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Research Article

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Physico-chemical Characterization of Surface Water and Pollutant Load of Effluent Discharge by a Bottling Company into Woji Creek, Port Harcourt, Nigeria

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Abstract

Indiscriminate disposal of wastewater without treatment into water bodies has been a menace by generating high levels of pollutants causing adverse effects on the water quality, the aquatic life as well as the fauna and flora of rivers, making it unsuitable for drinking and poses a greater risk to the human health. This study was an assessment of the physico-chemical characterization of surface water and pollutant load of effluent discharge by a Bottling Company into Woji Creek, Port Harcourt, Nigeria. The creek, which serves as a receptacle for industrial, domestic, and agricultural wastes, has been subjected to chronic pollution. Surface water and sediment samples were collected from six (6) stations; one control station upstream and five other sampling stations 100m apart and downstream from the NBC effluent discharge point. Physicochemical parameters were investigated following standard analytical methods. Sediment was collected from 0-15 and 15-30 cm. Field measurements and laboratory analyses were conducted to determine pH, temperature, dissolved oxygen, total suspended solids, biochemical oxygen demand (BOD), chemical oxygen demand (COD), electrical conductivity and total dissolved solids (TDS), sulphate, phosphate and nitrate. The results revealed significant variations in water quality parameters, indicating pollution from NBC's effluent discharges, pH levels ranged from 4.10 to 6.43 (which is below DPR limits of 6.5-8.5). Elevated levels of BOD, COD, and TDS exceeded national and international standards. The study also observed changes in the creek's aquatic life, including reduced species diversity and abundance. The findings highlight the need for improved wastewater management practices and stricter regulatory enforcement to mitigate environmental pollution. Recommendations include regular monitoring, treatment upgrades, and implementation of best management practices to minimize pollution and protect the creek's ecological integrity.

Keywords: Effluents, Trans-Amadi, Nutrients, Physico-chemical, Nigerian Bottling Company, pH

Introduction

Coastal and inland waters are highly valued for both their ecological richness and the multitude of human activities they sustain, making them one of the country's most significant natural resources. Coastal and inland waters, serve as an interface and link between land settings and the open seas or oceans. These coastal and inland tributaries host a variety of unusual habitats, including up-welling zones, mangrove forests, coastal wetlands, sea grass beds, coral reefs, rivers, streams and other marine estuaries. Many fish species depend on coastal waters for at least a portion of their life cycles. These waters also provide some of the world's most productive fisheries habitats, as well as support a wide range of other organisms with notable ecological significance or high public visibility, such as marine mammals, corals, and sea turtles, or submerged aquatic vegetation in an Assessment of the industrial influent and effluent water Quality of a Bottling Company in Aba, Abia State, carried out a single factor experiment in randomized complete block designs with three replications to assess the physiochemical properties of water from various sources within the bottling company [1]. No significant differences existed between colour intensity and turbidity values of the various water point sources. Effluent water was significantly the highest in TSS values, while the least TSS values were significantly recorded for treated water and rain water. Inland aquatic ecosystems are at risk from effluents when they are discharged without proper treatment into the environment [2]. Effluent discharges from factories and production plants penetrate the soil and contaminate both surface and groundwater in these environments. Untreated effluents can harm marsh plants in numerous ways and directly harm organisms by suffocating them, they pose the greatest threat to the aquatic ecosystem, especially the marine environment [3].

Effluent discharges into coastal and inland waterways form a surface slick whose components can follow many pathways. Some may pass through and contaminate various tributaries and estuaries before flowing into the mass of open seawater persisting for a long time before their eventual degradation by microorganisms in these waters.

The slick from untreated effluent discharges usually becomes more viscous and forms water-in-oil emulsion. Oil in water causes depletion of dissolved oxygen due to transformation of the organic component into inorganic compounds, loss of biodiversity through a decrease in amphipod population that is important in food chain, and eutrophication.The river system is the major source of fresh water. It carries along its course and tributaries a reasonable quantity or load of matter which are either in dissolved or particulate form. These may have originated from both natural and anthropogenic sources arising from rapid. Investigated the efficacy of Wastewater Treatment of a Nigerian Food and Beverage Processing Industry, located at Shagamu – Benin expressway, Ijebu-ode, Ogun State, Nigeria,industrialization with multiple industrial activities, discharging wastes into the aquatic environment [4,5].

Rivers are known to play major roles in transportation of goods and services. Also, they are involved in the transportation of wastes arising from municipal, domestic and industrial wastes. Researched on the assessment of the pollution load of the Woji Creek Water Body, Port Harcourt, Rivers State, South-South, Nigeria [6]. In their research methodology, DO, COD and BOD were assessed using three study stations in each area composed of the Woji, Akpajo and Rumuwoji River bodies. The DO, BOD, COD were analyzed using Titrimetry .The result showed that partial regeneration had occurred but these water bodies sampled were still polluted when compared to known permissible limits and previous research studies. Similarly, evaluated the quality of the 7-Up Bottling Company Wastewater Treatment Plant Effluent Discharged to the Environment of the Ninth Mile Corner, Amaeke Ngwo, Enugu State [7].

The quality of the effluent exiting the WWTP meets Nigeria Environmental Standards and Regulations Enforcement Agency limit with respect to all the physio-chemical parameters for which NESREA has established limits, except TSS [8].

The quality of the effluent exiting the WWTP as analysed indicated that the TDS and TSS mean values were below the 2016 NESREA Environmental Audit Report [8]. Runoffs from agricultural farms and other pollutant generating sources eventually are deposited in water columns of rivers which therefore, introduce pollutants into the river evaluated the Impact of Organic Wastes on Water Quality of the Woji Creek in Port Harcourt, Nigeria [9,10]. The study area is one of the several adjoining creeks of the Bonny River Estuary. Which lies between longitude 71'3''N and latitude 448'E & 452'E of Port Harcourt. TDS, Turbidity, pH, Electrical conductivity, DO, (BOD5), total alkalinity, chloride, hardness and Nitrate, were determined according to procedures outlined in the Standard Methods for the Examination of Water and Wastewater [11].

The findings of this study indicated that organic wastes are the major factors responsible for deterioration of the water quality of Woji Creek. The increasing values of other parameters of certain contaminants also indicated that the Woji Creek water should be designated to be unsafe for domestic purposes without some forms of physical and chemical treatments. Evaluated the Effluent Quality of a Carbonated Soft Drink (CSD) Company in Owerri, Imo State, Nigeria and its Receiving Water Body-the Nworie River, in Owerri, Imo state [12]. Standard physicochemical methods were used as described in the National field Manual [13]. Physico-chemical results obtained showed a pattern ($p<0.05$) with higher values recorded in the influent and least values in the effluent samples, while in the receiving water body, higher values were recorded in the discharge point, followed by downstream and least values in the upstream samples. The heavy metals pollutants were not considered as well as the soil sediment composition of the sampling stations. Evaluated the spatial variation of the physico-chemistry and heavy metals profile of the Woji Creek, found within the Upper Reaches of Bonny Estuary, Niger-Delta, Nigeria. The TDS levels were very high and above the permissible limits recommended by the WHO. The DO level was low and well below the permissible limits according to WHO.

Aquatic flora and fauna are always in continuous contact with water and pollutants which implies that they are directly affected by any change in water quality. Over exploitation and exploration of the natural environment without recourse to environmental legislations or principles result in the deposition of toxic substances in the ecosystem [15]. In this study, assessment of the physico-chemical characterization of Surface Water and pollutant load of effluent discharge by a bottling company into the Woji Creek, Port Harcourt, Nigeria was done. The wastewater facilities and discharges from study facilities are showed in Plates 1 to 5.

Plate 1: Rectangular Waste Water Sedimentation Tank

Plate 2: Aerobic Waste Water Treatment

Plate 3: Drainage Pipe Lines

Plate 4: Biological Wastewater Treatment Plant (WWTP)

Plate 5: Portal of Effluent discharges into the Woji Creek

Common BOD values

1. Low BOD (0-2 mg/L): indicates good water quality with minimal organic pollution
2. Moderate BOD (2-10 mg/L): suggests some organic pollution, but still relatively good water quality
3. High BOD (10-50 mg/L): indicates significant organic pollution, potentially harming aquatic life
4. Very high BOD (>50 mg/L): suggests severe organic pollution, potentially leading to water body degradation and harm to human health.

Methodology

Research Design

The Nigerian Bottling Company, located in a Trans-Amadi, generates a significant amount of wastewater effluent that is discharged into the Woji Creek a nearby water-body. The effluent may contain various pollutants, such as nutrients, organic compounds, and other contaminants, that can harm the aquatic ecosystem. To evaluate the impact of the wastewater effluent on the water quality and aquatic life in the receiving water-body, six sampling stations were established along the receiving water-body, including one control station located upstream of the wastewater effluent discharge point. The control station served as a reference point to compare the water quality and aquatic life in the impacted area.

The following water quality parameters were measured at each sampling station; pH, temperature, dissolved oxygen (DO), electrical conductivity, turbidity, nutrients (e.g., sulphate, phosphate, nitrate), total suspended solids, total dissolved solids (TDS), biochemical oxygen demand (BOD). Water samples were collected monthly for a period of 6 months to account for seasonal variations using a Van Dorn water sampler. Six Sampling stations were set up along the course of the receiving water body. Control Station (S1) were located upstream of the wastewater effluent discharge point, this station served as a reference point to compare the water quality and aquatic life in the impacted area. Sampling Station 2 (S2) was located 100 meters downstream of the wastewater effluent discharge point, this station was used to evaluate the immediate impact of the effluent on the water quality and aquatic life.

Sampling Station 3 (S3) was located 500 meters downstream of the wastewater effluent discharge point; this station was used to evaluate the impact of the effluent on the water quality and aquatic life at a moderate distance from the discharge point. Sampling Station 4 (S4) were located 1 kilometer downstream of the wastewater effluent discharge point, and used to evaluate the impact of the effluent on the water quality and aquatic life at a greater distance from the discharge point. Sampling Station 5 (S5) was located 2 kilometers downstream of the wastewater effluent discharge point and used to evaluate the impact of the effluent on the water quality and aquatic life at an even greater distance from the discharge point. Sampling Station 6 (S6) was then located 5 kilometers downstream of the wastewater effluent discharge point and used to evaluate the long-term impact of the effluent on the water quality and aquatic life.

Location of the Study Area

The Trans Amadi Industrial Area, is a 2500-acre (1,000 hectare) site, that lies between latitudes 4’48’00” N to 4’49’30” N, and longitudes 7’00’45” E to 7’03’45” E, located in Obio-Akpor Local Government Area (LGA) of Rivers State. It is a budding industrial center in Nigeria where tires, aluminum products, glass /PET bottles, and Paper are manufactured. The town also manufactures steel structural products, corrugated tin, paints, plastics, enamelware, wood and metal furniture, cement, concrete products and several other goods. It plays host to several International Oil Companies (IOC) including Total Exploration and Production, Halliburton Energy Services Ltd, Schlumberger Nig. Ltd, several banks and financial institutions, as well as a range of production companies like the PABOD breweries, makers of Grand Lager, Hero Lager and Grand Malt, construction companies like Julius Berger Nig. Ltd. and including our case study the Nigerian Bottling Company (NBC) makers of coca cola etc. The Rivers State Zoological Gardens, an Abattoir and a Government Technical College are also part of the Major Land Marks of the Area. Communities such as Oginigba, Azuabie, Rainbow Town, Some Sections of Elekahia and Nkpogu are also parts of the Trans Amadi Industrial Area.

Sampling Location

Samples for this study will be collected from four different locations along the Trans-Woji River in Trans-Amadi Industrial Layout, Obio-Akpor Local Government Area of Rivers State. Figure 1 showes the sampling points or locations of the study.

Field Sampling

In situ measurements for surface water temperature, turbidity, electrical conductivity, pH and dissolved oxygen were determined with the use of HANNAH H1 9828 V1.4 PH/ORP/EC/DO Meter. Total dissolved solids (TDS) were determined electrometrically in situ. The meter was calibrated with the standard HI 9828-25 Calibration solution. The desired physicochemical parameter was read off the LCD of the meter.

Sample Collection

Samples used for this study are surface water and sediments from six sampling stations along the Trans-Woji River, and a proximate point six as control (Plates 1 and 2). Sampling was done at an interval of once a month between April and October 2023, covering both the wet and dry seasons. Samples were collected in duplicates from each location, monthly. Sample collection in duplicates was done during hours when the river samples were collected. Sediment samples were collected from an inter-tidal surface of the river using a grab sampler. The grab sampler was thoroughly rinsed with wastewater along the same water course to remove any visible sediment before and after use. At each sampling point, the sampler was lowered to the water bed and the topmost layer of the sediment heaved out. The sediment sample was scooped from the grab’s cup and transferred into sterile sample container in two replicates at each sampling period. The sample was labeled and then transported to the laboratory in a cooler packed with ice blocks for analysis.

Sample Preparation

All samples for analyses will be processed using standard methods [16,17]. The sampling location maps are showed in Figure 1.

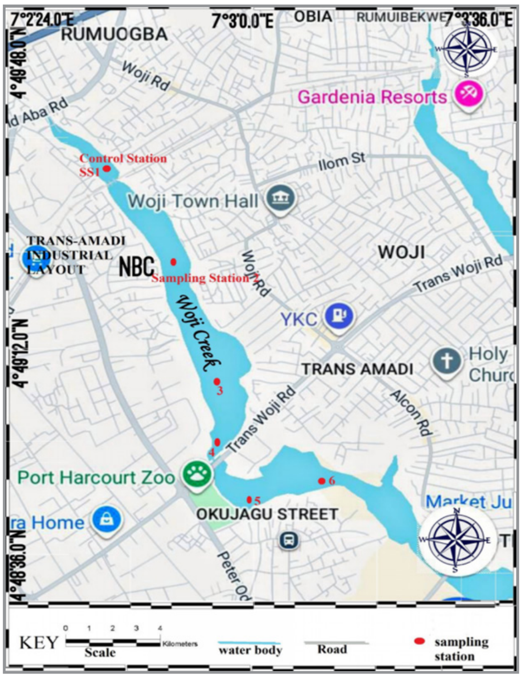

Figure 1: Trans-Woji Creek indicating Sampling Stations

Method for Determining Physical Parameters of Water Samples
Physiochemical parameters of the water samples was determined using standard methods (APHA 1998). The Physico-chemical parameters include; Temperature, pH, Electric conductivity, turbidity, total dissolved solids (TDS), dissolved Oxygen (DO), Biological Oxygen Demand (BOD) and total suspended solids while nitrate, phosphate, sulphate were the nutrient parameters. Table 1 shows the methodology adopted by this study.

Table 1: Determination of Physiochemical Parameters in Soil Samples

Parameter	Methodology	Reference/Model
1. Temperature	HANNAH H1 9828	V1.4 PH/ORP/EC/DO Meter (APHA,2005)
2. Nirate	Spectrophotometry	UV-Vis spectroscopy
3. Phosphate	Spectrophotometry	Molybdenum blue method
4. Sulphate	Ion Chromatogrphy	
5. BOD	Azide modification of Winkler's method	Sawyer and McCarty, (1978)
6. DO	HANNAH H1 9828	V1.4 PH/ORP/EC/DO Meter APHA (2005)
7. Turbidity	HANNAH H1 9828	V1.4 PH/ORP/EC/DO Meter
8. TDS	Electrochemical (in situ)	electrometrically in situ.(APHA, 2005)
9. Electrical Conductivity	HANNAH H1 9828	V1.4 PH/ORP/EC/DO Meter .(APHA,2005)
10. pH	HANNAH H1 9828	V1.4 PH/ORP/EC/DO Meter .(APHA,2005)
11.TSS	Hanna multi meter	Hanna

Water Quality Index (WQI)
The overall water quality index (WQI) will be determined using the equation from Sener et al., (2017) earlier.

$$WQI = \frac{\sum_{i}^{n} = 1qi\ wi}{\sum_{i}^{n} = 1wi} \qquad (3.1)$$

Where; qi = quality rating of ith water quality parameter; Wi = unit of ith water quality parameter = 1; Where: WQI Rating indicates that, 0- 50 = Excellent; 50-100 = Good;100 -200 = Poor; 200 – 300 = Very Poor; > 300 = Unsuitable for drinking

Results

Physico-chemical Characteristics

The results of the physico-chemical characteristics of the different sampling points due to effluent discharges into receiving water body during the wet and dry seasons are presented in Tables 3 and 4. The pH of the samples during wet season ranged from 4.10 to 6.43 (which is below DPR Limit of 6.5-8.5), while the pH of the samples during dry season ranged from 3.10 to 5.70. The pH was significantly different at P<0.005 across the sampling points and season. The pH results obtained in this study shows that pH was slightly acidic in all the sampling points in both seasons.

Total dissolved solid (TDS) and Electrical Conductivity (EC) levels of the five sampling points showed significant differences. The results of the TDS recorded were 489.00±15.56–867.50±3.54 mg/L for dry season and 639.00±55.15 - 967.50±3.54 mg/L for the wet season which was above DPR permissible Limit of 5000mg/L. Electrical Conductivity (EC) values during wet season ranged from 1380.00±226.27 to 1815.00±7.07 µS/cm. The values for dissolved oxygen, biological oxygen demand, turbidity, chloride recorded in this study varied at all sampling points and all also showed significant differences at P< 0.005.

Statistically, quantitative variation was observed in both the wet and dry season at the different sample locations. Figures 2 to 4 shows the seasonal variation of pH, DO and BOD5 of the effluent discharges and receiving water body sampled during the wet and dry seasons at different sampling points.

Table 3: Physico-chemical Characteristics of the Effluent Discharged and Receiving Water Body during Wet Season

S/N	Parameter	Unit	Sampling point 1	Sampling point 2	Sampling point 3	Sampling point 4	Sampling point 5	p-value (0.05)
1	pH	units	4.10±0.14a	4.75±0.07b	5.10±0.14b	5.90±0.14c	6.43±0.28d	0.000
2	Temperature	°C	28.50±0.71b	25.50±0.71a	24.50±0.71a	24.50±0.71a	24.50±0.71a	0.009
3	Turbidity	NTU	19.00±1.41d	14.50±0.71c	11.00±1.41b	9.00±.00ab	7.00±1.41a	0.001
4	Dissolved Oxygen	Mg/l	2.00±0.28a	2.40±0.00ab	2.70±0.14bc	3.10±0.14c	4.90±0.14d	0.000
5	Biological Oxygen Demand	Mg/l	1.35±0.07a	2.25±0.07c	2.55±0.07d	2.80±0.14d	1.70±0.14b	0.000
6	Total Dissolved Solid	Mg/l	967.50±3.54d	921.50±2.12d	856.00±5.66c	746.00±5.66b	639.00±55.15a	0.000
7	Electrical Conductivity	Us/cm	1815.00±7.07b	1746.00±5.66b	1607.50±109.60ab	1398.00±77.78a	1380.00±226.27a	0.043
8	Total Suspended Solid	Mg/l	490.00±14.14e	461.00±4.24d	341.00±1.41c	278.00±11.31b	171.50±2.12a	0.000

9	Sulphate	Mg/l	366.00±8.49c	275.00±7.07b	248.00±2.83ab	175.00±69.30a	206.00±8.49ab	0.011
10	Phosphate	Mg/l	243.00±2.83c	212.50±14.85bc	198.00±22.63b	126.00±5.66a	115.00±1.41a	0.001
11	Nitrate	Mg/l	176.00±12.73d	144.00±5.66c	122.50±10.61b	110.00±2.83ab	91.00±1.41a	0.001

Mean and Standard deviation of triplicate Values: a - e: different characters in the same row indicate values with significant difference ($p<0.05$) (Source- Researcher's compilation, 2024.)

Table 4: Physico-chemical Characteristics of the Effluent Discharged and Receiving Water Body during Dry Season

S/N	Parameter	Unit	Sampling point 1	Sampling point 2	Sampling point 3	Sampling point 4	Sampling point 5	p-value (0.05)
1	pH		3.10±0.14a	3.75±0.07b	4.10±0.14b	4.90±0.14c	5.70±0.28d	0.000
2	Temperature	°C	34.00±1.41c	32.00±1.41c	31.00±1.41bc	28.50±0.70ab	26.50±0.70a	0.008
3	Turbidity	NUT	14.50±0.71e	11.50±0.71d	9.50±0.71c	6.50±0.71d	4.50±0.71a	0.000
4	Dissolved Oxygen	Mg/l	3.65±0.35a	3.80±0.00a	3.90±0.42a	5.10±0.14b	5.60±0.28b	0.003
5	Biological Oxygen Demand	Mg/l	1.10±0.14a	2.11±0.15b	2.45±0.07b	2.35±0.07b	1.18±0.31a	0.001
6	Total Dissolved Solid	Mg/l	867.50±3.54e	821.50±2.12d	756.00±5.66c	546.00±5.66b	489.00±15.56a	0.000
7	Electrical Conductivity	Us/cm	1615.00±7.07e	1546.00±5.66d	1407.50±31.82c	1248.00±7.07b	830.00±14.14a	0.000
8	Total Suspended Solid	Mg/l	305.00±7.07d	254.50±13.44c	141.00±1.41b	83.00±4.24a	71.50±2.12a	0.000
9	Sulphate	Mg/l	266.00±8.49e	225.00±7.07d	205.00±7.07c	185.00±1.41b	126.00±2.83a	0.000
10	Phosphate	Mg/l	178.00±4.24d	157.50±6.36c	141.50±4.95b	106.00±8.49a	94.50±2.12a	0.000
11	Nitrate	Mg/l	126.00±1.41e	119.00±1.41d	107.50±3.54c	91.00±1.41b	84.00±1.41a	0.000

Mean and Standard deviation of triplicate values;a - e: different characters in the same row indicate values with significant difference ($p<0.05$) (Source- Researcher's compilation, 2024.)

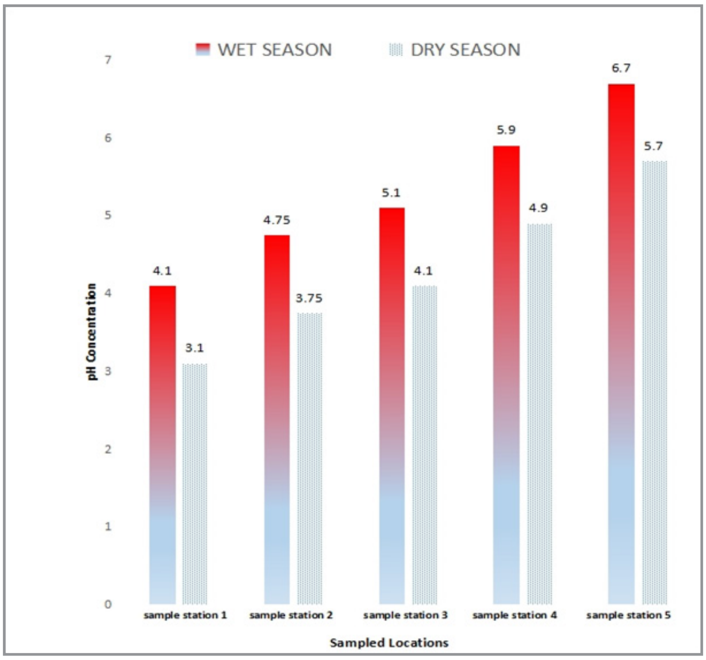

Figure 2: Seasonal Variation in the pH values for Wet and Dry Seasons
(Source- Researcher's compilation, 2024.)

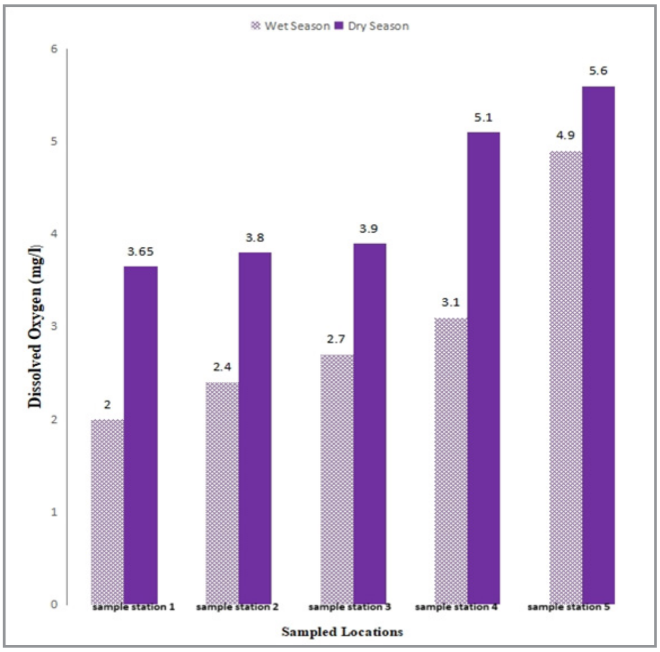

Figure 3: Seasonal Variation in the Dissolved Oxygen for Wet and Dry Seasons
(Source: Researcher's compilation, 2024)

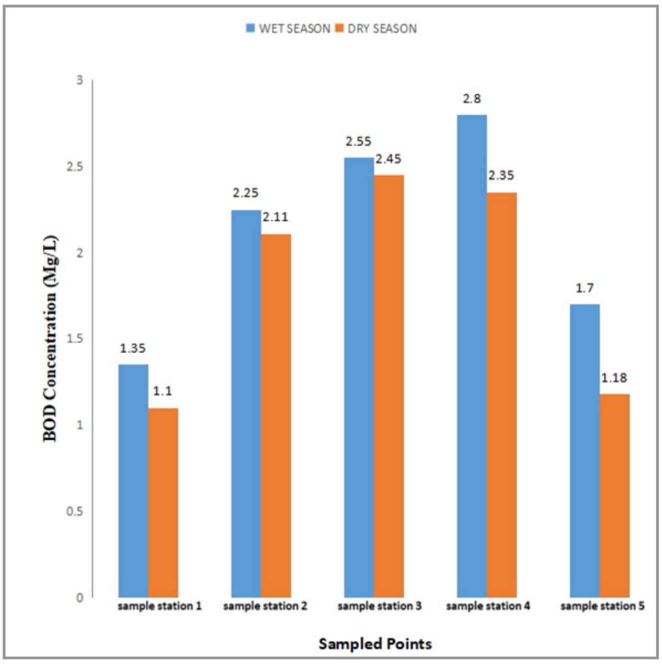

Figure 4: Seasonal Variation in the concentration Biochemical Oxygen Demand for Wet and Dry Seasons

Discussion

The pH is the concentrations of hydrogen ions (H+) concentration in water and it determines acidity or alkalinity. The pH is an important parameter of most of the aquatic animals and plants as it has an influencing role in metabolic activities of aquatic organisms. In present study the average pH value of two seasons of sampling from the five stations is 3.49 ± 0.38. 6.1 which is below the standard limits (6.5- 8.5), according [24]. During the dry season months the low pH value were more acidic which may be attributed to organic pollution and waste discharge from the various activities in the Nigerian breweries draining into the river systems, river water intrusions and other flourishing photosysnthetic activities of the aquatic plants as corroborated by other workers [18]. This implies that the river water are not potable especially during the dry seasons. However, the pH of a water body is known as one of the important factors in the determination of water quality as it affects other chemical reactions such as solubility and metal toxicity [20]. An important problem associated with acidic nature of surface waters is that these waters favour the mobility of non-biodegradable and hazardous trace elements within them[20].

Hydrogen concentration (pH) is important in water quality assessment as it influences many biological and chemical processes within a water body [21]. This low pH can cause skin irritation and make your eyes burn if you open them under water [22]. The variation in the pH in their respective seasons could also be due to the geochemical activities and properties of the formations of chemical [23]. The pH of water is a property that plays vital role in different microbial functions since it has the tendency to impact on the enzymes, hormonal balance, proteins, growth as well as control the metabolism of microorganisms and dissolution of minerals [22].

Similarly, the temperatures of the two terminals in the different seasons were within the limits of 33^{o}C. Temperature is another factor that affect the biotic components inherent in the water body [24]. Fishes and microorganisms are affected by the temperature and dissolved oxygen [25]. Temperature as recorded in this study is reasonably warm with consistent temperatures. The range values are normal for water in the tropics, and are attributed to weather conditions of the study area which is characterized by hot dry season and cold wet season. The difference in the water temperature between the wet and dry seasons were statistically ($p<0.05$) significant. Conversely, the recorded mean water temperature for each of the seasons showed variations within very narrow limit. Temperature influences the growth of microbes and aquatic inhabitants, colour, odour, and taste of water. Also change in temperature determines the increase or decrease of chemical reactions in water. Similarly the rate of biochemical reactions usually doubles for every rise in temperature.

The mean electrical conductivity values measured during the dry season are higher than those of the wet seasons. The most likely EC reflect the effect of dilution during the wet season. Explained that precipitation, fresh water discharge and low temperature conditions do not favour high concentration of ionized substances in water [26]. The EC content may be as a result of land runoff which contains large amounts of cations and anions as averred by [27]. Also certain levels of TDS are essential for aquatic organisms and high level of TDS may be unfavourable for aquatic life [26].

The mean Dissolved Oxygen (DO), concentration measured in this study were frequently below the 14 mg/L limit set by the Nigerian standard for drinking water quality and World Health Organization (2012) [24]. The observed low dissolved oxygen values possibly reflects early indication of undesirable conditions in the physical, chemical and biochemical factors within the water bodies [25]. Low DO may be attributed to high organic waste discharge into the stream/river from the various activities in the slum environment. High DO concentration are very vital and important for aquatic organisms as it is required for the metabolism of aerobic organisms and organic matter decomposition, of utmost concern is the low levels DO observe in the river during the dry season [27].

Though this may be attributed to high load of organic waste discharge and the microbial activity that degraded the matter leading to oxygen consumption, low oxygen in water negatively impacts the lives of low oxygen intolerant aquatic organisms such as fish [28,29]. The DO is one of the most important factors for healthy and survival of aquatic organisms, and is critical for maintaining oxygen balance in aquatic ecosystems [30,31].

Similar high biological oxygen demand (BOD), were recorded in this study compared to report by various researcher [30,32,33]. Nevertheless, the mean BOD values observed in this study were below the recommended standard for drinking water. BOD is a measure of the biological activities in a water body, which gives an indication of the organic load of water bodies, especially those receiving organic effluent. Biochemical Oxygen Demand (BOD5) is used as an index to determine the amount of dissolved oxygen required by aerobic biological organisms (microorganisms) to decompose organic materials and also biological activity in the water. Hence high concentrations of BOD are an indication of organic pollution Also, the BOD, concentrations obtained in the wet season were slightly higher than those obtained in the dry season but showed no significant difference [25,32]. Interpreted low BOD values as an indication of limited levels of organic matter decomposition requiring oxygen from the water [20]. The high BOD may be as result of delay of organic matter in the water systems, and is an indication of heavy pollution of the rivers as well as poor water quality [33]. The BOD has been described as an indicator of organic load in water [21].

Also, the mean values total dissolved solids, total suspended solids, turbidity, nitrate, sulphate, phosphate, of the dry season were higher than the obtained values in the wet season. Despite this, there was no significant difference between the two seasons. The total dissolved solids (TDS), turbidity, BOD, in the two seasons are below the DPR limits of 5000, 15 NTU, 125, 125 and 20, respectively, while the TSS of the the samples were far above the <50 DPR limits in the two seasons. Previous study has highlighted the effect of TDS on water body as it hinders the penetration of light thereby inhibiting the ability of algae which are the primary producers to photosynthesis [25]. The values of TDS and TSS obtained in this study are higher than the values reported by [25]; In previous studies [23]. The conductivity of a medium is an indication of its ability to conduct an electric current. It is often determined via the availability of total concentrations of ions, temperature [21,32]. These high values of electrical conductivity obtained in this Woji Creek could be attributed to the high decomposition of organic matter.

Conclusion

The assessment of effluent discharge of the Woji River of Obio/Akpor Local Government Area of Rivers State revealed wide variation in nitrates, phosphates and turbidity during the sampling period. However, narrow variations were observed in temperature, pH, nitrates, BOD and phosphates. The levels of several of these parameters were similar to those recorded for other inland waters of the Niger Delta area of Nigeria. Other than turbidity the other physico-chemical variables measured fell within recommended limits for aquatic life by the Federal Ministry of Environment. Sequel to the research finding of the study, the following recommendations should be adopted; the State Environmental Protection Agencies (SEPA) should develop practical standards and regulations for the protection of the waterways, mount regular surveillance to prevent further pollution of the channel and current approaches by the pollution and control department of Federal Ministry of Education (FMOE) aimed at reducing significant pollution should be maintained [34-45].

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APPENDIX I

Plate 1: Researcher collecting water sample from the Trans-Woji Creek

Plate 3: Researcher collecting sediment sample from the Trans-Woji Creek