Evaluation of Some Selected Heavy Metals in Groundwater from Samaru, North-western Nigeria

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Abstract- The chemical properties of selected heavy metals in groundwater from selected locations in Samaru, Zaria were determined and compared with Nigerian standards. Water samples were collected and chemical properties were determined. The Chemical properties such as Lead (Pb), Zinc (Zn), Copper (Cu), Cobalt (Co), Iron (Fe) Cadmium (Cd), Manganese (Mn), and Nickel (Ni) were determined. The chemical properties were determined following the American Public Health Association (APHA) procedure. The data were analyzed using the World Health Organization (WHO) and the Nigerian Standard of Drinking Water Quality (NSDWQ). The findings showed that Pb, Zn, Cu, Co in all the samples and Fe in samples B, D, F, and G were within the acceptable limit. While Cd, Mn, and Ni in all the samples and Fe in samples A, C, E, and H were more than the acceptable limit. Therefore, the results show that the Samaru Groundwater is not totally good for consumption since Cadmium (Cd), Manganese (Mn), and Nickel (Ni) were more than the acceptable limit. Moreover, it is recommended that urgent prevention measures should be put in place to prevent increased concentrations of Cd, Fe, Mn, and Ni as a result of anthropogenic activities.

Keywords- Concentration, Drinking water quality, Groundwater, Heavy metals

1 INTRODUCTION

Safe water is a significant natural resource that is required for human being for daily activities and it exists as surface, rain, or groundwater (Mohammed *et al.*, 2020). Predominantly, most of the water sources for African countries for domestic activities are surface and groundwater (Maryam *et al.*, 2018). The irregular supply of tap water makes Samaru dwellers over-dependent on groundwater from December to April for their domestic activities. Usually, 20 L of water would sell for about ₦20 by water vendors. This will likely increase to ₦50 per 20 L from March to April as a result of scarcity of water and increase stress on groundwater. Okonko *et al.*, (2008) and Adelana *et al.*, (2008) attributed the deterioration in the quality and quantity of surface water and public water supply system, in many developing countries to dependence on groundwater sources. Decline in groundwater quality in many countries is becoming a serious problem (Yang *et al.*, 2016). Ordinarily, groundwater is supposed to be one of the freshwater sources but its quality is declining as a result of heavy metals migration into it.

Heavy metals are naturally occurring elements that have a high atomic weight and a density at least 5 times greater than that of water (Tchounwou *et al.*, 2012). WHO (2011) define heavy metals as metallic element with an atomic weight >40. It also has a relatively high density and is toxic or poisonous even at low concentrations (Lenntech, 2004). They are metals of atomic weight greater than sodium (Brewer, 1983).

Heavy metals include lead (Pb), cobalt (Co), cadmium (Cd), zinc (Zn), mercury (Hg), manganese (Mn), arsenic (As), silver (Ag) chromium (Cr), copper (Cu), iron (Fe), etc. Heavy metals may be naturally present in the earth's crust and are persistent environmental contaminants since they cannot be degraded or destroyed. Therefore, these metals to a small extent, enter the body system through food, air, and water, thus bio-accumulate over some time. (Lenntech, 2004; UNEP/GPA, 2004).

Chowdhury and Chandra, (1987) reported that some heavy metals, in small quantities, maybe good for human bodybuilding whereas, Ukah *et al.*, (2019) reported that their excessive accumulation in the body is a big threat to human health. Although some heavy metals have bio importance as trace elements, the bio-toxic effects of many of them in human biochemistry are of great concern (Durube *et al.*, 2007). Among heavy metals of particular importance to the human body, zinc is vital for male reproductive activity and balances copper in the body (Nolan, 2003). Calcium is an essential element in human metabolism, the chief element in the production of very strong bones and teeth in mammals (Durube *et al.*, 2007). These elements are however harmful to the human body when exceeding the required limit.

Some of the heavy metals are toxic to a human being even at low concentrations. It has been reported by Steenland and Boffettan, (2000) and Singh *et al.*, (2011) that exposures to Pb have been implicated to cause lung cancer, mental retardation in children, anemia, and kidney dysfunction. Cr and Cd have been reported to be hepatotoxic, neurotoxic, renal-toxic, and carcinogenic (Jarup *et al.*, 2000; Martin and Griswold, 2009). Zn at high concentration obstruct respiratory function (Cooper, 2008).

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Section A- AGRICULTURAL ENGINEERING & BIOLOGICAL SCIENCES

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Therefore, heavy metal pollution has been considered a serious environmental health issue due to its toxicity even at low concentration, persistence, and bioaccumulation potential (Olagunju *et al.*, 2020). The higher the heavy metal concentrations are, the higher their contribution to the deterioration of water resources and the environment. Once water resources and the environment are contaminated with excess heavy metals, health risks, and hazards become inevitable (Ukah *et al.*, 2019). Since in Nigeria, the number of diseases caused by heavy metals is on increase, it is important to check the status of surface and groundwater intermittently, for monitoring and prevention of health hazards. This research aims at determining the concentration of some selected heavy metals in Samaru, Zaria Groundwater and compare them with NSDWQ.

1.1 STUDY AREA

Samaru is part of the Zaria urban setting. It lies within latitudes 11°06' N and 11°12' N of the equator and longitude 7°39' E and 7°45' E of the Greenwich meridian. Samaru is located at the central high plain of Northern Nigeria at a height of about 670 meters above sea level. It is located in Sabon Gari Local government area and it is bounded to the North and North-East by Bassawa military cantonment, to the South by Ahmadu Bello University (ABU) main campus, and to the West by Division of Agricultural Colleges, the area shaded with

red color in Fig. 1 indicate the study area with red color. Samaru is one of the suburbs of Zaria which is made up of distinct loosely coordinated units (Mortimore, 1970).

2 METHODOLOGY

The research commences with a preliminary site investigation so as to understand the study area and activities taking place there. The study area was divided into eight. In each location, one water sample was collected from a borehole or open well with a one-liter sample container. And the location coordinates were determined with GPS (global positioning system). The water samples were collected on the 29th of March, 2021. Moreover, the sample containers were washed with detergent, rinsed with distilled water, then with spirit, and finally with distilled water. The sample containers were further rinsed two times with the water sample at each sampling point collection. During the collection, no floating object was allowed to enter the bottle. The samples were taken to Multi-User Science Research Laboratory Ahmadu Bello University, Zaria for laboratory analysis of some selected heavy metals.

Moreover, the types of samples collected with their location are shown in Table 1. We were unable to measure the depth of the boreholes due to the unavailability of the appropriate measuring instrument.

Fig. 1: map of Sabon Gari Local Government Area showing the Study Area (Source: Okpanachi, 2015)

Table 1. Samples collection and locations (Source: Fieldwork, 2021)

Samples	Types	Depth (m)	GPS location	
			Latitude	Longitude
A	Open well	3	11°09'49.59972" N	7°38'31.54884" E
B	Open well	8	11°09'42.34824" N	7°38'53.55924" E
C	Borehole	-	11°09'37.3525" E	7°39'8.53632" E
D	Borehole	-	11°09'32.00696" N	7°39'20.18044" E
E	Open well	8	11°09'35.17596" N	7°39'39.73060" E
F	Borehole	-	11°09'41.73768" N	7°39'19.18548" N
G	Borehole	-	11°09'11.19416" N	7°39'21.18384" E
H	Borehole	-	11°09'46.40812" N	7°39'13.21857" N

2.1 LABORATORY ANALYSIS OF HEAVY METALS

For sample digestion, 0.5g of the sample was collected and transferred to beaker. Then 2.5ml of HCl and 7.5ml HNO₃ were added to the beaker. The mixture was put on a hot plate, at 100°C it was removed and allowed to cool. Waterdrop was added to it. After digestion, the concentration of heavy metals (Pb, Zn, Cu, Co, Cd, Fe, Ni, and Mn) from each of the filtered samples were determined using atomic absorption spectrophotometer (AAS) model AA500 at the Multi-User Science Research Laboratory, Ahmadu Bello University, Zaria. The laboratory procedures for sample analysis following American Public Health Association (APHA 2005) procedure.

3 RESULTS AND DISCUSSION

The concentration of chemical properties of water for samples A-H are represented in Table 2. Column 2 in the table represents the World Health Organization maximum permitted limit for drinking water of heavy metals while column 3 represents the Nigerian Standard for drinking-water quality maximum permitted limit of heavy metals. It was observed from the table that Lead (Pb) was below the detection limit since its concentration is 0mg/L in all the samples. This might be because there is no Pb mining taking place in the study area.

From all the samples Zinc (Zn) is below the acceptable limit. Also, Copper (Cu) is within the maximum permitted limit in the samples. It was observed from the table that Zn and Cu concentrations in sample A were higher than the remaining samples. This shows that sewage dumping site that is about 4m from the shallow well contributes to the increased percentage of the elements in the well.

However, it was reviewed by Beyene and Berhe (2015) that the World Health Organization (WHO) maximum permissible limit of Cobalt (Co) for drinking water is 0.005

mg/L, therefore it is realized from Table 2 that Co concentration in sample D is within the acceptable limit while in the other samples there were not Co in present. Therefore, base on Pb, Zn, Cu, and Co the water is very good for drinking since the elements were within NSDWQ and WHO standards for drinking water. Well, the results obtained were Agreed with Adesakin (2020) that the Chemical properties of the underground water from the Samaru community were within WHO and NSDWQ standards.

Moreover, Table 2 shows that Iron (Fe) was below the detection limit in samples B, D, F, and H but the concentration of Fe in samples A, C, E, and G were more than the acceptable limit. The high value of Fe in sample H might be as a result of leaching to the groundwater from the burial ground (cemetery) since the graveyard is not far from the borehole H (about 250 m from the graveyard). Okpanachi, (2015) had earlier reported that if an urgent step is not taken on the dumpsites, the heavy metal will continue to leach into the groundwater thereby contaminating the groundwater.

It was also observed from Table 2 that the concentration of Cadmium (Cd), Manganese (Mn), and Nickel (Ni) in all the samples were more than NSDWQ permitted limit. Therefore, concerning Cd, Ni and Mn the water is not safe for consumption. NSDWQ (2007) reported that Cd, Mn, and Ni present in water more than the recommended limit are toxic to the kidney, causing neurological disorder and carcinogenic respectively. Never the less the results obtained were agreed with what Okpanachi (2015) found that as a result of the high concentration of some heavy metals, the Samaru Groundwater is not totally safe for consumption.

Table 2. Concentration of Chemical properties of water samples at selected locations in the study areas

Parameters	WHO Maximum permitted (mg/L) (source: Beyene and Berhe, 2015)	Maximum permitted (mg/L) (source: NSDWQ, 2007)	Samples (mg/L)							
			A	B	C	D	E	F	G	H
Pb	0.01	0.01	0	0	0	0	0	0	0	0
Zn	3	3	0.260	0	0.53	0.223	0.288	0.472	0.425	0.115
Cu	2	1	0.235	0.185	0.130	0.020	0.165	0.120	0.175	0.195
Cd	0.005	0.003	0.150	0.130	0.190	0.175	0.185	0.195	0.135	0.220
Fe	0.3	0.3	0.562	0	3.020	0	1.530	0	0	7.00
Mn	0.4	0.2	0.59	1.28	0.645	0.475	0.500	0.450	0.630	0.730
Co	0.005	-	0	0	0	0	0.005	0	0	0
Ni	0.02	0.02	1.573	1.550	0.875	0.870	1.220	0.875	0.985	0.965

4 CONCLUSION

The chemical properties of water samples were analyzed. The results showed that the water is safe for consumption in terms of Pb, Zn, Cu, and Co because they agreed with NSDWQ permitted limit. But the concentration of Fe, Cd, Mn, and Ni indicated that the water is not safe for consumption regards to the elements. It is therefore recommended that urgent prevention measures should be put in place to prevent increasing concentration of Cd, Fe, Mn, and Ni as a result of anthropogenic activities.

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