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Analysis of Physical, Chemical and Biological Characteristics of Borehole Water in Awka, Awka South LGA, Anambra State, Nigeria

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Authors' contributions

This work was carried out in collaboration among all authors. 'All authors read and approved the final manuscript.

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ABSTRACT

This study aims determine the physical, chemical and biological characteristics of borehole water in Awka.

The Study Activities Include: Collection of borehole water samples, Identification of physical, chemical and biochemical characteristics present in the borehole water samples, analyzing the characteristics, comparing the characteristics of the water samples to the World Health Organizations (WHO) standards, Federal Environmental Protection Agency (FEPA) and the Nigerian Industrial Standard (NIS), Identification of health effects of imbalance in the characteristic and development recommendation for improving the quality of borehole water.

The study was carried out in Microbiology laboratory, Chukwuemeka Odumegwu Ojukwu University Uli, Anambra State, Nigeria (5.7699° N, 6.8361° E). It took six months to complete the study.

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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. This study presents results for these characteristics which ranges from: 28.3°C - 32°C for temperature which are all below WHO standards, 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, 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.

Conclusion: Results of these characteristics were compared with World Health 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 [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 [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 [3], and decreased water quality, which can lead to decreased agricultural productivity [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 [5]. Quality drinking water is essential for life. 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) [6].

2. MATERIALS 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 include; Umubelu N: 6°13'16.41936"

E: 7°3'57.0384"(BH1), Umubenechi
N: 6°11'16.26648"
E: 7°3'55.15596"(BH2), Amudo
N: 6°15'37.43568"
E: 7°6'38.10205"(BH3), Ifite
N: 6°11'16.41936"
E: 7°3'51.55092"(BH4), Isiagu
N: 6°12'40.1778"
E: 7°4'1.8138"(BH5), Umuogbunu I
N: 6°12'38.6082"
E: 7°4'516.6908"(BH6), Umuogwali
N: 6°12'28.82952"
E: 7°4'19.77384"(BH7), Umudioka
N: 6°12'30.078"

E: 7°4'26.17392"(BH8), Umukwa
N: 6°12'26.93772"
E: 7°4'25.53744"(BH9), Umueri
N: 6°12'15.5278"
E: 7°4'29.52696"(BH10).

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).

2.2.2 Determination of chloride

Chloride was obtained using Argentometric titration method and as described by APHA [7] and Adelowo and Agele [8].

2.2.3 Determination of chemical oxygen demand

The amount of chemical oxygen demand was determined according to APHA [7].

2.2.4 Determination of acidity

Total Acidity was determined using titrimetric method

2.2.5 Determination of total alkalinity

Total Alkalinity was determined by adopting the method of FSSAI (2015);

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 [8].

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 [7].

2.2.8 Ammoniacal nitrogen (NH3) determination

A phenate method was adopted for ammoniacal nitrogen determination according to the standard method of APHA [7].

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 [7] 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 [9,10].

2.2.11 Heavy metal determination

The method described by APHA [7] was used to determine the heavy metals content of the treated water [11,12].

2.3 Biological Analysis

Membrane filtration technique was adopted to determine microbial quality of the water samples in accordance with American Public Health Association [6].

3. RESULTS AND DISCUSSION

3.1 Temperature

Fig. 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.

3.2 pH

Fig. 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.

3.3 Electrical Conductivity

Fig. 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.

3.4 Total Dissolved Solids

Fig. 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.

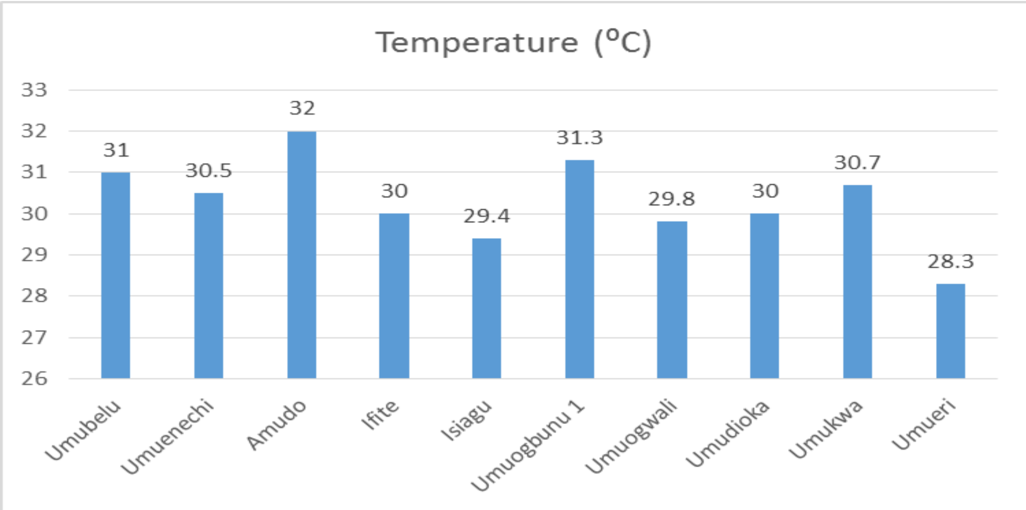

Fig. 1. Temperature

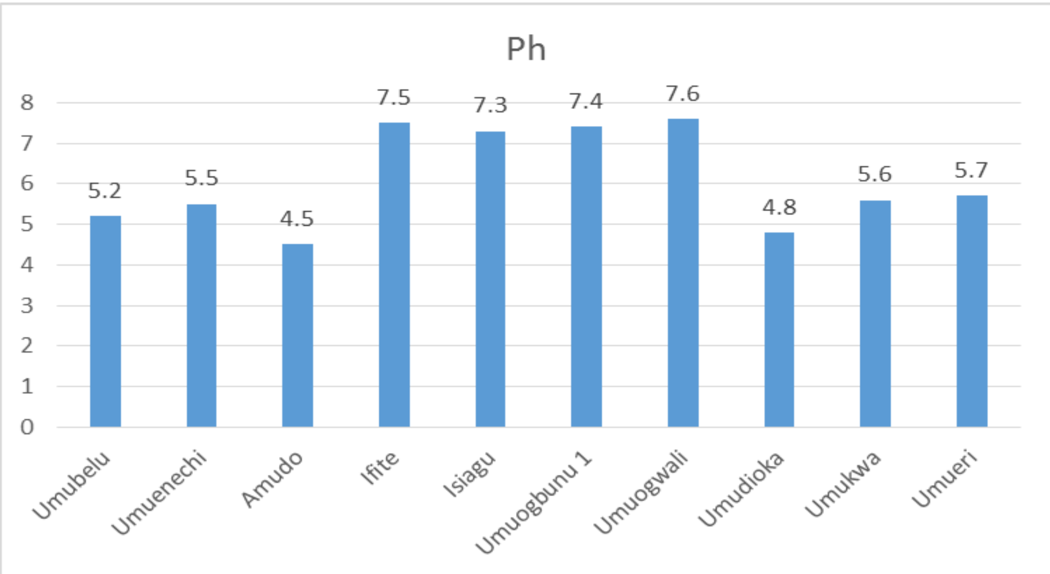

Fig. 2. pH value

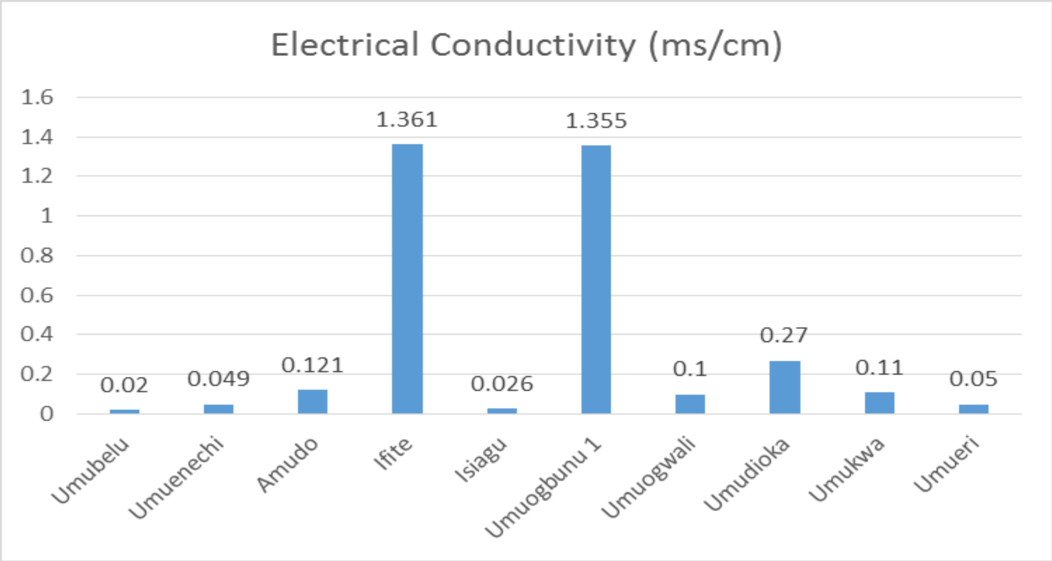

Fig. 3. Electrical conductivity

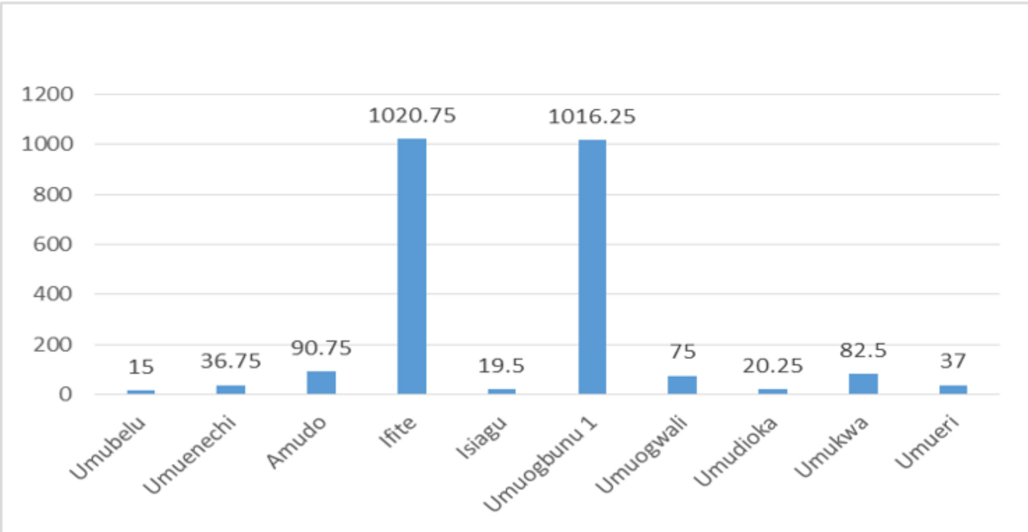

Fig. 4. Total dissolved solids

3.5 Dissolved Oxygen

Fig. 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.

3.6 Chloride

Fig. 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.

3.7 Chemical Oxygen Demand

Fig. 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.

3.8 Total Alkalinity

Fig..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.

3.9 Total Hardness

Fig. 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.

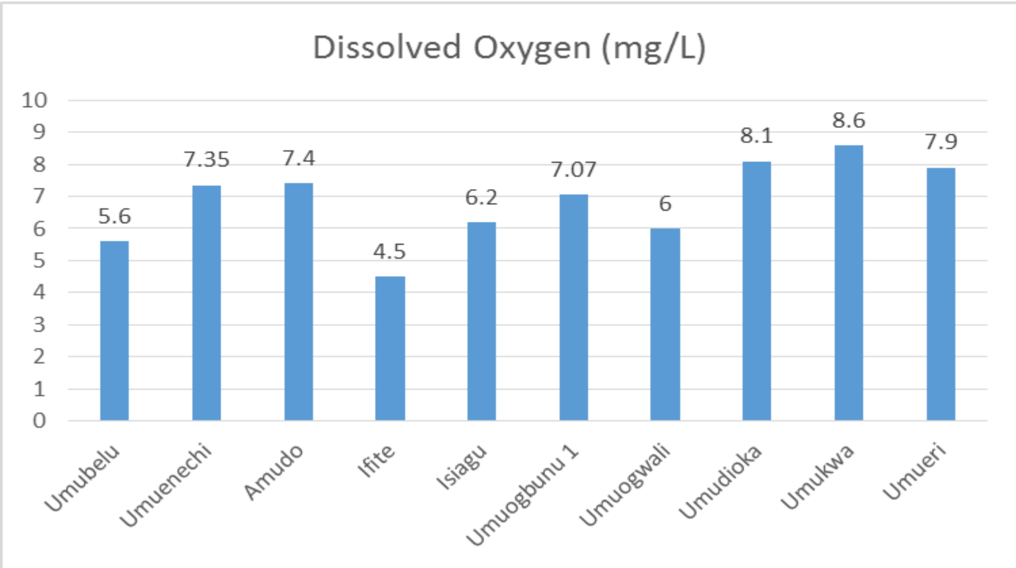

Fig. 5. Dissolved oxygen

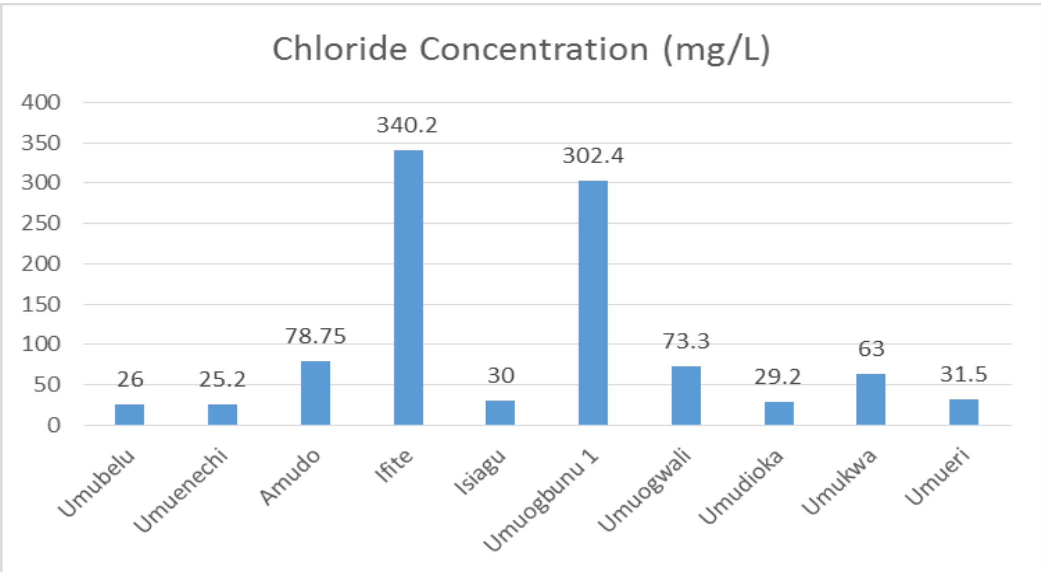

Fig. 6. Chloride concentration

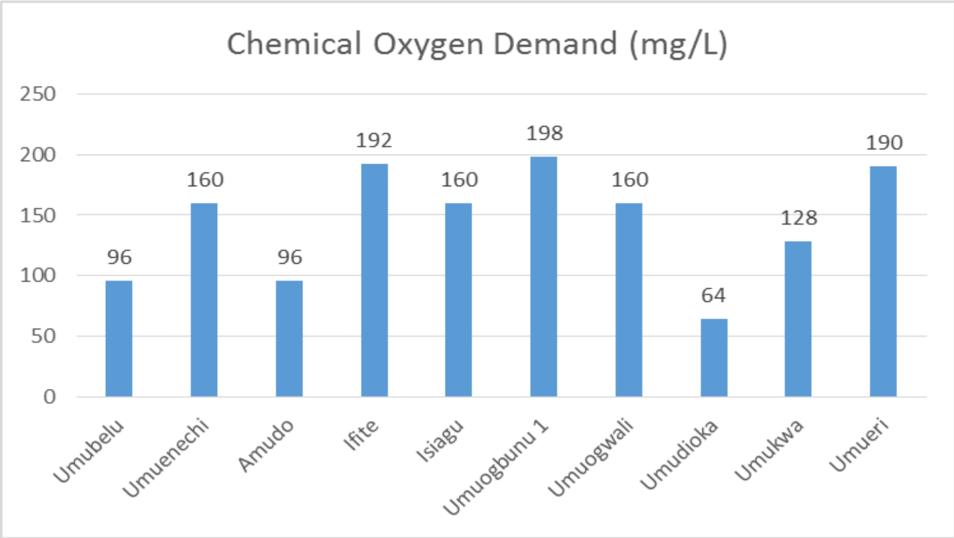

Fig. 7. Chemical oxygen demand

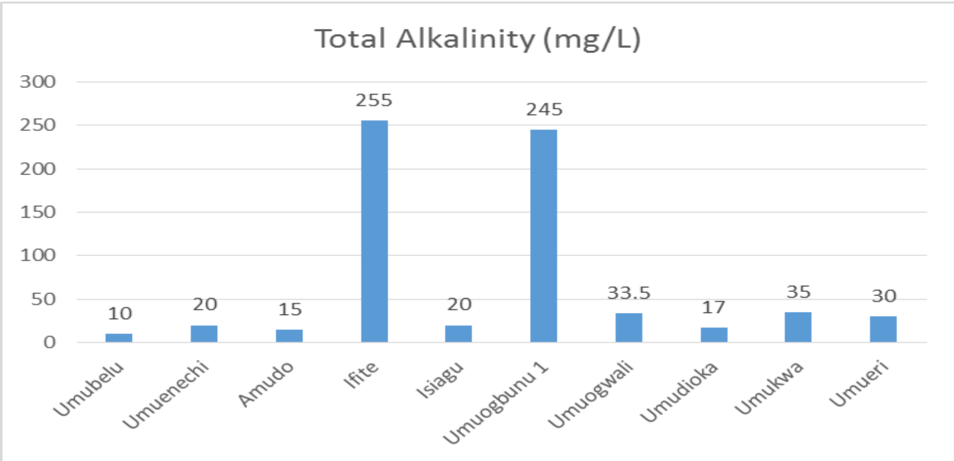

Fig. 8. Total alkalinity

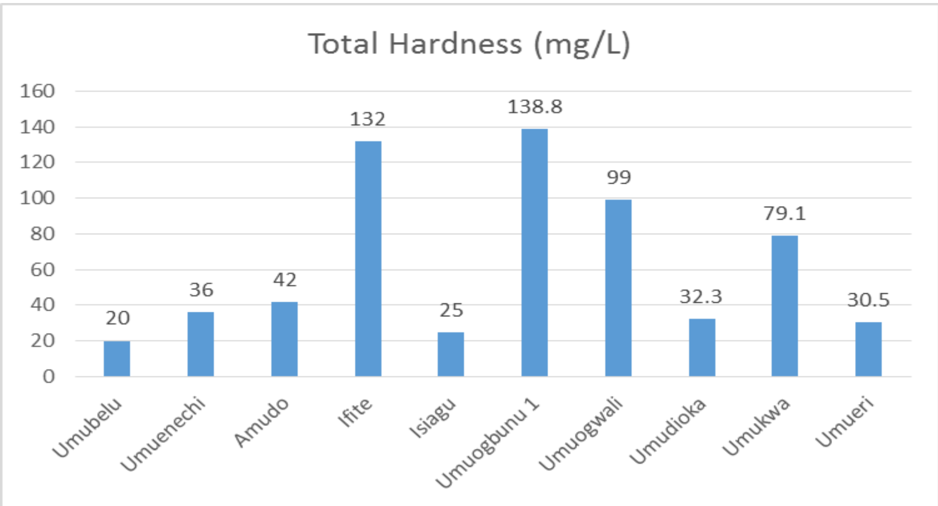

Fig. 9. Total hardness

3.10 Ammonia Content

Fig. 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.

3.11 Total Acidity

Fig. 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.

3.12 Phosphate

Fig. 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).

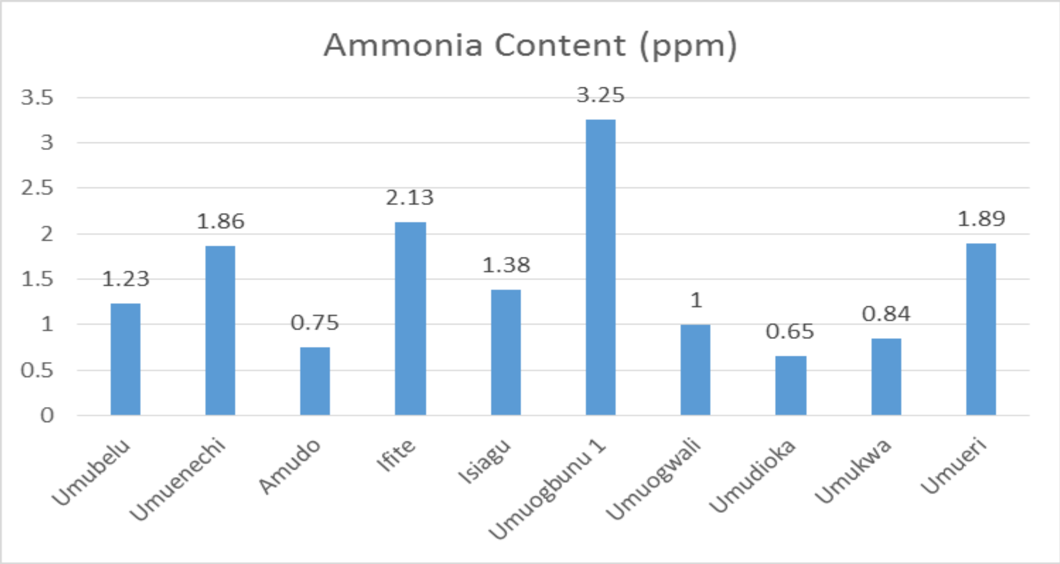

Fig. 10. Ammonia content

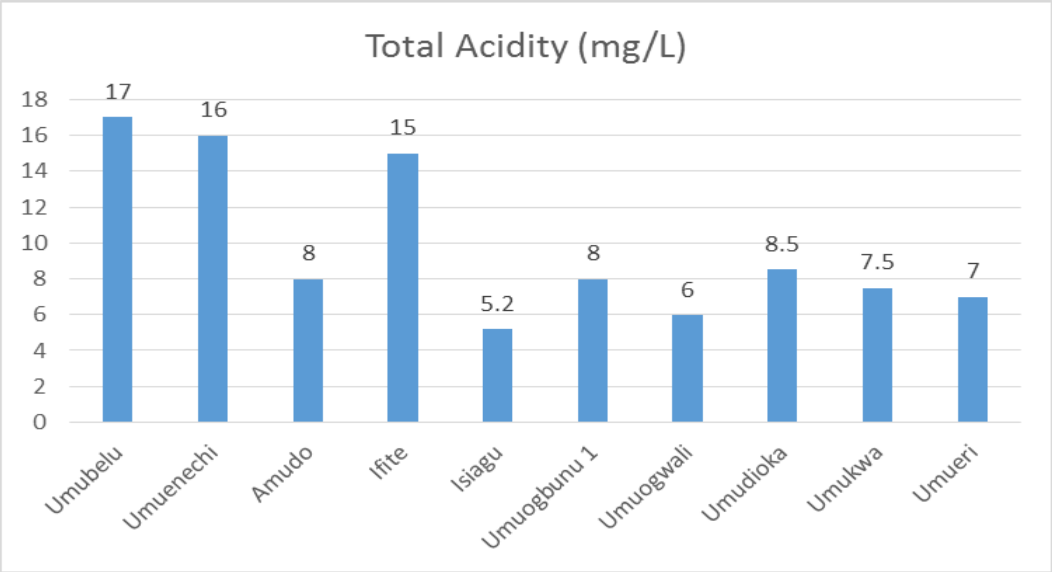

Fig. 11. Total acidity

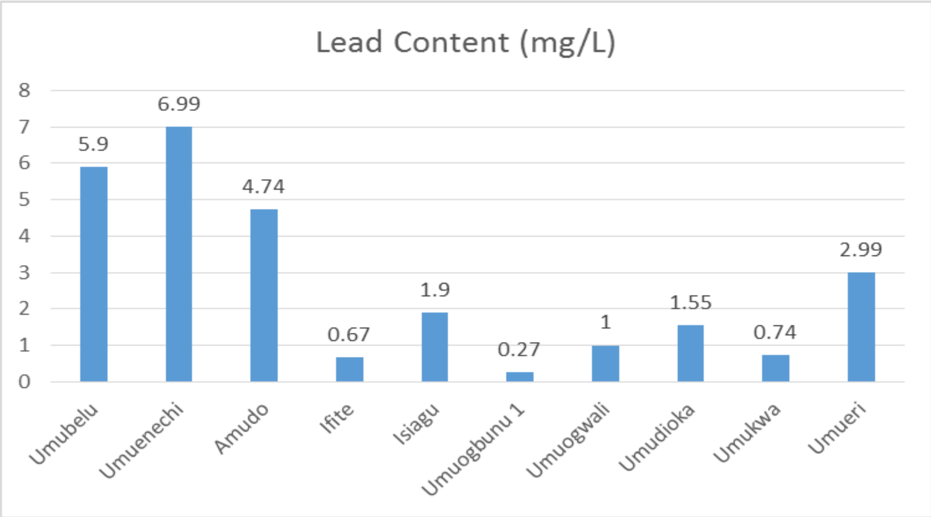

Fig. 12. Lead content

3.13 Lead

Fig. 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.

3.14 Zinc

Fig. 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.

3.15 Total coliform count

Fig. 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.

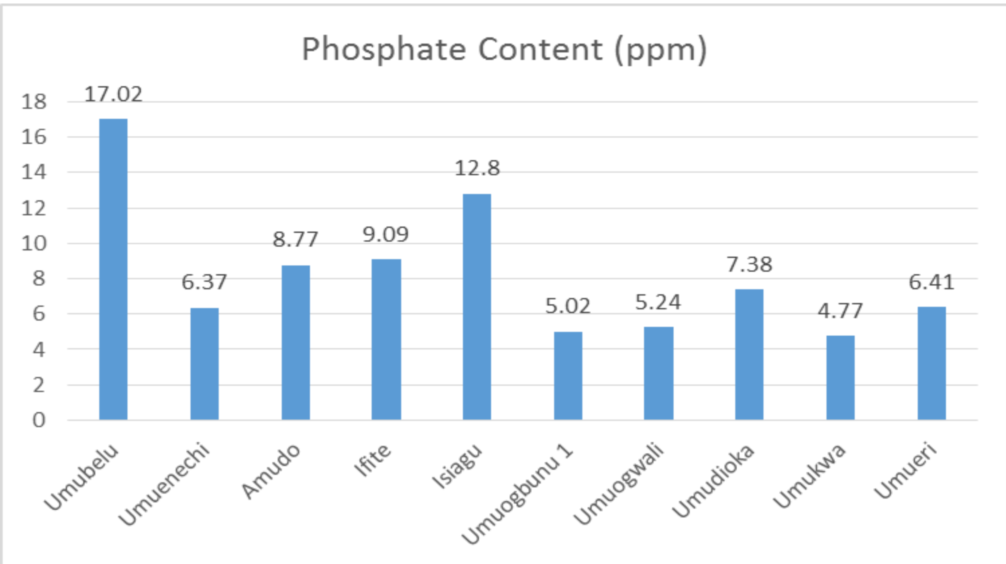

Fig. 13. Phosphate content

3.16 Total E.Coli count

Fig. 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.

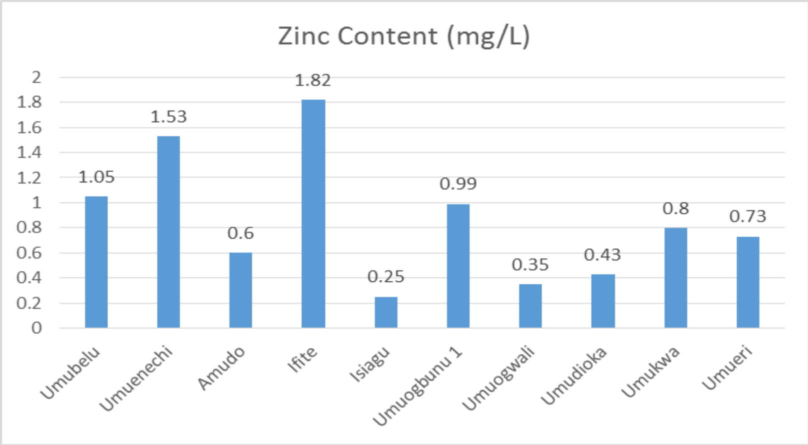

Fig. 14. Zinc content

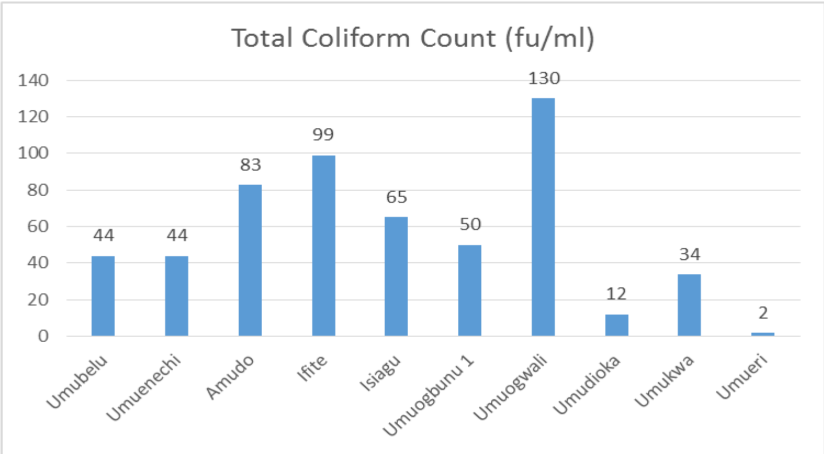

Fig. 15. Total coliform count

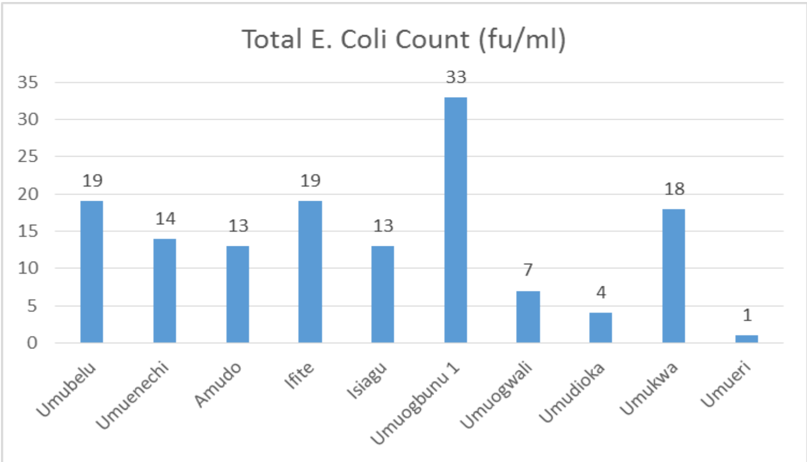

Fig. 16. Total E.Coli count

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

Parameters	BH1	BH2	BH3	BH4	BH5	BH6	BH7	BH8	BH9	BH10	AVG 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

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 WHO, FEPA and lead for all sample points exceeds the three water standards. It was found 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 was imbalance in some of the physical and chemical characteristics and this imbalance in the characteristics of the borehole water 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).

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COMPETING INTERESTS

Authors have declared that no competing interests exist.

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