Short Research Article

ANALYSIS OF PHYSICAL, CHEMICAL AND BIOLOGICAL CHARACTERISTICS OF BOREHOLE WATER IN AWKA, AWKA SOUTH LGA, ANAMBRA STATE, NIGERIA.

ABSTRACT

~~Aim:~~ ~~To~~**Aim:** To determine the physical, chemical and biological characteristics of borehole water in Awka.

Study design (Study activities):

- Collection of borehole water samples.
- Identify the physical, chemical and biochemical characteristics present in the borehole water samples.
- Analyze the characteristics of the water samples.
- Compare the characteristics of the water samples to the World Health Organizations (WHO) standards, Federal Environmental Protection Agency (FEPA) and the Nigerian Industrial Standard (NIS).
- Identify the health effects of imbalance in the characteristic.
- Develop recommendation for improving the quality of borehole water.

Place and duration of Study: Microbiology laboratory, Chukwuemeka Odumegwu Ojukwu University Uli, Anambra State, Nigeria. It took six months to complete the study.

Methodology: Ten borehole water samples were collected from different villages in Awka; Umubelu, Ifite, Umuenechi, Isiagu, Umueri, Umukwa, Umudioka, Umuogbunu 1, Umuogwali and Amudo. The physical, chemical and biological characteristics were carefully analyzed with the right methodology which includes HANNA INSTRUCTIONS FOR pH, Electrical Conductivity and temperature, GALVERMETRIC METHOD for Total Dissolved Oxygen, ARGENTOMETRIC METHOD for chloride, molybdenum blue phosphorous method for phosphate, PHENATE SPECTROPHOTOMETRIC METHOD for ammonia, WINKLER'S TITRIMETRIC METHOD for Dissolved Oxygen, TITRIMETRIC METHOD for total acidity, alkalinity and hardness, ATOMIC ABSORPTION SPECTROMETRY for heavy metals and MEMBRANE FILTERATION TECHNIQUE for total coliform and total E. Coli counts.

Results: This study presents results for these awhich ranges from: 28.3°C - 32°C for temperature, 4.5 - 7.6 for pH, 0.02ms/cm - 1.355ms/cm for Electrical Conductivity, 19.5mg/L - 1020.75 mg/L for Total Dissolved Solids, 4.5mg/L - 8.6mg/L for Dissolved Oxygen, 64mg/L - 198mg/L for Chemical Oxygen Demand, 20mg/L - 138.8mg/L for Total Hardness, 25.2mg/L - 340.2mg/L for Chloride, 5.02ppm - 17.6ppm for phosphate, 0.27mg/L - 6.99mg/L, 0.25mg/L - 1.82mg/L for zinc, 2fcu/100ml - 130fcu/100ml for Total coliform count, 1fcu/100ml - 33fcu/100ml, 5.2mg/L - 17mg/L for total acidity, 10mg/L - 255mg/L for total acidity and 0.75ppm - 3.25ppm for ammonia.

Conclusion: Results of these characteristics were compared with World Health

Comment [a1]: This is a list of study activities, not a design.

Comment [a2]: Place, must be the geographical area where the boreholes are located.

Comment [a3]: It is recommended to present the methodology of the work carried out globally, and not the analysis methodology.

Comment [a4]: Please include discusion, and reduce data on water quality to most importants.

~~Organisation~~Organization standards of drinking water, Nigeria Industrial Standards and Federal Environmental Protection Agency standards. The average values the parameters were as well compared to these standards and recommendations were developed for the maintenance and improvement of borehole water quality.

Keywords: Physical characteristics, chemical characteristics and biological characteristics, borehole water

1. INTRODUCTION

Water is an essential component of life and forms the basis of life on Earth. The availability of clean, safe water is essential for human health and well-being. There are two water sources: surface water and ground water. 50% of the world's population relies on ground water every day for drinking (Nweke et al., 2004)[1]. A significant source of drinking water in many parts of the world is ground water obtained from boreholes. However, despite the need to ensure sufficient water quantity, one of the biggest development challenges is ensuring sufficient water quality (Gundry et al., 2003)[2]. Water quality is assessed or determined by it's physical, chemical and biological characteristics. Imbalance of physiochemical and biological parameters of borehole water in Nigeria may lead to a variety of serious health and environmental impacts. These include increased risk of waterborne diseases, such as cholera and typhoid (Unicef, 2016)[3], and decreased water quality, which can lead to decreased agricultural productivity (Kolo et al., 2017)[4]. Some metals are essential for life and are naturally available in our food and water. In addition to metals essential for life, drinking water may contain metals which cause chronic or acute poisoning. The presence of heavy metals, such as lead and arsenic, in borehole water can cause serious health problems, including neurological damage, cancer, and birth defects (Adeniyi & Olukoya, 2016)[5]. Quality drinking water is essential for life. ~~Unfortunately~~Unfortunately, in many towns in Anambra state, including Awka, water has become a scarce commodity as only small proportion of the populace has access to quality water. It is for this reason and the effects of imbalance of the characteristics of borehole water that borehole water needs to be studied and analyzed to ascertain their conformity with World Health Organisation (WHO) standards for drinking water, Federal Environmental Protection Agency (FEPA) and Nigeria Industrial Standards (NIS)

2. MATERIAL AND METHODS

2.1 Collection of Borehole Water Samples

Water samples were collected from ten boreholes located in different villages in Awka, Awka south local government area, Anambra State. The ten villages ~~includes~~include; Umubelu (BH1), Umubenechi (BH2), Amudo (BH3), Ifite (BH4), Isiagu (BH5), Umuogbunu I (BH6), Umuogwali (BH7), Umudioka (BH8), Umukwa (BH9), Umueri (BH10).

Comment [a5]: Present a location map or UTM coordinates.

2.2 Physical and Chemical Analysis

2.2.1 Determination of temperature, pH and conductivity

The pH and temperature of the prepared samples was determined using Pocket – sized pH meter (HANNA instruments) while the conductivity of the liquid samples was determined using conductivity meter (DSS – 11A, China). The samples will be filtered and dispensed in beakers and triplicate readings were taken after calibrations of the instrument with buffer 7.0 and 1408 µS potassium chloride standards as instructed by the manufacturer (APHA, 2012).

2.2.2 Determination of Chloride

Chloride was obtained using Argentometric titration method and as described by APHA (1998) and Adelowo and Agele (2016).Potassium chromate indicator solution was prepared by dissolving 50 g K_2CrO_4 in a distilled water and $AgNO_3$ solution was added until red precipitate was formed. This solution was allowed to stand for 12 h, filtered and diluted to 1 L with distilled water. Then, 2.395 g $AgNO_3$ was dissolved in distilled water and diluted to 1000 mL and stored in a brown bottle. This is the standard silver nitrate solution. Thereafter, 50 mL of the effluent sample was measured into 250 mL conical flask followed by addition of 1 mL K_2CrO_4 solution (indicator) and will be titrated with $AgNO_3$ (titrant) to a pinkish yellow end point. The process was repeated for blank using 50 mL of distilled water.

2.2.3 Determination of Chemical Oxygen Demand

The amount of chemical oxygen demand was determined according to APHA (2012).
The culture tubes and caps were washed with 20 % Tetraoxosulphate(vi) acid before using to avoid contamination.
2.5ml aliquot portion of the sample was mixed with 1.5ml potassium dichromate solution ($K_2Cr_2O_7$) and 3.5ml sulphuric acid (Regent)
The tubes were heated in a water bath for 3 hours at150°C
Allow it to cool at room temperature and add ferroin indicator which changes it to green precipitate.
Titrate again with solution of ferrous ammonium sulphate [$Fe(NH_4)SO_4$]to get a reddish-brown Endpoint precipitate.

2.2.4 Determination of Acidity

Titrimetric method

- Three drops of phenolphthalein indicator were added to 50ml of sample.
- Titrate against a solution of sodium hydroxide (NaOH) till it turns pink precipitate.
- Take the burette readings and calculate.

2.2.5 Determination of Total Alkalinity

By adopting the method of FSSAI (2015);

- Added 3 drops mix indicator (methyl red+ bromocresol blue) to 20ml of sample.
- Titrate against solution of 0.2N H_2SO_4 till it turns faint pink precipitate

2.2.6 Determination of Total Dissolved Solids

Total dissolved solids content of the effluent sample was measured using the Gravimetric method and as described by APHA (1998) and Adelowo (2016). In this study, the weight of the dried filter paper was noted. The sample was homogenized and 50 mL measured using the sterile measuring cylinder, after which the sample will be filtered using dried filter paper. After the filtration, the filter paper with the residue was dried in the oven, cooled and the weight taken

2.2.7 Determination of Dissolved Oxygen

The amount of dissolved oxygen demand was determined using Winkler's method according to the description of APHA (2012).

- 1 mL of Magnesium sulfate ($MnSO_4$) followed by 1 mL of alkali potassium iodide reagent were added to a sample collected in 300 mL BOD bottle up to the brim and mixed well.
- The mixture was stirred until there is brown precipitate .
- 1ml of concentrated tetraoxosulphate acid (Conc. H_2SO_4) was added followed by addition of starch indicator which changed its color to blue black precipitate.

- Finally 200 mL of this solution was taken in a conical flask and was titrated against solution of sodium trisulfate (NaS2O3) till the blue black precipitate becomes colorless or transparent.

2.2.8 Ammoniacal nitrogen (NH3) determination

A phenate method was adopted for ammoniacal nitrogen determination according to the standard method of APHA (2012). One milliliter of phenate solution, sodium nitroprusside and 2.5 mL of oxidizing solution were added to a 25 mL water sample in a 50 mL flask and thorough mixed after each addition. The samples were covered with a plastic wrap and was allowed for colour development at temperature of 27°C in a subdued light for at least an hour. The absorbance was measured at 640 nm for each sample against the blank.

2.2.9 Determination of Phosphate

The amount of phosphate was determined using molybdenum blue phosphorous method in conjunction with UV - Visible spectrophotometer according to APHA (2012) and as described by Oladeji et al. (2016).

2.2.10 Total hardness

50 mL aliquot of water sample maximum was measured and placed in a 250 mL conical flask. Thereafter, 1 to 2 mL buffer solution was added to the sample solution so as to achieve pH of 10.0 to 10.1. Then, 2 mL Eriochrome black T indicator solution. The resultant was later titrated against standard EDTA solution stirring rapidly in the beginning and slowly towards the end till end point is reached when all the traces of red and purple color disappear and solution is clear sky blue in color.

2.2.11 Heavy metal Determination

The method described by APHA (1998) was used to determine the heavy metals content of the treated water. In this study, 2 mL of treated sample was introduced into 1.5 mL concentrated nitric acid and diluted with deionized distilled water, filtered through a Whatman filter paper into a 100 ml volumetric flask and subsequently made up to the mark using distilled water. Metal concentration were analyzed using Atomic Absorption Spectrometer manufactured by Buck Scientific, USA.

2.3 Biological Analysis

Membrane filtration technique was adopted to determine microbial quality of the water samples in accordance with American Public Health Association (APHA, 2012). A sterile filtration apparatus was put in position and connected to a vacuum pump. The apparatus was rinsed by passing small amount of sterile water and the water sample to be analyzed through the funnel using the vacuum pump. The water samples were thoroughly mixed after which one hundred milliliters (100 mL) of it was poured into the funnel containing the filter paper and slowly filtered through the membrane filter with the aid of the vacuum pump. Using sterile forceps, the membrane filters were removed from the filtration cup and transferred facing up on the surface of the Petri dishes containing Chromo cult coliform agar and incubated at 37 ºC for 48 hr. After incubation, number of bacterial colonies were enumerated and expressed as colony per 100 mL of sample.

Comment [a6]: The analysis procedure is not necessary, just the method name.

3. RESULTS AND DISCUSSION

3.1 Results

Table 1. below shows the results of the study for the ten borehole locations.

PARAMET	BH	BH	BH	BH4	BH	BH6	BH	BH	BH	BH	AVG

ERS	1	2	3		5		7	8	9	10	VALUE
Temperature (°C)	31	30.5	32	30	29.4	31.3	29.8	30	30.7	28.3	30.3
pH	5.2	5.5	4.5	7.5	7.3	7.4	7.6	4.8	5.6	5.7	6.11
EC (ms/cm)	0.020	0.049	0.121	1.361	0.026	1.355	0.1	0.027	0.110	0.05	0.3462
TDS (mg/L)	15	36.75	90.75	1020.7	19.5	1016.25	75	20.25	82.5	37	241.37
DO(mg/L)	5.6	7.35	7.4	4.5	6.2	7.07	6	8.10	8.6	7.9	7.432
Chloride (mg/L)	260	25.2	78.75	340.2	30	302.4	73.3	29.2	63	31.5	99.955
COD(mg/L)	96	160	96	192	160	198	160	64	128	190	144.4
Total Hardness (mg/L)	20	36	42	132	25	138.8	99	32.3	79.1	30.5	63.47
Total Alkalinity (mg/L)	10	20	15	255	20	245	33.3	17	35	30	68
Ammonia Content (ppm)	1.23	1.86	0.75	2.13	1.38	3.25	1	0.65	0.84	1.89	1.498
Total Acidity (mg/L)	17	16	8	15	5.2	8	6	8.5	7.5	7	9.79
Phospate (ppm)	17.02	6.37	8.77	9.09	12.8	5.02	5.24	7.38	4.77	6.41	8.345
Lead(mg/L)	5.9	6.99	4.74	0.67	1.9	0.27	1	1.55	0.74	2.99	2.675
Zinc(mg/L)	1.05	1.53	0.6	1.82	0.25	0.99	0.35	0.43	0.8	0.73	0.793
Total Coliform Count (CFu/ml)	44	44	83	109	65	50	130	12	34	2	56.3
Total E.Coli count (CFu/ml)	19	14	13	19	13	33	7	4	18	1	13.7

BH= Borehole Locations
AVG values= Average value of each parameter for the ten borehole locations.

3.2 Discussion

3.2.1 Temperature

Comment [a7]: It is requested to increase the discussion with more information that exists in scientific journals. The geographical location of the sampling points could provide the necessary elements to carry out a broader discussion.

Figure 1 showed the temperature profile of the different borehole location which ranges from 28.3°C to 32 °C. All the borehole samples are below the WHO temperature standard of 40°C but exceeded meet FEPA standard of 26°C. The temperature variation might have been affected by the depth of the borehole and climatic condition. Deeper boreholes generally have higher temperature

Tables & figures should be placed inside the text. Tables and figures should be presented as per their appearance in the text. It is suggested that the discussion about the tables and figures should appear in the text before the appearance of the respective tables and figures. No tables or figures should be given without discussion or reference inside the text.

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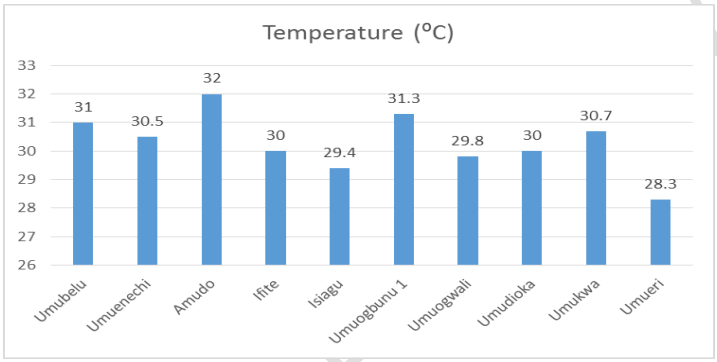

Fig. 1 Temperature

3.2.2 pH

Figure 2 showed the pH profile of the different borehole location which ranges from 4.5 to 7.6, Ifite, Isiagu, Umuogbunu I and Umuogwali pH values falls within the range provided by WHO (6.5-8.5), FEPA (6-9) and NIS (6.5-8.5), while Umubelu, Umubenechi, Amudo, Umudioka, Umukwa and Umueri did not meet the standards.

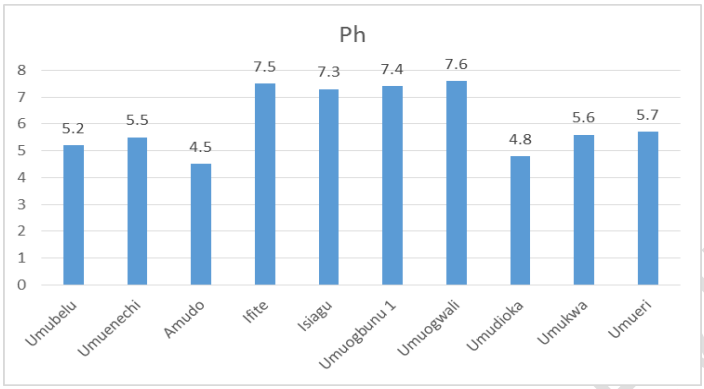

Fig. 2. pH value

3.2.3 Electrical Conductivity

Figure 3 showed the conductivity profile of the different borehole location which ranges from 0.02 µS/cm to 1.361 µS/cm. All borehole samples are below the standards of 5µS/cm and 70µS/cm for Who and FEPA respectively.

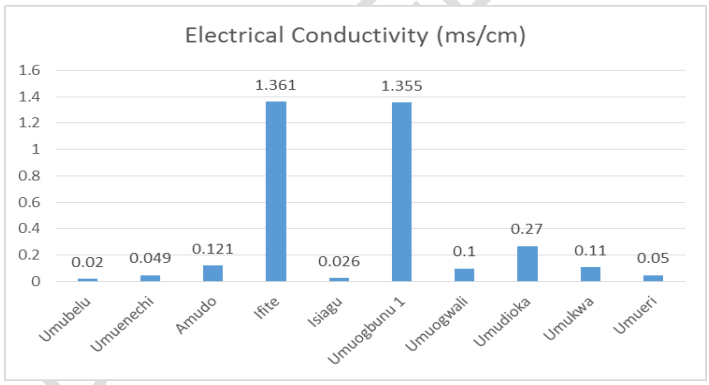

Fig. 3. Electrical Conductiviy

3.2.4 Total Dissolved Solids

Figure 4 showed the total dissolved solid profile of the different borehole location. From the result, Total dissolved solids ranges from 15mg/L to1020.75mg/L with Ifite having the highest value and Umubelu with the lowest value respectively. All the borehole samples are below the standard ls provided by WHO (500mg/L) and NIS (500mg/L) except Ifite and

Umuogbunu I which are above the standards while they are all below FEPA standard of 2000mg/L.

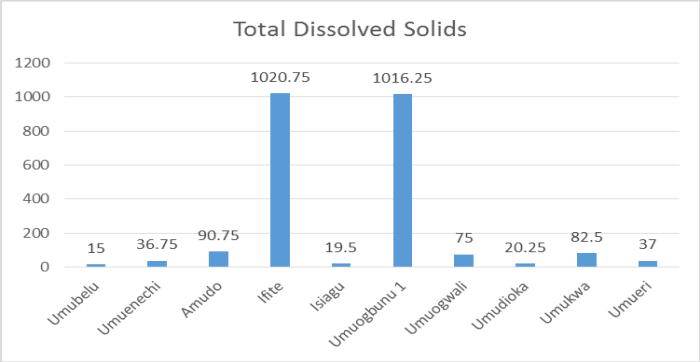

Fig. 4. Total Dissolved Solids

3.2.5 Dissolved Oxygen

Figure 5 showed the dissolved oxygen profile of the different borehole location which ranges between 4.5 mg/L to 8.6 mg/L. Umubelu, Ifite and Umuogwali are within the WHO standard of 6mg/L, while other sample locations are above the standard.

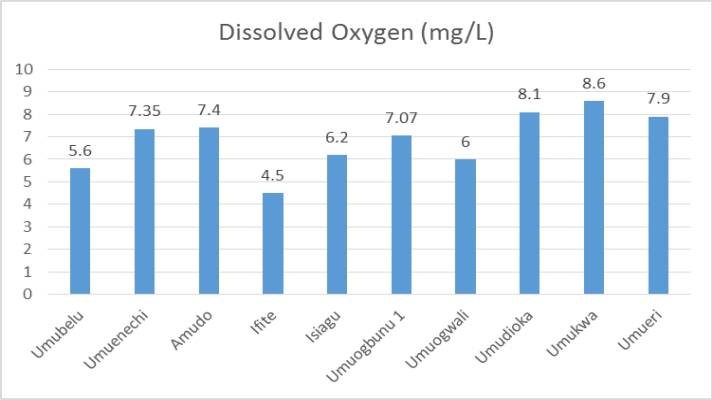

Fig. 5. Dissolved Oxygen

3.2.6 Chloride

Figure 6 showed the chloride profile of the different borehole location. From the result, Ifite had the highest chloride concentration of 340.2 mg/L while Umuenechi had the lowest Chloride concentration of 25.2 mg/L. The study showed that all borehole samples met the FEPA standard (600mg/L), for WHO standard (75mg/L), Amudo (78.75 mg/L), Ifite (340.2 mg/L) and Umuogbunu I (302.4 mg/L) are above while others are below the standards. All borehole samples are below the NIS standards (250 mg/L) except Ifite (340.2 mg/L) and Umuogbunu I (302.4 mg/L) which are above.

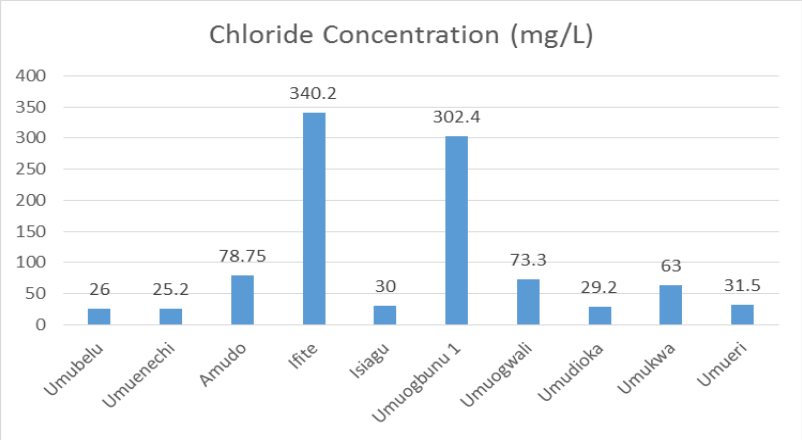

Fig. 6. Chloride Concentration

3.2.7 Chemical Oxygen Demand

Figure 7 showed the chemical oxygen demand profile of the different borehole location. From the result, COD ranges from 64 mg/L to 198 mg/L with Umudioka having lowest value and Umuogbunu I having the highest value respectively. The study showed that all the sample are below WHO stardard (1000mg/L) for COD, for FEPA, only Umudioka (64mg/L) is below their standard of 80mg/L while other borehole locations are above the standard.

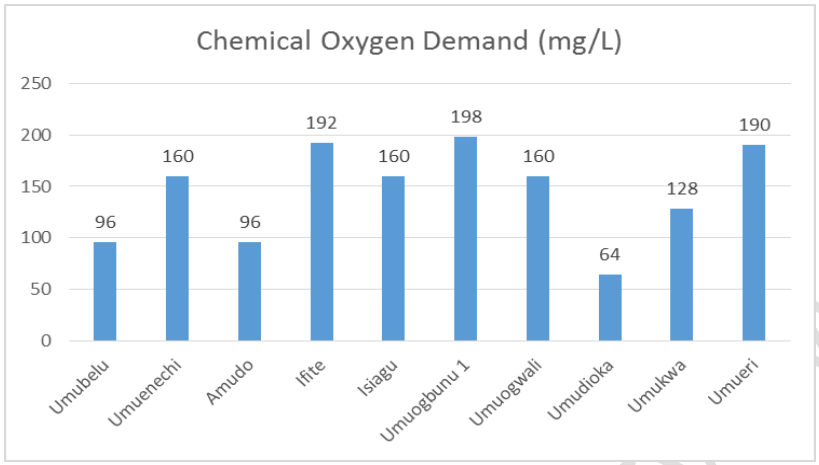

Fig. 7. Chemical Oxygen Demand

3.2.8 Total Alkalinity

Figure.8 showed the alkalinity profile of the different borehole location. From the result, ifite had the highest alkalinity level of 255mg CaCO3/L while Umubelu and Amudo had the lowest alkalinity level value of 10 and 15 mg CaCO3/L, respectively.

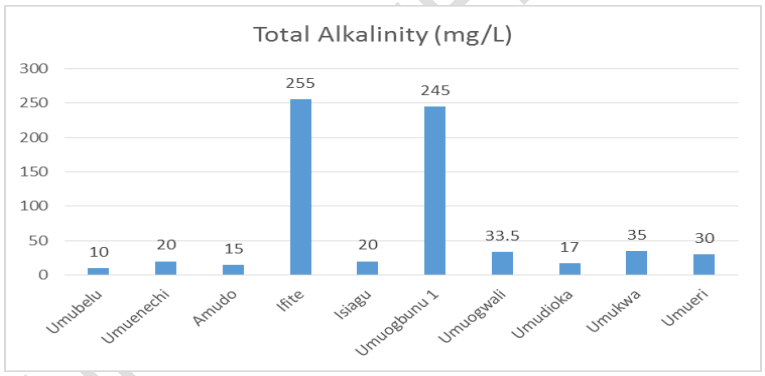

Fig. 8. Total Alkalinity

3.2.9 Total Hardness

Figure 9 showed the Total Hardness profile of the different borehole location. The results ranges from 20 to 138.8 mg/L with Umbelu having the lowest value and Umuogbunu I having the highest value respectively. The result showed that all the borehole samples are below WHO standard for drinking water and NIS Total Hardness standards of (500 mg/L) and (150 mg/L) respectively

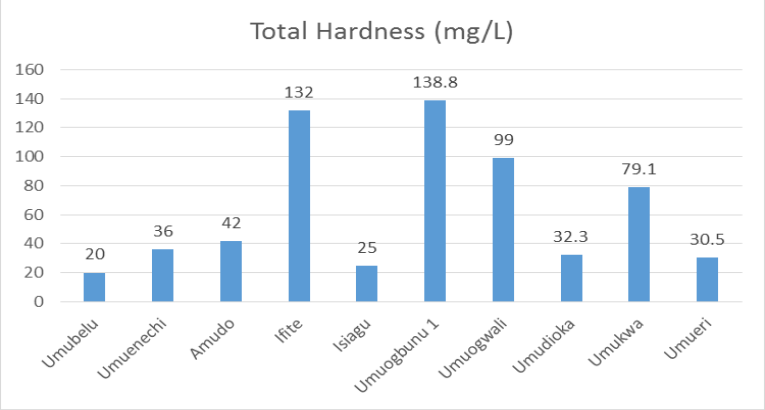

Fig. 9. Total Hardness

3.2.10 Ammonia Content

Figure 10 showed the ammonia profile of the different borehole location. From the result, Umuogbunu I had the highest ammonia level of 3.25 ppm while Umudioka and Amudo had the lowest highest ammonia level value of 0.65 and 0.75ppm, respectively.

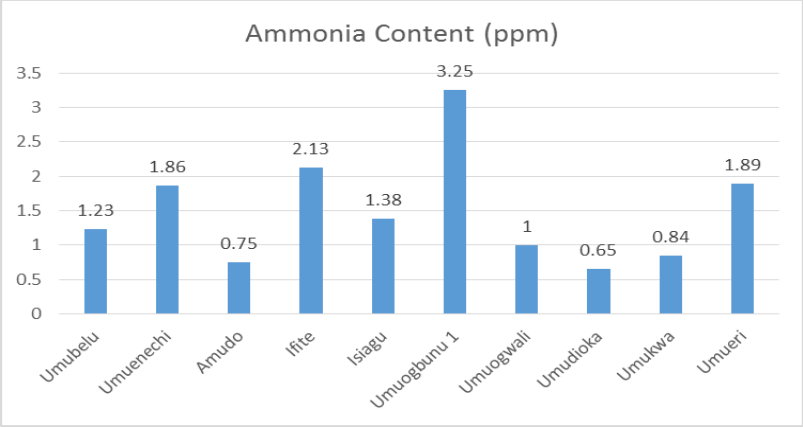

Fig. 10. Ammonia Content

3.2.11 Total Acidity

Figure 11 showed the acidity profile of the different borehole location. From the result, Umubelu had the highest acidity level of 17 mg/L while Isiagu and Umuogwali had the lowest Acidity level values of 5.2 and 6 mg/L, respectively.

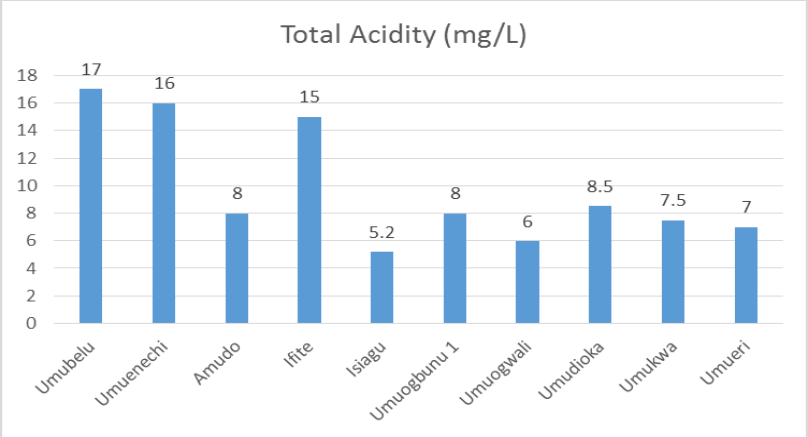

Fig. 11. Total Acidity

3.2.12 Phosphate

Figure 12 showed the phosphate profile of the different borehole locations which ranges from 4.77 ppm to 5.02 ppm. The study showed that all borehole samples exceeded the FEPA standard for phosphate (5Ppm)

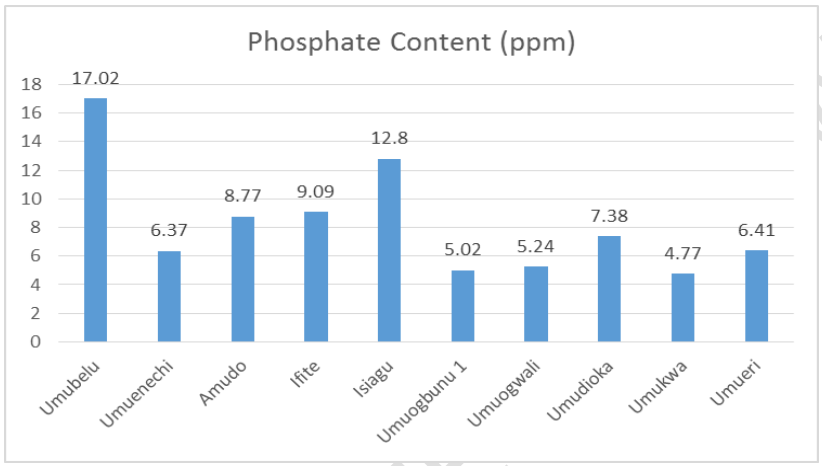

Fig. 12. Phosphate Content

3.2.13 Lead

Figure 13 showed the lead content profile of the different borehole location. From the result, the lead content ranges from 0.27 to 6.99 mg/L with Umuogbunu I having the lowest value and Umuenechi having the highest value, respectively. The study showed that all the borehole samples exceeded the WHO, FEPA and NIS standards.

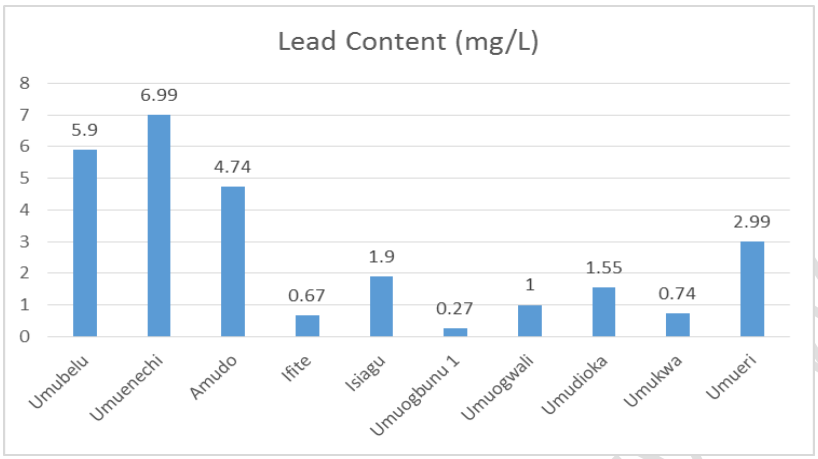

Fig. 13. Lead Content

3.2.14 Zinc

Figure 14 showed the zinc content profile of the different borehole location. The result showed that zinc content ranges from 0.25 to 1.82 mg/L. It showed that the values of zinc for all the borehole samples are below both WHO and NIS standards (5 and 3mg/L respectively) for FEPA standard (<1), Umbelu (1.05mg/L), Umubenechi (1.53mg/L) and Ifite (1.82 mg/L) are above the standards but other borehole samples are within the standard.

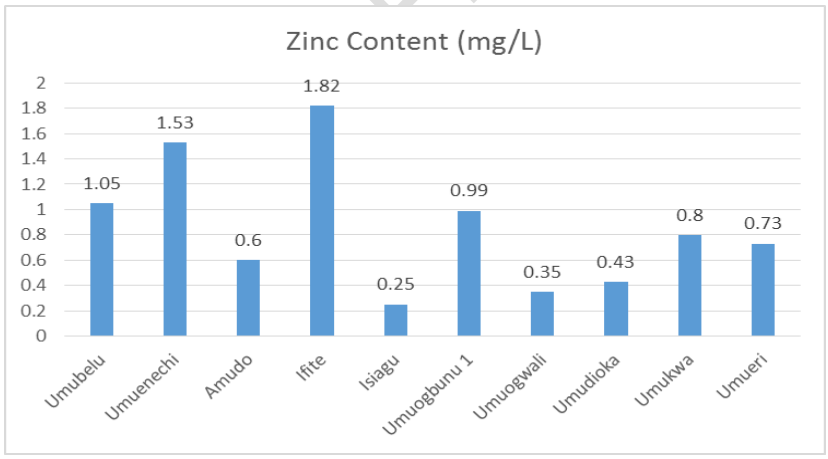

Fig. 14. Zinc Content

3.2.15 Total Coliform Count

Figure 15 showed the total coliform count profile of the different borehole location which ranges from 2 to 130 CFU/100 mL. The Total Coliform Count for all the borehole samples are below the FEPA recommended value of 400 fcu/ml.

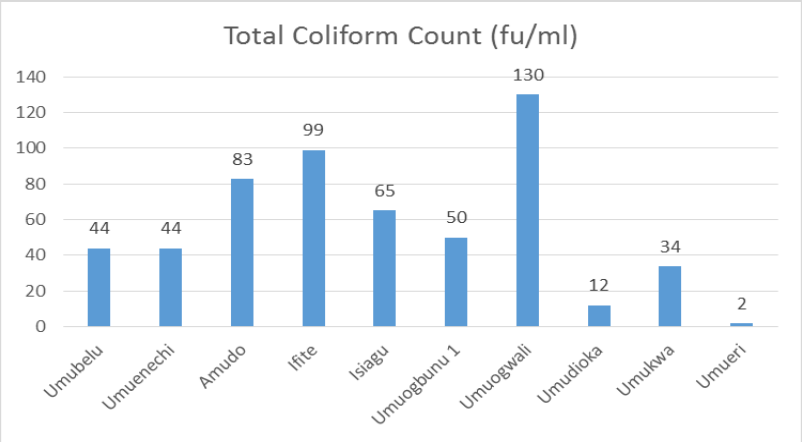

Fig. 15. Total Coliform Count

3.2.16 Total E.Coli Count

Figure 16 showed the total E. Coli count profile of the different borehole location. From the result, total coliform count ranges from 1 to 33 CFU/100 mL with Umueri having the lowest value and Umuogbunu 1 having the highest value, respectively.

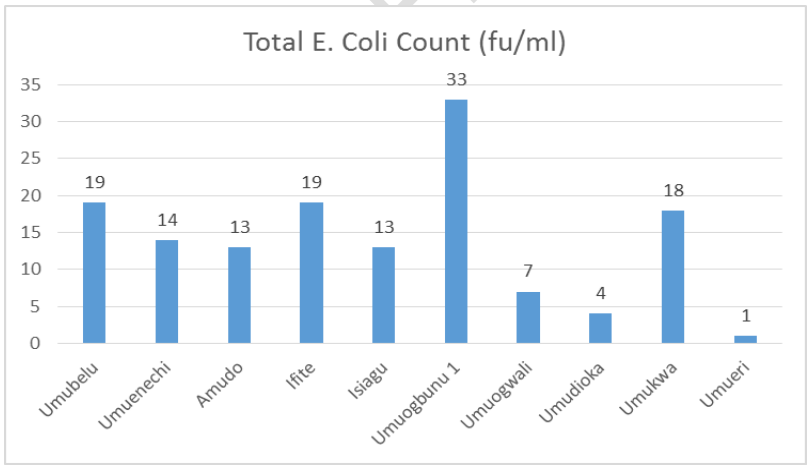

Fig. 16. Total E.Coli Count

4. CONCLUSION

Comparing the average values of the parameters with WHO, FEPA and NIS standards, it was found that pH, conductivity, Total Dissolved Solids and zinc meets the standards for ~~for~~ WHO, FEPA and NIS and lead for all sample points exceeds the three water standards.
It was found that ~~that~~ the average temperature falls within the WHO standards of 40°C but exceeded FEPA standard of 26°C. Average Dissolved Oxygen exceeded WHO standard of drinking water. Average ColOD as well falls within WHO standard and exceeded that if FEPA. Average Chloride value exceeded the value for WHO standards but meets FEPA and NIS standards.
The study showed that there ~~were~~was imbalance in some of the physical and chemical characteristics and ~~thes imbalance~~this imbalance in the characteristics of the borehole water ~~posses~~possess health risks like waterborne diseases, such as cholera and typhoid. The study showed that all the borehole samples exceeded the recommendation for lead content for WHO, FEPA and NIS standards and imbalance in lead content can lead to neurological damage, cancer, and birth defects (Adeniyi & Olukoya, 2016).

Comment [a8]: It is recommended that the conclusion be written in a single paragraph, which encompasses the message of the results responding to the objectives of the study.

REFERENCES

1. Nweke, F.N., Okaka, A.N.C. and Ezeonu, F.C. (2004a). Heavy metal concentrations in potable water sources among female inhabitants of Enyiagba, Ebonyi State, Nigeria. Journal of Science and Technology; 11:20-25.
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Comment [a9]: References should be significantly increased.