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Physicochemical Assessment of Borehole and Well Water Used in Akungba-Akoko, Ondo State, Nigeria

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Abstract: *The importance of access to good quality water cannot be overemphasised. Effective water quality monitoring could assist in checking the quality of water for consumption. This study was aimed to determine physicochemical quality of water parameters from boreholes and wells used in different locations at Akungba-Akoko, Ondo state, Nigeria. The water samples were collected from both drying and raining season and analysed using different types of analytical techniques. The parameters analysed includes pH, turbidity, odour, temperature, colour, TDS, TSS, conductivity and some heavy metals such as cadmium, nickel and lead using standard methods of analysis. The results obtained were compared with World Health Organisation standards (WHO), for drinking water. The physicochemical and the heavy metal analyses were in compliance with the WHO standards with exception of the concentration of total suspended solids during dry season which were higher in Okele for borehole water. They were above the limit of 5 mg/l recommended for well water at Igbelu in dry and wet season. The samples analysed for borehole water show that nickel were higher in the following samples locations Ilale 1, Ilale 2, Okusa 1, Okusa 2, Okele, Akunmi 1 and Abi 1 for dry season and also higher in Ilale1, Ilale 2, Okusa 1, Okele, Akunmi 1,Abi 1 and Etioro for wet season. Also, for well water, the samples analysed show that nickel were higher in the following samples location Supare-Akungba road, Emmanuel street, Okele and Akunnu for dry season and also higher in Supare-Akungba road for wet season. Proper sanitation should be strictly observed around the vicinity of the boreholes and the well water and appropriate treatment should be done according to seasonal variation with respect to the important physicochemical parameters. Method such as phytoremediation can be introduced to reduce the levels of Lead and Nickel in the water from the studied area.*

Keywords: *Boreholes water, well water, season, coefficient of variation, physicochemical properties.*

1.INTRODUCTION

Water is a universal solvent, which consist of hydrogen and oxygen atoms. Chemically, it could be defined as a chemical substance with two atoms of hydrogen and one atom of oxygen in each of its molecules; hence the molecular formula is H_2O. It is formed by the direct reaction of hydrogen with oxygen [4].Water is colourless, odourless and tasteless liquid in its pure form. It is an inorganic substance that occurs in three states; liquid, gaseous and solid states. Water covers 71% of the earth surface [4]and is vital for all known forms of life. On earth, it is found mostly in oceans and other large water bodies with 1.6% of water below ground in aquifers and 0.001% in the air as vapour clouds (formed from the solid and liquid water particles suspended in air), and precipitation. Oceans hold 97% of surface water, glacier and polar ice cap 2.4% and other land surface water such as rivers, lakes and ponds 0.6% [1]. A very small amount of the earth's water is contained within biological bodies and manufactured products.

Water on earth moves continually through a cycle of evaporation, transpiration, precipitation and runoff usually reaching the sea. Overland, evaporation and transpiration contribute to the precipitation. Clean and fresh drinking water is essential for human and other forms of life. Access to safe drinking water has improved steadily and substantially over the last decades in almost every part of the world [1; 11]. There is a correlation between access to safe water and GDP, per capita. However, some observers have estimated that by 2025 more than half of the world population will be facing water-based vulnerability [18].

Water is a chemical with the chemical formula H_20. Water is a combination of hydrogen and oxygen atoms connected by covalent bonds. It occurs as surface water in lakes, streams, rivers, ponds, shallow aquifers, oceans, seas, ice caps, glaciers, etc. and as ground water (when it accumulates in the ground) which is obtained as spring water, well water, and borehole water [7]. Small amount of gases like N_2, O_2 and CO_2 in the atmosphere are contained in all-natural water.

Water in its pure state is acclaimed key to health and the general contention is that water is more basic than all other essential things to life [4, 8].Man can go without food for twenty-eight days, but only three days without water, and two third of a person water consumption per day is through food while one third is obtained through drinking [4, 12].

Water is the most common solvent for many substances and it rarely occurs in its pure nature [4]. Water can be obtained from a number of sources, among which are streams, lakes, rivers, ponds, rain, springs and wells [15].Pollution as the deliberate or accidental contamination of the environment with man's waste.Agricultural processes involving the use of fertilisers, herbicides and pesticides produce toxic substances that are transported as effluents into water sources and these pollute water bodies [14]. Similarly, textile industries emit wastewater that contains organic dyes which introduce different ions into water that can alter its composition [5]. This inaccessibility to clean water poses a risk of water borne diseases as indicated by rampant water borne diseases like typhoid and diarrhoea. The inorganic chemicals hold a greater portion as contaminants in drinking water in comparison to organic chemicals. A part of inorganicsis in mineral form of heavy metals. Heavy metals tend to accumulate in human organs and nervous system and interfere with their normal functions. In recent years, heavy metals such as lead (Pb), arsenic (As), magnesium (Mg), nickel (Ni), copper (Cu), and zinc (Zn) have received significant attention due to causing health problems. Moreover, the cardiovascular diseases, kidney-related problems, neurocognitive diseases, and cancer are related to the traces of metals such as cadmium (Cd) and chromium (Cr) as reported in epidemiological studies [6]. The Pb is known to delay the physical and mental growth in infants, while arsenic (As) and mercury (Hg) can cause serious poisoning with skin pathology and cancer and further damage to kidney and liver, respectively. A number of scientific procedures and tools have been developed to assess the water contaminants. These procedures include the analysis of different parameters such as pH, turbidity, conductivity, total suspended solids (TSS), total dissolved solids (TDS) and heavy metals. These parameters can affect the drinking water quality, if their values are in higher concentrations than the safe limits set by the World Health Organization (WHO) and other regulatory bodies [20].

Therefore, the investigation of the drinking water quality by researchers and governmental departments has been performed regularly throughout the world. The World Health Organization recommends that the minimum daily amount of water per person should be 27litres. It is not clear how much water is explored per capita however it is obvious that many manage far less than 27 litres a day. There is a gap in knowledge of anthropogenic, geological and hydrological factors impacting on borehole water quality and the patterns of borehole water consumption to identify areas with water stress and understand consumption patterns, like the effects of distance from the borehole, household size and changing seasons on daily per capita borehole water consumption. Although some of these pollutants are essential, others are toxic to animals, man and plants. When these pollutants accumulate beyond the recognised and recommended limits, they become toxic to living organism (man, animals and plants). The consumption or use of water from polluted water sources is capable of causing water or chemical related diseases. Water is important natural resources on which the survival of human beings largely depends on. Disease contacted through drinking water kill about 5 million children annually and make $1/6^{th}$ of the world population sick [18, 19]. When pollutants accumulate beyond the recognized and recommended limits, they become toxic to living organism (6,18]. It is on these bases that an attempt is being made to determine the physicochemical parameters of boreholes and well water in Akungba-Akoko metropolis in Ondo state and also the extent of underground pollution of water sources in the city.

2.MATERIALS AND METHOD

2.1The Study Area

The study area is Akungba-Akoko in Akoko south west Local Government Area of Ondo State, Nigeria. Its geographical coordinates lies within Longitudes 5 0 44'E and 50 45'E and the Latitudes 70 27'N and 70 28'N as shown in Figure 1. It is bordered to the North by Ikare-Akoko, South by Oba-Akoko.East by Odowara and West by Supare-Akoko. The climate of Akungba-Akoko falls within the tropical region with rainfall which varies from 1100 - 2000 mm per annum. The temperature is between 26 and 28°C. There are alternate wet and dry seasons [2, 9]. It is located on an undulating and rocky terrain. The rocks in the study area are migmatitic with the most predominant components being the granite-gneiss and grey gneiss. These rocks are covered by regoliths with thickness variation across the town. The wells in many parts of Akungba are shallow reflecting the extent of the weathered profile in the study area. Structural features in the rocks are those typically found in metamorphic rocks. Faults and fractures are also present in the rocks [18].

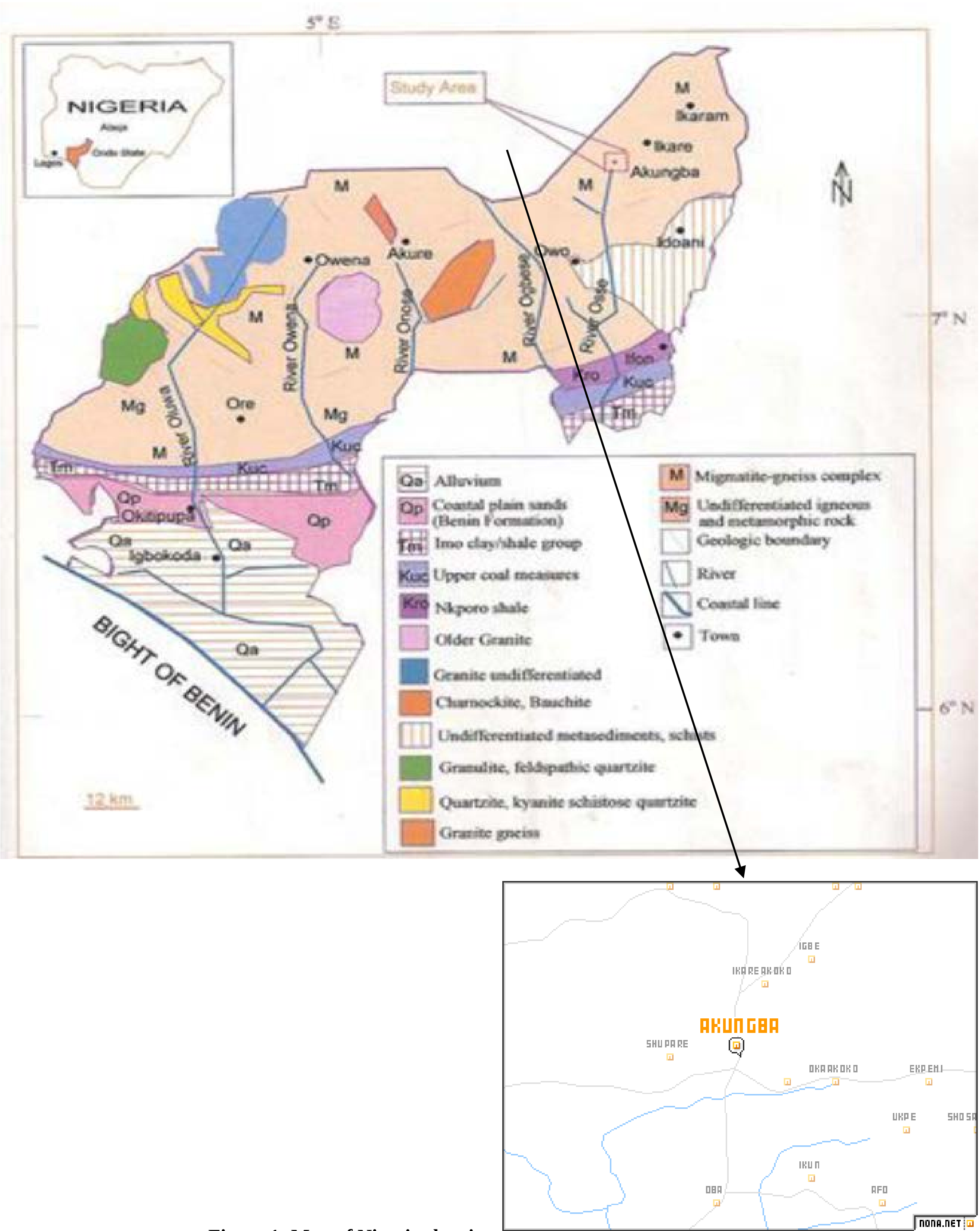

Figure 1: Map of Nigeria showing Ondo state and Akungba-Akoko
www.google.com.ng/search?q=map+of+Nigeria+show+ondo+state&client=ms-opera mini)

2.2Collections of Water Samples

The samples of borehole and well water were collected from different boreholes and wells as shown in Table 1 and 2 within Akungba-Akoko metropolis using sterile sampling bottles. The samples were transported in ice bath to the laboratory for physicochemical analysis such as turbidity, colour, temperature, odour, conductivity, total dissolved solids,total suspended solids and pH using turbidity meter, pH meter, conductivity meter and Mercury thermometer respectively.

Table 1: Area of collection of water in Akungba-Akoko

S/N	Borehole water	Well water
1	Ilale 1 and 2	Supare-Akungba
2	Okusa 1 and 2	Emmanuel street
3	Alale palace	Alale palace
4	Okele	Okele
5	Igbelu	Igbelu
6	Ibaka	Araromi 1 and 2
7	Akunnu 1 and 2	Alafiatayo
8	Abi 1 and 2	Akunnu
9	Etioro	

Table 2: Sampling code

Borehole water			
S/N	**Samples area**	**Dry season samples code**	**Rainy season sample code**
1	Ilale 1	S1	S1
2	Ilale 2	S2	S2
3	Okusa 1	S3	S3
4	Okusa 2	S4	S4
5	Alale palace	S5	S5
6	Okele	S6	S6
7	Igbelu	S7	S7
8	Ibaka	S8	S8
9	Akunnu 1	S9	S9
10	Akunnu 2	S10	S10
11	Abi 1	S11	S11
12	Abi 2	S12	S12
13	Etioro	S13	S13
Well water			
14	Supare-Akungba Road	S14	S14
15	Emmanuel street	S15	S15
16	Alale palace	S16	S16
17	Okele	S17	S17
18	Igbelu	S18	S18
19	Araromi 1	S19	S19
20	Araromi 2	S20	S20
21	Alafiatayo	S21	S21
22	Akunnu	S22	S22

2.3Methods of Analysis

Physicochemical properties such as pH, Conductivity, turbidity, colour, taste and odour, temperature, total dissolved solid, total suspended solids, Nickel, Lead and Cadmium were analysed of water samples from the two water sources by standard methods [3,18] as explained below:

On-site analyses of pH, conductivity, and turbidity were carried out at the site of sample collection following the standard protocols and methods of American Public Health Organization (APHA) [3]. The pH of the water samples was measured by using a pH meter (model HI 98130 HANNA, Mauritius, IramacSdn. Bhd.). The pH meter was calibrated, with three standard solutions (pH 4.0, 7.0, and 10.0), before taking the measurements. The value of each sample was taken after submerging the pH probe in the water sample and holding for a couple of minutes to achieve a stabilized reading. After the measurement of each sample, the probe was rinsed with deionized water to avoid cross contamination among different samples.

The conductivity of the samples was measured using a conductivity meter (model HI 98130 HANNA, Mauritius, IramacSdn. Bhd.). The probe was calibrated using a standard solution with a known conductivity. The probe was submerged in the water sample and the reading was recorded after the disappearance of stability indicator. After the measurement of each sample, the probe was rinsed with deionized water to avoid cross contamination among different samples. The turbidity of the water samples was measured using a turbidity meter (model 2100P Turbidimeter HACH, Colombia, USA, Arachem (M) Sdn. Bhd.). Each sample was poured in the sample holder and kept inside for a few minutes. After achieving the reading stability, the value was recorded. The temperature, colour, taste and odour were monitored directly with Max-Min Thermo Hydro *model*: CTU7635

The measurements of TSS and TDS in water samples were carried out according to the standard methods of APHA [3]. A fixed volume of water sample was poured on a pre-weighed glass fibre filter of a specified pore size before starting the vacuum filtration process. The filter was removed after the completion of the filtration process and placed in an aluminium dish in an oven at 100°C for 2-3 hours to completely dry off the remaining water. The filter was then weighed, and the gain in filter weight represented the TSS contents, expressed in mass per volume of sample filtered (mg/L). The TDS of the water samples were determined by the gravimetric method. After filtration for TSS analysis, the filtrate was heated in oven at above 100°C until all the water was completely evaporated. The remaining mass of the residue represents the amount of TDS in a sample. For analysis of Cd, Ni and Pb, direct extraction/air-acetylene flame method was used based on ASTM standards, which are approved by APHA using Flame Atomic Absorption Spectrometer (FAAS) (AAS, Perkin Elmer Analyst 400).

3. RESULTS AND DISCUSSION

3.1 Physicochemical properties of borehole water samples

The comparative analytical results of borehole water samples as shows in Tables 3 to Table 5 based on the chemical and physical analysis carried out on samples. The results of analyses show odour of all the borehole water are unobjectionable and the entire colours are within the safe limit recommended for drinking water by WHO standard. The results of analyses show temperature of all the water samples are within the WHO prescribed limit for drinking water. Temperature of water samples analysed have a mean and coefficient of variation of 26.45ºC and 9.07% for dry season as against a mean and coefficient of variation of 24.50ºC and 0.59% for the wet season. This shows that temperature of borehole is lower in the dry season than in the wet season. This may be due to the effect of harmattan. This is not unconnected with the ambient environment of the boreholes [10].

The results of analyses of water samples show pH of borehole water is all within the WHO allowable limit of 6.5-8.5 for drinking water for both dry and wet season. The pH of borehole water in the study area has a mean and coefficient of 6.02 and 9.96% for dry season as against a mean and coefficient of 6.40 and 7.18% for the wet season. This suggests pH is lower in the dry season than in the wet season. This may be due to greater values of water level and greater retention period. This is implied during wet season rainfall combines with carbon dioxide can influence the water toward acidity. The result was similar to Olajubu and Ogunika [16].

The analyses show electrical conductivity in water samples are within the WHO guide of 1000 (µscm^{-1}). The electrical conductivity in borehole water in the study area have a mean and coefficient of variation of 445.83 (µscm^{-1}) and 275.05% for dry season as against the mean of 466.92 (µscm^{-1}) and 32.17% for the wet season. Electrical conductivity in borehole water is noted to be higher in the wet season than the dry season. The higher values in the wet seasons may be due to the leaching of the minerals salt from the bedrock and re-suspended of solids.

Total dissolved solids test provides a quantitative measure of the amount of dissolved ions. Water samples analysed have a mean and coefficient of variation of 223.33 mg/l and 36.30% for dry season, and 236.00 mg/l and 31.99% for the wet season. The concentration of total dissolved solids in borehole water is noted to be lower in dry season than in wet season. This may be due to the present of silt, decaying plant and animal matter, industrial wastes, and sewage. This is consistent with the findings of Olubanjo [17].

Turbidity in water sample have a mean and coefficient of 0.1NTU and 40.85% for the dry season as against a mean and coefficient of 0.077NTU and 92.32% for the wet season. Turbidity concentrations in borehole water are noted to be higher in dry season than in the wet season. The cause of turbidity in boreholes may be traced to dissolved clay and mud materials into the groundwater. Frequency of drawn down from borehole can contribute to turbidity in water. The result obtained was similar to Ocheri *et al.*, [13]. Total suspended solids water samples analysed have a mean and coefficient of variation of 2.05 mg/l and 82.27% for dry season, and 1.35 mg/l and 84.04% for the wet season. The concentrations of total suspended solids in borehole water are noted to be higher in dry season than in wet season. This is in line with the report of Taiwo *et al.*, [18]. This will affect the transparency and turbidity of the water.

Table 3: Physicochemical analysis of borehole water during dry season

Samples code	**Turbidity (NTU)**	**Colour Hazen Unit**	**Temperature (ºC)**	**Odour**	**Conductivity (uscm^{-1})**	**TDS (mg/l)**	**TSS (mg/l)**	**pH**
S1	0.10	0.00	26.70	Unobj.	360.00	180.00	0.00	6.48
S2	0.10	0.00	26.90	Unobj.	640.00	320.00	4.00	6.26
S3	0.10	0.00	26.60	Unobj.	690.00	340.00	3.00	6.92

Samples code	Turbidity (NTU)	Colour Hazen Unit	Temperature (ºC)	Odour	Conductivity (uscm^{-1})	TDS (mg/l)	TSS (mg/l)	pH
S4	0.10	0.00	26.80	Unobj.	600.00	300.00	2.00	6.89
S5	0.10	0.00	26.50	Unobj.	200.00	100.00	0.00	6.50
S6	0.10	0.00	26.50	Unobj.	710.00	360.00	6.00	6.39
S7	0.10	0.00	26.70	Unobj.	510.00	260.00	2.60	6.91
S8	0.10	0.00	26.70	Unobj.	400.00	200.00	2.00	6.88
S9	0.10	0.00	26.80	Unobj.	240.00	120.00	0.00	6.40
S10	0.10	0.00	26.60	Unobj.	510.00	250.00	3.00	6.12
S11	0.20	0.00	26.60	Unobj.	490.00	250.00	2.00	6.50
S12	0.20	0.00	26.60	Unobj.	490.00	240.00	2.00	6.48
S13	0.10	0.00	26.62	Unobj.	240.00	255.00	2.00	6.55
WHO STANDARD	5	5	NA		1000	500	5	6.5-8.5

Note: Unobj. = Unobjectionable; TDS = Total dissolved solid (mg/l); TSS = Total suspended solid (mg/l)**;** NA - Not Applicable.

Table 4: Physicochemical analysis of borehole water during raining season

Samples code	Turbidity (NTU)	Colour Hazen Unit	Temp. (ºC)	Odour	Conductivity (uscm^{-1})	TDS (mg/l)	TSS (mg/l)	pH
S1	0.06	0.00	24.50	Unobj.	350.00	178.00	0.00	6.22
S2	0.06	0.00	24.60	Unobj.	630.00	318.00	2.00	6.34
S3	0.06	0.00	24.40	Unobj.	680.00	330.00	2.00	6.48
S4	0.08	0.00	24.60	Unobj.	590.00	294.00	1.00	7.00
S5	0.06	0.00	24.90	Unobj.	200.00	98.00	0.00	6.80
S6	0.08	0.00	24.80	Unobj.	700.00	354.00	4.00	6.25
S7	0.08	0.00	24.50	Unobj.	500.00	258.00	1.60	6.55
S8	0.06	0.00	24.60	Unobj.	390.00	196.00	2.00	6.35
S9	0.08	0.00	24.40	Unobj.	230.00	116.00	0.00	6.55
S10	0.10	0.00	24.70	Unobj.	500.00	248.00	2.00	6.00
S11	0.10	0.00	24.60	Unobj.	480.00	242.00	1.00	6.33
S12	0.10	0.00	24.50	Unobj.	480.00	236.00	1.00	6.15
S13	0.08	0.00	24.40	Unobj.	340.00	200.00	1.00	6.22
WHO STANDARD	5	5	NA		1000	500	5	6.5-8.5

Note: Unobj. = Unobjectionable; TDS = Total dissolved solid (mg/l); TSS = Total suspended solid (mg/l); NA - Not Applicable.

Table 5: Descriptive characteristics of physicochemical parameters of borehole water quality for dry and raining seasons

	Dry season					Wet season				
Parameters	**Min**	**Max**	**Mean**	**SD**	**CV**	**Min**	**Max**	**Mean**	**SD**	**CV**
Turbidity	0.10	0.20	0.10	0.04	40.85	0.06	0.10	0.08	0.92	92.32
Colour	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Temperature	26.50	26.90	26.45	2.22	9.07	24.40	24.90	24.50	0.14	0.59
Conductivity	200.00	710.00	445.83	162.08	275.05	200.00	700.00	466.92	150.23	32.17
TDS	100.00	360.00	223.33	81.07	36.30	98.00	354.00	236.00	75.04	31.99
TSS	0.00	6.00	2.05	1.69	82.27	0.00	4.00	1.35	1.14	84.04
pH	6.12	6.92	6.02	0.60	9.96	6.15	7.00	6.40	0.46	7.18
Nickel (Ni)	0.00	0.11	0.04	Nil	Nil	0.00	0.09	0.03	Nil	Nil
Lead (Pb)	0.00	0.00	0.00	Nil	Nil	0.00	0.00	0.00	Nil	Nil
Cadmium	0.00	0.01	0.0025	Nil	Nil	0.00	0.01	0.003	Nil	Nil

SD – Standard Deviation; CV –Coefficient of Variation

3.2 Physicochemical properties of well water samples

The comparative analytical results of well water samples as shows in Tables 6 to Table 8 based on the chemical and physical analysis carried out on samples. The results of analyses show odour of all the well water are unobjectionable and the entire colours were within the recommended safe limit for drinking water that is in conformity with WHO standard. The results of analyses show temperature of all the water samples are within the WHO prescribed limit for drinking water. Temperature of water samples analysed have a mean and coefficient of variation of 28.68ºC and 0.38% for dry season as against a mean and coefficient of variation of 26.63ºC and 0.43% for the wet season. This shows that temperature of well water is higher in the dry season than in the wet season. This is not unconnected with the ambient environment of the wells.

The results of analyses of water samples show pH of well water is all within the WHO allowable limit of 6.5-8.5 for drinking water for both dry and wet season. The pH of borehole water in the study area has a mean and coefficient of 6.74 and 3.63% for dry season as against a mean and coefficient of 6.80 and 4.96% for the wet season. This suggests pH is lower in the dry season than in the wet season. This is implied because during wet season rainfall combines with carbon dioxide can influence the water toward acidity.

The analyses show electrical conductivity in water samples are within the WHO guide of 1000 (µscm^{-1}). The electrical conductivity in well water in the study area have a mean and coefficient of variation of 341 (µscm^{-1}) and 65.71% for dry season as against the mean of 335.46 (µscm^{-1}) and 63.32% for the wet season. Electrical conductivity in well water is noted to be lower in the wet season than the dry season; reason being that the temperature was much lower and there is higher value of dissolved oxygen during the wet season, Olubanjo [17].

Total dissolved solids water has a mean and coefficient of variation of 171.00 mg/l and 66.55% for dry season, and 163.82 mg/l and 66.14% for the wet season. The concentration of total dissolved solids in well water is noted to be higher in dry season than in wet season.

Turbidity in water sample have a mean and coefficient of 0.21NTU and 75.14% for the dry season as against a mean and coefficient of 0.13NTU and 70.67% for the wet season. Turbidity concentrations in well water are noted to be higher in dry season than in the wet season. The cause of turbidity in well water may be traced to dissolved clay and mud materials into the groundwater. Frequency of drawn down from well can contribute to turbidity in water. The result obtained was similar to Ocheri *et al*. [13]

Total suspended solids water samples analysed have a mean and coefficient of variation of 2.00 mg/l and 148.33% for dry season, and 1.27 mg/l and 180.70% for the wet season. The concentrations of total suspended solids in well water are noted to be higher in dry season than in wet season. This may be due to the present of silt, decaying plant and animal matter, industrial wastes and sewage waste.

Table 6: Physicochemical analysis of well water during dry season

Samples code	Turbidity (NTU)	Colour Hazen Unit	Temp. (ºC)	Odour	Conduct. (uscm^{-1})	TDS (mg/l)	TSS (mg/l)	pH
S14	0.10	0.00	28.60	Unobj.	150.00	80.00	0.00	6.74
S15	0.10	0.00	28.60	Unobj.	320.00	160.00	2.00	6.66
S16	0.10	0.00	28.50	Unobj.	180.00	90.00	0.00	6.80
S17	0.30	1.00	28.70	Unobj.	270.00	130.00	2.00	7.22
S18	0.50	1.50	28.80	Unobj.	880.00	450.00	10.00	6.70
S19	0.10	0.00	28.60	Unobj.	150.00	80.00	0.00	6.38
S20	0.10	0.00	28.80	Unobj.	200.00	100.00	0.00	6.78
S21	0.10	0.00	28.60	Unobj.	210.00	100.00	0.00	6.55
S22	0.20	1.00	28.80	Unobj.	490.00	240.00	2.00	6.79
WHO STANDARD	5	5	NA		1000	500	5	6.5-8.5

Note: Unobj. =Unobjectionable; TDS = Total dissolved solid (mg/l); TSS = Total suspended solid (mg/l); NA - Not Applicable.

Table 7: Physicochemical analysis of the well water during raining season

Samples code	Turbidity (NTU)	Colour Hazen Unit	Temperature. (ºC)	Odour	Conductivity. (uscm^{-1})	TDS (mg/l)	TSS (mg/l)	pH
S14	0.30	1.00	26.70	Unobj.	150.00	76.00	0.00	6.34
S15	0.06	1.50	26.70	Unobj.	310.00	158.00	1.00	6.30
S16	0.06	0.00	26.60	Unobj.	170.00	88.00	0.00	6.90
S17	0.10	1.50	26.50	Unobj.	260.00	128.00	1.00	7.40
S18	0.30	1.50	26.50	Unobj.	870.00	444.00	8.00	6.85

Samples code	Turbidity (NTU)	Colour Hazen Unit	Temperature. (ºC)	Odour	Conductivity. (uscm^{-1})	TDS (mg/l)	TSS (mg/l)	pH
S19	0.08	0.00	26.70	Unobj.	140.00	78.00	0.00	6.50
S20	0.06	0.00	26.70	Unobj.	200.00	98.00	0.00	6.56
S21	0.08	1.00	26.80	Unobj.	200.00	96.00	0.00	6.80
S22	0.10	1.00	26.70	Unobj.	480.00	234.00	1.00	7.22
WHO STANDARD	5	5	NA		1000	500	5	6.5-8.5

Note: Unobj. = Unobjectionable; TDS = Total dissolved solid (mg/l); TSS = Total suspended solid (mg/l); NA - Not Applicable.

Table 8: Descriptive characteristics of physicochemical parameters of well water quality for dry and wet seasons

	Dry season					Wet season				
Parameters	**Min**	**Max**	**Mean**	**SD**	**CV**	**Min**	**Max**	**Mean**	**SD**	**CV**
Turbidity	0.10	0.50	0.21	0.16	75.14	0.06	0.30	0.13	0.09	70.67
Colour	0.00	0.50	0.40	0.54	134.63	0.00	2.00	0.95	0.06	68.68
Temperature	28.50	28.80	26.68	0.11	0.38	26.40	26.80	26.63	0.11	0.43
Conductivity	150.00	880.00	341.00	224.07	65.71	140.00	870.00	335.46	212.41	63.32
TDS	80.00	450.00	171.00	113.79	66.55	76.00	444.00	163.82	108.34	66.14
TSS	0.00	10.00	2.00	2.97	148.33	0.00	8.00	1.27	2.30	180.70
pH	6.38	7.22	6.74	0.21	3.63	6.30	7.40	6.80	0.34	4.96
Nickel (Ni)	0.00	0.05	0.021	Nil	Nil	0.00	0.05	0.01	Nil	Nil
Lead (Pb)	0.00	0.01	0.001	Nil	Nil	0.00	0.01	0.00	Nil	Nil
Cadmium	0.00	0.01	0.004	Nil	Nil	0.00	0.01	0.004	Nil	Nil

SD – Standard Deviation; CV –Coefficient of Variation

3.3 Heavy metals of borehole water sample

The comparative analytical results of borehole water samples based on the analysis of heavy metals as shows in Tables 9 and Table 10. Nickels (Ni) in water sample have a mean of 0.04 ppm for the dry season as against a mean of 0.03 ppm for the wet season. Nickel (Ni) concentrations in borehole water are noted to be higher in the dry season than in the wet season. The samples borehole water analysed show that nickel were higher in the following samples location Ilale 1, Ilale 2, Okusa 1, Okusa 2, Okele, Akunmi 1 and Abi1 for dry season and also higher in Ilale 1, Ilale2, Okusa 1, Okele, Akunmi 1;Abi 1 and Etioro for wet season. Leads (Pb) were below recommended limit of 0.01mg/l. This result was similar to Olajubu and Ogunika[16]who carried out the assessment of the physic-chemical and microbiological properties of borehole water samples from Akungba-Akoko. Cadmium (Cd) in water sample has a mean of 0.0025 ppm for the dry season as against a mean of 0.003 ppm for the wet season. Cadmium (Cd) concentrations in borehole water are noted to be lower in the dry season than in the wet season.

Table 9: Analysis of heavy metals on borehole water during dry season

Samples Code	Ni	Pb	Cd
S1	0.11	0.00	0.01
S2	0.09	0.00	0.00
S3	0.08	0.00	0.00
S4	0.04	0.00	0.00
S5	0.01	0.00	0.00
S6	0.05	0.00	0.00
S7	0.02	0.00	0.00
S8	0.00	0.00	0.01
S9	0.08	0.00	0.00
S10	0.00	0.00	0.00
S11	0.04	0.00	0.00
S12	0.00	0.00	0.01
S13	0.01	0.00	0.00
WHO STANDARD	0.02	0.01	0.003

Note: Cd = Cadmium (ppm); Pb = Lead(ppm); Ni = Nickel (ppm)

Table 10: Analysis of heavy metals on borehole water during raining season

Samples Code	**Ni**	**Pb**	**Cd**
S1	0.09	0.00	0.01
S2	0.05	0.00	0.00
S3	0.06	0.00	0.00
S4	0.02	0.00	0.01
S5	0.01	0.00	0.00
S6	0.03	0.00	0.00
S7	0.01	0.00	0.00
S8	0.00	0.00	0.01
S9	0.06	0.00	0.00
S10	0.00	0.00	0.00
S11	0.03	0.00	0.00
S12	0.00	0.00	0.01
S13	0.03	0.00	0.00
WHO STANDARD	0.02	0.01	0.003

Note: Cd = Cadmium (ppm); Pb = Lead (ppm); Ni = Nickel (ppm)

3.4 Heavy metals of well water sample

The comparative analytical results of well water samples based on the analysis of heavy metals as shows in Tables 11 and Table 12. Nickels (Ni) in water sample have a mean of 0.021 ppm for the dry season as against a mean of 0.012 ppm for the wet season. Nickel (Ni) concentrations in well water are noted to be higher in the dry season than in the wet season. The samples of well water analysed show that nickel were higher in the following samples location Supare-Akungba road, Emmanuel street, Okele and Akunnu for dry season and also higher in Supare-Akungba road for wet season. Leads (Pb) have a mean of 0.001 ppm for the dry season as against a mean of 0.0009 ppm for the wet season. However, all the samples were below the recommended limit of 0.01mg/l. This result was similar to Olajubu and Ogunika, [16] who carried out the assessment of the physic-chemical and microbiological properties of borehole water samples from Akungba-Akoko. Cadmium (Cd) in water sample has a mean of 0.004 ppm for the dry season as against a mean of 0.0036 ppm for the wet season. Cadmium (Cd) concentrations in well water are noted to be higher in the dry season than in the wet season.

Table 11: Analysis of heavy metals on well water during dry season

Samples Code	**Ni**	**Pb**	**Cd**
S14	0.05	0.00	0.01
S15	0.05	0.00	0.00
S16	0.00	0.00	0.00
S17	0.04	0.00	0.01
S18	0.00	0.00	0.00
S19	0.00	0.01	0.01
S20	0.00	0.00	0.00
S21	0.00	0.00	0.01
S22	0.03	0.00	0.00
WHO STANDARD	0.02	0.01	0.003

Note: Cd = Cadmium (ppm); Pb = Lead (ppm); Ni = Nickel (ppm)

Table 12: Analysis of the heavy metals on well water during rainy season

Samples Code	**Ni**	**Pb**	**Cd**
S14	0.03	0.00	0.01
S15	0.02	0.00	0.00
S16	0.00	0.00	0.00
S17	0.02	0.00	0.01
S18	0.00	0.00	0.00
S19	0.00	0.01	0.01
S20	0.00	0.00	0.00
S21	0.00	0.00	0.01

S22	0.01	0.00	0.00
WHO STANDARD	0.02	0.01	0.003

Note: Cd = Cadmium (ppm); Pb = Lead (ppm); Ni = Nickel (ppm)

4. CONCLUSION

Physicochemical assessment of borehole and well water samples from Akungba-Akoko metropolis was carried out in this research. Most of the physicochemical parameters were within the WHO standards of (5mg/l) with exception of the concentration of total suspended solids during dry season which were higher in borehole water at Okele. Well water at Igbelu in dry season and wet season were also above the recommended limit. High concentrations of suspended solids can cause many problems for stream health and aquatic life. The levels of heavy metals were also found to be within the recommended levels set by WHO with exception of nickel (Ni) nickel found in drinking water as a consequence of its presence in alloys used in contact with drinking water, chromium or nickel plating of fittings or its presence in water sources, usually as a consequence of dissolution from naturally occurring nickel-bearing strata in groundwater. However, since some of the results for nickel indicate high levels above the standard set by WHO safe limits, there is the tendency of high potential health hazards to the inhabitants of the areas that uses these water sources for drinking and other domestic purposes without treatment. From the result obtained, water quality monitoring is encouraged to be a continuous process. Proper sanitation should be strictly observed around the vicinity of the boreholes and the well water. Proper and appropriate treatment should be done according to seasonal variation with respect to the important physicochemical parameters. Government policies on waste disposal and management should be enacted and strictly enforced. Some other techniques like phytoremediation can be introduced to reduce the levels of the heavy metal contamination such as Lead and Nickel.

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