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Geochemical Soil Analysis for Groundwater Quality at Mokola Area, Ibadan, Southwestern Nigeria

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Abstract
The concentration of heavy metals in soil samples could be used to help determine the quality of ground water in that area. Therefore, geochemical study of soil samples from drilled boreholes was carried out in Mokola, Ibadan North Local Government Area. Soil samples were collected from ten different sampling points and analysed using atomic absorption spectrometer. The results of the heavy metal concentration obtained for each soil sample in each sampling point were compared with that of the standard regulatory bodies such as World Health Organisation (WHO). The mean concentrations of heavy metals: Lead (Pb), Cadmium(Cd), Arsenic (As) Nickel (Ni) and Chromium (Cr) were above the maximum contamination limit recommended by WHO (2017) except that of Copper (Cu) and Zinc (Zn). As a result of these findings, the research locations might have been contaminated with heavy metals, and that the groundwater could pose a major danger to the locals. It is therefore recommended that a groundwater remediation strategy be implemented to prevent further contamination.
Keywords: *Geochemical Investigation, Groundwater Quality, Soil contamination, Heavy metals*

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I. Introduction

Groundwater plays an essential role in human lives (Ayandiran *et al.*, 2018). Groundwater for human consumption should be potable, free from disease-causing organisms, minerals and other organic substances that could impair human health (Ademoroti, 1986;Ademoroti, 1996;Shabanda and Shabanda, 2015).However, groundwater may be polluted by uncontrolled disposal of solid wastes and sewage, intense agricultural activities and polluted surface water (Jain *et al.*, 1996).In Nigeria, over 66 million people lack access to good quality drinking water source and consumption of polluted or contaminated water from diverse sources had led to different health issues (WHO, 2017).Therefore, good quality drinking water is essential for improving the life of man and animal and also to prevent diseases (Mohammed *et al.*, 2013). As a result of human and environmental factors, the quality of drinking water has been negatively affected.

In both urban and rural communities in Nigeria, heavy metals are the major contaminants found in drinking water from boreholes and wells (Shabanda and Shabanda, 2015). Some heavy metals such as Copper (Cu), Selenium (Se), Zinc (Zn) are essential for the maintenance of metabolism in the human body. Among the heavy metals, Arsenic (As), Cadmium (Cd), lead (Pb), Chromium (Cr), Copper (Cu), Mercury (Hg) and Nickel (Ni) are of major concern because of their presence at relatively high concentrations in drinking water and theireffects on human health (ATSDR, 2015).High concentration of Cd in drinking water can cause kidney damage and cancer (Gobe and Crane, 2010). Chronic renal failure may be caused by drinking water contaminated with Hg (Bawaskar and Bawaskar, 2010; ATSDR, 2015). As groundwater flows through the ground, heavy metals are being dissolved in the water in high concentrations (Malik and Khan, 2016). Soil may become contaminated by the accumulation of heavy metals through emissions from vehicles, excessive application of fertilizers, animal manures, sewage sludge, pesticides, wastewater irrigation, coal combustion residue, spillage of petrochemicals from the rapidly expanding industrial areas, disposal of high metal wastes, contaminated paints and contaminated lead-acid batteries (Adaikpoh *et al.*, 2005; Kane *et al.*, 2012; Singh *et al.*, 2012; Harvey *et al.*, 2015). Most environmental contamination and human exposure to heavy metals result from anthropogenic activities from mining and smelting. Environmental contamination can also occur through metal corrosion, atmospheric deposition, soil erosion of metal ions and leaching of heavy metals, sediment re-suspension and metal evaporation from water resources to soil and groundwater. More than a few studies have shown that heavy metals for instance lead cadmium, nickel, manganese and chromium are responsible for certain diseases. These diseases include abdominal pain, chronic bronchitis, kidney disease, pulmonary edema (accumulation of fluid in the lungs), cancer of the lung and nasal sinus ulcers, convulsions, liver damage and even death (Hughes, 1996).

In different parts of Nigeria, many researches had been carried out on the determination of levels of heavy metal ions in the soil, rivers and groundwater. Geochemical studies were carried out on some water samples polluted with Municipal Wastes (MWs) within the region of Ibadan North Local Government. The result showed high level of heavy metals concentration in the samples and that may pose a great threat to health of traders, residents, passers-by as well as consumers in general. The chromium contents in the samples ranged from 0.04 to 0.10 ppm. When compared with the World Health Organization (WHO) standard, the values except for one were found above the maximum permissible limit of 0.05 ppm. Lead contents of the samples ranged from 0.02 to 0.05 ppm which was above the maximum permissible limit set by the regulatory body. The concentrations of cadmium in the samples were found to be between 0.01 and 0.07 ppm and were considered to be extremely high as compared to 0.003 ppm set by World Health Organization (WHO). The iron contents in the samples ranged from 0.33 to 4.02 ppm and the values were all found above the maximum permissible limit set by WHO (Abegunde and Abdulrahman, 2017).

Assessment of heavy metal concentration levels in water samples collected at Agodi Reservoir in Ibadan North Local Government Nigeria were determined by standard methods using Atomic Absorption Spectrophotometer (AAS) over a period of twelve (12) months covering both rainy and dry seasons. Results showed no seasonal variations in all the heavy metals except for Cobalt (Co). The heavy metal profile in Agodi Reservoir, measured in mg/L, was as follows: Mn (64.81) > Fe (43.75) > Zn (23.13) Cu (12.44) > Co (0.19) > Ni (0.17) > Cd (0.12). Concentrations of Cr and Pb were below the detectable level. Compared to WHO recommended limits, Co fell below while others were higher than the thresholds. This finding showed that Agodi Reservoir water has a potential environmental hazard unless treated before use (Ogunbile *et al.,* 2019).

Assessment of heavy metal concentration levels in water samples of Oluwa River, South-Western Nigeria, showed that almost all heavy metals analyzed deviated from the permissible levels recommended by WHO standards for drinking water (Ayandiran *et al.*, 2018). The geochemical analysis carried out on fifteenwater samples sourced from wells and boreholes in Ota, South Western Nigeria using Inductively Coupled Plasma Mass Spectrometry (ICP-MS) showed that majority of the trace elements falls within the permissible limit recommended by WHO for drinking water standards. These findings showed that the present status of groundwater in Ota is good for domestic and agricultural purposes. However, the presence of heavy metals such as Lead, Bromide, Copper, Potassium, Manganese, Rubidium and Silicon in fairly high quantities in the groundwater samples which may be as a result of dissolved salts in the groundwater may constitute major health hazards if not quickly rectified (Kayode *et al.,* 2016).

Evaluation of heavy metals contamination of deposited dust was carried out in Ibadan metropolis, South-western Nigeriausing Inductively Coupled Plasma Mass Spectrometry, Factor Analysis (FA) and Hierarchical Cluster Analysis (HCA)for source identification of heavy metals and Enrichment Factor (EF)to determine the degree of their contamination. The study revealed that the heavy metals are sourced from both geogenic and anthropogenic input and Pb and Zn are significantly contaminated which may pose serious threat to human health and ecosystem (Olatunji *et al.,* 2017).

Groundwater and soil samples from 16 locations near Petrol Stations (PS) and Mechanic Workshops (MW) around Calabar, Nigeria, were analyzed for heavy metals and hydrocarbons to determine their concentrations and assess the impact of the PS and MW on groundwater in the area. Results showed that mean concentrations of cadmium, chromium, manganese, nickel, and lead in groundwater are higher than the maximum admissible concentration level (Nganje *et al.,* 2007).

Industrial effluents could contribute to the level of the heavy metals such as lead in our environment (Ayodele *et al.,* 2007). Samples of industrial effluents from Sharada-an industrial area in Kano, Nigeria were assessed for heavy metals. The study showed that about 60% of the industries discharge effluents with heavy metal concentration higher than 0.30 mg/L. Lead and chromium ions were the most prevalent with values above the minimum tolerable limit. The presence of these metal ions could pose a serious public health hazard. It was therefore recommended that these effluents be adequately treated before being discharged.

In a study of soil samples from refuse dumps in Awka (Anambra State, Nigeria), the level of lead concentration (2467mg/kg) exceeded the limits set by the US Environmental Protection Agency. This study revealed that the refuse dumps in Awka may contribute to the increase the level of environmental heavy metals in Nigeria (Nduka *et al.,* 2006). Okoye (1991) reported that urban and industrial wastes discharged into the Lagos lagoon had a significant impact on the ecosystem. A study of heavy metal contamination of topsoil and dispersion in the vicinities of a reclaimed auto repair workshops in Iwo, Osun State, Nigeria, showed that the soil was significantly contaminated with Pb and Hg which was attributable to the disposal of waste lubricant oil and auto-exhaust emission (Ayodele *et al.,* 2007). There has been no research on the geochemical analysis of soil samples from boreholes in Mokola: hence this study is aimed at investigating geochemical analysis of soil samples and their effect on the inhabitants in the study area.

The Study Area

The study area is Mokola and it is located within the Ibadan North Local Government in Ibadan city as shown in Fig.1. It occupies a geographical coordinates of latitude $7^{0}24'44$"North and longitude $3^{0}53'21$" East. The climate is tropical with well-defined rainy (wet) and dry seasons.

The geology of this area is part of the Precambrian basement complex in southwestern Nigeria as shown in Fig. 2.The area is made up of Precambrian crystalline rocks that can be grouped into major and minor rock types. The major types are quartzite of the meta-sedimentary series and migmatite complex comprising banded gneiss, augen gneiss, and migmatite-gneiss. The minor rock types are pegmatite, quartz amphibolite and xenoliths(Adeola and Oyebola, 2016). The type of rock in an area is an important factor governing the characteristics of its groundwater. The rocks in the area serves as good aquifers because of the existence of secondary porosity and permeability which take place as a result of fractures and extreme degree of weathering in the study area.The entire western part of the community in which the study area is located is underlain by banded gneiss while the eastern part is predominantly made up ofgranite gneiss(Adeola and Oyebola, 2016).Mokola is accessible by a major road, which is tarred.

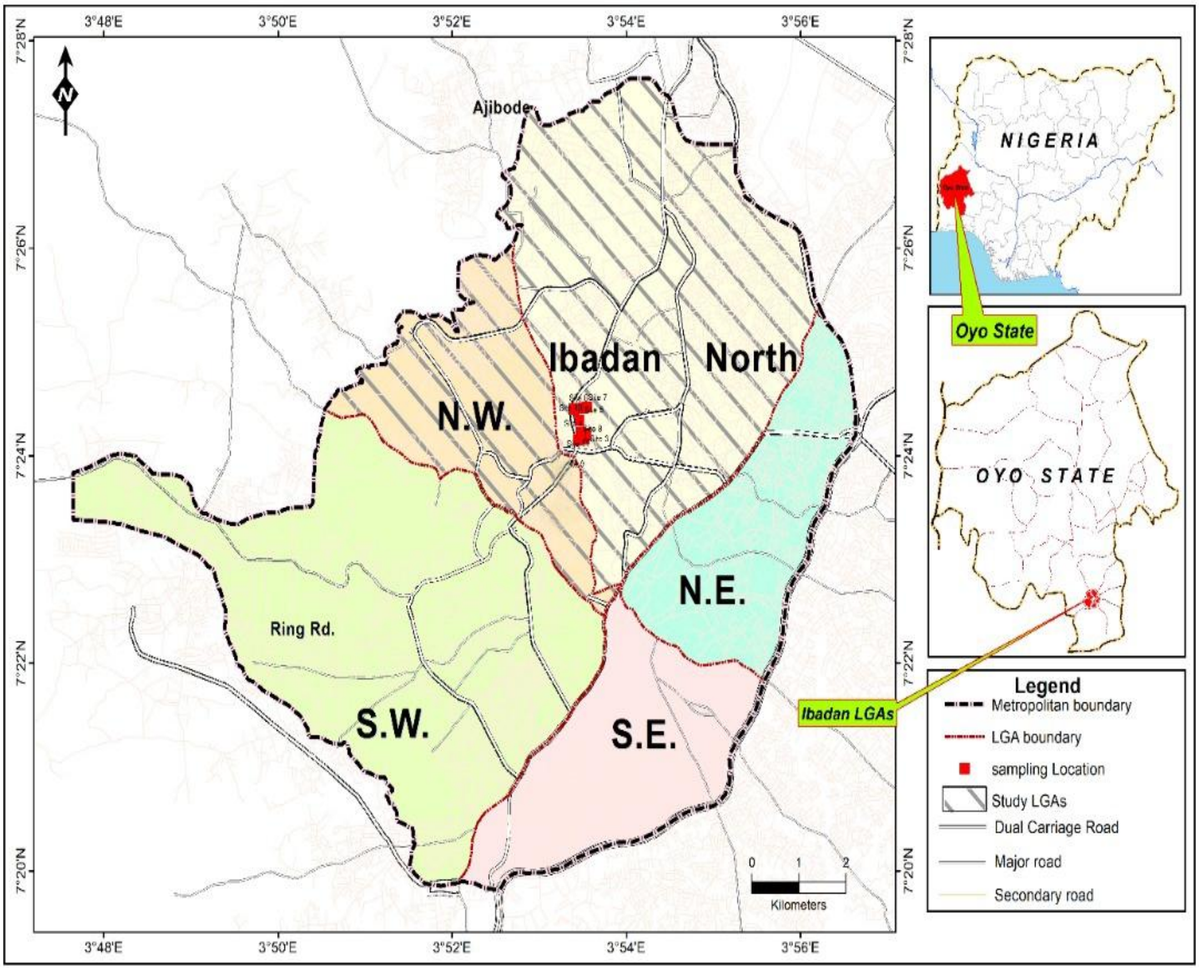

Figure 1: Map of Ibadan showing the study area

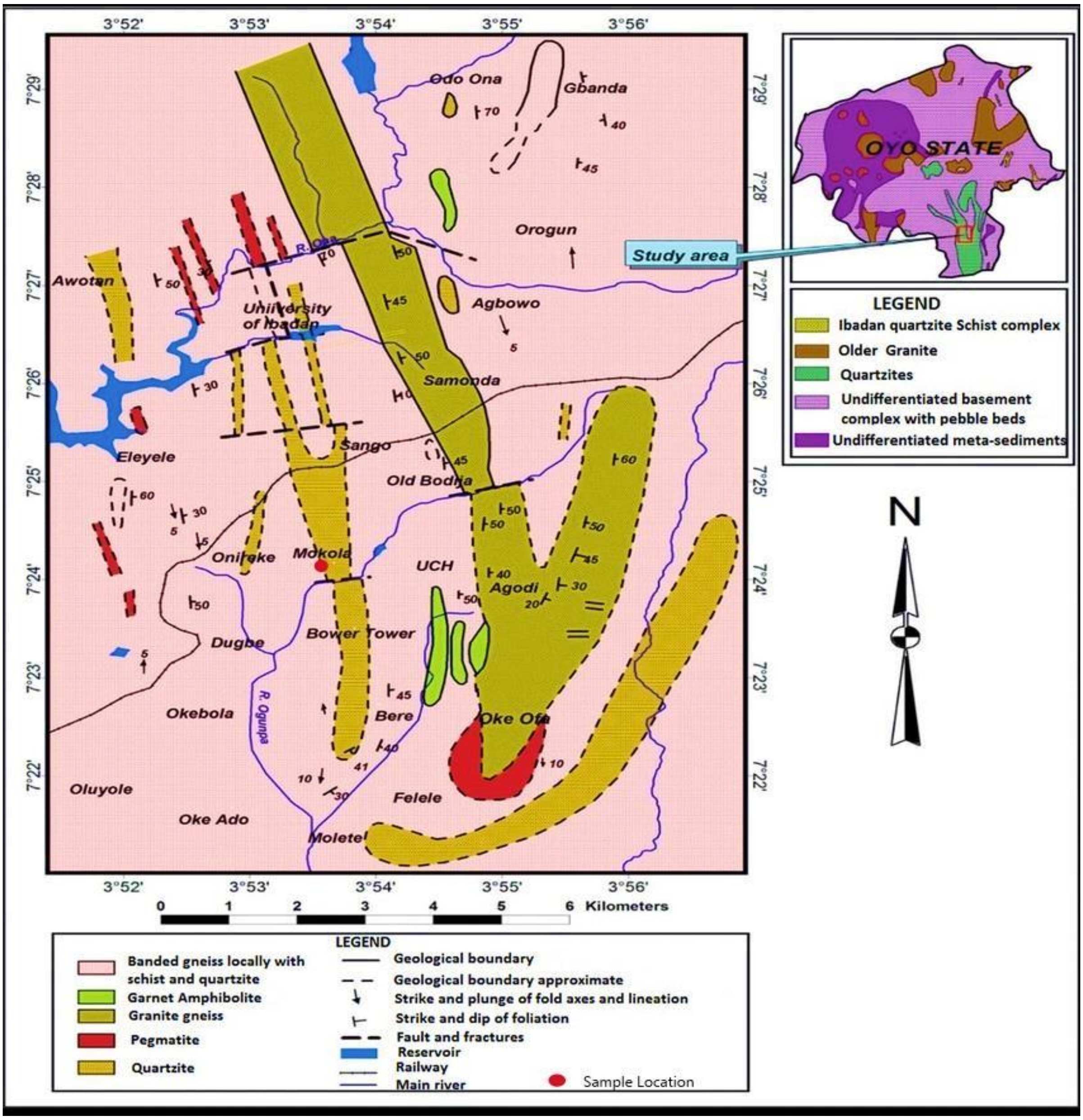

Figure2: Geologic map of Ibadan showing the study area

II. Material AndMethods

Ten soil samples were collected from ten boreholes in the study area and placed in clean polyethylene bags. The samples were then sun dried and pulverized using a mortar into fine powder. These were then sieved through a 2-mm- mesh sieve, weighed and stored at room temperature for digestion. A 5ml of reagent, concentrated perchloric acid ($HClO_4$) was added into a representative sample of 2 g and stirred for optimal mixing. Geochemical laboratory analysis was carried out on the samples to determine the concentration of heavy metals (Pb, Cu, Ni, As, Cr, Cd, Zn). Heavy metals were analyzed using Atomic Absorption Spectrometer (AAS) Perkin Elmer and the results obtained were compared with recommended standard regulatory.

III. Results And Discussion

The results obtained from the analysis of the heavy metals in various soil samplesfrom the ten sampling points (S1, S2, S3, S4, S5, S6, S7, S8, S9 and S10) using Atomic Absorption Spectrometry (AAS) are shown in Table 1. The concentration of lead in the study area ranged from 1.155 mg/L to 3.846 mg/L with a mean concentration of 1.9472 mg/L which is slightly higher than the WHO permissible limit for lead concentration. The maximum permissible limit in drinking water is 0.01 mg/L (WHO, 2017) as shown in Table 2. Higher concentration of lead in drinking water has its associated health effects in human being. Exposure to lead can cause hypertension, anaemia, renal impairment and affects the mental development in infants. It is toxic to the central nervous system and could lead to a disease called plumberism(Ayibawari *et al.*,2020). Exposure of pregnant women to high concentration of lead can cause premature birth, miscarriage and stillbirth (Ayibawari *et al.*,2020). Concentration of copper in the study area ranged from 1.10 mg/L to 1.40 mg/L with a mean concentration of 1.22 mg/L. The maximum permissible limit in drinking water is 2.0 mg/L (WHO, 2017). The concentration of copper in the study area is lower than the maximum permissible limit. However, copper-contaminated drinking- water causes gastrointestinal disorder, kidney and liver damage which can lead to untimely death (Nkuah and Agbemafie, 2019). Concentration of chromium in the study area ranged from 0.01 mg/L to 0.20 mg/L with a mean concentration of 0.056 mg/L. The maximum permissible limit in drinking water is 0.05 mg/L (WHO, 2017). The concentration of chromium in the study area is slightly higher than the maximum permissible limit. High concentration of chromium in the drinking water could also lead to kidney and liver damage, intestinal bleeding and diarrhea. (Ayibawari et al., 2020).

Concentration of cadmium in the study area ranged from 0.430 mg/L to 0.730 mg/L with a mean concentration of 0.5757 mg/L. The maximum permissible limit in drinking water is 0.003 mg/L (WHO, 2017).Cadmium-contaminated drinking water may be as a result of deterioration of galvanized zinc pipes and some metal fittings. Cadmium concentration in the soil may be due to dumped dry cell batteries. High concentration of cadmium in drinking water when consumed by man is toxic to the kidney and leads to liver, bone and blood damage (Hughes, 1996; Gobe and Crane, 2010).

Concentration of zinc in the study area ranged from 1.240 mg/L to 2.540 mg/L with a mean concentration of 2.134 mg/L. The maximum permissible limit in drinking water is 3.0 mg/L(WHO, 2017). The concentration of zinc in the study area falls within the permissible limit. High concentration of zinc in drinking water could be as a result of corrosion of pipes. Low concentration of zinc in soil could be due to the high organic matter content of the soil which makes it acidic in nature. Deficiency of zinc could lead to chronic ailments such as diarrhoea, fever and abdominal pains (WHO, 2017). Concentration of arsenic in the study area ranged from 0.752 mg/L to 1.231 mg/L with a mean concentration of 1.089 mg/L. The maximum permissible limit in drinking water is 0.01 mg/L (WHO, 2017). The mean concentration of arsenic exceeded the allowable limit for drinking. Arsenic is a natural component of the earth's crust and is present at high concentration in the groundwater. The high concentration of arsenic in the study area could be as a result of human activities such as uncontrollable waste disposal. Arsenic is highly toxic in its inorganic form while organic arsenic compounds which are found in seafood are has no harmful effect to health. Long-term exposure to arsenic from drinking water could lead to skin lesions and disease known as hyperkeratosis(WHO, 2017). Concentration of nickel in the study area ranged from 1.015 mg/L to 1.080 mg/L with a mean concentration of 1.029 mg/L. The maximum permissible limit in drinking water is 0.07 mg/L (WHO, 2017). The value of the mean concentration of nickel in the study area revealed that the soil is slightly contaminated which may be due to anthropogenic factors such as emissions from automobiles. Consumption of nickel contaminated water by man could affect the blood, liver and kidney (WHO, 2017).

Table 1 : Concentrations of heavy metals

Sampling points	**Concentration (mg/L)**						
	Arsenic (As)	**Zinc (Zn)**	**Copper (cu)**	**Lead (Pb)**	**Cadmium (Cd)**	**Chromium (Cr)**	**Nickel (Ni)**
S1	1.228	2.25	1.25	1.639	0.622	0.04	1.015
S2	1.231	2.05	1.23	1.451	0.73	0.03	1.018
S3	1.148	2.24	1.19	1.454	0.654	0.01	1.08
S4	1.172	2.23	1.18	1.155	0.43	0.08	1.02
S5	1.24	2.46	1.4	1.751	0.561	0.2	1.02
S6	0.752	2.54	1.22	1.841	0.46	0.04	1.03
S7	0.833	2.06	1.1	1.846	0.53	0.08	1.02
S8	0.84	2.24	1.38	3.846	0.526	0.04	1.04
S9	0.83	1.24	1.1	2.335	0.659	0.03	1.022
S10	1.62	2.03	1.15	2.154	0.585	0.02	1.028

Table 2: Mean concentration of heavy metals in comparison with WHO permissible limit

Heavy metals	Mean concentration(mg/L)	WHO permissible limit (mg/L)
Arsenic	1.089	0.01
Zinc	2.134	3
Copper	1.22	2
Lead	1.9472	0.01
Cadmium	0.5757	0.003
Chromium	0.056	0.05
Nickel	1.029	0.07

IV. Conclusion

Soil samples from ten boreholes at different sampling points in Mokola, Ibadan North were analyzed for geochemical study to evaluate the quality of groundwater for human consumption. The results of the study revealed that the concentration of arsenic, lead, cadmium, chromium and nickel in the boreholes were higher than the recommended World Health Organisation (WHO, 2017) standard for drinking water. The drinking water is therefore unsafe for human consumption as it poses a risk to the health of the inhabitants. It is therefore recommended that further treatment of the water should be carried out before consumption.

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