Quality Characteristics of Groundwater Within Hostels in Nnamdi Azikiwe University, Awka

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Abstract- Accessibility to quality water is essential for healthy living. This study aims to assess the quality of groundwater from hostels within Nnamdi Azikiwe University. Ten samples were randomly collected from various locations. The physicochemical analysis included pH, electrical conductivity, total dissolved solids (TDS), and total hardness. Heavy metals analyzed were lead, cadmium, arsenic, mercury, and aluminum. Results showed that pH ranged from 6.84 to 7.70, indicating slight acidity and alkalinity. Electrical conductivity ranged from 17.80 to 30.2 µS/cm, while TDS ranged from 49 to 702 mg/L, and total hardness ranged from 48 to 222 mg/L. Concentrations of lead, cadmium, arsenic, mercury, and aluminum ranged from 0.0000 to 0.5463 ppm, 0.003 to 0.029 ppm, 0.013 to 0.028 ppm, 0.007 to 0.079 ppm, and 0.001 to 0.019 ppm, respectively. While most physicochemical parameters met WHO and NSDWQ limits, lead exceeded the acceptable standard of 0.01 ppm, and arsenic and mercury were above 0.01 ppm and 0.0020 ppm, respectively. Cadmium and aluminum concentrations were below their respective acceptable limits. Risk assessment indicated that the water is generally fit for consumption based on Hazard Indices and Incremental Life Cancer Risk estimates. Therefore, simple treatment methods such as boiling, regular disinfection, and proper sewage disposal are recommended. Further investigation into the quality of borehole water in UNIZIK student hostels is essential for effective monitoring.

Indexed Terms- Groundwater, Physicochemical, Assessment, Hazard Indices

I. INTRODUCTION

Potable water is an essential ingredient for good health and the socio-economic development of man, but it is lacking in many societies. Clean water is priceless and a limited resource that man has recently begun to treasure after decades of pollution and waste. Drinking water is one of the most essential, inevitable, and necessary natural resources needed for life's actuality and man's survival [1], [2]. It is demanded for day-to-day use by all living organisms, including crops, animals, and human beings. Water can be seen as a naturally existing universal solvent on earth, whose main sources include streams, lakes, rivers, and ponds [3]. Water sources can be surface or underground. Surface water such as lakes, streams, rivers, and ponds, to a greater or lesser degree, is exposed to contamination by microorganisms from the atmospheric water during precipitation [4]. Groundwater, which is found in aquifers (a body of rock and/or sediment that holds groundwater), similar to springs, boreholes, and wells, is not directly exposed to rain, animals, or the atmosphere as they are protected from impurities. In addition, human activities can change the natural composition of groundwater through the disposal or dispersion of chemicals and microbial matter on the land surface and into soils, or through the injection of waste directly into groundwater. The closeness of some boreholes to solid waste dumpsites and animal feces being littered around them could also distort the quality of groundwater. The high prevalence of diseases such as diarrhea, typhoid fever, cholera, and bacillary dysentery among the population has been traced to the consumption of unsafe and unhygienic drinking water [5].

Water can be classified based on certain rates as potable water (clean, safe, and tasteless), polluted water (water with added substances that impair color, odor, or taste), or contaminated water (water that is rendered unsafe through the addition of discharges from humans or animals' intestines or rendered dangerous by the addition of chemicals). Poisonous natural chemicals are known to sink deep into the layers of the earth and terminate in ground waters, thereby constituting public health hazards. Natural activities such as weathering and anthropogenic duties such as mining, food products, and home and commercial wastes [6] have led to soil, air, and surface water pollution around the globe. Although the earth's outermost crust is an excellent sludge of particulate matter, the dissolvable chemicals and gases in soil, water, and air find their way into groundwater. When these dissolvable chemicals are brought into the environment, they are transported from the site where they were executed to the aquifers.

Life on Earth started in water; therefore, it is unsurprising that all living things cannot survive without water. In the case of human beings, water is not only a body constituent but is used every day in our homes, schools, industries, farms, etc. [7]. It is essential to have access to clean water to prevent diseases and enhance quality of life. Therefore, access to a consistent, secure, safe, and ample fresh water supply is essential for human survival, well-being, and socioeconomic development worldwide [8]. The quality of water is a window into the wholesomeness of most ecosystems. As a consequence, safe and clean water for human consumption is needed. Groundwater was formerly used considerably in Nigeria through wells and boreholes. Unfortunately, borehole water, like water from other sources, is not entirely pure. It varies in chastity depending on the geological conditions of the soil through which the groundwater overflows and some anthropogenic activities. Until veritable lately, ground water has been allowed to be a standard of water chastity in itself, and to a certain extent, that's indeed true [9]. Environmentalists have articulated concerns about the trustworthiness of groundwater sources as well as the products made from them. Because of the prevailing proliferation of impurities as well as changes in climate patterns, groundwater is no longer feasible for consumption and utilization, especially by students. The water force system in some parts of Anambra State, Nigeria, substantially UNIZIK students' hostels is inadequate. This is substantially driven by the unreliable and quality-compromised borehole water force in this area due to the perception and anticipation of pure and safe drinking water.

The aim of this research is to assess the physiochemical properties of borehole water within UNIZIK hostels and their qualities by analyzing their physicochemical parameters and comparing them to healthy recommended standards.

II. EXPERIMENTAL

2.1 Study area

This study was carried out in Awka, the capital of Anambra State. Nnamdi Azikiwe University (UNIZIK) is situated precisely in Awka South, which is one of the local government areas in Anambra State. Water samples were collected at four locations in the LGA (Okpuno, Ifitte, Amudo, and Amaku), especially from students' hostels. The major sources of drinkable water in Awka South are boreholes drilled in public and private houses, including UNIZIK students' hostels. The town has experienced a very large increase in population due to the commencement of institutions like UNIZIK and several other colleges of education. The need for a continuous large supply of water as an essentiality for students' residence has led to the exploration of ground and surface waters.

Fig 1: Map showing Awka

Source: www.researchgate.com

2.2 Equipments used

Equipments used in this research includes: pH meter (electrometric), Conductivity meter, Retort Stand, Beaker, Pipette, Total Dissolved Solids (TDS) Tester, Burette, Fiber filter disc, Desiccator, Evaporating dish, Steam bath, Weighing balance, Ultra-Violet light (UV) Spectrophotometer, Nessler's tube, Glass rod, Conical flask, Test tube, Porcelain dish, Crucible and Filter paper.

2.3 Reagents and chemicals used

Reagents and chemicals used in this research includes: Buffer solution of NH_3 added, Solocrome Black T indicator, 0.01EDTA solution, Phenol Disulphonic acid, Sodium Hydroxide (NaOH), Distilled Water, Tetra oxo sulphate (VI)(H_2SO_4), Ammonium persulphate, Potassium hydrogen phosphate, Hydrogen chloride (HCl), Barium Chloride (BaCl2).

2.4 Sample collection

Ten water samples were collected for this analysis. Seven of the samples were randomly taken from seven different student hostels in Ifitte Awka, one sample taken from Okpuno Awka, and the other two taken from two different locations at Aroma Awka, all in Anambra State. The samples were labeled A–J according to their locations. They were transported to the laboratory (Docchy Analytical Laboratories and Environment Services Limited, Awka) in a container free from contaminants. The pH, conductivity, and total dissolved solids of the sample were measured, after which they were stored prior to further analysis.

2.5 Analysis of physicochemical parameters

2.5.1 pH

pH was measured by Electrometric Method using Laboratory pH Meter Hanna model HI991300 [10].

Procedure: The electrodes were rinsed with distilled water and blotted dry. The pH electrodes were then rinsed in a small beaker with a portion of the sample. A sufficient amount of the sample was poured into a small beaker to allow the tips of the electrodes to be immersed to a depth of about 2 cm. The electrode was at least 1 cm away from the sides and bottom of the beaker; the temperature adjustment dial was adjusted accordingly; the pH meter was turned on; and the pH of the sample recorded.

2.5.2 Electrical Conductivity

Analysis was carried out according to the APHA 2510 B guideline for Model DDS-307 [10].

Procedures: The conductivity cell was rinsed with at least three portions of the sample. The temperature of the sample was then adjusted to 20 ± 0.1 ºC. The conductivity cell containing the electrodes was immersed in a sufficient volume of the sample. The conductivity meter was turned on, and the conductivity of the sample was recorded.

2.5.3 Determination of total dissolved solids

Method: Total dissolved solids were determined using the APHA 2510 A TDS 139 tester [10].

Procedure: The fiber filter disc was prepared by placing it, wrinkled side up, in the filtration apparatus. Vacuum was applied, and the disc was washed with three successive 20-ml washes of distilled water. Continuous suction was then applied to remove all traces of water. A clean evaporating dish was heated to 180 ± 2 ºC in an oven for 1 hour, cooled, and stored in a desiccator until needed. It was usually weighed immediately before use. A sample volume was chosen to yield between 2.5 and 200 mg of dried residue. 50 ml of well-mixed sample was filtered through the glass-fiber filter; it was washed with three successive 10 ml volumes of distilled water, allowing complete draining between washings. Suction was continually applied for about 3 minutes after filtration was complete. Filtrate was transferred to a weighed evaporating dish and evaporated to dryness on a steam bath. The evaporating dish was finally dried for at least 1 hour in an oven at 180 ± 2 ºC, cooled in a desiccator to balance temperature, and weighed.

Calculation:

$$TDS = (A - B) \times 103\, mg/l$$
$$Sample\ volume\ in\ ml$$
$$Where\ A = weight\ of\ dish + solids\ (mg)$$
$$B = weight\ of\ dish\ before\ use\ (mg)$$

2.5.4 Water hardness

50 cm^3 of the water sample was introduced into a beaker, and a 1 cm^3 buffer solution of NH3 was added. Three drops of Solocrome Black T indicator were also added, and the solution swirled properly. The mixture was titrated with 0.01 EDTA solution until the color changed from wine red to pure blue, with no bluish tinge remaining. The total hardness of the water sample was calculated.

$$Total\ hardness\ (mg/CaC03) = Volume\ of\ Titrate\ x\ 1000\ /Volume\ of\ samples\ (cm3)$$

2.5.5 Determination of Heavy Metals

Heavy metal analysis was conducted using a Varian AA240 atomic absorption spectrophotometer according to the [10] method (American Public Health Association).

Working Principle: The atomic absorption spectrometer's working principle is based on the sample being aspirated into the flame and atomized when the AAS's light beam is directed through the flame into the monochromator and onto the detector that measures the amount of light absorbed by the atomized element in the flame. Since metals have their own characteristic absorption wavelength, a source lamp composed of that element is used, making the method relatively free from spectral or radiational interferences. The amount of energy of the characteristic wavelength absorbed in the flame is proportional to the concentration of the element in the sample.

Sample Preparation: The sample is thoroughly mixed by shaking, and 100 ml is transferred into a glass beaker of 250 ml volume, to which 5 ml of conc. Nitric acid is added and heated to boil till the volume is reduced to about 15-20 ml by adding conc. Nitric acid in 5 ml increments till all the residue is completely dissolved. The mixture is cooled, transferred, and made up to 100 ml using metal-free distilled water. The sample is aspirated into the oxidizing air-acetylene flame. When the aqueous sample is aspirated, a sensitivity of 1% absorption is observed.

2.6 Health risk assessment model

A human health risk assessment was carried out to estimate the nature and probability of adverse health effects in humans as a result of exposure to heavy metals through water in the vicinity of the study areas. Assessments were carried out for both adults and children for carcinogenic health risks. Risk assessment conducted on heavy metals was done by determining the chronic daily intake (CDI); thereafter, the carcinogenic impact on adults and children was evaluated through ingestion and the dermal pathway, as shown in equation [11].

2.6.1 Carcinogenic analysis

The health risk assessment of each contaminant is based on the estimation of the risk level and is classified as carcinogenic or non-carcinogenic health hazards [11]. To estimate the heavy metal contamination and potential carcinogenic health risk caused through ingestion of heavy metals in the water, Hazard Quotients (HQ), Hazard Index (HI), and the Incremental Lifetime Cancer Risk (ILCR) were used. The studied groups in this study were adults and children. The numeric expressions for risk assessment as obtained from the USEPA Risk Assessment Guidance for Superfund (RAGS) methodology (USEPA, 2010) are given below:

$$CD_{Iing} = \frac{C_{wate}r \times DI \times ABS \times EF \times ED}{BW \times AT}$$

where CD_{ing} is exposure dose through ingestion of water (µg/kg/day); *C* water is concentration of the estimated metals in water (ppm); DI is daily average intake (2.2 L/day for adults; 1.1 L/day for children); EF is exposure frequency (350 days/year); ED is exposure duration (70 years for adults; and 6 years for children); BW is average body weight (70 kg for adults; 15 kg for children); AT is averaging time (25,550 days for adults; 2190 days for children); ABS (0.001)

2.62 Hazard quotient (HQ)

The HQ for individual heavy metals was estimated using the ratio of the computed mean daily intake (CDI, mg/kg/day) of a metal ingested with contaminated water to the reference oral dose (RfD) through oral ingestion for the residents. The sum of all HQs gives the total potential health risks, or hazard index (HI). The calculation of the HI caused by water is presented as:

$$HQ = \frac{CDI}{RfD}$$

Where, CDI and RfD are expressed in mg/kg-day.

2.63 Hazard Index (HI)

To estimate the total potential non-carcinogenic health impacts caused by exposure to a mixture of heavy metals in water, the HI for several heavy metals was computed according to the EPA guidelines for health risk assessment [11] using following Eq.

$$HI = HQ_{Pb} + HQ_{Cd} + HQ_{Hg} + HQ_{Al} + HQ_{As}$$

The computed HI is compared to standard values: there is the possibility that non-carcinogenic impacts may occur in the residents when HI > 1, while the exposed person is unexpected to experience evident harmful health impacts when HI < 1.

2.6.4 Carcinogenic analysis:

The probable cancer risks due to exposure to a specified dose of heavy metal in drinking water can be computed using the ILCR (USEPA, 2020).

$$ILCR = CDI \times CSF$$

Where, CSF is the cancer slope factor and is defined as the risk generated by a lifetime average amount of one mg/kg/day of carcinogen chemical and is contaminant specific. The permissible limits are considered to be 10^{-6} and $<10^{-4}$ for a single carcinogenic element and multi-element carcinogens [11]

Table 1: Standard values of Background values, toxicity factor, RFD, RFC, CSF and IUR [12].

Heavy metal	Background standard	TF	RfD	CSF
Cadmium	0.003	30	0.001	6.3
Mercury	0.050	2	0.005	
Aluminium	1.000	1	0.01	
Lead	0.010	5	0.5	8.5E-03
Arsenic	0.010	10	0.0003	1.5

III. RESULTS AND DISCUSSIONS

Table2: Physiochemical Parameters of Borehole Water

Samples code	pH	Conductivity (µs/cm)	Total Dissolved Solids (mg/l)	Hardness (mg/l)
A	6.84	26.90	702	160
B	7.31	30.20	129	50
C	7.14	17.80	193	128
D	7.21	25.20	136	222
E	7.67	18.70	306	142
F	7.20	27.10	155	68
G	7.17	28.20	86	86
H	7.28	26.40	49	116
I	7.70	26.70	635	148
J	7.19	24.90	482	48

The pH values of the samples lie between the permissible range given by W.H.O and NAFDAC standards of 6.5–8.5. The conductivity of the samples lies between 17.8 and 30.2 µs/cm, which lies below the acceptable limits and hence conforms to the standards given by W.H.O and NAFDAC for drinking water. The conductivity of the samples ranges from 17.8 to 30.2 µs/cm, which lies below the acceptable limits and hence conforms to the standards given by W.H.O. and NAFDAC for drinking water. The concentration of total dissolved solids in the samples in the range of 49–136 mg/L is excellent for drinking according to WHO standards of 50–150 mg/L, while those in the range of 155–193 mg/L are good. However, those in the range of 306–702 mg/L are poor and unsuitable for drinking because they do not meet World Health Organization (WHO) standards for drinking water [13]. The values for the total hardness of the samples conform to the acceptable limit of 150 mg/L given by WHO. The values, which range from 48 to 68 mg/L, indicate softness. Thus, there would be less precipitation of scum and less need for excess use of soap to achieve cleaning. The values between 86 and 148 mg/L are considered moderately hard, while those between 160 and 222 mg/L are considered very hard and require excess use of soap to achieve cleaning [14].

Table 3: Concentration of heavy metals in water samples

Sample code	Pb (ppm)	Cd (ppm)	As (ppm)	Hg (ppm)	Al (ppm)
A	0.5463	0.003	0.022	0.007	0.002
B	0.2035	0.014	0.017	0.079	0.008
C	0.0785	0.005	0.014	0.012	0.011
D	0.0368	0.029	0.019	0.022	0.003
E	0.0402	0.012	0.022	0.010	0.010
F	0.0033	0.013	0.016	0.016	0.010
G	0.0054	0.005	0.016	0.011	0.010
H	0.0247	0.018	0.019	0.033	0.013
I	0.0	0.016	0.028	0.028	0.019
J	0.0027	0.011	0.013	0.016	0.001
Mean	0.094	0.012	0.019	0.023	0.009

The concentration of lead in the samples ranges from 0.00 ppm to 0.0054 ppm and lies within the permissible limits given by EPA limit (0.015 ppm) and W.H.O limit (0.01 ppm) for drinking water. Meanwhile, samples in the range of 0.0247–0.4463 were above the acceptable limits of W.H.O. and EPA for drinking water. This could be a result of the nature of the plumbing materials used. It could also depend on several factors, such as pH, temperature, water hardness, and the standing time of the water with soft and acidic water, i.e., water with low pH values [13]. The concentration of cadmium in the samples was below the acceptable limit of cadmium (0.03 ppm), as allowed by NAFDAC and W.H.O. This implies that the samples may contain no material in sufficient quantities to be toxic or injurious to humans, including children, or to cause acute or chronic health problems. The concentration of arsenic in the samples was found to be above the EPA and W.H.O. acceptable limits of 0.01 ppm for drinking water. This could result from anthropogenic activities such as mining, agriculture, industrial waste, and municipal wastewater [13]. It could also result from the nature of the tube through which water is pumped from the ground. The mercury content in the samples was above the contaminant level given by the EPA of 0.002 ppm and the WHO standard of 0.001 ppm for drinking water. This could be a result of atmospheric deposition from coal-fired power plants. It could also result from industrial, agricultural, and occupational operations. The level of aluminum present in the samples was below the permissible standard of 0.2 ppm given by NAFDAC and W.H.O. This implies that the samples are unlikely to have harmful health effects on humans.

Table 4: Health risk assessment of heavy metal in water samples (Adult)

Heavy metals	Mean concentration	CDI_{Ing}	HQ	HI	ILCR
Lead	0.094	2.83 E-06	5.67 E-06	2.43 E-03	2.41 E-08
Cadmium	0.012	3.62 E-07	3.62 E-04		2.28 E-06
Arsenic	0.019	5.73 E-07	1.90 E-03		8.6E -07
Mercury	0.023	6.93 E-07	1.39 E-04		NA
Aluminum	0.009	2.71 E-07	2.71 E-05		NA
Total					3.16 E-06

NA: Not Available (No CSF Value)

Health risk assessment conducted for the concentration of heavy metal in adult reveal that the total hazard index is less than one (2.43E-03). In addition, the ILCR value is within the permissible limit as given by USEPA. Therefore the risk of possible carcinogen on ingestion of the analyzed water sample is minimal. This result opposes finding generated by [2] in which the analyzed water sample were found to be too toxic to human health.

Table 5: Health risk assessment of heavy metal in water samples (Children)

Heavy metals	Mean concentration	CDI_{Ing}	HQ	HI	ILCR
Lead	0.094	6.61 E-06	1.32 E-05	5.67 E-03	5.61 E-08
Cadmium	0.012	8.44 E-07	8.4E-04		5.32 E-06
Arsenic	0.019	1.33 E-06	4.43 E-03		2.0E -06
Mercury	0.023	1.62 E-06	3.24 E-04		NA
Aluminum	0.009	6.32 E-07	6.323 E-05		NA
Total					7.38 E-06

NA: Not Available (No CSF Value)

Health risk assessment conducted for the concentration of heavy metal in children reveal that the total hazard index is also less than one (5.67E-03). In addition, the ILCR value is within the permissible limit as given by USEPA. Therefore the risk of possible carcinogen on ingestion of the analyzed water sample is minimal. In summary toxicity level of water is found to be low in children compared to adult.

CONCLUSION

This study assesses the physicochemical characteristics and concentrations of heavy metals and their implications for health. The results indicate that the pH values of the water samples fall within the permissible range set by W.H.O. and NAFDAC standards, ensuring the suitability of the water for consumption. The conductivity levels also meet the recommended limits for drinking water, indicating a lack of contamination. However, the concentration of total dissolved solids revealed variations, with some samples exceeding the W.H.O. standards, suggesting a need for further scrutiny and potential water treatment in certain areas. The assessment of water hardness demonstrated that the samples mostly fell within the acceptable limits, with implications for soap usage and cleaning efficiency. The concentrations of heavy metals such as lead, cadmium, arsenic, mercury, and aluminum were evaluated against regulatory standards. Some samples' lead levels exceeded the acceptable limits, potentially due to factors like plumbing systems or water characteristics. Cadmium concentrations were within limits, indicating no immediate health concerns. However, elevated levels of arsenic and mercury in certain samples raise concerns about potential sources, such as anthropogenic activities or industrial discharges. In summary, while most water quality parameters conform to established standards, elevated levels of certain heavy metals emphasize the importance of ongoing monitoring and investigation. Further research and targeted interventions may be necessary to address specific contamination sources and ensure safe and potable water in the study area. It is therefore recommended that groundwater be treated before consumption. As such, treatment measures such as filtration and disinfection should be employed to ensure the water is safe for consumption. Also, regular water quality assessments should be conducted to monitor the effectiveness of these treatment measures.

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