Effect of Seasonal Variation on the Physicochemical Characteristics of Borehole Water in Ogbaru Communities, Anambra State, Nigeria

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Abstract Analysis of water boreholes in Ogbaru Communities, Anambra State was carried out during the dry and wet seasons to determine the effect of seasonal variation on their physicochemical characteristics. Fifteen drinking water boreholes were sampled from different locations in the communities. The pH values were in the range of 3.4-8.3; temperature, 28-29°C; electrical conductivity, 15-238us/cm; total suspended solids, 0.00-0.25mg/l; total alkalinity, 4.0-27.0mg/l; total acidity, 2.5-7.5mg/l; total hardness, 30.0-84.0mg/l; calcium hardness, 0.6-3.4mg/l; magnesium hardness, 6.8-18.0mg/l; total chlorides, 7.3-66.5mg/l; sulphates, 0.00-0.04mg/l; cadmium, 0.01-0.32mg/l; lead, 0.00-0.08mg/l; arsenic, 0.00-0.04mg/l and iron, 0.00-0.05mg/l during the dry season while the pH ranged from 4.8 to 8.5; temperature, 25-28°C; electrical conductivity, 41-910us/cm; total suspended solids, 0.03-2.01mg/l; total alkalinity, 12.0-40.0mg/l; total acidity, 5.0-22.5mg/l; total hardness, 45.0-94.0mg/l; calcium hardness, 1.8-10.4mg/l; magnesium hardness, 10.3-21.7mg/l; total chlorides, 52.8-96.6mg/l; sulphates, 0.00-0.06mg/l; cadmium, 0.03-0.34mg/l; lead, 0.01-0.20mg/l; arsenic, 0.00-0.04mg/l and iron, 0.02-0.08mg/l during the wet season. These results showed that the season had pronounced effect on the physicochemical characteristics of the water from the boreholes sampled. Some of the boreholes studied did not comply with the World Health Organization standards for potable water in terms of pH, total acidity, cadmium, lead and arsenic and require adequate treatment before drinking to safeguard the health of the users.

Keywords Seasonal Variation, Physicochemical, Characteristics, Borehole, Water, Ogbaru Communities

1. Introduction

Unsafe water is a global public health threat, placing persons at risk to a host of diarrheal and other diseases as

well as chemical intoxication [1]. It has devastating effect on young children in developing world. Each year, more than two million persons, mostly children less than five years of age die of diarrheal disease [2]. Ground water is a major source of drinking water in both urban and rural areas. In Nigeria, ground water contamination is one of the least recognized environmental problems because its problems are not readily detected and pathways for contamination are not as noticeable as those affecting surface water [3].

Ground water pollution occurs widely from a variety of anthropogenic sources such as waste disposal facilities, industrial pollution, agricultural practices and atmospheric fallout. Changes in land usage, such as the clearing of vegetation, over-abstraction of groundwater or excavation below the water table can also contribute significantly to groundwater pollution [4]. Pollution is usually associated with the presence of toxic substances or energy in quantity more than what can be attenuated by the environment on the basis of natural degradative changes. Drilling records showed that 20% of wells drilled for domestic water supplies contain high levels of manganese and iron above the WHO permissible limits of 0.01mg/l and 0.3mg/l for manganese and iron respectively [5].

Many agencies have contributed to the provision of water to the rural population through borehole drilling. Generally, the mode of operation of the different agencies results in different types of boreholes being drilled. As a result, some of these boreholes breakdown easily and become disused while others have been found to be polluted by iron, making their use extremely limited [6]. Ogbaru communities have several boreholes which have been in use for several years. Most of them have been scarcely maintained or rehabilitated since they were drilled. It is therefore imperative that the water from such boreholes must be analysed during the dry and wet seasons to determine the effect of seasonal variation on their physicochemical characteristics, which is the aim of this study.

2. Materials and Methods

2.1. Study Area

The study area is Ogbaru Communities in Ogbaru Local Government Area of Anambra State of Nigeria.

2.2. Samples Collection

Samples were collected from fifteen drinking water boreholes located within the study area. The locations were

- a. Odunze Street Atani
- b. Abiribose Atani
- c. Ujadimegwu Atani
- d. Ochuche
- e. Akili-Ozizor
- f. Cathedral Road Atani
- g. Umundu Ohita
- h. Odekpe
- i. Iyiowa Odekpe
- j. Okoti Odekpe
- k. Okpotuno Odekpe
- l. Atani Road Okoti
- m. Okpoko
- n. Imeogbe
- o. Anibueze Odekpe

Each of the samples was collected in two-litre plastic containers. The containers were first of all washed with detergent and rinsed severally with the water samples from the respective boreholes before collection. The temperature and pH values of the samples were taken at the site of collection. The samples were collected from each borehole in triplicates during the dry (January – March 2018) and wet (May – July 2018) seasons.

2.3. Determination of the Physical Characteristics

The physical characteristics of the borehole water samples were determined as described by Onuorah et al. [7].

2.3.1. Determination of Temperature

The temperature was measured at the point of collection using a thermometer. The thermometer was immersed vertically into the samples. It was allowed to stand till the temperature reading became stable and the value was taken and recorded.

2.3.2. Determination of pH

The pH was determined using a pH meter (JENWAY). The instrument was standardized using p^H buffers 4.0 and 7.0. The water sample was introduced into a beaker and the meter was switched on and allowed to stabilize before being lowered into the beaker. The p^H value was recorded when the meter reading stabilized.

2.3.3. Determination of Electrical Conductivity (EC)

The electrical conductivity was determined with Aquapro digital water conductivity meter. The water sample was introduced into a beaker and the meter was switched on and allowed to stabilize. The electrode was thereafter immersed into the sample and the value was recorded when the meter reading became stable.

2.3.4. Determination of Total Suspended Solids (TSS)

Fifty milliliters of the water sample were filtered through a pre weighed glass fiber filter. The filter was heated to constant mass at 105°C and then weighed. The mass increase divided by the water volume filtered is equal to the total suspended solids in mg/l.

$$\text{Total suspended solids (mg/l)} = \frac{(A-B) \times 1000}{\text{ml sample}}$$

A = weight of filter + dried residue
B = weight of filter

2.4. Determination of Chemical Characteristics

These were also determined as described by Onuorah et al. [7].

2.4.1. Determination of Total Alkalinity

One hundred milliliters of the water sample were introduced into a 250ml conical flask. Two drops of bromocresol green solution were added as the indicator and the mixture was titrated with 0.02N sulphuric acid till a colour change from green to yellow was observed and the titre value was recorded.

2.4.2. Determination of Total Acidity

One hundred milliliters of the water sample were introduced into a 250ml conical flask. A drop of a mixed solution of bromothymol blue and phenolphthalein was added and the mixture was titrated with barium hydroxide till a colour change from yellow to red was observed. The titre value was thereafter recorded.

2.4.3. Determination of Total Hardness

One hundred milliliters of the water sample were introduced into a 250ml conical flask. 1ml of buffer (pH 10.0), 2ml of sulphuric acid and 0.2ml of Eriochrome Black T indicator were added and the mixture was titrated with Ethylenediaminetetraacetic acid (EDTA) till a blue colour was observed and the titre value was recorded.

2.4.4. Determination of Calcium Hardness

One hundred milliliters of the water sample were introduced into a 250ml conical flask. 0.5ml of a mixed solution of murexide and sodium chloride were added. One milliliter of sodium hydroxide solution was also introduced and the mixture was titrated with EDTA solution till a change of colour to purple was observed. The titre value was thereafter recorded.

2.4.5. Determination of Magnesium Hardness

This was determined from the values of the total hardness and calcium hardness.

Magnesium Hardness = Total hardness – calcium hardness x 0.234 where 0.234 = constant.

2.4.6. Determination of Total Chlorides

One hundred milliliters of the water sample were introduced into a 250ml conical flask. 1ml of potassium dichromate indicator solution was added and the mixture was titrated with silver nitrate solution till a colour change from yellow to reddish brown was observed. The titre value was thereafter recorded.

2.4.7. Determination of Sulphates

One hundred milliliters of the water sample were passed through a filter paper into a conical flask and 10ml of barium nitrate were introduced into it. A new filter paper was weighed and the mixture was passed through it. The new filter paper was thereafter oven dried at 105°C for 30 seconds and the weight recorded.

$$\text{Sulphates} = \frac{(A-B) \times 1000}{\text{Volume of sample}}$$

A=weight of filter paper + suspended particles

B=weight of filter paper
1000= one litre

2.5. Determination of Heavy Metals

The heavy metals, cadmium, lead, arsenic and iron were determined by atomic absorption spectrometry as described by APHA [8].

The water sample was thoroughly mixed by shaking and one hundred milliliters of it were introduced into a 250ml beaker. The sample was digested with concentrated nitric acid and thereafter filtered into a sample bottle. The water sample was aspirated into the oxidizing air-acetylene flame. When the aqueous sample was aspirated, the absorbance was read using the Varian AA240 Atomic Absorption Spectrophotometer and the value was recorded.

2.6. Statistical Analysis

The data obtained for the physical, chemical and heavy metals characteristics during both the dry and wet seasons were subjected to correlation analysis using IBM SPSS version 20. The critical values were determined using t-distribution table.

3. Results

The physical characteristics investigated in the borehole water samples in Ogbaru communities during the dry season are presented in Table 1. The pH values were 3.4-8.3, temperature, 28-29°C; electrical conductivity, 15-238,us/cm and total suspended solids, 0.00-0.25mg/l.

Table 1. Physical characteristics investigated in the borehole water samples in Ogbaru Communities during the dry season

Borehole location	pH	Temp(°C)	EC(us/cm)	TSS (mg/l)
Odunze Street Atani	8.3	28	109	0.00
AbiriboseAtani	6.5	28	56	0.01
UjadimegwuAtani	6.6	29	52	0.01
Ochuche	6.5	29	24	0.00
Akili-Ozizor	7.5	29	22	0.01
Cathedral Road Atani	4.6	29	104	0.02
UmunduOhita	7.0	29	41	0.02
Odekpe	7.1	29	81	0.00
Iyiowa	6.7	29	77	0.02
OkotiOdekpe	6.7	29	238	0.01
OkpotunoOdekpe	8.0	29	232	0.16
Atani Road Okoti	3.4	29	41	0.03
Okpoko	4.6	29	21	0.25
Imeogbe	7.5	29	15	0.14
AnibuezeOdekpe	6.6	29	168	0.23
WHO Standard	6.5-8.5	25-40	1000	30

Temp = Temperature

EC = Electrical Conductivity

TSS = Total Suspended Solids

The physical characteristics investigated in the borehole water samples in Ogbaru Communities during the wet season are shown in Table 2. The pH ranged from 4.8 to 8.5; temperature, 25-28°C; electrical conductivity, 41-910us/cm and total suspended solids, 0.03-2.01mg/l.

Table 3 showed the chemical characteristics investigated in the borehole water samples in Ogbaru communities during the dry season. The total alkalinity values were 4.0-27.0mg/l; total acidity, 2.5-7.5mg/l; total hardness, 30.0-84.0mg/l; calcium hardness, 0.6-3.4mg/l; magnesium hardness, 6.8-18.0mg/l; total chlorides, 7.3-66.5mg/l and sulphates, 0.00-0.04mg/l.

Table 2. Physical characteristics investigated in the borehole water samples in Ogbaru Communities during the wet season

Borehole location	pH	Temp(^o C)	EC(us/cm)	TSS (mg/l)
Odunze Street Atani	8.5	26	201	0.12
AbiriboseAtani	7.7	26	132	0.41
UjadimegwuAtani	7.3	27	116	0.03
Ochuche	7.1	25	344	0.24
Akili-Ozizor	8.2	25	910	0.29
Cathedral Road Atani	5.6	27	292	0.20
UmunduOhita	8.4	27	495	1.60
Odekpe	7.7	25	85	0.10
Iyiowa	7.7	25	461	0.22
OkotiOdekpe	7.8	27	348	0.13
OkpotunoOdekpe	8.3	28	520	1.02
Atani Road Okoti	7.3	28	85	0.11
Okpoko	4.8	27	41	0.65
Imeogbe	7.6	27	53	1.10
AnibuezeOdekpe	7.4	28	170	2.01
WHO Standard	6.5-8.5	25-40	1000	30

Temp = Temperature

EC = Electrical Conductivity

TSS= Total Suspended Solids

Table 3. Chemical characteristics investigated in the borehole water samples in Ogbaru Communities during the dry season

Borehole location	Total Alkalinity (mg/l)	Total Acidity (mg/l)	Total Hardness (mg/l)	Calcium Hardness (mg/l)	Magnesium Hardness (mg/l)	Total Chlorides (mg/l)	Sulphates (mg/l)
Odunze Street Atani	8.0	7.5	30.0	1.6	6.8	27.3	0.02
AbiriboseAtani	8.0	5.1	40.0	1.6	9.2	20.0	0.02
UjadimegwuAtani	14.0	5.7	45.0	1.6	15.2	7.3	0.01
Ochuche	10.0	5.6	37.0	1.4	8.5	20.0	0.03
Akili-Ozizor	14.5	5.1	51.0	1.0	12.0	21.8	0.00
Cathedral Road Atani	10.0	5.0	64.0	2.8	14.7	49.2	0.04
UmunduOhita	27.0	5.0	84.0	3.4	18.0	25.5	0.00
Odekpe	17.0	6.3	72.0	2.0	16.8	43.7	0.01
Iyiowa	14.0	2.5	36.0	2.2	7.9	66.5	0.00
OkotiOdekpe	12.0	5.0	35.0	0.6	8.0	27.3	0.00
OkpotunoOdekpe	14.0	5.0	46.0	2.2	8.5	14.6	0.01
Atani Road Okoti	16.0	5.7	39.0	2.2	8.7	23.7	0.00
Okpoko	10.0	2.5	60.0	2.4	12.6	12.8	0.00
Imeogbe	4.0	6.3	45.0	2.3	10.2	62.0	0.01
AnibuezeOdekpe	16.0	6.3	54.0	2.2	12.1	52.8	0.01
WHO Standard	250	0.3	100	75	150	250	100

Table 4. Chemical characteristics investigated in the borehole water samples in Ogbaru Communities during the wet season

Borehole location	Total Alkalinity (mg/l)	Total Acidity (mg/l)	Total Hardness (mg/l)	Calcium Hardness (mg/l)	Magnesium Hardness (mg/l)	Total Chlorides (mg/l)	Sulphates (mg/l)
Odunze Street Atani	25.0	10.0	90.0	5.6	20.3	76.5	0.06
AbiriboseAtani	15.0	8.1	52.0	2.8	11.8	96.6	0.03
UjadimegwuAtani	17.5	22.5	65.0	3.2	15.2	81.1	0.04
Ochuche	13.5	7.5	45.0	2.2	10.3	74.7	0.05
Akili-Ozizor	16.0	7.5	65.0	2.2	15.1	52.8	0.02
Cathedral Road Atani	35.0	10.0	80.0	8.8	17.1	87.5	0.00
UmunduOhita	40.0	6.3	94.0	8.8	21.7	82.9	0.06
Odekpe	18.0	7.5	80.0	5.6	17.9	90.2	0.05
Iyiowa	16.0	5.0	50.0	3.0	11.5	69.2	0.02
OkotiOdekpe	17.0	5.0	48.0	1.8	11.4	90.2	0.01
OkpotunoOdekpe	16.0	5.0	60.0	10.4	13.9	73.8	0.01
Atani Road Okoti	21.0	7.5	50.0	2.6	11.5	90.2	0.01
Okpoko	22.5	6.3	72.0	7.6	16.8	88.4	0.01
Imeogbe	12.0	10.0	50.0	2.4	11.4	68.3	0.01
AnibuezeOdekpe	18.0	7.5	60.0	3.6	13.9	90.2	0.02
WHO Standard	250	0.3	100	75	150	250	100

The chemical characteristics investigated in the borehole water samples in Ogbaru communities during the wet season are shown in Table 4. The total alkalinity values were 12.0-40.0mg/l; total acidity, 5.0-22.5mg/l; total hardness, 45.0-94.0mg/l; calcium hardness, 1.8-10.4mg/l; magnesium hardness, 10.3-21.7mg/l; total chlorides, 52.8-96.6mg/l and sulphates, 0.00-0.06mg/l.

Table 5 showed the heavy metals characteristics investigated in the borehole water samples in Ogbaru communities during the dry season. The values for cadmium were 0.01-0.32mg/l; lead, 0.00-0.08mg/l; arsenic, 0.00-0.04mg/l and iron, 0.00-0.05mg/l.

Table 5. Heavy metals characteristics investigated in the borehole water samples in Ogbaru Communities during the dry season

Borehole location	Cadmium (mg/l)	Lead (mg/l)	Arsenic (mg/l)	Iron (mg/l)
Odunze Street Atani	0.16	0.01	0.03	0.02
AbiriboseAtani	0.05	0.08	0.02	0.04
UjadimegwuAtani	0.10	0.02	0.02	0.03
Ochuche	0.05	0.01	0.03	0.05
Akili-Ozizor	0.02	0.00	0.00	0.02
Cathedral Road Atani	0.10	0.00	0.02	0.02
UmunduOhita	0.10	0.08	0.02	0.03
Odekpe	0.32	0.01	0.04	0.04
Iyiowa	0.18	0.03	0.03	0.00
OkotiOdekpe	0.05	0.01	0.02	0.03
OkpotunoOdekpe	0.02	0.03	0.01	0.02
Atani Road Okoti	0.02	0.04	0.02	0.01
Okpoko	0.01	0.02	0.02	0.03
Imeogbe	0.12	0.02	0.00	0.03
AnibuezeOdekpe	0.16	0.02	0.02	0.02
WHO Standard	0.03	0.01	0.01	0.30

The heavy metals characteristics investigated in the borehole water samples in Ogbaru communities during the wet season are shown in Table 6. The values for cadmium were from 0.03 to 0.34mg/l; lead, 0.01-0.20mg/l; arsenic, 0.00-0.04mg/l and iron, 0.02-0.08mg/l.

Table 6. Heavy metals characteristics investigated in the borehole water samples in Ogbaru Communities during the wet season

Borehole location	Cadmium (mg/l)	Lead (mg/l)	Arsenic (mg/l)	Iron (mg/l)
Odunze Street Atani	0.22	0.02	0.03	0.07
AbiriboseAtani	0.05	0.09	0.03	0.06
UjadimegwuAtani	0.13	0.03	0.02	0.06
Ochuche	0.05	0.02	0.04	0.06
Akili-Ozizor	0.04	0.03	0.00	0.08
Cathedral Road Atani	0.15	0.01	0.04	0.02
UmunduOhita	0.19	0.20	0.04	0.04
Odekpe	0.34	0.04	0.04	0.05
Iyiowa	0.21	0.04	0.04	0.02
OkotiOdekpe	0.07	0.01	0.02	0.04
OkpotunoOdekpe	0.05	0.04	0.02	0.04
Atani Road Okoti	0.03	0.05	0.02	0.02
Okpoko	0.11	0.03	0.02	0.05
Imeogbe	0.17	0.04	0.00	0.04
AnibuezeOdekpe	0.19	0.02	0.20	0.03
WHO Standard	0.03	0.01	0.01	0.30

4. Discussion

Some of the borehole water samples analysed during both seasons were acidic while others were alkaline. The pH values of the samples measured during the dry season were 3.4-8.3 and 4.8-8.5 during the wet season (Tables 1 and 2). Twelve (80%) and thirteen (86.7%) of the boreholes examined during the dry and wet seasons respectively met the World Health Organization standard of 6.5-8.5 for drinking water. Studies on ground water in Wassa West District in the Western Region of Ghana by Kortasi [9] showed a pH range of 4.5-6.9. However, Onuorah et al.[7] analysed some public hand-pump borehole water in Onueke, Ezza Local Government Area of Ebonyi State, Nigeria and reported a pH range of 7.2-8.8 and 7.5-9.0 during the dry and rainy seasons respectively while Basavaraja et al. [10] and Abdullahi et al. [11] reported pH values ranging from 7.5-8.4 and 7.51-7.60 for the borehole water samples they analysed. Schaefer et al.[12] reported that low pH values would make water to be corrosive while Amoako et al.[13] reported that the geology of the soil could account for low pH values of borehole water in an area.

The temperature values of the borehole water examined were 28-29°C and 25-28°C during the dry and wet seasons respectively (Tables 1 and 2). All the samples complied with the World Health Organization standard of 25-40°C for potable water. This result agreed with Josiah et al.[14] that reported a temperature range of 26-30°C for the water samples they analysed. Temperature has been reported to influence the chemical and biochemical characteristics of water [15]. The electrical conductivity values of the samples were 15-238 μ S/cm and 41-910 μ S/cm during the dry and wet seasons respectively (Tables 1 and 2). The values for both seasons were within the World Health Organization standard of 1000 μ S/cm. Electrical conductivity is an indicator of water quality and soil salinity. This result conformed to the works of Olusiji et al. [16] and Bernard and Ayeni [17] that reported an electrical conductivity range of 20-750 μ S/cm and a mean conductivity value of 135 μ S/cm for the water samples they analysed. Lehloesa et al.[18] also obtained an electrical conductivity range of 222-689 μ S/cm in the borehole water they analysed in the Victoria District of South Africa.

The values for the total suspended solids were 0.00-0.25mg/l during the dry season and 0.03-2.01mg/l during the wet season (Tables 1 and 2). The values for both seasons were within the WHO permissible limit of 30mg/l for drinking water. Onuorah et al. [7] reported the total suspended solids values of 0.01-0.84mg/l and 0.01-0.48mg/l during the dry and wet seasons respectively for the borehole water samples they analysed. Onwughara et al.[20] however reported that the total suspended solids of the samples they analysed ranged from 31.3-55.0mg/l. The total alkalinity of the samples during the dry season were 4.0-27.0mg/l while they were 12.0-40.0mg/l during

the wet season (Tables 3 and 4). The values were within the WHO permissible limit of 250mg/l. Similar results were obtained by Okoye and Adiele [19] in their physicochemical studies of borehole water samples.

The total acidity of the samples ranged from 2.5 to 7.5mg/l during the dry season and 5.0 to 22.5mg/l during the wet season (Tables 3 and 4). All the samples examined did not comply with the WHO standard of 0.3mg/l for potable water. Taiwo et al. [21] also reported high acidity value of 1.00mg/l for the water samples they examined. The values for total hardness during the dry season were 30.0-84.0mg/l and 45.0-94.0mg/l during the wet season (Tables 3 and 4). All the values were within the WHO standard of 100mg/l for potable water. The calcium hardness values were 0.6-3.4mg/l during the dry season and 1.8-10.4mg/l during the wet season (Tables 3 and 4). All the values were within the WHO standard of 75mg/l for drinking water. Similar results were obtained by Onuorah et al.[7] who studied the physicochemical characteristics of public hand-pump boreholes in Onueke, Ebonyi State, Nigeria.

The values of magnesium hardness were 6.8-18.0mg/l and 10.3-21.7mg/l during the dry and wet seasons respectively (Tables 3 and 4). The values were within the WHO permissible limit of 150mg/l. The results agreed with those of Olusiji et al.[16] who reported a magnesium hardness of 3.4-25.9mg/l for the water samples they examined. High levels of magnesium in drinking water will render such water objectionable to consumers and may even become hazardous to health [20]. Drinking water with too low magnesium content is also harmful to human health. The minimum value is 10mg/l.

The total chlorides ranged from 7.3 to 66.5mg/l during the dry season and 52.8 to 96.6mg/l during the wet season (Tables 3 and 4). All the values were within the WHO permissible limit of 250mg/l for potable water. High levels of chlorides make water unfit for drinking by imparting salty taste and may harm metallic pipes [22]. Sulphates ranged from 0.00-0.04mg/l and 0.00-0.06mg/l during the dry and wet seasons respectively (Tables 3 and 4). The values were within the WHO standard of 100mg/l for potable water. Sulphate has been reported to have deleterious effect on young children who are very sensitive to it [23].

The values for cadmium in the samples were 0.01-0.32mg/l during the dry season and 0.03-0.34mg/l during the wet season (Tables 5 and 6). Four (26.7%) and one (6.7%) of the boreholes examined during the dry and wet seasons respectively complied with the WHO standard of 0.03mg/l for potable water. High level of cadmium in water has been linked to lung cancer, kidney diseases and bone defects in humans and animals. The lead content of the samples were 0.00-0.08mg/l during the dry season and 0.01-0.20 during the wet season (Tables 5 and 6). Six (40%) and two (13.3%) of the boreholes studied conformed to the WHO standard of 0.01mg/l for potable water. High

concentration of lead in water can cause serious damage to the brain, kidney, nervous system and the red blood cells. The values for arsenic in the samples were 0.00-0.04mg/l during the dry and wet seasons (Tables 5 and 6). Three (20%) and two (13.3%) of the boreholes analysed complied with the WHO standard of 0.01mg/l for drinking water. Arsenic in water is toxic to humans even at low concentration and may originate from agricultural practices or natural arsenic bearing rock [24].

The iron content of the samples ranged from 0.00-0.05mg/l during the dry season and 0.02-0.08mg/l during the wet season (Tables 5 and 6). All the values were within the WHO standard of 0.30mg/l for drinking water. Iron at a high concentration can cause transfusional siderosis in the spleen, disturbance in liver functions and diabetes mellitus [25]. The values of the physicochemical characteristics of the borehole water studied were relatively higher during the wet than the dry season. This may be attributed to the mild weather conditions prevalent during the wet season and the rain water which may not only have diluted the borehole water source but also introduced some leachates including organic and inorganic matters into the water body. The total hardness, total chlorides, cadmium and arsenic had significant correlation at 5% significance level using t-distribution indicating that they were significantly affected by the seasonal variation.

5. Conclusions

This study showed that some of the boreholes sampled did not comply with the standard set by the World Health Organization in terms of pH, total acidity, cadmium, lead and arsenic values and must be treated adequately before use. The use of geophysical method in selecting appropriate locations for ground water development should be encouraged within Ogbaru communities. Government effort should be geared towards the provision of waste disposal infrastructures such as incinerators and waste recycling facilities. In addition, periodic physicochemical analysis of the water from the boreholes in Ogbaru communities to determine their potability is recommended.

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