E-ISSN: 2347-5129
P-ISSN: 2394-0506
(ICV-Poland) Impact Value: 5.62
(GIF) Impact Factor: 0.549
IJFAS 2019; 7(3): 192-196

www.fisheriesjournal.com
Received: 22-03-2019
Accepted: 24-04-2019

Ukenye EA
Department of Biotechnology, Nigerian Institute for Oceanography and Marine Research, Victoria Island, Lagos, Nigeria

Taiwo IA
Department of Cell Biology and Genetics, University of Lagos, Lagos, Nigeria

Correspondence
Ukenye EA
Department of Biotechnology, Nigerian Institute for Oceanography and Marine Research, Victoria Island, Lagos, Nigeria

Studies on the physico chemical status and biological characteristics of some rivers in Nigerian coastal states

Ukenye EA and Taiwo IA

Abstract
The Nigerian coastal waters are complex and dynamic aquatic environment valued for human, animal and plant health. Physicochemical parameters of the coastal environment play an essential role in assessing the type of ecosystem of organisms. The present study was carried out to investigate the physicochemical and biological characteristics of the Nigerian coastal waters in order to ascertain the water quality and productivity. Water quality data were generated from 12 coastal rivers for a period of 3 months during the rainy season from April to July, 2012. Some of the water parameters investigated was as follows: water temperature, pH, conductivity, dissolved oxygen (DO), biological oxygen demand (BOD), salinity and dissolved nutrients such as inorganic phosphate, nitrate and sulphate. The values for each parameter sampled were within the tolerable limits for aquaculture. There were significant differences ($p<0.05$) in the parameters except for pH during the period of study. Furthermore, nutrients of water exhibited low values during the season and also varied due to a limited flow of freshwater, high salinity and utilization of phosphate by phytoplankton. The water quality of the coastal rivers is in normal condition indicating that the aquatic environment was conducive for the organisms during the study period. Though, sustainable management of the water bodies should be ensured.

Keywords: Physicochemical characteristics, water quality, nutrients, coastal waters

1. Introduction
Water quality may be assessed based on its physico-chemical and biological characteristics because of increasing industrialization, urbanization and anthropogenic activities around coastal water bodies. Estuarine and coastal areas as exemplified by Nigerian coastal waters are complex and dynamic aquatic environment. Coastal water has become a major concern because of its values for socioeconomic development and human health. With the growth of human populations and commercial industries, estuarine water has received large amounts of pollution from a variety of sources such as recreation, fish culture and the assimilation and transport of pollution effluents through river [1]. These developments have generated great pressure on the ecosystem, resulting in a decrease of water quality and biodiversity, loss of critical habitats [2].

Physicochemical properties play an essential role in the maintenance of healthy aquatic ecosystem [3]. These physicochemical parameters of water and the dependence of all life process of these factors make it desirable to take water as an environment. Maintenance of good water quality is essential for the survival of the aquatic habitats. Hamey *et al* [4]. stated that physicochemical characteristics of the aquatic environment directly influence the life inhabiting it. Though, considerable attention has been paid in the recent years to study the physicochemical parameters of the coastal waters around Eastern Africa in order to ascertain the water quality and productivity, very little information is available on a wider coverage of Nigerian coastal waters [5]. The present study covers more coastal states than most previous studies that are limited because of their respective low coverage areas. Because the studies considered one particular area at a time, the data obtained from such studies would not be representative. Although few studies have been carried out on the physicochemical parameters of important rivers in the Niger Delta by Dublin-Green [6]. on Andoni River; Yakubu *et al* [7]. On lower River Nun and Erondu and Chindah [8] on the lower New Calabar River; according to Francis and Sikoki [9]. monitoring brackish water environments is necessary due to its constant dynamic nature. Therefore to investigate the physicochemical and biological characteristics of the Nigerian coastal waters in order to ascertain the water quality and productivity necessitated this study.

Materials and Methods

Sampling Stations

The sampling locations for the study were Buguma and New Calabar in Rivers state, Ishaka and River Ethiope in Delta state, Epe and Badagry in Lagos state, Igbokoda and Oropo Ilaje in Ondo state, Oron and Ibaka in Akwa Ibom state and Brass and Iwoama in Bayelsa satate. Thus, two locations were selected per state to determine intra and inter specific variation and this gave a total of 12 locations. The sampling locations and their coordinates are shown in Table 1. All the locations are lagoons and creeks along the coast of Nigeria. The samples were collected for a period of three months from April to July, 2012.

Collection of Water Samples and analysis of Physico-chemical Parameters

Water samples for physico-chemical analysis were collected between 8 and 10 in the morning from the sampling stations 0.50 m below the water surface in $1dm^3$ water samplers and stored in 1 litre water bottles, properly labeled and stored in ice chests in the field. In the laboratory, the water samples were transferred into refrigerator (-4ºC) and analysed within 24hrs of collection. Surface water temperature was measured *in situ* using mercury-in-glass thermometers, while pH, conductivity, salinity and turbidity were analysed in the laboratory using a multi-meter water checker (Horiba U-10) according to APHA [10].

Dissolved Oxygen

Separate water samples were collected in 250ml Dissolved oxygen bottles at each station for dissolved oxygen estimation. Oxygen was fixed according to modified Winkler's method using Manganese Sulphate and Alkaline Sodium Iodide [11]. The Biological oxygen demand (BOD) was then determined from the calculation: $BOD = DO - DO_5$.

Nutrient Sampling

Nitrate, Phosphate and Sulphate were measured with LaMotte SMART spectrophotometer RMN26624 according to USEPA [12] at different wavelengths with their appropriate colour development reagents. The Smart Spectrophotometer is an EPA-Accepted instrument, meets the requirements for instrumentation as found in test procedures that are approved for the National Primary Drinking Water Regulations (NPDWR) or National Pollutant Discharge Elimination System (NPDES) compliance monitoring programs [13, 14].

Table 1: Geographical location of Sampling Stations

Location	Water body	Latitude	Longitude	State
Buguma	Lagoon	N04º 44.613[1]	E006º 57.401[1]	Rivers
New Calabar	River	N04º 448[1]	E07º 010[1]	Rivers
Ishaka	River	N05º 03.243[1]	E005º 45.332[1]	Delta
R. Ethiope	River	N05º 53.397[1]	E005º 33.671[1]	Delta
Epe	Lagoon	N06º 35.832[1]	E02º 59.096[1]	Lagos
Igbokoda	River	N06º 21.028[1]	E004º 48.319[1]	Ondo
Oropo Ilaje	Lagoon	N06º 25.238[1]	E04º 75.228[1]	Ondo
Iwoama	Lagoon	N04º 51.224[1]	E06º 28.333[1]	Bayelsa
Brass	River	N04º 31.500	E06º 24.167	Bayelsa
Badagry	Lagoon	N04º 25.012[1]	E02º 52.988[1]	Lagos
Oron	River	N04º 49.217[1]	E008º 04.625[1]	Akwa Ibom
Ibaka	Lagoon	N04º 27.200[1]	E007º 19.618[1]	Akwa Ibom

Data Analysis

The Data collected were analyzed for significant differences ($p<0.05$) by one-way Analysis of Variance (ANOVA) using computer Statistical Package for Social Sciences (SPSS) 15.0 for windows software (SPSS Inc, Chicago, IL) and descriptive statistics analysis.

Results

Physico-chemical Analysis

Results of the physico-chemical analysis showed that surface water temperature varied from 26.25ºC to 28.57ºC (Table 2). The highest mean temperature of 28.57 ±0.79 ºC was recorded in River Ethiope (Delta state) while the lowest (26.25ºC±0.85) in Ibaka (Akwa Ibom). The pH level ranged from7.2 to 7.9 and was highest in Bayelsa state. Dissolved Oxygen (DO) level varied from 3.42 mg/l to 9.25 mg/l. The DO concentration was fairly stable throughout the sampling period with a little abnormal decrease (3.42 $\pm$ 3.02) in Buguma (Rivers State). The biological oxygen demand (BOD) also showed a similar trend as dissolved oxygen (Buguma also had the lowest). Salinity regime in the study area evidenced brackish environment of the mean range of 6.25±7.42 ‰ and 25.20±4.16 ‰. Water salinity increases in Oron in Akwa Ibom state with an increase in DO. Low conductivity was observed and ranged from 4.95µS/cm to 23.65µS/cm.

Nutrient content analysis

The phosphate level of the studied water bodies in different locations ranged from 0.10mg/l±0.60 to 5.99±15.77 mg/l (Table 3). The highest mean phosphate was observed in New Calabar in Rivers state while the lowest was in Epe in Lagos state. The highest nitrate mean recorded was 0.37±0.44 mg/l in Igbokoda (Ondo state) while the lowest was 0.12±0.06 mg/l in New Calabar in Rivers state. There were significant differences ($p<0.05$) in the parameters except for pH during the period of study. The values for each parameter were within the tolerable limits for aquaculture indicating that the aquatic environment was conducive for the organism. For example; the expected range of pH for optimum aquaculture is usually within 6.5-8.5 and the pH range obtained coincides with this while the optimum value for dissolved oxygen is usually 5 mg/l and above but not more than 12 mg/ml and the result also concurred.

Table 2: Physicochemical Parameters of Sampling Stations (Mean ± SD)

Locations	States	Water Temp (°C)	pH	Conductivity (mS/cm)	Salinity (‰)	DO (mg/l)	BOD (mg/l)
River Ethiope	Delta	28.57 ± 1.0^{b}	7.56 ± 0.8^{a}	6.95 ± 0.8^{ab}	7.97 ± 0.8^{bc}	5.43 ± 0.8^{bc}	3.0 ± 0.8^{abc}
New Calabar	Rivers	27.43 ± 0.5^{ab}	7.55 ± 0.5^{a}	21.37 ± 0.5^{d}	11.84 ± 0.5^{e}	4.85 ± 0.5^{b}	2.38 ± 0.5^{ab}
Oron	Akwa Ibom	26.4 ± 1.0^{a}	7.43 ± 1.0^{a}	23.66 ± 0.5^{e}	25.2 ± 1.0^{i}	9.25 ± 0.8^{d}	3.16 ± 0.8^{abcd}
Brass	Bayelsa	27.5 ± 0.2^{ab}	7.97 ± 0.5^{a}	21.58 ± 1.0^{d}	22.8 ± 0.5^{h}	5.8 ± 0.5bc	3.16 ± 0.8^{abcd}
Igbokoda	Ondo	26.66 ± 0.8^{a}	7.85 ± 0.8^{a}	7.98 ± 0.5^{b}	6.25 ± 0.8^{a}	8.56 ± 0.8^{d}	4.2 ± 0.5^{cd}
Badagry	Lagos	27.56 ± 0.5^{ab}	7.56 ± 0.8^{a}	4.95 ± 1.6^{a}	6.79 ± 0.5^{ab}	6.20 ± 0.5^{c}	3.4 ± 0.8^{bcd}
Ishaka	Delta	28.1 ± 0.8^{b}	7.28 ± 0.5^{a}	5.85 ± 0.5^{a}	9.62 ± 1.0^{d}	4.8 ± 0.8^{b}	2.35 ± 0.5^{ab}
Buguma	Rivers	27.21 ± 0.5^{ab}	7.45 ± 1.0^{a}	20.15 ± 1.0^{d}	12.5 ± 0.5^{e}	3.42 ± 0.5^{a}	2.03 ± 0.8^{a}
Ibaka	Akwa Ibom	26.32 ± 0.8^{a}	7.3 ± 0.5^{a}	7.27 ± 0.5^{ab}	8.36 ± 0.8^{c}	6.62 ± 0.8^{c}	3.48 ± 0.5^{bcd}
Iwoama	Bayelsa	27.2 ± 1.0^{ab}	7.68 ± 0.8^{a}	11.2 ± 0.8^{c}	20.4 ± 0.5^{g}	8.81 ± 0.5^{d}	4.36 ± 0.8^{d}
Oropo Ilaje	Ondo	26.25 ± 0.8^{a}	7.75 ± 0.8^{a}	10.56 ± 0.5^{c}	16.15 ± 0.8^{f}	5.8 ± 0.8b^{c}	4.82 ± 0.5^{cd}
Epe	Lagos	27.3 ± 0.5^{ab}	7.3 ± 0.5^{a}	6.4 ± 0.5^{a}	9.82 ± 0.5^{d}	8.38 ± 0.8^{d}	4.1 ± 0.8^{cd}

Mean values in each row with similar superscript are not significantly different at ($p > 0.05$)

Table 3: Nutrient Result of Sampling Station (Mean Values ± SD)

Location	State	Phosphate (mg/l)	Nitrate (mg/l)	Sulphate (mg/l)
River Ethiope	Delta	0.16±0.15	0.19±0.13	4434.29±16
New Calabar	Rivers	5.99±15.77	0.12±0.06	3070.00±93
Oron	Akwa Ibom	0.56±0.33	0.22±0.15	2,744.00±10
Brass	Bayelsa	0.19±0.05	0.12±0.12	3,122.75±26
Igbokoda	Ondo	0.41±0.35	0.37±0.44	2,329.20±19
Badagry	Lagos	0.15±0.19	0.35±0.61	227.30±60
Ishaka	Delta	2.10±0.20	0.16±0.08	3846.10±18
Buguma	Rivers	4.65±12.01	0.20±0.12	4068.02±85
Ibaka	Akwa Ibom	0.20±2.30	0.19±0.13	2624.06±18
Iwoama	Bayelsa	0.36±0.02	0.21±0.06	2966.82±20
Oropo	Ondo	0.60±0.30	0.31±0.18	2018.45±30
Epe	Lagos	1.10±0.60	0.29±0.22	245.15±28

Discussion

In this study, 12 different locations were studied during the period of investigation, which lasted for 3 months. The observed low temperature was because the survey was carried out mainly during raining season. This could be attributed to strong land sea breeze and precipitation as was previously observed by Santhanam and Perumal [15]. The slight variation in water temperature may be due to the large tidal fluctuation in the estuary, with cold incoming seawater and warm out going fresh water. The relatively small variation range in temperature conforms to the result of Ajao [16]. in his work on temperature. A similar result was observed by Onyema and Popoola [17]. They agreed that temperature is a stable environmental factor in the shallow brackish environments of West Africa, and it is most unlikely that this variation in temperature constitutes an important ecological factor in this area.

According to Target Guidelines, the optimal water temperature of the coastal waters ranged from 28 °C – 30 °C, within which maximal growth rate, efficient food conversion, best condition of fish, resistance to disease and tolerance of toxins (metabolites and pollutants) are enhanced [18]. The temperature values recorded in these coastal waters are therefore considered normal since they are located in the Niger Delta, which is described by NEDECO [19]. as humid/semi-hot equatorial area.

The pH of the study locations remain alkaline of natural waters due to the presence of sufficient amount of carbonates and the influence of sea water mixing with the lagoon system. The high pH level in Bayelsa could be attributed to its closeness to the sea than other locations. No significant difference ($p>0.05$) was observed in pH of the studied location. The obtained pH result is in line with the findings of Abowei and George [20] who reported that the mean pH value of Okpoka Creek, Niger Delta ranged between 6.68 and 7.03. Waters with pH values of 6.5 to 9.0 are considered best for fish production, while the acid and alkaline death points are 4.0 and 11 respectively [21].

The dissolved oxygen level observed in this study falls within the level recommended by Olaniran [22] who stated that the desired range for the culture of warm water fish is 5mg/l and above but not more than 12mg/l. This is also in line with the dissolved oxygen finding of Thakur *et al*. [23]. UNESCO [24] also recommended 5 mg/1 for water quality assessment. Numerous scientific studies suggest that 4 - 9 mg/l of DO is the optimal range that will support a large, diverse fish population [25]. The obtained result also compares favorably with the finding of Biney [26]. that brackish waters have mean dissolved oxygen concentrations with a range of 6-8 mg/L. Hence, the dissolved oxygen (DO) levels measured in this study are considered moderate to sustain the aquatic biodiversity.

The biological oxygen demand (BOD) followed the same trend with DO. This may be due to the fact that the available oxygen is used for biodegradation of waste within the aquatic environment. Hence, very small amounts are left for biochemical (life processes) activities. This BOD is also indicative of high organic content of the coastal waters in accordance to the report of Nwankwo *et al*. [27], who reported that biological oxygen demand values less than 2.0 mg/l indicate clean water, 2.0 to 8.0 mg/l indicate moderate pollution while above 8.0 mg/l indicate severe stress. The moderate BOD recorded in this study may be attributed to the discharge of pollutants into the water through washing, sewage contamination, effluent discharge and the relative shallowness of the water bodies especially during the dry season. This finding is in agreement with the result obtained in New Calabar River by Ekeh and Sikoki [28]. Generally,

BOD depends on temperature, extent of biochemical activities, concentration of organic matter and such other related factors [29].

In the present study, the slight decrease in salinity of most the locations investigated may be attributed to a gradual decrease in the concentration of ions as rainfall increased at the period of the study. This observation is in agreement with findings of Francis *et al.* [9]. in Adoni River system and Ekeh and Sikoki [28] in the New Calabar River. The Salinity of the coastal waters recorded is a clear indication of brackish habitat and this agrees with the report of Egborge [30] that waters with salinity higher than 1‰ are brackish and marine. Conductivity and salinity have been reported by Onyema and Nwankwo [31]. as associated factors and this is established in this study as the conductivity values of the study sites increased with the rise in salinity. Nigerian coastal waters varied for many commonly measure physicochemical parameters except for pH which is relatively uniform for all the studied locations.

Nutrients are considered as one of the most important parameters in the estuarine environment which influences the growth, reproduction and metabolic activities of living beings. Low values of phosphate in the studied rivers could be attributed to the limited flow of freshwater, high salinity and utilization of phosphate by phytoplankton. The recorded low values of nitrate may also be due to its utilization by phytoplankton as evidenced by high photosynthetic activity and also due to the neritic water dominance, which contained only a negligible amount of nitrate [32]. On the other hand the increased nitrates level observed in Rivers could be attributed to fresh water inflow, leaves (litter fall) decomposition during the season. However, distribution of nutrients is mainly based on the season, tidal conditions and freshwater flow from land source.

Conclusion

From the present study, the water quality of the coastal rivers was in normal condition since the values for each parameter were within the tolerable limits for aquaculture indicating that the aquatic environment was conducive for the organism during the study period. Thus, reflecting a relatively moderate healthy environment. However, sustainable management of the water bodies should be ensured by the regulatory agencies and policy makers.

Acknowledgement

We wish to acknowledge the assistance and support of Biological Oceanography Department and Genomic Section of Biotechnology Department of Nigerian Institute for Oceanography and Marine Research (NIOMR) Lagos, Nigeria.

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