Research Journal of Environmental and Earth Sciences 1(2): 45-53, 2009
ISSN: 2041-0492

Submitted Date: August 07, 2009 Accepted Date: August 28, 2009 Published Date: October 30, 2009

Some Physical and Chemical Characteristics in Okpoka Creek, Niger Delta, Nigeria

[1]J.F.N. Abowei and [2]A.D.I. George
[1]Department of biological sciences, Faculty of Science, Niger Delta University, Wilberforce Island, Amassoma, Bayelsa State, Nigeria
[2]Department of fisheries and aquatic environment, Faculty of Agriculture, Rivers State University of science and Technology, Port Harcourt, Rivers State, Nigeria

Abstract: Some physical and chemical characteristics in okpoka creek was studied for one year. There was a long wet season stretching from April to October in and a dry season extending from November to March. The total monthly rainfall ranged from 1.8mm to 399.6mm. The highest total rainfall (399.6mm) was recorded in July while the lowest rainfall (1.8mm) was observed in January. The atmospheric temperature fluctuated from 28.5°C in July to 33°C in March. The monthly water temperature values ranged between 27°C and 31°C across the Stations. The mean temperatures were similar along the Stations (P£0.05) ranging from 28.98±0.23°C (Station 4) to 29.77±0.15°C (Station 5). A steady trend of temperature was observed in Stations 1, 2 and 4 as well as in stations 3 and 6. Generally, temperature values were stable across stations. Maximum temperature of 31°C was recorded in January, February, March, July, and October. While the lowest temperature of 27°C was observed in July, August and September. There was slight seasonal variation of temperature between dry (29.49±0.11°C) and wet season (29.09±0.125°C). A steady trend of temperature variation was observed. The mean pH value ranged between 6.68±0.07 (Station 1) and 7.03±0.05 (Station 6). The Spatial and temporal variations of pH were minimal. Seasonal variation in pH was observed between dry season (6.97±0.044) and wet season (6.81±0.367). Salinity values ranged between 0.60‰ and 20.90‰. The highest salinity value (20.90‰) was recorded in June at station 6 and the lowest salinity value (0.60‰) was observed in October at station 1. The means varied from 4.75±0.79 (Station 1) to 12.65±1.36‰ (Station 6). There was spatial variation with a general trend that showed increased salinity values from station 1 to station 6. Some Seasonal variation was also observed with higher salinity during the dry season (11.67±0.517‰) than the wet season (6.98±0.701‰). Dissolved oxygen values values range from 0.4mg/L and 8.34 mg/L. The highest dissolved oxygen concentration (9.6mg/L) was observed in station 3 while the lowest value (0.4mg/L) was recorded in station 6. The mean dissolved oxygen concentrations ranged between 3.72±041mg/L and 5.10±0.29mg/L across the stations. There was no seasonal and annual variation observed in the concentrations of dissolved oxygen. Biochemical oxygen demand varied from 0.0mg/L to 6.4mg/L. The lowest biochemical oxygen demand value (0.0mg/L) was recorded in December and the highest value (6.4mg/L) was observed in station 1 (March) as well as station 4. The mean biochemical oxygen demand oxygen ranged between 1.97±0.28mg/L and 2.69±0.26mg/L across the stations. No seasonal and temporal variations were observed in the biochemical oxygen demand. Monthly conductivity values observed ranged from 920mscm^{-1} and 33100mscm^{-1} across the stations. Generally, an increasing trend was observed from station 1 to station 6 with mean values varying from 10788.75±1053.87mscm^{-1} (Station 1) to 24877.92±1430.65mscm^{-1} (Station 6). Seasonal variation in conductivity with a general trend of higher conductivity in the dry season 18943.17±914.304mscm^{-1} than the wet 16794.38±985.154mscm^{-1} season was observed. Spatial variation of conductivity was significant ($p<0.05$) with a general trend of increase from station 1 (upstream) to station 6 (downstream).

Key words: Physical and chemical characteristics, Okpoba creek, Niger Delta and Nigeria

INTRODUCTION

Water is an extraordinary substance, which exist in the three states of matter (gaseous, liquid and solid states). It is often the most complex of all the familiar substances that are single chemical compounds. It is a very simple chemical compound composed of two atoms of hydrogen and one atom of oxygen, which bond covalently to form one molecule.

In its pure state, water is colorless, odorless, and insipid, freezes at O°C, and has boiling point of 100°C at a pressure of 760mmHg, with a maximum density of 1gcm^{-3} at 4°C. Chemically, it is a highly realistic substance, which is thermally stable at temperatures as high as 2,700°C (Wilson, 1990). It is neutral to litmus, with a pH of 7 and undergoes a very slight but important reversible self-ionization.

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 (Swingle, 1969; Moses, 1983). Oyewo

Corresponding Author: J.F.N. Abowei, Department of biological sciences, Faculty of Science, Niger Delta University, Wilberforce Island, Amassoma, Bayelsa State, Nigeria

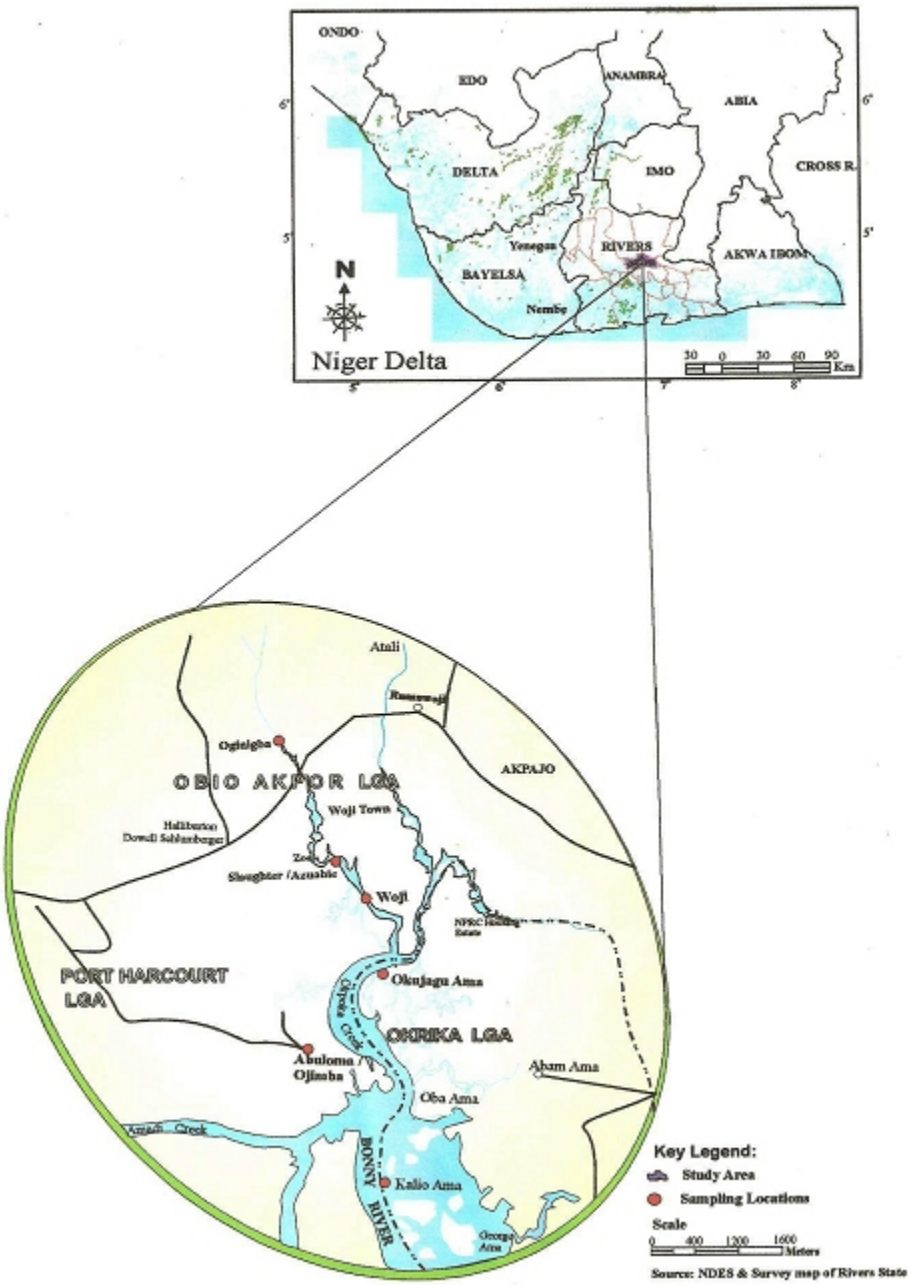

Fig 1: Map of Niger Delta showing Rivers State and the Study Area

and Don Pedro (2003) reported that 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.

Similarly, Ademoroti (1996) reported that water rising from market stalls and slaughter houses, streets washing and flushing sewage which flow through drains into rivers altered the chemical composition of the water body thereby causing pollution. Understanding the functional value of estuaries in relation to successful nekton recruitment requires knowledge of suitable physicochemical conditions, prey abundance, available habitat, and inter-actions with the organisms (Chazaro-Olvera and Peterson, 2004).

Physical and chemical factors such as temperature, turbidity, light intensity, pH, Dissolved ions such as $N0^{3-}$ and $P0^{4-}$ among others are reported by several workers (Collins, 1983; Ronald, 1988; Mukhtar, *et al*., 1998). Earlier studies have also shown that organic waste dump caused environmental stress in coastal waters which resulted to low landing of some important fisheries (Wyatt and Yolarda, 1992; Appasany and Landquist, 1993; Lemly, 1996; Nweke 2000).

The Okpoka creek is one of the most important river systems is the Niger delta. It is exceptionally prone to

human impacts because of the numerous human activities that are carried out: fishing, boat construction; welding, sand mining, dredging, mangrove cutting, engine boat transportation, etc may be potential sources of pollution to the environment. Besides, there is a lot of municipal waste discharges such as human waste, waste from abattoir, refuse dumps, sewage/septic waste, etc into the creek water. Inspite of all these activities, the area is still a good nursery and breeding ground for some commercially important fishes and invertebrates, for example, *Mugil* spp., *Sardinella, Tilapia* spp., *Chondrichthys* spp., *Gobids* spp., *Penaeus* spp., *Tympanotonus* spp., *Callinectes* spp., *Ostrea* spp., *Pitar* spp., *Tellina* spp. (Scott, 1966).

In their studies, Mitchell-Innes and Pitcher (1992) reported that size structure and biomass of phytoplankton population and production are closely related to physico-chemical conditions of the water body. Generally, changes in abiotic factors such as water chemistry and structure have been identified to interfere negatively with the food chain.

A part from Ezekiel *et al.* (2002), Abowei and Ezekiel (2003), Abowei *et al.* (2007), Abowei and Hart (2007), Abowei *et al.* (2008), Abowei and Hart (2008), Abowei and Hart, (2009) and Abowei and Davies, (2009) from different water bodies, there are no reliable data on the physical-chemical characteristics, Okopa Creek. This is essential for formulation of development plan in the fishing industry. This paper therefore provides information to fill that gap in Okopa Creek fisheries.

MATERIALS AND METHODS

Study area: The study was carried out in Okpoka creek, which is one of the several adjoining creeks off the Upper Bonny River estuary in the Niger Delta (Fig. 1). The Bonny River Estuary lies on the Southeastern edge of the Niger Delta, between longitudes 6°58' and 7°14" East, and latitudes 4°19" and 4°34" North. It has an estimated area of 206Km^2 and extends 7Km offshore to a depth of about 7.5 metres (Irving, 1962; Scott, 1966; Alalibo, 1988). The Bonny River is a major shipping route for crude oil and other cargoes, and leads to the Port Harcourt quays, Federal Ocean Terminal, Onne, and Port Harcourt Refinery company terminal jetty, Okirika. Specifically, the Okpoka creek lies between Longitudes 7°03′ and 7°05' East and Latitudes 4°06' and 4°24' and it is about 6 kilometers long.

Characteristically, the area is a typical estuarine tidal water zone with little fresh water input but with extensive mangrove swamps, inter-tidal mud flats, and influenced by semi-diurnal tidal regime. In the Bonny River estuary, the salinity fluctuates with the season and tide regime is influenced by the Atlantic ocean (Dangana, 1985). Tidal range in the area is about 0.8m at neap tides and 2.20m during spring tides (NEDECO, 1961).

It is strategically located southwestern flanks of Port Harcourt and Okirika of Rivers State. The creek is bounded by thick mangrove forest dominated by Rhizophora species interspersed by White mangrove (*Avecinia* sp.) and Nypa palm. Along the shores of the creek are located the Port Harcourt Trans- Amadi Industrial layout, several establishments, markets, the main Port Harcourt Zoological garden and several communities. The communities are Oginigba, Woji New layout, Azuabie, Okujagu- Ama, Ojimba- Ama, Abuloma, Okuru- Ama, Oba-Ama and Kalio- Ama.

Artisanal fishers mainly exploit the fisheries. The fishers use wooden/dug-out canoes ranging in size from 3 to 8m long. The canoes are either paddled or powered by small 0utboard engines, and manned by an average of two men. From these boats, the fishers operate their cast nets, hook and lines, gillnets, crab pots, etc.

Sampling stations: Six sampling stations were established along a spatial grid of the Okpoka creek covering a distance of about six kilometers. The sampling stations were established based on ecological settings, vegetation and human activities in the area (Fig.1). The sampling station is about one kilometer apart from each other.

Station 1: Located upstream of the Port Harcourt main abattoir at Oginigba waterfront with living houses on the left flank of the shoreline. Vegetation is sparse with mainly red mangrove (*Rhizophora* sp.,) white mangrove, Avicenia sp. and Nypa palm (*Nypa fructicans*).

Station 2: Situated at Azuabie / Port Harcourt main abattoir waterfront. It is located downstream of Station 1. The bank fringing the Azuabie/abattoir is bare with no visible plants except toilet houses, residential houses, animal pens, boats and badges, while at the opposite side there are few mangrove and Nypa palm. Human activities here include slaughtering of animals, marketing, fishering and boat building. It is located downstream of station 1 and it is main collection point of abattoir wastes and other human and market wastes.

Station 3: It is downstream from the Port Harcourt abattoir at the Woji sand-crete. It is about one kilometer away from Station 2. The major activities here included sand mining and loading.

Station 4: This station is located at Okujagu-Ama area. There are no industrial activities here. Mainly fishers occupy the area. Nypa palm dominates the marginal vegetation while the opposite side is thickly populated with red mangrove forest. *Rhizophora racemosa* and *Rhizophora mangle*. The main activity is fishing, boat ferryings and occasional sand moving.

Station 5: Is situated at Ojimba cum Abuloma waterfronts. There are no commercial activities apart from ferryboats operations. The shoreline fringes have mainly

Table 1: Monthly Mean Rainfall and Atmospheric Temperature Data.

Month	2006		2007	
	Total Rainfaill (mm)	Atmos. Temp. °C	Total Rainfall (mm)	Atmos. Temp. °C
January	1.8	32.5	17.1	32
February	46.5	31	85.9	33
March	50.7	331	70.8	31
April	120.7	32	121.4	30
May	132.8	30	247.3	31
June	243.7	30.5	383.2	32
July	399.6	28.5	252.9	30.5
August	210.1	30	228.4	29.0
September	352.4	30	285.2	30.5
October	218.1	32	195.2	31
November	95.7	30	28.7	31
December	5.4	31	6.8	32

Source: International Institute for Tropical Agriculture, Meteorological Station, Onne, Rivers State.

Table 2: A summary physico-chemical parameters at various of Okpoka Creek, Upper Bonny River, Niger Delta, Nigeria.

Parameters	*Sampling Stations*					
	1 Oginigba	2 Azuabie/ Slaughter	3 Woji	4 Okujagu	5 Ojimba/ Abuloma	6 Kalio-Ama
Temp. °C	29.10 ± 0.21^{b} (27.0 – 31.0)	29.02±0.23^{b} (27.0 – 31.0)	29.18±0.22^{ab} (27.0 – 31.0)	28.98±0.23^{b} (27.0 – 31.0)	29.77±0.15^{a} (28.5 – 31.0)	29.48±0.21^{ab} (27.0 – 31.0)
pH	6.68±0.07^{c} (5.7 – 7.1)	6.73±0.07^{c} (6.30 – 7.8)	6.81±0.05^{bc} (6.20 – 7.3)	6.97±0.07^{ab} (6.5 – 8.20)	7.02±0.06^{a} (5.8 – 7.6)	7.03±0.05^{a} (6.6 – 7.6)
Salinity ‰	4.75±0.79^{d} (0.17 – 11.1)	6.51±0.89^{cd} (0.71 – 13.40)	9.03±1.19^{bc} (1.02 – 17.4)	9.83±1.11^{ab} (1.20 – 18.4)	10.84±1.26^{ab} (1.52 – 21.2	12.65±1.36^{a} (1.64 – 25.7)
D.O. mg/l	4.17±0.34^{ab} (1.6 – 7.20)	3.72±0.41^{b} (0.90 – 7.20)	4.50±0.39^{ab} (2.40 – 9.60)	5.07±0.29^{a} (2.74 – 7.40)	5.10±0.29^{a} (2.74 – 7.40)	4.98±0.34^{a} (1.60 – 8.34)
B.O.D. mg/l	2.05±0.23^{a} (0.00 – 4.14)	1.97±0.28^{a} (0.00 – 4.80)	2.21±0.28^{a} (0.60 – 5.52)	2.69±0.26^{a} (0.80 – 6.40)	2.11±0.23^{a} (0.80 – 4.60)	2.17±0.23^{a} (0.40 – 5.98)
Conductivity µs/cm	10788.75±1053.87^{c} (960 – 19000)	13294.17±1300.0^{c} (920 – 19400)	14107.92±1590.63^{c} (790 – 27900)	19973.75±1433.90^{b} (1390 – 29500)	23095.83±1125.08^{ab} (10200 – 33400)	24877.92±1430.65^{a} (12800 – 37800)

( ) range values, a,b,c,d, means within columns carrying different superscript differ significantly at (P£ 0.05)

Nypa palm. The area is shallow and at low tide, the greater part of the bottom mud flat is exposed.

Station 6: Is located in front of Kalio-ama directly between Okpoka and Amadi creeks. The human activities here include jetty operations, oil and non-oil industrial activities, boat traffic and fishing. Vegetation is few dominated by red mangrove interspersed with white mangrove *Avicenia africana*.

Rainfall data were retrieved from the records of the International Institute of Tropical Agriculture (IITA), meteorological station Onne, Rivers State. From the data available, for the rainfall pattern, the sampling period was delineated into dry and wet seasons.

The physical and chemical parameters of the Okpoka creek water, investigated were water temperature, Hydrogen ion concentration (pH), salinity (S%o), Dissolved oxygen content (DO), Biochemical oxygen demand (BOD) and Electrical conductivity. The methods used were as described by Golterman *et. al.*, (1978) and APHA (1998). Data collected for the environmental parameters were subjected to statistical analysis using Analysis of variance (ANOVA) to determine their variations at stations and seasons.

RESULT

Table 1. Shows the monthly rainfall data. There was a long wet season stretching from April to October in and a dry season extending from November to March. The total monthly rainfall ranged from 1.8mm to 399.6mm. The highest total rainfall (399.6mm) was recorded in July while the lowest rainfall (1.8mm) was observed in January. The atmospheric temperature fluctuated from 28.5°C in July to 33°C in March in the first year. A summary of the other parameters studied (pH, temperature, salinity, Dissolved Oxygen, Biochemical oxygen demand and Conductivity) is presented in Table 2.

The monthly water temperature values ranged between 27°C and 31°C across the Stations. The mean temperatures were similar along the Stations (P£0.05) ranging from 28.98±0.23°C (Station 4) to 29.77±0.15°C (Station 5). A steady trend of temperature was observed in Stations 1, 2 and 4 as well as in stations 3 and 6.

Generally, temperature values were stable across stations. Maximum temperature of 31°C was recorded in January, February, March, July, and October. While the lowest temperature of 27°C was observed in July, August and September. There was slight seasonal variation of temperature between dry (29.49±0.11°C) and wet season (29.09±0.125°C). A steady trend of temperature variation was observed. The mean pH value ranged between 6.68±0.07 (Station 1) and 7.03±0.05 (Station 6). The Spatial and temporal variations of pH were minimal (Fig. 2). Seasonal variation in pH was observed between dry season (6.97±0.044) and wet season (6.81±0.367) (Fig. 3).

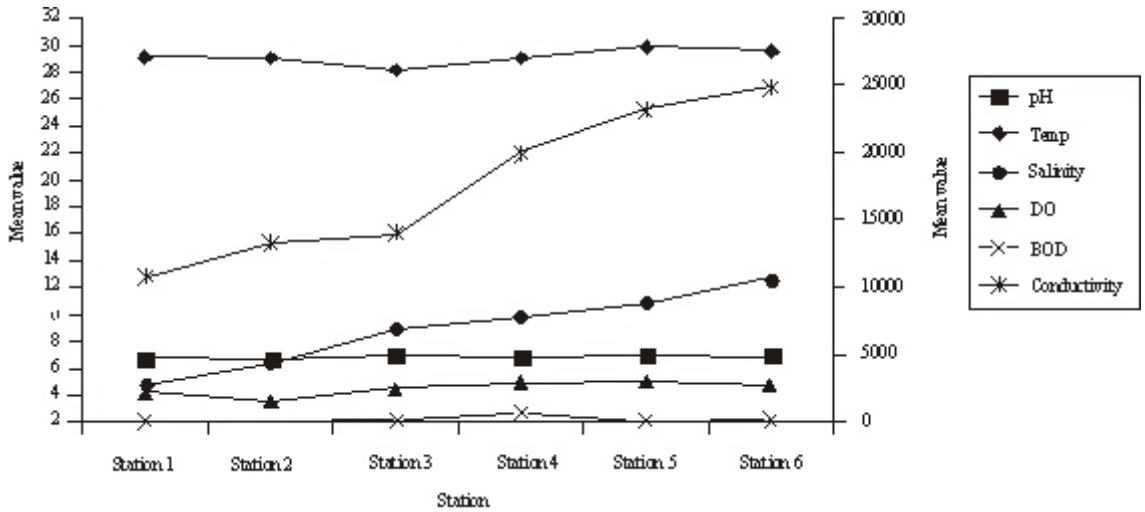

Fig 2: Spatial variation of the physico-chemical parameters in the study area

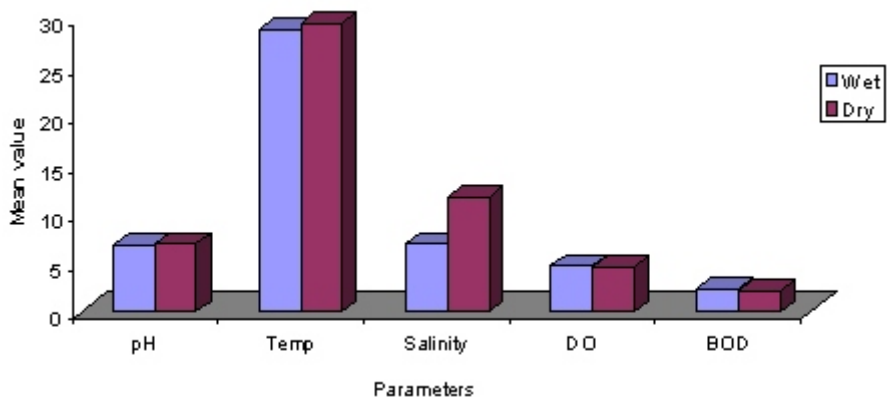

Fig 3: Seasonal variation of the physico-chemical parameters in the study area

Salinity values ranged between 0.60‰ and 20.90‰. The highest salinity value (20.90‰) was recorded in June at station 6 and the lowest salinity value (0.60‰) was observed in October at station 1. The means varied from 4.75±0.79 (Station 1) to 12.65±1.36‰ (Station 6). There was spatial variation with a general trend that showed increased salinity values from station 1 to station 6. Some Seasonal variation was also observed with higher salinity during the dry season (11.67±0.517‰) than the wet season (6.98±0.701‰) (Fig. 3).

Dissolved oxygen values values range from 0.4mg/L and 8.34 mg/L. The highest dissolved oxygen concentration (9.6mg/L) was observed in station 3 while the lowest value (0.4mg/L) was recorded in station 6. The mean dissolved oxygen concentrations ranged between 3.72±041mg/L and 5.10±0.29mg/L across the stations. There was no seasonal and annual variation observed in the concentrations of dissolved oxygen.

Biochemical oxygen demand varied from 0.0mg/L to 6.4mg/L. The lowest biochemical oxygen demand value (0.0mg/L) was recorded in December and the highest value (6.4mg/L) was observed in station 1 (March) as well as station 4. The mean biochemical oxygen demand oxygen ranged between 1.97±0.28mg/L and 2.69±0.26mg/L across the stations. No seasonal and temporal variations were observed in the biochemical oxygen demand.

Monthly conductivity values observed ranged from 920mscm^{-1} and 33100mscm^{-1} across the stations. Generally, an increasing trend was observed from station 1 to station 6 with mean values varying from 10788.75±1053.87mscm^{-1} (Station 1) to 24877.92±1430.65mscm^{-1} (Station 6). Seasonal variation in conductivity with a general trend of higher conductivity in the dry season 18943.17±914.304mscm^{-1} than the wet 16794.38±985.154mscm^{-1} season was observed. Spatial

variation of conductivity was significant ($p<0.05$) with a general trend of increase from station 1 (upstream) to station 6 (downstream).

DISCUSSION

The sub-surface water temperature ranges from 27°C to 31°C and the mean values ranged from 28.98±0.23°C to 29.77±0.15°C across the stations observed are considered normal with reference to the location in the Niger Delta, which is described as humid/semi hot equatorial climate (NEDECO, 1961). Alabaster and Lloyd, (1980) reported that temperature of natural inland waters in the tropics generally varies between 25°C and 35°C.

This findings agree with earlier reported works in the Niger Delta waters by Chindah *et al.* (1999) who reported temperature ranges of between 26°C and 30.5°C, Zabbey, (2002) between 26.3°C and 30.4°C, Braide *et al.* (2004) (26.64 ± 1.18°C and 30.83 ± 1.47°C), Ansa (2005) (25.9°C and 32.4°C); Hart and Zabbey (2005) (25.8°C and 30.4°C), Sikoki and Zabbey, (2006) (26°C and 27.8°C), Dibia (2006) (25°C to 27°C) and Jamabo (2008) reported a temperature range between 27°C and 30°C in the Upper Bonny River of Niger Delta .

Spatial differences in temperature were statistically significant (P£0.05). The highest mean temperature value of 29.77± 0.15°C was recorded in station 5 (Ojimba/Abuloma); indicating that this station heats up faster than the other five stations due to the shallow nature of the depth.

The shallow nature of the area and the absence of any stratification ensure adequate mixing and circulation of surface and bottom waters. Temperature showed significant seasonal variation (P£0.05) as shown. The temperature values are significantly higher in the dry season. A similar trend was reported in the main Bonny River by Dublin-Green, (1990) (31.2°C dry season and 27.5°C wet season); Amakiri (2006), (27.6°C wet season; 31.6°C dry season) whereas in the New Calabar, Ekeh and Sikoki, (2003) reported lowest temperature of 25°C in the wet season and 30°C in the dry season, and in Andoni River, Ansa (2005) reported 25.9°C wet season and 32.4°C dry season. Higher temperature values recorded in the dry months are expected since heat from sunlight increases temperature of surface water. Similarly the drop in water temperature in the wet season months is attributable to heavy rainfall experienced during the period.

The water temperature correlated significantly ($P<0.001$) with the pH, salinity and conductivity but has no significant correlation with Dissolved Oxygen and Biochemical Oxygen demand. The latter may be due to the increased photosynthetic process during the sampling period in the area as it was daylight.

The spatial distribution of pH ranging from 6.68±0.07 to 7.03±0.05, is characteristics of a tidal brackish water environment as noted by the International Joint Commission, (1977) and Ajao and Fagade, (2002). The generally lower pH values at the upstream (1 to 3) stations (6.68±0.07 - 6.81±0.05) than at the downstream (4 to 7) stations (6.97±0.07 - 7.03±0.05), may have resulted from decaying of the domestic and industrial waste litter in the upstream area contributing to the acidic nature of the water. However, pH values recorded in this study were well within the preferred pH of 6.5 to 9.0 recommended for optimal fish production (Boyd and Lichktopller, 1979).

The seasonal variation of pH values observed in this study is in agreement with results of previous studies conducted by Dublin-Green (1990) in Bonny River, where the highest pH values were recorded in the dry season and lower values of pH in the late rainy season. Similar trend was reported by Ekeh and Sikoki (2003) in the New Calabar River and also by Ansa (2005) in Andoni flats of the Niger Delta area. The seasonality in the pH of Okpoka creek water may be due to the influx and decay of debris in the area as well as imbalance level of H^+ ions input from surface run-offs during the rains. This assertion is based on the result of the correlation analyses between pH and other parameters.

The spatial distribution of salinity values ranging from 4.75±0.79 to 12.65±1.36‰ with Station 1 (0.17%) and station 6 (25.7‰), showed gradual increase of salinity values from the upstream stations to downstream stations along the creek. This trend could be attributed to effluent water discharges from several industrial establishments, slaughterhouse operations and domestic activities that are prevalent along the upstream area of the creek. Higher salinity value (11.67±0.517‰) recorded during the dry season (November to March) than the wet season (6.98±0.701‰) April to October also compared favorably the report by Payne, 1976.

The months of April to October in West Africa usually coincide with the rainy season when high volumes of freshwater are discharged into coastal or estuarine waters that lower or dilute the water. Similarly, McLusky (1989) reported that rainfall could cause dilution of estuaries and hence cause reduction in salinity, while heat generated by sunlight in dry season months would cause evaporation of the surface water making it saltier and hence more saline.

From the rainfall data available the month of April and June were rainy months therefore the high salinity values recorded in them may be attributed to factors such as days of sampling, time of sampling and nature of effluents discharged to the sampling stations before or during the sampling. The results of the study showed that salinity of the study area generally alternated between Oligohaline (0-5‰) and mesohaline (5-18‰) as classified by Venice system (1959).

The dissolved oxygen values were higher at the upstream sampling stations than the downstream stations with the highest of 9.6mg/l observed in station 3 and the lowest 0.4mg/l in station 6. Similar trend was also reported by Hart and Zabbey, (2005) for Woji Creek. Davies *et al.* (2008) also made similar report for the Trans-Amadi (Woji) creek, Port Harcourt. They attributed

it to the effects of higher temperature and abattoir wastes. There was no significant (P<0.05) difference in the variation between the dry and wet seasons in the area. This is contrary to results of (Plimmer, 1978 and McNeely, *et al.*, 1979) who reported that at high temperature, which is usually observed in dry season, the solubility of oxygen decreases while at lower temperature (wet season) it increases. Davies *et al.* (2008) also reported lowered dissolved oxygen (4.48mg/l) in wet season than dry season (5.14mg/l) and attributed it to be due to reduced photoperiod and photosynthetic activities of aquatic plants.

The higher mean dissolved oxygen value recorded in the dry season, did not agree with the findings of Egborge (1971), who reported that dissolved oxygen is generally higher in the wet season in the tropics. A possible explanation for the lower mean dissolved oxygen values in the wet season could be the turbidity nature of the water at this period due to inflows from run-offs and decomposition of organic matter in the water. In fact, Braide, *et al.* (2004) also had similar results in their study of water quality of Miniweja stream in Eastern Niger Delta, Nigeria.

In considering the temperature profile of the Okpoka Creek, it is clear that the dissolved oxygen values recorded in this study are lower than the standard values (8.38mg/l and 7.64mg/l) quoted by Boyd and Lichktoppler (1979) at equivalent temperature range of 23°c to 29°c. However, since dissolved oxygen concentration are usually low in the morning and rises to a maximum in the afternoon, the concentrations reported in this study show that the creek contains high concentration of dissolved oxygen as the readings were taken in the morning. The range of dissolved oxygen was still within the acceptable limit of aquatic life (McNeely *et al*, 199).

Biochemical Oxygen demand (BOD) concentration ranged between 1.97±0.28mg/l and 2.69±0.26mg/l. The biochemical oxygen demand exhibited similar profile with dissolved oxygen concentration with higher values recorded at the upstream stations than at the downstream stations. The higher BOD load observed in the months of March and June could be attributed to increased degradable organic waste load observed during the study as noted by McNeely *et al.* (1979) and Clerk, (1986).

The Biochemical Oxygen Demand values were generally stable in all stations and exhibited no significant difference (P<0.05) in seasonal and temporal variations. Based on the observed results it could be stated that both the downstream stations with BOD values (2.11 ± 0.23 – 2.69 ± 0.26) and upstream BOD values (1.97 ± 0.28 – 2.21 ± 0.28) may be considered as clean water since they have lower BOD than 3.0mg/l.

This assertion follows the classification of Moore and Moore (1976) who opined that water bodies with BOD concentrations between 1.0 and 2.0mg/l were considered clean 3.0mg/l fairly clean, 5.0mg/l doubtful and 10.0mg/l definitely bad and polluted. BOD concentrations in the creek may therefore serve as a pointer to the level of organic pollution. This agreed with the observation by Braide *et al.* (2004) in their study on water quality of Miniweja stream in Eastern Niger Delta.

The conductivity results (10788.75 ± 1053 - 24877.92 ± 1430.65mscm^{-1}) of the Okpoka creek show that the water is brackish as noted by Egborge (1994). Egborge (1994) in his study of the Warri River, Niger Delta classified waters with conductivity value above 40,000mscm^{-1} as marine, below 1000mscm^{-1} as fresh and in between the two units as brackish. Conductivity results showed similar trends as salinity. Distinct seasonality in conductivity was evident in this study as there was a significant difference (P<0.05) between the wet and dry season conductivity values.

This assertion corroborated with the results of the other scientists who worked in different water bodies within Niger Delta (Dublin-Green, 1990; main Bonny River; King and Nkanta 1991: rain forest pond, Nigeria; Mallin *et al.* 1999; Dibia, 2006; Mini-Chinidah stream Port Harcourt, Niger Delta. and Davies, *et al.* 2008, Trans-Amadi (Woji) creek, Niger Delta. Bishop (1973) and Petr (1983) had earlier explained conductivity values increase in the dry season as a result of the concentration of the ions by evaporation and increased mineralization of organic matter. In fact, the results from this study compared favorably with the results of Dublin-Green (1990) in Bonny River and Zabbey (2002) in Woji creek.

A possible explanation for this trend may be due to the influx allocutions organic and inorganic materials from the surrounding catchments area during the rains. The results also showed that conductivity increases as one moves downstream. The conductivity values observed were significantly different (P<0.05) between stations. This could be attributed to nutrient regeneration from bottom sediments, decomposition and mineralization of microbes downstream as noted by Dibia, (2006). It was observed in this station that conductivity significantly correlated with temperature, pH and salinity, which agreed with Boyd and Lichktoppler (1979).

The results of the correlation matrix analysis showed significant correlation between the variables at different stations. It is also important to note that the association between the environmental variables in the Okpoka Creek was generally similar. This is expected as the water at the stations is seemingly from the same source, Atlantic Ocean through Bonny River. The positive association observed also suggests functional similarity. Also, Chindah and Nduaguibe (2003) attributed the varying magnitude of the relationship between the water variables in lower Bonny River of Niger Delta to micro habit differences.

The rainfall data obtained from the International Institute for Tropical Agriculture, Onne, Rivers State, Nigeria indicated seven months wet season period, which stretches from April to October, and a dry season extending from November to March. The maximum mean rainfall (399.6mm) was observed in July. This maximum rainfall occurred in the coastal area where the thickness of the humid southwesterly air mass is greater than 1.5km as

noted by Hastenrath, (1985) and Ajao and Fagade, (2002). A primary period of peak rains extending from June – July and a secondary peak in September - October that according to NEDECO, 1980 is a characteristic of a coastal rainfall pattern. From the results obtained, it is evident that most of the physico-chemical parameters of the Okpoka creek were influenced by rainfall which was noted as the characteristics of many Nigerian and tropical waters by Adebisi (1988), Egborge (1988 and 1994) and Okogwu and Ugwumba (2006) respectively.

The atmospheric temperature obtained from International Institute for Tropical Agriculture, Onne Rivers State fluctuated between 28.5°C in July to 32.5°C in January. The temperature ranges represented a typical humid/semi-hot equatorial region as noted by (NEDECO, 1961).

REFERENCES

Abowei, J.F.N. and E.N. Ezekiel, 2003. Aspects of some physicochemical parameters of the fresh water reaches of the Lower Num River, Niger Delta. Int. J. Sci., Tech., 2(1): 5-9.

Abowei, J.F.N. and A.I. Hart, 2007. Size composition, age, mortality and exploitation rate of *Chrysichthys nigrodigitatus* from Nun river, Niger Delta, Nigeria. Afr. J. Appl. Zool. Environ. Biol., 9: 44-50.

Abowei, J.F.N., F.D. Sikoki, A.I. Hart and M.E. Allison, 2007. Catch composition and seasonality of Fin fish in the fresh water reaches of the lower Nun River, Niger Delta. J. Field Aquat. Stud., 3: 8-21.

Abowei, J.F.N. C.C. Tawari, A.I. Hart and D.U. Garicks, 2008. Finfish species composition, abundance and distribution in the lower Sombreiro River, Niger Delta, Nigeria. Int. J. of Trop. Agri. and Food systems, 2(1): 46-53.

Abowei, J.F.N. and A.1. HART, 2008. Artisanal fisheries characteristics of the fresh water reaches of lower Nun River, Niger Delta, Nigeria. J. Appl. Sci. Environ. Manage., www.bioline.org.br/ja. 12(1): 5-7.

Abowei, J.F.N and A.I. Hart, 2009. Some morphormetric parameters of ten finfish species from the lower Nun River, Niger Delta, Nigeria. Medwell Journals (Pakistan). Res. J. Biol. Sci., 4(3): 282-288.

Abowei, J.F.N. and A.O. Davies, 2009. Some population parameters of Clarotes laticeps (Rupell, 1829) from the fresh water reaches of the lower river, Niger Delta, Nigeria. Am. J. Sci. Res., 2: 15-19. http:// www. eurojournals.com/ajsr.htm

Adebisi, A.A., 1988. The physico-chemical hydrology of a tropical seasonal river Upper Ogun River. Hydrologia, 79:159-165.

Ademoroti, L.M.A., 1996. Environment Chemistry and Toxicology. Foluelex Press Ltd, Ibadan, pp: 217.

Ajao, E.A. and S.O. Fagade, 2002. The ecology of *Neritina glabrata* in Lagos Lagoon, Nigeria. Arch. Hydrobiol., 119(3): 339-350.

Alabaster, J.S. and R Lloyd., 1980. Water quality criteria for freshwater fish. Butter worth's, London, U.K., pp: 297.

Alalibo, O.O., 1988. The fisheries resource exploitation of the Bonny/New Calabar Estuarine fishing ground in the Niger Delta M.Phil Thesis, Rivers State University of Science and Technology, Port Harcourt, pp: 111.

Amakiri, N.E., 2006. Aspects of the Biology of *Pseudotolithus elongatus* (Bowdich, 1825) of Bonny Estuary, Niger Delta, Nigeria, M.Sc. Thesis, Rivers State University of Science and Technology, Nkpolu-Oroworukwo, Port Harcourt, pp: 99.

Ansa, E.J., 2005. Studies of the benthic macrofauna of the Andoni flats in the Niger Delta Area of Nigeria. Ph.D Thesis University of Port Harcourt, Port Harcourt, Nigeria, pp: 242.

Appasany, P., and Jan-Landquist, 1993. Water supply and wastes disposal strategies for Madras, Ambio, 22(7): 442-448.

Bishop, J.E., 1973, Limnology of a small Malayan River, Sungai Gombak, Dr. W. Junk. The Hague, pp: 129.

Boyd, C.E. and F. Lichtkoppler, 1979. Water quality management in fishpond, Research and Dev. Series No.22. International centre for Aquaculture and Agriculture (I.C.A.A.), Experimental station Auburn University, Alabama, pp: 45-47.

Braide, S.A., W.A.L. Izonfuo, P.U. Adiukwu, A.C. Chindah, and C.C. Obunwo, 2004. Water Quality of Miniweja stream, A Swamp forest stream receiving non-point source waste discharges in Eastern Niger Delta, Nigeria. Scientia Africana, 3(1): 1-8.

Chazaro-Olvera, S. and M.S. Peterson, 2004. Effects of salinity on growth and molting of sympatric *Callinectes* spp. from Camaronera Lagoon, Veracruz, Mexico. Bull. Marine Sci., 74(1): 115-127.

Chindah, A.C., S.A. Braide, and C. Obunwo, 1998. The effect of municipal waste discharge on the physico-chemical and phytoplankton in a brackish wetland in Bonny Estuary. Acta Hydrobiol., 40: 9-15.

Chindah, A.C. and U. Nduaguibe, 2003. Effect of tank farm waste water on water quality and periphyton of lower Bonny river, Niger Delta, Nigeria. J. Nigerian Environ. Soci., 1(2): 206-222.

Clerk, R.B., 1986. Marine Pollution: Clarandon Press, Oxford, London, pp: 256.

Collins, V.G., 1983. The distribution and Ecology of Bacteria in freshwater. Proceedings Soil Water Treatment and Examination, 12: 40-73.

Dangana, L.B., 1985. Hydrogeomorphological controls of the mangrove environment In: Proceedings of a Workshop on the mangrove ecosystem of the Niger Delta. University of Port Harcourt. pp: 357.

Davies,O.A., A.A.A. Ugwumba, and Abolude D.S., 2008. Physico- chemistry quality of Trans- Amadi (Woji) creek, Port Harcourt, Niger Delta, Nigeria. J. Fish. Int., 3(3): 91-97.

Dibia, A.E.N., 2006. Effect of biotope difference on aquatic Macrophytes along Mini-Chindah Stream in Port Harcourt, Rivers State M.Sc. Thesis, Rivers State University of Science and Technology, Port Harcourt, Nigeria, pp: 120.

Dublin-Green, C.O., 1990. Seasonal variations in some physico-chemical parameters of the Bonny Estuary, Niger Delta. NIOMR Technical Paper, 59: 21-25.

Egborge, A.B.M., 1971. The chemical hydrology of River Oshun, Western State, Nigeria. Freshwater Biol., 1: 257-271.

Egborge, A.M.B., 1988. Salinity and water hyacinth occurrence in the Lagos harbour Badagry Creek system. Proceedings of International Workshop/Seminar on water hyacinth. Federal Ministry of Science and Technology, Lagos, Nigeria. pp: 46-51.

Egborge, A.M.B., 1994. Salinity and the distribution of rotifers in the Lagos Harbour-Badagry Creek system, Nigeria. Hydrobiologia, 272: 95-104.

Ekeh, I.B. and Sikoki, F.D., 2003. The state and seasonal variability of some physico-chemical parameters in the New Calabar River, Nigeria. Supp. ad Acta Hydrobiol., 5: 45-60.

Ezekiel, E.N., J.F.N. Abowei and A. Hart, 2002. The Fish Species Assemblage in the Flood Plains of Odhioku-Ekpeye, Niger Delta. Int. J. Sci. Technol., 1: 54-59.

Hastenrath, S., 1985. Climate and circulation of the Tropics. D. Reidel. Publication Coy. Dordrecht, Holland, pp: 205.

Hart, A.I. and Zabbey, N., 2005. Physico-chemical and benthic fauna of Woji Creek in the Lower Niger Delta, Nigeria. Environ. Ecol., 23(2): 361-368.

International Joint Commission., 1977. New and revised specific water quality objectives. Great Lakes Water Quality Board Report, 11: 42-59.

Irving, E.G., 1996. Bonny River entrance (Admiralty Chart, 3287), The Admiralty, London, pp: 249.

Jamabo, N.A., 2008., Ecology of *Tympanotonus fuscatus* (Linnaeus, 1758) in the mangrove swamps of the Upper Bonny River, Niger Delta, Nigeria. PhD. Thesis, Rivers State University. pp: 340.

King, R.P., and N.A. Nkata, 1991. The status and seasonality in the physico-chemical hydrology of a Nigerian rainforest pond. J. Limnol., 52: 1-12.

Lemly, A.D., 1996. Wastewater discharges may be most hazardous to fish during Winter. Environ. Pollu., 93(2): 169-173.

Mallin, M.A., M.H. Posey, G.C. Shank, M.R. Mclver, S.H. Ensign and T.D. Alphin, 1999. Hurricane effects on water quality and benthos in the Cape Fear Water-Shed: Natural and Anthropogenic Impacts, Ecol. Appell., 9: 350-362.

Mclusky, D.S., 1989. The estuarine ecosystem 2nd Edn. Chapman and Hall, New York pp: 214.

McNeely, R.N., V.P. Neimanis, and L. Dwyer, 1979. Water quality sourcesbook – A guide to water quality parameters. pp: 112.

Mitchell-Innes, B.A. and G.C. Pitcher, 1992. Hydrographic parameters as indicators of the suitability of phytoplankton populations as food herbivorous copepods. S. Afr. J. Mar. Sci., 12(1): 355-365.

Moses, B.S., 1983. Introduction to Tropical Fisheries. University Press, Ibadan, pp: 105.

Mukhtar, M.D. and Y.Y. Deeni, 1998. Microbiological and Physicochemical. Studies on Salata river, South-Central Kano Metropolis. 9th/10th Annual conferences. Proceedings: Nigerian Association for Aquatic Sciences. pp: 241-250

NEDECO, 1961. The waters of the Niger Delta Report of an investigation by NEDECO (Netherlands Engineering consultants). The Hague, pp: 210-228.

Nweke, A.A., 2000. Impact of organic waste pollution on the macrobenthos and fish fauna of Elechi Greek. Ph.D Thesis, Rivers State University of Science and Technology, Port Harcourt, Nigeria, pp: 287.

Okogwu O.I. and O.A. Ugwumba, 2006. The Zooplankton and Environmental characteristics of Ologe Lagoon, South-West Nigeria, The Zoologist 1(4): 86-92.

Oyewo, E.O. and K.N. Don-Pedro, 2003. Influence of salinity variability on heavy metal toxicity of three estuarine organisms. J. Nigeria Environ. Sci., 1(2): 141-155.

Payne, A.I., 1976. The relative abundance and feeding habits of the grey mullet species occurring in an estuary in Sierra Leone, West Africa. Marine Biol., 35: 275- 286.

Petr., T., 1983. The Purari-tropical environment of a high rainfall River basin. Dr. W. Junk. The Hague, pp: 265.

Plimmer, R.J., 1978. Degradation methodology-chemical and physical effects. Procedure of the workshop on microbial degradation, Pensacola Beach Florida, pp: 423-431.

Ronald, M.A., 1988. Microbiology, concept and application 2nd Edn. Macmillan Co New York. pp: 102

Scott, J.S., 1966. Report on the Fisheries of the Niger Delta Special Area. NDDB Port Harcourt, Nigeria. pp: 160.

Sikoki, F.D. and N. Zabbey, 2006. Environmental gradients and Benthic community of the middle reaches of Imo River, South-Eastern Nigeria. Environ. Ecol., 24(1): 32-36

Swingle, H.S., 1969. Methods of analysis for waters, organic matter and pond bottom soils used in fisheries research. Auburn University, Auburn, Alabama, pp: 119.

Wilson, E.M., 1990. Engineering Hydrology Macmillan Press Ltd Houndmills, Basingstoke Hampshire RG216XS and London, pp: 348.

Wyatt, T. and P. Yolarda, 1992, Harmful algal bloom: UNESCO, An IOC Newsletter on topic Algae and Algal bloom, 62: 1-8.

Zabbey, N., 2002. An ecological survey of benthic macroinvertebrates of Woji Creek, off the Bonny River System Rivers State. Msc. Thesis, University of Port Harcourt, pp: 102.