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# An Evaluation of the Physicochemical Quality of Lobia Creek in the Niger Delta

**Iyeritei Flora*, Obire, Omokaro and S. I. Douglas**

*Department of Microbiology, Rivers State University, Nkpolu-Oroworukwo, P.M.B 5080, Port Harcourt, Nigeria*

**Corresponding author*

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**A B S T R A C T**

The physicochemical properties of water play a major role in evaluating water quality and could serve as a tool to determine the impact of human activities on the water body. Water samples were collected from four different stations with human activities (Abattoir, toilet, jetty, and drinking water points) along Lobia creek and from the fifth station without any human activity which served as a control. The impact of human activities on the physicochemical characteristics of Lobia creek was investigated and determined using the APHA method. Results showed that the temperature of the water samples ranged from 27.20±1.13 to 27.35±0.92ºC with the abattoir station recording the highest value while the control had the least temperature value. The pH values ranged from 6.80±0.52 to 7.23±0.95. The control had the highest while the toilet and jetty stations recorded the least pH value. Electrical conductivity (EC) ranged from 6300±1.41 to 16100±8.69µs/cm and Total dissolved solids (TDS) ranged from 3905±70.4 to 11075±7.69mg/L. The jetty station recorded the highest TDS while the drinking water station had the least. The salinity ranged from 0.03±0.04 to 0.16±0.15mg/L. The turbidity values ranged from 0.30±0.12 to 0.69±0.001 NTU. Chlorine and Bromine values recorded were<0.001mg/L in all stations. DO values ranged from 1.30±0.42 to 2.30±0.98mg/L. The jetty had the highest DO compared to all other stations. The$BOD_5$ ranged from 0.85±0.07 to 1.90±0.56mg/L. Total petroleum hydrocarbon (TPH) ranged from 0.49±0.36 to 0.82±0.19 mg/L and the toilet station had the highest value. There was no significant difference ($P>0.05$) in the temperature, pH, salinity, chlorine, bromine, EC, and BOD values across the five stations of the Lobia Creek. While there were significant differences ($P\leq0.05$) in the values of TDS and turbidity across the five stations of the Lobia Creek. The correlation results revealed that Temperature, Salinity, and DO were significantly correlated with pH, EC, and TDS, while the total and feacal coliforms showed a negative significant correlation with turbidity. The variation in the values of the physicochemical parameters is attributed to the different anthropogenic activities in each station. Generally, water samples of the drinking water station and the Control station were of better quality than the other stations. This showed that human activities have an impact on the water quality of Lobia creek. Based on the findings, the Lobia creek water is not fit for drinking and for other purposes for which it is currently being used. Proper treatment of the water before use and proper treatment of waste before disposal is therefore advocated to avoid public health hazards in the Lobia community.

## Introduction

Water is a plentiful natural resource that is essential for survival in many parts of life, and it is a precious resource that must be well-managed (Iyerite *et al.,* 2021). Water as a life-sustaining liquid is required by living beings for metabolism (Akpan and Ajayi, 2016) and it is also used for physical sustenance, and food production, including economic development through downstream applications (Enetimi and Sylvester, 2017). Surface water resources are used for a variety of functions in developing countries like Nigeria, including transportation, a source of livelihood through fishing, drinking water sources, and residential water sources (such as washing, cooking, and bathing), particularly in coastal rural areas (Enetimi and Sylvester, 2017). The majority of the freshwater supply is used for drinking and most domestic needs. According to Izah *et al.,* (2016), surface water is mostly utilised in places where groundwater supplies, such as boreholes, are sparse and/or residential areas are far.

The issues of water (surface and ground) and sediment pollution have been of concern to all stakeholders in Nigeria's Niger Delta because of the rate and amount of environmental and aquatic damage caused by human activities, notably from industrial and home sources (Adesuyi *et al.,* 2016). Oil extraction and related operations in the Niger Delta have also boosted the region's population growth rate as well as the amount of garbage generated (Adesuyi *et al.,* 2015). Waste discharges into the aquatic environment are increasing as a result of the continuous increase in population density, which is accompanied by fast urbanization and industrial activities (Edori *et al.,* 2019). This population increase has led to overexploitation and contamination of surface water. According to Kpee and Ekpete (2014), overexploitation and exploration of the natural environment without regard for established laws or principles have led to the accumulation of harmful compounds in the ecosystem. These contaminants could in turn alter the concentrations of the physical and chemical properties of the water. According to Enetimi *et al.,* (2016), the disparity in the physicochemical parameters of water quality is to a large extent influenced by the polluting substances. Water quality refers to the chemical, physical, biological, and radiological characteristics of water (Diersing, 2009). It is a measure of the condition of water relative to the requirement of one or more biotic species and or to any human need or purpose. The quality of the River is reportedly altered by anthropogenic agents originating from runoffs and the toxicity or adverse effects of these agents are largely dependent on their physicochemical properties, leachability, and source (Angaye *et al.,* 2015). Furthermore, Aurecon (2011) also opined that factor such as weather, runoff, and waste discharged into the river alter the quality of the water and the parameters. Thus, this alteration could either result to an imbalance either due to increased concentration or decreased concentrations of the water parameter especially variations reported in previous studies of water impacted by human activities (Adekunle and Eniola, 2008).

Water quality assessment is mostly used to measure the magnitude of water pollution (Kgabi, 2015). Water quality assessment is the complete process of evaluation of the physical, chemical, and biological nature of water-based on human effects and intended uses (Mwangi, 2014). Globally, numerous deaths have been reported due to water resources not meeting their constituents' concentration (Afiti *et al.,* 2015). Improved water resource management ensures that water resources have less risk of contamination and the water is suitable for both human lives and the environment at large. The spatial extent of pollution is critical as the mixing of pollutants occurs over a given distance (Islam *et al.,* 2007). The risk associated with pollution depends on both the extent of the temporal and spatial variation of the pollutant (Remesan and Panda, 2008). The health of the aquatic ecosystem especially the Lobia Creek could be negatively affected by the presence of toxic substances due to various activities around the creek. Most of the other natural constituents enter the environment as a consequence of weathering and erosion and are also released into the aquatic environment through the storm, water runoff, and wastewater discharges which eventually have the potential to be toxic to biota above certain threshold concentrations (Obire and Aguda, 2002). These conditions may also affect wildlife, which uses surface water for drinking or as a habitat.

Generally, for measuring water quality, the physical parameters (turbidity, electrical conductivity, temperature, total dissolved solids, color, and taste), chemical parameters (pH, COD, BOD, nonmetals, metals, and persistent organic pollutants, POPs), and biological (fecal coliform, total coliform, and enterococci count) analyses are usually used (DWA, 2013).

Although the most significant parameter when it comes to human health are microorganisms that come into the water from human and animal excreta, alteration of the physicochemical parameters of water bodies could be used as a tool to determine their quality (WHO, 2011). It is therefore important to determine the physicochemical parameters of the Lobia creek which is a source of water supply to the rural indwellers so as to bridge the gap of information on the water quality in terms of the physical and chemical parameters. Thus, this study, therefore, aims to evaluate the physicochemical parameters of the Lobia creek at different points.

## Materials and Methods

### Description of the Study Area

This research was carried out on surface water samples collected from Lobia Creek in the Southern Ijaw region of Bayelsa State located in the central Niger Delta in Nigeria (Iyerite *et al.*, 2021) The Lobia Creek is about 85km long with several communities located along its banks. The communities engage in similar economic activities and so they generate similar waste and adopted the same method of disposal. The sampling stations were along the Lobia Creek area where Lobia communities are located.

### Description of Sampled Stations on Lobia Creek

The peculiar nature and sources of pollution from human activities along the studied creek was the major factor that influenced the choice of sampled stations in this study. Five stations were chosen and designated as station 1, station 2, station 3, station, 4, and station 5 respectively, for the purpose of this study. Distances between stations were not consistent as choices of stations were based on sites where waste materials from human activities are channeled into or directly deposited into the creek. Station 1 is a toilet on wood planks where raw human feaces and urine are directly discharged by residents around the creek into the surface water without treatment, station 2 is a jetty where marine bolts related and other anthropogenic activities are being carried out along the creek, station 3 is a fishabattoir dumpsite point where fishes are being slaughtered and many organic wastes are deposited, station 4 is the drinking water point where people around the creek uses a canoe to get water for domestic consumption. Station 5 is the last station and is located downstream from all other stations. It is located about 300 meters away from station 4 and is free of any human activities hence use as a control station. Figure 1 shows the map of the study area and sampled locations.

### Collection of Water Samples

Water samples for Microbiological and Physicochemical analysis were collected from the sampling stations at monthly intervals for a period of six months from August 2020 to January 2021. Sample bottles were sterilized by autoclaving at 121ºC for 15 minutes at 15psi and were wrapped in aluminum foil prior to the collection of water samples. Samples were collected from station 1 (Toilet station) using a sterile bottle with a rope from the hole in the middle of the toilet, at station 2 (Jetty station) samples were collected from concrete step down the jetty, station 3 (Abattoir) samples were collected using a sterile bottle with rope while at stations 4 and 5 (Drinking and Control) samples were collected using a sterile bottle after being transported to the point on a canoe. The necks of the bottles were slightly tilted upwards and towards the water current. The bottle is allowed to get filled and the cover is replaced while still underwater (Cheesbrough, 2006). Methods adopted in the collection of water samples were in accordance with APHA (2012). During each monthly sample collection, two sets of water samples were collected using 100 ml sterile glass bottles for Microbiological determinations. Another two sets of water samples were also collected for Dissolved oxygen (DO) determination with 60 ml Winchester glass stoppered bottles. One set of DO samples was fixed with 0.5 ml each of Winkler I and II reagents on the field immediately after collection. The other set was fixed after 5 days of incubation at 20$^{o}$C for biological oxygen demand (BOD) determination. Separate sterile plastic and glass bottles of 500ml capacity were used for collecting water samples for other physicochemical parameters. Water Quality parameters such as organics which may be affected by organic containers were stored in glass bottles. Each sample bottle was appropriately labeled with the station code number immediately after collection at each station, and stored in a portable cooler box containing an ice pack before transportation to the laboratory for analysis. Five (5) samples were collected from each station and a total of 25 samples were collected during each visit from the five stations. A total of 150 creek water samples were collected and analyzed during the six months sample period.

## Physicochemical Analysis

### The pH (Hydrogen Ion Concentration)

Measurement of pH was carried out as described by APHA (2012). The pH of the water samples was measured using the pH meter model 291 Mk2. Prior to the analysis, a standard buffer solution of pH 7, 4, 10 was used in calibrating the pH meter. This was done by pouring small amount of the buffer, pH 7 into a clean beaker and a magnetic stirrer bar dropped into it and the beaker placed on magnetic stirrer to get a homogenous mixture. The pH meter electrode was lowered into the beaker, so that the tip became immersed in the buffer solution and the magnetic stirrer started. The meter was adjusted to take readings of the buffer. Electrode was removed, washed using distilled water then dried.

Same process was repeated using pH 4 and 10. After calibration of the meter, the pH of the sample was analysed using the same procedure as stated above and the meter results recorded for the samples.

### Temperature

Temperature measurements were carried out electrometrically using digital ExStik pH Meter. This was done by immersing the electrode of the meter into about 50ml of the test water in the beaker. Sufficient time was allowed for the meter to attain a constant reading (APHA, 2012). The readings were recorded in $^{0}$C for the samples.

### Conductivity

Conductivity is defined as the ability of an aqueous solution to carry an electric current. This may be possible because of the presence of ions, mobility, their total concentration, number and temperature (APHA, 2012). The conductivity of the samples was determined using a standard solution of potassium chloride of known conductivity cell (0.01NKCl, 745.6mg in 1.0L de-ionized water = 1413µmhos/cm). The electrode was washed three times in the 0.01N KCl solution and the conductivity of the solution was measured by immersing the electrode into the sample and the readings were recorded (APHA, 2012).

### Total Dissolved Solids

This was carried out electrometrically using the digital TDS Meter of range 0 – 1999µS/cm (TDSSCAN 20) by immersing the electrode of the meter into about 50mL of the test water in the beaker. Sufficient time was allowed for the meter to attain a constant reading before the final readings were taken.

**Salinity**

This was determined in accordance with the method described by APHA (2012). One (1) ml of potassium chromate indicator solution was added to 100ml of sample. This was titrated with standard silver nitrate titrant, (0.0141N) to a pinkish yellow end point. Silver nitrate was standardized using standard sodium chloride solution (0.141N). About 25ml of the standard sodium chloride solution was introduced into 150ml Erlenmeyer flask and 6 drops of potassium chromate indicator was added to it. The solution was titrated with silver nitrate solution until a red precipitate appeared. The flask was stoppered and shaken vigorously to break the curds of silver chloride. Titration was continued to end point and volume of silver nitrate utilized, recorded. A blank, prepared with distilled water was also titrated with silver nitrate to end point and the volume of the titrant recorded. Chloride concentration was calculated thus:

$$CT\left(\frac{mg}{L}\right) = (A+B)\ x\ N\ x\frac{3550}{ml}\ sample \quad \text{...eqn 1}$$

Note: A, represents titration volume for sample (ml); B, represents titration volume for blank (ml) and N represents normality of silver nitrate; NaCl = CT x 1.65 (mg/L)

**Turbidity**

Distilled water was used to calibrate the nephelometer (0 NTU). Hydrazine sulphate 1.0g was dissolved in 100ml of distilled water to form solution 1. Also, hexamethylenetetramine 10.0g was dissolved in distilled water and made up to 100ml in volumetric flask; solution 2. Then 5ml of solutions 1 and 2 were mixed in a volumetric flask and kept for 24 hrs at about 25$^{o}$C.

The mixture was diluted to 1000ml with distilled water to give a 400 NTU stock suspension. Afterwards, 10ml of the stock solution was diluted to 100ml with distilled water to give 40NTU standard solution. Both mixtures were thoroughly being recorded in nephelometric tube.

Turbidity (NTU) = Nephelometer readings x Dilution factor…eqn 2

If the turbidity of the sample is >40 NTU, then the sample is diluted and the dilution factor is accounted for in the final calculations, APHA (2012).

**Dissolved Oxygen (DO)**

This is the concentration of oxygen in the sample. A fresh was collected in 300ml BOD bottles, completely filled with the sample. Entrapping atmospheric oxygen was avoided. The bottles were carefully stoppered and water sealed. The sample was examined immediately upon arrival at the laboratory. The dissolved oxygen with electrode system was calibrated against a sample of known DO, as determined by the 10-iodometric method. The water seal was decanted from BOD bottles containing the sample. The ground glass stopper was then removed and the electrode system of the DO meter was immersed into the sample in the BOD bottle. The DO meter reading was carefully observed and recorded.

**Biochemical Oxygen Demand (BOD)**

Airtight 300ml capacity BOD bottles were filled to the brim with the samples. The initial dissolved oxygen in the sample was determined. The diluent was prepared by measuring out 22.5g/L $MgSO_4.7H_20$, 27.8g/L $CaCl_2.2H_2O$, and 0.25g/L $FeCl_3$. $6H_2O$, Phosphate buffer: 8.5g $KHPO_4$; 21.7g of $K_2HPO_4.7H_2O$; 1.7g of NaCl and pH 7.2 into a measuring container making up volume to 1L with distilled water. The contents of the flask were mixed by swirling gently and covered. The dilution water was first saturated with dissolved oxygen by shaking in a partially filled bottle before using to dilute the samples. BOD bottles were then filled with the diluted samples and another two bottles with the dilution water to serve as blank. The bottles were stoppered carefully to avoid the entrapment of air. The blank and one experimental BOD bottles were used for the initial dissolved oxygen (DO) determination. The remaining two BOD bottles were water-sealed by filling the flared neck of the bottles with distilled water from a wash bottle. The cover cap supplied with the BOD bottles was used to retain the water. The bottles were incubated at 20ºC for 5days. At the end of this period, the final DO was determined. The $BOD_5$ in mg/L of the sample was estimated using the formula;

$$BOD5\left(\frac{mg}{L}\right) = DI - D2/P \quad \text{…Eqn 2}$$

$D_1$ represents Dissolved Oxygen (mg/L) of sample 15 minutes after preparation

$D_2$ represents Dissolved Oxygen (mg/L) of sample 5 days after incubation at $20^0$C

P represents Decimal volumetric fraction of sample used, APHA (2012).

### Determination of Total Petroleum Hydrocarbon (TPH) and Polycyclic Aromatic Hydrocarbons (PAHs)

Determination of TPH in aqueous samples is an analysis conducted in many environmental testing laboratories. Traditional methodologies typically involve manual liquid-liquid extraction (LLE) of the water samples with an immiscible solvent, such as n-hexane or dichloromethane; subsequently, the extract is dried using specially prepared anhydrous sodium sulphate, concentrated through an evaporation step, which may incorporate a solvent exchange, and analysed using conventional split/spitless GC-FID equipment. Within contemporary environmental testing laboratories, the use of solid-phase extraction (SPE) technology, as an alternative to LLE, is not widespread.

### Extraction process

The samples (surface water) were extracted using the standard method for the analyses of TPH and PAHs. The water samples were extracted using the cold extraction method as adopted by Inengite *et al.,* (2015); 250ml of the water sample was transferred into a separation funnel. A 16 hour of soxhlet extraction was applied for TPH extraction by using 95% n-hexane solvent, while a 1:1 mix ratio of n-hexane/ dichloromethane solvents was used to extract PAHs. The organic extract was collected into a receiving container bypassing the organic extract through an extraction column packed with glass-wool, silica gel, and anhydrous sodium sulphate.

### Measurement of Total Petroleum Hydrocarbon

The Hydrocarbon content of the sample was determined through the principle of Gas Chromatography with flame ionization detector as sample extracts are being forced through an immobile, inert stationary phase (1,3-dimethylsiloxane) and components of low solubility take a longer elution time leading to the differential mobilities of the fractional components of the Total Petroleum Hydrocarbon (TPH). Samples were automatically detected as they emerged from the column (at a constant flow rate) by the FID detector whose response was dependent upon the composition of the respective constituent fractions.

### Principle of gas chromatography

The sample solution injected into the instrument enters a gas stream which transports the sample into a separation tube known as the "column." (Helium is used as the carrier gas). The various components are separated inside the column. Hydrogen and air at a flow rate of 30psi served as ignition gases (Uzoekwe and Aigberua, 2019).

### Statistical Analysis

The mean and standard deviations of the parameters were computed. The Analysis of variance (ANOVA) was used in checking for the significant difference in the various parameters across the samples while the Duncan test was used in separating the means. All analysis was done using SPSS (version 25).

## Results and Discussion

Results of the physicochemical parameters of the water samples examined are presented in Table 1. Results showed that the temperature of the water samples ranged from 27.20±1.13to 27.35±0.92ºC with the abattoir station showing a higher temperature followed by the toilet and jetty stations which had a similar temperature range while the drink water sample was slightly lower than the control and had the least temperature value. The temperature values showed no significant difference ($P>0.05$) across the stations of the Lobia Creek. The pH values ranged from 6.80±0.52to 7.23±0.95.The toilet and jetty station had the least pH value and were slightly lower than the pH of the abattoir station while the control had the highest pH value followed by the drinking station. More so, there was no significant difference in the pH values across the sampling stations of the Lobia Creek despite the disparity in the pH values across the sample stations. The electrical conductivity (EC) ranged from6300±1.41to 16100±8.69µs/cm, with the jetty station having the highest EC value followed by the toilet and the abattoir station. More so, the EC values of the control were higher than the EC value of the drinking station which had the least EC value. Results of the TDS ranged from 3905±70.4to 11075±7.69mg/L. Results also showed that the samples collected from the jetty had the highest TDS followed by the abattoir, toilet, and control while the least TDS values were recorded in the drinking water sample. More so, there was a significant difference ($P\leq0.05$) in the TDS across the five sampled stations of the Lobia Creek. The values of the salinity of the stations ranged from 0.03±0.04to 0.16±0.15mg/L. The control water samples had a higher salinity value than the drinking water sample which had the second higher salinity value. The salinity value of the toilet which was the third higher value was greater than the salinity value of the abattoir sample while the jetty sample had the least salinity value. Despite the fluctuations of the salinity in the various stations of the Lobia creek, results showed no significant difference across the five sampled stations of the Lobia Creek. The turbidity values ranged from 0.30±0.12to 0.69±0.001NTU.The most turbid sampled station was the control followed by the abattoir and the drinking water while the abattoir and jetty had the least turbid values. There was a significant difference ($P\leq0.05$) in the turbidity values across the five sampled stations of the Lobia Creek. The Chlorine and Bromine recorded <0.001 mg/L across the five sampled stations of the Lobia Creek with no fluctuations. The DO ranged from 1.30±0.42 to 2.30±0.98 mg/L. Results of the DO showed that the jetty station had the highest value followed by the control and drink water station which was higher than the DO values of the abattoir station while the toilet station had the least DO value. Despite the observed fluctuations in DO values, there was no significant difference ($P>0.05$) across the five sampled stations of the Lobia Creek. The values of the BOD ranged from 0.85±0.07 to 1.90±0.56 mg/L. The BOD values showed that the toilet and control had similar values which were the least while the jetty station recorded the highest value followed by the drinking and abattoir stations, respectively. There was also no significant difference ($P>0.05$) in the BOD values across the five sampled stations of the Lobia Creek. The TPH ranged from 0.49±0.36 to 0.82±0.19 mg/L with the toilet Station having the highest value while the abattoir station had the least TPH value. More so, the TPH value of control was higher than the values for jetty and drinking station, respectively. Results showed that there was no significant difference across the five sampled stations. The results of the physicochemical properties were also correlated with previous results of the microbial load (total heterotrophic bacteria, total heterotrophic fungi, total coliforms, and feacal coliforms) of Lobia creek reported by the authors (Iyerite *et al.,* 2021). The results of the correlation of the physiochemical parameters with the microbial load of the water samples are presented in Table 2. Results revealed that Temperature, Salinity, and DO were significantly correlated with pH, EC, and TDS.

Results also show that the BOD was significantly correlated with TDS. It was found out that the total coliforms and feacal coliforms showed a negative significant correlation with turbidity. Generally, except for coliforms that were positively correlated with turbidity, there was no significant correlation of microbial load with the physicochemical characteristics evaluated in this study.

The present study has revealed the physicochemical status and hence the water quality of Lobia creek water samples. The results of the pH of the sample stations showed that the pH was slightly acidic in stations of the toilet, Jetty and abattoir while pH was slightly alkaline in stations of drinking water (pH 7.04) and control (pH 7.23). The mean pH values of drinking water and control recorded in this study were within the acceptable range of 6.5 - 8.5 prescribed by the regulatory agency (NSDWQ, 2008) and 7.0 to 8.5 by WHO(2012). The pH is important in water quality assessment as it influences many biological and chemical processes within a water body (Obire *et al.,* 2003).

The slightly acidic pH values in stations 1, 2, and 3 (toilet, Jetty and abattoir) could be associated with human activities in these stations and on microbial activity on the organic wastes, yielding various organic acids that would result in the lowering of pH. The variation of pH between control and other stations is low. Obire *et al.,* (2003) reported a pH range of 6.3 to 7.71 for a brackish water system. The pH values in this study are higher than the values of 5.4 to 6.5 reported by Puyate and Rim-Rukeh (2008) of surface water in some parts of the Niger Delta. Although, this acidic pH values in their study were influenced by the presence of humic acid from decaying organic matter.

Temperature values recorded in the water samples of the five stations of Lobia creek were reasonably warm with consistent temperatures, ranging values within the mesophilic range. The values reported in this present study are normal for water in the tropics and are attributed to the weather conditions of the study area which is characterized by a hot dry season and cold wet season (Akpan *et al.,* 2015).

The difference in the water temperature between the stations was expectedly due to the various activities at the sampling stations but statistically ($p<0.05$) no significant difference was observed. Conversely, the recorded mean temperature for each of the stations was within the standard permissible limits recommended by (NSDWQ, 2008; WHO, 2012).

The EC in natural waters is the normalized measure of the ability of the water to conduct electricity. Waters with EC values between 500 and 1000 µs /cm are not usually recommended for human consumption, and such waters are also not suitable for irrigation except for high salt-tolerant crops with special techniques of management (Kuyeli *et al.,* 2009). The mean EC values measured in the water sample from the five sampled stations of Lobia Creek were generally high and exceeded the permissible limit of 500 and 1000 µs/cm standard of the NSDWQ (2008) and WHO (2012), respectively. The EC values measured in Station 2 (Jetty) was the highest followed by Station 1 while station 4 which is the drinking water recorded the lowest value (6300±1.41 µs/cm). Akpan *et al.,* (2015) explained that precipitation, freshwater discharge and low-temperature conditions do not favour high concentrations of ionized substances in water. Ephraim and Ajayi (2015), considered waters with EC values less than 250 µs/cm as excellent waters. Statistically, results showed that there was a significant difference in the EC values across the sampled stations of the Lobia Creek. Turbidity is considered an important water quality parameter because of the pathogenic properties it has on drinking water. The higher the mineral content, the more the total suspended solids present in the water. The higher the turbidity level, the more likely taste, and odour problems may arise in the water. Although the mean values of turbidity for the sampled stations were below the acceptable 5.0 NTU limit prescribed by the Nigerian Standard for drinking water quality (NSDWQ, 2008; WHO, 2012). Water with turbidity values above 5.0 NTU is not only visible and objectionable but facilitates transmission of disease by microorganisms associated with particulate matter (Salem *et al.,* 2000). Thus, the relatively low values in the turbidity could represent that the water despite the anthropogenic activities being carried out does not have many suspended materials and this could be attributed to the continuous flow of the water. These values are contrary to the values of 19 and 48 NTU reported in creeks around Niger Delta, Nigeria in a previous study (Puyate and Rim-Rukeh, 2008).

**Table.1** Physicochemical Parameters of Water Samples from the Five Sampled Stations of Lobia Creek

| Parameter | Stations of Lobia Creek | | | | | | | |
|---|---|---|---|---|---|---|---|---|
| | **Toilet** | **Jetty** | **Abattoir** | **Drinking** | **Control** | P-value | NSDWQ (2008) | WHO (2012) |
| **pH** | 6.84±0.52 [a] | 6.84±0.52 [a] | 6.90±0.43 [a] | 7.04±0.65 [a] | 7.23±0.95 [a] | 0.9618 | 6.5-8.5 | 7.0 to 8.5 |
| **Temperature(°C)** | 27.30±0.99 [a] | 27.35±0.92 [a] | 27.30±0.99 [a] | 27.20±1.13 [a] | 27.25±1.06 [a] | 0.9999 | 20-33 °C | ND |
| **Electrical Conductivity (us/cm)** | 14850±6.77 a | 16100±8.69 a | 13600±6.22 [a] | 6300±1.41 [a] | 8450±77.7 [a] | 0.6981 | 500 µs/cm | 250 µs/cm |
| **Total Dissolved Solids (mg/L)** | 10357.5±9.65 a | 11075±7.69 a | 10680±7.88 [a] | 3905±70.4 [a] | 5372.5±53.1 [a] | 0.7681 | 1000mg/l | 500mg/l |
| **Salinity (mg/L)** | 0.06±0.01 [a] | 0.03±0.04 [a] | 0.04±0.04 [a] | 0.09±0.07 [a] | 0.16±0.15 [a] | 0.5194 | ND | ND |
| **Turbidity (NTU)** | 0.30±0.12 [e] | 0.33±0.47 [d] | 0.68±0.001 [b] | 0.65±0.02 [c] | 0.69±0.001 [a] | <.0001* | 5.00 NTU | 5.00 NTU |
| **Chlorine (mg/L)** | <0.001 [a] | <0.001 [a] | <0.001 [a] | <0.001 [a] | <0.001 [a] | NA | 1.0 mg/L | 1.0 mg/L |
| **Bromine (mg/L)** | <0.001 [a] | <0.001 [a] | <0.001 [a] | <0.001 [a] | <0.001 [a] | NA | 5 mg/L | 5 mg/L |
| **Dissolved Oxygen (mg/L)** | 1.30±0.42 [a] | 2.30±0.98 [a] | 1.70±0.99 [a] | 1.75±0.20 [a] | 1.85±1.34 [a] | 0.9530 | 14 mg/l | 14 mg/l |
| **Biochemical Oxygen Demand (mg/L)** | 0.85±0.07 [a] | 1.90±0.56 [a] | 1.25±0.64 [a] | 1.30±0.85 [a] | 0.85±0.21 [a] | 0.7290 | <5 mg/l | <5 mg/l |
| **TPH ( mg/L)** | 0.82±0.19 [a] | 0.59±0.32 [a] | 0.47±0.40 [a] | 0.49±0.36 [a] | 0.71±0.03 [a] | 0.9238 | 0.02 mg/l | 0.01 mg/l |

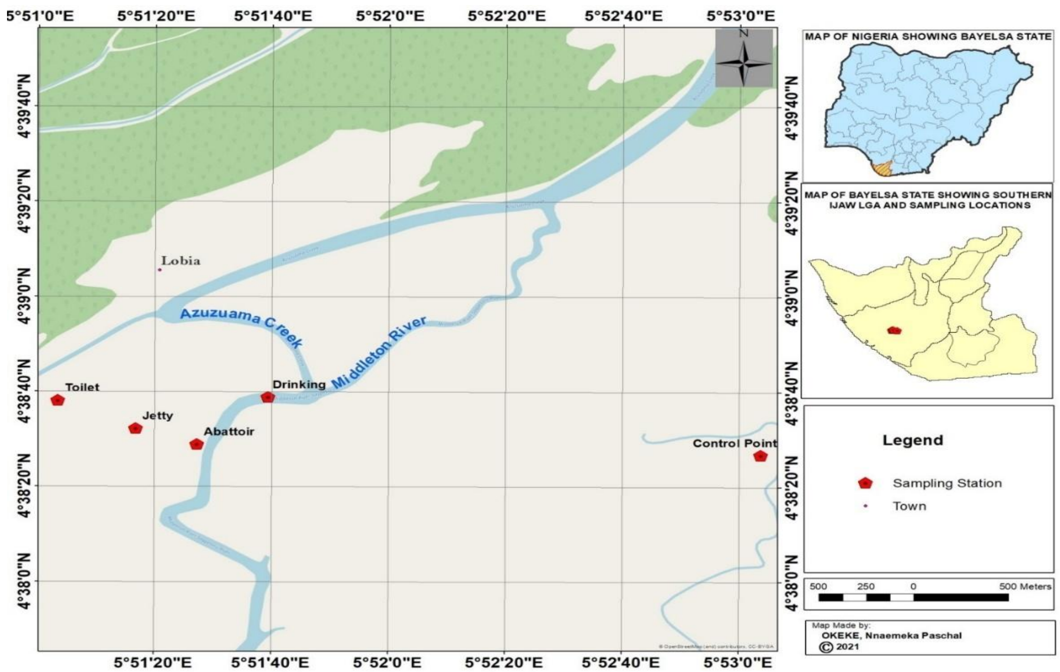
**Means with different superscript ([abcde]) shows Significant Difference while means with the same superscript ([abcde]) shows no significant Difference along columns at P ≤0.05**

**Table.2** Correlation of the physiochemical characteristics with the microbial property

| Parameters | pH | Temperature | Electrical Conductivity | Total Dissolved Solids | Salinity | Turbidity | Chlorine | Bromine | Dissolved Oxygen | Biochemical Oxygen Demand | TPH | Total Heterotrophic Bacteria | Total Heterotrophic Fungi | Total Coliform | Feacal Coliform |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| **pH** | 1.0000 | | | | | | | | | | | | | | |
| **Temperature(°C)** | **0.8998** | 1.0000 | | | | | | | | | | | | | |
| **EC(μS/cm)** | 0.3366 | **0.6375** | 1.0000 | | | | | | | | | | | | |
| **TDS(mg/L)** | 0.4089 | **0.7074** | **0.9819** | 1.0000 | | | | | | | | | | | |
| **Salinity (mg/L)** | **0.6648** | 0.3224 | -0.3605 | -0.3288 | 1.0000 | | | | | | | | | | |
| **Turbidity (NTU)** | 0.1685 | 0.0053 | -0.1397 | -0.1003 | 0.1631 | 1.0000 | | | | | | | | | |
| **Chlorine (mg/L)** | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | | | | | | | | |
| **Bromine (mg/L)** | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | | | | | | | |
| **DO (mg/L)** | **0.8157** | **0.8652** | 0.5844 | 0.6205 | 0.2369 | 0.2266 | 0.0000 | 0.0000 | 1.0000 | | | | | | |
| **BOD (mg/L)** | 0.4713 | **0.6603** | 0.6243 | **0.6325** | -0.1970 | 0.1593 | 0.0000 | 0.0000 | **0.8769** | 1.0000 | | | | | |
| **TPH (mg/L)** | 0.5946 | **0.7590** | **0.7242** | **0.7341** | 0.0939 | -0.1898 | 0.0000 | 0.0000 | 0.5160 | 0.3835 | 1.0000 | | | | |
| **THB(CFU/ml)** | -0.1714 | 0.1264 | 0.5295 | 0.5203 | -0.3902 | -0.6075 | 0.0000 | 0.0000 | -0.1592 | -0.1003 | 0.2692 | 1.0000 | | | |
| **THF(CFU/ml)** | -0.3966 | -0.1689 | 0.2113 | 0.2069 | -0.4257 | -0.5197 | 0.0000 | 0.0000 | -0.3302 | -0.2063 | -0.1400 | **0.8773** | 1.0000 | | |
| **Total Coliform(CFU/ml)** | -0.2229 | 0.0150 | 0.2436 | 0.2547 | -0.2820 | **-0.7704** | 0.0000 | 0.0000 | -0.2833 | -0.2294 | 0.1027 | **0.9173** | **0.9078** | 1.0000 | |
| **Feacal Coliform(CFU/ml)** | -0.2205 | 0.0093 | 0.3352 | 0.2991 | -0.2476 | **-0.7752** | 0.0000 | 0.0000 | -0.2944 | -0.2581 | 0.1945 | **0.9451** | **0.8514** | **0.9478** | 1.0000 |

***Bold values signifies significant correlation**

**Fig.1** Map of the Study Area (Source: Iyerite *et al.*, 2021)




The DO is a vital parameter in water analysis due to its role in the aquatic environment as aquatic life is highly reliant on its availability. The mean dissolved oxygen concentration measured in the sampled stations of Lobia creek varied in all the stations and the values are generally below the 10 mg/L limits set by the Nigerian standard for drinking water quality (NSDWQ, 2008; WHO, 2012). The observed DO in the present study does not corroborate the values reported by Puyate and Rim-Rukeh (2008). The observed low DO values could possibly reflectan early indication of undesirable conditions in the physical, chemical, and biochemical factors within the water bodies due to human activities around and within the creek. More so, Rim-Rukeh and Agboz (2013) reported that low dissolved oxygen could lead to the poor degradation of organic matters. The BOD, which is a measure of the biological activities in a water body, gives an indication of the organic load of water bodies, especially those receiving organic effluent such as stations 1 and 3. BOD values for the investigated waters samples from the five stations of Lobia Creek varied in all the stations. Very low BOD was observed in station 3 where fish wastes are dumped. Ephraim and Ajayi (2015) interpreted low BOD values as an indication of limited levels of organic matter decomposition requiring oxygen from the water.

The TPH concentrations can be potentially toxic and dangerous when they cross the food chain especially water into the biological system. The mean total petroleum hydrocarbon recorded from the surface water samples across the five stations such as the Toilet station, Jetty station, Fish abattoir, drinking water, and control stations varied in all the stations with station 1 having the highest value and Station 3 having the least value. The spike of total petroleum hydrocarbon recorded in this study indicated that the surface water of Lobia Creek is not good for domestic uses such as drinking and cooking because a trace of hydrocarbon product in drinking water is a serious public health concern as it may results in various kinds of diseases including cancer (WHO, 2012), TPH is classified as environmentally hazardous pollutants due to their known hydrophobic, mutagenic, and carcinogenic characteristics (Godson *et al.*, 2009). However, oil production activities generally pollute surfaces with Terphenyl, benzene, toulene, ethylbenzene, and xylene (BTEX) as well as other toxic chemicals (Godson *et al.,* 2009). The results of the correlation of the physiochemical parameters with the microbial load of the water samples revealed that Temperature, Salinity, and DO were significantly correlated with pH, EC, and TDS, and the BOD was significantly correlated with TDS. It was found out that the total coliforms and feacal coliforms showed a negative significant correlation with turbidity. Generally, except for coliforms that were positively correlated with turbidity, there was no significant correlation of microbial load (total heterotrophic bacteria, total fungi) with the physicochemical characteristics evaluated in this study.

The reliance on surface water sources by the rural communities without water treatment facilities and poor basic hygienic practices therefore pose a serious public health risk especially where there are no other alternative water sources for most rural communities of Lobia in Bayelsa State, Nigeria. Clean, safe and adequate freshwater is vital for the survival of all living organisms and proper functioning of ecosystems, communities and economies (Iyerite *et al.*, 2021). Declining water quality has become a global issue of concern as human populations growth, anthropogenic, industrial and agricultural activities expand, and climate change threatens to cause major alterations to the hydrologic cycle (UNDESA, 2009), which directly affects fragile ecosystem created by the discharge of various organic pollutants into the rivers. In the marine environment, pollution can be due to natural seepage or land-based sources, river discharges, urban runoffs, and other industrial wastes (Nasher *et al.,* 2013).

The physicochemical parameters of the Lobia creek which is consumed by different persons within the communities without proper treatment showed that the water is not fit for drinking. Although certain physicochemical parameters such as pH, turbidity, chlorine, and bromine concentrations were within the recommended limit, the presence of waste and increased values of TPH and low values of DO including BOD renders the water unfit for drinking as TPH values higher than the recommended limit are implicated in ailments such as cancer.

More so, it could be asserted that the different activities such as waste disposal, discharge of human excreta directly into the water without treatment, dredging activities, transportation activities and other forms of anthropogenic activities carried out in the creek has a major influence on the physical and chemical composition of the creek. Efforts should be geared towards reducing the indiscriminate disposal of untreated wastes and oil pollution in this area and also, and water from this creek should undergo proper treatment before consumption as it could also serve as a breeding ground for microorganisms.

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