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Some Physical and Chemical Parameters of Luubara Creek, Ogoni Land, Niger Delta, Nigeria

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Abstract: Some physical and chemical conditions of Luubara creek in Ogoni land area of Nigeria was studied for a period of two years(January, 2006 to December, 2007).The mean monthly rainfall during the sampling period was 169.28±117.57 mm; while the mean monthly humidity was 75.10±5.3%. The ambient temperature recorded for the study area was between 27.65 and 34.35ºC with a mean of 30.62±0.37ºC. The surface water temperature ranged from 25.05 to 32.20ºC with a mean of 27.58±0.18ºC. The pH values ranged from 5.00 and 7.5 (acidic to neutral). All the three stations were slightly acidic (pH 6.33-6.56) with a mean of 6.43±0.09. Station 1 and 3 showed slight alkalinity. The lowest pH was recorded in station 2 while station 1 recorded the highest pH. Total alkalinity values ranged from 5.0 and 15.0 mg/L with a mean of 8.11±0.23 mg/L. Station 3 recorded the highest alkalinity (8.35±2.2 mg/L) while station 2 had the lowest alkalinity (7.89±2.10 mg/L). The alkalinity pattern of the creek was variable. Electrical conductivity ranged from 8.0 and 24.50 µs/cm and the mean conductivity was 13.37±1.27 µs/cm. Station 1 had the lowest electrical conductivity (12.32±4.13 µs/cm). The turbidity of the water ranged from 1.50 NIU to 10.00 NTU with a mean of 4.92±0.09 NTU. Station 1 recorded the lowest mean turbidity (4.28±2.05 NTU) while station 2 had the highest mean turbidity (4.50±2.46 NTU).The dissolved oxygen concentration values ranged from 4.00 to 7.50 mg/L with a mean of 5.88±0.21 mg/L. There was a fall in the oxygen concentration. Station 3 had the highest mean oxygen concentration (6.19±0.99 mg/L) while station 2 had the highest mean concentration of 5.73±0.89 mg/L. The dissolved oxygen concentration values ranged from 4.00 to 7.50 mg/L with a mean of 5.88±0.21 mg/L. There was a fall in the oxygen concentration. Station 3 had the highest mean oxygen concentration (6.19±0.99 mg/L) while station 2 had the highest mean concentration of 5.73±0.89 mg/L. Luubara creek is a fresh water creek. Station 1 and station 2 had zero salinity. The mean salinity was 0.03±0.04‰.The phosphate concentration levels ranged from 0.02 to 0.86 mg/L with a mean of 0.54±0.32 mg/L. Station 1 had the least phosphate concentration (0.73±0.11 mg/L) while station 2 recorded the highest phosphate concentration (0.86±0.12 mg/L). The nitrate concentration values ranged from 0.03 to 1.95mg/L (0.30±0.09 mg/L). Station 1 had the lowest mean nitrate concentration of 0.22±0.03 mg/L while station 3 had the highest mean nitrate concentration (0.43±0.54 mg/L).

Key words: Luubara Creek, Niger Delta, Nigeria, Ogoni land, water conditions

INTRODUCTION

Water quality parameters are important for the survival of aquatic flora and fauna. Some important physical and chemical factors influencing the aquatic environment are temperature, rainfall, pH, conductivity, salinity and dissolved oxygen. Others are phosphate, nitrate, chloride, turbidity, transparency, other dissolved gasses and depth of water.

Temperature can be defined as the degree of hotness or coldness in the body of living organisms either in water or on land (Kutty, 1987; Odum, 1971; Boyd, 1979). It is very important in waters, because it determines the rate of metabolism of aquatic organisms. The concentration of dissolved gases and their solubility in water also depends on the prevailing air temperature. The growth, feeding reproduction and migratory behavior of aquatic organisms including fish and shrimps is greatly influenced by the temperature of water (Largler *et al.*, 1977; Suski *et al.*, 2006; Fey, 2006; Crillet and Quetin, 2006).

Aquatic organisms have their own tolerance limits to temperature and this affects their distribution. High temperatures are recorded on the surface of river waters during midday and become low during the latter part of

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the night (Kutty, 1968). River water shows little thermal stratification because of the turbulent flow which ensures that any heat received is evenly distributed.

The amount of dissolved oxygen in water is very important for aquatic organisms. Dissolved oxygen affects the growth, survival, distribution, behavior and physiology of shrimps and other aquatic organisms (Solis, 1988). For instance, only fishes that tolerate low oxygen can survive in swamps and forest streams. Oxygen distribution also strongly affects the solubility of inorganic nutrients since it helps to change the redox potential of the medium. It can determine whether the environment is aerobic or anaerobic (Beadle, 1981).

The principal source of oxygen that is dissolved in water is by direct absorption at the air-water interface, which is greatly influenced by temperature (Plimmer, 1978, Kutty, 1987). At low temperature more oxygen diffuses into water because the partial pressure is reduced, while at high temperature when the partial pressure is high oxygen diffuses out of the water. The solubility of oxygen in water is controlled by some major factors namely temperature, salinity, pressure and turbulence in the water caused by wind, current and waves. Surface agitation of water helps to increase the solubility of dissolved oxygen in water (Boyd, 1982). In rivers and streams the turbulence ensures that oxygen is uniformly distributed across the water and in very shallow streams the water may be super saturated (Abowei *et al.*, 2010).

The hydrogen ion concentration of waters is usually measured in terms of pH, which is defined as the negative logarithm of hydrogen ion concentration (Boyd, 1979). Pure water ionizes at 25ºC to give a concentration of 10^{-7}g/L.

This concentration is the pH of neutrality and is equal to 7. pH higher than 7 indicates increasing salinity and basicity while values lower than 7 tend towards acidity i.e. increase in hydrogen ion concentration. Abowei (2010) noted that pH higher than 7 but lower than 8.5 is ideal for biological productivity while pH lower than 4 is detrimental to aquatic life. Most organisms including shrimps do not tolerate wide variations of pH over time and if such conditions persist death may occur. Therefore, waters with little change in pH are usually more conducive to aquatic life.

The pH of natural waters is greatly influenced by the concentration of carbon dioxide which is an acidic gas. Boyd and LichtKoppler (1979) stated that phytoplankton and other aquatic vegetation remove carbon dioxide from the water during photosynthesis, so the pH of a water body rises during the day and decreases at night. Other factors that may affect pH are total alkalinity, acid rain and river-off from surrounding rocks and water discharges. Rivers flowing through forest have been reported to contain holmic acid, which is the result of the decomposition and oxidation of organic matter in them hence has low pH (Beadle, 1981).

The alkalinity (HCO^-_3 and CO^-_3) of a water body refers to the quantity and kinds of dissolved ions (anions), which collectively shift the pH to the alkalinity side of the scale. It is an indirect measure of the concentration of anions in water. It is caused by or attributed to the presence of bicarbonates, carbonates, hydroxides and less frequently by borates, silicates and phosphates (McNeely *et al.*, 1979). These ions are derived from dissolved rocks, salts, soils, industrial wastewater discharges and plant activities. There are three types of alkalinity namely: carbonate alkalinity (caused by carbonates and bicarbonates), phenolphthalein alkalinity (due to hydroxyl ions) and total alkalinity (the sum total of the two). It is the total alkalinity of water that is usually determined. It is expressed as milligram per litre equivalent of calcium trixocarbonate (iv) ($CaCO_3$).

The availability of carbon (iv) oxide for phytoplankton growth is related to alkalinity. Boyd (1982) observed that waters with total alkalinities between 20 and 50 mg/L permit plankton production for fish culture. Waters with high alkalinity are undesirable because of the associated excessive hardness or high concentration of sodium salts. Alkalinity in the range of 30 to 500 mg/L is generally acceptable to fish and shrimp production (McNeely *et al.,* 1979). Alkalinity in natural surface waters rarely exceeds 500 mg/L and it is desirable that there should be no sudden variations in the alkalinity of waters so that productivity is not affected (ESB, 1973; Manaham, 1994).

Salinity can be defined as the total concentration of electrically charged ions in water. These ions are the four major cations - calcium, magnesium, potassium and sodium and the four common anions- carbonates (CO_3), sulphates (SO^-_4), Chloride (Cl^-) and bicarbonates (HCO^-_3). Other components of salinity are charged nitrogenous compounds such as nitrates (NO^-_3), ammonium ions (NH_4^+) and phosphates ($PO_4^=$). Salinity is expressed either as a mass of these ions per unit volume of water or as milli-equivalent of the ions per volume of water. In general the salinity of surface waters depends on the drainage area, the nature of its rock, precipitation, human activity in the area and its proximity to marine water (McNeely *et al.*, 1979).

Conductivity is a measure of the ability of water to conduct an electrical current. The conductivity of water is dependent on its ionic concentration and temperature. Distilled water has a conductivity of about 1 µmhos/cm and natural waters have conductivity of 20-1500 µmhos/cm (Boyd, 1979). Conductivity provides a good indication of the changes in a water composition particularly its mineral concentration.

Variations of dissolved solids in water could affect conductivity measurements, but provides no indication of the relative quantities of the various components. There is a relationship between conductivity and total dissolved solids in water. As more dissolved solids are added, water's conductivity increases (McNeely *et al.*, 1979).

Conductivity of salt waters is usually higher than freshwater because the former contains more electrically charged ions than the latter. The freshwater zone of the rivers of the Niger Delta can thus be said to be low in ions.

Phosphorus is present in natural waters either as orthophosphate or undifferentiated organic phosphate. In water, the combined form of the element is continually changing due to the process of decomposition and synthesis between organically bound forms and oxidized inorganic forms (Kutty, 1987). Phosphorus gets into the water through various sources including leached or weathered soils from igneous rocks and domestic sewage containing human excrement. Other sources are phosphates from detergents in industrial effluents and run offs from fertilized farm lands. Phosphorus is very important for plant growth including algal growth in water (Boyd, 1979). Phosphates are absorbed by aquatic plants and algae and constitute an integral part of their body component. The total concentration of phosphorus in uncontaminated waters is reported to be about 0.01 mg/l (McNeely *et al*., 1979). The phosphate concentration of the waters of the Niger Delta is low.

Nitrate (NO_3) is the major form of nitrogen found in natural waters. Other forms of nitrogen present in natural waters include molecular nitrogen (N_2) in solution; ammonia as NH_3; ammonium and ammonia hydroxides (NH_4 and NH_4OH) and nitrate as NO_3. McNeely *et al.* (1979) reported that surface waters rarely contain as much as 5 mg/L and often less than 1 mg/L of nitrate. However where inorganic fertilizers are used ground waters may contain up to 1000 mg/L. The sources of nitrates in water include human and animal wastes; weathering of igneous and volcanic rocks; oxidation of vegetable and animal debris.

Other sources include excrement and the nitrification (conversion of ammonia or nitrite to nitrate) process in the nitrogen cycle in water. Nitrates are important for growth of plants and aquatic organisms such as algae. Weidner and Keifer (1981) observed that nitrates limit phytoplankton growth in water. Small concentrations of nitrates are sufficient to stimulate phytoplankton growth (Kutty, 1987). Hepher and Pruginin (1981) reported that nitrate levels higher than 1.4mg/L did not have any effects in fish ponds in Israel. Wickins (1981) noted that below 100 mg/NO_3 - N/L no toxic effects to fish were observed. Despite the importance of the parameters, information on the isstill lacking in Lubara creek in Ogoni Land. This study bridges the gap.

MATERIALS AND METHODS

Study area: The study was carried out in Luubara creek, Ogoin land in Khana Local Government Area of Rivers State of the Federal Republic of Nigeria for a period of two years (January, 2006-December, 2007). The creek is a tributary of the Imo River and is located between longitudes 7º15′E – 7º32′E and latitudes 4º32′-4º37′ N in the eastern part of the Niger Delta. The upper part of the creek extends from Bori and meanders through Wiiyaakara, Luegbo, Duburo and joins the Imo River at Kalooko.

The creek is divided into two distinct sections brackish water and freshwater. The brackish water stretch is between Bane and Kalooko while the freshwater stretch extends from Bane to Bori. The brackish water area has the normal mangrove vegetation comprising of trees such as *Rhizophora racemosa*, *Avecenia africana*, *Laguncularia racemosa* etc., whereas the freshwater has dense vegetation comprising of large trees, various palms and aquatic macrophytes at the low intertical zone. In freshwater area are *Cocos* sp., *Eliasis* sp., *Nymphea* sp., *Lemna* sp. and *Raffia* sp.. It is characterized by high ambient temperature usually about 25.5ºC and above; high relative humidity, which fluctuates between 60 and 95% and high rainfall averaging about 2500 mm (Gobo, 1988). This high rainfall often increases the volume of water in the creek hence providing good fishing opportunity for the residents. Fishing is one of the major activities going on along the creek because it is the main water route of the Khana people in Ogoni area of the Niger Delta.

The fishes caught in the area include *chrysichthys auratus*, *C. nigrodigitatus*, *Hydrocynus forskalii, Clarias gariepinus*, *Pellonula leonensis*, *Malapterurus*, *electricus*, *Gymnarchus niloticus*, *Synodontis nigri Hepsetus odoe*, *Hernichromis fasciatus*, *Tilapia zilli*, *Tilapia guineensis*, *Sarotherodon melanotheron* and *Eleotris senegalensis* and shellfish (crabs and shrimps) especially *Uca tangeri Callinectes amnicola*, *Goniopsis pelli*, *Cardisoma armatum M. macrobrachion*, *M. vollenhoveni*, *M. equidens*, *Palaemonetes africanus*, *Caridina africana* and *Desmocaris tripisnosa*.

Field activities: For each sampling day in the field the following activities took place. Two plastic bottles measuring one thousand millilitres each were used to collect water samples. The bottles were immersed to about 6 cm below the water surface and filled to capacity, brought out of the water and properly closed. Each bottle was flushed to ensure that no air bubble existed and transported to the laboratory for further analysis. Water temperature was measured in situ using mercury - in-glass thermometer. The thermometer was immersed in water to about 6 cm below the water surface and left to stabilize for about five minutes and the average value was recorded in degrees centigrade. Ambient temperature was also measured at the sample site with mercury - in- glass thermometer. The thermometer was held up right in the air with the fingers with the lower part exposed to the air for about five minutes to stabilize and average value recorded in degrees centigrade.

Hydrogen - ion concentration (pH) was taken

immediately at the sampling site. A multiple meter, model U - 10 micro from Horiba Limited, Japan was used to determine pH of water. The electrode was immersed into the beaker of water sample and values recorded after five minutes to stabilize.

Electrical conductivity was determined by the use of multiple meters; model U-10 from Horiba Limited, Japan. The electrode was immersed into the beaker of water and the readings were taken, after five minutes when the values have stabilised. After taking three readings the average value was recorded.

Salinity of the water was determined by the use of refract meter (Antergo, 28). A drop of the test water was placed on the lens of the instrument while the meter was held horizontally. The test water was allowed to remain for about five minutes and the salinity was then read off from the eyepiece and average values recorded in parts per thousand.

Dissolved oxygen in the water was fixed during the sample collection. One hundred millimetres of water was put into a clean oxygen bottle and flushed several times until all air bubbles escaped. Two millimetres of Manganeous sulphate (Wrinkler's solution I) and another two millimetres of Potassium iodide - Sodium Hydroxide (Wrinkler's solution II) were added to the bottle using a pipette. The bottle was closed and thoroughly shaken to ensure proper mixing. A brown precipitate forms at the bottom of the bottle after this process. The bottle was then, transported to the laboratory for further analysis.

Laboratory activities: The titrimetric method (APHA, 1998) was used to determine the alkalinity of the water. One hundred millimeters test water was placed in an Erlenmeyer flask and two drops of methyl orange solution was added. The flask was shaken and color changed to yellow. The solution was then titrated with 0.02N sulphuric acid (H_2S0_4) color changed from yellow to pink at the end of the titration. This procedure was repeated three times and the average value recorded. The value was used for estimating of total alkalinity with the formula:

$$Total\ Alkalinity\ mg/L\ C_a\ CO_3 = \frac{A \times N \times 500}{ml\ of\ sample}$$ (APHA, 1998)

where,

A = mL of acid used in titration of sample
N = normality of acid used
Ml sample = volume of water sample in ml

The amount of oxygen in the water was estimated by tritrimetric methods (Schwoerbel, 1979; APHA, 1998). In the laboratory, the oxygen bottle was opened and 3 mL of sodium bisulphate solution were put to dissolve the precipitate. The bottle was closed again and shaken to dissolve the precipitate. 50 mL of contents were transferred to 200 mL conical flask and 1ml starch solution was added to sample and titrated with N/100 thiosulphate solution ($Na_2S0_4 . 5H_20$) until sample changed from dark blue to colorless. The titration was repeated three times and average end point recorded. The oxygen content per litre in the water was calculated using the formula:

$$mgO_2 / L = \frac{nF80}{V - v}$$ (Schwoerbel, 1979)

where,

n = Volume (ml) of thiosulphate used
f = Titration factor of thiosulphate solution (= about 1)
V = Exact volume of the oxygen flask used
v = Total volume of $MnSO_4$ and NaOH added.

The stannous chloride method was used for Phosphate (APHA, 1998). The principle is that phosphate ions combine with ammonium to form a molybdate complex. The molybdate contained in the complex is reduced by stannous chloride to a blue color. The phosphate in the sample, causing a color can be measured photo metrically using a spectrophotometer. 50 mL of water to be treated was placed in a volumetric flask and 2 mL of molybdate was added.

Turbidity was measured using a spectrophotometer model 12ID. 0.2 mL stannous chloride reagent was added and properly shaken. After 10 min, 4 mL of treated sample was placed in a corvette and values read at 690 nm wavelength using a spectrophotometer model 12ID. Blank sample of de-ionized water was also analyzed using the same procedure. The phosphate in the water was determined using the following formula:

$$C = \frac{C_1 \times 1000}{V}$$ (APHA, 1998)

where,

$$C_1 = \frac{A}{a}$$

V = Original volume (mL) of sample taken for analysis
A = Measured absorbance of treated sample
a = Molar absorptivity
C_1 = $P0_4$ (mg/L) in the portion of sample taken for analysis
C = PO_4 (mg/L) sample

The brucine method was used for the estimation of Nitrate - Nitrogen (APHA, 1998). The method is based on the principle that brucine in acidic medium reacts with Nitrate (NO_3) to produce a yellow color at elevated temperatures. Ten millimeters of water to be tested was measured into a test tube before gently adding sulphuric

acid, H_2SO_4. The test tube content was cooled in a water bath for twenty minutes and 0.2 mL of brucine sulphate was added and properly mixed.

The sample was then allowed to boil for 25 min in a water bath. The boiled sample was removed and allowed to cool in a cold bath. Four millimeters of this sample was placed in a corvette and values read off at 410 nm using a spectrophotometer model 121D. This procedure was repeated using a blank sample of distilled water which was used as the reference reading to compare. The quantity of Nitrate (NO_3) was calculated as follows:

$$C = \frac{A}{a}$$ (APHA, 1998)

where,

C = Concentration of N-$N0_3$ in sample
A = Measured absorbance for the sample
a = Molar absorptivity

RESULTS

The results of physical and chemical parameters during the study are summarized in Table 1, 2 and 3. Table 1 shows the monthly rainfall data and humidity for the area. The mean monthly rainfall during the sampling period was 169.28±117.57 mm; while the mean monthly humidity was 75.10±5.3%.

The ambient temperature recorded for the study area was between 27.65 and 34.35ºC (Table 2) with a mean of 30.62±0.37ºC (Table 3). The surface water temperature ranged from 25.05 to 32.20ºC with a mean of 27.58±0.18ºC.

The pH values ranged from 5.00 and 7.5 (acidic to neutral). All the three stations were slightly acidic (pH 6.33-6.56) with a mean of 6.43±0.09. Station 1 and 3 showed slight alkalinity. The lowest pH was recorded in station 2 while station 1 recorded the highest pH.

Total alkalinity values ranged from 5.0 mg/L and 15.0 mg/L with a mean of 8.11±0.23 mg/L. Station 3 recorded the highest alkalinity (8.35±2.2 mg/L) while station 2 had the lowest alkalinity (7.89±2.10 mg/L). The alkalinity pattern of the creek was variable.

Electrical conductivity ranged from 8.0 and 24.50 µs/cm and the mean conductivity was 13.37±1.27 µs/cm. Station 1 had the lowest electrical conductivity (12.32±4.13 µs/cm). The turbidity of the water ranged from 1.50 NIU to 10.00 NTU with a mean of 4.92±0.09 NTU. Station 1 recorded the lowest mean turbidity (4.28±2.05 NTU) while station 2 had the highest mean turbidity (4.50±2.46 NTU).

The dissolved oxygen concentration values ranged from 4.00 to 7.50 mg/L with a mean of 5.88±0.21 mg/L. There was a fall in the oxygen concentration. Station 3 had the highest mean oxygen concentration (6.19±0.99 mg/L) while station 2 had the highest mean concentration of 5.73±0.89 mg/L.

Table 1: Mean monthly rainfall and humidity of the study area

Month	Rainfall (mm)	Relative humidity (%)
January, 2006	1.8	68.80
February	46.5	65.75
March	50.7	71.60
April	120.7	75.00
May	132.8	74.75
June	243.7	78.00
July	399.6	80.60
August	210.1	80.20
September	352.4	76.00
October	218.1	76.75
November	95.7	72.25
December	5.4	69.75
Mean		66.4
January, 2007	17.1	68.00
February	85.9	72.06
March	170.8	75.25
April	121.4	77.75
May	247.3	84.00
June	383.2	85.00
July	252.9	82.4
August	228.4	79.75
September	285.2	74.75
October	195.2	74.75
November	28.7	72.50
Mean	169.28	75.10
SD	117.57	5.30

Source: IITA, Onne (2008) in Abowei and George(2009)

Luubara creek is a fresh water creek. Station 1 and station 2 had zero salinity throughout the study period. It was only in station 3 that salinity increased from 0 to 0.2‰ in the dry season. The mean salinity was 0.03±0.0‰.

The phosphate concentration in the study area ranged from 0.02 to 0.86 mg/L with a mean of 0.54±0.32 mg/L. Station 1 had the least phosphate concentration (0.73±0.11 mg/L) while station 2 recorded the highest phosphate concentration (0.86±0.12 mg/L).

The nitrate concentration values ranged from 0.03 to 1.95 mg/L (0.30±0.09 mg/L. Station 1 had the lowest mean nitrate concentration of 0.22±0.03 mg/L while station 3 had the highest mean nitrate concentration (0.43±0.54 mg/L).

DISCUSSION

The surface water temperature obtained for Luubara creek during the study (25.05-32.20ºC) with a mean of 27.58±0.18ºC. is comparable to that of Chindah and Braide (2004) for Elechi creek (26.1-30.4ºC) and that of Zabbey and Hart (2005) for the freshwater section of Woji creek (25.8-28.9ºC); Erondu and Chindah (1999a) for the upper reaches of the New Calabar River (25.5-32ºC), and Dibia (2007) for the Mini Chindah stream, Port Harcourt (25.0-27ºC). The surface water temperature was lower

Table 2: The range, mean and standard deviation of physical and chemical parameters of water at the various stations in Luubara creek

Physico-chemcial parameters	Station 1		Station 2		Station 3	
	Range	Mean±SD	Range	Mean±SD	Range	Mean±SD
Ambient temperature (ºC)	27.85-33.60	30.41±17.7	27.65-33.00	30.33±1.69	27.75-34.35	31.16±2.0
Water temperature (ºC)	26.20-32.20	27.79±1.67	26.65-31.00	27.62±1.32	25.05-30.65	27.34±1.76
pH	5.55-7.50	6.53±51	5.00-7.50	6.33±0.59	5.41-2.50	6.56±0.57
Alkalinity (mg/L)	5.0-15.0	8.35±2.2	5.05-11.50	7.89±2	5.05-11.50	7.89±2.10
Conductivity (µs/cm)	10-18.0	12.32±2.11	9.00-20.00	12.78±2.99	8.0-24.50	15.02±4.13
Turbidity (NTU)	2-80	4.28±2.05	1.50-10.00	4.50±2.46	2.0-8.50	4.48±2.49
Dissolved oxygen (mg/L)	4.50-6.9	5.73±0.77	4.00-7.00	5.73±0.89	4.60-7.55	6.19±0.99
Salinity ($\%_0$)	0.00-0.00	0.00-0.00	0.00-0.00	0.00-0.00	0.00-0.02	0.01±0.04
Phosphate ($P0_4$ (mg/L)	0.02-0.06	0.73±0.11	0.02-0.80	0.08±0.15	0.00-0.65	0.86±0.12
Nitrate (NO_3) (mg/L)	0.03-1.00	0.22±0.33	0.03-1.00	0.25±0.25	0.03-1.95	0.43±0.54

Table 3: Mean values of physical and chemical parameters of water measured in Luubara creek

Physico-chemical	Station 1	Station 2	Station 3	Mean	SD
Ambient temperature (ºC)	30.41±1.77	30.33±6.90	31.16±2.00	30.62	0.37
Water temperature (ºC)	27.79±1.65	27.62±1.32	27.34±1.76	27.58	0.18
pH	6.50±0.51	6.30±0.59	6.50±0.57	6.43	0.09
Alkalinity (mg/L)	8.35±2.20	7.89±2.00	7.89±2.10	8.11	0.23
Conductivity (µs/cm)	12.32±2.11	12.78±2.99	15.02±4.13	3.37	1.27
Turbidity (NTU)	4.28±2.05	4.50±2.46	4.48±2.49	4.92	0.09
Dissolved oxygen (mg/L)	5.73±0.77	5.73±0.89	6.19±0.99	5.88	0.21
Salinity ($\%_0$)	0.00	0.00	0.10±0.04	0.03	0.04
Phosphate (PO_4) (mg/L)	0.73±0.11	0.08±0.15	8.86±0.12	0.54	0.32
Nitrate (NO_3) (mg/L)	0.22±0.33	0.25±0.25	0.43±0.54	0.30	0.09

than the ambient temperature which ranged from 27-35.4ºC, (31.03±2.22). This corroborate with the results of Abowei (2000) who noted a water temperature of 27.83-28.02ºC (28.0±1.32ºC) for the lower Nun river. This trend was equally observed by Dublin-Green (1990), Chindah (2004), Braide *et al.* (2004) and Davies *et al.* (2008) in their studies in the Niger Delta. When the surface temperature values of this study were subjected to analysis, there were no significant differences in values between the stations and also between the years ($p>0.05$).

The slight variations in both ambient and water temperatures (31.16±2.00ºC) observed could be attributed to a number of factors such as climatic conditions, surrounding vegetation, volume of water and the degree of exposure to sunlight. Surface water temperatures are usually lower than ambient temperatures because during the day, most of the heat absorbed into the water is lost through convection of currents, reflection at the surface and diffraction process (Tait, 1981). Generally, the surface water temperature follows the pattern observed for the ambient temperature and is influenced by inflows and heat exchange between the two (Awachie, 1981).

The values reported by Kosa (2007) are relatively narrow when compared to that observed in the present study. However, when the ambient temperature values of this study were subjected to statistical analysis, there were significant differences in ambient temperature of water between station 1 and station 2 in 2006 ($p<0.05$) but there were no significant differences between station 1 and station 3 in 2006. There were also no significant differences in ambient temperature between station 1 and station 3 ($p>0.05$) and also between station 2 and station 3 in 2007.

The rainfall range for the study area from the record was 1.8-399.6 mm (169.29±117.57). The results obtained during this study are within this range (200-300 mm) as suggested by Iloeje (1972).

The hydrogen ion concentration, (pH) of Luubara creek observed in this study ranged from acidic to neutral (pH 5.00-7.50). It is known that freshwaters of the Niger Delta tend to be acidic with pH range between 5.5-7.0 (Hamor and Philip-Howards, 1985; Adeniyi, 1986 and Chindah, 2003), while estuaries are alkaline (pH 8.18-8.7) (Chindah and Braide 2004).

The pH values 5.00-7.00 obtained for this study are within the limits to supports aquatic life as suggested by Boyd and Lichtkoppler (1979) for optimum fish and shrimp production (pH 6.5-9.0). However, the water is slightly acidic, a situation which was also observed by Kosa (2007) for upper Luubara creek (pH 6.60-6.71). Statistical analysis of this study show that there were no significant differences between the pH values of the stations and also between the years ($p>0.05$)

The electrical conductivity of the Luubara creek water recorded in this study ranged between 8.0 and 24.50 µs/cm (13.37±1.17 µs/cm). The conductivity result also compare favorably with the range obtained by Deekae and Henrion (1993) for the freshwater section of the New Calabar, Rivers State (22-350 µmhos).

The fact that the conductivity has a mean of 14.80 µs/cm suggests that Luubara creek is a freshwater habitat. This classification is based on Egborge (1994)

classification of waters where he suggested that conductivity values below 100 µs/cm are fresh waters while those above 1000 µs/cm are marine or salt water, whereas those in-between are brackish water. However, since the results of this study (8.0-24.50 µs/cm (13.37±1.17 µs/cm) were below 100 µs/cm, it is evident that Luubara creek is fresh water.

When the conductivity values of this study were subjected to analysis, there were no significant differences in conductivity values between station 1 and station 2 and also between station 2 and 3 in 2006 ($p>0.05$), while there were no significance differences between station 2 and station 3 in 2007. When the results of total alkalinity obtained in this study were analyzed, there were significant differences in alkalinity values between station 1 and station 2 in 2006 ($p<0.05$) and also between station 2 and station 3. There were also significant differences between the stations in 2007 ($p<0.05$).

Turbidity values observed for the Luubara creek ranged between 1.00 and 10.00 NTU (4.42±0.09 NTU). Turbidity depends on the amount of colloidal materials in water especially persistent clay particles (Mallin *et al.*, 1999). The values obtained showed that the water had little suspended particles. This means that there was enough light penetration into the water column which is necessary for the survival of its constituent organisms including shrimps. These values are however higher than the result obtained by Garricks (2008) in the lower Sombreiro river (1.7-2.0 (1.8±0.09) NTU.

The salinity of Luubara creek especially at Duburo (station 3) was between 0.00-0.04‰ which is indicative that the creek is a freshwater habitat with some salt water intrusion. Its closeness to Andoni river estuary might be responsible for the salt that was observed at this station in the dry season. Other stations were typically fresh water for both seasons.

The values of phosphate (PO_4) for Luubara creek was between 0.02 and 0.8 mg/L (0.54±0.32 mg/L), while that of nitrate was 0.03-1.61 mg/L (0.45±0.59 mg/L). These values are within the recommended range for optimum shrimp growth. It is also within the optimum range recommended for phytoplankton growth (Boyd 1982; Kautsky, 1982). Kutty (1987) suggested that very low concentration of phosphate (0.1 mg/L) and nitrate (0.01 mg/L are required for effective plankton development which is the base of the food chain for aquatic organisms; hence Luubara creek environment could be favorable for shrimp production. When the results of the phosphate values obtained in this study were subjected to analysis no significant differences were observed between station 1 and 2 in 2006 ($p>0.05$). However, there were significant differences in phosphate values between station 1 and 3 in 2006 ($p<0.05$). There were also significant differences in phosphate values between station 1 and station 2 in 2007.

When the results of the nitrate values obtained in this study were subjected to analysis there were no significant differences between station 1 and station 2 in 2006 ($p>0.05$ and also between station 2 and station 3 in 2006. However, there were significant differences in nitrate values between station 2 and station 3 in 2007 ($p<0.05$) but there were no significant differences between station 1 and station 2 in 2007 ($p>0.05$).

The quantity of oxygen in the Luubara creek water ranged from 4.00-7.5 mg/L (5.88±0.24 mg/L). It is also within the range recommended for fish production (5 -75 mg/L) (Kutty, 1987; Anyawu, 1988; Boyd and Litchtkoppler, 1979).

Generally, oxygen levels in Luubara creek compare favorably with the results of Erondu and Chindah (1991b) in New Calabar (5.0-7.0 mg/L); Hart and Zabbey (2005) in Woji creek (1.6-10.1 mg/L), Adeniyi (1986) in the Bonny estuary (freshwater section) 1-4.0 mg/L) and Garricks (2008) for the lower Sombreiro river (6.8-7.0 mg/L).

Other factors affecting supply oxygen are vegetation cover, biological oxygen demand, phytoplankton development, size of the creek and wind action (Kutty, 1987). The results from the Luubara creek are typical of freshwater systems of the Niger Delta and contain adequate dissolved oxygen for fish and shrimp production. When the results of the oxygen concentration obtained in this study were subjected to analysis, no significant differences were observed in the values between the stations and between the years ($p>0.05$).

CONCLUSION

- Luubara creek is typical of freshwater systems of the Niger Delta and contain adequate dissolved oxygen for fish and shrimp production.
- The results compared favorably with results of similar studies from similar water bodies.
- It provides sufficient data for the management of the fishery and other similar fisheries.

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