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RESEARCH ARTICLE

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Effects of flooding on surface water physical and chemical characteristics in Amassoma Flood Plain; Niger Delta, Nigeria

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ABSTRACT

The Effects of Flooding on surface water physical and chemical characteristics of Amassoma Flood Plain, Niger Delta, Nigeria, was studied for a period of six months (November – December, 2012 and January, 2013 for the dry season and April, May and June; 2013 for the Wet season) and compared with previous results obtained in the study area. The mean surface water physical and chemical characteristics values before flooding were pH (7.28); Conductivity (44.06µS/cm); Salinity($1.74\frac{0}{00}$); Dissolved Oxygen (4.98mg/l); Biochemical Oxygen Demand (2.40mg/l) and Temperature(24.760c); while after flooding values were pH (9.27); Conductivity (64.09µS/cm); Salinity($1.35\frac{0}{00}$); Dissolved Oxygen (11.55mg/l); Biochemical Oxygen Demand (1.86mg/l) and Temperature(27.400c). pH; Conductivity; Dissolved Oxygen and Temperature values were higher than values after flooding than before flooding. Salinity and Temperature values were lower after flooding than after flooding. There was significant difference in mean surface water, physical and chemical characteristics values before and after flooding. However there was no significant variation within stations.

Key words: Flooding effects, physic-chemical characteristics, Flood plain, Niger Delta, Nigeria

INTRODUCTION

Water is a simple chemical compound composed of two atoms of hydrogen and one atom of oxygen which bond covalently to form one molecule. It is known as the most complex of all the familiar substances that are single chemical compounds. It is an extraordinary substance which exists in the three states of matter (gaseous, liquid and solid states). In its pure state, water is colorless, odorless, and insipid, freezes at 0^0C, and has boiling point of 100^0C at a pressure of 760mmHg, with a maximum density of $1gcm^{-3}$ at 4^0C. It is thermally stable at temperatures as high as 2700^0C. Water is neutral to litmus, with a pH of 7 and undergoes a very slight but important reversible self-ionization. Water quality plays a role in the distribution of fish [1]. The importance of measuring physical, chemical and biological variables was considered at the Technical Consultation on Enhancement of Fisheries of Small Water Bodies in Harare [2]. The Physical and chemical characteristics of water are important parameters as they may directly or indirectly affect its quality and consequently its suitability for the distribution and production of fish and other aquatic animals[3].

Variability of water quality influences the toxicity levels of heavy metals on estuarine organisms as it affects the Physical and chemical composition of the ecosystem. Water rising from market stalls and slaughter houses, streets washing and flushing of sewage which flow through drains into rivers altered the chemical composition of the water body thereby causing pollution[4]. Optimum fish production can be achieved only when the water quality is effectively managed. The required levels of physical and chemical characteristics of the culture medium, is necessary for fish culture. The availability of food organisms (planktons) and the influence of naturally occurring substances such as dissolved oxygen, carbon dioxide, ammonium nitrite and hydrogen ions (H^+) are important factors affecting the growth and survival of cultured fish. The role of temperature, salinity and various pollutants in fish culture cannot be over looked. Thus, the water used for the cultivation of fish cannot yield maximum production, if the environmental conditions are not optimal for the growth of fish and other aquatic organisms. Therefore, there is the need to ensure that, these environmental factors are properly managed and regulated on a daily basis. This maintains these factors within a desirable range for the survival and growth of the fish.

The water body used for fish culture is an ecosystem consisting of biotic and abiotic factors. These factors interact to produce an exchange of materials. Functionally, four components can be recognized in the ecosystem.

- Inorganic and organic compounds in the environment (Abiotic component)
- Producers which synthesis food from inorganic and organic compounds (autotrophs)
- Consumers, which depend on food, synthesized by the autotrophs e.g. herbivores, carnivores and omnivores.
- Decomposers, which break down complex compounds in the process of feeding. Decomposition results in the release of substances usable by the producers e.g. bacteria and fungi. They are called saprophytes.

The producers, consumers and decomposers form the biotic factor in the aquatic ecosystem. Different trophic levels exist in such ecosystem. Aquatic plants occupy the first trophic level while herbivores and carnivores occupy the second and third trophic levels respectively. An organism in an ecosystem can occupy more than one trophic level according to the sources of energy assimilation. This chapter treats the chemical and physical analysis to determine the quality of water used in fish culture.

Water quality is one of the most overlooked aspects of pond management - until it affects fish production. Clay turbidity in ponds is one of the most common quality issues we address. However, several other variables influence water quality for fish including water temperature, phytoplankton, photosynthesis and pH, carbon dioxide, alkalinity and hardness. Additionally, water quality can be affected through the interaction of these factors. Temperature, turbidity light intensity, pH, dissolved ions such as $N0_3$ and PO_4 are reported to marshal the activities and composition of organisms [5]. Organic waste dump caused environmental stress in coastal waters which resulted in the low landing of some important fisheries [6]. Size, structure and biomass of phytoplankton population and production are closely related to physico-chemical conditions of the water body [7].

Floodplain or flood plain is an area of land adjacent to a stream or river that stretches from the banks of its channel to the base of the enclosing valley walls and experiences flooding during periods of high discharge. It includes the floodway, which consists of the stream channel, and adjacent areas that actively carry flood flows downstream, and the flood fringe, which are areas inundated by the flood, but which do not experience a strong current. In other words, a floodplain is an area near a river or a stream which floods when the water level reaches flood stage. Flood plains are made by a meander eroding sideways as they travel downstream. When a river breaks its banks and floods, it leaves behind layers of alluvium (silt). These gradually build up to create the floor of the flood plain. Floodplains generally contain unconsolidated sediments, often extending below the bed of the stream. These are accumulations of sand, gravel, loam, silt, and/or clay, and are often important aquifers, the water drawn from them being pre-filtered compared to the water in the river.

Geologically ancient floodplains are often represented in the landscape by fluvial terraces (Fig. 1). These are old floodplains that remain relatively high above the present floodplain and indicate former courses of a stream. Sections of the Missouri River floodplain taken by the United States Geological Survey show a great variety of material of varying coarseness, the stream bed having been scoured at one place and filled at another by currents and floods of varying swiftness, so that sometimes the deposits are of coarse gravel, sometimes of fine sand or of fine silt. It is probable that any section of such an alluvial plain would show deposits of a similar character.

The floodplain during its formation is marked by meandering or anastigmatic streams, ox-bow lakes and bayous, marshes or stagnant pools, and is occasionally completely covered with water. When the drainage system has ceased to act or is entirely diverted for any reason, the floodplain may become a level area of great fertility, similar in appearance to the floor of an old lake. The floodplain differs, however, because it is not altogether flat. It has a gentle slope down-stream, and often, for a distance, from the side towards the centre. Floodplains can support particularly rich ecosystems, both in quantity and diversity. Amassoma forests form an ecosystem associated with floodplains. They are a category of riparian zones or systems. A floodplain can contain 100 or even 1,000 times as many species as a river. Wetting of the floodplain soil releases an immediate surge of nutrients: those left over from the last flood, and those that result from the rapid decomposition of organic matter that has accumulated since then. Microscopic organisms thrive and larger species enter a rapid breeding cycle. Opportunistic feeders (particularly birds) move in to take advantage. The production of nutrients peaks and falls away quickly; however the surge of new growth endures for some time. This makes floodplains particularly valuable for agriculture.

Plate 1: Amassoma Floodplain

The word "flood" comes from the Old English </wiki/Old_English_language> /flod/, a word common to Germanic languages (compare German /Flut/, Dutch /vloed/ from the same root as is seen in /flow, float/; also compare with Latin /fluctus/, /flumen/). Deluge myths are mythical stories of a great flood sent by a deity or deities to destroy civilization as an act of divine retribution, and are featured in the mythology of many cultures. Floods can also occur in rivers, when flow exceeds the capacity of the river channel, particularly at bends or meanders. Floods often cause damage to homes and businesses if they are placed in natural flood plains of rivers. While flood damage can be virtually eliminated by moving away from rivers and other bodies of water, since time out of mind, people have lived and worked by the water to seek sustenance and capitalize on the gains of cheap and easy travel and commerce by being near water. That humans continue to inhabit areas threatened by flood damage is evidence that the perceived value of living near the water exceeds the cost of repeated periodic flooding [8].

Floods (Plate 1) are also known to renew wetland areas which in turn host a wide range of flora and fauna. Preventing flood waters from entering such wetland areas will create imbalance to the natural state of things resulting in destruction of natural habitats and even extinction of various species of animals and plants. Floods play an important part in various ecosystems. Humans, therefore, should be careful when they try to prevent or control floods. Oftentimes, human intervention causes more harm than good [9]. Flooding of the rivers in the country is not uncommon; the September 2012 devastating flood which was clearly a natural disaster was a pointer to prior preparations being a proactive effort at mitigation of impacts of such disasters, but little information exits on how these flood events affect water and overbank sediment quality within the affected areas.

Floods are caused by many factors: heavy rainfall, highly accelerated snowmelt, severe winds over water, unusual high tides, tsunamis, or failure of dams, levees, retention ponds, or other structures that retain water. Flooding can be exacerbated by increased amounts of impervious surface or by other natural hazards such as wildfires, which reduce the supply of vegetation that can absorb rainfall. Periodic floods occur on many rivers, forming a surrounding region known as the flood plain. During times of rain, some of the water is retained in ponds or soil, some is absorbed by grass and vegetation, some evaporates, and the rest travels over the land as surface runoff. Floods occur when ponds, lakes, riverbeds, soil, and vegetation cannot absorb all the water. Water then runs off the land in quantities that cannot be carried within stream channels or retained in natural ponds, lakes, and man-made reservoirs. About 30 percent of all precipitation becomes runoff and that amount might be increased by water from other flood causing factors.

River flooding is often caused by heavy rain, sometimes increased by melting snow. A flood that rises rapidly, with little or no advance warning, is called a flash flood. Flash floods usually result from intense rainfall over a relatively small area, or if the area was already saturated from previous precipitation. Even when rainfall is relatively light, the shorelines of lakes and bays can be flooded by severe winds that blow water into the shore areas. Coastal areas are also sometimes flooded by unusually high tides, such as spring tides, especially when compounded by high winds and storm surges. Tsunamis which are high, large waves, typically caused by undersea earthquakes, volcanic eruptions or massive explosions also cause flood.

There are many disruptive effects of flooding on human settlements and economic activities. However, floods (in particular the more frequent/smaller floods) can also bring many benefits, such as recharging ground water, making soil more fertile and providing nutrients in which it is deficient. Flood waters provide much needed water resources in particular in arid and semi-arid regions where precipitation events can be very unevenly distributed throughout the year. Freshwater floods, particularly, play an important role in maintaining ecosystems in river corridors and are a key factor in maintaining floodplain biodiversity.

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768 x 510.95KB jpeg
Source:Nayanet.com/news/source/1092p.html

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Plate 2. Cases of flooding in Amassoma flood plain

Flooding adds a lot of nutrients to lakes and rivers which leads to improved fisheries for a few years; also because of the suitability of a floodplain for spawning (little predation and a lot of nutrients). Fish like the weather fish make use of floods to reach new habitats. Together with fish birds also profit from the boost in production caused by flooding. Periodic flooding was essential to the well-being of ancient communities along the Tigris-Euphrates Rivers, the Nile River, the Indus River, the Ganges and the Yellow River, among others. The viability for hydrological based renewable sources of energy is higher in flood prone regions.

MATERIALS AND METHODS

Study Area

The Niger Delta (Fig. 1) covers 20,000 km² within wetlands of 70,000 km² formed primarily by sediment deposition. Home to 20 million people and 40 different ethnic groups, this floodplain makes up 7.5% of Nigeria's total land mass. It is the largest wetland and maintains the third-largest drainage basin in Africa. The Delta's environment can be broken down into four ecological zones: coastal barrier islands, mangrove swamp forests, freshwater swamps, and lowland rainforests [10]. This incredibly well-endowed ecosystem contains one of the highest concentrations of biodiversity on the planet, in addition to supporting abundant flora and fauna, arable terrain that can sustain a wide variety of crops, lumber or agricultural trees and more species of freshwater fish than any ecosystem in West Africa [11]. The region could experience a loss of 40% of its inhabitable terrain in the next thirty years as a result of extensive dam construction in the region. The carelessness of the oil industry has also precipitated this situation, which can perhaps be best encapsulated by a 1983 report issued by the NNPC, long before popular unrest surfaced. There has been the slow poisoning of the waters of this country and the destruction of vegetation and agricultural land by oil spills which occur during petroleum operations. But since the inception of the oil industry in Nigeria, more than twenty-five years ago, there has been no concerned and effective effort on the part of the government, let alone the oil operators, to control environmental problems associated with the industry (Powell, 2009). It is estimated that:

- 1.5% of the country is at risk from direct flooding from the sea
- About 7% of the country is likely to flood at least once every 100 years from rivers
- 1.7m homes and 130,000 commercial properties, worth more than £200 billion, are at risk from river or coastal flooding in England
- Many more properties are also at risk from flash floods.

The Amassoma flood plain is located in Latitude 4.9702778 / 4° 58'; Longitude6.1097222 / 6° 6' 34.9986" in Bayelsa State of Nigeria.

Fig.1 Location of the Niger Delta

Sample collection

The study was carried out in Amassoma flood plain, in the Niger Delta of Nigeria for a period of six months (November – December, 2012 and January, 2013 for the dry season and April, May and June; 2013 for the Wet season) and compared with results obtained [12][13] by Ezekiel, 2001 and Abowei, 2010. Four sampling stations were established along the length of the Amassoma River whenever, it was accessible by road. For each sampling day in the field the following activities took place. Two plastic bottles measuring one thousand milliliters 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. The titrimetric method [14 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 colour changed to yellow. The solution was then titrated with 0.02N sulphuric acid (H_2 S04) colour 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:

$$Total\ alkalinity\ mg/LCO\left(\frac{ma}{L}\right) C_{12CO_3} = \frac{A\ x\ N\ x\ 500}{ml\ of\ sample} [14]$$

Where,
A = mL of acid used in titration of sample C_{12}
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 [14]. 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 (Na2 S04 . 5H2 0) until sample changed from dark blue to colourless. The titration was repeated three times and average end point recorded. The oxygen content per litre in the water was calculated using the formula:

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

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 [14]. 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:

$$C = C_1 \times \frac{1000}{v} [14]$$

Where, $C_1 = \frac{A}{a}$; V = Original volume (mL) of sample taken for analysis
A = Measured absorbance of treated sample
a = Molar absorptivity
Cl = $P0_4$ (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 [14]. The method is based on the principle that brucine in acidic medium reacts with Nitrate (NO_3) to produce a yellow colour 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:

$$C_1 = \frac{A}{a} \ [14]$$

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

RESULTS

Table 1 shows the surface water physical and chemical characteristics before and after flooding in the study area. The mean surface water physical and chemical characteristics values before flooding were pH (7.28); Conductivity (44.06µS/cm); Salinity(1.74 $\frac{0}{00}$); Dissolved Oxygen (4.98mg/l); Biochemical Oxygen Demand (2.40mg/l) and Temperature(24.76^{0}c); while after flooding values were pH (9.27); Conductivity (64.09µS/cm); Salinity(1.35 $\frac{0}{00}$); Dissolved Oxygen (11.55mg/l); Biochemical Oxygen Demand (1.86mg/l) and Temperature(27.40^{0}c). pH; Conductivity; Dissolved Oxygen and Temperature values were higher than values after flooding than before flooding. Salinity and Temperature values were lower after flooding than after flooding. There was significant difference in mean surface water, physical and chemical characteristics values before and after flooding. However there was no significant variation within stations.

Table 1 Surface Water Physical And Chemical Characteristics

Surface water Parameter	Before flooding				After Flooding			
	Station 1	Station 2	Station 3	Mean	Station 1	Station 2	Station 3	Mean
pH	8.02	7.43	6.40	7.28	9.42	8.23	9.16	9.27
Conductivity(µS/cm)	41.95	43.27	46.95	44.06	69.41	63.48	59.37	64.09
Salinity($\frac{0}{00}$)	1.53	1.73	1.96	1.74	1.43	1.36	1.27	1.35
Dissolved Oxygen(mg/l)	9.06	8.89	7.00	4.98	11.43	12.87	11.33	11.55
Biochemical Oxygen Demand (mg/l)	4.13	3.79	2.37	2.40	2.16	2.09	1.33	1.86
Temperature(^{0}c)	26.85	29.35	28.19	24.76	26.13	27.40	28.63	27.40

DISCUSSION

Generally, surface water temperature obtained for Amassoma flood plain during the study varies with that of Chindah and Braide (2004) for Elechi creek and that of Zabbey and Hart (2005) for the freshwater section of W oji creek; Erondu and Chindah (1999a) for the upper reaches of the New Calabar River and Dibia (2007) for the Mini Chindah stream, Port Harcourt [15-18]. The surface water temperature was lower than the ambient temperature. This is similar to the results of Abowei (2000) who noted a water temperature of 27.83- 28.02ºC (28.0±1.32ºC) for the lower Nun River [19]. This trend was equally observed by Dublin-Green (1990), Chindah (2004), Braide *et a*l. (2004) and Davies *et a*l. (2008) in their studies in the Niger Delta [20-23]. 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 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[24]. Generally, 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) [25]. The hydrogen ion concentration, (pH) of Amassoma flood plains observed in this study ranged from acidic to neutral. It is known that freshwaters of the Niger Delta tend to be acidic with pH range between 5.5-7.0 [26][27][28], while estuaries are alkaline (pH 8.18-8.7). 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) [29]. However, the water is slightly acidic, a situation which was also observed by Kosa (2007) for upper Luubara creek (pH 6.60-6.71) [30]. 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 Sombreiro River ranged from 41. 95 – 69.41 µS/cm. This varies with those reported by Deekae, *et al* 2010 for Luubara creek [31]. 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 favourably with the range obtained by Deekae and Henrion (1993) for the freshwater section of the New Calabar [32], Rivers State (22-350 µS/cm). The fact that conductivity values ranged from 41. 95 to 69.41 µS/cm, showed that the Amassoma flood is a freshwater habitat. This classification was based on Egborge (1994) classification of waters where he suggested that conductivity values below 100 :s/cm are fresh waters while those above 1000 µS/cm are marine or salt water, whereas those in-between are brackish water [33]. 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 Amassoma flood plain is fresh water. When the conductivity values of this study were subjected to analysis, there were no significant differences in conductivity values between station but there was significant difference between before and after flooding ($p>0.05$).

The turbidity values obtained showed that the water had little suspended particles. Turbidity depends on the amount of colloidal materials in water especially persistent clay particles [34]. 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 [35]. The salinity values indicate that the river is a freshwater habitat. The values of phosphate (PO4) values are within the recommended range for fish production. It is also within the optimum range recommended for phytoplankton growth [36][37]. 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 Sombreiro River environment could be favourable for fish production [38]. When the results of the phosphate values obtained in this study were subjected to analysis, no significant differences were observed between station ($p>0.05$). However, there were significant differences in phosphate values between before and after flooding ($p<0.05$). The trend was similar for other water parameters.

Generally, oxygen levels in Sombreiro River compare favorably with the results of Erondu and Chindah (1991b) in New Calabar (5.0-7.0 mg/L); Zabbey and Hart (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) [39][16][27][35]. Other factors affecting supply oxygen are vegetation cover, biological oxygen demand, phytoplankton development, size of the creek and wind action [38]. The results from the Sombreiro River 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 ($p>0.05$).

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