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Full Length Research Article

ASSESSMENT OF TRACE METAL CONCENTRATIONS IN DRINKING WATER SAMPLES FROM SELECTED LOCATIONS IN GEZAWA AND GABASAWA LOCAL GOVERNMENT AREAS, KANO STATE, NIGERIA

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ABSTRACT

The problem of drinking water with high concentrations of trace metals is a major health concern in developing countries. Trace metal concentrations (Cd, Ni, Cu, Pb, and Fe) in water samples of different locations in Gezawa and Gabasawa Local Government were evaluated. The water samples used for the study were borehole water, sachet water, well water and river water and were collected from different geographical coordinates on the site i.e. Gezawa and Gabasawa Local Government in polythene plastic containers of 7liters capacity. The concentration levels of selected trace metals, (Cu, Cd, Fe, Ni, and Pb) were determined in water in (µg/L) using Microwave Plasma Atomic Emission Spectroscopy (MPAES). The highest mean concentrations (µg/L) of the trace metals in the water sources are Cd (0.12), Fe (43.38), Cu (2.64), Ni (0.527) and Pb (1.52). When the highest mean concentrations of trace metals in the water were considered, Iron has the highest mean concentration in the water with a concentration of 43.38 (µg/L) and cadmium had the lowest concentration with a value of 0.12 (µg/L). Comparison of these results showed that, their highest levels are within the standard values obtained in Nigeria and some developed countries.

Keywords: Heavy metal, Safety, MPAES, Gezawa, Gabasawa, Nigeria.

INTRODUCTION

Potable water is one that is free from contamination, low in compounds that are acutely toxic and have great long-term effects on human health. Water is the precious resource that qualifies the planet earth to be habitat of the biosphere. Water covers 71% of the earth surface and it is vital for all known forms of life. It is a transparent fluid which forms the world's streams, lakes, oceans and rain, and is the major constituent of the fluids of organisms (Orji and Oghonim, 2023). Easy access to safe potable water is one of the challenges for the water systems regardless of the obsolete infrastructure, reduced source water, and tensed finances (Ur Rehman *et al.,* 2020).

Water quality monitoring and assessment is important for a variety of reasons. It helps to determine how safe the water sources are for drinking (Ighalo *et al*., 2020a). Researchers can furthermore isolate the specific parameter that are below regulatory threshold (Ighalo *et al*., 2020b). Water quality in Nigeria remains a critical issue due to its significant reliance on surface and groundwater for drinking, irrigation, and industrial use. Previous reviews have provided valuable insights but also highlighted certain gaps and limitations. Abugu *et al*., (2024) assessed the hydrochemical characteristics of water used for irrigation, identifying dominant water facies and chemical influences, but lacked comprehensive water quality analyses for the South-South and North-Central zones.

Heavy metals can accumulate in the human body system and cause major harm to the nervous system, including cardiovascular illnesses, reproductive problems and cancer. Heavy metals are not biodegradable (Li *et al*., 2022; Umar *et al*., 2023). Heavy metals, for example, Fe, Cu, Zn and Ni, are essential micronutrients for animal life and vegetation but are dangerous at excess levels, whereas Cr, Cd, Pb, and Co have no known physiological functions but are harmful at a certain level (Aktar *et al*., 2010; Nasiru *et al.,* 2021). Furthermore, Cr, Cd, and Ni are carcinogenic, while Pb may cause damage to human health (Okegye & Gajere, 2015; Kamalu & Habibu, 2023). The damages include gastrointestinal, liver, renal, lung, intestinal, neurological, and reproductive disorders. Infants, the elderly, and pregnant women are especially vulnerable to the consequences (Tsor *et al.,* 2022). As the World Health Organization (WHO, 2007) indicated, inappropriate or polluted water causes around 80% of all diseases in human beings.

Public health concerns on surface and groundwater contamination worldwide have increased. Sachet water contamination has also raised serious concerns across many developing countries. The intake of contaminated sachet water exposes the citizens to waterborne and carcinogenic diseases (Agbasi *et al*., 2024).

MATERIALS AND METHODS

Study Area

Figure 1 shows the locations include Gezawa (Tanda, Danladi A, Tsamiyar kara, Bilkara, Danladi B, Sabon fegi, Jogana, Dausayi, Tsamiyar Kara Government Girls Islamic School), Gabasawa (Kagane, Azare, Zakirai, Waro, Zakirai education, Ginan, Tankarau) areas of Kano, Kano State. Water samples were collected in well cleaned 7-liter polythene plastic containers; the sample containers were rinsed with their respective water sample before filling each with the sample.

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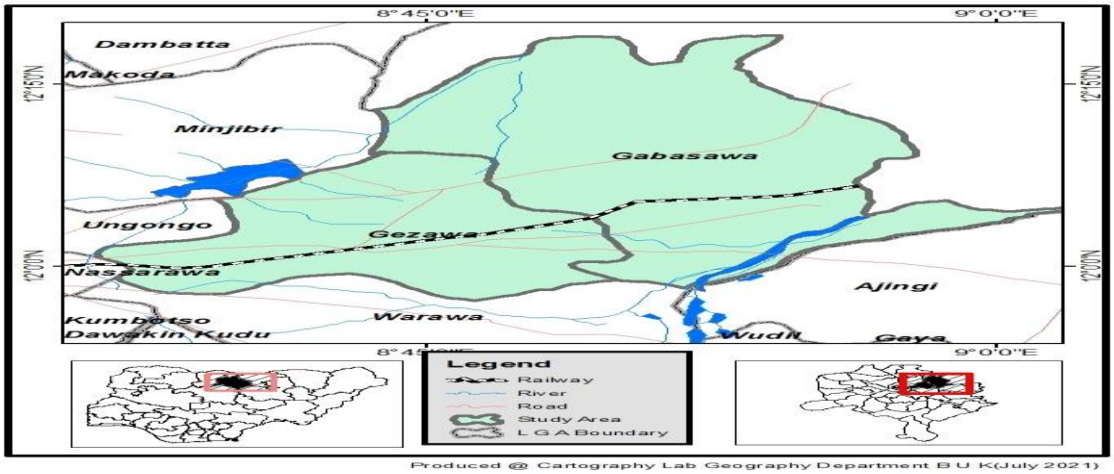

Figure 1: Map showing the study locations

Table 1: Identification of sample sites

S/No	Sampling sites	Sampling code
1	Bilkara	BH1
2	Dausayi Unguwar Gabas	BH7
3	Sabon Fegi	BH4
4	Danldi B	BH2
5	'YAM MUSA	P3
6	Al-Lazeez	P2
7	Jogana Unguwar Gabas	BH6
8	Jogana Hospital	BH5
9	Ginan	RW3
10	Tsamiyar Kara GGIS	BH9
11	Jogana Kasuwar Duniya	BH10
12	Waro	WW6
13	Dausayi Unguwar Fulani	BH8
14	HASH	P5
15	Tankarau	RW4
16	Dausayi	P6
17	Tanda	WW1
18	Danladi A	WW2
19	Tsamiyar Kara	WW9
20	Tsamiyar Kara	WW8
21	Zakirai	WW5
22	Zakirai Education	WW7
23	Fai-Fai	RW1
24	Azare	WW4
25	Tsamiyar kara	WW10
26	Mai zuma	P1
27	Kagane	WW3
28	Barwa	RW2
29	Diyam Nour	P4
30	Danladi A	BH3

Key: BH = Borehole Water
RW = River Water
PW = Sachet Water
WW = Well Water

Collection of Samples

The water samples used for the study were bore hole water, sachet water, well water and river water, with polythene plastic containers of five litres and two litres. Thirty water samples were randomly collected from the various sampling sites (10 well water, 10 boreholes, 4 rivers, 6 sachets in different areas of Gezawa and Gabasawa local government area of Kano state and were labelled.

Sample Analysis

The samples were first allowed to settle, followed by decantation. For samples containing sediments, boiling and cooling were performed before decantation. Exactly 5 liters of each sample were measured and transferred into a new aluminum pot for evaporation on a sand bath. When the volume was reduced to approximately 250–300 mL, the concentrated sample was transferred to a Pyrex beaker to complete the evaporation to dryness. The residue was then dissolved in a beaker using 50 mL of 0.25 M nitric acid (HNO_3). The solution was gently heated to ensure complete dissolution and subsequently filtered through Whatman filter paper (90 mm diameter, 11-micron pore size). The filtrate was transferred into a 50 mL sample bottle and brought up to volume with 0.25 M HNO_3.

The presence and concentration of the five metals were analyzed in the sample solution using Microwave Plasma Atomic Emission Spectrophotometer (MPAES). All emission measurements of the five metals were analyzed in the sample solution using Microwave Plasma Atomic Emission Spectrophotometer (MPAES). Microwave Plasma Atomic Emission spectrophotometer is commonly used in many analytical laboratories for the determination of trace elements in water samples and in acid digests of sediments or biological tissues.

The blank (0.25 M analytical grade nitric acid) which was treated as samples was analyzed along with the other samples using Microwave Plasma Atomic Emission spectrophotometer i.e. was treated as a sample. A calibration curve of absorbance against concentration for each element under investigation was constructed and finally, the concentration of each of the element in the samples was determined from standards calibration curve exploration.

Data analysis

All data collected were subjected to one-way analysis of variance (ANOVA) ($p<0.05$) in order to assess whether they varied significantly between the water samples. All statistical calculations were performed using JMP Pro4 and the results are shown in appendices.

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RESULTS AND DISCUSSION

Table 2 presents the concentrations of the five heavy metals in µ/L obtained from the analysis of water samples from wells, boreholes, rivers, and sachet water in Gezawa and Gabasawa Local Government. The concentrations in all the water samples are below the World Health Organization (WHO) standard.

Table 2: Trace metal concentrations (µg/L) for water samples analysed

SN	SAMPLE CODE	Cd (µ/L)	Fe (µ/L)	Cu (µ/L)	Ni (µ/L)	Pb (µ/L)
1	BH1	0.1	30	0.4	ND	ND
2	BH7	0.1	ND	0.3	ND	ND
3	BH4	0.1	ND	0.4	ND	ND
4	BH2	0.2	ND	1.0	0.2	2.8
5	P3	0.1	ND	0.8	ND	0.1
6	P2	ND	ND	0.3	ND	0.1
7	BH6	0.1	20	0.9	ND	ND
8	BH5	ND	90	0.3	ND	ND
9	RW3	0.1	ND	4.7	ND	ND
10	BH9	0.1	ND	0.9	ND	0.2
11	BH10	ND	3.1	0.6	ND	ND
12	WW6	ND	ND	1.0	ND	3.7
13	BH8	ND	86.7	0.3	ND	ND
14	P5	0.1	ND	0.7	0.2	0.5
15	RW4	0.1	ND	3.0	0.7	1.5
16	P6	0.1	ND	5.2	0.2	1.8
17	WW1	ND	27.3	0.4	ND	ND
18	WW2	ND	0.34	0.5	ND	ND
19	WW9	0.1	ND	0.9	0.1	0.4
20	WW8	0.2	0.19	0.1	1.0	0.3
21	WW5	0.1	ND	5.2	0.5	1.3
22	WW7	0.1	ND	7.4	0.4	2.0
23	RW1	ND	0.93	0.5	0.2	ND
24	WW4	ND	ND	1.4	0.6	1.0
25	WW10	0.1	0.49	1.6	0.5	ND
26	P1	0.1	ND	2.1	0.8	2.1
27	WW3	ND	ND	0.1	ND	ND
28	RW2	ND	ND	2.3	0.1	ND
29	P4	ND	ND	4.7	ND	ND
30	BH3	ND	49.7	0.3	ND	ND

ND=NOT DETECTED

Table 3 shows the mean and the standard error of the metals in which iron has the highest mean concentration while cadmium has the least mean concentration among the water sources;

Table 3: Mean ± Standard Error of the metal concentrations of the water sources

Sources	Cd (µg/L)	Cu (µg/L)	Fe (µg/L)	Ni (µg/L)	Pb (µg/L)
Bore hole	0.103± 0.018	0.538± 0.057	43.38± 12.18	0.160± 0.319)	1.520± 0.878)
River	0.070± 0.032	2.640± 0.090	7.594± 2.982	0.333± 0.185	1.500± 1.241
Sachet	0.072± 0.020	2.307± 0.074	ND	0.393± 0.185	0.924± 0.555
Well	0.120± 0.020	1.944± 0.057	9.375± 1.491	0.527± 0.131	1.453± 0.507
WHO	3.0	50	300	6.0	10

Cadmium

The concentrations of cadmium (Figure 1) in the samples range from 0.1-0.2 µg/L, none of the samples have concentrations above the W.H.O threshold limit of 3.0 µg/L while in the rest of the samples, Cd was not detected. All the water samples analyzed for cadmium were found below WHO permissible limits of 3.0 µg/L (WHO 2011). High levels of Cd in mining pond, underground mining site and borehole could be linked to the weathering and subsequent dissolution of the chalcopyrite and pyrite ores in the area Obasi and Akudinobi (2020).

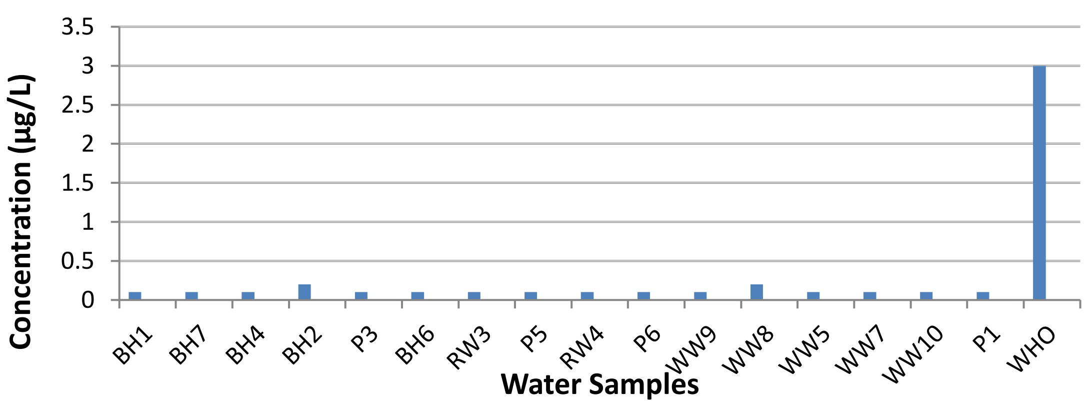

Figure 1: Concentration of Cadmium in water source

The result of the mean concentration of cadmium among the water sources obtained from various sampling sites at Gezawa and Gabasawa Local Government is represented in Figure 2 below. High level of cadmium was found in well water with a mean of 0.12 µg/L and a lower mean concentration of 0.070 µg/L was found in river water. All the four water sources have a mean cadmium concentration level below the World Health Organisation of 3.0 µg/L (2011). The values are similar to the values reported by Badamasi *et al.* (2021) in their study evaluation of heavy metals pollution status of the groundwater around Riruwai mining area,

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Kano state, the results revealed that for cadmium metal their mean concentrations were below the WHO threshold limits but were not similar to the findings of Amankwah*et al.* (2023), who examimed the water quality in boreholes from Tagrayire (Magazine) in Wa Municipal, their findings showed that the concentration of cadmium were significantly high compared to the maximum acceptable safe concentration of cadmium of 3.0 mg/L. The ANOVA results for cadmium obtained from the water sources showed that in cadmium values there was no significant difference among the water sources (p=0.3361).

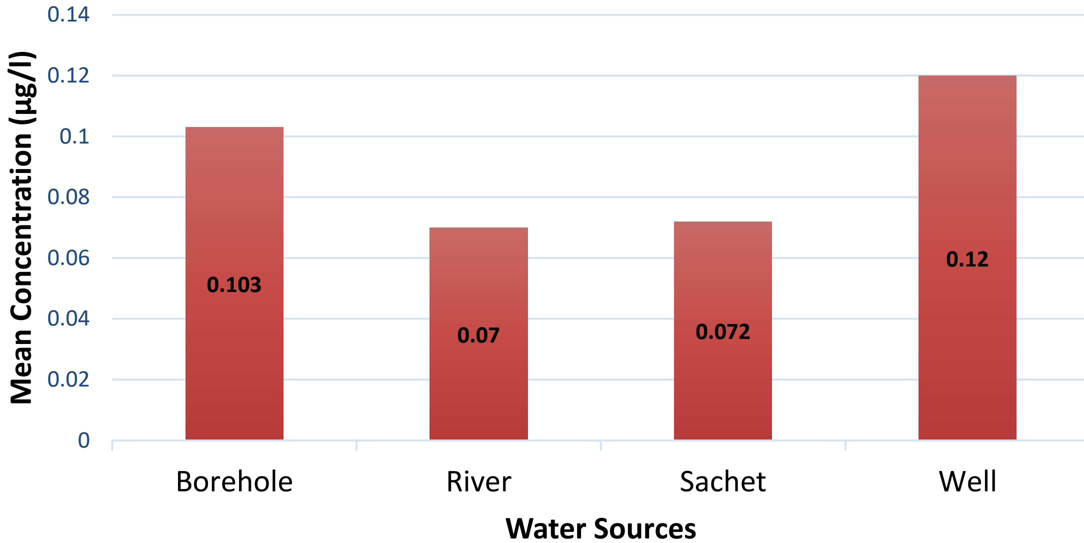

Figure 2: Mean concentration of cadmium of the water source

Iron

Iron was detected in eleven water samples, but the highest concentrations of 90 µg/L was detected in sample BH5 which is borehole water and the lowest concentration of 0.19 µg/L was detected in sample WW8 which is well water as shown in the Figure 3.

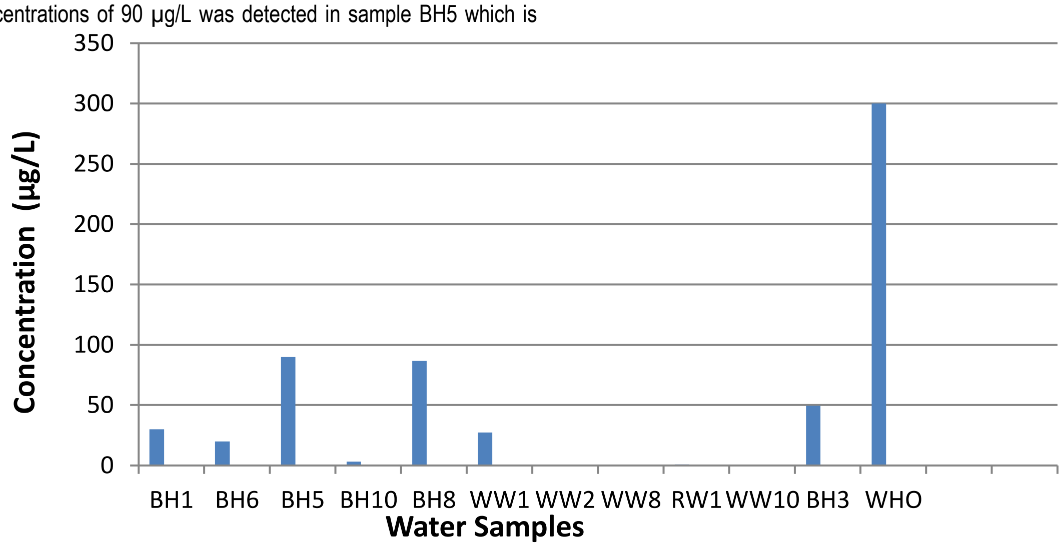

Figure 3: Mean Concentration of Iron in water sample

Borehole water were found to have the highest mean iron concentration of 43.38 µg/L from the water sources in the study area, and the least mean concentration was observed in river water with a mean of 7.594 µg/L while sachet water was not detected (Figure 4). All the four water sources have a mean iron concentration level below the World Health Organisation (2011) of 300 µg/L. Abubakar *et al.* (2024) obtained the mean concentration of iron in the evaluated samples ranged from 0.028 to 0.004-2.001± 0.011 mg/Lthere was a significant variation in iron levels among the borehole water samples having a mean concentration below the maximum limit set by WHO. The findings was not in consistent with the findings of Mshelia and Bulama (2023) in their study of comparison of groundwater quality in Kano metropolis, Nigeria, in which the water samples from the boreholes studied were found not safe for drinking.

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The analysis of variance (ANOVA) shows that (p=0.1800), this means there is no significant difference in iron concentration among the water sources.

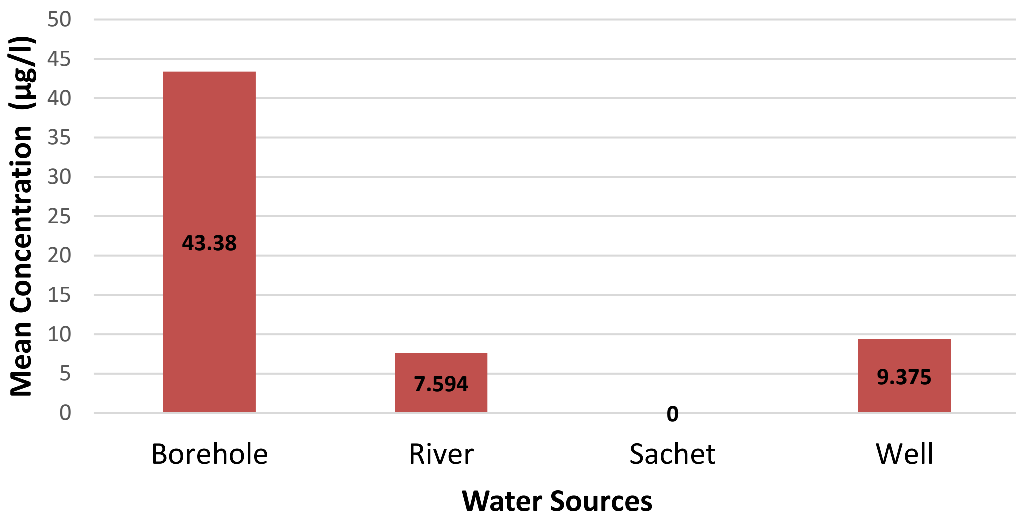

Figure 4: Mean concentration of iron in water source

Copper

Copper was detected in all the water samples and the highest concentration of 7.4 µg/L was found in well water seven (WW7) and the lowest concentration of 0.1 µg/L was found in WW8 and WW3 as shown in Figure 5. Cu is an essential element in water, but higher doses can produce injury to liver and kidney, stomach and intestinal irritation and anaemia Mensah *et al.* (2020).

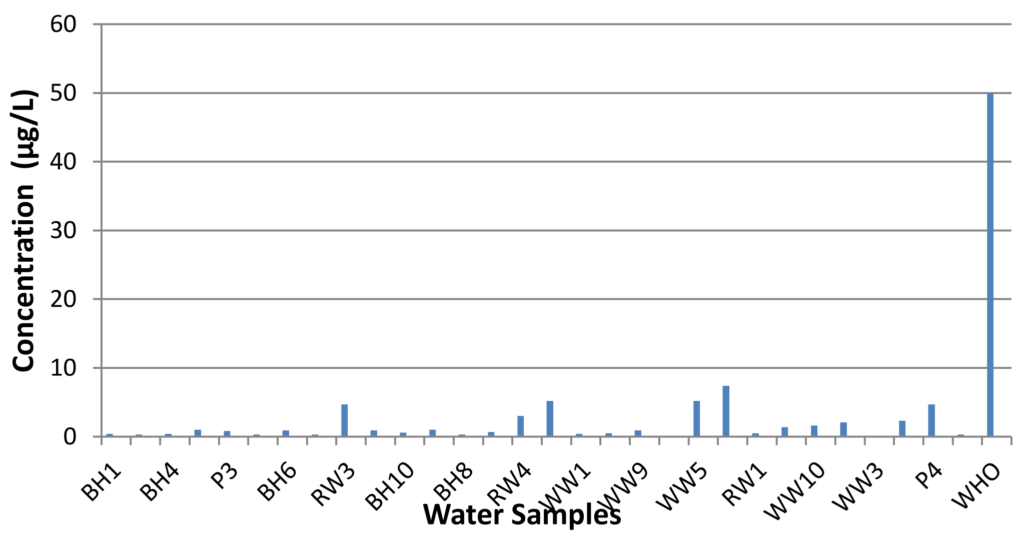

Figure 5: Concentration of copper in water sample

The mean concentration of copper in the sampling site of Gezawa and Gabasawa Local Government are represented in the figure below with a range value of (0.538-2.64) µg/l. From Figure 6 it was clear that all the water sources had copper levels below the World Health Organisation's maximum permissible limit of 50 µg/l and are safe for drinking, these value are lower than the one reported by Kapil Parihar *et al.* (2020), in their study assessment of copper and iron concentration in water of Yamuna River, Delhi, India with a copper exceeding WHO standards. The analysis of variance (ANOVA) shows that (p=0.1353), this means there is no significant difference in copper concentration among the water sources.

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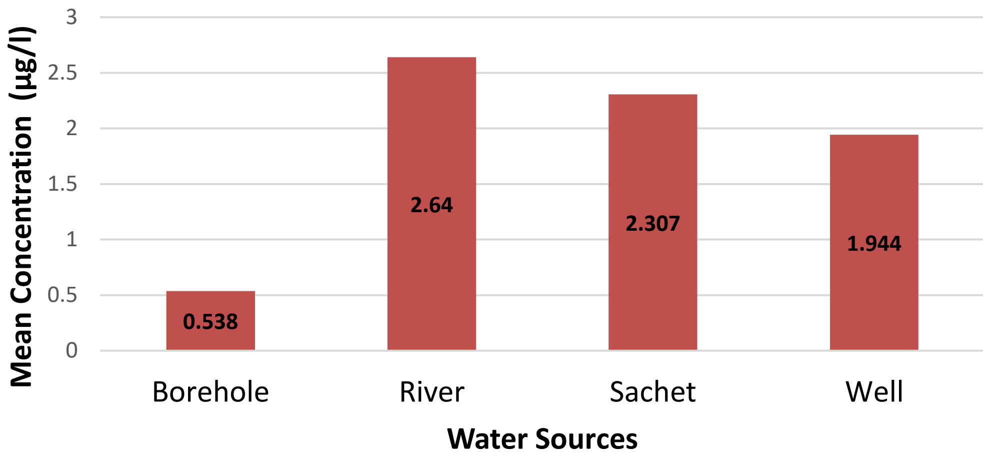

Figure 6: Mean concentration of copper of the water source

Nickel

The concentrations of nickel in the sample was detected in 13 water samples which ranges from 0.1 µg/L-1.0 µg/L, no samples have concentrations above the W.H.O threshold limit of 6.0 µg/L and also nickel was not detected in the remaining seventeen water samples in the Figure 7.

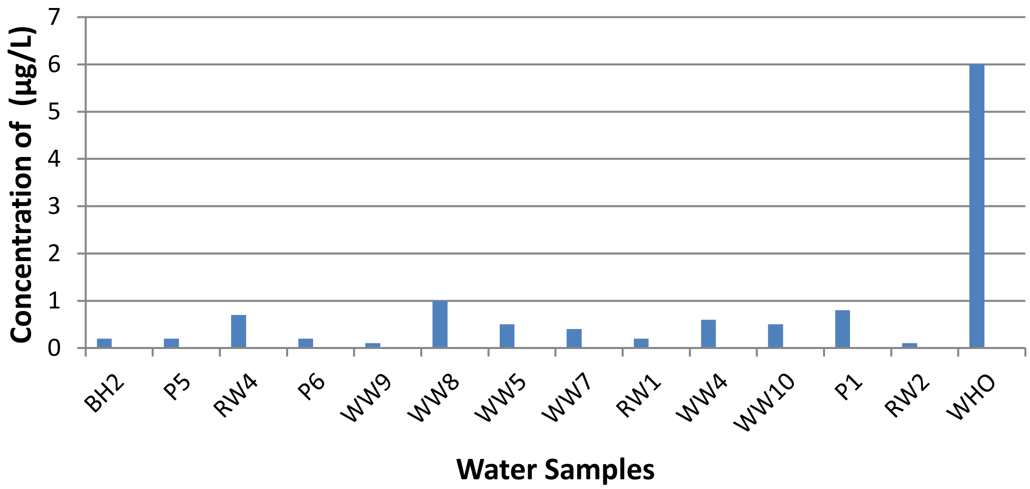

Figure 7: Concentration of nickel in water sample

In Figure 8, nickel recorded its highest mean concentration in well water with a value of 0.527 µg/L and has a lower mean concentration of 0.160 µg/L in borehole water, all the values were found not exceed the acceptable limit of value of 6 µg/L by World Health Organisation (2011). The results in the present study are not in consistent with the findings of Ma Aruf *et al*., (2024), their result showed concentrations of nickel to be above WHO standards and also are not similar to the findings of Evaristus *et al.* (2024) on their evaluation of predicting heavy metal transport in groundwater around Lemna dumpsite: implications for residence utilizing borehole water in Cross River State, Nigeria in which nickel having concentration above the maximum limit set by WHO in BH2, BH3, BH5 and BH6. The analysis of variance (ANOVA) shows that (p=0.6772), this means there is no significant difference in nickel concentration among the water sources.

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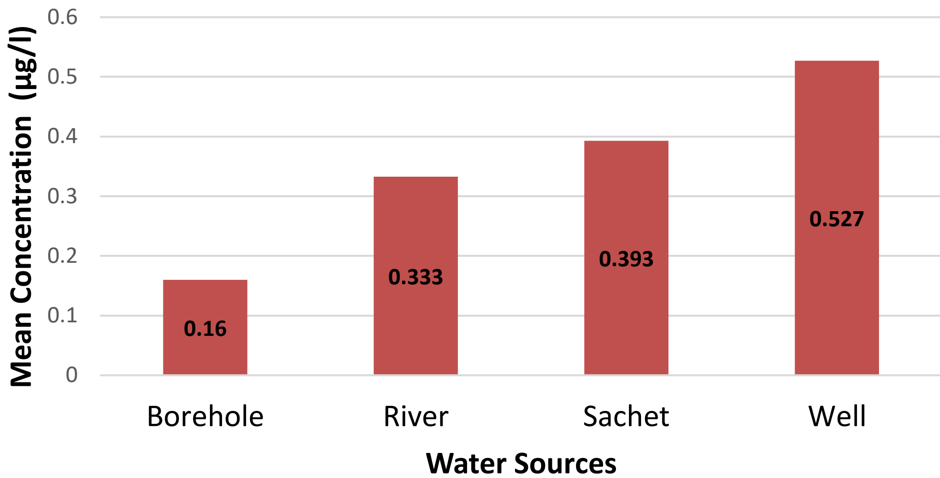

Figure 8: Mean Concentration of Nickel of the Water source

Lead

The concentrations of lead in water samples were found in river water, borehole water, sachet water and well water samples. The lowest concentration of 0.1 µg/L was found in two water samples which are both sachet water while the highest concentration of 3.7 µg/L was found in well water as shown in the Figure 9. All the samples analyzed were found below WHO permissible limits for lead in drinking water of 10 µg/L (WHO 2011). Lead toxicity is an important environmental disease and its effects on the human body are devastating with its toxicity dependent upon the absorbed dose, the route of exposure as well as the duration of exposure. There is almost no function in the human body which is not affected by lead toxicity Aliyu and Musa (2021).

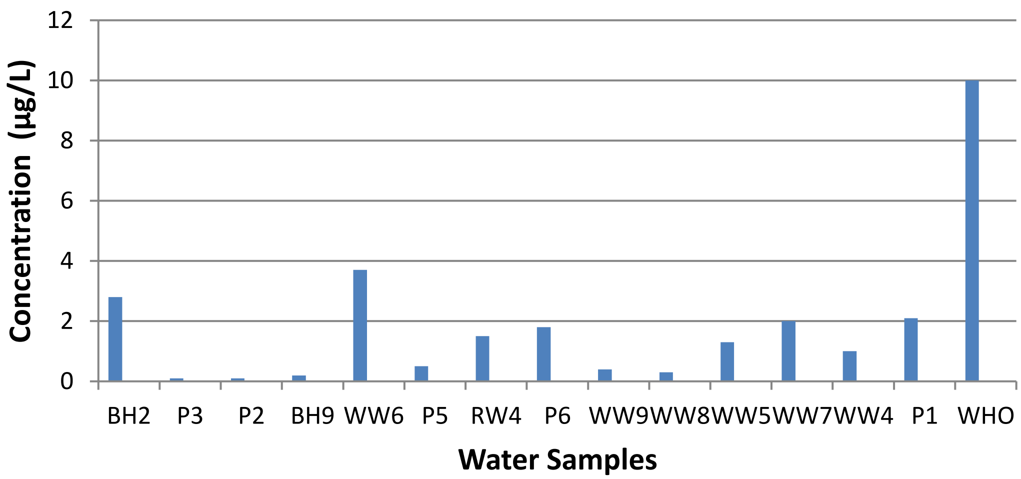

Figure 9: Concentration of lead in water sample

In Figure 10, lead had its highest mean concentration of 1.520 µg/l in borehole water and a least mean concentration of 0.924 µg/l in sachet water, in this study, the reported mean value of lead in all the water sources does not exceeds the World Health Organisation recommended limits of 10 µg/l (WHO, 2011). Similar trend of heavy metal concentrations was reported in the work of Somsiri and Prasert (2020) in their studies of risk assessment of lead and cadmium in drinking water for school use in Nakhon Si Thammarat Province, Thailand and also it was not in consistent with the work of Abubakar *et al.* (2024) in their studies assessment of heavy metals content in borehole water samples drilled near public conveniences in Kano Metropolis Nigeria, in which lead has exceeded the WHO's maximum acceptable limit. The maximum lead concentration was found at SHKYK B (0.057±0.002 mg/l).

The analysis of variance (ANOVA) shows that (p=0.8861), this means there is no significant difference in lead concentration among the water sources.

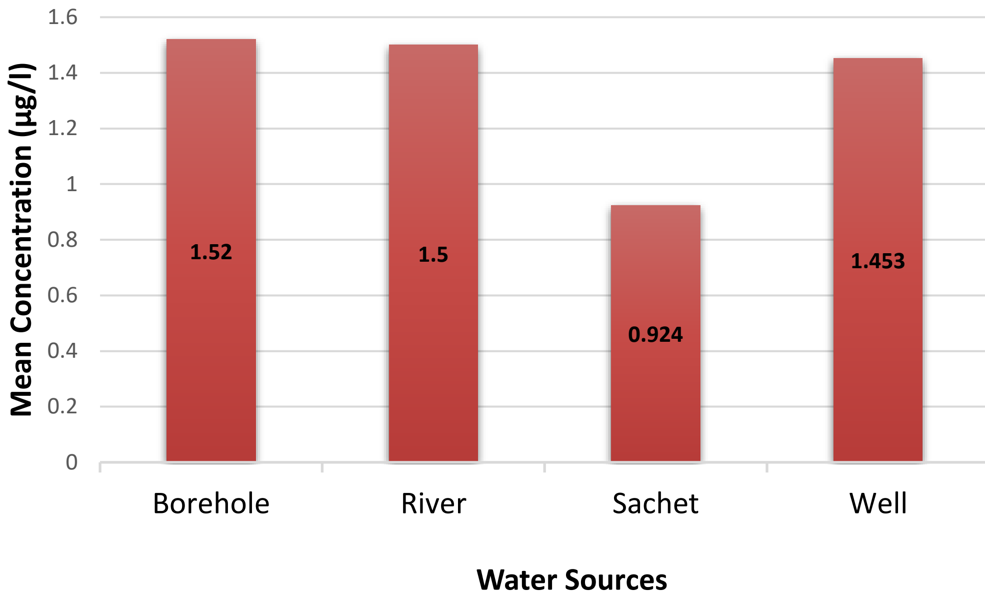

Figure 10: Mean concentration of lead of the water source

Conclusion

Assessment of trace metals concentration in drinking water samples from some selected areas of Gezawa and Gabasawa Local Government areas, Kano state, Nigeria was carried out using MPEAS. All the trace metals i.e. lead, cadmium, iron, nickel and copper were below the World Health Organisation (2011) recommended levels and there was no significant difference in lead, nickel, iron, cadmium and copper analyzed.

It is indeed difficult to conclude the level of long-term contamination of water quality from a short period of the measurements such as the results presented in this work which were based only on a particular period. However, this study revealed a healthy state of the people at Gezawa and Gabasawa Local Governments but the status of iron metal concentrations at the time of study shows a higher level concentration of 90 µg/l which may be attributed by different factors both from domestic and industrial activities, it is therefore suggested and advised as a matter of National health importance that the water from the borehole be subjected to purification and treatment process to reduce iron levels before exposure to public use.

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