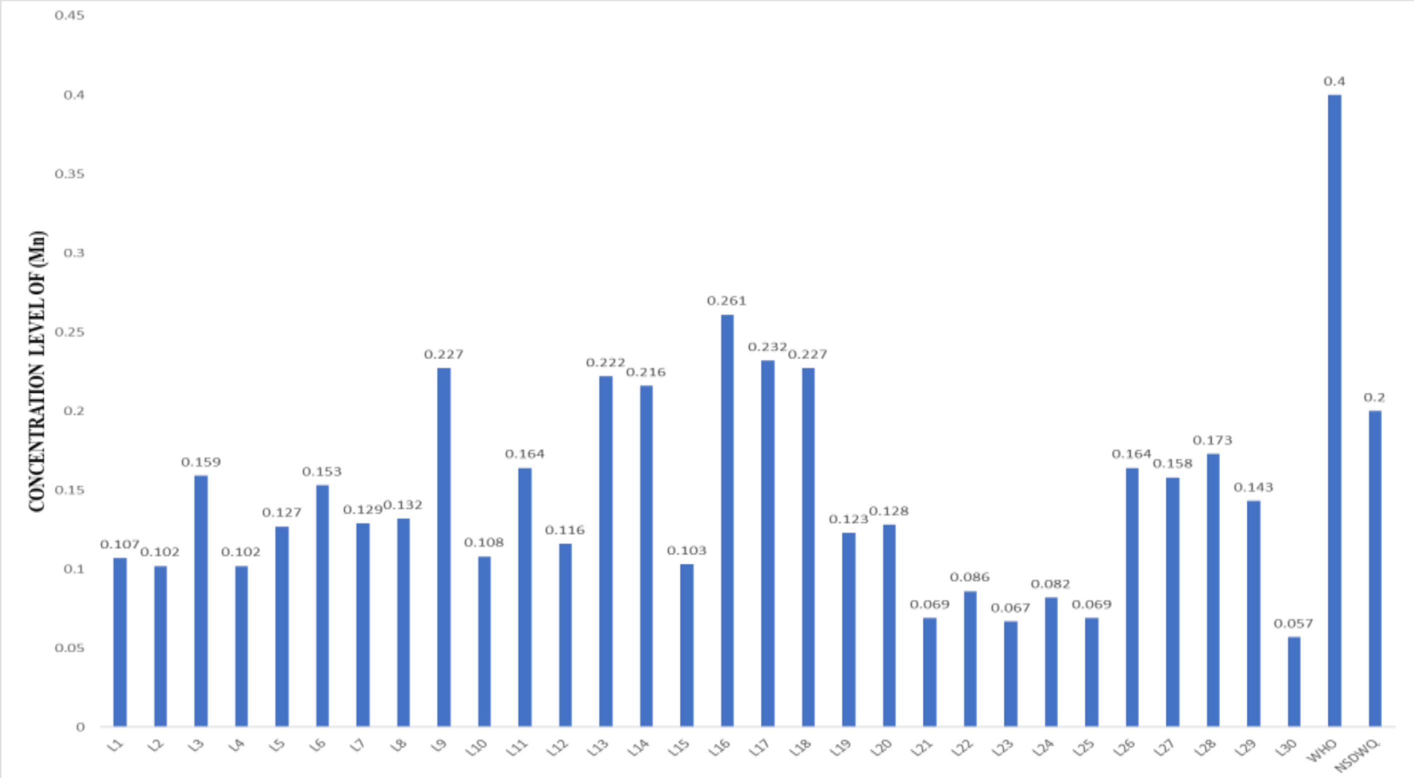


Figure 6: Spatial Distribution of Manganese (Mn) Concentration within the Study Area

3.1.6 Zinc (Zn)

The concentration level for Zn ranged from 0.021 to 0.056 mg/L. The concentrations (Zn) in all sampled locations are below WHO permissible limits. For the sampled location 2 has the lowest concentration level 0.021mg/L, while sampled location 26 has the highest concentration value of 0.056 mg/l.

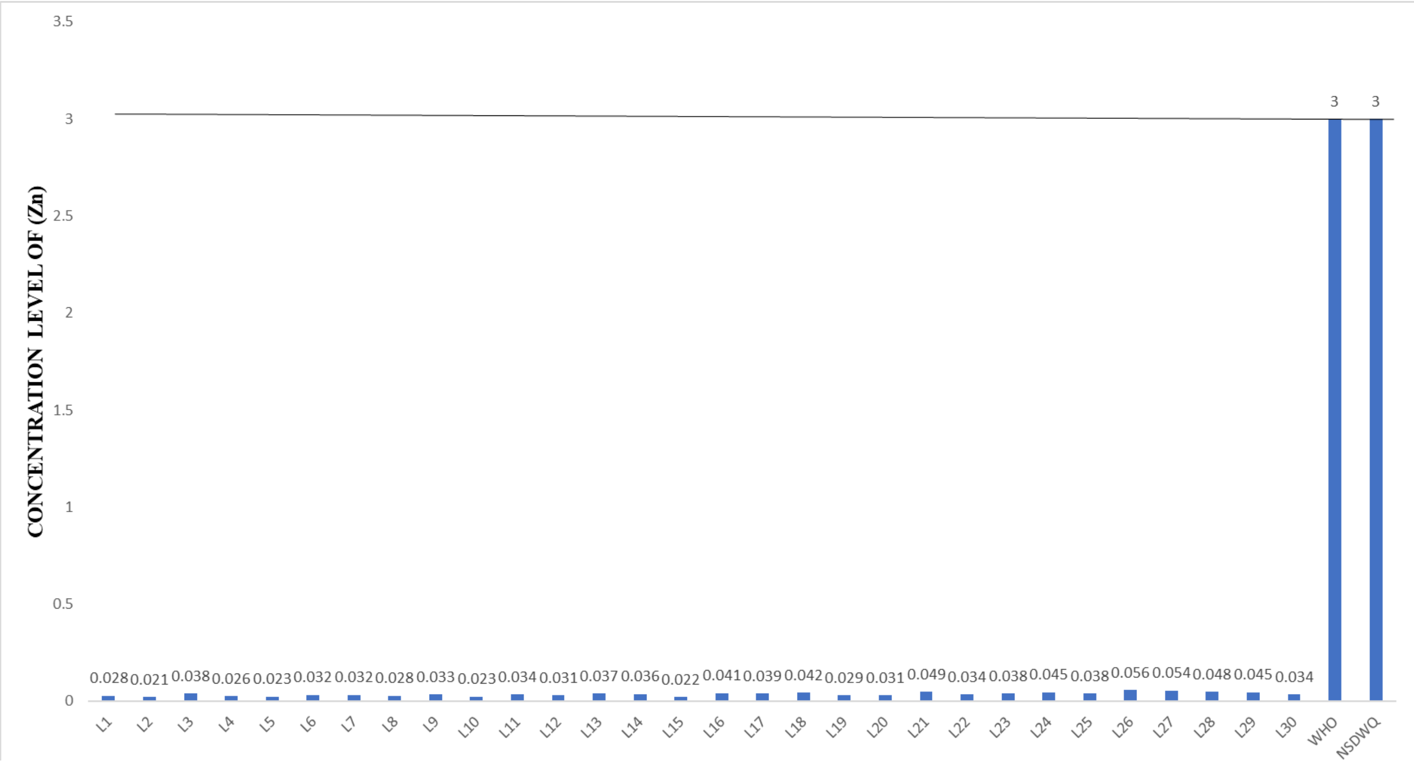


Figure 7: Spatial Distribution of Zinc (Zn) Concentration within the Study Area

3.1.7 Nickel (Ni)

Level of concentration ranged from < 0.003 to 0.006 mg/L, with about 12 sampled locations having the lowest mean value and location 16 having the highest value. The values obtained were all below the WHO acceptable limit of 0.07 figures 8.

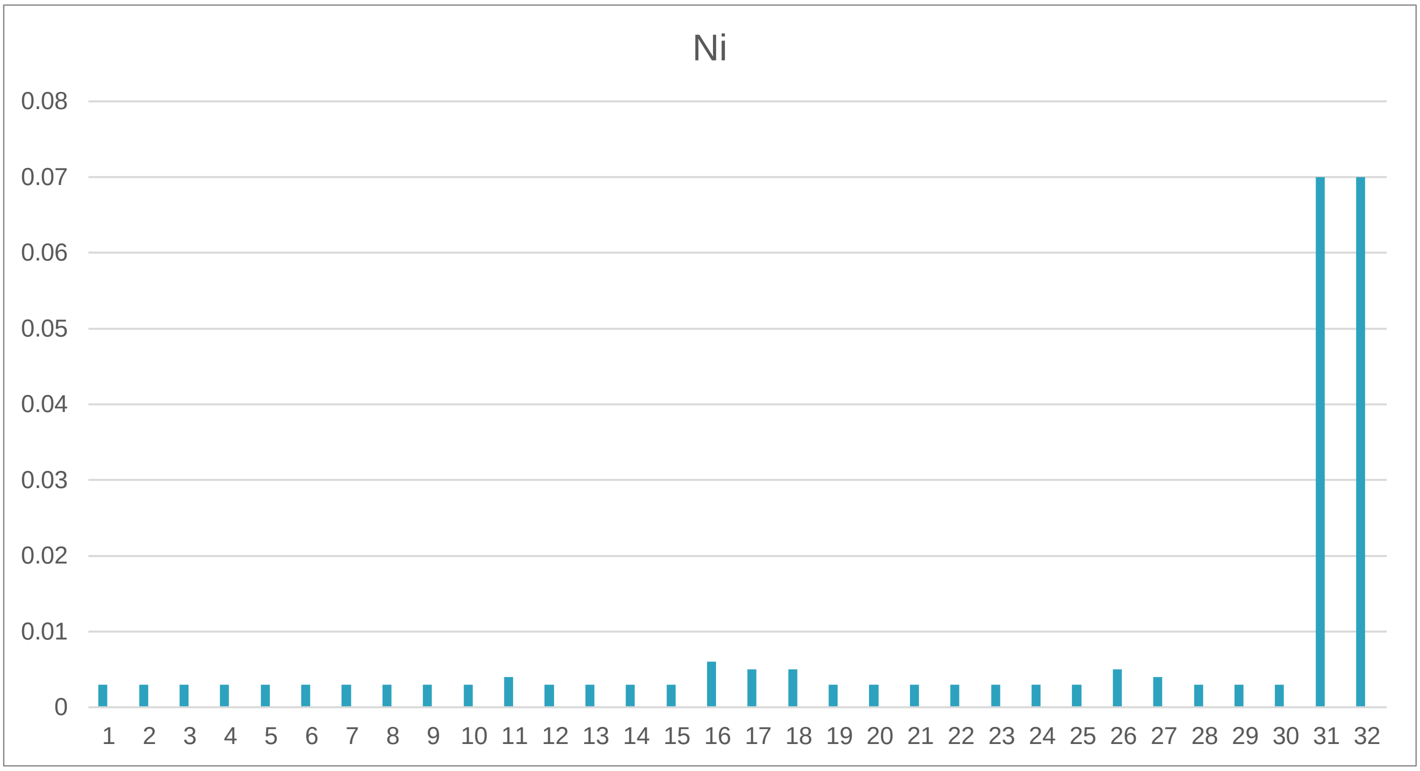


Figure 8: Spatial Distribution of Nickel (Ni) Concentration within the Study Area

3.1.9 Cadmium (Cd)

Content ranges from < 0.002 to 0.003 mg/L. All the sampled locations that were analyzed had Cd concentrations that were below the permissible range outlined by WHO. The minimum and maximum concentrations that were found were < 0.002 and 0.003 mg/l respectively, found in Figure 9.

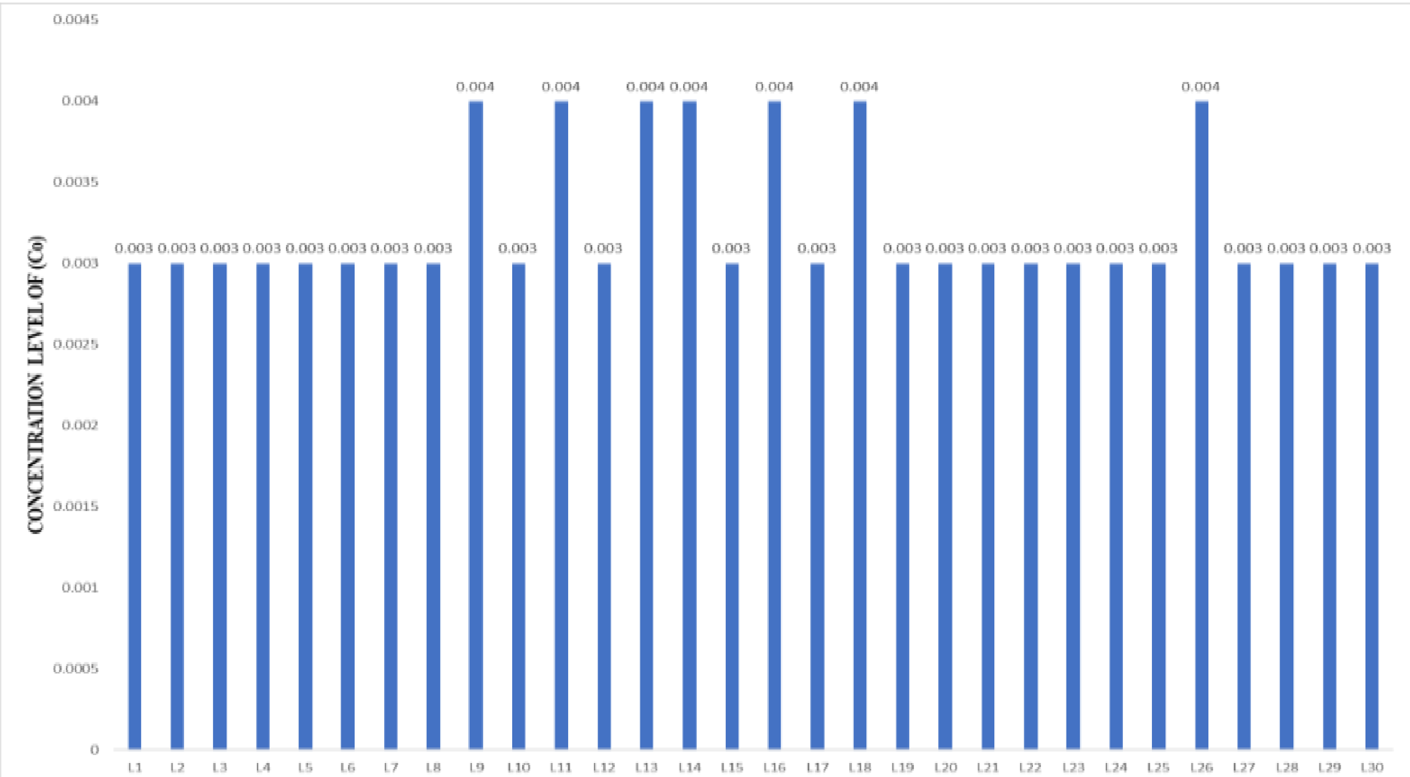


Figure 9: Spatial Distribution of Cadmium (Cd) Concentration within the Study Area

4. Conclusions

Groundwater pollution from heavy metals is a significant concern in parts of Ilorin, with industrial influence, poorly managed waste disposal sites, and other anthropogenic activities being primary sources. The findings from this study revealed that heavy metals concentration in some areas exceeds acceptable limits for human consumption, posing health risks. Heavy metals like lead, cadmium, and chromium can cause several health problems, including liver and kidney damage, and contribute to cancer risk. The health risk impacts of heavy metals, even at low concentrations, make it a required assessment for water quality determination. Hence the exact idea of water quality was determined when concentration of these elements were compared as shown in table 1, the result reveal that Fe an Pb all had high concentration when compared to W.H.O and NSDWQ acceptable limits as shown in figure 1 and 2 while Cu, Cr, Zn, and Cd across all sampled had concertation within or below the W.H.O and NSDWQ permissible limit for drinking water standard. This study demonstrates that groundwater in Ilorin, Nigeria is contaminated with heavy metals, particularly Fe and Pb, which pose potential health risks to consumers. The study suggests that necessary treatment measures must be put in place in order to make the water potable for human consumption.

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