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Assessment of Heavy Metals Concentration of Borehole Water in the Polytechnic Ibadan, Nigeria

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Abstract-Borehole water is a major source of water supply in public institutions such as The Polytechnic, Ibadan, Nigeria, with a population of approximately twenty thousand (20,000). Water is consumed in large quantities on a daily basis therefore the importance of quality control on water consumed cannot be overemphasized. Heavy metal concentration analysis is one of the water quality control measures due to its bioaccumulation tendency in the body. This study aimed at assessing the heavy metal concentration in water borehole in The Polytechnic Ibadan by revealing the quality of the water consumed on the campus. Twelve active boreholes were investigated within the polytechnic campus. Recommended procedure and Atomic Absorption Spectrometer were used for the analysis. The pH and conductivity were taken in-situ with an in-situ pH conductivity meter. The pH of the borehole water samples in all locations ranged between 6.22 and 7.9 and fall within recommended safe limit. Samples were electrically neutral since conductivity ranged between 40.4 and 175.6µs/cm. The range of heavy metal concentrations in the borehole water samples for Zinc, Iron, Lead and Chromium were 0.51 - 0.98mg/L, 0.15 - 0.40mg/L, 0.00 - 0.09mg/L and 0.01 - 0.21mg/L respectively while Cadmium was detected in only one sample at 0.01mg/l. Level of heavy metals concentration in water samples indicate that water from sampled boreholes does not pose health challenges and therefore good for drinking and other domestic chores with little water treatment required.

Keywords*-Heavy Metals, AAS, Borehole, pH, Electrical Conductivity*

I. INTRODUCTION

Water is a very important chemical that is widely used by human. The integrity of water is easily compromised by the introduction of anthropogenic pollutants from different sources such as industrial, domestic, agricultural, medical and technological of which heavy metals play an important role. In recent times, groundwater had become an indispensable source of drinking water especially in Nigeria due to lack of portable water from the government-controlled water plants. Groundwater resource is a major indication of its water quality characteristics. The quality of water available from underground aquifers may be superior to the quality of surface water. Groundwater contains higher dissolved solids concentrations than the surface waters of the same environment. Borehole is a well drilled into the sub-surface aquifer for the purpose of exploiting groundwater, it is situated in unconfined sedimentary basin that exceeds 2000m.

The environmental problem of heavy metals is that they are unaffected during breakdown of organic waste and have toxic effects on living organisms when they exceed a certain concentration [1]. The accumulation of the hazardous heavy metals in groundwater is due to the dissolution, seepage and leaching of environmental components into water forms whose sources are coal, petroleum, smelting operations, fossil fuels combustion, sewage sludge disposal, fertilizer application, volcanic eruptions and forest fires [2].

Heavy metal toxicity can be appreciated by the effect they had on human at different exposure levels. Lead can have drastic effects on children and pregnant women. Lead in children reduces the physical and mental growth, reduction in intelligent quotient; chronic exposure to lead can cause anemia, kidney damage, headache, fatigue and irritable mood [3]. Cadmium exposure can cause renal dysfunction, calcium metabolism disorders and also increased incidence of some forms of cancer.

Children can easily absorb heavy metals especially cadmium and lead due to their active digestive system and sensitivity to hemoglobin [4]. Cadmium is highly toxic and responsible for several cases of poisoning through food. Chromium toxicity in the environment is rare; it still presents some risks to human health since chromium can be accumulated on skin, lungs, muscle, fat in liver, dorsal spin, hair, nails and placenta where it is traceable to various health conditions [5]. Iron is essential for good health and help in transport of oxygen in the blood. Zinc is an essential trace element for plants, animals and humans found in virtually all food and portable water in the form of salts or organic complexes. However zinc toxicity may induce symptoms of irritability, muscular stiffness and pain [6].

The concern of these toxicity based on the bio-accumulative nature of heavy metals informed the determination of the following heavy metals (lead, cadmium, chromium, iron and zinc) in borehole water in The Polytechnic, Ibadan which is the major source of portable water in the campus.

II. DESCRIPTION OF THE STUDY AREA

The study area is situated within the basement complex of SouthWestern, Nigeria. The site is located inside the campus of The Polytechnic, Ibadan and it is accessible through many tarred roads via major road from Sango- Eleyele road in the south and Ijokodo – Apete road from the west. The topography is gentle with surface elevation ranging from 200m – 215m above sea level. It is drained by two rivers, Awba and Ona which flow in the western direction. Both rivers serve as tributary to Eleyele River (figure 1). The climatic condition is typically tropical with alternating wet and dry season. The wet season (April-October) is characterized by heavy rainfall with corresponding low temperatures while the dry season (November-March) comes with high temperatures and little or no rainfall. Annual temperature is usually at an average of 27 ^{0}C but it rarely drops below 21^{o}C. The area under study is underlain by Basement Complex rocks with the predominant rocks being gneissic rocks, banded gneiss, quartz - schist with some pegmatite intrusion within the granite .The banded gneiss in study area shows alternate bands of light colour minerals and dark colour minerals. It is generally low-lying and consists basically of quartz, feldspar and biotite. Quartzites are metamorphosed arenaceous rock and it occurs in form of ridges in the study area. It is characterized by numerous joint and cracks and consist mainly quartz as the major mineral occupying about 90%. Schistose rocks occur in define beds and can be seen to out crop in front of Physics department of the Campus and the central mosque (figure 1).

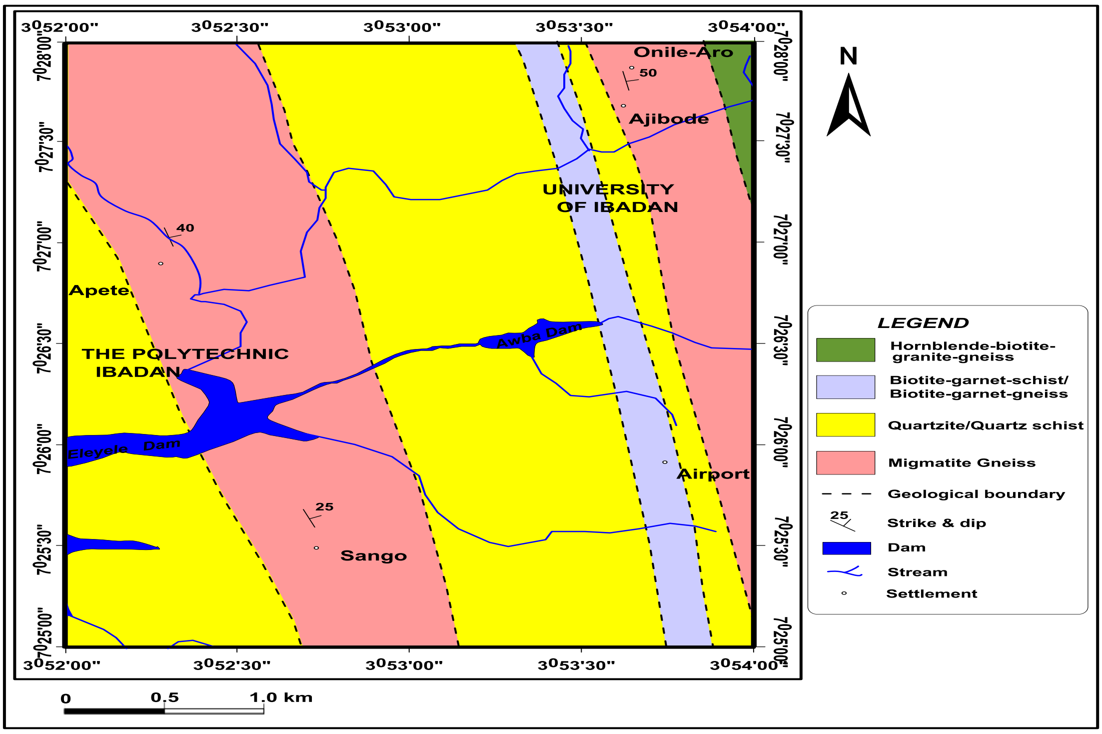

Figure 1. Geological map of study area [7]

III. MATERIALS AND METHODS

A. *Sampling and Sample collection*

Twelve water samples from boreholes within The Polytechnic, Ibadan campus were randomly collected. The locations and codes were: Ramat Hall of residence (A); Olori Hall Annex (B), Olori Hall of residence (C), Poly Pure water factory (D), U.I. road (E), Old Rector's Office (F), Middle belt (G), Health center (H), Conference Centre (I), Bank (J), Deputy Rector's office (K) and Orisun Hall of residence (L) respectively (figure 2). Distilled water collected from Chemistry Department, The Polytechnic, Ibadan was used as control. Samples were collected into pre-washed and sterilized plastic containers. pH and electrical conductivity were done in-situ using Metler Toledo pH meter and 4310 Jenway conductivity meter.

B. *Sample Preparation*

Water samples were collected from the taps and stored inside plastic water bottles from the twelve locations and were spiked with 1ml of concentrated trioxonitrate (V) acid to preserve metals and avoid precipitation. Concentrated trioxonitrate (V) acid (10ml) were added to 20mls of each water sample and were poured into twelve conical flasks. The mixture was heated slowly for thirty (30) minutes. The solution was filtered and the filtrate made up to 100ml mark for heavy metal determination in each sample.

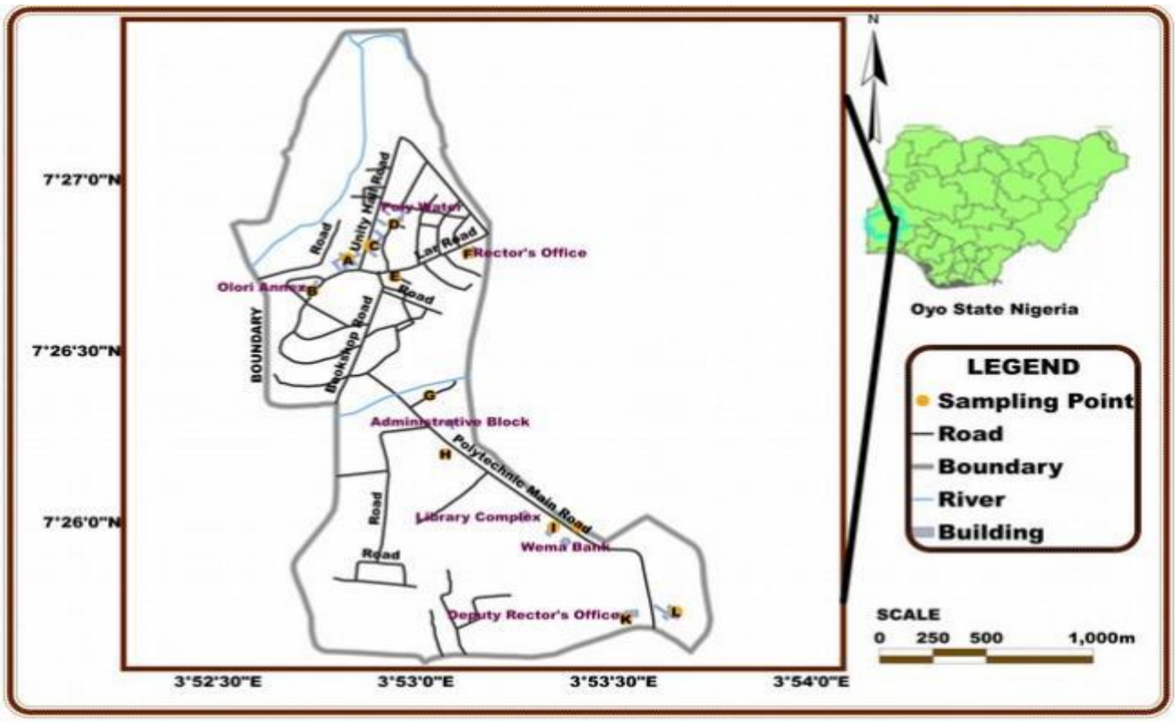

Figure 2. Borehole water sample locations within The Polytechnic, Ibadan

C. Heavy Metal Determination

Heavy metals were determined using Atomic Absorption Spectrophotometer of the AA220Fs Buck Scientific model, air-acetylene flame was at a flame temperature of 26000C and flame height of 6mm. The wavelength of each lamp disc at which values were taken for each metal ions are: Zinc (213.9nm), Lead (217.0nm), Cadmium (228.8nm), chromium and Iron (510.0nm).

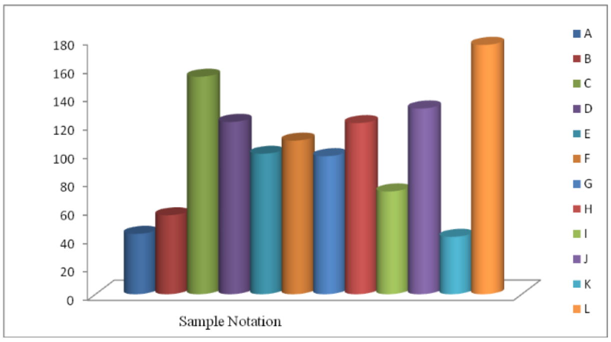

Figure 4. Electrical conductivity of selected boreholes

IV. RESULTS

Results are shown in charts below:

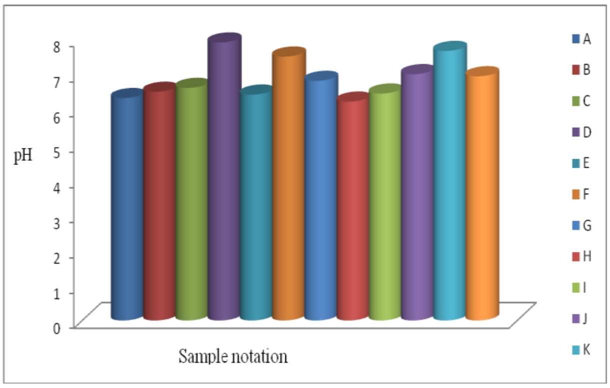

Figure 3. pH of selected boreholes

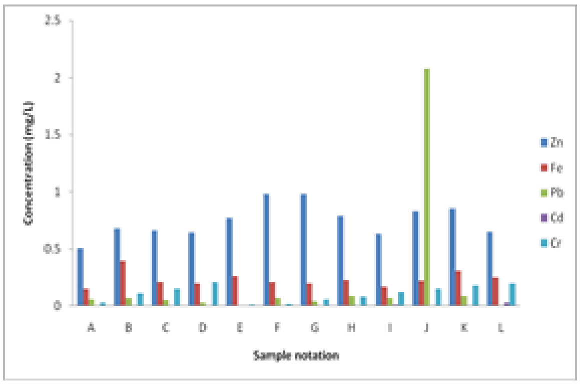

Figure 5. Heavy metal concentration in selected boreholes

From figure 5, Zn had a range of 0.51 - 0.98mg/L; Fe had 0.15 - 0.40mg/L; Pb had a range of 0.00 - 0.09mg/L; Cd was detected in only one sample at 0.01mg/L and Cr with a range of 0.01 - 0.21mg/L.

V. DISCUSSION

The physicochemical analyses of the twelve boreholes indicated that the pH values obtained in this study (6.22 - 7.9) were within the recommended value of World Health Organisation (WHO) and National Agency for Drug Administration and Control (NAFDAC) of 6.5 - 8.5. It is in agreement with earlier results conducted in Delta and Bayelsa states in Nigeria [8, 9]. This is an indication that the water samples are not acidic.

The Polytechnic Ibadan is underlain by gneissic rocks and quartzs schists [10] and this imparts on the chemistry of the underground water. In terms of mineral composition, gneissic rocks are made up of micas, feldspars and quartzs among others. Percolation of water through these rocks makes it to have a longer weathering and dissolution effects on their mineral components. This is how anions and cations including heavy metals get into underground water apart from those that come through anthropogenic sources. In addition to the above processes, iron may be introduced into underground water by well casing, pump parts and piping.

Electrical conductivity is a measure of water's capacity to allow electrical energy to flow. Low conductivity indicates that concentration of ions in water is fewer and the water samples are electrically neutral. Electrical Conductivity in the present study of 40.4 and 175.6μs/cm is lower than NAFDAC recommended level of 1000μs/cm and WHO, 2015 permissible level of900μs/cm. Similar studies indicated thatelectrical conductivity range of 250 and 300μs/cm was reported in effluent discharged from Kaduna Refinery [11], while conductivity of between 94 and 277μs/cm was reported in borehole water in Ozoro town Delta State, Nigeria [9].

The results of heavy metals in the present study indicate that zinc concentration in all twelve samples was lower than the water quality recommendation of 5.0mg/L [12]. The present result however has higher zinc concentration than the work conducted in Ife north local government of Osun state in Nigeria, [13]. The implication of low concentration of zinc is that the water sampled is good for drinking and other domestic chores due to the absence of caustic taste. Iron concentration was lower in all other samples except for the boreholes in Olori Hall Annex (0.40 mg/L) and Bank (0.31 mg/L) which were slightly higher than WHO recommendation of 0.30mg/L but was in agreement with NAFDAC recommended concentration which is 0.50mg/L [14]. However the result was higher than that of the work conducted in ozoro town, Delta state [9]. Lead was within the maximum contaminant level set by WHO 2015 which is in agreement with a similar study [9]. In comparison with other studies, higher concentration of lead in samples from Aliero, Kebbi State, Nigeria has been reported [15]. With the use of Anodic Stripping Voltametry (ASV) to assess heavy metals in ground surface and tap water, lead and cadmium were found to be above WHO maximum acceptable concentration (MAC) [16]. However, cadmium in this work was not detected except in a sample which was in agreement with similar work done in Ife north local government of Osun state in Nigeria, [13] but at variance with work of Lekwot and Cobbina, [11, 17] which reported that at the point of entry of the effluent into the river the concentration of cadmium was higher than WHO MAC and in drinking water sources in mining communities. Chromium level in this work was below WHO MAC in only three samples while the others were above 0.05mg/L recommended by WHO standard, but follow a similar trend with the work carried out in Nassarawa state of Nigeria [18]. Higher concentration in the borehole can be due to rock formation in the sampling areas.

VI. CONCLUSION

Periodic monitoring of water quality especially heavy metals is of great concern because of the toxicity. Borehole assessed in The Polytechnic, Ibadan is the main source of water supply to the community. Only iron concentration was higher than the permissible limit, cadmium was not detected while other metals were below the permissible levels. It can be said that water samples were good for consumption, but there is a need for proper periodic monitoring to ascertain the safety of the water.

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