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Assessment of Physico-Chemical Parameters of Waters in Ilaje Local Government Area of Ondo State, Nigeria

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ABSTRACT
The quality of water from four coastal towns (Ayetoro, Idiogba, Bijimi and Asumogha) in Ilaje local government area of Ondo State was assessed using standard methods with the view of determining the level of pollution through anthropogenic activities and state of the aquatic ecosystem. The results of the analyses of the water samples showed that Dissolved Oxygen (DO) had the highest mean of 7.66 mg/l in Ayetoro while the lowest mean (7.53 mg/l) was recorded in Bijimi; Temperature had minimum mean value of 29.42 °C in both Bijimi and Idiogba and maximum mean of 29.75 °C recorded in Asumogha. The minimum mean of pH across the four locations was recorded in Asumogha (6.63) and the maximum mean was recorded in Idiogba (6.71). The conductivity of Idiogba had the least mean value of 41.00 µS/cm and Ayetoro had the highest mean value of 41.83 µS/cm. Salinity ranged from 16.35 ‰ in Asumogha to 16.65 ‰ in Idiogba and the minimum mean of hardness (84.57 mg/l) was recorded in Asumogha while the maximum mean of 87.16 mg/l was recorded in Ayetoro. Also, turbidity ranged between 41.95 NTU in Bijimi and 45.36 NTU in Asumogha. The result revealed that all the physico-chemical parameters of water determined (except turbidity and hardness) showed no significant difference across the four sampling stations at $P<0.05$. The result obtained is within the permissible level of aquatic biodiversity, set by United State Environmental Protection Agency and World Health Organization thus, the water can be classified as brackish and a good, stable and healthy aquatic ecosystem.

Keywords: Physico-chemical, Coastal water, Salinity, Conductivity, Dissolved Oxygen.

1. Introduction

Curing In recent years, a number of events affecting water quality have resulted in increased public concern about surface water quality [1]. Macer [2] postulated that the presence of impurities, reduces the quality and uses to which water may be deployed as well as well serve as a major factor controlling the state of health in both cultured and wild fishes. Water must be analysed to determine its acceptability for the intended purpose. Non availability of portable water to settlements necessitates heavy reliance on coastal waters for domestic, agricultural or recreational purposes. The possibility of trans-boundary transportation of coastal pollutants [3] makes determination of coastal water quality and monitoring essential.

The ever-increasing pollution of the environment has been one of the greatest concerns of science and the general public in the last fifty years [4, 5]. Idowu *et al.* [6] positioned that the pollution of the aquatic environment by inorganic and organic chemicals is a major factor posing serious threat to the survival of aquatic organisms. Man-made toxic compounds are also resistant to physical, chemical, or biological degradation and thus represent an environmental burden of considerable magnitude [4]. Opukri and Ibaba [7] opined that the effect of anthropogenic activities on the quantity and quality of water resources are felt over a wide range of space and time scales.

In advanced countries, environmental monitoring agencies are more effective and environmental laws are strictly followed. General environmental quality monitoring is compulsory and the monitoring of the quality of water resources is done on a regular basis [8, 9, 10, 11]. Water pollution in Nigeria occurs in both rural and urban areas. In rural areas, water from natural sources such as rivers and streams is usually polluted by organic substances from upstream users who use water for agricultural activities [12]. As a result, any abnormal changes in the environment or water quality can easily be detected and appropriate action taken before the outbreak of epidemics. The case is quite opposite in many developing countries.

Coastal waters are one of the nation's most important natural resources, valued for their ecological richness as well as for the many human activities they support [13]. As the interface between terrestrial environments and the open ocean, coastal waters encompass many unique habitats, such as estuaries, coastal wetlands, seagrass, meadows, coral reefs, mangrove and kelp forests, and upwelling areas [14]. Coastal waters support many fish species for at least part of their life cycle, offering some of the most productive fisheries habitats in the world and support many other organisms with high public visibility (e.g., marine mammals, corals, and sea turtles) or unique ecological significance (e.g., submerged aquatic vegetation) [14].
The study area for the work is Ilaje local government area of Ondo State, Nigeria, which empties into the Atlantic Ocean and to some other parts of the country and it is known for sea foods [15, 16] which mean that its pollution may have national and global health and ecological effects. In the last three to four decades, many investigators have conducted research on the Niger Delta aquatic ecosystem with a view to understanding the characteristics of the various water types [17, 18, 1]. Moreover, extensive researches have been carried out to investigate the pollution status and fisheries of the coastal waters of Ondo State as well as the Niger Delta region: Asaolu [19] on the chemical pollution studies of coastal waters of Ondo State; Adebowale [15] impacts of natural and anthropogenic multiple sources of pollution on the environment conditions of Ondo State coastal water; Abdus-Salam [20] on physicochemical assessment of water quality of oil producing areas of Ilaje, Ondo State among others. This article will provide data on some physiochemical parameters of water in coastal areas of Ondo State, Nigeria to compliments existing data, provides baseline information for management decisions in the management of the fishery and similar water bodies.

2. Materials and Methods

2.1 Study Area

The coastal area of Ondo State lies on Latitude 5° 50'N – 6° 09'N and Longitude 4° 45'E – 5° 05'E (Figure 1). Four (4) major fishing communities, Ayetoro, Asumogha, Idiogba, and Bijimi were selected in Ilaje Local Government Area of Ondo State. The site selection was based on the population/aggregation of fishing families/possible anthropogenic inputs, geographic distribution, catch volume and species diversities of the fish catches in the area.

2.2 Sampling and Preservation

Water samples for all the physico-chemical analysis were collected on monthly schedule from each of the study area at sub-surface level, using 250 ml sampling bottles and transported in ice chest to the Fisheries and Aquaculture Laboratory of the Federal University of Technology, Akure for analysis. Water samples were taken on the same day and at the same sampling points for ease of reference. Water samples were collected into 250 ml high density polyethylene (HDPE) plastic vials pre-treated with 4M HNO_3 and properly rinsed with de-ionized water followed by doubly distilled water before use. Samples handling and preservation were done in accordance with standard method [3].

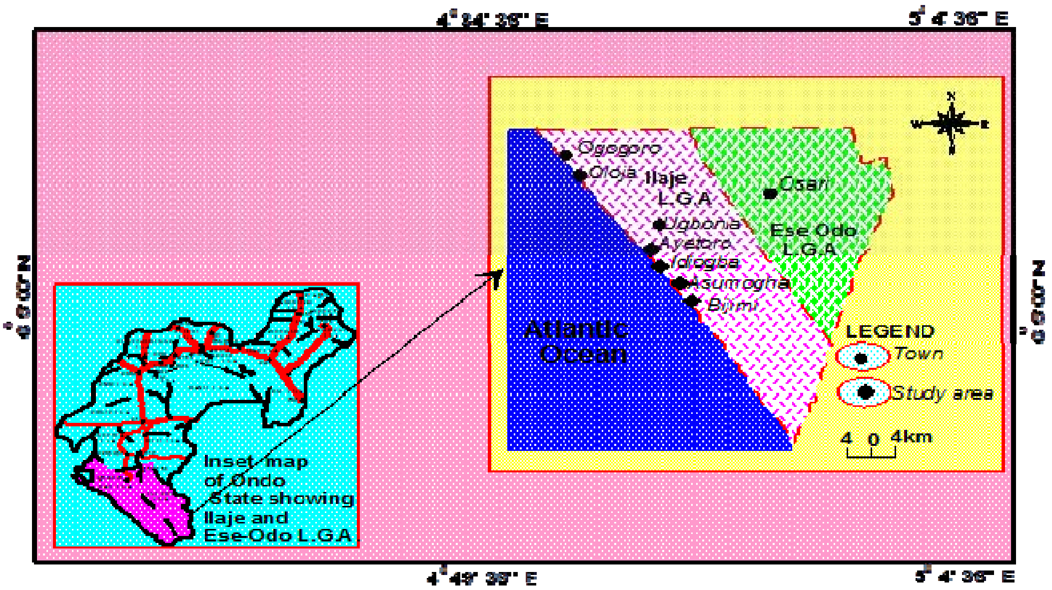

Fig 1: Coastal waters of Ondo State

2.3 Physical and Chemical Analysis:

Some physical parameter measurements of the water samples were done on the field with standard, calibrated portable meters and instruments. The temperature, turbidity and conductivity of the water samples were measured with standard mercury-in-glass thermometer and Knick Portamess conductivity Meter (Model 913) respectively, while pH, Salinity and Dissolved Oxygen (DO) were determined using the Hanna multi-parameter kit (Model Hi9828). However, the hardness was determined in the laboratory using methods prescribed by APHA [22].

2.4 Data Analysis

Data obtained from physical and chemical measurements were statistically analyzed for variance using the Statistical Package for Social Sciences (SPSS), Version 16.0 and was tested at a level ($P<0.05$) for significance. The mean values were compared with the water quality criteria of the World Health Organization (WHO) and Nigerian Federal Environmental Protection Agency (FEPA).

3. Results and Discussion

The dissolved oxygen (D.O) of the water samples was not significantly different (P<0.05) across the locations during the period of study according to Table 1. Dissolved oxygen is an important environmental parameter for the survival of aquatic life. Dissolved oxygen affects the growth, survival, distribution, behavior and physiology of shrimps and other aquatic organisms [23]. Oxygen distribution also strongly affects the solubility of inorganic nutrients since it helps to change the redox potential of the medium. It can also determine whether the environment is aerobic or anaerobic [24]. 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 [25, 26]. Dissolved oxygen concentration of 5.0 mg/L and above are desirable for fish survival [27]. Low dissolved oxygen concentrations are known to be one of the major problems of faunal and floral survival in the aquatic environment. This has been reported by Erkk [28] in their study of the Black and Baltic Sea. Low concentration of dissolved oxygen created anoxic condition within the Black and Baltic Sea [29]. The problems of anoxia are the major causes of faunal depletion in aquatic ecosystems.

Numerous scientific studies suggest that 4 - 9 mg/L of DO is the optimal range that will support a large, diverse fish population [20]. As a general rule, concentrations of DO above 5 mg/L are considered supportive of marine life, while concentrations below this are potentially harmful. At about 3 mg/L, bottom fishes may start to leave the area, and the growth of sensitive species such as crab larvae is reduced. At 2.5 mg/L, the larvae of less sensitive species of crustaceans may start to die, and the growth of crab species is more severely limited. Below 2 mg/L, some juvenile fish and crustaceans that cannot leave the area may die, and below 1 mg/L, fish totally avoid the area or begin to die in large numbers [30, 11].

The quantity of mean dissolved oxygen in coastal waters of Ondo State ranged from 7.53-7.66 mg/L with a mean value of 7.58 mg/L. This mean value agrees with the report of Boyd and Lichtokoppler [27] that dissolved oxygen concentration of 5.0 mg/L and above are desirable for fish survival. The obtained result also compares favorably with the finding of Biney [31] that brackish waters have mean dissolved oxygen concentrations with a range of 6-8 mg/L. Nwadiaro [32] in their studies of drinking water quality of some rivers in the Niger Delta reported a mean dissolved oxygen value of 7.29 mg/L. In the Cross River System, Moses [33] recorded dissolved oxygen values ranging from 2.8 to 4.5 mg/L with the lowest values at Eban Station. Polluted water with untreated sewage, sawdust, petrochemical materials, detergent and industrial effluents has been reported to have low DO values. Emmanuel and Onyema [34] reported dissolved oxygen range of 3.4-4.5 mg/L. Nkwoji [35] reported highest DO value of 5.2 mg/L from the stations of Lagos Lagoon.

UNESCO [36] recommended 5 mg1 for water quality assessment. Egborge [37] reported that degradation results in oxygen depletion. Abowei and George [38] reported mean dissolved oxygen concentrations range of between 3.72±0.41 and 5.10±0.29 mg/L in Okpoka Creek, Niger Delta, Nigeria. They observed no seasonal and annual variations in the concentration of dissolved oxygen. Abowei [39] also reported mean dissolved oxygen of 7.00±0.06 mg/L in Sombreiro River. Deekae [40] reported that in Luubara Creek, Ogoni land, Niger Delta, the dissolved oxygen concentration values ranged from 4.00 to 7.5 mg/L with a mean of 5.88±0.21 mg/L. Hart and Zabbey [41] reported that in Woji Creek in the lower Niger Delta dissolved oxygen ranged between 1.6 and 10.1 mg/L. Edogbolu and Aleleye-Wokoma [42] reported dissolved oxygen range of 0.24-23 mg/L in Ntawoba Creek, Port Harcourt.

The coastal waters of Ondo State are a very lotic environment and Boyd [43] reported that surface agitation of water helps to increase the solubility of dissolved oxygen. Oxygen concentration in water is controlled by four factors: Photosynthesis, respiration, exchanges at the air-water interface and the supply of water to the water body [44, 45]. A major part of dissolved oxygen is observed to come from photosynthesis processes and only a small part originates from the atmosphere [46].

Ali [47] stated that DO level in good fishing waters generally averages about 9.0 mg/L, but high DO concentrations (>20 mg/L) are toxic to fish and cause physiological dysfunctions and developmental abnormalities in fertilised eggs and larvae. Hence, the dissolved oxygen (DO) levels (7.53 - 7.66 mg/L) measured in this study is considered moderate to sustain the aquatic biodiversity.

Aiyesanmi [48] also stated that organic wastes and other nutrient inputs from sewage and industrial discharges, agricultural and urban runoff can result in decreased oxygen levels. Nutrient input often leads to excessive algal growth; when the algae die, the organic matter is decomposed by bacteria, a process which consumes a great deal of oxygen that could lead to oxygen sag. These multiple but interrelated effects result in poor water quality.

High water temperature enhances the growth of microorganisms however the effect of changes in temperature on living organisms can be critical. Temperature controls the solubility of gases in water, and the reaction rate of chemicals, the toxicity of ammonia, and of chemotherapeutics to fish. Temperature is the most important physical variable affecting the metabolic rate of fish and is therefore one of the most important water quality attributes in aquaculture [49]. The mean temperature value (29.42 °C – 29.75 °C) of the coastal waters of Ondo State (as in Table 1) fell within the optimal water temperatures (Target Guidelines) of 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 [50].

The result was in line with earlier reported works in the Niger Delta waters by Chindah [51] who reported temperature ranges of between 26 °C and 30.5 °C. Zabbey [52] also reported a temperature between 26.3 °C and 30.4 °C. Braide [53] stated that temperature range of 26.64±1.18 °C and 30.83 ± 1.47 °C as being optimum for shellfish propagation, this corresponds with the report of Ansa [54] (25.9 °C and 32.4 °C). Hart and Zabbey [41] also reported a temperature range of 25.8 °C and 30.4 °C, while Sikoki and Zabbey [55] reported a temperature range of between 26 °C and 27.8 °C, similar to what was reported by Dibia [56] (25 to 27 °C) and Jamabo [57] also reported a temperature range between 27 °C and 30 °C as being ideal for growth and well-being of shellfishes. The temperature values recorded in coastal waters of Ondo State are considered normal since it is located in the Niger Delta, which is described by NEDECO [58] as humid/semi-hot equatorial area.

Also, the observed temperature regime in this study is in agreement with the reports of Alabaster and Lloyd [59] who also stated that the temperature of natural inland waters in the tropics generally ranged from 25-35 ºC. The temperature values obtained in this study compare favorably with those reported by earlier workers in the Niger Delta waters. These include Edogbolu and Aleleye-Wokoma [42] (26- 31 ºC), Abowei and George [38] (27-31 ºC) and Deekae [40] (25.05-32.20 ºC). Furthermore, it compares favorably with Lagos Lagoon waters reported by Emmanuel and Onyema [34] (23.5-30.8 ºC) and Nkwoji [35] (29-29.5 ºC). There were no significant difference in the temperature of all the stations and this is also similar to the report of Ogamba [60] who attributed minimal variation in temperature between stations to the absence of micro climatic variations in temperature.

In water hydrogen ion concentration is measured in terms of pH, which is defined as the negative logarithm of hydrogen ion concentration [61]. This concentration is the pH of neutrality and is equal to 7. When the pH is higher than 7 it indicates increasing salinity and basicity while values lower than 7 tend towards acidity i.e. increase in hydrogen ion concentration. The pH higher than 7, but lower than 8.5 is ideal for biological productivity while pH lower than 4 is detrimental to aquatic life [62]. 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 generally more conducive to aquatic life. Boyd [61] reported that the pH of natural waters is greatly influenced by the concentration of Carbon (IV) oxide which is an acidic gas. Phytoplankton and other aquatic vegetation, remove carbon (IV) oxide from the water during photosynthesis, so the pH of a water body rises during the day and decreases at night [27].

Table 1: Monthly Variation of Physico-chemical parameters of water in coastal waters of Ondo State, between September and December, 2011.

		Location				
Parameters	**Month**	**Asumogha**	**Ayetoro**	**Bijimi**	**Idiogba**	
DO	September	7.53	7.76	7.70	7.54	
(mg/l)	October	7.64	7.48	7.43	7.61	
	November	7.54	7.78	7.39	7.39	
	December	7.67	7.63	7.58	7.63	
	Mean	**7.60 a**	**7.66 a**	**7.53 a**	**7.54 a**	**7.58**
Temperature	September	29.67	29.00	29.33	29.00	
(ºC)	October	30.00	29.67	29.67	29.33	
	November	29.67	29.67	29.33	29.67	
	December	29.67	29.67	29.33	29.67	
	Mean	**29.75 a**	**29.50 a**	**29.42a**	**29.42 a**	**29.52**
pH	September	6.67	6.53	6.53	6.63	
	October	6.68	6.71	6.70	6.74	
	November	6.67	6.77	6.78	6.77	
	December	6.63	6.73	6.75	6.70	
	Mean	**6.66 a**	**6.68 a**	**6.69 a**	**6.71 a**	**6.69**
Turbidity	September	44.23	40.20	35.40	40.93	
(NTU)	October	45.70	46.17	42.13	44.43	
	November	44.87	46.03	43.43	42.63	
	December	46.63	47.07	46.83	47.77	
	Mean	**45.36 b**	**44.87 b**	**41.95a**	**43.94ab**	**44.03**
Salinity	September	10.01	10.01	9.89	9.93	
(º/ₒₒ)	October	15.03	15.08	14.96	15.03	
	November	17.16	17.34	17.11	17.49	
	December	23.21	23.77	23.49	24.14	
	Mean	**16.35 a**	**16.55 a**	**16.36a**	**16.65 a**	**16.48**
Hardness	September	83.65	84.00	84.03	83.26	
(mg/l)	October	83.13	85.70	86.33	83.19	
	November	84.77	88.60	87.40	85.57	
	December	86.73	90.33	90.33	87.00	
	Mean	**84.57 a**	**87.16 b**	**87.03b**	**84.75 a**	**85.88**
Conductivity	September	40.00	40.00	39.67	39.00	
(mS/cm)	October	41.00	40.33	40.67	40.00	
	November	42.00	42.67	42.33	41.33	
	December	43.33	44.33	44.00	43.67	
	Mean	**41.58a**	**41.83a**	**41.67a**	**41.00a**	**41.52**

Means for groups in homogeneous superscripts are not significantly different at P<0.05.

The pH recorded in this study ranged from 6.66 to 6.71 with a mean value of 6.69 (Table 1) and this is in line with the findings of Riley and Chester [63] who reported that the pH of sea water in the open ocean falls within limits of 6.5-8.4. Also, Abowei and George [38] reported that the mean pH value of Okpoka Creek, Niger Delta ranged between 6.68 and 7.03 while the spatial and temporal variations were minimal. 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, [64, 43].

The pH of an aquatic system is an important indicator of the water quality and the extent of pollution in the watershed areas. Low pH values or acidic waters are known to allow toxic elements and compounds such as heavy metals to become mobile thus producing conditions that are inimical to aquatic life [65]. The pH showed no significant difference in the four locations ($P < 0.05$) and this is also similar to the reports of other authors on Niger Delta water bodies [32, 66, 67, 41, 42, 40]. The observed acidic pH in this study agrees with the report of Abowei [62] that waters with little change in pH are generally more conducive to aquatic life. Furthermore, the pH values obtained were within the WHO standard (6.8-8.5).

Turbidity is an important operational parameter in process control and can indicate problems with treatment processes, particularly coagulation/sedimentation and filtration. It causes undesired tastes and odours and affects the process of photosynthesis for algal growth [49]. Turbidity reflects the materials dispersed or dissolved in the water column, be they, living organisms or not, organic or inorganic. In this work, turbidity values of between 41.95 NTU in Bijimi and 45.36 NTU in Asumogha were recorded (Table 1), indicating that the biological processes had little effect on the material in the water column. The variation observed could be attributed to the release of suspended particles as a result of dredging and sand mining activities in the area and this is in line with the report of Nkwoji [35] that variation in turbidity was probably due to allochthonus inputs from river discharges.

Boyd and Lichtkoppler, [29] stated that low level of turbidity could be attributed to low wave actions and minimal turbulence while high turbidity indicates the presence of colloidal particles arising from clay and silt during rainfall or from discharges of sewage and industrial waste or the presence of a large number of microorganisms. Also, high riverine sediment loads adversely affect: the coastal sea, by increasing water turbidity – which reduces the light penetration, hence the primary production, then the secondary and tertiary biological production, including fish – and the sedimentation [68].

Hardness in water comprises the determination of calcium and magnesium as the main constituents and their widespread abundance in rock formations leads often to very considerable hardness levels in surface waters. One of several arbitrary classifications of waters by hardness include: Soft up to 50 mg/L$CaCO_3$; Moderately Soft 51 - 100 mg/L$CaCO_3$; Slightly Hard 101 - 150 mg/L$CaCO_3$; Moderately Hard 151 - 250 mg/L$CaCO_3$; Hard 251 - 350 mg/LCaCO3; Excessively Hard over 350 mg/L$CaCO_3$ [49]. The hardness values recorded for this study were within the moderately soft classification as they ranged from 84.57 mg/L$CaCO_3$ to 87.16 mg/L$CaCO_3$ with a mean of 85.88 mg/L$CaCO_3$ according to Table 1.

Although hardness may have significant aesthetic effects, a maximum acceptable level has not been established because public acceptance of hardness may vary considerably according to the local conditions. Water supplies with hardness greater than 200 mg/ L$CaCO_3$ are considered poor, but have been tolerated by consumers; those in excess of 500 mg/L$CaCO_3$ are unacceptable for most domestic purposes [69]. It has been suggested that a hardness level of 80 to 100 mg/L (as $CaCO_3$) provides an acceptable balance between corrosion and incrustation [69]. Also, a number of ecological and analytical epidemiological investigations have suggested that there is an inverse statistical correlation between drinking water hardness and certain types of cardiovascular disease [69, 70].

Ali [47] and Iqbal [68] stated that more than 15 mg /L $CaCO_3$ hardness (as recorded in this study) is suitable for fish growth, while less than this value causes slow growth of fish and require liming for high fish production. According to table 1, the hardness recorded in Asumogha and Idiogba were not significantly different from each other however they were significantly different from both Ayetoro and Idiogba (which were also not significantly different from each other at $P < 0.05$). The variation in hardness observed in this study agreed with the result of Benson [71] and can be linked to the different water level per month as a result of the decrease in rainfall from September through December. Also, Onuoha [72] opined that reduced rain events and its associated input of floodwaters from rivers, creeks, adjoining wetlands and the effect of the tidal seawater incursion probably leads to this trend of environmental gradients.

Conductivity of salt water is usually higher than that of fresh water because the former contains more electrically charged ions than the latter. The total load of salts of water is in direct relation with its conductivity [73, 74]. Conductivity is an index of the total ionic content of water, and therefore indicates freshness or otherwise of the water [37, 75].

Conductivity of freshwater varies between 50 to 1500 hrs/cm [61], but some polluted waters reach 10,000 hrs/cm. Seawater has conductivity around 35,000 hrs/cm and above. The major constituents of the dissolved substances in water are calcium ion (Ca_2^+), Magnesium (Mg_2^+), hydrogen trioxocarbonate (iv) (HCO_3), trioxocarbonate (iv) (CO_3), trioxonitrate (v) (NO_3) and tetraoxophosphate (vi) (PO_4). They are the necessary constituents of aquatic animals which partly come from their food [24]. Verheust [76] stated that conductivity can be used as an indicator of primary production (chemical richness) and thus fish production.

Sikoki and Veen [77] observed a conductivity range of 3.8-10 hrs/cm in Shiroro Lake (Imo State) which was described as extremely poor in chemicals. They were of the view that fishes differ in their ability to maintain osmotic pressure, therefore the optimum conductivity for fish production differ from one species to another. The electrical conductivity of coastal waters of Ondo State recorded in this study ranged between 41.00 and 41.83 ms/cm (Table 1). The result, therefore indicates that the study area is brackish. Egborge [78] and Ogbeibu and Victor [75] reported that conductivity is an index of the total ionic content of water, and therefore indicates freshness or otherwise of the water. The conductivity of the study area compares favorably with a report of Boyd [61] and other workers within the Niger Delta [79, 33, 52, 38, 62, 80].

The variations recorded over the study period was in line with CWT [81] which states that rain falling into a waterbody, or rain runoff flowing into it, will decrease conductivity/salinity because the salinity/conductivity of coastal waters is influenced by sea spray that can carry salts into the air, which then fall back into the waters with rainfall. Evaporation and loss of freshwater will increase the conductivity and salinity of a waterbody, also, warm weather can even increase ocean conductivity [81].

Conductivity and salinity have been reported by Onyema and Nwankwo [82] as associated factors and this is established in this study as the conductivity values of the study sites increased with the rise in salinity. Salinity which is defined as the total concentration of electrically charged ions in the water. These ions are the four major cations-calcium, magnesium, potassium and sodium, and the four common anions carbonates (CO_3), sulphates (SO_4), chlorides (Cl) and bicarbonates (HCO). Other components of salinity are charged nitrogenous compounds such as nitrates (NO_3), ammonium ions (NH_4) and phosphates (PO_4) [36]. 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 [83]. Waters with salinity below 1‰ are fresh and waters with salinity higher than 1‰ are brackish/marine [78]. Ramane and Schlieper [84] opined that salinity is the major environmental factor restricting the distribution of marine and lacustrine taxa, resulting in the paucity of species in brackish water.

Salinity of surface water is relatively uniform as it is generally well mixed by waves, wind and tides. However, variation of surface water salinity due to the effects of rainfall, evaporation, precipitation, and other weather related factors are often observed. Salinity is considerably higher during the dry season when sea water penetrates far up the rivers, than in the wet season when rain water and flood from the Niger and Benue rivers drive the salt water back towards the sea. Salinity is a major driving factor that affects the density and growth of aquatic organism's population in the mangrove swamp [85, 86, 54, 57].

The Salinity of coastal waters of Ondo State recorded in this study was between 16.35 - 16.65 ‰ which is a clear indication of brackish habitat and this agrees with the report of Egborge [37] that waters with salinity higher than 1‰ are brackish/marine. The four stations were not significantly different from one another at $P<0.05$ (Table 1), and this compares favorably with the reports of Hart and Zabbey [41], Emmanuel and Onyema [34], Abowei and George [38], Deekae [40] and Nkwoji [35]. The profound differences observed in the monthly salinity in this study area have also been reported from other water bodies in Nigeria [82, 35, 40, 41, 34].

Also, the seasonal variations in the physical and chemical quality of water in the Niger Delta have been reported by [87, 1, 60] and may be attributed to drainage area, the nature of its rocks precipitation, human activity in the area and proximity to marine water [83]. This variation could be attributed to the influx of water mainly due to rainfall as many workers [88, 89, 90, 91] reported that this has been a major factor controlling the seasonal distribution of salinity in Lagos Lagoon and environs.

4. Conclusion

In conclusion, a critical look at the physico-chemical parameters of the water samples from all the stations and WHO standard indicate that the water samples fall within the stipulated range of acceptability hence the water can be classified as a good, stable and healthy aquatic ecosystem. There should be a constant monitoring of the physico-chemical parameters in future because of the increase in anthropogenic activities around the area. It is further recommended that proper education, monitoring and clean up procedure be carried out promptly in these regions whenever they are stressed by pollutants generated from domestic, agricultural and industrial activities as well as effect of oil spills.

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