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Physicochemical and Microbial Assessment of Oguta Lake, Southeastern Nigeria

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Abstract:- The ease of accessing surface water bodies has made them susceptible to contamination especially by anthropogenic activities. Oguta Lake is one of such endangered surface water bodies, which is located between latitudes 05^0 40' – 05^0 44'N and longitudes 06^0 46' – 06^0 50'E. Twenty (20) samples of water and sediments were collected over two seasons and these samples were analyzed for physicochemical and microbial parameters using standard methods. The result of the physicochemical analysis for the water and sediment samples shows that most parameters were within the WHO acceptable limits in both seasons. However, phosphate, mercury and lead, were observed to be above the acceptable limits in the water while iron, lead and phosphate were observed to be above the acceptable limit in the sediment. Microbial analysis for total coliform, faecal coliform and total bacterial count in the water and sediments were also carried out and the results show that the total coliform and total bacterial count exceeded the value of 10cfu/ml and 10^{2}cfu/ml set by Standard Organization of Nigeria and World Health Organization respectively in most of the samples while indications of feacal contamination was observed in 50% of the analyzed water samples and feacal coliform count in 100% of the sediment samples were too few to count.

Keywords:- *Water Quality, Sediment Quality, Anthropogenic Activities, Oguta Lake, Nigeria.*

I. INTRODUCTION

Water is one of the most important and most precious natural resources on earth and it is essential in the life of all living organisms from the simplest plant and microorganisms to the most complex living system known as the human body. Water supply sources include groundwater, surface water, or rainwater and amongst these sources of water, surface water is the most prone to contamination. The effect of physicochemical parameters on the quality of surface water is a major environmental challenge in our society today(1) . Water is contaminated when natural processes or anthropogenic activities, alter the acceptable quality to the extent that its intended usage for commercial and domestic purposes is hampered(2). Water contamination is a global issue and the ease of accessing streams, rivers, and lakes has made them very susceptible to contamination, especially by anthropogenic activities. Surface water bodies are often associated with unprecedented forms of water contamination and Oguta Lake, which is the largest natural freshwater lake in southeastern part of Nigeria (3), is not an exception. Natural and anthropogenic activities around the lake affect its characteristics as well as its resource and usefulness. Hence, there is a need for the evaluation of the physical, chemical, and microbial properties of the water to ascertain its quality.

II. LOCATION OF THE STUDY AREA

Oguta Lake is located in Imo state and it is bounded by Latitudes 05^0 40' to 05^0 44'N and Longitudes 06^0 46' to 06^0 50'E, with an elevation of 50m above sea level. The lake occupies a surface area, which ranges between 1.8km^2 in dry season and 2.5km^2 during the peak of rainy season, with maximum and mean depths of 8.0m and 5.5m respectively (4). According to (3), the water covers 61.2% of the total surface area while the degraded portions covers the remaining 38.8%. The degraded portion includes areas under intense human activities (36.91%), areas covered by sediments (1.39%), and eutrophication (0.5%).

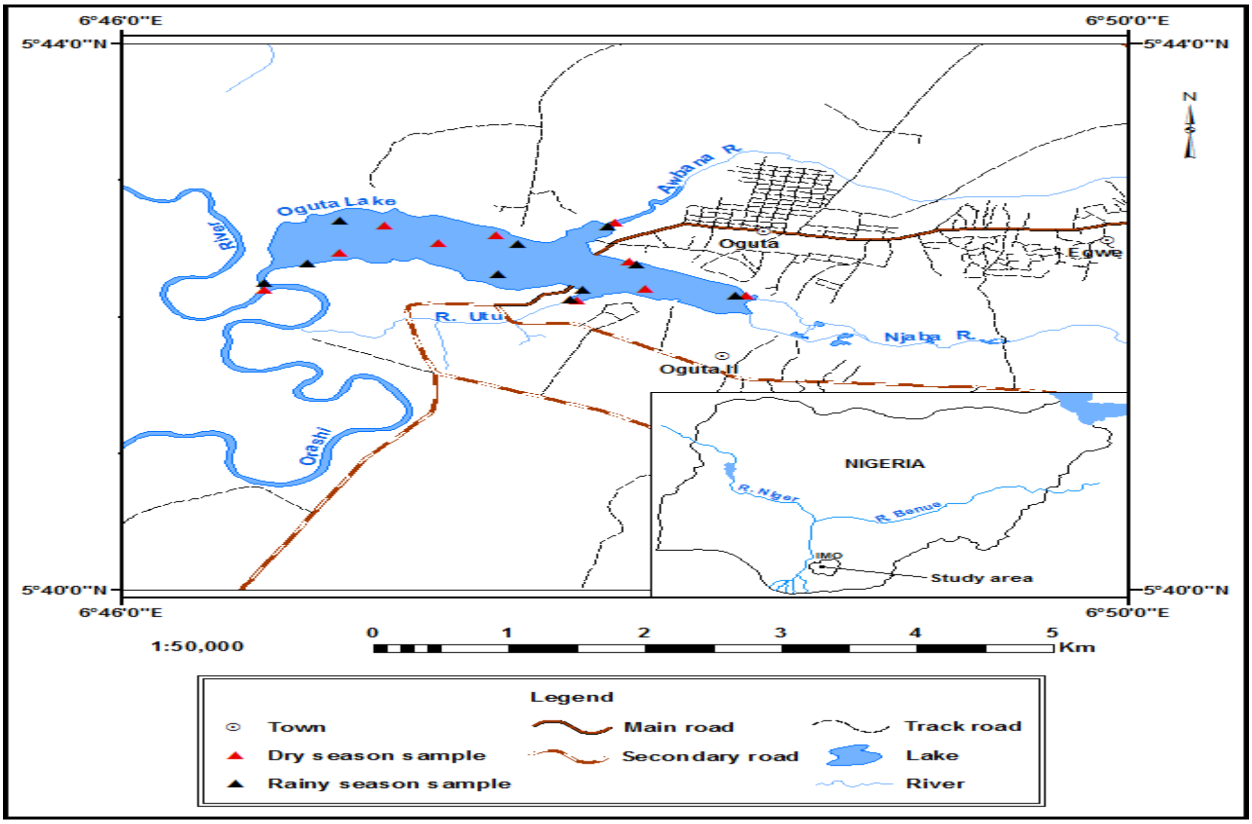

Fig. 1: Map of the study area showing the sampling location for both seasons

III. GEOLOGY AND HYDROGEOLOGY OF THE STUDY AREA

The study area lies within the Niger Delta basin, which consists of three lithostratigraphic units, which are the Akata, Agbada, and the Benin Formations respectively. Oguta Lake lies predominantly on the Benin Formation which consists of continental sands with lenses of clay/shale and some isolated units of gravel, conglomerate, and sandstones (5). The formation is Oligocene to recent in age (6). Four rivers (Njaba, Awbana, Utu and Orashi River) are associated with Oguta Lake (7) and these rivers play a significant role in its recharge. Njaba and Awbana Rivers discharges into the lake all year round, the perennial Utu Stream flows into lake during the rainy season while Orashi River flows past the lake in its southwestern portion. The total annual inflow from the rivers and stream is estimated to be 25,801.60m^3(3). The annual return and overland flow into the lake is also estimated to be 69,000m^3 and 138,000m^3 respectively while the annual recharge of the lake from precipitation is about 693, 000m^3(8). The annual groundwater inflow into the lake is also estimated at 2,750,400m^3(3). These statistics show that Oguta Lake is adequately recharged all the year round.

IV. MATERIALS AND METHODS

A. Sample size and sampling procedure

Twenty (20) samples each of water and sediment were collected in both dry and rainy seasons. The water samples were collected in one-liter plastic sample bottles. The bottles were rinsed three times using the lake water before collecting the samples. After collection, the sample bottles were corked immediately underwater to prevent oxidation. Each sample was properly labeled at the point of collection and stored in a cool box with ice cubes and transported to the laboratory for analysis.

B. Physicochemical Analysis

The collected samples were analyzed for various physicochemical parameters using standard methods (9). Distilled water was used in the preparation of solutions and rinsing of all equipment after testing each sample. In-situ measurements of electrical conductivity, dissolved oxygen, pH, and turbidity was carried out using an EC meter (HI-99300), DO meter (JENWAY-3405), pH meter (HI-991300), and turbidity meter (D-336444) respectively. Ion-selective electrode method was used to determine nitrate using the ion meter JENWAY-3345, Ultraviolet-visible spectrophotometer PO-3000UV was used to analyze phosphate, flame photometer was used to analyze sodium and potassium, Argentometric method was used to determine chloride, volumetric titration against ethylenediamine tetra-acetic acids (EDTA) was used for total hardness, magnesium and calcium ions and volumetric titration method was used to analyze total alkalinity.

C. Microbiological analysis

The determination of total bacteria, total coliform, and faecal coliform in water and sediment was done using the membrane filtration technique.

D. Statistical Analysis

Descriptive statistics (such as mean and standard deviation) were performed on all the data.

V. RESULTS AND DISCUSSION

A. Physicochemical analysis of water

Physicochemical analysis of the water samples from the study area was carried out to determine the various concentrations of the parameters for both dry and rainy season and the results are presented in Table 1.

	Dry Season			Rainy Seaso			
Parameters	**Minimum**	**Maximum**	**Mean ± SD**	**Minimum**	**Maximum**	**Mean ± SD**	**WHO**
pH	6.51	6.95	6.71±0.12	6.51	6.96	6.74±0.15	6.5 – 8.5
Turbidity NTU	0.40	20.60	3.97±6.52	0.80	23.30	4.79±7.44	5
Conductivity µS/cm	12.00	104.70	78.03±35.81	10.60	105.80	78.75±36.51	500
Acidity mg/l	2.50	8.75	5.63±1.79	4.50	8.70	5.83±1.34	
Hardness mg/l	8.00	20.00	13.50±7.04	6.80	32.00	13.60±7.88	200
Alkalinity mg/l	7.50	137.50	73.25±32.38	7.20	136.50	71.87±32.34	200
Chloride mg/l	27.00	37.00	32.25±3.55	24.80	36.40	30.82±3.79	200
Nitrate mg/l	8.93	18.44	12.76±2.70	8.63	15.46	12.29±2.06	50
Phosphate mg/l	0.22	42.00	14.16±12.78	0.24	41.80	14.53±12.56	0.05
Sulphate mg/l	58.64	111.23	71.73±15.70	60.54	118.25	74.75±16.53	250–500
Magnesium mg/l	0.10	0.26	0.15±0.05	0.10	0.27	0.15±0.05	150
Sodium mg/l	0.00	0.01	0.004±0.004	0.001	0.03	0.03±0.06	200
Potassium mg/l	2.09	3.10	2.45±0.36	2.08	3.19	2.49±0.39	50
Calcium mg/l	2.09	4.90	3.48±0.88	2.07	4.90	3.49±0.90	75
Bicarbonate mg/l	73.20	167.75	97.91±27.10	72.0	165.75	95.87±27.55	250
Carbonate mg/l	36.00	82.50	48.15±13.63	33.50	80.20	46.75±13.62	
TSS mg/l	2.20	19.60	5.44±5.55	2.70	20.60	6.21±5.58	<30
TS mg/l	16.00	147.00	43.90±43.02	18.00	148.00	45.50±42.93	
TDS mg/l	7.60	127.40	38.46±38.90	7.80	128.40	38.98±39.15	500
COD mg/l	151.20	728.00	493.22±187.07	155.20	758.00	509.03±187.94	
BOD mg/l	70.00	210.00	99.80±45.53	72.00	211.00	102.01±45.08	
OD_1 mg/l	16.30	29.10	21.85±4.64	16.50	29.50	22.02±4.66	
OD_2 mg/l	12.20	22.60	17.10±3.31	12.40	22.80	17.26±3.36	
Zinc mg/l	0.00	0.08	0.03±0.02	0.00	0.09	0.03±0.02	5
Nickel mg/l	0.00	0.01	0.01±0.002	0.001	0.01	0.006±0.002	0.07
Copper mg/l	0.00	0.002	0.0005±0.001	0.00	0.1	0.0019±0.003	1.5
Iron mg/l	0.00	0.02	0.01±0.01	0.004	0.03	0.02±0.007	0.3
Cobalt mg/l	0.00	0.003	0.0007±0.001	0.00	0.01	0.0025±0.003	0.05
Manganese mg/l	0.002	0.01	0.0066±0.003	0.003	0.015	0.008±0.004	0.4
Aluminum mg/l	0.00	0.02	0.0053±0.01	0.00	0.03	0.0115±0.01	0.05
Lead mg/l	0.16	0.27	0.23±0.04	0.16	0.27	0.22±0.04	0.01
Cadmium mg/l	0.00	0.00	0.00	0.00	0.00	0.00	0.05
Mercury mg/l	0.01	0.03	0.0241±0.01	0.018	0.061	0.03±0.01	0.006
Chromium mg/l	0.00	0.02	0.0064±0.01	0.00	0.025	0.01±0.01	0.05
Arsenic mg/l	0.00	0.00	0.00	0.00	0.00	0.00	0.01
Silver mg/l	0.00	0.002	0.0002±0.001	0.00	0.002	0.0002±0.001	0.07

Table 1: Physicochemical parameters of water samples and their concentration in dry and rainy season

The results show clearly the various concentrations of physicochemical parameters in the water samples in both dry and rainy seasons. From the results, most of the evaluated physicochemical parameters were within the WHO acceptable limits except for phosphate, mercury, and lead, which were observed to be above the acceptable limit in both seasons. The concentration of phosphate ranges between 0.22mg/l to 42mg/l in the dry season, and 0.24mg/l to 41.80mg/l in the rainy season, with a mean value of 14.16±12.78mg/l and 14.53±12.56mg/l respectively. This high concentration of phosphate can be attributed to the use of detergents and runoff from fertilized agricultural farmlands, since various domestic and agricultural activities take place within and around the lake respectively. The concentration of mercury ranges between 0.01mg/l to 0.03mg/l in the dry season, and 0.018mg/l to 0.061mg/l in the rainy season, with a mean value of 0.02±0.01mg/l and 0.03±0.01mg/l respectively. This concentration is above the acceptable limit in both seasons. Lead is both a toxic and non-essential metal, which has no nutritional value to living organisms(1) and the observed value of lead in the study was high in both seasons, with values ranging from

0.16mg/l to 0.27mg/l in the dry season and 0.16mg/l to 0.27mg/l in the rainy season. The high concentration of lead and mercury corresponds with the work of (10), where it was observed that lead and mercury concentrations were higher than the WHO acceptable limit in the upstream and downstream parts of Njaba River and they attributed these high concentrations to be from anthropogenic activities around the area. From the result of their study, the Njaba River may have largely contributed to the high concentration of these heavy metals in Oguta Lake.

According to (11), turbidity levels are dependent on the amount of suspended particles present in the water and suspended particles act as a substrate for microorganisms in the water, thus promoting growth of the microbial populations. High turbidity level is often associated with higher level of disease-causing microorganisms such as bacteria and other parasites. Turbidity values in this study range between 0.4NTU - 20.6NTU in the dry season and 0.8NTU - 23.3NTU in the rainy season. Natural and anthropogenic inputs of sediments and dissolved organic matter can result in increased turbidity. Thus, the highest value of turbidity in both seasons was recorded for the samples collected at the confluence between the lake and Orashi River as well as the confluence between the lake and the Utu Stream. These high values can be attributed to the sand dredging activity that is taking place at the confluence of the Utu stream and the influx of allochthonous organic materials (Kadiri, 1999) received by the lake during the rainy season.

The values of pH range between 6.50 - 6.98 in the dry season and 6.51 – 6.96 in the rainy season, with mean values of 6.71±0.12 and 6.74±0.15 respectively. The hydrogen ion concentration (pH) in both seasons were within the WHO acceptable limit and the range for inland waters (6.5 – 8.5), as reported by Antoine and Al-Saadi, (1982). (13) reported that pH range of 6.09 - 8.45 as being ideal for supporting aquatic life including fish. The electrical conductivity (EC) of a water body is a very useful parameter for determining the water quality. Jayalakshmi *et al.*, (2011) reported that electric conductivity is a measurement of water's current and is directly related to the concentrations of ionized substance in the water and the levels affected by the EC of water are a direct function of its total dissolved solids, organic compounds and temperature. Electrical conductivity values range between 12μs/cm - 104.7μS/cm in the dry season and 10.6μS/cm - 105.8μS/cm in the rainy season, with mean values of 78.03±35.818μS/cm and 78.75±36.518μS/cm respectively and these values are within the WHO acceptable limit in both seasons. The conductivity of water is a useful and accessible indicator of its salinity or total salt content and the relatively low conductivity values observed in this study may be attributed to low concentrations of chloride, sulphate and TDS, which are indicators of lower salt content (14).

Acidity, alkalinity and total hardness values in this study range between 2.50mg/l – 8.75mg/l, 7.70mg/l - 137.50mg/l, and 8mg/l – 20mg/l respectively in the dry season, with mean values of 5.63±1.798mg/l, 73.25±32.388mg/l and 13.50±7.048mg/l, while the rainy season values range between 4.50mg/l - 8.70mg/l, 7.20mg/l - 136.50mg/l, and 6.80mg/l – 32.00mg/l respectively, with mean values of 5.83±1.34mg/l, 71.87±32.34mg/l, and 13.60±7.88mg/l. These observed values are within the acceptable limit in both seasons. The alkalinity values agree with the findings from (15), who had a similar report. Hardness is a related measure used in evaluating water quality and it refers to the calcium and magnesium salts combined with the bicarbonate/carbonate and other ions which compensate for acidity(1). The higher total hardness level observed in the rainy season could be due to a higher concentration of calcium and magnesium and the utilization of these ions by organisms must have caused the decrease in the concentration of the total hardness in the dry season (16).

Chloride is one of the most important parameters that is used to assess water quality and its concentration in this study range between 27.00mg/l – 37.00mg/l in the dry season and 24.80mg/l – 36.40mg/l in the rainy season with mean values of 32.25±3.55mg/l and 30.82±3.79mg/l respectively. The values of nitrate range between 8.91mg/l - 18.443mg/l in the dry season and 8.63mg/l - 15.46mg/l in the rainy season, with mean values of 12.76±2.708mg/l and 12.29±2.068mg/l respectively. This shows that a higher values of nitrate was observed in the dry season than in the rainy season and this is in agreement with (17) who concluded that nitrates are usually built up during dry seasons and that high levels of nitrates are only observed during early rainy seasons. This is because initial rains flush out deposited nitrate from near-surface soils and nitrate level reduces drastically as rainy season progresses. Sulphate is a stable, highly oxidized, soluble form of Sulphur (18), which is generally present in water and its values range between 58.64mg/l - 111.23mg/l in the dry season and 60.54mg.l - 118.25mg/l in the rainy season, with mean values of 71.73±15.708mg/l and 74.75±16.538mg/l respectively. Higher sulphate values were recorded in the rainy season than in the dry season and this corroborates the findings of(19)in Imo River Estuary where a similar trend was observed.

Calcium and magnesium are directly related to hardness and their values range between 2.09mg/l - 4.89mg/l and 0.10mg/l - 0.26mg/l respectively in the dry season, with mean values of 3.48±0.88 mg/l and 0.15±0.05mg/l respectively while the values range between 2.07mg/l - 4.90mg/l and 0.10mg/l - 0.27mg/l respectively in the rainy season, with mean values of 3.49±0.908mg/l and 0.15±0.058mg/l. The values of sodium and potassium in dry season ranges between 0mg/l – 0.01mg/l and 2.10mg/l - 3.10mg/l, with mean values of 0.004±0.0048mg/l and 2.45±0.368mg/l respectively. In the rainy season, the values range between 0.001mg/l - 0.03mg/l and 0.10mg/l - 0.27mg/l respectively, with mean values of 0.03±0.068mg/l and 2.49±0.398mg/l. Carbonate and bicarbonate values range between 36mg/l – 82.50mg/l and 73.20mg/l - 167.75mg/l respectively in the dry season, with mean values of 48.15±13.638mg/l and 97.91±27.108mg/l. In the rainy season, the values range between 33.50mg/l – 80.20mg/l and 72mg/l - 165.75mg/l respectively, with mean values of 46.75±13.62mg/l and 95.87±27.55mg/l.

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Biochemical oxygen demand (BOD) is a measure of the quantity of oxygen used by microorganisms (e.g., aerobic bacteria) in the oxidation of organic matter. The values of BOD obtained from this study range between 70mg/l – 210mg/l in the dry season, with a mean value of 99.80±45.53mg/l while the values in the rainy season range between 72mg/l – 211mg/l, with a mean value of 102.01±45.08mg/l. In this study, BOD was found to be higher in the rainy season compared to the dry season and this can be ascribed to the input of decaying organic matter from surface runoff during the rains. This is also reflected in the findings of (20) and (21). Chemical oxygen demand (COD) is used as a measure of the oxygen equivalent of the organic matter content of a sample that is susceptible to oxidation by strong chemical oxidant. COD values ranges between 151.20mg/l – 728mg/l in the dry season, with mean value 493.22±187.07mg/l while the values in the rainy season range between 155.20mg/l – 758mg/l, with a mean value of 509.03±187.94mg/l. The observed COD values in both seasons can be attributed to the high rate of organic decomposition resulting from human activities around the lake and this negatively impacts on the water quality.

The values for total solids (TS), Total suspended solids (TSS) and total dissolved solids (TDS) range between 16mg/l – 147mg/l, 2.20mg/l – 19.60mg/l, and 7.60mg/l - 127.40mg/l respectively in the dry season, with mean values of 43.90±43.028mg/l, 5.44±5.558mg/l and 38.46±38.908mg/l while in the rainy season, the values ranges between 18mg/l – 148mg/l, 2.70mg/l – 20.60mg/l, 7.80mg/l - 128.40mg/l respectively, with mean values of 45.50±42.93mg/l, 6.21±5.58mg/l and 38.98±39.15mg/l. The values were slightly higher in the rainy season than in the dry season - a phenomenon common in most inland waters. This could be attributed to the fact that during the rainy season, more run-offs and allochthonous materials are washed into the lake. The suspended solids may settle out on the surface of the lake and thus, impede the growth of living organisms and silting up the water body. The higher values of TDS in the rainy season is in agreement with the findings of(20)where higher TDS values were observed during the wet season and it was attributed to increased precipitation and subsequent runoff from surrounding lands.

Cadmium and arsenic were not observed in the samples for both seasons while chromium and silver range between 0mg/l - 0.019mg/l and 0 – 0.002mg/l in the dry season with mean values of 0.0064±0.01mg/l and 0.0002±0.001mg/l respectively. In the rainy season, the values range between 0mg/l – 0.025mg/l and 0mg/l – 0.002mg/l, with mean values of 0.0082±0.01mg/l and 0.0002±0.001mg/l. These values are within the WHO acceptable limits in both seasons. The various concentrations of some physicochemical parameters in dry and rainy seasons are presented in fig 2 below:

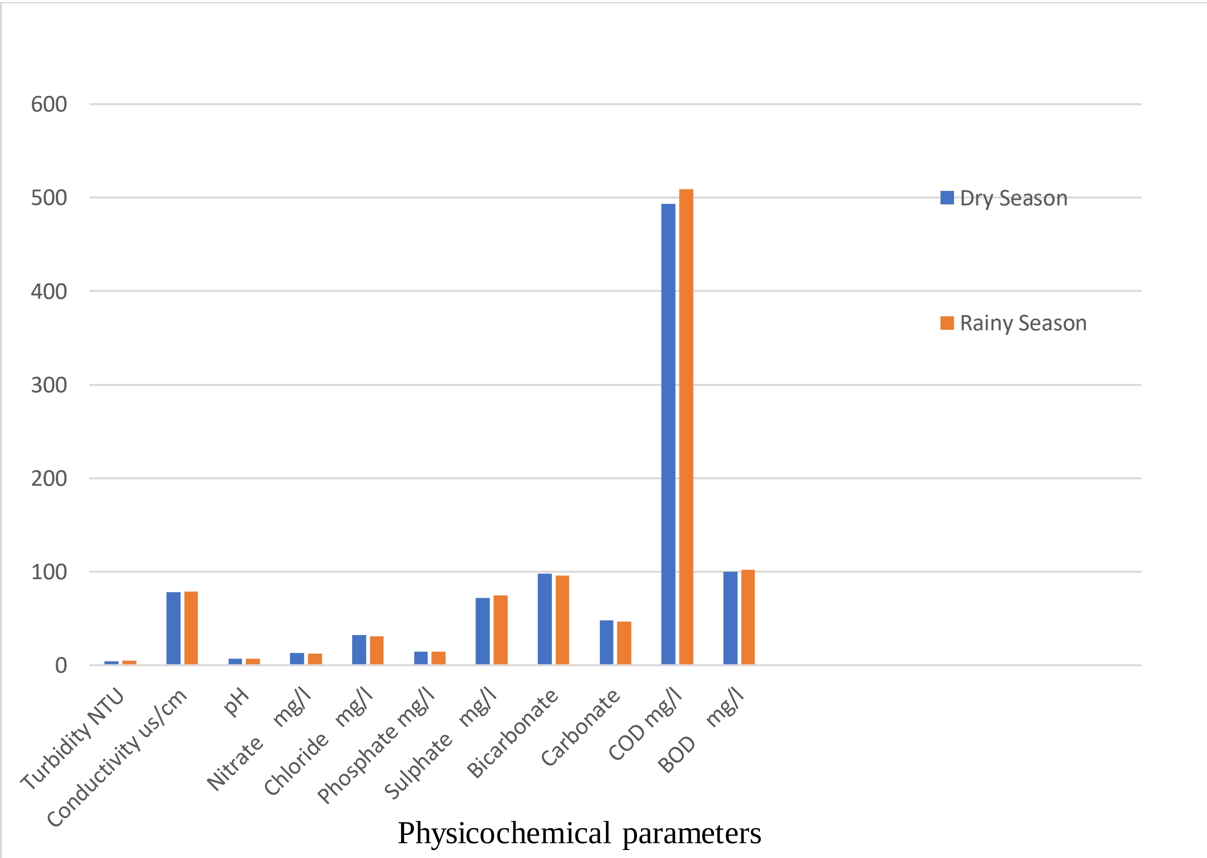

Fig. 2: The concentration of some physicochemical parameters in the water for dry and rainy seasons

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The mean concentrations of major cations and anions in the water for dry and rainy season are Ca^{2+}(3.48±0.88 and 3.49±0.90), Mg^{2+}(0.15±0.05 and 0.15±0.05), Na^{+}(0.004±0.004 and 0.03±0.06) and K^{+}(2.45±0.36 and 2.49±0.39) for cations while anions have mean values of (97.91±27.10, 95.87±27.55), (71.73±15.70, 74.75±16.53), (48.15±13.63, 46.75±13.62) and (32.25±3.55, 30.82±3.79) for HCO_3^-, SO_4^{2-}, CO_3^{2-} and Cl^- respectively. These results revealed that they are all within acceptable limits in both season and thus, their concentrations follow the trend, Ca^{2+} > K^{+}> Mg^{2+}> Na^{+} (*Fig. 3*) and HCO_3 >SO_4^{2-}> CO_3^{2-}> Cl^- (*Fig 4*) for cations and anions respectively.

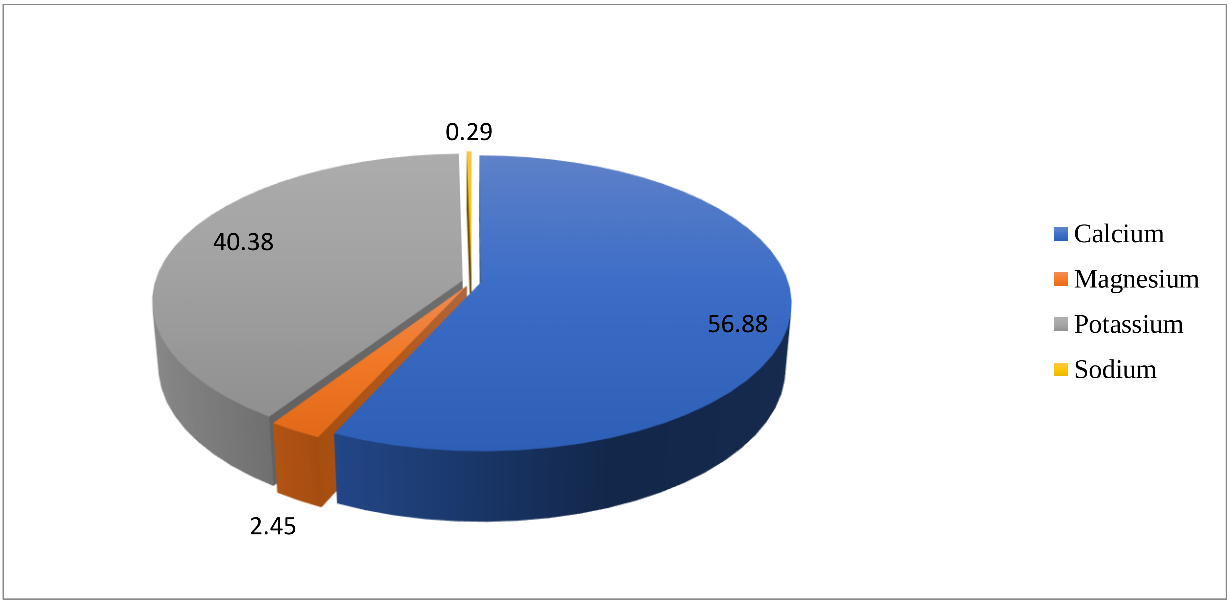

Fig 3: The relative abundance of cations in Oguta Lake

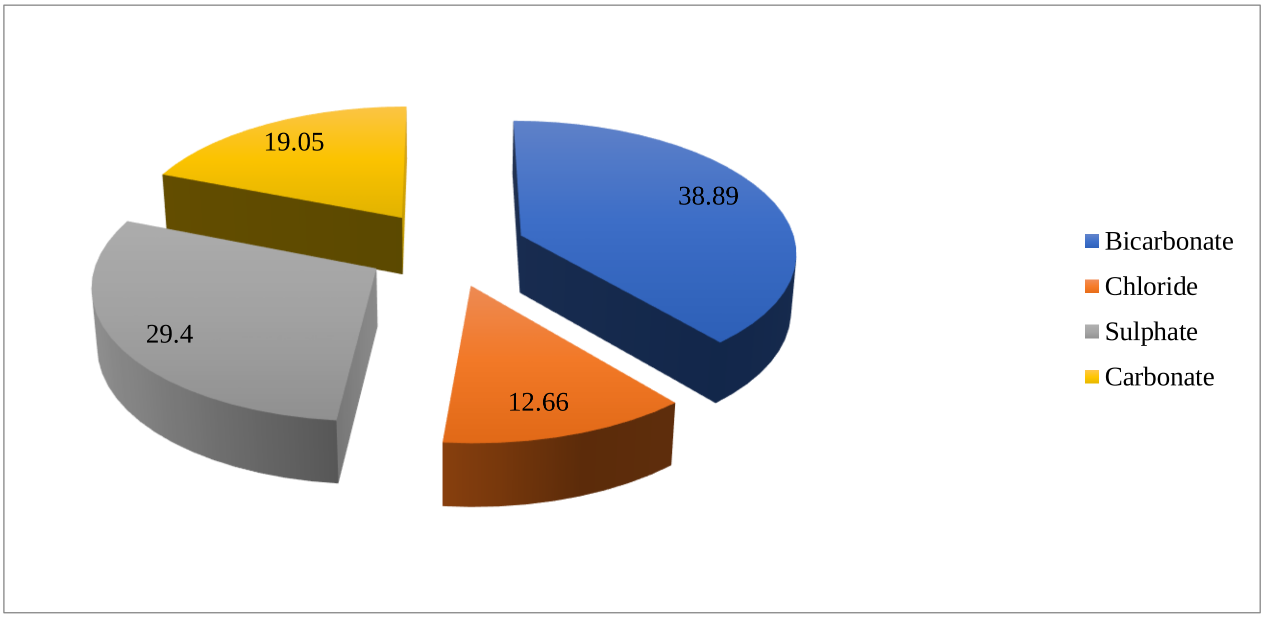

Fig. 4: The relative abundance of anions in Oguta Lake

B. Physicochemical analysis of Sediments

Physicochemical analysis of the sediment samples from the study area was also carried out and the results are presented in Tables 2.

	Dry Season			Rainy Season			
Parameters	**Minimum**	**Maximum**	**Mean ± SD**	**Minimum**	**Maximum**	**Mean ± SD**	**WHO**
pH	6.71	6.96	6.846±0.12	6.62	7.5	6.74±0.15	6.5 – 8.5
Conductivity µS/cm	112.6	309.6	222.29±68.27	115.6	306.8	225.09±67.62	500
Acidity mg/kg	5.25	20.25	10.925±5.22	4.25	22.25	10.501±5.35	
Hardness mg/kg	7.8	14	10.06±2.28	5.4	13.5	9.37±2.59	200
Alkalinity mg/kg	7.5	137.5	73.25±32.38	7.2	136.5	71.87±32.34	200
Chloride mg/kg	27.5	52.5	41±9.66	28	55.5	42.08±9.12	200
Nitrate mg/kg	13	21.14	16.188±2.76	10	22.15	15.921±3.46	50
Phosphate mg/kg	3.39	52.45	17.975±15.80	3.82	55.45	18.519±16.63	0.05
Sulphate mg/kg	60.78	103.03	81.637±17.43	61.58	103.33	82.228±16.97	250–500
Magnesium ppm	0.990	2.259	1.4934±0.36	1.168	2.55	1.622±0.39	150
Sodium ppm	0.005	0.34	0.1116±0.12	0.015	0.348	0.1236±0.13	200
Potassium ppm	4.446	9.877	6.479±1.61	4.848	9.87	6.8179±1.66	50
Zinc ppm	0.350	3.068	0.9529±0.89	0.352	3.168	1.0011±0.91	5
Nickel ppm	0.007	0.019	0.0131±0.004	0.002	0.019	0.0136±0.005	0.1
Copper ppm	0.00	0.028	0.0088±0.01	0.005	0.038	0.0124±0.01	1.5
Iron ppm	0.073	1.941	1.1817±0.61	0.075	1.962	1.1911±0.60	0.3
Cobalt ppm	0.00	0.010	0.0053±0.004	0.002	0.01	0.007±0.003	0.05
Manganese ppm	0.007	0.169	0.0356±0.05	0.005	0.048	0.0423±0.05	0.4
Aluminum ppm	0.109	0.967	0.514±0.28	0.118	0.959	0.5467±0.28	0.05
Lead ppm	0.026	0.190	0.1149±0.06	0.028	0.210	0.1269±0.06	0.01
Cadmium ppm	0.00	0.00	0.00	0.00	0.00	0.00	0.05
Mercury ppm	0.015	0.152	0.0364±0.04	0.012	0.180	0.0384±0.05	0.006
Chromium ppm	0.00	0.009	0.003±0.004	0.00	0.019	0.0064±0.01	
Arsenic ppm	0.00	0.022	0.0067±0.01	0.00	0.028	0.0087±0.01	0.01
Silver ppm	0.00	0.027	0.0044±0.01	0.00	0.042	0.0101±0.01	0.07
% Sand	76.834	88.024	82.0569±6.83	64.802	88.524	80.5994±6.98	
% Silt	6.804	30.048	12.7094±7.04	6.304	31.048	13.3862±7.12	
% Clay	2.082	8.15	5.0914±2.12	2.312	8.734	6.0144±2.12	
Bulk density g/ml	1.229	1.433	1.3135±0.06	1.249	1.420	1.3298±0.06	

Table 2: Physicochemical parameters of sediment samples and their concentrations in dry and rainy season

From the results, most of the physicochemical parameters were within the WHO acceptable limits in both seasons except for iron, lead, mercury and phosphate. The high concentrations of phosphate, mercury and lead in the sediment correspond with what was observed in the water samples. The value of phosphate ranges between 3.39mg/l to 52.45mg/l in the dry season and 3.82mg/l to 55.45mg/l in the rainy season, with a mean value of 17.98±15.80mg/l and 18.52±16.63mg/l respectively. The concentration of lead on the other hand, ranges from 0.03mg/l to 0.19mg/l in the dry season and 0.03mg/l to 0.21mg/l in the rainy season, with a mean value of 0.1149±0.06 and 0.1269±0.06 respectively. Mercury values range between 0.015mg/l – 0.152mg/l in the dry season and 0.012mg/l – 0.18mg/l in the rainy season with mean values of 0.0364±0.04mg/l and 0.04±0.05mg/l respectively. The concentration of iron in the sediment ranges between 0.07mg/l to 1.94mg/l in the dry season and 0.08mg/l to 1.96mg/l in the rainy season, with a mean concentration of 1.18±0.61mg/l and 1.19±0.6mg/l respectively. Iron (Fe) is one of the most abundant and common elements in the Earth's crust and this could be a reason for the high iron concentration in the sediment. This high concentration of iron corresponds with study of (22) in the study area, where iron concentration was also found to be above National Environmental Standard and Regulation Enforcement Agency (NESREA) recommended limit for aquatic life. They noted that the channeling of Oguta town drainage system into the lake might have contributed to the high concentration of iron as runoffs from corroded roofs are drained into the lake.

The values of pH in the sediment range between 6.71 - 6.96 in the dry season and 6.62 - 7.50 in the rainy season, with a mean value of 6.85±0.12 and 6.74±0.15 respectively. The pH values are in conformity with the WHO stipulated limits for domestic water purposes. Electrical conductivity values range between 112.60µS/cm - 309.60µS/cm in the dry season and 115.6µS/cm - 306.8µS/cm in the rainy season, with mean values of 222.29±68.278µS/cm and 225.09±67.628µS/cm respectively. Electrical conductivity values in the sediment exceed the values observed in the water sample in all the samples in both season and this can be attributed to the fact that in a water body, sediments contain more electrolytes than the water. Nitrate values in the dry season ranges between 13mg/kg - 21.14mg/kg, with a mean value of 16.19±2.76mg/kg while in the rainy season, the values range between 10mg/kg - 22.15mg/kg, with mean values of 15.921±3.46mg/kg.

The mean values of major cations and anions in the sediments for dry and rainy season are Mg^{2+}(1.49±0.36 and 1.62±0.39), Na^{+}(0.11±0.12 and 0.12±0.13) and K^{+}(6.48±1.61 and 6.82±1.66) for cations while anions values are SO_4^{2-} (81.64±17.43, 82.23±16.97) and Cl^{-} (41±9.66, 42.08±9.12). This results on major cations and anions revealed that they were all within acceptable limit. Thus, the concentration of major cations and anions follows the trend, K^{+}> Mg^{2+}> Na^{+} and SO_4^{2-}> Cl^{-} respectively.

The mean values for zinc, nickel, copper, iron, cobalt, manganese and Aluminum are 0.95±0.89, 0.01±0.004, 0.0088±0.01, 1.18±0.61, 0.0053±0.004, 0.04±0.05 and 0.51±0.28 respectively in the dry season while the mean values in the rainy season are 1.0011±0.91, 0.0136±0.005, 0.0124±0.01, 1.19±0.60, 0.007±0.003, 0.04±0.05 and 0.55±0.28 respectively. These values are all within the WHO acceptable limits in both seasons. The various concentrations of some physicochemical parameters in dry and rainy seasons in sediment are presented in fig 4.4 below

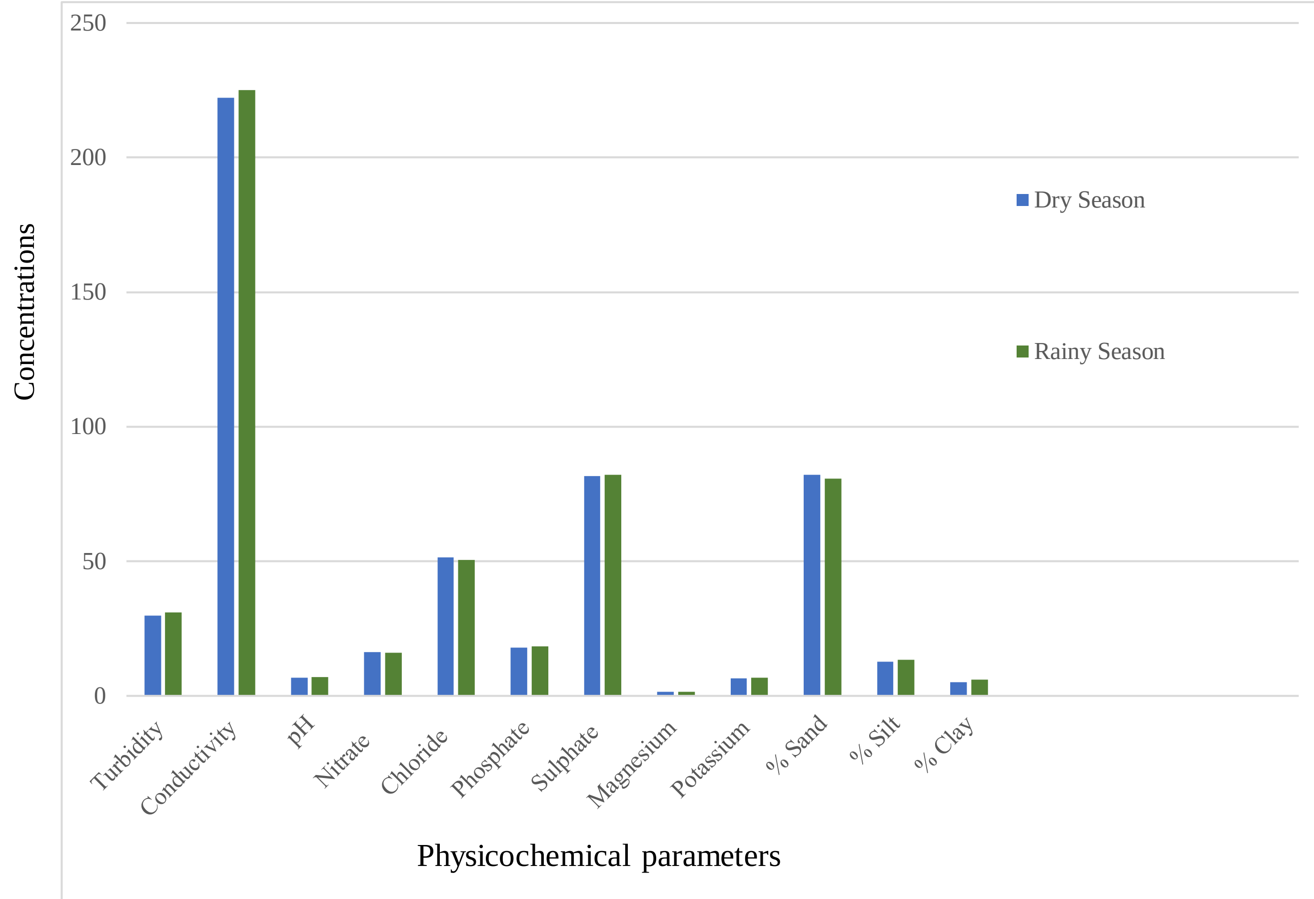

Fig. 5: The concentration of some physicochemical parameters in the sediments for dry and rainy seasons

The mean values of the particle size distribution of the sediments obtained from the lake for both seasons are (sand 82.10%, silt 12.70% and clay 5.10%) and (sand 80.60%, silt 13.40% and clay 6%) for dry and rainy seasons respectively. This high percentage of sand shows that sand is the main geologic material in the study area. Particle size plays an important role in nutrient accumulation in the sediments because fine-grained particles often have greater surface to volume ratio and more organic matter (23); (24).

C. Microbial analysis of water and sediment

The sources of microbes in water are human and animal excreta, although there are other sources that may also be significant(25). The detection of each pathogenic organism in water is technically difficult, time consuming and expensive and therefore, not used for routine water testing procedures. Instead, indicator organisms are routinely used to access the microbiological quality of water and provide an easy, rapid and reliable indication of the microbiological quality of water. Thus, the presence of coliform in water is taken, as an indication of the presence of pathogenic organisms and the most commonly used coliform organisms are total coliform and faecal coliform. The microbial analysis of the water and sediment samples were carried out to determine the total coliform count, faecal (thermotolerant) coliform and total bacteria count and the result is presented in Table 3.

	Water Sample			Sediment Sample		
	TC	**FC**	**TB**	**TC**	**FC**	**TB**
S1	20	3	$5.0x10^5$	$4.70x10^5$	TFTC	$2.53x10^6$
S2	50	8	$1.56x10^6$	$4.10x10^5$	TFTC	$2.31x10^6$
S3	Nil	Nil	TFTC	$2.10x10^5$	TFTC	$1.76x10^6$
S4	22	4	$7.0\ x10^5$	$1.90x10^5$	TFTC	$1.52x10^6$
S5	2	Nil	$5.3x10^5$	TFTC	TFTC	$9.20x10^5$
S6	10	1	$2.3x10^4$	TFTC	TFTC	$1.06x10^6$
S7	1	Nil	TFTC	TFTC	TFTC	$6.50x10^5$
S8	27	4	$1.45\ x10^6$	$3.90x10^5$	TFTC	$2.22x10^6$
S9	3	Nil	TFTC	TFTC	TFTC	$2.09x10^6$
S10	8	Nil	$1.9x10^4$	$1.70x10^5$	TFTC	$2.53x10^6$

Table 3: Microbial analysis of water and sediment

TFTC = Too few to count, TCC = Total Coliform Count, FCC = Feacal Coliform Count, TBC = Total Bacteria Count

Total coliform count was observed in 90% of water samples and the values ranged from 1cfu/100ml to 50cfu/100ml, with the exception of S3 in which no coliform count was detected. The presence of Faecal (thermotolerant) coliform nearly always indicates faecal contamination and more than 95 per cent of thermotolerant coliforms isolated from water are the gut organism Escherichia coli, the presence of which is definitive proof of faecal contamination (WHO, 2008). Faecal coliform was observed in 50% of the water samples with values ranging between 1cfu/100ml to 8cfu/100ml. The observed faecal coliforms in the water samples S1, S2, S4, S6 and S8 are indication of possible faecal contamination, which may have been contributed by runoffs from agricultural lands where animal manures are used as fertilizer while the zero faecal count observed in samples S3, S5, S7, S9 and S10 can be attributed to the relatively low anthropogenic activities taking place in these areas.Total bacterial count was observed in 80% of the water samples and the values ranged from $1.9x10^4$cfu/ml to $1.56x10^6$cfu/ml, with sample S2 having the highest count and sample S10 with the lowest count. Samples S3 and S9 were too few to count because they do not have a statistically significant number of colonies; hence, no bacteria count was recorded for both samples. The observed values for total bacteria in 80% of the water samples exceeded the value of 10^2cfu/ml recommended by World Health Organization.

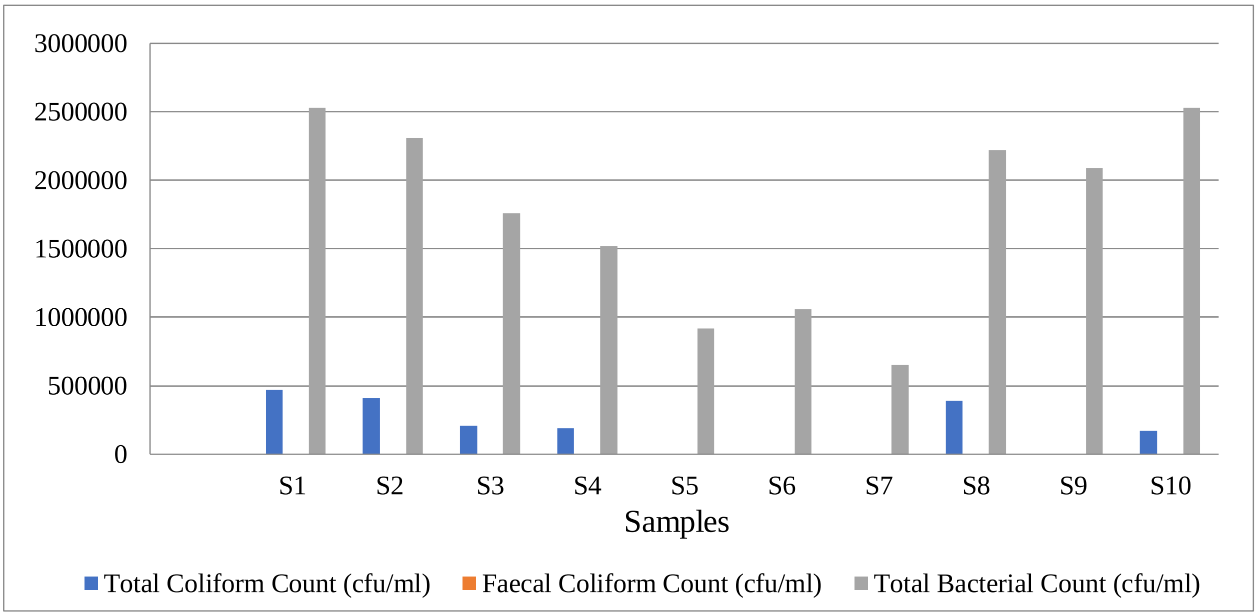

Fig. 6: Microbial contamination in water samples

The total coliform count was observed in 60% of the sediment and the values ranged between 1.70 x 10^5 to 4.7 x 10^5, with the exception of samples S5, S6, S7, and S9 that were too few to count (TFTC). The observed values for total coliform exceed the limit of 10cfu/ml specified by Standard Organization of Nigeria.Faecal coliforms were too few to count in all the samples because they do not have a statistically significant number of colonies while the total bacteria count was recorded in 100% of the samples and the values ranged between 6.50x10^5cfu/ml and 2.53x10^6cfu/ml, with sample S1and S10 having the highest count and sample S7 with the lowest count. These values show that the bacteria counts exceeded the value of 10^2cfu/ml recommended by World Health Organization. The observed values of total bacteria, total coliform and faecal coliform (water) in the samples indicate that the water is unfit consumption.

VI. CONCLUSION

This study assessed the physicochemical properties of the water and sediment in the study area for both dry an rainy season, as well as its microbial content and the result shows that almost all the evaluated physicochemical parameters for water and sediment in both seasons were within the acceptable limit except for phosphate, mercury and lead in the water samples and phosphate, mercury, lead, and iron in the sediment samples. The result of the microbial assessment shows that the bacteria counts exceeded the value of 10^2cfu/ml recommended by World Health Organization while most of the samples exceeded the limit of 10cfu/ml specified by Standard Organization of Nigeria for total coliform in both water and sediments. There were also indications of faecal contamination in the water and as such, the water is unfit for human consumption and therefore requires adequate treatment before use.

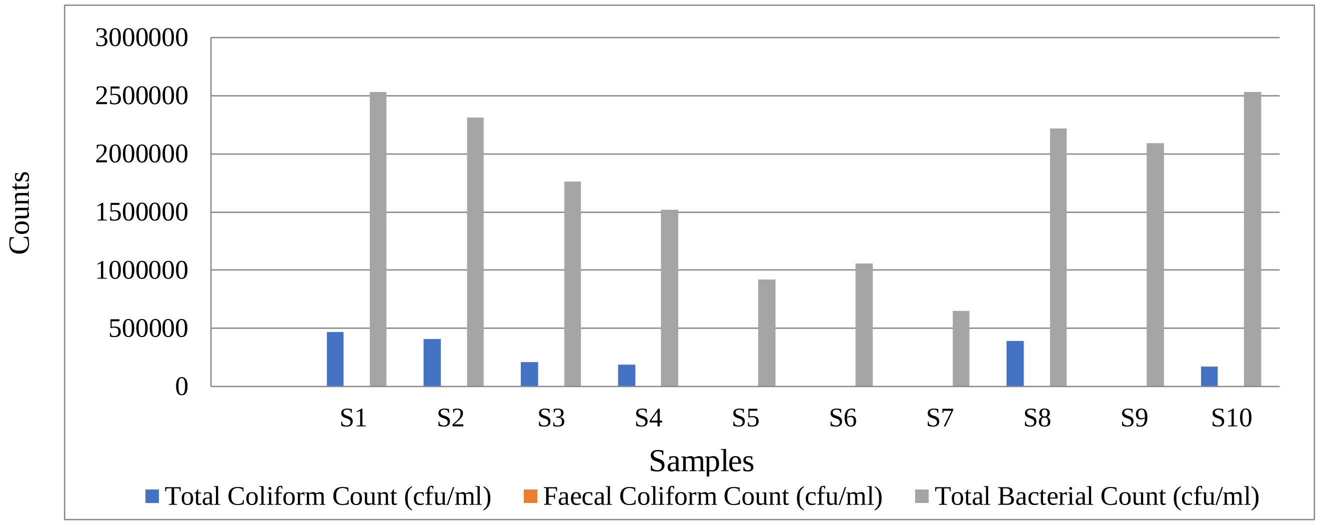

Fig. 7: Microbial contamination in sediment sample

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