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ASSESSMENT OF GROUNDWATER QUALITY NEAR HOSPITAL WASTE TREATMENT PLANT

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ABSTRACT

The study conducted a comprehensive assessment of the quality of selected groundwater sources around the liquid waste treatment plant of Ahmadu University Teaching Hospital Shika, Nigeria. Water samples were collected from four (4) hand-dug wells following standard procedures, ten (10) physicochemical parameters, and seven (7) heavy metals were analyzed. All the physicochemical parameters studied were within the WHO-specified limits except for D.O., which was less, and turbidity, which was higher. Heavy metals were found in all groundwater sources that were studied. However, the concentration of some heavy metals exceeded the specified limits recommended by the World Health Organization (WHO). The heavy metal presence in the groundwater sources may be connected to human activities such as waste disposal containing these metals around the groundwater sources and liquid waste from the hospital, which may have seeped into the wells. By implication, this study shows that the hand-dug wells were not safe for drinking. It is recommended that wells be sited away from dumpsites and waste treatment plants. Effluents from waste treatment plants should also be appropriately treated before their subsequent discharge into the environment. This study has generated baseline data that will be useful in monitoring heavy metal pollution.

Keywords: Groundwater, Effluents, Heavy metals, Physicochemical parameters, Lead, Iron

INTRODUCTION

Water is a necessity for the sustenance of a healthy life (Abubakar, 2018). Therefore, the provision of good drinking water is becoming a huge task for the government, decision-making bodies, and institutions spearheading water management in nations with an increasing populace (Ismaila Rimi Abubakar, 2019). Good drinking water relates to water protected from external contamination and is required for healthy living (Abubakar, 2018; Owamah, 2020).

In 2015, only 24% of the 319 million dwellers of sub-Saharan Africa had access to good drinking water (Owamah, 2020), in contrast to Latin America and the Caribbean (65%), West Asia, and North Africa (90%), East Asia and Southeast Asia (94%) respectively.

Nigeria, one of the countries of sub-Saharan Africa, was reported in 2015 to have provided 67% of its population access to water free of contamination. However, it is still below the 77% MDG target and the global mean of 91% (World Health & United Nations Children's, 2015). In 2013, reports obtained from Nigeria Demographic and Health Surveys revealed that 50.8% of rural dwellers and 14.4% of urban dwellers in Nigeria use drinking water from sources that are not safe (Abubakar, 2019). Studies conducted in Nigeria revealed several contaminated water sources (Bamigboye et al., 2020; Ibe et al., 2020; Oyelami et al., 2013; Zacchaeus et al., 2020). However, it is sad to note that water consumption is from these unsafe sources in Nigeria and many other developing nations (Owamah, 2020; World Health, 2012). The consumption of contaminated water, together with poor hygiene and sanitation, has been revealed as the cause of more than a million deaths globally (WHO 2012). Reports show that the use of contaminated water sources, open defecation, and poor hygiene are responsible for more the 80% of water-borne diseases in developing countries (Owamah, 2020).

Nigeria's population was estimated in 2017 to be more than 190 million. Despite this large population, Nigeria still has considerable drawbacks in providing safe drinking to rural dwellers and small towns (Owamah, 2020). This large population has created a significant dependence on groundwater sources that are not free from contamination because of human activities like open defecation, poor disposal of solid waste and inefficient sewage disposal, etc. (Dahunsi et al., 2014; Sojobi, 2016).

The quality of groundwater sources is not well documented for the Shika district of the Giwa local government area of Kaduna State. Therefore, a robust database is needed to aid in formulating policies that will improve water quality, and sanitation and eventually enhance human health. Therefore, this study was carried out to ascertain the physicochemical quality and heavy metal content of some groundwater sources near the Ahmadu Bello University Teaching Hospital in Shika, Kaduna State, Nigeria.

MATERIALS AND METHODS

Description of the study area

This study was carried out near the liquid waste treatment plant of Ahmadu University Teaching Hospital Shika, Nigeria. The integrity of Four hand-dug wells was accessed for possible contamination. For this study, the wells were coded U1, U2, U3, and U4 correspondingly (Figure 2).

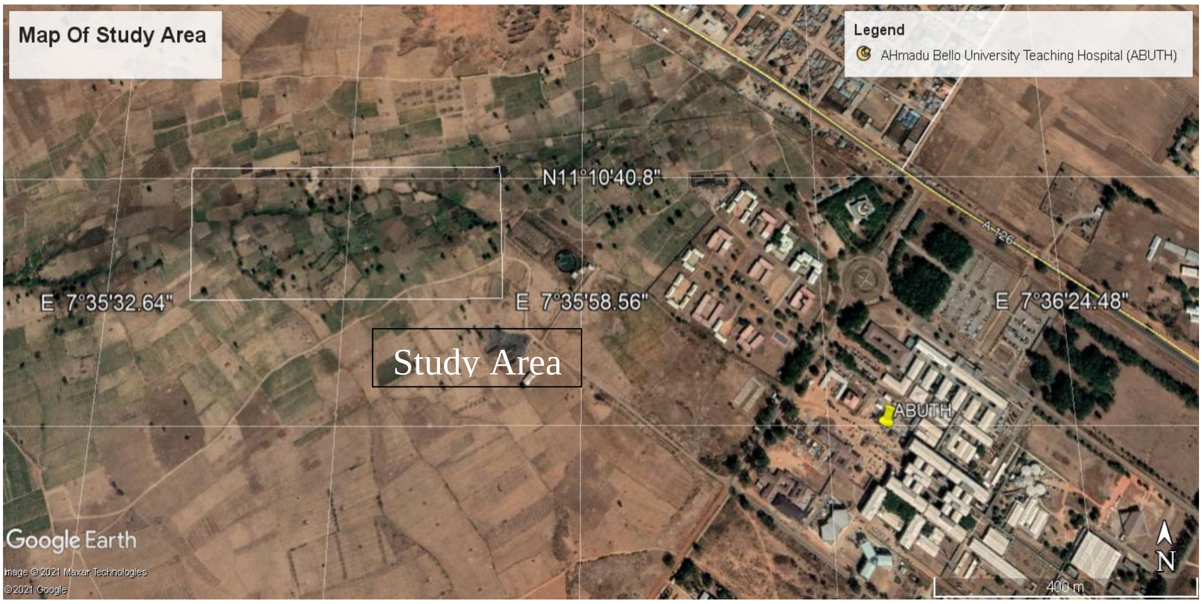

Figure 1: A map of the study area.

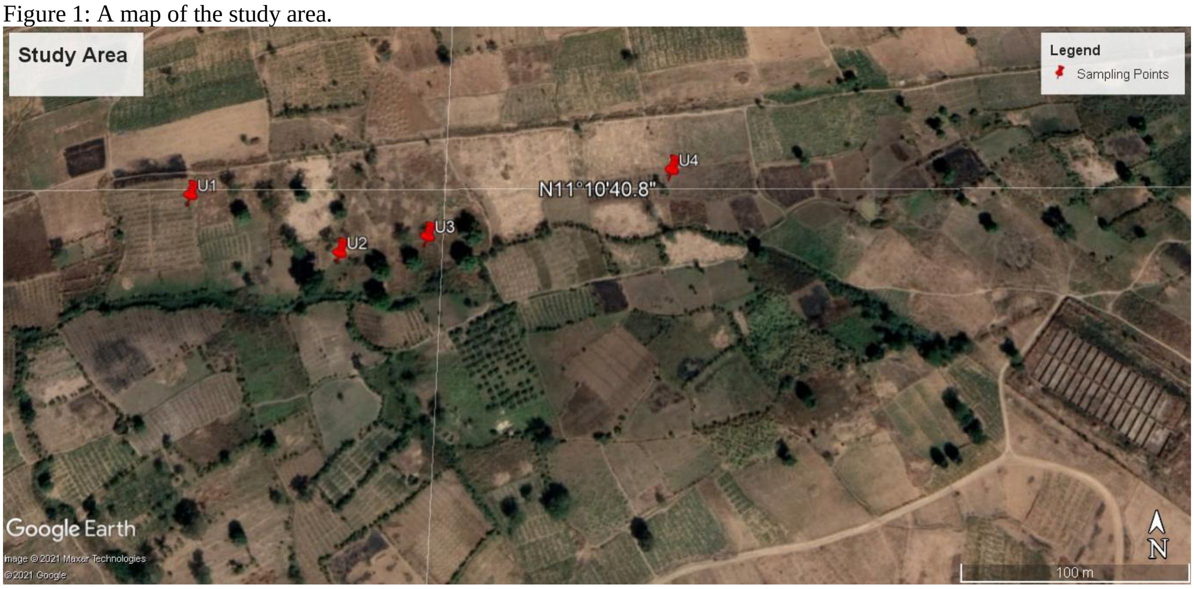

Figure 2: Study Area showing the Sampling Points

Sample collection and preparation

The water samples were obtained in clean, sterile bottles from the study area using standard methods for collection and preservation (Rice, Bridgewater, Association, Association, & Federation, 2012). The samples for physicochemical assay were preserved in ice before transportation to the Water Resources Laboratory of Ahmadu Bello University Zaria, Nigeria. They were subsequently stored in a refrigerator at 4º C before carrying out the laboratory procedures.

Determination of physicochemical parameters and heavy metal content

Water quality parameters such as electrical conductivity (E.C.), temperature, and hydrogen ion concentration (pH) of the samples were verified utilizing a portable HANNA, H19813-5 model. Turbidity was measured using a turbidimeter (HACH), while nitrate, phosphate, sulfate, dissolved oxygen (D.O.), biological oxygen demand (BOD), and chemical oxygen demand (COD) were verified according to (Rice et al., 2012) methods. The assay of the heavy metal content was performed using the atomic absorption spectrophotometer (AAS) (AA-6800 SHIMADZU model).

RESULTS AND DISCUSSION

Physicochemical levels in groundwater

The pH of water is a reflection of its alkalinity or acidity. Generally, the samples were slightly acidic and alkaline among the sites. pH does not directly impact human beings, but its indirect effects cannot be ignored (Adekunle et al., 2007). All pH values except U4 were within the specified levels of WHO (2012). This exception may be connected with the geology of the study area (Addo, Boateng, & Obiri-Danso, 2016). Electrical conductivity (E.C.) is the degree of the number of dissolved salts in water. It gives the ionic conductance of all ionic water factors, including dissolved nutrients and micronutrients (Das et al., 2013). The presence of high dissolved salts in water can affect soil's productivity and properties when used for irrigation (Rezaei et al., 2020). The E.C. results obtained in the study are within the specified levels of WHO (2012). D.O. is a significant pointer to the stability of an aquatic ecosystem as low D.O. values cannot sustain aquatic life (Ezemonye et al., 2019). The D.O. values obtained in this study were lower than the specified levels of 5 mg/L specified by WHO (2012). BOD is an indication of the organic pollution load of water (Owamah, 2020). High

BOD values reflect the presence of organic pollution. The BOD is within the WHO (2012) specified limit of 6 mg/L and indicates the absence of organic pollution in the groundwater study. The mean turbidity values ranged from 5.70 to 7.40 NTU. The turbidity values obtained in this study are above the WHO (2012) specified value of 5 NTU. This may be connected to anthropogenic activities, microorganisms, colloidal organic matter, and suspended particles (Alexander et al., 2019). Nitrate values in the range of 3.40 mg/L to 18.90 mg/L were obtained in this study. A high concentration of nitrate in water is hazardous to human health and can harm the respiratory system (Bhat et al., 2019; Singh et al., 2016). Sulfate values ranged from 1.20 mg/L to 6.90 mg/L. This is lower than the specified value of 50 mg/L (WHO, 2012). The low sulfate concentration could be attributed to the minimizing effects of aquifers, preventing sulfide oxidation (Tirkey et al., 2017). The phosphate content varied from 0.10 mg/L to 1.40 mg/L. The presence of phosphate could be associated with fertilizers by the farmers (Egbueri, 2018). There is no health-related effect associated with phosphate in water (Owamah, 2020). Temperature is a criterion of the level of hotness or coldness of the water. It ranged from 25 to 27˚C. There is no specified value for temperature, but it exceeded room temperature of 20 - 22 ˚C. There is no reported health implication for temperatures above the ambient level. All the physicochemical parameters studied did not show a significant difference ($P < 0.05$) except for COD which varied significantly ($P < 0.05$) within the study area.

Heavy metal levels in groundwater

The results of the heavy levels are shown in table 2. The Cr value obtained in this study exceeded the WHO (2012) specified level of 0.05 mg/L this suggests that the end users of the water source are at a risk of ingesting Cr in high concentrations which can induce gastrointestinal cancer (Ibe et al., 2020). The Pb levels in the groundwater exceeded the WHO (2012) specified level of 0.01 mg/L. This may be connected to inappropriate dumping of waste containing Pb within the vicinity of the groundwater. It is required by the body but ingesting it in high levels could result in health issues such as subencelophalopathic disorders (Oni & Hassan, 2013; Sojobi, 2016). The level of Cd recorded in this study was above the WHO (2012) specified level of 0.003 mg/L. Cd ranks third in the list of heavy metals frequently reported in water. Concerns have been raised because of its carcinogenic nature (Dahunsi et al., 2014). Ingestion of cadmium-contaminated water has been reported to cause renal failure, anemia, hypertension, cardiovascular diseases, kidney diseases, lung damage, and fragile bones (Bawaskar et al., 2008; Gobe & Crane, 2010). Iron is a beneficial component of the human diet (Zacchaeus et al., 2020). The high iron level may be a consequence of pipe corrosion (Prakash & Somashekar, 2006). There is no specified health limit for iron. All the values of Manganese obtained in this study were above the WHO (2012) specified value of 0.05 mg/L except for site U4. Manganese is vital to the human body, but it can become harmful to the body when ingested in high amounts (Zacchaeus et al., 2020). The Nickel level exceeded the WHO-specified value of 0.02 mg/L. The groundwater situation around a dumpsite could account for the presence of Ni (Vetrimurugan et al., 2017). Ni plays a crucial role in the biological activities of microorganisms and plants (Asare-Donkor et al., 2016; McGregor et al, 2000). However, at high levels, Ni is toxic (McGregor et al., 2000). The Cobalt content recorded in the study varied from 0.22-0.40 mg/L. Co may have resulted from dumpsite leachate in the study area (Purushotham et al., 2013).

Assessment of the origin of physicochemical parameters and heavy metal using correlation

A strong positive correlation was observed between COD and temperature ($r = 0.976$, $p > 0.05$) while a strong negative correlation was observed between COD and pH ($r = -0.990$, $p > 0.01$) and DO and turbidity ($r = -0.988$, $p > 0.05$). This predicates that the same anthropogenic activities influenced COD and temperature, whereas different activities influenced COD and pH (Ibe et al., 2020).

Similarly, the presence of a strong positive correlation between the heavy metals presupposes that the metals emanated from the same source or that their presence may have been a consequence of similar human activities (Owamah, 2020).

Table 1: Statistics of the levels of physicochemical parameters in groundwater

Parameters	U1	U2	U3	U4	WHO (2012)
pH	6.80±0.02	7.23±0.01	7.00±0.01	6.30±0.01	6.5-8.5
E.C. (µS/cm)	62.00±1.00	44.00±1.00	49.00±1.00	43.00±1.00	500-1500
D.O (mg/L)	1.40±0.10	1.13±0.10	1.20±0.10	1.50±0.10	5
B.O.D (mg/L)	0.50±0.20	0.13±0.10	0.13±0.10	0.30±.10	6
C.O.D (mg/L)	1.80±1.00	3.50±2.00	2.31±1.20	6.70±2.00	10
Turbidity (NTU)	6.00±0.01	7.40±0.01	7.20±0.01	5.70±0.01	5
Nitrate (mg/L)	3.40±0.20	13.70±0.10	18.90±0.10	16.40±0.10	50
Sulphate (mg/L)	1.90±0.10	6.90±0.10	1.20±0.10	1.50±0.20	500
Phosphate (mg/L)	0.10±0.00	1.40±0.20	0.60±0.12	0.40±0.10	-
Temperature (ºC)	25	26	25	27	-

Values are mean± SD of 3 determinations of the parameters.

Table 2: Statistics of heavy metal levels in groundwater

Metal (mg/L)	U1	U2	U3	U4	WHO (2012)
Cr	$0.20±0.10^{a}$	$0.80±0.11^{a}$	$0.22±0.14^{c}$	$0.44±0.04^{b}$	0.05
Pb	$1.71±1.20^{a}$	$3.01±0.83^{a}$	$3.20±1.51^{a}$	$1.90±0.71^{a}$	0.01
Cd	$0.03±0.00^{ab}$	$0.06±0.01^{c}$	$0.02±0.11^{a}$	$0.10±0.01^{bc}$	0.003
Fe	$2.19±1.32^{a}$	$11.40±0.30^{c}$	$2.50±0.65^{a}$	$5.20±0.44^{b}$	-
Mn	$0.10±0.01^{a}$	$0.20±0.05^{a}$	$0.50±0.10^{b}$	$0.05±0.10^{a}$	0.05
Ni	$0.04±0.10^{a}$	$0.11±0.05^{a}$	$0.14±0.10^{a}$	$0.06±0.05^{a}$	0.02

Co	0.40±0.33ᵃ	0.22±0.14ᵃ	0.35±0.04ᵃ	0.40±0.20ᵃ	-

Values are mean± SD of 3 determinations of the heavy metal concentration of the groundwater samples. The mean values in the same row with the same superscript letters are not significantly different (*p*>0.05).

Table 3: Correlation between physicochemical parameters in groundwater

Parameters	pH	EC	DO	BOD	COD	Turbidity	Nitrate	Sulfate	Phosphate	Temperature
pH	1.000									
EC	0.652	1.000								
DO	-0.581	0.232	1.000							
BOD	0.000	0.740	0.763	1.000						
COD	0.990**	-0.716	0.489	-0.068	1.000					
Turbidity	0.538	-0.288	-0.988*	-0.829	-0.457	1.000				
Nitrate	-0.440	-0.837	-0.271	-0.824	0.448	0.392	1.000			
Sulfate	0.182	-0.346	-0.683	-0.429	-0.042	0.587	-0.043	1.000		
Phosphate	0.073	-0.642	-0.821	-0.798	0.055	0.792	0.411	0.885	1.000	
Temperature	-0.938	-0.734	0.381	-0.091	0.976*	-0.379	0.368	0.164	0.203	1.000

***. Correlation is significant at the 0.01 level (2-tailed)*
**. Correlation is significant at the 0.05 level (2-tailed)*

Table 4: Correlation between heavy metals in groundwater

Metal	Cr	Pb	Cd	Fe	Mn	Ni	Co
Cr	1.000						
Pb	0.341	1.000					
Cd	0.891	-0.124	1.000				
Fe	0.996**	0.392	0.861	1.000			
Mn	-0.197	0.836	-0.611	-0.155	1.000		
Ni	0.179	0.985*	-0.287	0.238	0.897	1.000	
Co	-0.870	-0.600	-0.625	-0.910	-0.065	-0.494	1.000

***. Correlation is significant at the 0.01 level (2-tailed).*
**. Correlation is significant at the 0.05 level (2-tailed).*

CONCLUSION

A precise appraisal of some groundwater sources' physicochemical parameters and heavy metal content in the vicinity of the liquid waste treatment plant of Ahmadu Bello University Teaching Hospital, Shika, was carried out. All the physicochemical parameters studied were within the WHO-specified limits except for D.O. and turbidity. Heavy metals were found in all the groundwater sources that were studied. However, the concentration of some heavy metals exceeded the specified limits recommended by the World Health Organization (WHO). The heavy metal presence in the groundwater sources may be connected to human activities such as waste disposal containing these metals around the groundwater sources and liquid waste from the hospital seeping into the wells. We can be inferred from this study that water from these hand-dug wells is not safe for drinking. It is recommended that wells be sited away from dumpsites and waste treatment plants. Waste management agencies should appropriately treat effluents before their subsequent discharge into the environment. This study generated baseline data that will be useful in monitoring heavy metal pollution.

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