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# Assessment of physicochemical, minerals and microbiological qualities of borehole and well water: A case study of Akure Metropolis, Nigeria

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## Abstract

Groundwater constitutes a substantial reservoir of fresh water utilized for agricultural irrigation and drinking, emphasizing the critical importance of safeguarding its availability and quality. Contamination of groundwater can arise from chemical, physical, or microbiological sources, each contributing to various health-related issues. In the region of FUTA Southgate, Southwest Nigeria, an assessment was conducted on the physicochemical and microbiological characteristics of groundwater from hand-dug wells and boreholes to ascertain its suitability for human consumption. The analysis indicated that parameters such as BOD, DO TS, TH, and nitrate content were within the acceptable limits set by the World Health Organization (WHO) and the Nigerian Standard for Drinking Water Quality (NSDQ). However, the presence of heavy metals like Fe, Cu, Cr, Pb, Mn, Cd, and Zn was detected using an atomic absorption spectrometer, revealing a slight level of contamination in both water sources. Furthermore, microbiological examination identified Total Coliform Counts of 382 cfu and 159 cfu in hand-dug wells and boreholes, respectively, indicating fecal contamination. The findings suggest that inadequate sewage systems and improper waste disposal practices contribute to the compromised water quality and elevated nitrate levels in hand-dug wells, rendering the shallow aquifer groundwater unsafe for drinking purposes across all evaluated parameters. Consequently, appropriate treatment and disinfection measures are imperative before utilizing the contaminated borehole and groundwater wells for human consumption or industrial purposes.

**Keywords:** Minerals; Microbiological qualities; Heavy Metals; Ground water

## 1. Introduction

Freshwater is indispensable in numerous aspects of human life (Witek et al., 2009), widely regarded as a crucial input for human productivity and a catalyst for economic development (Rezar, 2010). It holds a pivotal role in societal well-being (Rezar, 2010; Yang, 2010) and the overall welfare of individuals (Adiyiah et al., 2011). Baptist (1980) emphasizes water as among the most abundant natural resources and the second most vital necessity for humanity. Water primarily exists as surface or groundwater, with rivers, lakes, ponds, streams, and dams categorized as surface water, while wells and boreholes constitute groundwater, serving purposes such as drinking, irrigation, and power supply (Neha et al., 2013).

According to BGS (2003), groundwater stands as the cornerstone of the hydrological cycle, serving as a crucial source of potable water in Africa and comprising about two-thirds of the world's freshwater resources. Surface water, however, is often unevenly distributed and inaccessible to significant portions of the global population (Diane, 2004). Groundwater offers a relatively stable supply for domestic, livestock, and irrigation needs, resilient to natural conditions, thereby mitigating the impacts of rainfall variability across seasons (Calow et al., 2011). In many arid and semi-arid regions of Africa, borehole water serves as a solution to water scarcity issues in areas with limited surface water availability (David, 2011).

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Regrettably, in various countries worldwide, including Nigeria and specifically Akure, some drinking water sources have become contaminated (Akoto, 2007; Adiyiah et al., 2011), while the declining quality of surface waters poses a significant concern globally (WITEK et al., 2009). Water pollution from diffuse sources and diverse pollutants not only constitutes a severe environmental challenge but also poses economic and public health risks (Yang, 2010; Akoto, 2007; Adiyiah et al., 2011). Natural water hosts numerous dissolved substances, and contamination from bacteria, viruses, heavy metals, nitrates, and salt arises due to inadequate waste treatment and disposal from human and livestock activities, industrial discharges, and overexploitation of limited water resources (Singh and Mosley, 2003). Monitoring water quality through routine tests and comparing results with established standards enables the assessment of pollution probability, extent, and the presence of pathogenic microorganisms (Yang, 2010; Akoto, 2007). The primary objective of water quality management is to minimize health risks associated with direct or indirect water usage, with standards and guidelines rooted in the imperative to safeguard human health. Water contamination has emerged as a pressing environmental issue after prolonged pollution (Akpoveta et al., 2011). This research endeavors to assess the groundwater quality in FUTA, Akure South Gate area, encompassing physicochemical, mineral, and microbiological aspects, to determine compliance with World Health Organization standards and recommendations.

## 2. Materials and methods

### 2.1. Materials

All the reagents used for this project were of analytical grade, collected from Chemistry department store Federal University of technology Akure. All apparatus used are all in good condition.

### 2.2. Sample Collection

Water samples were collected from boreholes and wells in FUTA Southgate, Akure. For physicochemical analysis, the samples were collected in 5-liter plastic bottles meticulously washed three times with distilled water and water from the source. Similarly, for microbial analysis, samples were collected in 1-liter plastic bottles, also washed three times with distilled water and water from the source, and filled halfway. These samples were then transported to the laboratory at the Department of Chemistry, Federal University of Technology, Akure, for subsequent physicochemical and microbial analysis.

### 2.3. Determination of physico-chemical parameters

The pH of the samples was determined on-site utilizing a portable pH meter. A specific volume of the water sample was transferred into a glass container. The pH meter was activated, cleaned with distilled water, and then immersed into the sample. The recorded pH meter reading was then documented. The temperature measurements of the samples were conducted at the collection site employing a portable thermometer and documented, as it is a parameter that needs to be measured on-site. A specific amount of the sample was moved into a container. The thermometer was subsequently placed into the sample and kept there until the mercury column reached a stable position. This process was repeated three times at five-minute intervals, and the average value was calculated to determine the sample temperature. The color of the samples was visually inspected on-site, and any observations were duly noted. The electrical conductivity of the samples was assessed in the laboratory using the FDS/COND. Meter (WINLAB model) after calibration with a 0.01M KCl solution. The calibration process involved activating the CAL. Button to set the EC value to 1413.00 µs/m. Following calibration, the EC electrode was rinsed with distilled water and then with the sample. A measured volume of the sample was poured into a clean container, and the EC electrode of the meter was immersed into it. The recorded reading was then documented. The turbidity of the samples was determined through the nephelometric method. The Uniscope UV-Visible spectrometer (transmittance mode-No wavelength) was calibrated using formazin standard solutions. The samples were mixed until air bubbles dissipated, transferred into a clean nephelometer sample tube, and placed in the instrument's sample compartment. The resulting readings were promptly observed and recorded in NRUN units.

### 2.4. Determination of Total Solids· (Alpha, 1995)

A clean evaporating dish was dried in the oven for 15-20 minutes and cooled in desiccators for 30 minutes. The weight of the empty evaporating dish was taken to the nearest 0.001g using the analytical balance. Using pipette, 25ml of well-mixed water sample was measured into the pre-weighed dish and evaporated to dryness on a hot plate. It was ensured that the water sample did not boil. The dish was then dried in the oven at 105°C and cooled in desiccators for 30 minutes and weighed. The processes of drying, cooling, desiccating and weighing was repeated until weight loss was less than 4% of previous weight or 0.5mg whichever is less.

$$\text{Total Solids } (^{mg}/_{L}) = \frac{(A-B)x1000}{Volume\ of\ Sample\ (mL)}$$

Where A = weight of dried + dish in mg;

B =Weight of dish in mg

### 2.5. Determination of Total Suspended Solids (TSS)

TSS level in the collected water samples was determined using gravimetric method. Using pipette, 25ml of well-mixed water sample was measured into the pre-weighed glass fiber filter. The filter was dried in the oven at temperature of 105 °c overnight. The filter paper was removed and allowed to cool to room temperature in a desiccator and weighted to constant weight. The increase in mass of the dry filter paper was later recorded and used for calculating TSS.

TSS is calculated using the formula:

$$\text{Total Solids } (^{mg}/_{L}) = \frac{(A-B)x1000}{Volume\ of\ Sample\ (mL)}$$

Where A= weight of the filter after filtration (mg); B = weight of the filter before filtration (mg).

### 2.6. Determination of Total Dissolve Solids (TDS)

The difference in values between total Solids and total Susppended Solids is a measure of total dissolve Solids. This was done for each of the sample collected.

### 2.7. Biochemical Oxygen Demand (BOD)

The Biochemical Oxygen Demand (BOD) of the water samples was assessed utilizing the dilution method. Dilution water was prepared by combining 10 mL of each reagent—phosphate buffer, magnesium sulfate, calcium chloride, ferric chloride, sodium sulfite, and ammonium chloride—into 2 L of water.

Subsequently, 50 mL of the water sample was measured into a clean standard flask, and the sample was then filled up with dilution water to the 1 L mark. Two 300 mL amber bottles were filled completely with the diluted water. One bottle was incubated at 20°C for 5 days. For the second bottle, a solution containing MnSO4, alkali-iodide-azide reagent, and concentrated sulfuric acid was added. Dissolved oxygen (DO) in the wastewater sample was determined through iodometric titration. For the measurement of dissolved oxygen at day zero ($DO_0$), a 50 mL aliquot of the solution was titrated against sodium thiosulfate solution using starch solution as an indicator until a colorless endpoint was achieved. Following the 5-day incubation period, the sample from the incubator was retrieved, and dissolved oxygen at day five after incubation ($DO_s$) was determined using the same procedure employed for $DO_0$. A blank sample was prepared in a transparent bottle for $DO_0$, while another blank sample was prepared in an amber bottle and incubated with the sample for $DO_s$ assessment.

$$\text{BODs (mg/L)} = \frac{(\text{DO0} - \text{DO5}) \text{ x Volume of BOD bottle}}{\text{Volume of Sample (mL)}}$$

### 2.8. Dissolved Oxygen (Winkler's Method)

This was done in situ by filling 250mL brown bottle with the sample without bubbles being trapped in 2mL each of MnSo4 and alkaline-iodide solution was added. This was carefully stopped so as to avoid inclusion of air bubbles and thoroughly mixed by rotating and inverting the bottles several times. The precipitate was allowed to settle after which 4ml of cone. Sulphuric acid was added. The solution was thoroughly mixed again and 100mL of the solution was measured into the conical flask. This titrated with 0.025M or 0.0125N Na2S2O3.SH2O using 2mL of starch as indicator. The colour change of straw yellow to blue was observed at the end point.

$$\text{DO (mg/L)} = \frac{\text{V1 X M X 8 X 1000}}{\text{V2}}$$

Where V1= Volume of 0.025M or 0.0125N $Na_2S_2O_3$. 5H20; V2 = Volume of sample taken

Determination of Chloride

The quality of chloride present in the samples were determined by measuring 50mL of the sample using a volumetric flask into a conical flask. Calcium carbonate was then added in bit. I mL of 5% potassium chromate solution prepared by dissolving 5g if potassium chromate in deionized water and diluted to 100ml was then added as nitrate crystals in 1 dm"3 distilled deionized water was then poured into a burette until it got to the zero reading. The mixture of the sample, $CACO_3$ and indicator was then titrated against the standard silver nitrate solution ensuring that the mixture was shaken continuously until a permanent reddish-brown precipitate was obtained. The reading of the lower meniscus on the burette was then obtained by subtracting the final reading from the initial reading to obtain the titer value and substituted into the formula below.

$$\text{Cl (mg/L)} = \frac{\mathbf{Xx\ M}\ x70900}{\text{Volume of Sample ml}}$$

### 2.9. Total hardness (EDTA Titrimetric Method)

The aggregate hardness of the specimen was determined through the measurement of 50mL of the specimen using a volumetric flask transferred into a conical flask. A mL of buffer solution was prepared by dissolving lg of borax in 200mL of distilled water, 2.5mL of NaOH, Na2S dissolved in 25mL of distilled water, and the addition of potassium cyanide was made. Two droplets of 0.0I M Eriochrome black T solution, derived from 3.723g of disodium ethylene-diamine tetra acetic acid (EDTA) dissolved in one liter of distilled water, were included as an indicator. A trace of 1mL KCN was introduced. The mixture was agitated, resulting in a wine hue. Subsequently, it was titrated against O.OIM EDTA solution, with continuous shaking until a consistent blue solution was achieved. The reading on the lower meniscus of the burette was noted and documented. The initial EDTA volume was deducted from the final volume and substituted into the formula below to ascertain the total hardness content in the specimen.

$$\text{Total Hardness (mg/CaCo3)} = \frac{\mathbf{XxMx}1000}{\text{Volume of Sample mL}}$$

### 2.10. Calcium hardness

The calcium hardness of the samples were determined by measuring 100ml of the sample using a volumetric flask into a conical flask. 1ml of IM NAOH solution added. NACL. Solution was finally added, the mixture was shaken together and a pink solution was obtained. It was then titrated against 0.0IM EDTA solution untill a permanent purple solution was seen. The reading on the lower m niscus of the burette was observed and recorded. The initial volume of the EDTA was then substracted from the final volume and substituted inro the formula below to obtain the quantity of calcium hardness present in the sample.

$$\text{Calcium Hardness} = \frac{X\ x\ Mx\ 100000}{Vol\ of\ Sample\ (ml)}$$

### 2.11. Magnesium hardness

The quantity of magnesium hardness present in the samples were determined by subtracting the quantity of calcium hardness present from the total hardness present

Magnesium Hardness= Total Hardness - Calcium Hardness

### 2.12. Total alkalinity

The total Alkalinity of the samples were determined using a titrimetric method. 50mL of the sample was measured using a volumetric flask and poured into a conical flask. Two drops of methyl orange prepared by dissolving 0.05g methyl orange in 100mL carbon (iv) oxide, distilled water shaken vigorously. 0.02N HCl in one liter of distill water. The solution was then poured into a burette until it got to zero reading and then titrated against the mixture of sample and methyl orange ensuring it was shaken continuously until the colour was seen to have changed completely from yellow to orange. The reading of the lower meniscus on the burette was then observed and recorded. The final titre value was obtained by subtracting the initial volume from the final volume and substituted into the formula below:

$$\text{Total Alkalinity} = \frac{\mathbf{Xx\ M\ x100000}}{Volume\ of\ sample(mL)}$$

### 2.13. Total Acidity

The total Acidity of the sample were determined in the laboratory by measuring 50mL of the sample using a volumetric flask into a conical flask. One drop of indicator prepared by dissolving 0.lg thymol blue 100mL of 5% ethanol and mixed in the ratio 1:3 of thymol blue and phenolphthalein added. The mixture was then titrated against 0.1 M NaOH prepared by dissolving 4g NaOH in 250mL beaker, transferred into one litre standard flask and made up with distilled water. This was done ensuring that the solution was shaken continuously until colourless solution was obtained. The reading of the lower meniscus on the burette was observed and recorded. The initial volume of the NAOH was subtracted from the final volume and substituted into the formula below to obtain the total acidity present in the sample.

$$\text{Total Alkalinity} = \frac{\mathbf{Xx\ M\ x100000}}{Volume\ of\ sample(mL)}$$

### 2.14. Determination of sulphate (Colorimetric method)

Sulphate stock standard solution of l000mg/L was prepared by dissolving 1.479g of anhydrous Na2SO4 in 500mL of distilled water in 1000mL size volumetric flask. The flask was later filled up with distilled water. From the stock solution, lower concentrations of 2.00, 4.00, 6.00, 8.00 and 10.00mg/L in 100mL volumetric flask were prepared by employing serial dilution method ($C_1V_1 = C_2V_2$). Reagent blank was also prepared, 70mL of each standard solution was measured into the volumetric flask and was thoroughly shaken with the addition of 10mL of Alcohol-Glycerol mixture and finally 5.0g of finely divided BaCh crystal was added and the volume was filled to mark. The absorbance of the reagent blank and standards were taken with Uniscope UV-spectrophotometer between the wavelength (11,) 380-420nm. The absorbance was plotted against standard concentrations and a calibration graph was obtained. The concentration of the sample was known from the above procedures. Linear regression equation was applied to compute the concentration.

### 2.15. Determination of nitrate (Colorimetric method)

The calibration standards of the range 0.1 to l.0mg/L were prepared by diluting appropriate volume to 50mL. One sachet of the Nitraver 5 powder pillow was added to 10mL of each standard into different volumetric flasks. The solution was thoroughly shaken, allowed to stand for 5 minutes after which amber colour developed. The absorbance was determined at 540nm and distilled water was used as blank. A calibration was obtained as in sulphate and phosphate determination. The same procedure was carried out on sample and the absorbance of the sample was obtained.

### 2.16. Determination of heavy metals

Heavy metals present in the samples were determined in the laboratory by measuring 50mL of the acidified sample using a volumetric flask and poured into a conical flask. 5mL of concentrated nitric acid was then added and heated for fifteen minutes using an electrical cooker until it got to 60 °C. The conical flask was then brought down and allowed to cook. 20mL of distilled water and nitric acid was added and it was then filtered using a filtered paper and a funnel. The filtrate obtained was then made up to 100mL inside 100mL sample bottle by adding distill water. The sample was then finally analyzed for zinc, Iron, Copper, Lead and Cadmium, using the atomic absorption spectrometer (Varian model spectral AA 220) and then recorded

### 2.17. Bacteriological analysis

Bacteriological analysis was conducted utilizing the spread plate technique. A volume of 1 cm^3 of the water sample was transferred into prepared sterilized medium (MacConkey agar) in a glass petri dish. The contents of the petri dish were gently mixed by agitation, cooled, and then placed in the incubator for 24 hours at 35°C. Durham tubes were employed for the detection of coliforms.

Total coliform counts in the samples were determined using the multiple tube fermentation technique. This method involved inoculating multiple fermentation tubes containing MacConkey broth with 1 cm^3 of water samples and incubating them at 37°C for 24 hours. Subsequently, the count was conducted using a Suwtex 560 colony counter. Detection of *E. coli* in the water was performed using presumptive and confirmatory tests.

## 3. Results

Tables 1 and 2 present the results of physicochemical properties and heavy metal concentrations, respectively, for borehole and well water samples. Additionally, table 3 displays the microbial properties of the samples. These tables collectively depict the physicochemical properties, heavy metal concentrations, and microbial properties of borehole and well water in the FUTA Southgate area, Akure.

The quality of the borehole and well water was evaluated based on the mean values of physicochemical parameters, and comparisons were made with the recommended limits set by the World Health Organization (WHO) to ensure the proper functioning of biological systems in human beings.

**Table 1** Physicochemical properties of borehole and well water samples

| **Parameters** | **Sample A** | **Sample B** | **WHO** |
|---|---|---|---|
| | Mean/(STD) | Mean/(STD) | |
| Colour | Unobjectionable | Unobjectionable | |
| Odour | Unobjectionable | Unobjectionable | |
| Taste | Unobjectionable | Unobjectionable | |
| Temperature 0C | 28.73(±0.11) | 28.73(±0.11) | 25-30 |
| pH | 7.35(±0.0045) | 7.93(±0.01) | 25-30 |
| Turbidity (NTU) | 1.31(±0.060) | 2.48(±0.031) | 5.0 |
| Total Alkalinity (mg/L) | 23.33(±1.15) | 36.66(±1.15) | 600 |
| Total Acidity (mg/L) | 106.66(±11.54) | 606.66(±11.54) | |
| Conductivity (µs/cm) | 186.33(±0.57) | 479.66(±3.21) | 7.5 |
| Total Hardness (mg/L) | 0.97(±0.064) | 2.66(±0.23) | 150 - 500 |
| DO(mg/L) | 2.40(±1.17) | 3.60(±0.17) | 7.5 |
| TS (mg/L) | 3.56(±0.058) | 1.23(±0.0086) | |
| Chloride (mg/L) | 53.40(±4.97) | 176.30(±2.16) | 250.00 |
| Nitrate (mg/L) | 7.57(±0.079) | . 3.67(±0.050) | 10.00 |

**Table 2** Concentration of Heavy metals of borehole and well water samples measured in Milligram per litre (mg/I).

| **Parameters** | **Sample A** | **Sample B** | **WHO** |
|---|---|---|---|
| | Mean/(STD) | Mean/(STD) | |
| Cupper | 0.93(±0.01) | 0.53(±O.01) | 1.00 |
| Chromium | 0.15(±0.01) | 0.045(±0.015)- | 0.05 |
| Lead | 0.089(±0.0038) | 0.04(±0.2) | 0.01 |
| Manganese | 0.95(±0.015) | 0.64(±0.030) | 0.20 |
| Iron | 4.17(±0.015) | 2.17(±0.01) | 0.30 |
| Cadmium | 0.033(±0.0026) | 0.006(±0.001) | 0.003 |
| Zinc | 3.42(±0.01) | 1.37(±0.045) | 3.00 |

**Table 3** Microbial results of borehole and well water sample

| **Borehole Water** | **Well water** | **Standard** | |
|---|---|---|---|
| cfu/mL | Sample | Sample | |
| *Total Viable Counts* | 159 | 382 | lxl0$^3$ |
| *E.coli* | 0 | 0 | 0 |
| *Faecal Streptococci* | 0 | 0 | 0 |
| *Coliform* | 18 | 26 | 0 |
| *Pseudomonas aeruginosa* | 0 | 0 | 0 |
| *Yeast/mould* | 10 | 14 | l x l0$^3$ |

## 4. Discussion

The observed color for borehole water sample was unobjectionable. The observed color for well water sample was objectionable. Both samples odor was unobjectionable in the water samples collected. This is an indication that serious biochemical reactions leading to foul odour generation may be minimal.

The total hardness values for both borehole and well water samples were 0.97 mg/L and 2.66 mg/L respectively. Total hardness concentrations in all groundwater samples were within the permissible limits (< 500 mg/L). Hardness is an important parameter in decreasing the toxic effect of poisonous element. Total hardness ($CaCO_3$) was found to be high above the permissible limit. Similar observations were recorded by Kataria (2000). Hardness has no adverse effect on human health and water above hardness of 200 mg/L may cause scale deposition in the water distribution system and more soap consumption. Soft water below hardness less than I00 mg/L is more corrosive for water pipes (WHO, 1972; Remia and Logaswamy, 2010).

BOD value recorded for borehole water sample was 1.33 mg/L while the value recorded for well water sample was 1.60 mg/L. Both samples were within the WHO limits for drinking. Biological oxygen demand (BOD) is a measure of the oxygen used by microorganisms to decompose this waste. If there is a large quantity of organic waste in the water supply, there will also be a lot of bacteria present working to decompose this waste. In this case, the demand for oxygen will be high (due to all the bacteria) so the BOD level will be high. As the waste is consumed or dispersed through the water, BOD levels will begin to decline.

pH values for both borehole and well water sample were 7.35 mg/Land 7.93 mg/L respectively, which complies with the permissible limits (6.5-8.5 mg/L). The pH has no direct adverse effect on health, but at the same time alters the taste of water. Higher pH reduces the germinal potentiality of chlorine and induces the formation of toxic tribalomethanes (Trivedy and Goel, 1986; Remia and Logaswamy, 2010).

The temperature of both borehole and well water sample were 28.73 and 28.73 mg/L respectively, which were within are the allowable WHO standard limits (25 - 30°C). Temperature of drinking water is often not a major concern to consumers especially in terms of drinking water quality. The quality of water with respect to temperature is usually lef to the individual taste and preference and there are no set guidelines for drinking water temperature (Nishiguchi, 2000). In the present study, temperature varied from 22 to 34C. The variation in the groundwater temperature may be due to different timing of collection and influence of seasons (Jayraman *et al*., 2003; Priyanka *et al*., 2010).

The conductivity of borehole water sample had a value of 186.33 µs/cm while that of well water was 479.66 µs/cm. The electrical conductivity (EC) of aqueous solution is ability to carry an electrical current. The current is conducted in solution by the movement of ions. The ions in solution are formed by dissociation of inorganic compounds. For this reason, the measurement of conductivity gives a good indicator of the concentration of dissolved salts in water. In the present study EC values were in the permissible limits.

The turbidity values for borehole water sample was 1.31 (NTU) while that of well water sample was 2.48 (NTU). Both samples showed turbidity values that were within the permissible limits (5 NTU). It is estimated that high turbidity may constitute health risk through protection of microorganisms from treatment and stimulation of microbial growth.

Turbidity is the reflection of the total suspended matter to which it is inversely related on one hand and is an indication of clay and inert particles (Nkansah *et al*., 2011).

The alkalinity value of 23.33 mg/L was recorded for borehole water sample whereas the value of 36.66 mg/L was recorded for well water sample. The alkalinity values for both samples were lower than the permissible limits (600 mg/L). Alkalinity therefore acts as a stabiliser for the acidity present in the water. Therefore, low Alkalinity of the both samples indicated that both samples are slightly acidic but sample B is more acidic than sample A. Alkalinity increases as the amount of dissolved carbonates and bicarbonates increase.

The total solid value for borehole water sample were found to be 3.56 mg/L while that of well water sample was found to be 1.23 mg/L. The low concentration implies less solids in both the borehole and well water samples. High TS is commonly objectionable or offensive to taste. A higher concentration of TS usually serves as no health threat to humans.

Both Sample A and Sample B have a dissolved oxygen concentration of 3.86(±0.11) and 3.53(±0.11) mg/L respectively, which were less than the maximum limits of 7.5 mg/L set by WHO (Geneva, 2011). The DO concentration gives an indication of the relative availability of dissolved oxygen in the river and its availability to support life through aerobic respiration. Therefore, shows a slightly low pollution of both the river and well water and minimal treatment will be required to get rid of the organic pollutants contained in the water

The value of chloride observed for borehole water sample was lower than that of well water sample, but still within the permissible limits at both samples (< 250 $mgL^{-1}$). Chloride concentration in water indicates presence of organic waste particularly of animal origin (Thresh et al., 1949). Increase in chloride concentration on discharge of municipal and industrial waste has been reported (Ownby and Kee, 1967; Priyanka *et al.,* 2010). Chloride in water may react with sodium to form sodium chloride. Since sodium chloride has the salty taste, it can be deduced that chloride in water impacts a salty taste in the water. In the present study, the chloride values were lower than the permissible limits in all groundwater samples.

The value of nitrate for borehole water sample was recorded at 7.57 mg/L, whereas well water sample has a value of 3.67. The nitrate contents of the samples were within the pennissible limits (< 45 mg/L). Excessive levels of nitrate in drinking water may cause serious illness and sometimes death. Nitrates have the potential to cause shortness of breath, "blue babies" syndrome in infant ' [or diuresis, an increase in starchy deposits and haemorrhaging the spleen (USEPA, 2004). The concentration of nitrogenous compounds indicates the occurrence of extensive anaerobic bacterial activities. It was reported that groundwater was contaminated from nitrate fertilizers and manures used in agriculture (Mccasl *et al*., 1985; Munsuz and Unver, 1995). Furthermore, nitrate is used by microorganisms as food resources. In addition, high nitrate levels are often accompanied by bacterial and pesticide contamination (Bundy *et al*., 1994; Aydin, 2007).

### 4.1. Heavy metals

Results from analysis have shown that these heavy metals: Fe, Pb, Zn, Cr, Cd, Cu and Mn were all present in both samples analysed while the concentration of Fe and Zn were the highest. This is an indication that both the borehole and well water samples are highly contaminated with heavy metals.

### 4.2. Microbial

Table 3 showed that the borehole and well water samples were contaminated with yeast, total coliform and faecal coliform and also reveals total plate count of 159 colony forming units (cfu/mL) for borehole water sample and total plate count of 382 colony forming units per ml (cfu/mL) for well water. This shows very high bacterial contamination in both borehole and well water samples. There is indication of pathogenic microorganisms in both water samples. Total coliform and yeast/mould were found when assessed which showed that the efficiency of both the river water and well water is low and cannot be recommended for drinking. The observation on the bacteriological quality of water samples is not entirely a new findings, some water drawn from an improved source of water such as stand-pipe, bore- hole and well water are not always free from contamination. The level of Total coliform and faecal coliform bacteria contamination of all water samples in both areas may be as a result of the location of the hand-dug well water, domestic animals that normally visit the site to drink and defecate around the well water. These activities could enhance bacterial spores to contaminate the water through the opening of the well. The use of contaminated drawers/ containers to draw water from some well is another source of contamination. Moreover, total and *faecal coliform* contamination may be due to environmental factors especially human activities in around the well.

## 5. Conclusion

Groundwater quality evaluation have been carried out to evaluate the groundwater portability for consumption in FUTA Southgate area of Akure, Southwestern, Nigeria. Water sample were collected from borehole and wells for physicochemical and microbial analysis. The :;:esults showed BOD, DO TS, TH, nitrate concentration in the hand dug well and borehole water is within the maximum permissible limit of 50mg/I postulated by World Health Organization (WHO) and Nigerian Standard for Drinking Water Quality (NSDQ). The manganese, iron, cadmium, chromium, lead, copper contents of borehole and well water samples were within the range of WHO limit but were slightly contaminated. The total bacteria, yeast/mould and total coliform counts in the water samples revealed microbial contaminations which is slightly above the standard range. Based on the analytical results, it is observed that the groundwater within the study area is slightly contaminated and hence not suitable for drinking and other domestic purposes. Therefore, appropriate remedial treatment is recommended for the groundwater at the locations where the trace elements are at the upper limit of WHO recommended. It could therefore be concluded that the groundwater in the study area is not too safe for drinking and domestic purposes.

## Compliance with ethical standards

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### *Disclosure of conflict of interest*

Authors have declared that no competing interest exist

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