

# Seasonal Variations in the Physicochemical Parameters of Ikpoba River Water Samples

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## ABSTRACT

Water is one of the most common natural resources that profoundly influence life. Water pollution occurs when there is adverse change in the physical, chemical or biological condition of the water which harmfully affects the quality of human life including other animal and plants life. Studies on River water pollution and their implication to public health have been ongoing. An assessment of the seasonal changes in the physicochemical properties of Ikpoba River, Benin City, Nigeria polluted by brewery effluent was carried out between the months of January to March and May to July for the dry and wet seasons' respectively. Standard procedures were employed in the study. Results showed a temperature range of 23<sup>o</sup>C to 33<sup>o</sup>C. The dry season Discharge point (DP) sample had the highest temperature. The pH values of most of the samples were within the optimum range for aquatic organisms (6.5 - 9.0). There was a significant difference ( $p \leq 0.05$ ) in pH along the sampling points and days in the two seasons. The range of the electrical conductivity was 70 - 1750 $\mu$ s/cm in dry season and 90.2 - 1320  $\mu$ s/cm in wet season. The discharge point (DP) samples had the highest values followed by the downstream (DS) samples with the upstream (US) samples having the lowest values. Salinity in the dry season was higher than those of the wet season. Physical and spectrophotometric assessment showed remarkable color change particularly in the DP samples followed by the DS samples. The effect was mild in the US samples. Turbidity values in this study ranged from 2.8NTU - 16.1NTU with higher values during the wet season. Total suspended solid (TSS) ranged from 4.2 mg/l - 39.9mg/l. Total dissolved solid (TDS) were higher in the dry season. There was significant difference ( $p \leq 0.05$ ) in DO along the sampling points and days in dry and wet seasons. The Chemical Oxygen Demand (COD) values were much higher than those of BOD<sub>5</sub>. There was significant difference ( $p \leq 0.05$ ) in COD and BOD<sub>5</sub> along the sampling points and days in the two seasons. Carbonate, sodium, potassium, phosphorus, ammonium, nitrate, chloride and sulphate. There was significant difference ( $p \leq 0.05$ ) in nitrate composition along the sampling points and days in the two seasons. There was significant difference ( $p \leq 0.05$ ) in lead composition along the sampling point in the two seasons except on Day 42 at DS and US. There was presence of hydrocarbon (HC) in water the samples which showed significant difference ( $p \leq 0.05$ ) along the sampling points throughout the period of study. The physicochemical properties of the River showed that it is unfit for human consumption and is a cause for public health concern.

**Key-words:** Physicochemical properties, seasonal variation, River water samples, pollution

## INTRODUCTION

Water is a common natural resource indispensable for all living organisms. It is one of the most important factors that profoundly influence life. Water pollution occurs when there is change in the physical, chemical or

biological condition in the environment which harmfully affects the quality of human life including other animal and plant life <sup>[1]</sup>. In other to determine the state of pollution in rivers, a continuous monitoring of water quality is essential. Water quality deals with the physical, chemical and biological features in relation to all other hydrological properties.

Deterioration of surface water quality has been attributed to both natural processes and anthropogenic activities, including hydrological features, climate change, precipitation, agricultural land use, and sewage discharge <sup>[2]</sup>.

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Good water quality resources depend on a large number of physicochemical parameters and the magnitude and sources of any pollution load, and to assess that, monitoring of these parameters is essential <sup>[3]</sup>. Monitoring of water quality parameters provides important information for water management <sup>[4,5]</sup>. Good management of water bodies is required if they are to be used for diverse purposes such as domestic and industrial supply, irrigation, transport, recreation, and fisheries <sup>[6]</sup>. Urbanization and industrialization have increased the extent of pollution of rivers. Pollution affects the ecosystems and significantly depletes biodiversity of species.

Ikpoba River, Benin City, Edo State receives effluents from Guinness Plc. (a brewery industry). Brewery effluents are rich in organic and inorganic substances capable of producing adverse effects on the lives of humans and the ecosystem. Ikpoba River is a fourth order stream located in Benin City, Edo State in Southern, Nigeria. It is one of such Rivers that receive domestic, abattoir and agricultural waste from Oregbeni and other communities living at its banks.

Pollution is said to have occurred when the values of certain physicochemical parameters such as pH, temperature, Dissolved Oxygen (DO), Electrical Conductivity (EC), salinity, turbidity, Total Suspended Solid (TSS), Biochemical Oxygen Demand (BOD<sub>5</sub>), and Chemical Oxygen Demand (COD) are above the recommended standard for drinking <sup>[7]</sup>. Ikpoba River receives large quantity of wastes, directly from the brewery effluents and indirectly within the metropolis through runoff resulting in complete deterioration of water quality. The largest share of pollution comes from the brewery influents, and the untreated wastes, in turn, contaminate the River, which adversely affect the aquatic lives with concomitant negative effect on human health <sup>[8]</sup>. The healthy environment and sufficient nutrients are essential for living and growth of aquatic organisms. Physicochemical characteristics of the water body help to determine the productivity level of aquatic organisms. The highest productivity is obtained when the physical and chemical parameters are at the ideal level. Water quality contributes to helping decision-making process for pollution control in environment protection purpose <sup>[7]</sup>. A number of studies have been carried out on Ikpoba River <sup>[9,10]</sup>. Water quality assessment is a continuous process as it gives an update of the health

status of water and its suitability for diverse purposes such as bathing, drinking, irrigation and its ability to support aquatic lives <sup>[11]</sup>.

This study is very important because it deals with the comparative analysis of the physicochemical properties of Ikpoba River in dry and wet seasons.

## MATERIALS AND METHODS

**Samples collection-** Water samples were collected from Ikpoba River at three different sampling points. The sampling points were designated upstream (US), Downstream (DS), and Discharge point (DP). The three sampling points were 100 m distant from each other. Three samples were collected into a 500ml clean sterile screw cap container from each sampling point making a total of nine (9) samples at each time of sampling and this was done fortnightly for 10 times for the two seasons. The samples were collected by immersing the sample container 30cm deep into the River towards the current.

Dry season samples were collected from January to March 2017 and wet season samples were obtained from May to July 2017. Samples were analyzed at the Microbiology Laboratory of Ambrose Alli University, Ekpoma, Nigeria.

**Determination of Physicochemical parameters-** The physicochemical parameters investigated include temperature which was determined in-situ using a digital thermometer (Kris-Alloy model) with an accuracy of  $\pm 0.4^{\circ}\text{C}$ , pH was determined in-situ using a pH meter (Hanna model, H196107), with pH range of 0-14, conductivity was determined in-situ using a conductivity meter, salinity was determined using a salinometer, turbidity was measured using HACH turbidimeter, Biological Oxygen Demand (BOD<sub>5</sub>) was determined by modified Winkler's method <sup>[12]</sup>, Total suspended solid (TSS) was determined by gravimetric method, Dissolved Oxygen (DO) was determined by modified Winkler's method <sup>[13]</sup>. Chemical oxygen demand (COD) was determined as described <sup>[12]</sup>, Carbonate (HCO<sub>3</sub>) by using phenolphthalein and methyl orange indicator method, Phosphorus by Ascorbic Acid Reduction colorimetric method <sup>[14]</sup>, Chloride was determined by silver nitrate titration method <sup>[13]</sup>, Ammonium nitrogen (NH<sub>4</sub>N) by the method described by American Public Health Association <sup>[12]</sup>, Nitrate was determined by Brucine colorimetric

method, Sulphate by turbidimetric method <sup>[13]</sup>. The colour was determined by the spectrophotometric method, sodium and potassium were determined by flame photometry. Total Hydrocarbon (THC) was determined as described by American Public Health Association <sup>[14]</sup>. All heavy metals: Fe, Mn, Zn, Cu, Cr, Cd, Ni, Pb, V were determined using Atomic Absorption Spectrophotometric (AAS) method.

**Statistical Analysis** The data were analyzed using analysis of variance (ANOVA) while significant means were separated with Duncan's multiple range tests using SPSS 17.0 statistics.

## RESULTS AND DISCUSSIONS

The physicochemical parameters investigated in the two (wet and dry) seasons include: temperature, pH, Electrical Conductivity (EC), salinity, colour, turbidity, Total Suspended Solid (TSS), Total Dissolved Solid (TDS), Dissolved Oxygen (DO), Biochemical Oxygen Demands (BOD<sub>5</sub>), Chemical Oxygen Demand (COD), carbonate (HCO<sub>3</sub>) sodium (Na), potassium (K), calcium (Ca), magnesium (mg), chloride (Cl), phosphorus (P), ammonium nitrogen (NH<sub>4</sub>N), nitrate (NO<sub>3</sub>), sulphate (SO<sub>4</sub>), heavy metals; Fe, Mn, Zn, Cu, Cr, Cd, Ni, Pb, V, and total hydrocarbon (THC).

Tables 1 to 5 showed the dry and wet season results of the physicochemical parameters of Ikpoba River water samples. The temperature of 33°C for DP dry season Day 1 sample was the highest obtained throughout the study. In the wet season for Day 1, the temperature ranged from 27.5°C - 30°C. In Day 2 the dry and wet season temperatures ranged from 30.0°C - 32.4°C and 27°C - 30.5°C respectively. The Day 3 temperatures were 30.0°C - 32.5°C (dry season) and 26°C - 28°C (wet season). In Day 4 the temperatures were 30°C - 32°C (dry season) and 23.5°C-26°C (wet season). The Day 5 temperatures for the dry and wet seasons were respectively 29.1°C- 31.9°C and 23°C- 26°C. The lowest temperature of 23°C was obtained from the wet season Day 5 US sample.

The research showed that temperature values were higher during dry season. The temperature difference at any aquatic habitat is affected by weather and the extent of shade from direct exposure to sunlight <sup>[10]</sup>. The temperature values recorded were comparable to those previously reported <sup>[10]</sup>. Elevated temperature diminishes

the solubility of dissolved oxygen (DO) and thus, decreases the availability of this essential gas when the metabolism of organisms increases (i.e. at the time when it is most needed). The deficit could result in the death of fish and other aquatic organisms living in the water body <sup>[15]</sup>.

The pH values of the various samples were within the optimum range for aquatic organisms but at the threshold values (6.5 - 9.0) except for the Day 4 wet season US sample and Day 5 dry season DP sample which was 5.9 and 5.3 respectively. The pH of Ikpoba River fluctuates between weak acidity and strong alkalinity. There was significant difference ( $p \leq 0.05$ ) in pH along the sampling points and days in the two seasons. The pH ranged 5.3 – 9.5 in dry season and 5.9 - 9.0 in wet season. The pH of 9.5 recorded at DP in dry season slightly deviated from the optimum value (6.5 - 9.0) for aquatic organisms. Outside this pH, aquatic organisms become stressed or even die in the process. Beside biological effects, extreme pH level usually increases the solubility of elements and compounds, making toxic chemicals more "mobile" thereby increasing the risk of absorption by aquatic life. Some of the extreme alkaline pH recorded at DP could have resulted from the use of caustic soda and detergent for washing and bathing within the vicinity of the DP and from the brewery company that uses detergent for cleaning their utensils.

The highest electrical conductivity (1750  $\mu\text{s}/\text{cm}$ ) in the entire analysis was associated with the dry season Day 5 DP sample. Electrical conductivity is a measure of the ability of water to pass an electrical current. Conductivity in water is affected by the presence of inorganic dissolved solids such as chloride, nitrate, sulphate etc that carry negative charges or sodium, magnesium, calcium etc that carry positive charges. Conductivity is also affected to a great extent by temperature. Temperature increases the mobility of ions in water thereby increasing conductivity. The optimum conductivity for most species of fish is between 50 - 1500  $\mu\text{s}/\text{cm}$ , conductivity outside this range is not suitable for most species of fish. A significant change in conductivity is an indication that a discharge or some forms of pollution has occurred in the stream. The conductivity of Ikpoba River was highest during the dry season. The range was 70 - 1750  $\mu\text{s}/\text{cm}$  in dry season and 90.2 - 1320  $\mu\text{s}/\text{cm}$  in wet season. It was observed that the conductivity values recorded at the various sampling

points were attributed to the level of dissolved solids coupled with temperature. The values of conductivity from highest to lowest are in the order: DP > DS > US.

Salinity measures the salt concentration in water. Salinity in the dry season was higher than those of the wet season. This could simply be attributed to high evaporation during dry season because salinity increases with temperature<sup>[16]</sup>. Physical and spectrophotometric assessment showed remarkable color change particularly at the DP followed by DS. The effect was mild in the US. The color change in River at the two main points (i.e. DP and DS) could be ascribed to brewery wastewater being discharged. Research on the effect of human activities on the physicochemical parameters and microbiological quality of Otamiri River, Owerri, Imo State, Nigeria did not detect color<sup>[17]</sup>.

Turbidity is a measure of the amount of suspended particles in water. World health organization (WHO) has established that the turbidity of drinking water should not exceed 5 NTU while aquatic organisms require turbidity less than 50 NTU. The range in this study was 2.8 NTU - 12.0 NTU in dry season. The rainy season ranged between 5.2 NTU - 16.1 NTU. The turbidity values recorded in the wet season were higher than dry season. The high turbidity in wet season could be attributed to weathering of soil and runoff. The turbidity values recorded in this research were lower than those earlier reported<sup>[10,18]</sup>. The lower turbidity values recorded in comparison to the two works cited above could be attributed to reduced human activities such as construction, mining and agricultural activities that disturb land<sup>[19]</sup>. Because of organic matter composition, DP and DS have higher turbidity values than US. Total suspended solid (TSS) at the US and DS were moderate in the entire analyses except at DP in dry season. But values increased moderately in wet season. It ranged between 4.2mg/l – 32.7mg/l in dry season. The wet season values ranged from 4.8mg/l – 39.9mg/l. Total dissolved solid (TDS) is a measure of all organic and inorganic substances. TDS could also be used to estimate electrical conductivity. The difference between TDS and TSS is that the latter cannot pass through a sieve of 2 $\mu$ m and are indefinitely suspended. High values of TDS were observed in the dry season. This also accounts for the high conductivity values recorded in the period. Fluctuated values were observed in the wet season.

The impact of brewery effluent on Ikpoba River was evident at DP and its vicinity. Its turbidity was high with reduced transparency and dissolved oxygen level coupled with remarkable colour change. Exogenous substances of organic origin are known to increase water colour, turbidity, suspended and dissolved solids which impair transparency<sup>[20,21]</sup>. The increase in organic matter composition at DP reduced the DO, raises the oxygen tension of microorganisms thereby increasing the biological oxygen demand (BOD)<sup>[22]</sup>. The observation in this research was in line with the work on the effects of brewery effluent on the water quality and rotifers of Ikpoba River, Benin City, Nigeria<sup>[23]</sup>. The State of Wisconsin has set a minimum standard of 5 mg/l DO as necessary for a stream to support fish and other aquatic lives. The values recorded at DP and DS showed that aquatic organisms (except some aquatic plants) cannot thrive at these points except at US. There was significant difference ( $p \leq 0.05$ ) in DO along the sampling points and days in dry and wet seasons. The Chemical Oxygen Demand (COD) values were much higher than those of BOD because COD measures everything that can be chemically oxidized while BOD measures levels of biologically active organic matter. The COD range was 10.2 mg/l - 194.2 mg/l in dry season. Wet season COD values ranged from 12.2 mg/l - 366.3 mg/l. There was significant difference ( $p \leq 0.05$ ) in COD and BOD<sub>5</sub> along the sampling points and days in the two seasons.

The presence of carbonate, sodium and potassium could be attributed to pollution from point and non-point sources resulting from weathering of rocks and other sources. Phosphorus, ammonium, nitrate and sulphate were also observed with high proportion of chloride. There was significant difference ( $p \leq 0.05$ ) in nitrate composition along the sampling points and days in the two seasons. Day 28 and 42 at US in dry season and day 1 and 14 at DS in wet season had significant difference ( $p \leq 0.05$ ). The presence of these inorganic compounds in water usually results from agricultural runoff, domestic effluent, sewage disposal, industrial discharges, leachates from refuse dumps etc<sup>[24]</sup>. Their presence is also a reflection of human activities like farming that takes place at the bank of the River<sup>[12]</sup>. The presence of these inorganic compounds in River water sample has been earlier reported. Excess of these inorganic compounds in water could enrich the water body

there by resulting in eutrophication. This could further results in excessive algal growth that could lead to oxygen depletion. Excess of chloride in water corrodes metals and could lead to the death of fish and other aquatic life.

The wet season samples had more heavy metals than the dry season samples. Nickel and Vanadium were not detected in the River in the months of January and February. Cadmium was not detected in the US sample in February but found in other sampling points (i.e. DP and DS). Metals such as Fe, Mn, Zn, Cu, Cr, Cd, Ni, Pb, and V were detected at all points apart from the period stated above. Their proportions were lower in dry season than wet season. There was significant difference ( $p \leq 0.05$ ) in lead composition along the sampling point in the two seasons except on Day 42 at DS and US. There was no significant difference ( $p \leq 0.05$ ) in lead composition between some of the sampling days. This aligns with earlier work where traces of heavy metals were detected in the marine environment [25]. Metals are introduced into aquatic system as a result of weathering of soil and

rocks from volcanic eruption and a variety of human activities such as mining and other substances that contain metal pollutant. Metals such as manganese, iron, copper and zinc are essential as micronutrients. They are essential for life in the right concentration, but in excess, they are poisonous. The maximum permissible concentrations of some metals (for human health) in natural waters as recommended by USEPA [19] include Pb 5 mg/m<sup>3</sup>, Cd 10 mg/m<sup>3</sup>, Ni 13.4 mg/m<sup>3</sup>, Mn 50 mg/m<sup>3</sup>, Cr 50 mg/m<sup>3</sup>, Fe 300 mg/m<sup>3</sup>. The presence of lead could be from the PVC pipe that takes the effluent to the River and is very toxic when in excess. The presence hydrocarbon (HC) in water could result from industrial processes and man induced activities such as oil spillage and from runoff. There was significant difference ( $p \leq 0.05$ ) in total hydrocarbon (THC) composition along the sampling points throughout the periods but significant difference ( $p \leq 0.05$ ) was not recorded between some of the sampling days. On high pollution, oil affects the aesthetics of water and respiration of fish by adhering to the gills.

**Table 1: Physicochemical Analysis of Dry and Wet Seasons Samples- Day 1**

Parameters	Dry season Sample Code			Wet season Sample Code			
	DS	DP	US	DS	DP	US	US
Temp. (°C)	31.0	33.0	30.5	28.0	30.0		27.5
pH	6.89	8.92	6.14	7.8	9.0		6.6
EC (µS/cm)	146.2	582.2	130.1	126.1	362.5		120.1
Sal. (g/l)	0.080	0.151	0.088	0.06	0.27		0.056
Col. (Pt.Co)	7.2	12.3	4.2	7.6	15.1		3.6
Turb. (NTU)	4.6	10.3	3.8	7.7	13.2		5.2
TSS (mg/l)	8.4	20.1	6.1	9.5	30.4		6.8
TDS (mg/l)	90.6	230.2	56.5	56.3	261.1		46.3
DO (mg/l)	4.1	3.9	5.9	6.3	5.0		7.2
BOD <sub>5</sub> (mg/l)	28	72.3	19.0	20.3	31.5		3.6
COD (mg/l)	40.9	180.1	12.1	36.6	130.8		12.2
HCO <sub>3</sub> (mg/l)	52.6	68.9	31.7	68.1	120.6		41.3
Na (mg/l)	2.91	4.21	1.21	2.1	6.21		0.92
K (mg/l)	0.60	1.20	0.41	0.38	3.25		0.16
Ca (mg/l)	5.12	10.16	5.10	2.66	12.10		2.12

Mg (mg/l)	1.87	4.50	1.12	1.62	3.64	0.81
Cl (mg/l)	31.4	140.1	26.4	33.1	261.5	26.3
P (mg/l)	2.69	8.10	0.84	1.32	8.91	1.02
NH <sub>4</sub> N (mg/l)	0.059	0.986	0.021	0.161	1.180	0.062
NO <sub>3</sub> (mg/l)	3.24	7.95	1.76	1.82	10.21	1.32
SO <sub>4</sub> (mg/l)	0.16	0.34	0.61	0.81	4.19	0.38
Fe (mg/l)	1.21	2.60	0.91	2.01	6.10	1.20
Mn (mg/l)	0.009	0.012	0.007	0.055	0.100	0.029
Zn (mg/l)	0.14	0.91	0.13	0.90	2.13	0.60
Cu (mg/l)	0.077	0.121	0.016	0.040	0.089	0.010
Cr (mg/l)	0.015	0.050	0.004	0.018	0.062	0.011
Cd (mg/l)	0.011	0.021	0.003	0.019	0.058	0.010
Ni (mg/l)	ND	ND	ND	0.012	0.026	0.006
Pb (mg/l)	0.006	0.010	0.002	0.019	0.030	0.003
V (mg/l)	ND	ND	ND	0.006	0.020	0.001
THC (mg/l)	0.04	0.11	0.01	0.31	0.45	0.08

US– Upstream, DS– Downstream, DP– Discharge Point, ND– Not Detected

Table 2: Physicochemical Analysis of Dry and Wet Seasons Samples – Day 14

Parameters	Dry Season Sample Code			Wet Season Sample Code		
	DS	DP	US	DS	DP	US
Temp. (°C)	31.0	32.4	30.0	28.0	30.5	27.0
pH	7.5	9.2	6.6	6.9	8.8	6.1
EC (µS/cm)	150.1	620.1	131.1	120.3	312.6	123.4
Sal. (g/l)	0.09	0.171	0.086	0.05	0.26	0.046
Col. (Pt.Co)	8.3	14.4	3.2	8.1	17.0	4.3
Turb. (NTU)	4.3	11.6	3.0	5.3	13.1	6.0
TSS (mg/l)	7.15	21.2	6.1	10.0	36.8	8.3
TDS (mg/l)	91.6	280.3	53.5	60.0	146.2	52.1
DO (mg/l)	4.0	3.6	6.3	6.8	5.8	7.5
BOD <sub>5</sub> (mg/l)	28.3	57.4	8.7	16.6	30.8	4.8
COD (mg/l)	39.6	183.1	12.6	70.2	201.3	16.1
HCO <sub>3</sub> (mg/l)	42.2	67.8	33.8	61.1	121.3	40.1
Na (mg/l)	3.11	5.30	1.41	1.85	6.99	1.26
K (mg/l)	0.61	0.31	0.45	0.19	3.61	0.11
Ca (mg/l)	5.14	10.25	4.12	3.71	16.1	2.30

Mg (mg/l)	1.92	5.11	1.13	1.70	4.11	1.12
Cl (mg/l)	34.1	146.6	29.5	36.1	282.3	29.1
P (mg/l)	3.10	9.10	0.94	1.91	10.12	1.26
NH <sub>4</sub> N (mg/l)	0.060	1.020	0.034	0.119	2.120	0.053
NO <sub>3</sub> (mg/l)	3.36	8.11	2.10	1.81	7.18	1.44
SO <sub>4</sub> (mg/l)	0.16	0.40	0.81	0.90	4.11	0.40
Fe (mg/l)	1.30	2.65	0.11	2.11	6.81	1.69
Mn (mg/l)	0.013	0.016	0.009	0.08	0.112	0.042
Zn (mg/l)	0.13	0.10	0.15	1.00	3.10	0.71
Cu (mg/l)	0.065	0.128	0.019	0.30	0.78	0.012
Cr (mg/l)	0.014	0.018	0.002	0.016	0.056	0.009
Cd (mg/l)	0.012	0.046	0.006	0.025	0.061	0.017
Ni (mg/l)	ND	ND	ND	0.018	0.039	0.005
Pb (mg/l)	0.005	0.011	0.001	0.021	0.038	0.013
V (mg/l)	ND	ND	ND	0.005	0.021	0.003
THC (mg/l)	0.08	0.14	0.03	0.24	0.38	0.06

US– Upstream, DS– Downstream, DP– Discharge Point, ND– Not Detected

Table 3: Physicochemical Analysis of Dry and Wet Seasons Samples– Day 28

Parameters	Dry Season Sample Code			Wet Season Sample Code		
	DS	DP	US	DS	DP	US
Temp. (°C)	30.5	32.5	30.0	26.0	28.0	26.0
pH	7.1	9.5	6.4	6.5	8.3	6.0
EC (µS/cm)	153.4	290.1	121.8	140.0	168.1	102.2
Sal. (g/l)	0.069	0.131	0.055	0.050	0.086	0.037
Col. (Pt.Co)	5.7	9.1	3.8	9.8	25.6	6.8
Turb. (NTU)	4.4	8.3	2.9	9.6	15.1	5.9
TSS (mg/l)	6.1	12.4	4.2	10.7	36.1	4.8
TDS (mg/l)	78.7	150.3	61.7	68.4	160.3	30.1
DO (mg/l)	4.2	3.8	5.6	6.0	5.2	7.6
BOD <sub>5</sub> (mg/l)	10.4	39.2	2.5	18.6	50.1	6.0
COD (mg/l)	37.6	153.8	10.2	90.1	366.3	14.9
HCO <sub>3</sub> (mg/l)	54.9	61.1	42.7	57.6	101.2	26.3
Na (mg/l)	2.46	5.11	1.80	2.6	11.3	1.4
K (mg/l)	0.43	0.98	0.33	0.18	2.66	0.17

Ca (mg/l)	4.28	9.33	3.40	3.28	16.3	1.29
Mg (mg/l)	1.27	3.65	1.02	1.39	4.22	1.62
Cl (mg/l)	21.2	35.4	17.7	28.9	202.1	26.1
P (mg/l)	3.69	7.38	0.74	1.89	11.1	1.65
NH <sub>4</sub> N (mg/l)	0.047	0.335	0.018	0.116	2.002	0.063
NO <sub>3</sub> (mg/l)	2.44	9.56	1.02	2.71	10.7	2.1
SO <sub>4</sub> (mg/l)	0.34	0.61	0.15	0.81	3.29	0.41
Fe (mg/l)	1.36	2.44	0.82	2.94	6.86	1.21
Mn (mg/l)	0.011	0.018	0.027	0.091	0.109	0.048
Zn (mg/l)	0.32	0.94	0.12	0.80	3.16	0.66
Cu (mg/l)	0.098	0.134	0.017	0.33	0.92	0.016
Cr (mg/l)	0.019	0.036	0.006	0.014	0.060	0.010
Cd (mg/l)	0.010	0.024	ND	0.031	0.066	0.012
Ni (mg/l)	ND	ND	ND	0.014	0.036	0.006
Pb (mg/l)	0.007	0.013	0.004	0.023	0.051	0.004
V (mg/l)	ND	ND	ND	0.004	0.032	0.006
THC (mg/l)	0.06	0.10	0.02	0.26	0.42	0.07

US– Upstream, DS– Downstream, DP– Discharge Point, ND– Not Detected

Table 4: Physicochemical Analysis of Dry and Wet Seasons Samples– Day 42

Parameters	Dry Season Sample Code			Wet Season Sample Code		
	DS	DP	US	DS	DP	US
Temp. (°C)	30.0	32.0	30.0	24.0	26.0	23.5
pH	7.0	9.3	6.2	6.1	8.7	5.9
EC (µS/cm)	143.4	300.2	126.2	136	1,320	110
Sal. (g/l)	0.071	0.133	0.061	0.051	0.078	0.040
Col. (Pt.Co)	5.3	8.1	3.7	9.3	22.5	5.8
Turb. (NTU)	3.4	9.4	2.8	8.9	16.1	5.4
TSS (mg/l)	6.6	13.1	4.3	10.2	39.9	8.4
TDS (mg/l)	75.8	161.3	62.4	69.6	201.0	51.6
DO (mg/l)	4.9	4.0	5.8	7.0	5.4	7.8
BOD <sub>5</sub> (mg/l)	22.5	78.2	27.0	20.0	48.6	7.6
COD (mg/l)	36.7	151.9	10.3	88.6	269.5	13.8
HCO <sub>3</sub> (mg/l)	56.4	62.1	42.6	56.6	199.0	25.6
Na (mg/l)	2.41	5.14	1.83	2.7	9.4	14.0
K (mg/l)	0.46	0.88	0.38	0.19	2.21	0.15

Ca (mg/l)	4.38	9.21	3.41	3.3	17.2	1.2
Mg (mg/l)	1.30	3.61	1.03	1.31	4.60	1.71
Cl (mg/l)	23.1	27.8	18.1	29.1	220.0	25.6
P (mg/l)	3.80	7.50	0.67	2.0	15.6	1.8
NH <sub>4</sub> N (mg/l)	0.050	0.420	0.019	0.117	2.11	0.060
NO <sub>3</sub> (mg/l)	2.60	8.75	1.04	2.8	12.5	2.5
SO <sub>4</sub> (mg/l)	0.24	0.64	0.16	0.90	3.20	0.38
Fe (mg/l)	1.39	3.10	0.61	2.84	6.01	2.10
Mn (mg/l)	0.012	0.020	0.031	0.089	0.106	0.051
Zn (mg/l)	0.36	1.02	0.10	0.80	3.66	0.75
Cu (mg/l)	0.03	0.04	0.02	0.40	1.01	0.018
Cr (mg/l)	0.088	0.146	0.025	0.024	0.620	0.016
Cd (mg/l)	0.011	0.028	0.001	0.036	0.073	0.013
Ni (mg/l)	0.002	0.004	ND	0.016	0.039	0.050
Pb (mg/l)	0.009	0.015	0.003	0.021	0.041	0.020
V (mg/l)	ND	0.006	ND	0.003	0.038	0.004
THC (mg/l)	0.08	0.12	0.03	0.29	0.45	0.07

US– Upstream, DS– Downstream, DP– Discharge Point, ND– Not Detected

Table 5: Physicochemical Analysis of Dry and Wet Seasons Samples – Day 56

Parameters	Dry Season Sample Code			Wet Season Sample Code		
	DS	DP	US	DS	DP	US
Temp. (°C)	29.5	31.9	29.1	24.0	26.0	23.0
pH	6.3	5.3	6.1	6.7	8.5	6.4
EC (µS/cm)	120	1750	70	131.0	260.1	90.2
Sal. (g/l)	0.054	0.791	0.032	0.021	0.063	0.010
Col. (Pt.Co)	8.9	16.8	6.6	8.99	19.4	7.0
Turb. (NTU)	7.1	12.0	5.2	8.5	14.4	5.6
TSS (mg/l)	9.0	32.7	5.8	10.3	34.8	6.8
TDS (mg/l)	59	880	34	50.1	240.0	20.0
DO (mg/l)	4.8	4.3	6.1	5.2	4.9	7.0
BOD <sub>5</sub> (mg/l)	19.1	55.8	4.6	18.8	53.4	5.5
COD (mg/l)	63.9	194.2	15.8	73.3	255.1	23.2
HCO <sub>3</sub> (mg/l)	67.1	98.6	30.5	66.1	101.5	39.1
Na (mg/l)	1.95	9.53	1.39	1.86	6.12	2.30
K (mg/l)	0.27	2.86	0.10	0.36	3.63	0.92

<b>Ca (mg/l)</b>	3.65	14.2	2.11	2.88	15.3	2.68
<b>Mg (mg/l)</b>	1.38	4.05	0.82	1.44	4.11	1.67
<b>Cl (mg/l)</b>	26.8	191.5	24.8	30.8	214.5	20.2
<b>P (mg/l)</b>	1.69	9.59	1.14	1.21	8.10	1.15
<b>NH<sub>4</sub>N (mg/l)</b>	0.108	1.160	0.052	0.192	1.261	0.022
<b>NO<sub>3</sub> (mg/l)</b>	1.71	6.83	1.33	2.10	10.3	1.24
<b>SO<sub>4</sub> (mg/l)</b>	0.65	3.19	0.26	0.80	4.19	0.36
<b>Fe (mg/l)</b>	1.94	5.39	0.63	2.11	6.43	1.98
<b>Mn (mg/l)</b>	0.065	0.091	0.032	0.091	0.124	0.062
<b>Zn (mg/l)</b>	0.76	1.13	0.40	0.89	3.88	0.83
<b>Cu (mg/l)</b>	0.036	0.077	0.009	0.51	1.18	0.020
<b>Cr (mg/l)</b>	0.028	0.057	0.014	0.010	0.69	0.016
<b>Cd (mg/l)</b>	0.017	0.048	0.012	0.032	0.068	0.014
<b>Ni (mg/l)</b>	0.011	0.021	0.003	0.019	0.041	0.006
<b>Pb (mg/l)</b>	0.016	0.027	ND	0.018	0.029	0.003
<b>V (mg/l)</b>	0.009	0.018	0.002	0.010	0.020	0.004
<b>THC (mg/l)</b>	0.19	0.35	0.09	0.22	0.41	0.11

US– Upstream, DS– Downstream, DP– Discharge Point, ND– Not Detected

## CONCLUSIONS

The research has unraveled that brewery effluent is mainly responsible for the pollution of Ikpoba River resulting in the discharged of organic and inorganic wastes. The result of physicochemical analysis revealed the presence of organic and inorganic compounds such as Hydrocarbon, Magnesium, Calcium, Phosphorus, Chloride, Ammonium Nitrogen (NH<sub>4</sub>N), Nitrate, Sulphate and heavy metals due to discharge of brewery effluent, farming activities at the bank of the River (through the application of fertilizer) and non-point sources (through weathering). The presence of inorganic compounds such as Phosphorus, Ammonium Nitrogen, Nitrate, Sulphate could enrich the water body, promote algal growth, clog the water surface thereby making the water anoxic. The deficit of this essential gas could result in the death of aquatic organisms. Also, the presence of heavy metals like lead, cadmium etc. (when in reasonable proportions) poses a serious health threat to the popular when they are incorporated into the cells of small aquatic organisms (diatoms) in the water, fishes in the water feed on them and the fishes are caught and consumed by human beings. This could result in mass death of people in near

future if stringent measures are not taken.

Those farming at the bank of the River should avoid excessive use of fertilizer that could drain into the River and enrich the water body. The brewery close to the River should endeavor to treat their wastewater before discharging into the Ikpoba River to protect the natural resources, retain the aesthetic value and protect the ecosystem from extinction. The present physicochemical status of Ikpoba River calls for public health attention as the water did not meet up with the acceptable standard for potable.

## CONTRIBUTION OF AUTHORS

**Akpe Azuka Romanus**– Research concept/Design, Supervision, Funding, Data analysis and interpretation, writing article, critical review and final approval.

**Femi Imah Justus**– Sample collection and Processing, sourcing for materials/reagents, Funding, Literature search, Data analysis and interpretation and writing of article

**Okwu Grace Ifeoma**– Literature search, Sample processing, Funding and Critical review.

**Obiazi Helen**– Literature search, sourcing for materials/reagents, Sample processing, Funding.

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