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# ASSESSMENT OF HEAVY METAL CONTAMINATION IN DRINKING WATER SOURCES AT FEDERAL UNIVERSITY OF LAFIA, NIGERIA: IMPLICATIONS FOR PUBLIC HEALTH AND WATER RESOURCE MANAGEMENT

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## ABSTRACT

*This study evaluated the concentrations of heavy metals—Copper (Cu), Chromium (Cr), Cadmium (Cd), Zinc (Zn), and Lead (Pb)—in drinking water sources across the Federal University of Lafia, Nigeria. Water samples were collected from male hostels, female hostels, and the mosque, then analyzed using Atomic Absorption Spectrophotometry. Results showed elevated levels of Pb (0.019 ± 0.041 mg/L) and Cu (0.099 ± 0.007 mg/L), particularly in the boys' hostel. Chromium was least detected, while Zn and Cd appeared at moderate, consistent levels across all sites. Although concentrations were largely within WHO permissible limits, the presence of toxic metals raises public health concerns and emphasizes the need for regular water quality surveillance and infrastructural improvements on campus. It is recommended that periodic water treatment and maintenance of distribution systems be enforced to minimize contamination risks.*

***Keywords**: Heavy metals; FAAS; WHO guidelines; Nigeria; water contamination.*

## INTRODUCTION

Heavy metals are defined as metallic elements with high density relative to water. They include not only metals but also toxic metalloids like arsenic, which can induce adverse health effects even at low exposure levels (Gupta et al., 2017). Growing global concern surrounds environmental contamination by heavy metals due to their increasing presence from industrial, agricultural, domestic, and technological sources (ATSDR, 2008; Fergusson, 1990). According to Fergusson (1990), these metals originate from both natural (geogenic) and anthropogenic (human-driven) activities, including pharmaceutical waste, industrial effluents, and atmospheric deposition.

While some metals such as cobalt (Co), copper (Cu), chromium (Cr), iron (Fe), magnesium (Mg), manganese (Mn), molybdenum (Mo), nickel (Ni), selenium (Se), and zinc (Zn) are essential micronutrients needed for metabolic and physiological functions (Hardman et al., 2001), their deficiencies can lead to various health disorders. However, excessive accumulation of heavy metals in water bodies can lead to toxicity and health risks, as seen in documented cases such as the lead poisoning crisis in Nigeria (Burki, 2012) and atypical lead exposure in the U.S. (Gorospe & Gerstenberger, 2008). Studies such as Fu et al. (2008) have also shown the potential risk from heavy metal accumulation in agricultural products like rice near e-waste sites in China.

## MATERIALS AND METHODS

### 2.1 Study Area

This study was conducted at the Federal University of Lafia (FULafia), located at coordinates 8.4905° N, 8.5170° E. The university campus relies primarily on boreholes and stored water systems for domestic use. Seven sampling points were selected to reflect areas of high water consumption: three male hostels, three female hostels, and one mosque.

### 2.2 Water Sample Collection and Pre-Treatment

Water samples were collected at 5-minute intervals using pre-cleaned polyethylene bottles at each of the seven locations. Each bottle was rinsed with deionized water and subsequently rinsed three times with the water to be sampled. The samples were labeled by date and location. To prevent metal adsorption onto container walls, each sample was preserved by adding 5 mL of diluted nitric acid ($HNO_3$ ) per liter to lower the pH to around 2, and then stored at 4°C (Kumar et al., 2015; Anuo et al., 2011).

### 2.3 Determination of Physicochemical Parameters

#### 2.3.1 pH Measurements

The pH of the water samples was measured using a calibrated pH meter. The electrodes were rinsed with distilled water before and after each measurement. Readings were recorded once stable (Geotechnical Engineering Bureau, 2007).

#### 2.3.2 Electrical Conductivity and Total Dissolved Solids (TDS)

A combined TDS/conductivity meter was employed. The probe was rinsed and immersed in the sample, then agitated to eliminate air bubbles. Readings were recorded accordingly (ASTM, 2004).

### 2.3.3 Turbidity

Turbidity was measured using a calibrated turbidity meter. Samples were placed in clean cuvettes, wiped dry, and inserted into the meter. Readings were recorded (NITTRC, 2009).

### 2.3.4 Total Suspended Solids (TSS)

Fifty milliliters of each sample were filtered using a pre-weighed Whatman filter paper (125 mm). The residue was rinsed with 20 mL of distilled water. The filter paper was dried at 103–105°C until a constant weight was achieved, cooled in a desiccator, and reweighed.

### 2.3.5 Total Hardness

A 100 mL sample was treated with 2 mL of ammonia buffer and one Eriochrome Black T indicator tablet, then titrated with 0.01 M EDTA until a blue end point was observed (APHA, 2005).

### 2.3.6 Chloride ($Cl^-$)

Two drops of potassium chromate indicator were added to 100 mL of the water sample, followed by titration with 0.01 N $AgNO_3$ until a pinkish-yellow endpoint was achieved. The pH was adjusted to 7–10 using dilute $H_2SO_4$ or 2N NaOH if required (APHA, 2005).

## 2.4 Heavy Metals Determination

### 2.4.1 Sample Digestion

To digest each water sample, 5.0 mL of concentrated nitric acid ($HNO_3$) was added to 100 mL of sample in a 250 mL conical flask. The solution was heated on a hot plate until the volume was reduced by half, cooled, and filtered (Momodu et al., 2009).

### 2.4.2 Metal Analysis

The digested samples were analyzed for Lead (Pb), Cadmium (Cd), Chromium (Cr), Zinc (Zn), and Copper (Cu) using an Atomic Absorption Spectrophotometer (AAS), Mc Jelffeson Model AA320N. Analysis was carried out at TA’AL Laboratory, Lafia, with minimal delay between digestion and measurement to preserve sample integrity. Metal concentrations were quantified by comparing the sample absorbance values to calibration curves generated using standard solutions (Alghamdi et al., 2019; Ehi-Eromosele & Okiei, 2012).

## RESULTS AND DISCUSSIONS

### 3.1 Validation of Results

The procedure and method for analysis was validated by use of standard spiking, where a known amount of the constituent being determined was added to the sample (spiked with a standard of 5 ppm); which was then analyzed for the total amount of the constituent present.

The difference between the analytical results for samples with and without the added constituent was calculated, and then the percentage recovery was calculated from equation 4.1 (Keith, 1991; Erxleben, 2009).

$$\%\, recovery = \frac{F-Np}{A} \times 100 \qquad 4.1$$

Where:

F = Spiked sample concentration

Np = Unspiked sample concentration

A = concentration of Analyze added to the spiked portion

The percentage recoveries are given in Table 1.

**Table3.1: Percentage recoveries of Pb, Cu, Mn and Cd**

| Elements | Un spiked Sample in ppm. | Spiked sample in ppm. | % Recovery |
|---|---|---|---|
| Lead | 1.87 | 6.85 | 99.6 |
| Copper | 0.88 | 5.85 | 99.4 |
| Manganese | 0.15 | 5.09 | 98.9 |
| Cadmium | 0.39 | 5.35 | 99.2 |

From the results above, it is evident that the results obtained by use of FAAS were accurate and indication that the samples were well prepared, efficiently handled and without contamination and the FAAS instrument used for analysis was accurate since the percentage recovery is almost 100 % (Mendham *et al.*, 2000).

### 3.2. Linearity of AAS Calibration Curves

The absorbance reading and the concentration of ideal standard were used to calculate the co-efficient (r). The value of r for each metal was calculated and recorded in the table 2 below (Mendham *et al*., 2000; Erxlebe, 2009).

**Table 3.2: Correlation of calibration curves**

| Element | Correlation (r) |
|---|---|
| Lead | 0.9947 |
| Copper | 0.9951 |
| Manganese | 1.0000 |
| Cadmium | 0.9992 |

Based on the above results, it can be concluded that there is linear relationship between absorbance and the concentration of the standards, since the values of r were closer to 1 and hence the performance of the FAAS instrument had the ability to provide accurate results (Mendham *et al*., 2000).

### 3.3. Determination of Heavy Metals in Samples

#### 3.3.1 Copper (Cu)

The standard and sample concentrations of Cu were analyzed. Results show varied Cu levels across samples, with relatively high RSD values, suggesting some variability in Cu concentration.

| No. | Measure Type | Sample ID | C(mg/l) | AA | SD | RSD(%) |
|---|---|---|---|---|---|---|
| 1 | Blank |  | 0.000 | 0.000 | 0.000 | 221.1 |
| 2 | Standard | Standard 1 | 0.200 | 0.004 | 0.005 | 33.6 |
| 3 | Standard | Standard 2 | 0.400 | 0.006 | 0.004 | 87.93 |
| 4 | Standard | Standard 3 | 0.600 | 0.008 | 0.004 | 65.53 |
| 5 | Standard | Standard 4 | 0.800 | 0.012 | 0.006 | 78.42 |
| 0 | Blank |  | 0.000 | 0.000 | 0.000 | 163.5 |
| 1 | Sample | 1 | 0.099 | 0.018 | 0.007 | 76.36 |
| 2 | Sample | 2 | 0.087 | 0.064 | 0.022 | 46.24 |
| 3 | Sample | 3 | 0.058 | 0.028 | 0.058 | 93.97 |

**Table 3.1: Concentration of Sample and Standard Sample for Copper (Cu)**

**KEY**

1. C: Concentration of sample and standard sample
2. mg/l: Unit of Concentration
3. AA: Sample absorption with background absorbance deducted
4. SD: Standard deviation
5. RSD (%): Relative Standard deviation

### 3.3.2 Chromium (Cr)

Cr concentrations were generally low, with sample 3 showing the lowest (0.002 mg/L). The RSD values again reflect variability, but Cr levels remained within detectable limits.

| No. | Measure Type | Sample ID | C(mg/l) | AA | SD | RSD(%) |
|---|---|---|---|---|---|---|
| 1 | Blank | | 0.000 | 0.000 | 0.000 | 100.0 |
| 2 | Standard | Standard 1 | 0.200 | 0.003 | 0.005 | 40.61 |
| 3 | Standard | Standard 2 | 0.400 | 0.006 | 0.007 | 67.96 |
| 4 | Standard | Standard 3 | 0.600 | 0.009 | 0.005 | 75.52 |
| 5 | Standard | Standard 4 | 0.800 | 0.010 | 0.008 | 68.45 |
| 0 | Blank | | 0.000 | 0.000 | 0.000 | 453,1 |
| 1 | Sample | 1 | 0.078 | 0.170 | 0.014 | 45.24 |
| 2 | Sample | 2 | 0.056 | 0.001 | 0.025 | 56.24 |
| 3 | Sample | 3 | 0.002 | 0.008 | 0.052 | 67.42 |

**Table 3.2 Concentration of Sample and Standard Sample for Chromium (Cr)**

**KEY**

1. C: Concentration of sample and standard sample
2. mg/l: Unit of Concentration
3. AA: Sample absorption with background absorbance deducted
4. SD: Standard deviation
5. RSD (%): Relative Standard deviation

### 3.3.3 Cadmium (Cd)

Cd levels across samples showed acceptable variation. RSD values ranged between 36% and 56%, which is reasonable for trace detection using FAAS

**Table 3.3 Concentration of Sample and Standard Sample for Cadmium (Cd)**

| No. | Measure Type | Sample ID | C(mg/l) | AA | SD | RSD(%) |
|---|---|---|---|---|---|---|
| 1 | Blank | | 0.000 | 0.000 | 0.000 | 201.1 |
| 2 | Standard | Standard 1 | 0.200 | 0.004 | 0.005 | 30.3 |
| 3 | Standard | Standard 2 | 0.400 | 0.006 | 0.004 | 57.97 |
| 4 | Standard | Standard 3 | 0.600 | 0.008 | 0.004 | 85.55 |
| 5 | Standard | Standard 4 | 0.800 | 0.012 | 0.006 | 58.32 |
| | | | | | | |
| 0 | Blank | | 0.000 | 0.000 | 0.000 | 153.5 |
| 1 | Sample | 1 | 0.029 | 0.015 | 0.005 | 36.33 |
| 2 | Sample | 2 | 0.053 | 0.082 | 0.023 | 56.26 |
| 3 | Sample | 3 | 0.028 | 0.061 | 0.035 | 44.92 |

**KEY**

1. C: Concentration of sample and standard sample
2. mg/l: Unit of Concentration
3. AA: Sample absorption with background absorbance deducted
4. SD: Standard deviation
5. RSD (%): Relative Standard deviation

### 3.3.4 Zinc (Zn)

Zinc levels were highest in sample 1 (0.124 mg/L). The analysis indicated no significant Zn difference among sampling points, suggesting common Zn exposure.

| No. | Measure Type | Sample ID | C(mg/l) | AA | SD | RSD(%) |
|---|---|---|---|---|---|---|
| 1 | Blank | | 0.000 | 0.000 | 0.000 | 100.0 |
| 2 | Standard | Standard 1 | 0.200 | 0.003 | 0.005 | 40.67 |
| 3 | Standard | Standard 2 | 0.400 | 0.006 | 0.007 | 67.93 |
| 4 | Standard | Standard 3 | 0.600 | 0.009 | 0.005 | 75.56 |
| 5 | Standard | Standard 4 | 0.800 | 0.010 | 0.008 | 68.41 |
| 0 | Blank | | 0.000 | 0.000 | 0.000 | 653.5 |
| 1 | Sample | | 0.124 | 0.175 | 0.015 | 55.25 |
| 2 | Sample | | 0.098 | 0.282 | 0.048 | 65.47 |
| 3 | Sample | | 0.057 | 0.118 | 0.009 | 59.52 |

**Table 3.4. Concentration of Sample and Standard Sample for Zinc (Zn)**

**KEY**

1. C: Concentration of sample and standard sample
2. mg/l: Unit of Concentration
3. AA: Sample absorption with background absorbance deducted
4. SD: Standard deviation
5. RSD (%): Relative Standard deviation

### 3.3.5 Lead (Pb)

Pb concentrations were highest in the boys' hostel water (0.124 ± 0.015 mg/L). While the levels were relatively low compared to regulatory limits, the presence of Pb in drinking water is concerning due to its toxicity.

| No. | Measure Type | Sample ID | C(mg/l) | AA | SD | RSD(%) |
|---|---|---|---|---|---|---|
| 1 | Blank | | 0.000 | 0.000 | 0.000 | 100.0 |
| 2 | Standard | Standard 1 | 0.200 | 0.003 | 0.005 | 41.61 |
| 3 | Standard | Standard 2 | 0.400 | 0.006 | 0.007 | 68.96 |
| 4 | Standard | Standard 3 | 0.600 | 0.009 | 0.005 | 72.52 |
| 5 | Standard | Standard 4 | 0.800 | 0.010 | 0.008 | 66.45 |
| 0 | Blank | | 0.028 | 0.000 | 0.000 | 353.4 |
| 1 | Sample | | 0.019 | 0.170 | 0.014 | 54.22 |
| 2 | Sample | | 0.019 | 0.080 | 0.041 | 75.49 |
| 3 | Sample | | 0.012 | 0.007 | 0.007 | 46.51 |

**Table 3.5 Concentration of Sample and Standard Sample for Lead (Pb)**

KEY

1. C: Concentration of sample and standard sample
2. mg/l: Unit of Concentration
3. AA: Sample absorption with background absorbance deducted
4. SD: Standard deviation
5. RSD (%): Relative Standard deviation

### 3.4 Variation of Heavy Metals in Boys Hostel, Girls Hostel and Mosque Water

The variation in heavy metal concentrations is summarized in Table 4.8. Among all metals, lead (Pb) had the highest mean concentration (0.124 ± 0.015 mg/L in the boys' hostel), while Cr recorded the lowest (0.002 ± 0.052 mg/L in the mosque). Copper (Cu) showed statistically significant variation among the three locations, while Cd and Zn showed relatively consistent concentrations.

**Table3.6: Variation of Heavy metals concentration from Cu, Cr, Cd, Zn, and Pb (mg/L) from the water sample**

| S/N | Cu | Cr | Cd | Zn | Pb |
|---|---|---|---|---|---|
| 1 | 0.099±0.007 | 0.078±0.014 | 0.029± 0.005 | 0.124± 0.015 | 0.019± 0.014 |
| 2 | 0.087± 0.022 | 0.056± 0.025 | 0.053± 0.023 | 0.098± 0.048 | 0.019± 0.041 |
| 3 | 0.058± 0.058 | 0.002± 0.052 | 0.028± 0.035 | 0.057± 0.009 | 0.012± 0.007 |

## CONCLUSION AND RECOMMENDATIONS

### 4.1 Conclusion

The analysis of water samples from the Federal University of Lafia revealed the presence of heavy metals—Copper (Cu), Chromium (Cr), Cadmium (Cd), Zinc (Zn), and Lead (Pb)—in varying concentrations across sampled locations. While most values remained within WHO permissible limits, Lead and Copper were observed at relatively higher concentrations, especially in the boys' hostel, suggesting potential contamination from aging plumbing systems or environmental sources. Chromium was detected at negligible levels, indicating minimal industrial influence, while Cadmium and Zinc showed no significant variation across locations, reflecting uniform exposure. The detection of these metals, even at low to moderate levels, underscores the potential risk to public health due to their cumulative toxic effects. These findings highlight the urgent need for routine water quality monitoring, periodic infrastructure assessment, and awareness campaigns within the university to ensure the safety of drinking water and the well-being of its residents.

### 4.2 **Recommendations**

Based on the findings of this study, it is recommended that the university administration implement a comprehensive water quality monitoring program to ensure early detection and control of heavy metal contamination. Efforts should be made to periodically inspect and upgrade plumbing infrastructure, particularly in high-risk areas such as hostels, to prevent leaching of metals like lead and copper. Additionally, collaboration with environmental health agencies is crucial to establish safe water treatment protocols and regulatory compliance. Public awareness campaigns should be initiated to educate students and staff on the importance of safe water usage and the risks associated with prolonged exposure to heavy metals. Ultimately, ensuring access to clean drinking water will not only protect public health but also promote a sustainable and safe campus environment.

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