

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

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Abstract: The seasonal variation of some physical and chemical conditions in Luubara creek of Ogoni land in the Niger Delta area of Nigeria was studied for a period of two years (January, 2006 to December, 2007). Dry season ambient temperature range from 31.76-32.74°C (32.27±0.40°C) while the wet season range was 29.17-30.14°C (±29.58 ±0.41°C (28.80±15°C) while the wet season values were between 26.45°C and 26.90 (26.70±0.19°C). The pH recorded in the dry season was between 6.01 and 6.13 (6.08±0.05) while the wet season values were 6.55-6.87 (6.74±0.14). The total alkalinity in the dry season range from 9.50 to 9.72 mg/L with a mean of 9.59±0.9 mg/L. This was higher than the wet season which was between 6.73 and 9.34 mg/L (7.90±1.08 mg/L). The electrical conductivity in the dry season was within the range of 13.39 and 22.22 µ/cm (16.08±4.48 while the wet season values range from 11.68 to 15.46 µ/cm (13.44±1.55). The turbidity values in the dry season were between 2.44 NTU and 2.56 NTU (3.40±1.31). This was lower than the wet season values which was between 5.25 NTU and 5.79 NTU (5.61±0.25 NTU). The dry season dissolved oxygen values ranged between 5.17 and 5.83mg/L (5.63±0.33 mg/L). This was lower than the wet season values which range between 5.89 and 6.43 mg/L (6.14±0.22 mg/L). The salinity in the wet season was zero for all the stations. However, station 3 recorded salinity of 0 to 0.09‰ (0.03±0.04‰). The phosphate values in the dry season range between 0.05 and 0.14 mg/L (0.11±0.04 mg/L) while the wet season range was between 0.05 and 0.09 mg/L (0.06±0.02 mg/L). The nitrate values in the dry season range between 0.33 to 0.56 mg/L (0.42±0.10 mg/L) which was higher than the wet season values which range 0.11-0.34 mg/L (0.21±0.10 mg/L).

Key words: Luubara creek, Nigeria, Ogoni Land, physical and chemical condition, seasonal variation

INTRODUCTION

Luubara creek is one of the numerous water bodies in Ogoni land of the Niger Delta region providing nursery and breeding grounds for a variety of fish species. Seasonality 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 the night (Kutty, 1981). 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 (Abowei, 2010).

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, 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 25°C 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 (Abowei and George, 2009).

The alkalinity (HCO_3^- and CO_3^{2-}) 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 (EPA, 2003; Ogbeibu and Victor, 1995).

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 trioxocarbonate (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 500mg/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 1µmhos/cm and natural waters have conductivity of 20-1500 µmhos/cm (Abowei *et al.*, 2010). 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 (Abowei *et al.*, 2010). 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 (Abowei *et al.*, 2010). 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 (Abowei, 2010). The phosphate concentration of the waters of the Niger Delta is low.

Nitrate (NO₃) is the major form of nitrogen found in natural waters. Other forms of nitrogen present in natural waters include molecular nitrogen (N₂) in solution; ammonia as NH₃; ammonium and ammonia hydroxides (NH₄ and NH₄OH) and nitrate as NO₃. Davies *et al.* (2008) 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). Hopher and Pruginin (1981) reported that nitrate levels higher than 1.4 mg/L did not have any effects in fish ponds in Israel. Wickins (1981) noted that below 100 mg/NO₃ - N/L no toxic effects to fish were observed. A study of the seasonality of physicochemical parameter in luubara creek provides base line literature to compliment other literatures in the area, particularly, Ogoni Land.

MATERIALS AND METHODS

Study area: The study was carried out in Luubara creek in Ogoni land from 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 7°15'E -7°32'E and latitudes 4°32'-4°37'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*, *Aveenia africana*, *Laguncularia racemosa* etc., whereas the freshwater has dense vegetation comprising of large trees, various palms and aquatic macrophytes at the low intertidal zone. In freshwater area are *Cocos* sp., *Eliasis* sp., *Nymphaea* sp., *Lemna* sp. and *Raffia* sp. It is characterized by high ambient temperature usually about 25.5°C and above; high relative humidity which fluctuates between 60 and 95% and high rainfall averaging about 2500 mm (Gibo, 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 *Desmocarid 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 5 min 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 5 min 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 5 min 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. 100 mm of water was put into a clean oxygen bottle and flushed several times until all air bubbles escaped. 2 mm of Manganese sulphate (Winkler's solution I) and another 2 mm of Potassium iodide - Sodium Hydroxide (Winkler'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 0.02 N sulphuric acid (H₂SO₄) 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:

$$\text{Total Alkalinity mg / L } C_a \text{ CO}_3 = \frac{A \times N \times 500}{\text{ml of sample}}$$

(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 titrimetric 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 (Na₂SO₄. 5H₂O) 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:

$$\text{mgO}_2 / \text{L} = \frac{nF80}{V-v} \text{ (Schwoerbel, 1979)}$$

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 MnSO₄ 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 121D. 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 121D. Blank sample of de-ionized water was also analyzed using the same procedure. The phosphate in the water was determined using the following formula:

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

where,

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

- V = Original volume (mL) of sample taken for analysis
- A = Measured absorbance of treated sample
- a = Molar absorptivity
- C₁ = PO₄ (mg/L) in the portion of sample taken for analysis
- C = PO₄ (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 (NO₃) to produce a yellow color at elevated temperatures. 10 mm of water to be tested was measured into a test tube before gently adding sulphuric acid, H₂SO₄. The test tube content was cooled in a water bath for 20 min and 0.2 mL of brucine sulphate was added and properly mixed.

Table 1: Dry season mean values and standard deviation of physical and chemical parameters of water at the various stations in Luubara creek

Physical and chemical parameters	Station 1	Station 2	Station 3	Mean	SD
Ambient temperature (°C)	32.31±0.70	31.76±1.14	32.74±1.26	32.27	0.40
Water temperature (°C)	29.02±2.22	28.73±1.02	28.66±1.88	28.80	0.15
pH	6.13±0.39	6.01±0.42	6.09±0.36	6.08	0.05
Alkalinity (mg/L)	9.50±0.94	9.56±0.93	9.72±1.50	9.59	0.09
Conductivity (µs/cm)	13.39±2.33	22.22±2.04	14.33±3.56	16.08	4.48
Turbidity (NTU)	2.56±0.83	2.50±0.53	2.44±6.37	3.40	1.31
Dissolved oxygen (mg/L)	5.49±0.80	5.17±1.02	5.83±0.98	5.63	0.33
Salinity (‰)	0.00	0.00	0.09±0.07	0.03	0.04
Phosphate (PO ₄) (mg/L)	0.05±0.03	0.14±0.23	0.14±0.18	0.11	0.04
Nitrate (NO ₃) (mg/L)	0.33±0.40	0.38±0.31	0.56±0.99	0.42	0.10

Table 2: Wet season mean values and standard deviation of physical and chemical parameters at the various stations in Luubara creek

Physico-chemical	Station 1	Station 2	Station 3	Mean	SD
Ambient temperature (°C)	29.17±0.92	29.42±1.23	30.14±1.77	29.58	0.41
Water temperature (°C)	26.74±0.55	26.90±0.88	26.45±0.76	26.70	0.19
pH	6.80±0.39	6.55±0.57	6.87±0.44	6.74	0.14
Alkalinity (mg/L)	7.62±2.44	9.34±2.48	6.73±1.42	7.90	1.08
Conductivity (µs/cm)	11.68±1.68	13.19±3.30	15.46±4.27	13.44	1.55
Turbidity (NTU)	5.25±1.92	5.79±2.27	5.79±2.30	5.61	0.25
Dissolved oxygen (mg/L)	5.89±0.07	6.09±0.51	6.43±0.89	6.14	0.22
Salinity (‰)	0.00	0.00	0.00	0.00	0.00
Phosphate (PO ₄) (mg/L)	0.09±0.14	6.05±0.02	0.05±0.04	0.06	0.02
Nitrate (NO ₃) (mg/L)	0.11±0.19	0.18±0.28	0.34±0.54	0.21	0.10

Table 3: Combined seasonal mean values, standard deviation and size range of dry and wet season physico-chemical parameters in water of Luubara creek

Parameter	Dry season		Wet season	
	Mean ± SD	Range	Mean ± SD	Range
Ambient temperature (°C)	32.27±0.40	31.76-32.74	29.58±0.41	29.17-30.14
Water temperature (°C)	28.80±0.15	26.66-29.02	26.70±0.19	26.45-26.90
pH	6.08±0.05	6.01-6.13	6.74±0.14	6.55-6.87
Alkalinity (mg/L)	9.59±0.09	9.50-9.72	7.90±1.08	6.73-9.34
Conductivity (µs/cm)	16.08±4.45	13.39-22.22	13.44±1.55	11.68-15.46
Turbidity (NTU)	3.40±1.31	2.44-2.56	5.61±0.25	5.25-5.79
Dissolved oxygen (mg/L)	5.63±0.33	5.17-5.83	6.14±0.22	5.89-6.43
Salinity (‰)	0.03-0.04	0.00-0.09	0.00-0.00	0.00-0.00
Phosphate (PO ₄) (mg/L)	0.11±0.04	0.05-0.14	0.06±0.02	0.05-0.09
Nitrate (NO ₃) (mg/L)	0.42±0.10	0.33-0.56	0.21±0.10	0.11-0.34

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. 4 mm 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 (NO₃) was calculated as follows:

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

where,

- C = Concentration of N-NO₃ in sample
- A = Measured absorbance for the sample
- a = Molar absorptivity

RESULTS

The seasonal variation of the physical and chemical parameters is given in Table 1, 2 and 3. Dry season mean values of the physical and chemical parameters are shown

in Table 1; while the wet season values are on Table 2. The combined seasonal parameters are shown in Table 3. The dry season ambient temperature range from 31.76-32.74°C (32.27±0.40°C) while the wet season range was 29.17-30.14°C (±29.58±0.41°C (28.80±15°C) while the wet season values were between 26.45 and 26.90°C (26.70±0.19°C). The pH recorded in the dry season was between 6.01 and 6.13 (6.08±0.05) while the wet season values were 6.55-6.87 (6.74±0.14).

The total alkalinity in the dry season range from 9.50 to 9.72 mg/L with a mean of 9.59±0.9 mg/L. This was higher than the wet season which was between 6.73 and 9.34 mg/L (7.90±1.08 mg/L). The electrical conductivity in the dry season was within the range of 13.39 and 22.22 µs/cm (16.08±4.48 while the wet season values range from 11.68 to 15.46 µs/cm (13.44±1.55). The turbidity values in the dry season were between 2.44 and 2.56 NTU (3.40±1.31). This was lower than the wet season values which was between 5.25 and 5.79 NTU (5.61±0.25 NTU).

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5.89 and 6.43 mg/L (6.14 ± 0.22 mg/L). The salinity in the wet season was zero for all the stations. However, station 3 recorded salinity of 0 to 0.09‰ (0.03 ± 0.04 ‰). The phosphate values in the dry season range between 0.05 and 0.14 mg/L (0.11 ± 0.04 mg/L) while the wet season range was between 0.05 and 0.09 mg/L (0.06 ± 0.02 mg/L). The nitrate values in the dry season range between 0.33 to 0.56 mg/L (0.42 ± 0.10 mg/L) which was higher than the wet season values which range 0.11-0.34 mg/L (0.21 ± 0.10 mg/L).

DISCUSSION

Rainfall patterns in Luubara creek area had seasonal differences. Based on the results obtained from the IITA records for the rainfall pattern one can delineate the dry season starting from November to March and the wet season from April to October. In the wet season the range of rainfall observed was between 120.7 and 399.6 mm (235 ± 78.02) while in the dry season the range was 1.8-170.8 mm (55.84 ± 51.12). 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 Iloje (1972). When the results of this study were subjected to statistical there were significant differences in the rainfall between the seasons ($p > 0.05$).

Slight seasonal differences in ambient temperature were also observed in Luubara creek system. Dry season values (31.76 - 32.74°C) with a mean of ($32.27 \pm 0.4^\circ\text{C}$) were relatively higher than that of the wet season (29.17 - 30.14°C) with a mean of (29.58 ± 0.41). This is similar to the observation of Chindah and Braide (2004) for the Elechi creek and Kosa (2007) who reported that the range of water temperature in the wet season for upper Luubara creek was 26.47 - 26.67°C (26.56 ± 0.10) and for the dry season he gave the range as 28.97 - 29.07°C (29.03 ± 0.06).

The mean pH value during the dry season was 6.08 and that of wet season was 6.74. Thus, pH of the Luubara creek remained relatively constant for the both seasons. There were differences between the seasonal values of conductivity. During the dry season, the mean conductivity was 16.08 ± 4.48 $\mu\text{s/cm}$ and in the wet season the value was 13.44 ± 1.55 $\mu\text{s/cm}$. Ajibade *et al.* (2008) also reported seasonal variation in the values of electrical conductivity in the major rivers of Kainji National park. The dry season rise in conductivity could result from concentration of ions by evaporation and increased mineralization of organic matter (Petr, 1983). The high conductivity of the wet season could also result from influx of materials from the surrounding area during rainfall. The electrical conductivity could therefore be high in any season.

The mean total alkalinity for the dry season was 9.59 ± 0.09 mg/L which was higher than the wet season,

7.90 ± 1.08 mg/L. This could be attributed to fact that during the dry season there is evaporation and concentration of ions in water. Adebisi (1981) reported higher concentrations of total alkalinity in the upper Ogun River during the dry season while Hart and Zabbey (2005) and Davies *et al.* (2008) for Woji creek similarly obtained higher alkalinity values in the dry season as compared to the wet season.

Both seasonal values of alkalinity obtained for Luubara creek shows that the water contained enough quantities of carbon (IV) oxide that may permit plankton growth, fish and shrimp. In the wet season the turbidity was 5.20-5.79 NTU (5.61 ± 0.25) while in the dry season, the values were 2.44-2.56 NTU (3.40 ± 1.31). Higher values of turbidity in the wet season was also observed by Dublin-Green (1990), Braide *et al.* (2004), Sikoki and Zabbey (2006), Allison *et al.* (2007) and Davies *et al.* (2008) in their various studies in the Niger Delta.

During the wet season there is continuous rainfall hence the run off from surrounding catchment areas carries a lot of suspended materials into the creek leading to high turbidity values. Also during the wet season the suspended particles in the water column are always in motion due to water circulation whereas in the dry season the particles tends to settle on submerged logs as there is little turbulence. When the results of turbidity obtained in this study were subjected to analysis, no significant differences were obtained between the stations and between the years.

The concentration of phosphate did not show much seasonal differences. The dry season values were between 0.05 and 0.14 mg/L (0.11 ± 0.04 mg/L) while the wet season values were between 0.05 and 0.09 mg/L (0.06 ± 0.02). This observation is in contrast to those reported by Egborge (1976), Hall *et al.* (1977) and Etienne *et al.* (1977). These reports individually showed that phosphate concentrations are higher in the dry season. They related the high phosphate concentrations in the dry season to high rate of decomposition of organic matter and mineralization of the mineral salts through evaporation in the dry season.

This in fact agrees with the observations of Kosa (2007) for upper Luubara creek and Ogbeibu and Victor (1995) for water bodies in Okomu forest reserve Delta State, which indicated that nitrate concentrations were more in the wet season than dry season ($p < 0.05$) and also between station 2 and station 3 in 2007. However, there was difference in the nitrate concentration in the dry season, 0.33-0.56 mg/L (0.42 ± 0.10) and the wet season 0.011-0.34 (0.21 ± 0.56 mg/L (0.42 ± 0.10) for this study.

Seasonal differences in dissolved oxygen concentration were observed during the study. The wet season had more dissolved oxygen concentration (5.89 - 6.43 mg/L (6.14 ± 0.22)) than the dry season (5.17 - 5.83 mg/L (5.63 ± 0.33)). Abowei (2000) and Allison *et al.* (2007) both recorded high oxygen concentrations

Nun River in the wet season. During the wet season, there is usually increased runoff from the surrounding catchment area bringing in freshwater that contains oxygen.

CONCLUSION

- Rainfall patterns in Luubara creek area had seasonal differences.
- Slight seasonal differences in ambient temperature existed in Luubara creek system.
- pH of the Luubara creek remained relatively constant for the both seasons. There were differences between the seasonal values of conductivity.
- The mean total alkalinity for the dry season was higher than the wet season. The concentration of phosphate did not show much seasonal differences. There was seasonal difference in dissolved oxygen concentration.
- The wet season had more dissolved oxygen concentration.
- The study provides base line literature to compliment other literatures in the area, particularly, Ogoni Land for management decision in managing the fishery and similar water bodies.

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