ORIGINAL ARTICLE

PHYSICO-CHEMICAL AND MICROBIAL ANALYSES OF WATER SAMPLES FROM HAND-DUG WELLS AROUND THE FEDERAL UNIVERSITY OF TECHNOLOGY, AKURE, NIGERIA

| Olajide Ayodele [1*] | Edward Olorunsola Olanipekun [1, 2] | Michael Adedayo Banjo [1] | Yusuf Laide Saka [1] | and | |Adefusioye Adegalu Adebawore [2] |

[1.] The Federal University of Technology | Department of Chemistry | Akure | Nigeria |
[2.] Ekiti State University | Department of Chemistry | Ado-Ekiti | Nigeria |

|Received | 29 June 2017 | |Accepted 24 July 2017| |Published | 22 August 2017|

ABSTRACT

Background: Consequent on the importance placed on potable water across the globe and the recurrent water borne diseases inherent from the consumption of polluted water, there is the need to periodically monitor the quality of water utilized domestically and industrially. **Objective**: The study is aimed at evaluating the physicochemical and microbial analyses of water samples from hand-dug wells around The Federal University of Technology, Akure, Nigeria. **Materials and Methods:** Water samples were collected from cased wells at selected locations around the North and South Gates of the Federal University of Technology, Akure(FUTA), Nigeria. The samples were subjected to physicochemical and microbiological analyses using standard analytical procedures. **Results**: The following results were obtained: pH (5.61 - 6.77); chloride (45.05 - 155.70 mg/L); nitrate (0.027 - 2.800 mg/L); sulphate (23.20 - 244.00 mg/L); phosphate (BDL - 20.52); total hardness (36.20 - 208.74 mg/L); sodium (9.51 - 58.64 mg/L); potassium (1.62 - 10.00 mg/L); temperature (26.00 - 28.1^{o}C); turbidity (0.1 - 0.6 NTU); conductivity (129.00 - 586.00 µS/cm); acidity (63.00 - 108.00 mg/L); dissolved oxygen (DO) (29.17 - 50.00 mg/L); biochemical oxygen demand (BOD) (1.00 – 400.00 mg/L); and alkalinity (43.26 - 382.20 mg/L). The levels of total solids, total suspended solids and total dissolved solids were 0.19 - 1.15, 0.02 - 0.07, and 0.16 - 1.08 mg/L, respectively. Metal analysis showed the presence of K, Na, Mn, Fe, Cu, Zn, and Cr in varied amounts. However, Pb was below detection limit (BDL) in all the water samples. Microbial analysis revealed the presence of *Staphylococcus aureus*, *Salmonella sp*, *Klebsiella sp*, *Shigella sp*, *Enterobacter sp*, *E. coli*, and *Bacillus sp*. **Conclusion**: All the results obtained were compared with the permissible limits of the World Health Organisation (WHO), and it was observed that all the water samples studied did not conform in totality with the standards stipulated by WHO.
Keywords: *cased wells; turbidity; coliform counts; heavy metals.*

1. INTRODUCTION

Water is an essential commodity to life; it is undoubtedly the most precious natural resource that exists on our planet [1]. The quality of water available to people has tremendous impact on their living standard and well-being; thus global and local efforts are wide-spread at ensuring adequate provision of clean and safe water to the world's growing population [2]. Water supports human life as well as biodiversity; it is also a good medium for transmitting diseases when the quality is compromised. Water-borne diseases are caused by pathogenic microorganisms which are directly transmitted when contaminated water is consumed [3]. Population growth coupled with other factors such as urbanization, agricultural activities, industrial and commercial processes have resulted in the accumulation of wastes and pollutants which end up in water bodies, thereby altering the water quality, species composition and biodiversity in many aquatic systems [4].

Physicochemical parameters such as temperature, pH, Dissolved Oxygen (DO), salinity, and nutrient loads have been reported to influence biochemical reactions within water systems [5]. The consequence of such is a compromise on the water quality available for human use.

Presence of heavy metals such as lead (Pb) and cadmium (Cd) in the environment which are toxic has been a source of concern to environmentalists, government agencies and health practitioners [6]. Water in its pure form is colourless, tasteless and sparkling in nature [7]. The provision of potable water which is free from toxic substances and every disease-causing microorganisms deleterious to health is necessary to prevent health hazard [8]. Water can be gotten from different sources such as streams, lakes, rivers, ponds, well, rain and springs [9], it is the most basic and fundamental component of the earth: ocean (92.2 %), polar caps (2.14 %), underground water (0.61 %) and surface water (0.009 %) while the remaining 0.041 % is contained in soil and atmospheric moisture [10]. The presence of safe and reliable drinking water is an essential prerequisite for a stable community, so quality of water is to be determined for a locality for various purposes. Drinking water quality is a matter of concern as it is related to human health, and many hazardous problems may arise due to various contaminants present in it. Poor water quality and bad sanitation are deadly, as 5 million deaths are reported annually in the developing countries [11]. In the light of this, the present

study evaluated the quality of water (Hand-Dug wells) available for domestic activities for residents around the North and South gates of The Federal University of Technology, Akure, Nigeria.

2. MATERIALS AND METHODS

2.1. Study Design

The study design was on a laboratory scale. It was carried out at Chemistry Department, The Federal University of Technology Akure, Nigeria. Water samples were obtained from different wells around the premises of the University, and were subsequently analyzed for their physico-chemical and microbial properties.

2.2. Study Area: Three different wells were sampled each from North and South gates of the institution. All the wells sampled were lined with concrete rings. The descriptions of the locations are presented in Table 1.

Table 1: Sample description and location.

Area	Sample location	code	Geographical Coordinates
North gate	MFM lodge	A	Longitude N 0736135 and latitude 0808526 UTM
	Winners lodge	B	longitude N 0736208 and latitude 0808376 UTM
	His Grace lodge	C	N 0736287 and latitude 0808373 UTM (+31)
South gate	RCF Secretariat	D	50 9′ 18.18″ North, 70 17′ 33.9″ East
	Wesyside Hostel	E	50 9′ 7.05″ North, 70 17′ 32.21″ East
	Glory Villa Lodge	F	50 9′ 11.98″ North, 70 17′ 33.28″ East

2.3. Sample Collection: Water samples were collected from hand-dug wells at different locations in the vicinity of the Federal University of Technology, Akure, Nigeria as presented in Figures 1 and 2.

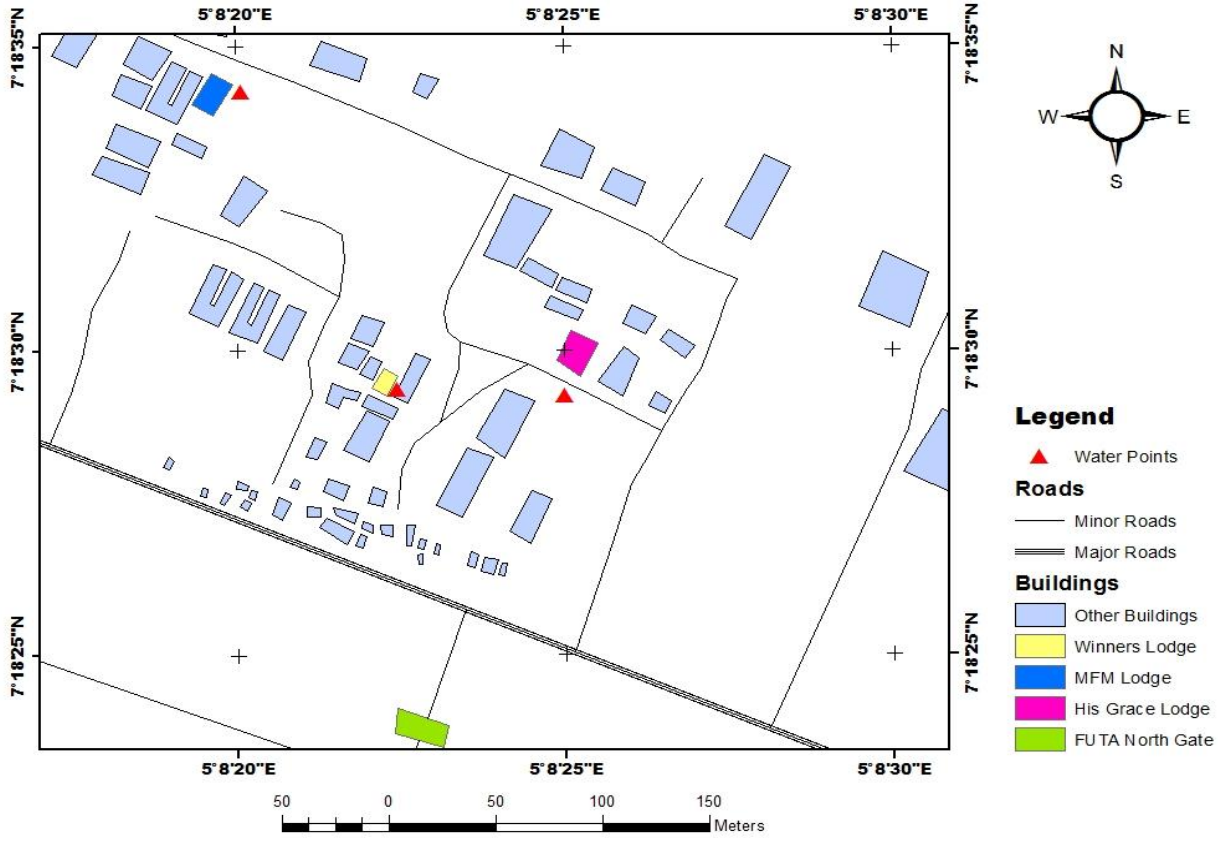

Figure 1: The figure presents the sample locations at the Federal University of Technology, Akure (FUTA) North gate.

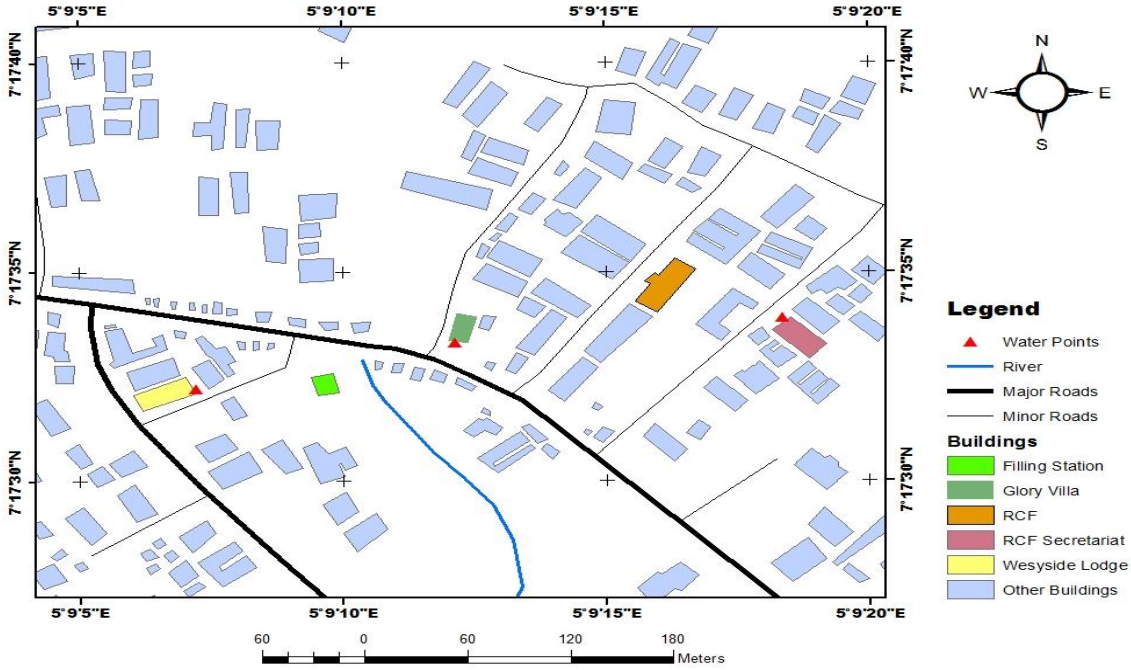

Figure 2: The figure presents the sample locations at the Federal University of Technology, Akure (FUTA) South gate.

2.4. Physico-chemical Analysis of Water Samples

2.4.1. Determination of pH, temperature and conductivity of water samples: The pH of the water samples was taken using Techmel and Techmel USA pH meter. The temperature of the sample was determined at the sampling point using a thermometer. The conductivity values of the water samples were obtained using a conductivity meter (DDS-307).

2.4.2. Total suspended solids (TSS) determination: The water sample was thoroughly shaken; 50 mL of the sample was measured into a beaker and filtered using a filter paper of known weight. After the filter paper was dried in an oven, it was transferred into a desiccator for some minutes, and this was repeated until a constant weight was obtained. The total suspended solids was calculated as follows:

$$Total\ suspended\ solids = \frac{weight\ of\ total\ suspended\ solids}{volume\ of\ water\ taken} \times 1000 \quad (1)$$

2.4.3. Determination of total dissolved solids (TDS): Water sample was first filtered using Whatman filter paper, then 50 mL of the filtrate was transferred into an already weighed evaporating dish. This was evaporated to dryness before drying to a constant weight in an oven at 105°C. The weight of the dish was subtracted from the final weight to obtain the weight of the total dissolved solids. The total dissolved solids was calculated as follows:

$$Total\ dissolved\ solids\ (\frac{mg}{L}) = \frac{weight\ of\ total\ dissolved\ solids}{volume\ of\ water\ taken} \times 1000 \quad (2)$$

2.4.4. Determination of dissolved oxygen (DO) and biochemical oxygen demand (BOD): This was carried out using the Wrinkler's method. 50 mL water sample was measured into a sample bottle, 5 drops of azide, 5 drops of $MnSO_4$ and 10 drops of H_2SO_4 were added into the water sample which gave a yellow colouration. The mixture was shaken properly, 5 mL of the mixture was measured into a small sample bottle and 1 drop of starch solution was added. This was then titrated against 0.025 M sodium thiosulphate solution until the blue colour was decolourized and the volume of thiosulphate used was then recorded. This was repeated two more times and the average titre was recorded. The water sample was incubated in a dark place for 5 days after which the process was repeated again.

$$Dissolved\ oxygen\ (DO)\ (\frac{mg}{L}) = \frac{1000 \times m \times v}{(V_2/V_1)\ (V_1 - V_2)} \quad (3)$$

Where **M** = molarity of thiosulphate used, **V** = volume of thiosulphate used, V_2 = volume of DO bottle, V_1 = volume of sample. Biochemical oxygen demand was calculated from the value of DO obtained the first day (DO_0) and the one gotten after five days (DO_f) as presented in equation 4:

$$\text{BOD (mg/L)} = (DO_o - DO_f) \times \frac{\text{volume of BOD bottle}}{\text{volume of sample used}} \quad (4)$$

2.4.5. Determination of total alkalinity and acidity: Total alkalinity was carried out by measuring 100 mL of water sample into a conical flask, adding a few drops of phenolphthalein indicator and this was titrated against standard HCl solution; the pink colour of the solution disappeared upon equilibrium which indicated phenolphthalein alkalinity. Few drops of methyl orange indicator were added into the sample and then titrated against HCl. The endpoint indicated total alkalinity.

$$\text{Total alkalinity as mg/L}CaCO_3 = \frac{V_T \times \text{M} \times 100{,}000}{\text{volume of sample}} \quad (5)$$

$\mathbf{V}_T$ = Volume of acid used, **M** = Molarity of acid used

Acidity of water sample was determined by measuring 100 mL of water into a conical flask, and adding few drops of phenolphthalein indicator. This was then titrated against standard NaOH solution until a pink colour was observed, and the volume of NaOH used was recorded.

$$\text{Acidity (mg/L)} = \frac{V \times \text{M} \times 100{,}000}{\text{volume of sample}} \quad (6)$$

V = volume of NaOH used, **M** = Molarity of NaOH used

2.4.6. Total hardness determination: Total hardness in water samples was determined titrimetrically using sodium salt of ethylene diamine tetra-acetic acid (EDTA) as titrant. Into 50 mL of the water sample, 2 mL ammonia/ammonium chloride buffer (pH 10) and 2 mL of 2 % potassium cyanide (KCN) were added as masking agent. This was followed by the addition of little quantity of Erichrome Black T / NaCl indicator mixture, and the solution titrated with 0.015 M EDTA solution to end point.

$$\text{Total hardness (mg/L)}\ CaCO_3 = \frac{V \times \text{A} \times 1000}{\text{volume of sample}} \quad (7)$$

V = volume of acid used, A = mg $CaCO_3$ equivalent to 1mL EDTA titrant

2.4.7. Determination of calcium hardness: Calcium and magnesium ions in the water samples were determined using the EDTA titration method. Into 50 mL of water sample, 2 mL of 0.018 M NaOH solution was added, followed by a little quantity of murexide/NaCl mixed indicator. The solution was then titrated with 0.015 M EDTA solution to a purple colour. The titre value represents concentration of Ca^{2+} in mg/L, while Mg^{2+} was calculated from the difference in values of total hardness and calcium hardness.

$$\text{Calcium hardness (mg/L)} = \frac{40080 \times 0.015\text{M EDTA} \times VV_T}{\text{volume of sample}} \quad (8)$$

2.4.8. Chloride determination: Chloride content was determined using the Mohr's method. 1 mL of potassium chromate indicator was added to 100 mL of sample in a conical flask. The resulting yellow – coloured solution was then titrated with 0.009 M silver nitrate solution to a reddish brown colour. A blank titration using distilled water was also conducted. Chloride concentration (mg/L) was calculated from the difference in volume between the sample and blank.

$$Chloride\ content = \frac{(A-B) \times m \times 70900}{volume\ of\ sample} \quad (9)$$

A = Volume of $AgNO_3$ used by sample, **B** = Volume of $AgNO_3$ used by blank, **M** = Molarity of $AgNO_3$

2.4.9 Phosphate determination: The method used for phosphate determination was the vanado - molybdate colorimetric method as described by Ademoroti (1996) [12]. 25 mL of the solution was measured into a standard

volumetric flask, 100 mL of vanadate-molybdate reagent was added and the solution made up to the mark with distilled water. A blank was prepared using 25 mL of distilled water. The absorbance was measured at 470 nm.

$$PO_4^{3-}(\frac{mg}{L}) = \frac{Reading\ from\ curve \times 1000 \times D}{volume\ of\ sample} \quad (10)$$

Where **D** is dilution factor

2.4.10 Nitrate determination: Colorimetric method was used for nitrate determination. 0.5 mL of each sample was introduced into a test tube using micropipette. Then 1 mL of salicylic acid solution was added, the contents were mixed and allowed to stand for 30 min. Thereafter, 10 mL of sodium hydroxide solution was added to each test tube and the mixture was left for colour development. The absorbance was read at 410 nm.

$$\text{Nitrate}(\frac{mg}{L}) = \frac{Reading\ from\ curve \times 1000 \times D}{volume\ of\ sample} \quad (11)$$

Where **D** is dilution factor

2.4.11. Sulphate determination: Turbidimetric method was employed using $BaCl_2$ as precipitant. 10 mL of water sample was introduced into a 25 mL volumetric flask and 10 mL of distilled water was added. This was followed by the addition 2 mL of gelatin - $BaCl_2$ reagent. The mixture was made up to mark with distilled water. The mixture was allowed to stand for 30 min and the optical density was determined at 420 nm.

$$SO_4^{2-}(\frac{mg}{L}) = \frac{Reading\ from\ curve \times 1000 \times D}{volume\ of\ sample} \quad (12)$$

Where **D** is dilution factor

2.4.12. Determination of metals: The sample was first treated by adding 5 ml of concentrated HNO_3 to 100 ml of water sample. The sample was evaporated to almost dryness leaving behind a small volume which was later made up to the mark in a 50 mL volumetric flask with distilled water. Heavy metals and the alkali metals were determined using an Atomic Absorption Spectrometer (Buck Scientific 210/211 VGP) and a Flame Photometer (FP 640), respectively.

2.5. Microbial Analysis

2.5.1. Determination of most probable number (MPN) of coliform: The total coliforms were estimated using 5-tube most probable number method. Sterile lactose broth of single strength and double strength were used for the presumptive test and samples of 10, 1, and 0.1 mL were inoculated into respective dilution tubes containing inverted Durham's tubes and incubated at 37 ^oC for 24 h. At the end of 24 h incubation, each tube was examined for presence of gas. The negative tubes were re-incubated for a further 24 h period. After incubation, the tubes again were checked for gas production. Gas production at the end of either 24 or 48 h incubation is presumed to be due to the presence of coliforms in the samples. Numbers of positive tubes with acid (Yellow colouration) and gas production were matched with the Mecrady's Statistical Table, and the most probable number (MPN) of coliforms present in 100 mL of each sample was thus determined [13].

2.5.2. Total viable bacterial counts: Samples were serially diluted with sterile distilled water following ten-fold dilution procedure in ten test tubes. One mL of the sample was collected using 1.0 mL sterile pipette and dispensed into 9 mL of distilled water. Then different dilutions were made using 9mL of distilled water in the remaining tubes. 1 mL of the diluted sample from test tube 10^{-3} and 10^{-4} of each sample was dispensed into the nutrient agar, MacConkey agar, Salmonella-Shigella agar and Eosin methylene blue plates using a pour plate technique. The inoculated plates were incubated at 37 ^oC for 24 h. Viable bacterial counts were carried out using hand lens; discrete colonies were transferred into slants for gram staining reaction and other biochemical tests according to the method of Cheesbrough (2006) [13].

2.5.3. Identification of bacteria: Identification of bacteria was based on morphological characteristics and biochemical tests carried out on isolates. Morphological characteristics were observed for each bacteria colony after 24 h of growth. The appearance of the colony of each isolate on agar medium was studied and the characteristics observed include; shape, elevation, edge, optical characteristics, consistency, colony surface and pigmentation. Biochemical characterizations were done according to the method of Cheesbrough (2006) [13].

3. RESULTS

3.1 Physicochemical Parameters of Water Samples: Table 2 shows the physicochemical parameters of water samples collected from hand-dug wells situated at North and South Gates of the Federal University of Technology, Akure, Nigeria.

Table 2: The table presents the physicochemical characteristics of water samples.

Parameter	FUTA North Gate Samples			FUTA South Gate Samples		
	A	B	C	D	E	F
Temperature °C	27.0	27.3	28.1	26.00	26.50	27.5
pH	6.04	5.65	5.61	5.83	6.37	6.77
Turbidity (NTU)	0.60	0.30	0.40	0.10	0.40	0.40
TDS (mg/L)	0.16	0.16	0.16	0.76	0.81	1.08
TSS (mg/L)	0.06	0.03	0.03	0.02	0.03	0.07
Total solids (mg/L)	0.22	0.19	0.19	0.78	0.84	1.15
Acidity (mg/L)	87.48	64.08	78.12	108.00	73.80	63.00
Total alkalinity (mg/L)	82.74	54.60	43.26	109.20	210.00	382.20
Chloride (mg/L)	45.05	47.22	51.05	57.40	155.70	113.60
Total Hardness (mg/L)	36.17	46.16	41.16	61.74	170.52	208.74
Ca^{2+} Hardness (mg/L)	6.01	6.37	7.21	12.02	50.50	39.67
Mg^{2+} Hardness (mg/L)	30.15	39.79	33.95	49.72	120.02	169.07
Nitrate (mg/L)	0.027	0.706	1.07	1.52	2.53	2.80
Sulphate (mg/L)	58.01	23.2	34.8	34.80	203.00	244.00
Phosphate (mg/L)	20.52	6.84	6.84	6.80	13.7	0.00
Dissolved oxygen (mg/L)	45.83	50.00	29.17	41.60	37.50	25.00
BOD (mg/L)	2.00	4.00	1.00	4.00	1.00	1.00
Conductivity (µS/cm)	129.00	144.00	137.00	180.00	585.00	586.00

FUTA: Federal University of Technology, Akure.

3.2 Mineral Analyses of Water Samples: Table 3 shows the results of mineral analyses of the water samples obtained from two different areas (North and South Gates) of The Federal University of Technology, Akure, Nigeria.

Table 3: The table presents the concentration (mg/L) of metals in water samples.

Parameters	FUTA North Gate Area			FUTA South Gate Area		
	A	B	C	D	E	F
K	3.50	4.45	3.60	1.62	10.00	2.20
Na	9.66	9.51	10.21	15.36	58.64	42.43
Mn	0.51	0.32	0.22	0.10	0.51	0.10
Fe	6.41	1.74	1.01	0.91	0.84	0.72
Cu	0.06	0.03	0.03	BDL	BDL	0.03
Zn	0.15	0.13	0.12	0.12	0.11	0.10
Cr	0.75	0.10	BDL	BDL	BDL	BDL
Pb	BDL	BDL	BDL	BDL	BDL	BDL

FUTA: Federal University of Technology, Akure; **BDL**: Below detection limit.

3.3. Microbial Analyses of Water Samples: The microbial analyses of the different water samples obtained from the North and South Gates of The Federal University of Technology, Akure (FUTA), Nigeria are presented in Table 4.

Table 4: The table presents the bacteriological characteristics of the water samples.

Isolate	Count in Sample A ($log10^2$ cfu/mL)	Count in Sample B ($log10^2$ cfu/mL)	Count in Sample C ($log10^2$ cfu/mL)	Count in Sample D ($log10^2$ cfu/mL)	Count in Sample E ($log10^2$ cfu/mL)	Count in Sample F ($log10^2$ cfu/mL)
E. coli	3.00	1.30	0.90	2.8	3.3	3.1
Staphylococcus aureus	4.55	1.55	3.25	1.6	2.2	1.6
Klebsiella sp	1.05	1.35	1.20	1.3	1.1	0
Samonella sp	1.40	3.10	1.00	4.1	4.1	1.4
Shigella sp	1.85	2.00	1.60	5.2	1.1	3.3
Enterobacter sp	2.20	2.20	1.60	2.0	2.0	1.6
Bacillus sp	1.05	1.00	1.20	0	1.0	0

4. DISCUSSION

The physicochemical parameters of the samples are presented in Table 2. The pH ranged from 5.61 – 6.77 with sample F having the highest value, while sample C had the lowest value. The pH values did not fall within the permissible limit

of 6.5 – 8.5 for drinking water as prescribed by WHO (2008) [8] except sample E with a pH value of 6.77. Low pH values of water could be attributed to mineral salts dissolved in water [14].

Temperature ranged from 26.00 – 28.10 ^{o}C, the variation in temperature could be attributed to the weather condition at the moment of collection. Temperature of a water body is affected by a number of factors such as climate or temperature of the geographical area, extent of shade from direct sunlight and depth of the water [15].

Turbidity is an important parameter that affects quality of water, it ranged from 0.1 - 0.6 NTU with sample A having the highest value of 0.6 NTU while sample C had the least value of 0.1 VTU. Turbidity values for all the water samples were within the permissible limit of 5.0 NTU for drinking water as spelt out by WHO (2008) [8], this could be as a result of the fact that total solids in the samples were low. The results compared favourably with the results obtained by Kurup *et al.* (2010) in microbiological and physico-chemical analysis of drinking water in George Town, Guaya [16]. High turbidity is often associated with high level of disease-causing micro-organisms such as bacteria and other parasites [17]. For total solids (TS), the values ranged between 0.19 – 1.15 mg/L, sample E had the highest value while samples B and C had the lowest value; all the TS values fell within the permissible limit of 500 mg/L according to WHO (2008) for drinking water. For total suspended solids (TSS), the values ranged from 0.02 - 0.07 mg/L. Total dissolved solids (TDS) ranged from 0.16 - 1.08 mg/L. The TSS and TDS values were within the maximum permissible limits for drinking water. The low value of total solids probably accounted for the reason why the appearance was clear, not turbid with no odour. Similar results were obtained by Edema *et al.* (2001) in microbiological and physicochemical analysis of different sources of drinking water [18].

Alkalinity is a measure of capacity to neutralise acid. It is caused by the presence of HCO_3^-, CO_3^{2-} or OH^- [20]. In this study, the alkalinity values for samples A, B, C, D, E, and F were within the stipulated limit of 30–500 mg/L as stated by WHO [8] and Nigerian Industrial Standard for Drinking Water (NIS) [19].

Chloride is the most anion present in water [20]. The values obtained ranged between 45.05 – 155.70 mg/L. Sample A had the lowest value while Sample D had the highest value of 155.70 mg/L. There was however no evidence of pollution since the concentrations of chloride obtained in all the samples were not beyond the maximum limit of 250 mg/L as stated by WHO (2008) [8]. This could be due to the ability of the soil to purify water naturally [18].

Hardness is the property of water which prevents lather formation with soap and increases the boiling point of water. It depends mainly upon the amount of calcium and magnesium salts. The total hardness value ranged from 36.20 – 208.74 mg/L. The values obtained for total, calcium and magnesium hardness were within the permissible limits of WHO (2008) [8]. The results were similar to those obtained by Adeyeye and Abulude (2004) in analytical assessment of some surface and ground water [21].

The acidity values for water samples B, C, E and F were within the permissible limits of 4.5 – 82 mg/L according to WHO except for samples A and D having 87.48 and 108.00 mg/L respectively. Acid water can lead to corrosion of copper pipes which in turn, lead to poisoning. Copper contamination in water is responsible for health hazards such as abdominal pains, nausea, vomiting, diarrhoea, headache, and dizziness [22].

Nitrate values ranged from 0.027 – 2.80 mg/L, with sample A having the lowest value while sample F had the highest value. These values were within the acceptable limits of 10 mg/L stipulated by WHO (2008) [8] and NIS (2007) [19]. Sulphate contents of the water samples ranged from 23.2 – 244.00 mg/L, with sample D having the highest value, while sample B had the least value. The results showed that the sulphate contents for all the water samples were below the maximum permissible limit of 500 mg/L .Phosphate contents ranged from BDL – 20.52 mg/L. The results obtained except for sample F, which was below detection level were above the required standard of 5.00 mg/L. Biochemical oxygen demand (BOD) measures the amount of oxygen used by microorganism. In this case, bacteria oxidize organic matter present within the water [18]. The value of BOD ranged between 1.0 – 4.0 mg/L, samples B and D had the highest values of 4.00 mg/L while samples C, E and F had the least values of 1.00 mg/L.

The values of conductivity for the samples which ranged from 129 -586 µS/cm were below the maximum permissible limits of 1200 uS/cm (WHO, 2008). Generally, conductivity is affected by the geology of the area through which the water flows, however temperature and rainfall have been known to be a factor [23]. The conductivity values obtained were similar to the findings of John *et al.* (2008) [14].

Metal analysis as presented in Table 3 showed the presence of Potassium (K), Sodium (Na), Manganese (Mn), Iron (Fe), Copper (Cu), Zinc (Zn), and Chromium (Cr). The concentrations of all the metals were within the acceptable limits of WHO [8] except for Iron (6.41 mg/L) and Chromium (0.75 mg/L) in sample A which were above 3.00 mg/L and 0.05 mg/L, respectively as stipulated by WHO.

The presence of *Streptococcus species, Staphylococcus aureus, Samonella spp, klebsiella species, Bacillus species, E. coli, and Shigella sp* was an indication of contamination. The presence of these pathogens could account for the incident of diarrhoea and food poisoning common in the University environments especially among the students. According to Hunter (1997), food intoxication could occur due to the presence of pathogenic bacteria such as *Staphylococcus* and

Bacillus sp in drinking water [24]. As presented in Table 4, the presence of coliforms was an indication of faecal contamination, and this consequently could pose danger of food poisoning and other related gastrointestinal disorders from consumption of the well waters. And so the wells need to undergo appropriate sterilization, so as to conform to international standards. In Table 4, *E. coli* ranged from 1.30 - 3.00 x 10^2 in which sample A gave the highest counts while sample B had the lowest counts; *Staphylococcus aureus* ranged from 1.55 - 4.55 x 10^2 where sample A recorded the highest counts and sample B recorded the lowest counts; *Klebsiella spp* ranged from 0.00 - 1.35 x 10^2, the highest count was recorded in B, however *Klebsiella sp* was not detected in sample F; *Salmonella sp* counts ranged from 1.00 - 4.1 x 10^2 where samples D and E gave the highest counts while sample C gave the lowest counts; *Shigella sp* counts ranged from 1.10-5.20 x 10^2 where sample D recorded the highest counts and sample E gave the lowest counts. *Bacillus sp* counts ranged from BDL - 1.2 x 10^2; whereas sample C recorded the highest counts of 1.20 x 10^2, the counts for samples D and F were below detection limits. The counts for *Enterobacter sp* ranged from 1.60 - 2.20 x 10^2; samples A and B gave the highest value of 2.20 x 10^2 while samples C and F gave the lowest counts of 1.60 x 10^2.

The presence of coliforms at values above the maximum accepted standards (as specified by WHO) for all the samples was a revelation of high faecal contamination, hence, the samples are not suitable for consumption.

5. CONCLUSION

In the present study, it was observed that the water samples from the wells under investigation are considered polluted. The results of the microbial and physicochemical parameters revealed that the samples did not conform in totality to the standard limits set by the World Health Organisation. Faecal contamination in the well water samples is a concern as it could cause several diseases. The presence of coliform could be as a result of closeness of the well sites to septic systems which could warrant seepage of faecal materials into the wells; the use of multiple fetchers or drawers could also bring different forms of pollutants into the wells. Since all the water samples that were analysed failed to agree with the standard permissible limits spelt out by the World Health Organisation, therefore, the water from the wells is not suitable for human consumption. In order to protect the health of the people living on those wells, there is the need to identify the sources of those pollutants detected in the water samples, and treat the wells to guarantee their wholesomeness.

REFERENCES

1. Abowei, J.F.N. and George, A.D.I. Some Physical and Chemical Characteristics in Okpoka Creek, Niger Delta Nigeria, Res. *J. Environ. Earth Science*, 2009; 1: 45- 53. Available: https://www.ajol.info/index.php/ajest/article/download/88655/7824
2. Adekunle, E.I.M., Adetunji, M.T., Gbadebo, A.M.and Banjoko, O.B., Assessment of Groundwater Quality in a Typical Rural Settlement in Southwest Nigeria. *International Journal of Environ. Res. Public Health*, 2007; 4(4): 307 - 318. Available: www.aascit.org/journal/archive2?journalId=980&paperId=1782
3. DWAF (Department of Water Affairs and Forestry, Strategic Framework for Water Services). *Government Printer*, South Africa, (2003). Available: https://books.google.com.ng/books?isbn=9048193672
4. Dike, N.I., Ezealor, A.U. and Oniye, S.J., Concentration of Pb, Cu, Fe and Cd during the dry season in Jakara, Kano, Nigeria. *Chem Class J*, 2004; 1: 78 – 81. Available: https://www.ajol.info/index.php/ajest/article/download/88655/78247
5. Gulson, B.L., Sheehan, A., Giblin, A.M., Chiaradia, M. and Conradt, B. The efficiency of Removal of lead and others elements from Domestic Drinking water Using a Bench – top water filter System. *Sci Tot. Environ*, 1997; 196: 205-216. Available : https://www.ncbi.nlm.nih.gov/pubmed/9141715
6. Hacioglu, N. and Dugler, B. Monthly Variation of some physicochemical and Microbial, Parameters in Biga stream (Biga, Canakkale, Turkey), *Afr. J. of Bio*., 2009; 8: 1927 – 1937. Available: https://scholar.google.com.hk/citations?user=z6CIW68AAAA
7. Egereonu, U.U. Physico-chemical assessment of raw water from two Rain gauged Stations in the Rainforest region, *J. Chem Soc. Nigeria*, 2006; 1: 429-437. Available: journal.unaab.edu.ng/index.php/NAHS/article/download/928/896
8. WHO. Guidelines for Drinking Water Quality, 3rd Edn. WHO, 20 Avenue Appia, 1211 Geneva 27, Switzerland, 2008; 688. Available: https://www.who.int/water_sanitation_health/dwq/fulltext.pd
9. Okonko, I.O., Adejoye, O.D., Ogunnusi, T.A., Fajobi, E.A. and Shittu, O.B. Microbiological and physicochemical analysis of different water samples used for domestic purposes in Abeokuta and Ojota, Lagos State, Nigeria. *African Journal of Biotechnolology*, 2008; 7(3): 617-621. . Available: www.sapub.org/journal/editorialdetails.aspx?JournalID=1094&PersonID=16342
10. Agu. Special Report "water vapour in the climate system, 1995. Available: https://www.eso.org/gen-fac/pubs/astclim/espas/pwv/mockler.html.
11. UNEP. Environmentally Sound Technology for Waste Water and Storm Water Management. An International Source Book. *IWA Publishing*, 2002. Available: https://books.google.com › Technology & Engineering › Environmental › General
12. Ademoroti, C.M.A. Environmental Chemistry and Toxicology; *Foludex press limited Ibadan*, 1996. Available: https://www.zunn.org/index.php/ARI/article/view/173.
13. Cheesbrough, M. District Laboratory Practice for Tropical Countries, part 2, second edition. *Cambridge University Press*, 2006. Available: https://www.medbox.org/district-laboratory-practice...tropical-countries-part-2/download.
14. John, K.N., Orish, E.O. and Linus, O.E. Some Physicochemical and Parameters of Portable Water Supply in Warri, Niger Delta Area of Nigeria. *Sci. Res. and Essay*, 2008; 3(11): 547-551. Available: https://www.wudpeckerresearchjournals.org/.../Nwanchukwu%20and%20Ume.pdf
15. Ekhaise, F.O. and Anyansi, C.C., Influence of Brewery Effluent Discharge on the Microbiological and Physicochemical Quality of Ikpoba River, Nigeria. *African Journal of Biotechnology*, 2005; 4(10): 1062–1065. Available: www.academicjournals.org/article/article1380106548_Ekhaise%20and%20Anyasi.pdf
16. Kurup, R., Persuad, R., Caesar, J. and Raja V. Microbiological and Physico-Chemical Analysis of drinking water in George town, Guaya, *Nature and Science*,2010; 8: 1-5. Available: www.sciencepub.net/nature/ns0808/31_3526ns0808_261_265.pdf
17. Shittu, O.B., Olaitan, J.O. and Amusa, Y.S. Physicochemical and Bacteriological analysis of water used for drinking and swimming purposes in Abeokuta, Nigeria. *African Journal of Biotechnology Research*, 2008; 11: 285-290. Available: https://www.ajol.info/index.php/ajbr/article/view/50739
18. Edema, M.O., Omeemu, A.M. and Fapetu, O.M. Microbiological and physicochemical analysis of different sources of drinking water. *Nigeria Journal of Microbiology*, 2001; 15: 57-61. Available: www.sciencepub.net/nature/ns1001/005_7547ns1001_36_41.pdf
19. NIS. Nigerian Industrial Standard for Drinking Water Nigeria, NIS 527, specialization for water standard organization of Nigeria, Lagos, Nigeria, 2007. Available: https://www.unicef.org/nigeria/ng_publications_Nigerian_Standard_for_Drinking_Water
20. Asuquo, J.E. and Etim, E.E. Physicochemical and Bcteriological studies of Selected Borehole Water in Uyo Metropolis in Akwa Ibom State. *International Journal of Modern Chemistry*, 2012; 2(1): 7-14. Available: www.modernscientificpress.com/Journals/ViewArticle.aspx?H86Z5Noa2iKDNvH/
21. Adeyeye, E.J. and Abulude, R.O. Analytical Assessment of some surface and ground water, *Nigeria Journal of Chemical Society of Nigeria*, 2004; 29: 98-103. Available: www.modernscientificpress.com/Journals/ViewArticle.aspx?H86Z5Noa2iKDNvH/

22. American Society for Testing and Materials, Standard methods for Acidity or Alkalinity of water. Publ. D 1067–70. American Soc., Testing and Materials Philadelphia, 1982. Available: https://www.researchgate.net/file.PostFileLoader.html?id...assetKey
23. APHA. Standard Methods for examination of Waste Water, 20th Ed. American Public Health Association, 1998. Available: www.worldcat.org/.../standard-methods-for-the-examination-of-water-and-wastewater
24. Hunter, P. Waterborne disease Epidemology and Ecology. Chichester: Wiley, 1997. Available: https://books.google.com.ng/books?isbn=0471966460

Cite this article: Olajide Ayodele, Edward Olorunsola Olanipekun, Michael Adedayo Banjo, Yusuf Laide Saka, and Adefusioye Adegalu Adebawore. PHYSICO-CHEMICAL AND MICROBIAL ANALYSES OF WATER SAMPLES FROM HAND-DUG WELLS AROUND THE FEDERAL UNIVERSITY OF TECHNOLOGY, AKURE, NIGERIA. *Am. J. innov. res. appl. sci.* 2017; 5(3): 228-236.