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SPATIO-TEMPORAL VARIATIONS IN THE LEVEL OF CONCENTRATIONS OF THE HEAVY METALS IN THE UNRECLAIMED MINING PONDS IN BUKURU, JOS SOUTH LOCAL GOVERNMENT AREA, PLATEAU STATE

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Abstract

This study examined the Assessment of Heavy Metals in unreclamed Mining Ponds in Jos South Local Government Area, Plateau State, Nigeria. Purposive sampling was used to select 5 sampling points in Bukuru town, Jos South Local Government Area (L.G.A) mined out areas while a sampling point was chosen in Riyom (which serves as the control) for collection of water. The sampling points were chosen because they represented the best location for collecting the water samples in the mined-out areas and also suitable for easy sampling of the current contamination status given their accessibility and geospatial spread. The result of the analysis of the water samples using the Atomic Absorption Spectrometer (AAS) for 8 heavy metals which includes cadmium, manganese, mercury, copper, nickel, lead and zinc. Mean levels of Heavy metal were 0.04356ppm, 0.046290ppm, 0.001627ppm, 0.110409ppm, 0.025214ppm, 0.020995ppm, 0 .25077ppm for cadmium, manganese, Mercury, copper, nickel, lead and zinc respectively. Results show that mean concentrations of cadmium, manganese and Lead were higher when compared with the WHO/NESREA standards. The study recommends more reclamation initiatives towards planting phytochemical plants in the unreclaimed areas especially those that can lower the chemical concentrations of heavy metals such as Cadmium and Lead which were both high in surface water in both seasons and are very hazardous to human health. More so, there should be there should be constant surveillance and review of the pollution status of the heavy metals in the unreclaimed mines in the study area in order to monitor progress and ensure compliance.

Keywords: Unreclaimed mines, surface water pollution. Heavy metals, Jos south, mining, spatio-temporal variation

1. INTRODUCTION

Mining and mineral processing activities modify the environment negatively in a variety of ways without adequate reclamation. This happens when the legislation protecting the environment are not strictly followed. Many of the countries of the world including Nigeria have no specific legislation regulating mining and mineral processing activities until mining has gone on for a long time (Carla, 2021). For example, the Jos Plateau, Nigeria where mining has been reported ever since the pre-colonial era has no specific legislation regulating mining and mineral processing activities until 1949 (Oladunni *et al*, 2015). In addition, it was also observed that these legislations are not being appropriately implemented or enforced thereby leaving many unreclaimed or abandoned mining sites which are not only environmentally unaesthetic but also constitute death traps to people and animals (Komolafe, 2002). Heavy metals contaminated water in the unreclaimed mines could also find their way into human body through ingestion when plants and aquatic animals in which they are accumulated are consumed by man and or other animals (Komolafe *et al*, 2023). Heavy metals are some of the most critical threats to the soil and water resources as well as to human health (Mafuyi *et al*, 2019). Pollution with heavy metals can affect the whole environment, but a major environmental concern and the longest effects due to anthropogenic activities are the contamination of soil and water (Waida, et al., 2022). These metals are released into the environment through mining, smelting of metal ores, industrial emissions, application of pesticides, herbicides and fertilizers. Metals, such as Cadmium, Copper, Lead, Zinc and metalloids such as Arsenic (As), are considered to be environmental metallic pollutants due to their persistence and bio-accumulative nature thereby causing serious health problems to human and other animals.

Mining is an important source of heavy metal contamination (Uzoekwe, and Mbamalu, 2020; Yaw, 2022; Lu, et al., 2024). The promulgation of the Mineral Act in 1946 (Now Nigeria Mineral Act 1999) in Nigeria for example, though paved way for the reclamation of mined out lands in the Jos Plateau like in some other parts of Nigeria however, meaningful reclamation efforts did not begin until 1949 thereby leaving many unreclaim mine dumps which are unsightly and many times constitute death traps (Komolafe, 2002). In addition, these unreclaim or abandoned mines which become mining ponds are sometimes so deep that they are recharged by groundwater, thus making them permanent water bodies with high potentials for irrigation, fisheries, water supply and recreation (Adeboye, 2012). These unreclaim mining ponds with their adjoining mine tailings are also potential source of heavy metals which are very toxic to humans. In Bukuru town, relicts of unreclaim or abandoned tin mines and tin ore processing sites abound. Mine tailings from the processing of the tin ore (often associated with Pb, ZnS ores) are disposed indiscriminately. Unreclaim mining pits which subsequently becomes mining lakes and the water used for irrigation and fishing are also potential sources of heavy metals (Lar et al., 2014). In addition, the Jos area is predominantly granitic consisting mainly of the Younger granites ring complexes overlain by basaltic volcanic rocks which have been decomposed to lateritic soil. This soil contains heavy metals such as Pb, Ni, Cd, Cu, Fe, Hg, Zn, Mn and Ar with high potential to contaminate the water and thus the plants they are used to irrigate (Lar *et al*, 2014). The water in the mining ponds can likewise contaminate the fish inside them. Vegetables and fish constitute essential diet component by contributing protein, vitamin, iron, calcium and other nutrients, which are usually in short supply thereby leading to their high demand but with their attendant high levels of heavy metals toxicity.

In addition, the Jos area is predominantly granitic consisting mainly of the younger granites ring complexes overlain by basaltic volcanic rocks which have been decomposed to lateritic soil. This soil contains heavy metals such as Pb, Ni, Cd, Cu, Fe, Hg, Zn, Mn and Ar with high potential to contaminate the environment. These toxic substances could reach human beings through various absorption pathways of ingestion, bodily contact, and diet through the soil-plant-water chain, inhalation, and oral intake. The metals accumulation and distribution in soil, water, and environment are increasing at a faster rate causing deposition and sedimentation in water reservoirs and affecting aquatic organisms (Okafor and Opuene, 2007; Mohiuddin et al., 2010). According to Nafea and Zyada (2015), high levels of Cd, Cu, Pb, and Fe can act as ecological toxins in aquatic and terrestrial ecosystems. Heavy metals are potentially harmful to humans and various ecological receptors due to their toxicity, persistence, bio-accumulative characteristics, and their nonbiodegradable nature (Yaw, 2022). Toxic metals can cause different health problems depending on the type of the metal concerned, its concentration, and oxidation state (Uzoekwe, and Mbamalu, 2020; Yaw, 2022; Lu, et al., 2024). Authors have also argued that heavy metals among the most toxic and persistent pollutants in freshwater systems (Okafor and Opuene, 2007; Mohiuddin et al., 2010). Certain heavy metals and metalloids are toxic and can cause adverse effects and severe problems such as oxidative stress by formation of free radicals even at low concentrations (Mudipalli, 2008; Ali et al., 2013).

Heavy metals contamination can result in several diseases and deformities; for instance, in the 1950s, an advanced country such as Japan was devastated by heavy metal poisoning known as the Fetal Minamata Disease, which resulted from contamination of fishes by organic mercury. The situation led to severe nerve damage of newborn babies from pregnant women (Harada, 1995). In Iraq, babies walked at later age due to consumption of organic mercury contaminated grains by pregnant mothers. Similar incidence occurred in Faroe Islands where school children scored lower grades on brain function test due to consumption of mercury-contaminated whale meat by pregnant women (Debes et al., 2006). In March 2024, Nigeria reported cases of suspected heavy metal poisoning in Sokoto State. About a month later, neighboring Zamfara State reported similar incidents, prompting an investigation by the Nigeria CDC on May 20, 2024, which led to the activation of the Emergency Operations Centre (EOC) for an effective response (AfricaCDC, 2024). According to the report, in the Epidemiological Week 23, (seven days of assessment), 847 suspected cases had been reported, with 95 confirmed and 42 deaths (Case Fatality Rate: 5.0%). The majority, 697 (82.3%) of the suspected cases were children aged 0-14 (AfricaCDC, 2024). Another study aimed at assessing heavy metal bioaccumulation in spinach, jute mallow, and tomato in farms within Kaduna State revealed that the concentrations of heavy metals in agricultural soil samples were generally higher than the World Health Organization/Food and Agriculture Organization of the United Nations (WHO/FAO) maximum permissive limits for lead and cadmium, but lower for nickel (Ni) and chromium (Cr) (John and Kakulu, 2012). The mean concentrations of heavy metals in vegetables were found to be above the permitted limits for all the heavy metals, except nickel. Audu and Lawal (2005), in their investigation of the variation of metal contents of irrigated vegetable farms in Kano metropolis, found relative abundance of heavy metals in the farm produce followed the sequence Fe > Zn > Mn > Cu > Ni > Pb > Co > Cr. The above findings and concern for public health safety calls for urgent attention and continuous monitoring of environmental biomarkers and pollution indicators especially since heavy metals are non-biodegradable toxins and have the capacity to accumulate in the environment and the human body, causing severe and chronic health problems. More so, such monitoring does not only ensure compliance to standards, it help promote public and environmental safety by enabling rapid detection and remediation of contaminated water and soil before widespread harm occurs, preventing chronic diseases and ecosystem degradation. This study therefore aimed at spatial temporal monitoring of heavy metals concentrations from unreclaimed mining Ponds of Bukuru in Jos South Local Government Area, Plateau State.

2. MATERIALS AND METHODS

The Study Area

Bukuru town is in Jos South Local Government Area, Plateau State in North Central Nigeria as shown on Figure 1. Jos South is bordered in the north by Jos North and part of Bassa Local government Areas, Plateau State, in the east by Jos East and Barkin-Ladi Local Government Areas, in the south by Riyom Local Government Area and in the west by parts of Riyom and Bassa Local Government Areas. Jos South L.G.A is located within latitude 9^0 54' N and longitude 08^0 52' E as shown on Figure 1. The study area is accessible with a major road, minor and secondary roads. The major road is Jos-Bukuru express Road. The minor roads include Rayfield- Bukuru, and Jos-Riyom roads.

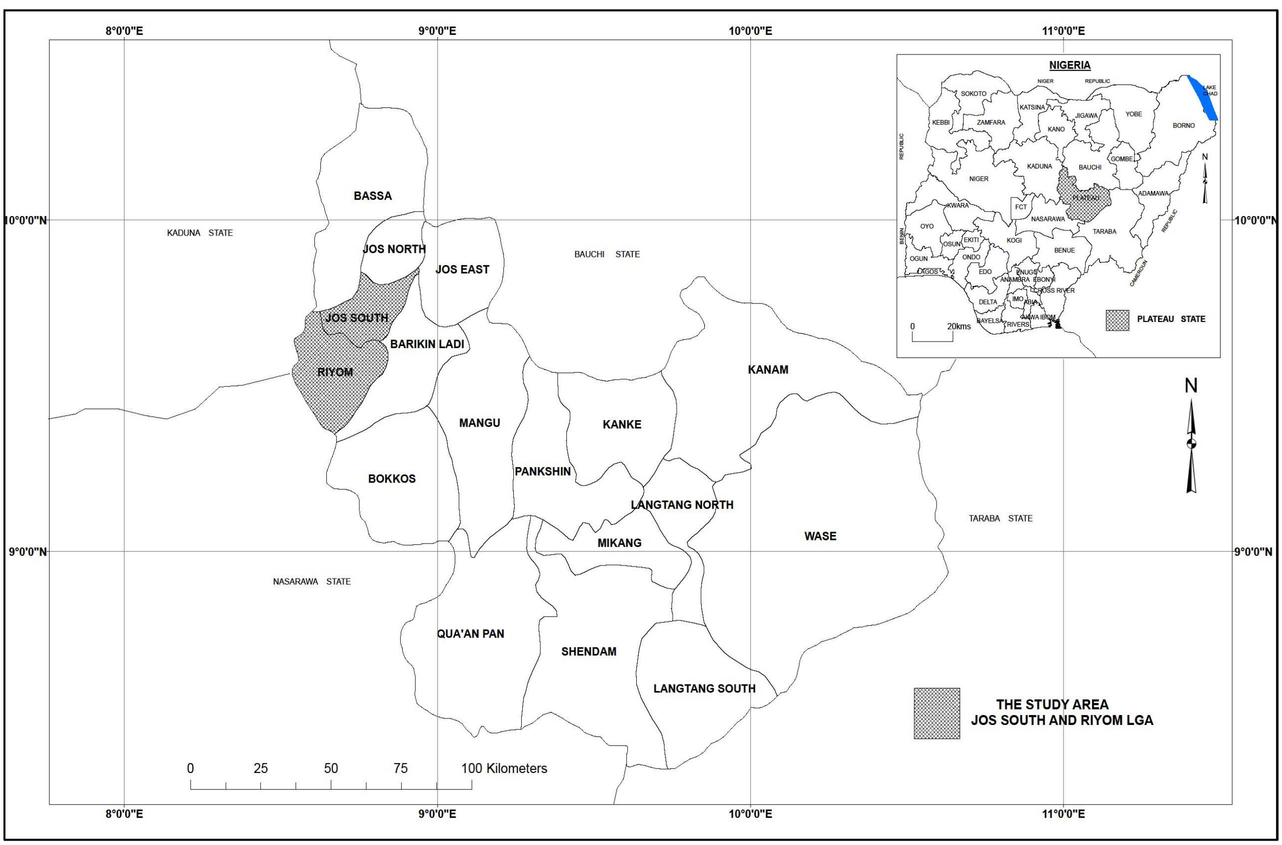

Figure 1: Jos South and Riyom Local Government Area.
Source: Geography Department NDA Kaduna (2018).

Method of Data Collection

A total of Five (5) representative unreclaim ponds were purposively selected in unreclaim mined out ponds of Bukuru while a point was selected in Riyom, Riyom L.G.A which serves as control. Samples of water were taken in each of the 5 selected sampling points in Bukuru, while a sample of water was collected from the control point in Riyom (control point) as shown on Figure I. The sampling points were chosen because they represented the best location for collecting the water samples in the mined-out areas and also suitable for easy sampling of the current contamination status given their accessibility and geospatial spread. At each of the sampling points, a GPS was used in recording the geographical coordinates of the location.

Sample Collection Technique

Eleven (11) water samples were collected in Bukuru for each of March and November while one (1) sample was collected in the control point in Riyom in the dry season. The surface water samples were collected in December 4th to 6th, 2020 and March 4th to 6th, 2021 representing the dry season while the samples for the raining season were collected in May 1st to 3rd and August 5th to 7th, 2021. The surface water samples were collected between 7 a:m to 11.30 a:m and 4 p:m to 6 p:m on the days of sample collection using four (4) plastic rubbers. The surface water samples were collected at these times to prevent the sampler and the samples from the harsh weather condition that may affect the quality of the samples. The sampling plastic rubbers were disinfected with methylated spirit and thoroughly rinsed with the sample water to ensure no contaminant is introduced into the sample as recommended by EPA (2016). Two percent (2%) of HNO3 - Trioxonitrate (v) acid – was added to the water to reduce the chances of precipitation. The water samples were collected using grab sampling method by dipping a 500 ml plastic bottle 30 cm below the water surface at each selected sampling point away from the edge of the pond. The sample bottles were labelled with appropriate source and date of collection before being transported to the laboratory of the Kaduna State Environmental Protection Agency (KEPA) where they were stored for analysis.

Sample Preparation

The water containerized and labeled before being taken to the laboratory for analysis. 50ml thoroughly shaken water samples from each sampling points were measured accurately into a beaker and digested with 5ml of concentrated HNO_3 for a few hours on a hot plate at 100^oC till the solutions were reduced to less than 20ml by volume. The solutions were then transferred to 100ml plastic container and taken for heavy metals determination on Atomic Absorption Spectrometer (AAS).

Analytical Technique

The Atomic Absorption Spectroscopy (AAS) method was used because of the accuracy, simplicity, reliability and cost effectiveness. All analytical method based on Atomic Absorption Spectrometer (AAS) are specific. This is because absorption lines are narrow, and transition energies are unique for each element. The heavy metal samples were determined using Bulk Scientific Model 200H Atomic Absorption Spectrometer with an air acetylene flame. Principally the equipment consists of a light source (hollow cathode lamp) compartment, a sample aspiration, a flame silt opening, lenses, monochromatic and detector. Light from the hollow tube with a particular wave length of maximum absorbance of atom of metal element to be analyzed is allowed to pass through the flame in which a spirit rated samples is atomized. A long narrow flame is desirable to put adequate number of atom into light path. The monochrome (a prism or grating) separates the wave length of light of interest out and directs it to photocell (photomultiplier) of the detector measurement. The higher the concentration of atom, the greater the absorbance of light by the atom, and therefore the lesser the fraction of the light being transmitted across the other end of flame. A comparison of the photocell reading for the samples and those for the standard solution gives the concentration of the element in the curve constructed on arithmetic graph paper or by calculation.

3. RESULTS AND DISCUSSION

The results of the laboratory analysis of the water samples collected from the 11 sample locations in Bukuru with the control point in Riyom in the dry and wet seasons as shown on Tables 1 and 2.

Table 1: Concentration of heavy metals in surface water in Bukuru and the Control Point in Riyom in the dry season.

Water Dry Season	Cadmium (Mg/L)	Manganese (Mg/L)	Mercury (Mg/L)	Copper (Mg/L)	Nickel (Mg/L)	Lead (Mg/)	Zinc (Mg/L)
1 Bukuru	0.0001	0.07	0.0001	0.45	0.011	0.0024	0.074
2 Bukuru	0.018	0.018	0.017	0.21	0.12	0.046	0.267
3 Bukuru	0.044	0.06	0.0005	0.023	0.012	0.012	0.074
4 Bukuru	0.06	0.08	0.0001	0.013	0.025	0.020	0.78
5 Bukuru	0.04	0.06	0.0006	0.021	0.022	0.013	1.054
6 Bukuru	0.07	0.05	0.0006	0.04	0.0001	0.011	0.80
7 Bukuru	0.12	0.015	0.0011	0.06	0.024	0.007	0.031
8 Bukuru	0.05	0.043	0.004	0.18	0.025	0.045	0.223
9 Bukuru	0.04	0.056	0.0014	0.055	0.035	0.080	0.26
10 Bukuru	0.12	0.063	0.0061	0.62	0.022	0.012	0.22
11 Bukuru	0.06	0.11	0.0001	0.15	0.017	0.061	0.10
Riyom (Control)	0.0099	0.0031	0.0001	0.0026	0.0013	0.0001	0.029
NESREA	0.01	0.2	0.001	1	0.1	0.01	3

Source: NESREA (2021) and Field work, 2021

Table 2: Concentration of heavy metals in surface water in Bukuru and the Control Point in Riyom in the raining season.

Water Raining Season	**Cd (Mg/L)**	**Mn (Mg/L)**	**Hg (Mg/L)**	**Cu (Mg/L)**	**Ni (Mg/L)**	**Pb (Mg/L)**	**Zn (Mg/L)**
1Bukuru	0.0037	0.071	0.0001	0.016	0.0068	0.0015	0.26
2 Bukuru	0.0042	0.018	0.0001	0.066	0.0044	0.019	0.25
3 Bukuru	0.035	0.032	0.0001	0.052	0.0016	0.025	0.059
4 Bukuru	0.060	0.038	0.0017	0.056	0.064	0.011	0.033
5 Bukuru	0.041	0.041	0.0001	0.046	0.012	0.012	0.14
6 Bukuru	0.049	0.032	0.0016	0.046	0.016	0.011	0.043

7 Bukuru	0.012	0.025	0.0001	0.066	0.048	0.013	0.27
8 Bukuru	0.051	0.029	0.0001	0.059	0.025	0.025	0.048
9 Bukuru	0.064	0.088	0.0001	0.115	0.012	0.011	0.061
10 Bukuru	0.012	0.0084	0.0001	0.024	0.047	0.012	0.22
11 Bukuru	0.0044	0.011	0.0001	0.061	0.0048	0.012	0.25
Riyom(Control)	0.0002	0.0011	0.0001	0.0021	0.0006	0.0001	0.0028
NESREA	0.01	0.2	0.001	1	0.1	0.01	3

Source: NESREA (2021) and Field work, 2021.

The concentration of cadmium are relatively high in all the sampling points for both seasons, when compared with the NESREA standard of 0.01 mg/l and the Control value of 0.0099 mg/l (Table 1). The point with the highest concentration in Bukuru is Point 10 (Abbatoir Junction-Phototec) being 0.12 mg/l while Point 1(ECWA Farm) is the lowest being 0.0001 mg/l. The relatively high levels of Cadmium may be attributed to the high concentration in the sediment and other natural and anthropogenic activities such as weathering, erosion and mining. This is in agreement with Oladunni (2015) who said there is a correlation between the Gyel-Bukuru ore and the surface water in the abandoned mines. In rainy season on the other hand sampling Point 9 (Gwafan 1/ECWA FC 1) in Bukuru has the highest concentration of 0.064 mg/l while Point 1 (ECWA Farm 1) has the lowest concentration of 0.0037 mg/l (Table 2). The high concentration of Cadmium in most sampling points in the raining season can also be attributed to the high concentration in the sediment due to mining and other possible anthropogenic sources of discharge into the environment in agreement with Carla (2021) and Waida *et al* (2022). From Table 1, the concentration of Mercury was low for both seasons in most of the sampling Points in Bukuru when compared with the NESREA standard of 0.001 mg/l and the Control point value of 0.0001 mg/l. The point with the highest concentration is Bukuru Point 2 (Behind ECWA Farm 1) being 0.017 mg/l while Bukuru Point 11(Gwafan 2/ECWA FCT 2) is the lowest being 0.0001 mg/l. The low concentration of Mercury in the surface water samples in Bukuru may be attributed to its absorption in the tissues of fish or other aquatic animal in the abandoned mine ponds in agreement with Aderibigbe *et al* (2024). In rainy season, Point 4 (Behind ECWA Farm 1) has the highest concentration of 0.0017 mg/l while Points 1, 2, 3 and 9 (ECWA Farm 1, ECWA Farm 2, Behind Yelwa Club Junction and Gwafan 1/ECWA FC 1) have the lowest concentration of 0.0001 mg/l (Table 2). The low concentration of Mercury in the surface water in Bukuru during rainy season may be attributed to it presence from a secondary source from storm water and this is in agreement with Oladunni *et al* (2015). Its absorption in the tissues of the aquatic animals in the surface water (as earlier mentioned) in agreement with Aderibigbe *et al* (2024) may be another reason. There is a considerable low concentration of copper in all the sampling points for both seasons when compared to the NESREA standard of 1 mg/l and the Control point value of 0.0026 mg/l in the surface water samples. The point with the highest concentration in Bukuru is Point 1(ECWA Farm 1) being 0.45 mg/l while Bukuru Point 4

(ECWA Farm 1) is the lowest being 0.013 mg/l. The low concentration of copper in the water samples in dry season may be attributed to its uptake as macro nutrient since it is relatively high in the sediment samples in the sampling location as also claimed by Mafuyi et al (2019). Sampling point 9 (Gwafan 1/ECWA FC 1) has the highest concentration in Bukuru being 0.115 mg/l while Point 1 (ECWA Farm 1) has the lowest concentration of 0.016 in rainy season (Table 2). The low concentration of copper may be attributed to its dissolved nature in water according to Mafuyi *et al* (2019). The concentration of Nickel in dry season was low in all the sampling points and the control except point, when compared with NESREA standard of 0.1 mg/l and the Control point value of 0.0013 mg/l. The point with the highest concentration in dry season is point 2 (ECWA Farm 2) being 0.12 mg/l while Point 6 (Zawan Junction) is the lowest being 0.0001 mg/l. The low concentration of Nickel in the surface water samples can be attributed to its uptake as macro nutrient since it is relatively high in the sediment samples in accordance with Mafuyi et al (2019).in the rainy season, the highest concentration in rainy Point 4 (Behind ECWA Farm 1) being 0.064 mg/l while the lowest is 3 (Behind Yelwa Clud junction) being 0.002 mg/l (Table 2). The concentration of Lead was high in most of the sampling points across the two seasons, when compared with NESREA standard of 0.01 mg/l and Control point value of 0.0001 mg/l. Point 11 (Gwafan 2/ECWA FCT 2) has the highest concentration being 0.061 mg/l while Point 1 (ECWA Farm 1) is the lowest being 0.0024 mg/l (Table 1). The low concentration of Lead may be attributed to its absortion in the tissues of fish or other aquatic animal in the abandoned mine ponds as also reported by Aderibigbe *et al* (2024). In the rainy season, the highest concentration in Bukuru is Sampling Point 3 (Behind Yelwa Clud junction) being 0.025 mg/l while Point 1 (ECWA Farm 1) has the lowest concentration being 0.002 mg/l (Table 2). The high concentration of Lead may be attributed to the mining activities in the area in agreement with Collins (2022) who claimed that lead is easily accumulated in contaminated surface water in aquartic and humans. The concentration of Zinc on the other hand was low in all the sampling points when compared with NESREA standard of 3 mg/l and the Control point value of 0.029 mg/l. The point with the highest concentration in dry season is Point 5 (ECWA Family Church) being 1.054 mg/l while Bukuru Point 1 (ECWA Farm 1) is the lowest being 0.074 mg/l. This is not unusual since the concentration of Zinc is also low in the sediment samples. The low concentration of Zinc in the surface water is anticipated since it is also low in the. The low concentration of Zinc in the surface water and sediment may be attributed to its uptake as macro nutrient by plants in consonance with Mafuyi *et al (*2019) who claimed that heavy metals such as Zinc are often being absorbed by plats during irrigation. For the rainy season, sampling Point 7 (Bukuru By Pass – D.B Zang) in Bukuru has the highest concentration of 0.27 mg/l while Sampling Point 4 (Behind ECWA Farm 1) has the lowest concentration of 0.033 mg/l. The low concentration of Zinc in the surface water samples in both dry and raining seasons may be attributed to its low concentrations in the sediment as also observed by Waida (2022) and Sangeetha (2022).

Health Implications of Heavy Metals in Unreclaim mine ponds of Bukuru and Rayfield

The mean values of the concentrations of each of the heavy metals in the water of the unreclaim mining ponds of Bukuru were compared with World Health Organization (WHO) and National Environmental Standards and Regulations Enforcement Agency (NESREA) guidelines for water in order to ascertain the pollution status of these heavy metals and their implications on humans' health. The mean concentrations of cadmium, Manganese and Lead were higher when compared with the WHO/NESREA standards Table 3.

Table 3: Comparisons of Observed Values of Levels of the heavy metals in water with WHO and NESREA Standards

Parameters	Mean (ppm)	WHO (ppm)	NESREA (ppm)
Cadmium	0.04356	0.003	0.001
Manganese	0.046290	0.04	
Mercury	0 .001627	0.05	0.006
Copper	0.110409	2	0.01
Nickel	0.025214	0.07	0.1
Lead	0.020995	0.01	0.1
Zinc	0 .25077	3	0.2

Source: Fieldwork, 2019.

Since the water in unreclaim mining ponds in Bukuru are used for fishing, irrigating and domestic purposes, it is of great concern that Cd is in high concentration because it is extremely toxic and carcinogenic (Vivian *et al* 2012). The consumption of water with high concentration of Cd can cause adverse health effects to end users since Cd has been found to be toxic to fish and other aquatic organisms which conform to similar reports of Falusi and Olanipekun (2007). Cadmium is extremely toxic even in low concentrations, and will bio-accumulate in organisms and ecosystems and it has along biological half-life in the human body ranging from 10 to 33years. Cadmium is considered no-essential for living organisms and long-term exposures to Cadmium also induces renal damage, cancer and increased blood pressure (Chaitali and Jayashree, 2013). The known fatal effects of heavy metal toxicity in drinking water include damaged or reduced mental and central nervous function and lower energy level. The also cause irregularity in blood composition, badly effect vital organs such as kidneys and liver (Sher, et al., Ahmad, 2011). The long-term exposure of these metals result in physical, muscular, neurological degenerative processes that cause Alzheimer's disease, Parkinson's disease (degenerative disease of the brain), muscular dystrophy (progressive skeletal muscle weakness), multiple sclerosis (a nervous system disease that affects brain and spinal cord) Chaitali and Jayashree, 2013). Lead on the other hand is an environmental toxicant (Yu et al., 2023). High levels of lead exposure can lead to hypertension and renal failure by (Batuman et al., 1983). Lead enters the body primarily through inhalation and ingestion. Many studies have reported that environmental lead exposure has been linked to hypertension (Staessen et al., 1984, Staessen et al., 1996; Yang et al., 2018), renal dysfunction (Mujaj et al., 2018) or cardiovascular disease (Yang et al., 2017; Yu et al., 2019). In addition, cadmium and lead can be transported to the human body via inhalation of urban soils, because soil can also be easily lifted into the air by wind or human feet, producing airborne particles that can pose a potential health risk through inhalation (Yuswir, et al., 2015). Cadmium and lead are classified as hazardous elements to human health, as noted earlier. The International Agency for Research Cancer has categorised Cd as a human carcinogen (IARC) (Chen, et al., 2016).

4. CONCLUSION AND RECOMMENDATION

This study examined the spatio-temporal levels of Heavy Metals in Unreclamed Mining Ponds in Jos South Local Government Area, Plateau State, Nigeria. A purposive sampling was used to select 5 sampling points in each of Bukuru and Rayfield Local Government Area (L.G.A) mined out areas while a sampling point was chosen in Riyom (which serves as the control) for collection of water samples. The result of the analysis of the water samples using the Atomic Absorption Spectrometer (AAS) for 8 heavy metals which includes cadmium, manganese, mercury, copper, nickel, lead, and zinc. Results show that mean concentrations of cadmium, manganese and Lead were higher when compared with the WHO/NESREA standards. Since the water in unreclaim mining ponds in Bukuru are used for fishing, irrigating and domestic purposes, any of the heavy metals in high concentration such as Cd, Mn and Pb could be of a serious health concern because they are extremely toxic and carcinogenic. In view of the importance of water to the sampled communities and for the fat that these unreclaim mine pits are used for agriculture and fishery, it is necessary to ensure regular monitoring of the pits water and fish meant for consumption for the purpose of public safety.

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