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Evaluation of the average physical parameters of selected borehole water Samples in Agbor, Delta State, Nigeria

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ABSTRACT

Potable water is one that is free from contamination, low in compounds that are acutely toxic and have great long-term effects on human health. Physical parameters of some borehole water samples in Agbor, Delta State were carried out to determine its potability for drinking and domestic purposes. Sixty water samples from fifteen boreholes were sampled in Juneand July, 2022 (rainy season); and January and February, 2023 (dry season). The physical parameters were analyzed according to standard methods. The examination of the physical parameters of selected borehole water samples in Agbor,Delta State, Nigeria showed that all the values obtained were within the WHO 2006, maximum permissible limit of 5 NTU for drinking water. However, the turbidity values were generally lower during the dry season. The increased values during the rainy season could be attributed to surface runoff and erosion carrying soil and partially dissolved/un-dissolved organic matters. The low recharge in the dry season may have resulted in lower turbidity of the borehole water.

Keywords: Physical parameters, borehole, water, samples, Agbor, Delta State and Nigeria

INTRODUCTION

Water is the precious resource that qualifies the planet earth to be habitat of the biosphere. Water covers 71% of the earth surface and it is vital for all known forms of life. It is a transparent fluid which forms the world's streams, lakes, oceans and rain, and is the major constituent of the fluids of organisms. Borehole is a type of groundwater that form an integral part of water supply systems in rural and urban areas especially in Nigeria [1]. Over one billion people lack access to clean safe water worldwide, up to 300 million rural people in Sub Sahara Africa have no access to safe water supplies and this is on the rise [2]. The only realistic option for meeting rural water demands is through groundwater exploitation [2]. Water is vital to many life processes and they could also serve as route through which disease-causing pathogens can be transmitted. It can also contain heavy metals and other chemical substances that may adversely affect human health. Ensuring good quality of drinking water is a basic factor for guaranteeing public health [3]. Potable water is that which is odourless, colourless, practically tasteless and free from physical, chemical and biological contaminants [4]. Water is exploited by man for several commercial, agricultural, domestic and industrial usages; and the usage of water for any activity usually depends on the cleanness of the water. The quality of water is determined by its physical, chemical and microbiological characteristics [5]. The paucity of water supply in Nigeria has forced residents to depend on shallow dug boreholes as the sources of water for drinking and domestic purposes [5]. Agbor in Delta State depends mostly on ground water, its abstraction account for 20% of the total water usage. Currently, demands for groundwater usage have been increasing due to population growth and diminishing opportunities to economically develop potable water supplies [6]. The management of the resource is lagging behind the pace of development, and often, very little sanitary practice is exercised in its exploitation. The current groundwater resources development and supply status is unacceptably low and needs a major transformation [7]. The digging of more boreholes in Agbor brings the need to monitor the issue of water quality that remains a major contender of its supposed existence in abundance essentially its quality is as equally important as its quantity. The quality of water is of vital concern for mankind since it is directly linked with human welfare. According to [8], the quality of public health depends to a greater extent the quality of groundwater. Physicochemical and bacteriological parameters of water indicate the safety of potable water [9] and their analysis is important for public Health and pollution studies [10].

Aim of the study

The aim of this study was to evaluate the physical parameters of some selected borehole water samples in Agbor, Delta State, Nigeria

MATERIALS AND METHODS

Study area

Agbor is the headquarters of Ika South Local Government Area of Delta State in the South Southern part of Nigeria. Agbor has a population in excess of 250,000 people and a land mass of 685km2. The geographical coordinates of Agbor are 6.254oC latitude, 6.194oC longitude and 427ft elevation. The topography within two miles of Agbor contains only variations in the elevation with a maximum elevation of 367ft and an average elevation above sea level of 504ft. Agbor lies within the equatorial climate with two distinct seasons, the wet (April to September) and dry (October to March), high humidity of between 24oC to 27oC, which supports the rainforest vegetation. The discovery and exploration of oil in commercial quantity in Ekuku Agbor and environs have earned Agbor the status of oil producing city within the Niger Delta region of Nigeria. Agbor has the blessing of abundant natural water bodies. The people of Agbor are known for commerce and agricultural activities. Agbor hosts amenities such as University of Delta, Delta College of Nursing, 181 Army Amphibious battalion, National Psychiatric Hospital, General Hospital, Area Command of Nigeria Police Force, and the adorable Dein Royal Palace. The Dein of Agbor is the traditional ruler of Agbor Kingdom with over seventy communities [11].

A drive around the borehole locations was undertaken to enable proper capture of the accurate borehole points using the handheld Global Positioning System. The coordinates of the actual positions were acquired and inputted on the Google map. On-screen vectorization of features like towns, roads and boundaries were directly observed and recorded. The features from the Google map were zoomed to a very high resolution where all the features became very clear as represented in the samples map presented in this work. The mapping was carried out in collaboration with Geo-trust Project Services Ltd, a surveying firm in Agbor.

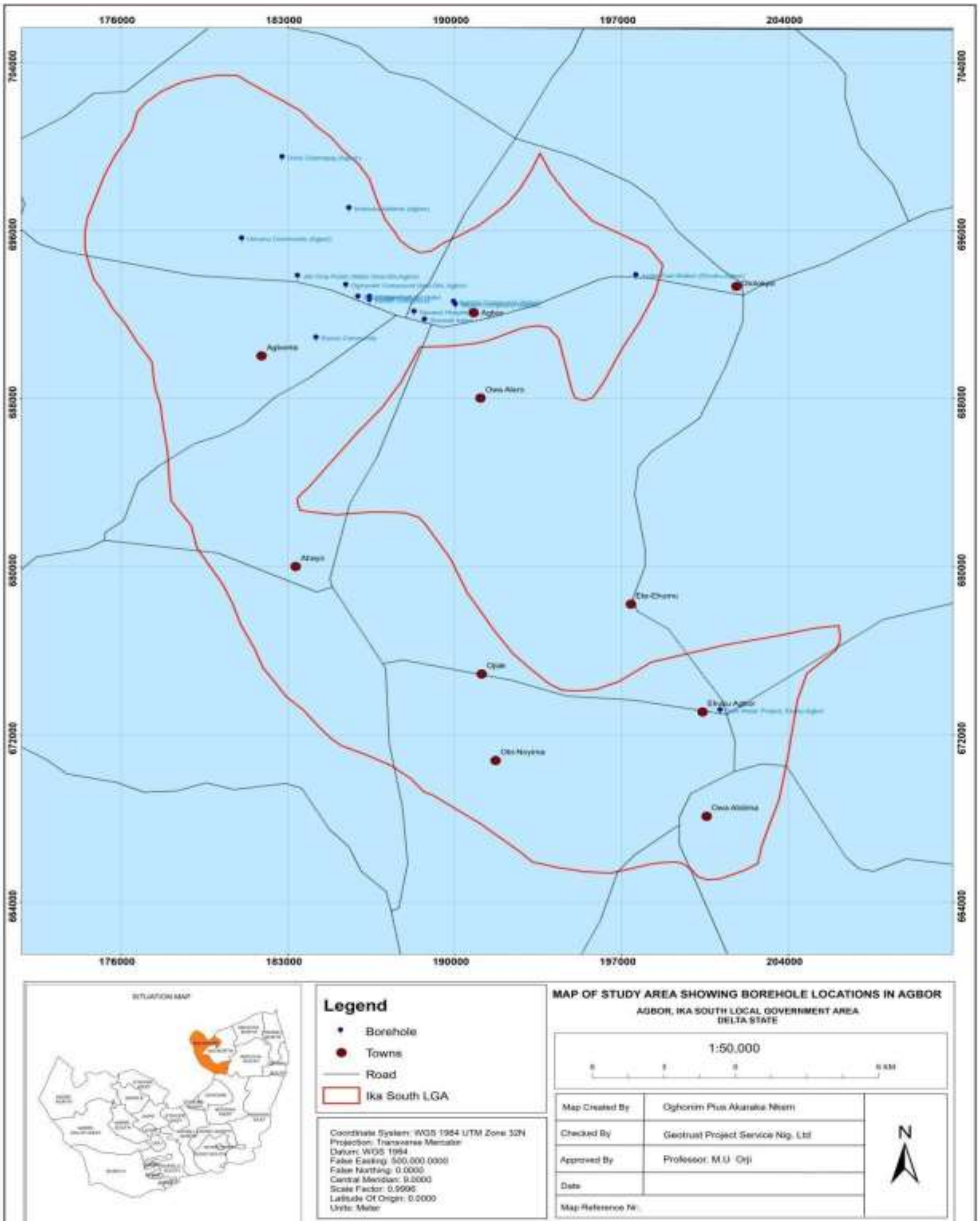

Fig. 1: Map of the study area, 2023. Source: Geo-trust Project Services Ltd.

Research center

The physical analysis was done at Projects Development Institute (PRODA) Enugu, bacteriological analyses were done in Applied Microbiology and Brewing laboratory Nnamdi Azikiwe University, Awka, while molecular characterization was done at International Institute of Tropical Agriculture, Ibadan Headquarters, Nigeria.

Sample collection for physicochemical analysis

All the sampled points were selected randomly within Agbor, Delta State. Sixty (60) samples were aseptically collected from 15 different boreholes between June and July, 2022 (rainy season); January and February, 2023 (dry season). The selected borehole waters were those used for drinking and for other domestic purposes. These water samples were collected in the morning period (7am – 9am). During the rainy season, fifteen samples were collected in June, analyzed and recorded, this was repeated in July and average of the values was taken, making it a total of thirty samples. This was also done in the dry season period to give a total of sixty samples for both seasons. Samples for physicochemical analysis were collected using one-litre plastic containers. The containers were first washed with sterile water and thereafter it was rinsed with water from the respective boreholes three times before collecting the water samples. Samples for the bacteriological analysis were aseptically collected in sterilized one-litre plastic container (which was sterilized by rinsing with 70% ethanol and then with sterile water and thereafter with the respective water sample three times before collection). The water was left to rush for 2 minutes (This allows the nozzle of the tap to be flushed and any stagnant water in the service pipe to be discharged). A piece of cotton-wool soaked in ethanol and lighter was used to decontaminate the faucet of the borehole before collection. The collected samples were kept at 4°C in the cooler box packed with ice and transported to the laboratory for analysis within two hours as described by [12]. These boreholes were: Oghonim, Aziken, Agholor, Aliagwu, Dein, Golden Cocktail, Police, Ewuru, Jim Ovia, Omumu, Uvbe Ozanogo, Idumukwu, Central Hospital, Lucky Irabor, and Jodes.

Physical analysis

The physical parameters evaluated were temperature, pH, electrical conductivity, total suspended solids, total solids, total dissolved solids and turbidity. The evaluation was carried out as described by [13]. Temperature, pH, dissolved oxygen, turbidity and electrical conductivity were measured in-situ because of low stability.

Physical parameters

Determination of temperature

The temperature of the water samples was measured at the point of collection (in situ) using portable hand-held mercury-in-glass thermometer. The thermometer probe was placed inside a 250ml beaker containing the borehole water samples immediately after collection and left for five (5) minutes to allow it adjust to the water temperature and the reading was recorded.

Determination of pH

The pH meter was calibrated using the standard buffer solutions (4.00, 7.00 and 10.00) and the water samples were introduced into 250ml beakers and the meter sensor was submerged into the samples to determine the pH (in situ). The reading was allowed to stabilize for five (5) minutes before recording the value.

Determination of electrical conductivity

The conductivity meter (Myron L6) was calibrated using the buffer solutions (1413 µS/cm and buffer 12.88 mS/cm). The conductivity meter censor was submerged into each of the samples in 250ml beaker to determine the conductivity. The reading was allowed to stabilize before recording the value. This was done in situ.

Determination of total suspended solids

TS mg/l – TDS mg/l = TSS mg/l
Where;
TS = total solids
TDS = total dissolved solidsTSS = total suspended solids

Determination of total solids

The beakers were washed and dried using an oven at 1050C for 20 minutes and allowed to cool in a desiccator. The beakers were weighed immediately before use and noted as (B). The samples were homogenized and 50ml of samples were measured using a neat measuring cylinder. The samples were heated at 1050C in an oven, until dried. They were cooled in the desiccator and the weights noted as (A).

Total Solid mg/l = (A-B) / Volume of sample × 1000 A = Weight of the beaker + residue.
B = Weight of the beaker.

Determination of total dissolved solids

The measuring cylinders were washed and dried using the oven at 1050C for 20 minutes and cooled in the desiccators. The weight of the filter papers was weighed and recorded. Fifty (50) ml of the water samples were measured into a measuring cylinder after proper homogenization and the samples were filtered using the weighed filter papers. The filter papers with its residues were dried in the oven at 1050C until samples got dried before being cooled in the desiccator and the weights recorded.

Total dissolved solid mg/l = Residue × 1000 / volume of sample

Determination of turbidity

The turbidity of the samples was determined at the point of collection by table top turbidity meter manufactured by Lab Science. Turbidity was expressed as Nephelometric Turbidity Units (NTU).

RESULTS

Results for Survey of Sanitary conditions within the sampled locations

During the assessment, it was observed that most of the boreholes were hand-dug wells connected to an overhead tank through a pipe and submersible machine for pumping the water, while some are drilled boreholes that are shallow and sited close to waste dump site, septic tank, poultry house, farm lands, mechanic workshops, with shallow aprons, empty lands were people go for open defecation and dump refuse. These wells are often covered with dirty rusted iron sheaths with no proper concrete aprons raised above ground level to prevent contamination from run-off water. The pipes for water distribution are old and leaky which might possibly introduce dirt and leachates (lead) into water. No proper drainage and sewer system existed within the area. Waste water from anthropogenic activities were disposed onto the ground which often leach into water sources.

Table 1: Average values of the physical characteristics of borehole water samples during rainy season

Borehole Location	Temp (°C)	pH	EC (µs/cm)	TSS (mg/l)	TS (mg/l)	DS (mg/l)	Turbidity (NTU)
Oghonim	28	8.09	210	0.24	7.36	7.12	1.86
Aziken	29	7.04	273	0.19	3.24	3.05	1.90
Agholor	29	7.37	196	0.22	2.70	2.48	1.89
Aliagwu	29	8.30	204	0.29	6.40	6.11	1.79
Dein	27	6.42	117	0.04	2.89	2.85	1.34
Golden Cocktail	26	8.76	207	0.51	8.60	8.09	1.52
Police	26	7.32	191	0.62	4.19	3.57	1.71
Ewuru	27	7.93	136	0.11	2.12	2.01	1.80
Jim Ovia	30	7.54	311	0.84	15.89	15.05	2.11
Omumu	28	7.02	164	0.09	2.40	2.31	1.36
Uvbe Ozanogog	30	8.00	361	0.59	9.65	9.06	2.49
Idumukwu	29	7.37	198	0.36	4.49	4.13	1.50
Central Hospital	29	7.13	300	0.70	9.87	9.17	1.47
Lucky Irabor	30	8.02	215	0.39	7.77	7.38	2.29
Jodes	29	6.80	150	0.18	4.29	4.11	1.31

Hint: NTU= Nephelometric turbidity unit.

Average values of the physical parameters in dry season

The physical parameters of the borehole water samples during the dry season were shown in Table1. Temperature values ranged from 25oC-29oC, pH ranged from 6.27-7.65, electrical conductivity ranged from 20 µs/cm-136µs/cm, total suspended solids 0.01mg/l-0.58mg/l, total solids ranged from 0.11mg/l-2.64mg/l, dissolved solids ranged from 0.10mg/l-2.06mg/l, turbidity ranged from 0.55NTU-1.87NTU.

Table 2: Average values of the physical characteristics of borehole water samples during dry season

Borehole Location	Temp (°C)	pH	EC (µs/cm)	TSS (mg/l)	TS (mg/l)	DS (mg/l)	Turbidity (NTU)
Oghonim	27	7.04	90	0.13	0.39	0.26	1.60
Aziken	28	6.56	68	0.11	0.35	0.24	1.61
Agholor	26	6.79	55	0.07	0.20	0.13	1.27
Aliagwu	28	7.65	63	0.08	0.19	0.11	1.32
Dein	25	6.40	20	0.01	0.11	0.10	0.55
Golden Cocktail	27	6.66	47	0.08	0.26	0.18	0.78
Police	27	6.62	50	0.06	0.23	0.17	1.19
Ewuru	27	6.27	38	0.04	0.24	0.20	0.73
Jim Ovia	28	7.09	136	0.58	2.64	2.06	1.87
Omumu	27	6.40	45	0.16	0.37	0.21	0.88
Uvbe Ozanogog	29	7.67	106	0.25	1.05	0.80	1.81
Idumukwu	26	6.53	57	0.09	0.36	0.27	1.27
Central Hospital	28	6.80	105	0.17	0.68	0.51	1.32
Lucky Irabor	27	7.01	62	0.08	0.31	0.23	1.41
Jodes	27	7.10	31	0.04	0.15	0.11	0.56

Average physical parameters of the borehole water samples during both seasons compared with W.H.O (2006) standard

The average values of the physical parameters compared with [14] standard was shown in Table 3. Temperature values (26°C-29°C) were within [14] standard (25°C-32°C). 93.33% of the pH values (6.40°C-7.97°C) were within [14] standard (6.5-8.5). Electrical conductivity values (68.5 µs/cm -233.5 µs/cm) were within [14] standard (1000µs/cm). Total suspended solids values were within the [14] acceptable standard, and total solids were within 500mg/l of [14] permissible limits. Dissolved solids (1.10-8.55mg/l) range were within 500mg/l of [14] permissible limits, while values were within the [14] acceptable standard. The physical parameters were analyzed using two-way analysis of variance on the data obtained showed that there was no significant difference($p < 0.2604$) between the various drinking water samples in both rainy and dry season.

Table 3: Comparison of the average values of physical characteristics of the borehole water samples during both seasons with(W.H.O) standard

Borehole Locations	Temperature (°C)	pH	EC (μs/cm)	Total Suspendedsolid (mg/l)	Total solid (mg/l)	Dissolved solid (mg/l)	Turbidity(NTU)
Oghonim	27.5	7.56	150	0.18	3.87	3.69	1.73
Aziken	28.5	6.8	170.5	0.15	1.79	1.64	1.75
Agholor	27.5	7.08	125.5	0.14	1.45	1.30	1.58
Aliagwu	28.5	7.97	133.5	0.18	3.29	3.11	1.55
Dein	26	6.41	68.5	0.02	1.5	1.47	0.94
Golden Cocktail	26.5	7.71	127	0.29	4.43	4.13	1.15
Police	26.5	6.97	120.5	0.34	2.21	1.87	1.45
Ewuru	27	7.1	87	0.07	1.18	1.10	1.26
Jim Ovia	29	7.31	223.5	0.71	9.26	8.55	1.99
Omumu	27.5	6.71	104.5	0.12	1.38	1.26	1.12
Uvbe Ozanogog	29.5	7.83	233.5	0.42	5.35	4.93	2.15
Idumukwu	27.5	6.95	127.5	0.22	2.42	2.2	1.38
Central Hospital	28.5	6.96	202.5	0.43	5.27	4.84	1.39
Lucky Irabor	28.5	7.51	138.5	0.23	4.04	3.80	1.85
Jodes	28	6.95	90.5	0.11	2.22	2.11	0.93
WHO (2006)	**25-32**	**6.5-8.5**	**1000**	**_**	**500**	**500**	**5**

DISCUSSION

Groundwater has been considered as a safe source of drinking water. However, nowadays, the quality of drinking water is deteriorating [15]. Groundwater exploitation is generally considered as the only realistic option for meeting dispersed rural and urban water demand. Due to inability of governments to meet the ever-increasing water demand, residents' resort to shallow wells etc as alternative water resources for domestic purposes. The effect of uncontrolled disposal systems and other bad sanitary practices in Agbor can render groundwater unsafe for human, agricultural and recreational use, hence, posing a threat to human life and is therefore against the principle of sustainable development. Therefore, the present study focuses on the seasonal evaluation of the physical parameters of some selected borehole water samples in Agbor, Delta State, Nigeria. The physical characteristics of the borehole water samples in Agbor varied and this may be attributed to varying degrees of improper sanitary conditions. The variations observed in the physicochemical properties of the borehole water samples carried out in Nigeria could be attributed to the influences of the micro-climatic, topographic and edaphic conditions in these areas within the country.

Temperature of an organism is defined as the level of hotness or coldness in the body of a living organism either in water or land. As water temperature increases, it holds less oxygen. These factors commonly result in less available oxygen in water. The temperature values observed in the well waters during the rainy and dry seasons ranged from 26oC-30oC (Table 1) and 250C to 290C (Table 2) respectively and were within [14] maximum containment level goal (250C- 320C). The average temperature values obtained from both seasons ranged from 260C to 290C as in (Table 3) and were within the WHO standard. The average values were similar to the report by [16] who also recorded a temperature range of 27oC-28oC from the borehole water samples in Awka Metropolis. The observed water temperatures in the rainy and dry are considered normal for use.

The pH is a measure of acidity or alkalinity of the water substances [17]. The pH of the water samples ranged from 6.42-8.76 during the rainy season (Table 1) and 6.27-7.65 in dry season (Table 2). The average pH values obtained from both seasons ranged from 6.40-7.97 as in (Table 3). 93.33% of the pH values were within the [14] standard of 6.5 to 8.5 [14]. The variation in pH of the water samples might be due to the site of sample collection. The results showed that the boreholes water pH values were satisfactory for drinking and domestic water usage. These findings were similar to the works presented by [18]. The high pH in the rainy season may be due to the presence of limestone in the aquifer formation that dissolved to release CaCO3 into the water. The low pH in the dry season may have been caused by high temperatures that increased the concentration of H+ ions, hence decreasing the pH of the borehole water. The sedimentary rocks are sources of Calcium ions which might have increased the pH of borehole water during rainy season.

Electrical conductivity is the ability of a solution to conduct an electrical current that is governed by the migration of ions in solutions which is dependent on the nature and numbers of the ionic species in that solution [19]. It is a useful tool to assess the purity of water. Conductivity indicates the presence of dissolved solids and contaminants especially electrolytes, but does not give inspiration about specific chemicals. The electrical conductivity of the water samples from the boreholes varied from 117-361 μS/cm during the rainy season, (Table 1) while it varied from 20-136 μS/cm during the dry season (Table 2). The mean conductivity during both seasons ranged from 68.5-233.5 μS/cm (Table 3). The conductivity of the water samples was within the acceptable standard for drinking water. These findings are similar to the work presented by [20] who stated that all the values obtained were below the [14], maximum permissible limit of 1000μS/cm for drinking water. The higher values obtained during the wet season could be ascribed to high concentrations of ionic constituents in the water bodies resulting from surface runoff into the ground water or attributed to the presence of organic matter pollution and run-off with high suspended matter content into the wells.

The total suspended solids (TSS) are made up of carbonates, bicarbonates, chlorides, phosphates and nitrates of metals such as calcium, magnesium sodium, potassium, magnesium as well as other particles. TSS affects the turbidity of water bodies [21]. The mean TSS values during both seasons ranged from 0.02-0.71 μS/cm (Table 3) and are within the WHO recommended limit, and therefore fit for domestic use. The values were below 31.3 mg/l to 55.0mg/l reported by [22] from groundwater samples in Abia State, which he attributed to high presence of suspended matters in his study area.

Total solids (TS) are a combination of dissolved solids and total suspended solids. The mean TS values during both seasons ranged from 1.18-9.26 µS/cm (Table 3) and are within the WHO recommended limit, and therefore fit for domestic purposes. The values were below 0.31 mg/l to 20.09 mg/l reported by [16] from hand-dug shallow well water samples in Awka Metropolis, which may be attributed to high presence of suspended matters because most of the wells were not covered which can bring about surface water infiltration.

Total Dissolved Solids (TDS) is an indication of the amount of dissolved substances. The mean TS values during both seasons ranged from 1.10-8.55 µS/cm (Table 3) and are within the WHO recommended limit, and therefore fit for domestic purposes. The values agreed with the work of [20], who stated that TDS values obtained were within the 500 mg/l maximum permissible limit [14]. This may be as a result less concentration of organic materials in the study areas.

Turbidity stems from the reduction of transparency due to the presence of percolate matter such as clay silt, finely divided organic matter etc. The turbidity imparted in the groundwater might be due to the suspended particles and undesirable substances [23]. The turbidity values obtained during the rainy season ranged from 1.31-2.49 NTU with that of dry season ranging from 0.55-1.87NTU. The average turbidity values for both seasons ranged from 0.93-2.15NTU (Table 3) and are within the W.H.O. standard of 5 NTU. These findings are similar to the work presented by [20] who stated that all the values obtained were within the [14], maximum permissible limit of 5 NTU for drinking water. However, the turbidity values were generally lower during the dry season. The increased values during the rainy season could be attributed to surface runoff and erosion carrying soil and partially dissolved/un-dissolved organic matters. The low recharge in the dry season may have resulted in lower turbidity of the borehole water. The physical parameters were analyzed using two-way analysis of variance on the data obtained which showed that there was no significant difference ($p < 0.2604$) between the various drinking water samples in both rainy and dry season.

CONCLUSION

The examination of the physical parameters of selected borehole water samples in Agbor, Delta State, Nigeria showed that all the values obtained were within the [14], maximum permissible limit of 5 NTU for drinking water. However, the turbidity values were generally lower during the dry season. The increased values during the rainy season could be attributed to surface runoff and erosion carrying soil and partially dissolved/un-dissolved organic matters. The low recharge in the dry season may have resulted in lower turbidity of the borehole water.

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