doi.org/10.54473/IJTRET.2024.8601
International Journal of Trendy Research in Engineering and Technology
Volume 8 Issue 6 December 2024
ISSN No. 2582-0958

ASSESSMENT OF HEAVY METAL CONCENTRATION IN WATER AROUND THE IJOKODO CATCHMENT AREA IN IBADAN, OYO STATE. NIGERIA

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Received 15 July 2024 Received in Revised Form 19 July 2024 Accepted 21 July 2024

ABSTRACT

The aim of this study is to determine the levels of heavy metals and related physicochemical factors in surface and groundwater as a foundational dataset for assessing water quality for drinking and irrigation in Ijokodo area, Ibadan. Fifteen (15) water samples were gathered and evaluated for heavy metals and physicochemical characteristics using ICP-MS and standard methods, respectively. The pH of the water samples evaluated varied from 5.7 to 7.8, while the TDS levels ranged between 15 and 482 mg/L. The data indicate that the water near Ijokodo is within normal parameters. The concentration ranges of heavy metals found in water were as follows: Cr (0.011 to 0.042), Se (0.010 to 0.042), Sb (0.02 to 0.022), Ni (0.027 to 0.072), Cu (0.72 to 2.04), As (<0.01), Cd (0.003), Pb (0.01 to 0.019). These values fall under the concentration limit levels established by WHO. Hence, the presence of heavy metal toxicity in the research area is minimal which indicate surface and groundwater in the study is not contaminated. Possible baseline data include elevated levels of chromium, nickel, copper, arsenic, cadmium, Selenium, Antimony, and lead in water, as well as pH and TDS due to their heightened sensitivity to pollution. Proper monitoring and protection of both surface and groundwater from leachate pollution from nearby dumpsites in the Ijokodo catchment area is strongly advised.

Keywords: Heavy metal, Physiochemical, Water contamination, Surface water and Groundwater.

I. INTRODUCTION

Water resources are crucial for both the natural environment and human advancement, necessary for farming, manufacturing, and human survival. Therefore, water is a necessary element for the continuation of life on the planet [1]. This includes minerals that are significant for both humans and for the well-being of life on land and in water. Any changes in the quality of water could pose a threat to the survival of these organisms. Increasing human and environmental impacts greatly affect the amount and quality of water in all lake systems. The urgent need to assess and preserve water quality worldwide stems from the rising need for water due to population growth, agriculture, and industrial development, necessitating the evaluation of its chemical, physical, and biological attributes in natural water sources for healthy survival. Natural processes and human activities are the primary causes of heavy metal contamination in surface and groundwater [2,3,4,5,6]. No matter where it comes from, the rise in heavy metal levels in water is becoming a significant danger to both human health and aquatic environments [7]. The key heavy metals that pose health risks to humans are arsenic, cadmium, chromium, lead, nickel, and zinc [8,9]. If the levels of heavy metals in water surpass the limits tolerated by the environment, using this water for agricultural purposes like irrigation could harm both the aquatic ecosystem and humans body systems through the food chain [10]. For the data to be useful, it is important to acknowledge that natural forces like erosion, atmospheric deposition, volcanic activity, and forest fires can also affect the concentration of heavy metals in water [3,6]. The levels of heavy metal in water or sediments are influenced by pH, Total Dissolved Solids (TDS), as well as seasonal temperature and rainfall fluctuations in a specific area [11]. The relationship between heavy metal levels and changes in rainfall can be intricate, as stated by [12]. Ijokodo area serve a great economic importance; it provides water for domestic, agricultural, and industrial use, support subsistence and artisanal fisheries surrounded by various communities that discharge their domestic waste directly lake, water. Discharging waste from various sources into a water body can change its physical, chemical, and biological features, rendering it unsuitable for its intended use. The goal of the research is to determine the levels of heavy metals and related physiochemical properties in surface water and groundwater in Ijokodo, Ibadan, for drinking and irrigation purposes.

II. MATERIAL AND METHOD

2.1 The Study Area

The study area covers the geographical coordinates from $7^0$25'N to $7^0$28'N and $3^0$50'E to $3^0$53'E (Fig. 1) within Ibadan, Oyo State, Nigeria. The research area is located within the Precambrian basement complex consisting of quartzite, quartz-schist, and biotite-andbiotite-hornblende-gneiss (migmatite) as the primary rock formations (Fig. 2). Approximately 60% of the research site is covered by quartzschist, which creates ridges, with most of them being heavily weathered. Samples consist of minerals such as quartz, feldspar, and mica, with a medium to coarse grained texture and showing signs of joints and fractures. Geographically, Ibadan city has rolling land with quartzite ridge and Inselbergs of gneisses enclosed by nearby plains [13,14]. The Ijokodo Area catchment region experiences two different seasons: the wet season, from March to October, with an average yearly rainfall of around 1250mm, and the dry season, from November to February [13]. The speeds of the flowing water decrease in the catchment areas during the dry season. Ijokodo region sees an inflow of around four sources that contribute to its diverse discharges. Apete is located within the northeast, Eleyele in the southeast, Olopomewa in the south, and Awotan in the northwest.

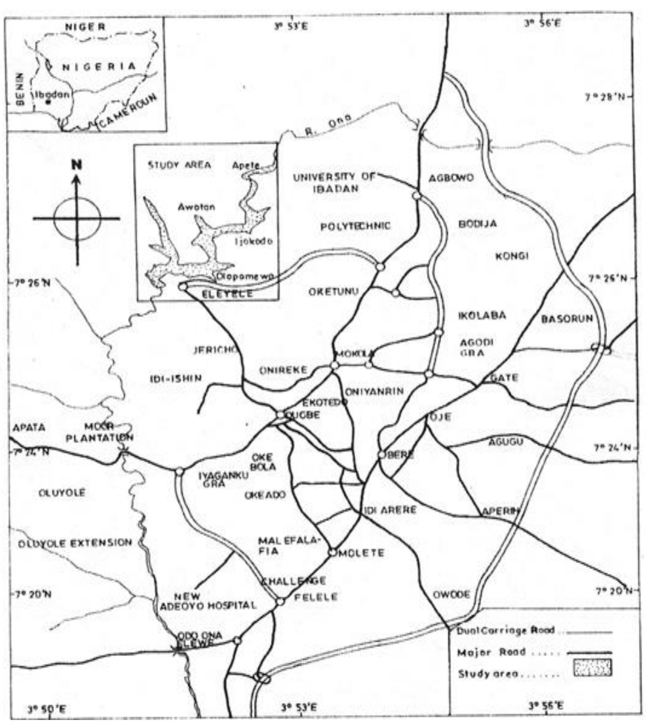

Figure 1. Map of the Study Area (Ijokodo) in Rectangle

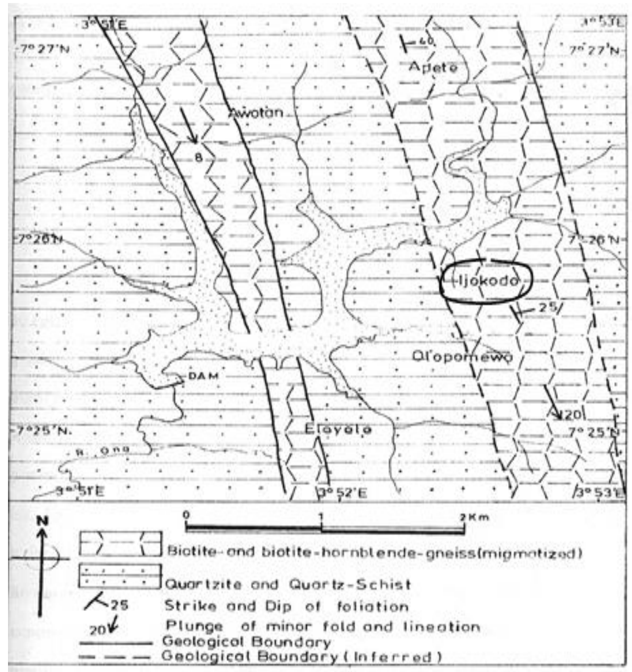

Figure 2. Geological Map of the Study Area.

2.2 Water Sample Collection and Pretreatment.

To prevent rain from affecting heavy metal levels, fifteen (15) samples of surface and groundwater were gathered. Water samples were gathered haphazardly from both the upstream and downstream sections of the Ijokodo catchment area. To prevent contamination, 1litre clear polyethylene bottles were prewashed with distilled water. Before collecting water samples at each site, the sample bottles and bailer were rinsed thoroughly with the water that would be collected. Drawing water samples using a bailer multiple times before collecting a sample enabled the collection of representative water samples with accurate heavy metal concentrations from the sampling location. In the end, a single liter of water sample was collected and placed in a clear polyethylene bottle, then stored in a cooler at 40^0C. Afterward, each sample was split into two parts. The initial part of the process involved pH and TDS evaluated following the standard protocol outlined in [15]. The additional part of the sample underwent filtration using a 0.45 µm pore size filter to eliminate unwanted substances [16] and the first part of the filtered substance was used to clean the 100 ml conical flasks used for collecting the sample. Next, 2 mL of nitric acid was added to the sample filtrate to stabilize it, preventing bacterial growth and heavy metal absorption on the container surface. After prepping, the samples were placed in a 50 mL plastic centrifuge tube, sealed, and refrigerated at 4°C for transportation to the Geoearth Project Limited's analytical lab in Nigeria.

2.3 Determination of Heavy Metal Concentrations

The heavy metal concentration was determined using the ICP-MS Thermo Scientific x Series 2, which ionizes analytes in a sample and separates and detects ions to determine metal concentration. The process consisted of two steps. Initially, the spectrometer was calibrated by injecting a multi-element standard solution into the inductively coupled plasma and the mass analyzer to produce a spectrum for creating a calibration curve. In the next step, 5 mL of deionized water was added to 5 mL of the water sample in a centrifuge vial, and the mixture was acidified with 1% w/v nitric acid to concentrate analytes within the desired range. To enhance the precision and responsiveness of the ICP-MS measurements, Rh, Re and Ge were included as internal standards in the sample solution prior to being analyzed in the ICP-MS. The identification and levels of elements were subsequently ascertained following established protocols detailed elsewhere [17]. Following this method, the spectrum produced on a Multi-Channel Analyzer (MCA) is matched against the calibration curve to detect the elements and measure their concentrations with the help of internal standards for quality assurance. The metal levels in the water samples from the research site were measured in micrograms of metal per liter of water. Because heavy metals are known to be carcinogenic to both humans and the environment, various agencies and nations worldwide have established maximum limits that should not be exceeded, with recommendations for mitigation actions. Therefore, to compare, Table 1 shows the Maximum Permissible Concentrations (MPC) of these elements in drinking water and aquatic ecosystem as well as the limits of detection.

III. RESULTS AND DISCUSSION

Tables 1 shows the information on measured physicochemical properties and heavy metal concentrations in water.

3.1 Physicochemical Properties of Water

Table 1 shows that approximately 55% of the water samples (IJ1, IJ2, IJ4, IJB8, IJ9, IJB13, IJ14, and IJ15) had acidity levels between 5.7 and 6.8, while around 45% of the samples (IJB3, IJ5, IJB6 IJB7, IJB10, IJ11, and J12) were alkaline with pH levels ranging from 7.1 to 7.8. The pH levels of 5.7 to 7.8 in the Ijokodo surface and groundwater suggest that the water being studied is within a normal range. Due to the absence of industrial air pollutants in Ijokodo, it is evident that rainfall with a pH of approximately 5.6 will not significantly impact the physio-chemical parameters listed in Table 1. Proper monitoring of pH levels is essential to guarantee effective purification and sanitization while reducing water corrosion. Exposure to high pH levels (> 11) can lead to eye, skin, and mucous membrane irritation and cause hair fibers to expand in humans. pH levels below 6.5 are considered too acidic for human consumption and may result in health issues like acidosis. The pH values provided in Table 1 serve as a reference point for evaluating heavy metal pollution in the research area. Higher TDS values were observed in groundwater samples (IJB3, JB6, IJB7, IJB8, IJB10, and IJB13) compared to surface water samples (IJ1, IJ2, IJ4, IJ5, IJ9, IJ11, IJ12, IJ14, and IJ15) as shown in Table 1. This variation is due to the extended period ground water stays in rocks, allowing heavy metals more time to dissolve compared to surface water. The elevated TDS levels in the groundwater could be attributed to the specific conditions of the surrounding area, including geological factors and land use practices.

3.2 Heavy Metal Concentrations

The concentration of chromium (Cr), Selenium (Se), Antimony (Sb), Nickel (Ni), Copper (Cu), Arsenic (As) and Cadmium (Cd) were analyzed to determine their degree of contamination in the surface and groundwater in Ijokodo catchment area in Ibadan (Fig 3 -7). In Table 1, selenium (IJ7B), Antimony (IJ10B), Nickel (IJ3B), and Copper (IJ2) shows that the water samples are slightly above the limit levels at certain sampling sites, while values of other metals at all sampling areas are below the Maximum Permissible Concentration (MPC) established by [9,18]. This data shows that the levels of heavy metals in the water at Ijokodo catchment area are below the Maximum Permissible Concentration (MPC) set by drinking water and irrigation standards, indicating that the water quality in the samples evaluated is acceptable. These values could serve as baseline information as detecting high metal concentrations at specific sampling locations above MPC indicates heavy metal pollution. The analyzed water samples from Ijokodo catchment indicates the groundwater and surface water could be used for drinking and irrigation purposes without posing any threat to the community health well-being and crop production.

International Journal of Trendy Research in Engineering and Technology
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Table 1. Sampling Locations for Surface water (IJ) and Groundwater (IJB) from the study area

Samples	pH	TDS (mg\L)	Cr (mg\L)	Se (mg\L)	Sb (mg\L)	Ni (mg\L)	Cu (mg\L)	As (mg\L)	Cd (mg\L)
IJ1	5.7	64	0.022	0.01	0.01	0.071	1.93	<0.01	0.003
IJ2	6.7	15	0.031	0.012	<0.02	0.062	2.04	<0.01	0.003
IJ3B	7.1	443.7	0.011	0.014	0.012	0.072	2.02	<0.01	0.003
IJ4	6.5	18.6	0.03	0.021	0.019	0.048	1.11	<0.01	0.003
IJ5	7.2	58.3	0.041	0.011	0.014	0.041	1.19	<0.01	0.003
IJ6B	7.1	370	0.036	0.033	0.021	0.039	0.91	<0.01	0.003
IJ7B	7.8	252.2	0.021	0.042	0.016	0.027	1.82	<0.01	0.003
IJ8B	6.2	421.9	0.042	0.041	0.018	0.022	0.72	<0.01	0.003
IJ9	6.4	117.4	0.039	0.032	0.014	0.032	2.02	<0.01	0.003
IJ10B	7.8	286.5	0.04	0.015	0.022	0.031	1.42	<0.01	0.003
IJ11	7.6	103.5	0.012	0.026	0.015	0.041	1.52	<0.01	0.003
IJ12	7.2	56.9	0.031	0.013	0.012	0.026	1.72	<0.01	0.003
IJ13B	5.8	482	0.033	0.017	<0.02	0.048	1.66	<0.01	0.003
IJ14	5.9	54.8	0.037	0.039	<0.02	0.053	0.99	<0.01	0.003
IJ15	6.6	25.7	0.039	0.014	0.014	0.069	1.82	<0.01	0.003
WHO limit	6.5-8.5	500-1000	0.05	0.04	0.02	0.07	2	0.01	0.003

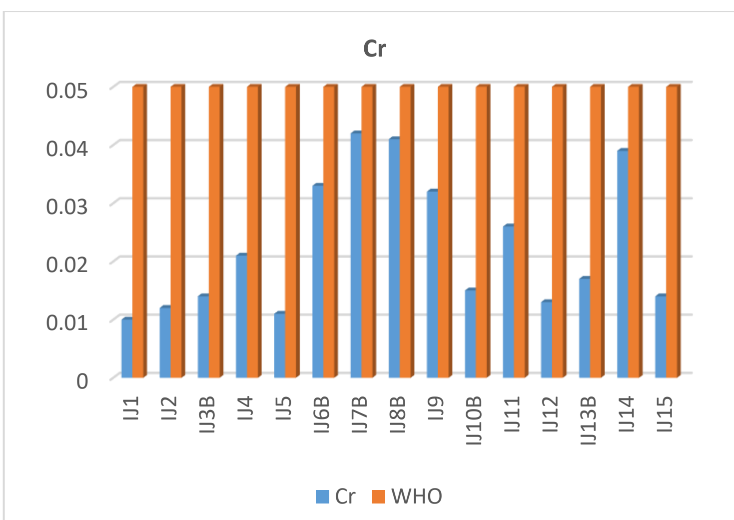

Figure 3. Chromium content in the analyzed water samples

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International Journal of Trendy Research in Engineering and Technology
Volume 8 Issue 6 December 2024
ISSN No. 2582-0958

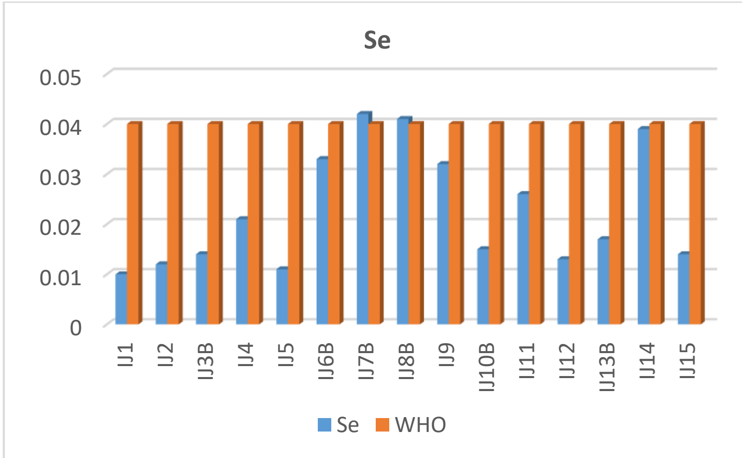

Figure 4. Selenium content in the analyzed water samples

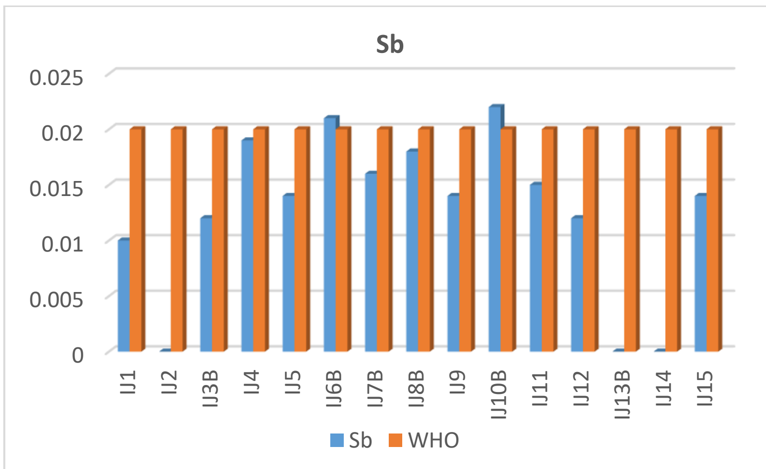

Figure 5. Antimony content in the analyzed water samples

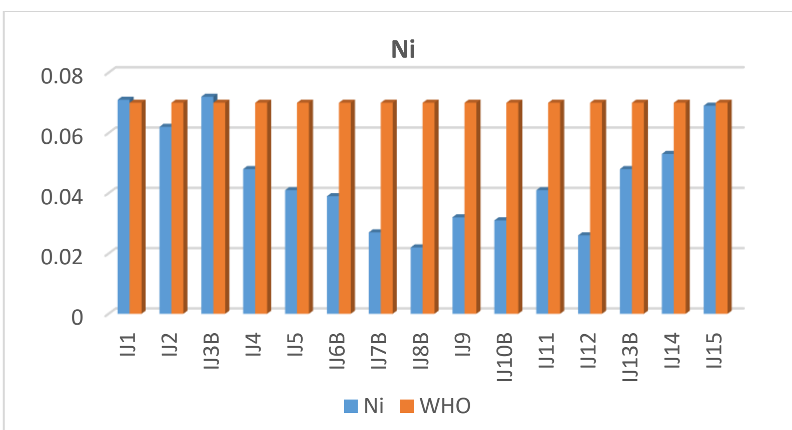

Figure 6. Nickel content in the analyzed water samples

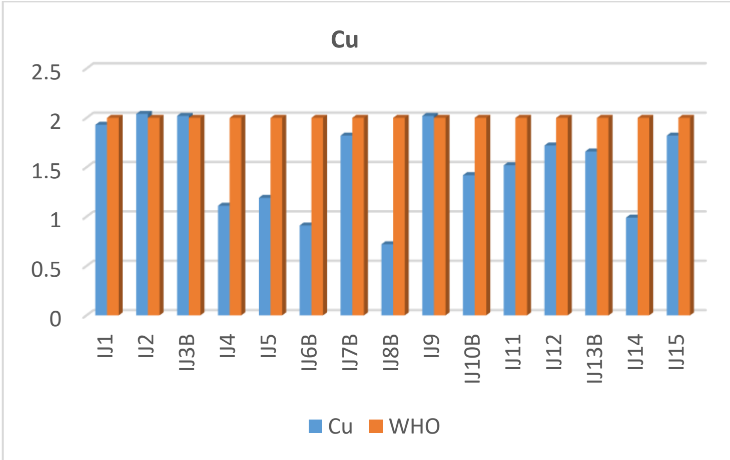

Figure 7. Copper content in the analyzed water samples

IV. CONCLUSION

Data regarding pH, TDS, and heavy metal levels in water near the Ijokodo catchment area was collected to confirm adherence to water quality guidelines for drinking and irrigation purposes. The physiochemical parameters indicate that the water near the Ijokodo catchment area is within normal range. Also, the heavy metal concentration suggests that the toxicity in the study area is minimal. It is advised to continuously monitor and safeguard both the surface and groundwater in the Ijokodo catchment area to prevent contamination from leachate from nearby dumpsites.

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