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Physicochemical Analysis of the Coastal Waters of Ondo State, Nigeria

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ABSTRACT

Analysis of water parameters of the coastal waters of Ondo State, Nigeria was conducted between June 2011-December, 2012 in Ilaje local government area using Mahin, Ugbo and Ugbo-Nla as study areas. Water analysis done *in-situ* on a monthly basis for a period of 18 months showed the mean values of dissolved oxygen, pH, temperature and water transparency were 7.35 ± 0.104 mg/l, 6.35±0.036 mg/l, 28.15±0.19 ^{o}C and 0.67±0.015 m respectively. There was no significant difference in these parameters at P>0.05 across the seasons. Conductivity ranged from 80.8±1.56 µhoms/cm in December to 93.6± 1.35±µhoms/cm in the rainy month of July. Phosphate ranged from 1.17 mg/l ±0.15 in December to 5.67±0.13 mg/l in July and differs significantly at P<0.05 across the seasons. The higher values of conductivity and phosphate in the wet season might be due to large water flooding, runoffs or bioturbation by bottom-dwelling fishes. Rainfall ranged from 1.5mm in November and December to 647.3 mm in July and 1099 mm in September. A high positive correlation 'r' existed between rainfall and phosphate level (0.69) and conductivity (0.76). Silicates ranged from1.68±0.035mg/l to 18.43±0.21 mg/l. The higher silicate level recorded in the wet season might be due to leaching out of silicates from bottom soil due to large runoffs. Mean values of nitrate, Nitrite, alkalinity of 1.34± 0.074 mg/l ,0.27 ±0.005 and 56.31±0.368 mg/l differ significantly at P<0.05 probably due to high bacterial decomposition and mineralization through evaporation of the water hyacinth-infested coastal waters.The researcher revealed the coastal waters of Ondo State of Nigeria was still conducive to fish production since most of the physicochemical parameters still fell within W.H.O tolerable limits.To avoid loss of aquatic biodiversity and protection of the existing stock especially the monospecific families like the Arapaimidae/Osteoglosidae, Hepsetidae and Gymnarchidae, there is a need for regular monitoring of the physicochemical parameters of the coastal waters in view of the on-going industrialization, oil-exploration,high anthropogenic activities and perennial occurrence of water hyacinth. More funds should be committed by the government to researches on water quality, population dynamics and biomass estimate of our coastal waters.

Keywords: Physicochemical, parameters, coastal, bioturbation, mineralization, biodiversity, biomass

INTRODUCTION

Environmental pollution and degradation affect sustainability through loss of fish breeding grounds and habitats in the study of the coastal waters of Ondo State. Fertility of a water body is related to its chemical properties so understanding water chemistry and dynamics serves as a basis for considering whether the system is poor or rich in biological production). Density and diversity of flora and fauna depends on chemical regime of water (Adeniji *et.al*, 2007; Adebowale *et. al*, 2008).

Pollution studies in coastal rivers of Nigeria (a major oil-producing nation) is relatively recent though crude oil production began in 1958 Records of different causes of oil spills between 1976-1997 showed over 4 million barrels of crude oil have been spilled and this phenomenon still persists to date.(Awobayo,1981; Sikoki and Otobokere,1999).

FAO (2012) recorded that there was no serious pollution problem until industrialization started. Most natural undisturbed aquatic ecosystems in African countries like Uganda, Kenya, Tanzania enjoyed

pristine ecological environment with abundant flora and fauna but as industrialization started, pollution increased, hence the need for constant monitoring of our territorial waters since water quality monitoring is a means of determining the health of our water bodies, impact of human activities can be assessed, suitability for its varied uses (Obande *et.al*, 2012).

Adebisi (1981) reported *that* knowledge of physicochemical regime of a water body is indispensable in the determination of productivity and other characteristics. Whatever affects water quality would affect productivity and reduce drastically fish species diversity and fecundity in an aquatic ecosystem. Onuoha(1994) also reported that primary productivity was lower at the refinery effluents than non-effluent water, air-breathing roots of mangrove if coated with oil becomes hazardous creating physiological stress. Pollution affects migration patterns, natural reproductive processes, fish behaviour, apart from reduction in species diversity (Egborge, 1994; Onuoha and Deekae, 2005). Analysis of physicochemical parameters of Ebonyi River was found to fall within tolerable limit according to the study conducted by Ude (2012). Fish ranching, regulation of fishing activities and environmental monitoring were among the suggested management options that would guarantee sustainable fish production in Ebonyi River.

Awobayo (1981) reported absence of adequate enforcement of existing environmental protection laws. Industrial wastes are discharged untreated into our rivers and coastal waters. Spillages are improperly cleaned up (Ademoroti, 1996). Akegbejo-Samsons (1995) reported the need for routine investigations for monitoring purposes for conservation and sustainability efforts in Nigeria. Organic pollutants common in the coastal waters are done in few laboratories. In view of the fact that Ondo State is a crude oil-producing area that is highly susceptible to environmental pollution and the fact that the Ilaje inhabitants are predominantly fisher folks contributing mainly to the domestic fish output, there is a need for routine investigation into the quality of the coastal waters.

King 1998) reported scantiness of definite information on water quality parameters on Nigerian aquatic ecosystems. Only few investigations have been conducted to assess the physicochemical status of aquatic systems to serve as guidelines for rational fisheries management and resource conservation.This view is supported by few previous workers (Obasohan, 2005; Obande *et.al*, 2012). Dearth of information on the current status of quality of Ondo State coastal waters was reported by Akegbejo-Samsons (1995) while same was reported in the water bodies within the Gulf of Guinea according to Odulate (2010).This study is therefore an attempt to evaluate the physicochemical parameters of the coastal waters of Ondo State, an oil-producing, fish-endowed maritime State of Nigeria.

MATERIALS AND METHOD

The study area is located in Ilaje local government area of Ondo State of Nigeria. The local government area with a population of 277,034 according to National Population Commission census was created on 1st of October 1996 by the Federal government of Nigeria and consists of over 400 towns and villages covering an area of 3000 km^2.Ilaje local government Area has the longest coastline of about 180 kilometers in Nigeria. It is bounded in the West by Ogun State coastline, in the East by Delta and Edo States, in the south by the Atlantic ocean and in the North by the land mass of Okitipupa and Irele local government areas. The study area is contiguous to Nigeria South West coastline which is characterized by extensive lagoons of Niger Delta systems. It ranges from 4^o to 6^o latitude and it is part of the approximately 670 kilometers coastline of Nigeria. There is a large concentration of mangrove and fresh water swamps. The area is subject to tidal flunctuations with salt water incursion, between two to ten months of the year. There are wet and dry seasons. The rainy season spans May-October while the dry season starts from November and end by April.

RESULTS

The results of the physicochemical analysis of the coastal waters of Ondo State conducted for 18 months (June 2011-December 2012) revealed the dissolved oxygen measurement, a key test in water pollution control activities and waste treatment process control was highest in May with mean value of 8.43±0.21mg/l, thus coinciding with the onset of rains and lowest in November at 6.51 ±1.47 mg/l which coincides with the beginning of the dry season (Table 1).

Secchi-disc Water transparency of the coastal waters was observed to be highest in the month of February at 0.83 ±0.03m and lowest in the wet month of June with mean value of 0.45 ± 0.06m. The annual mean value for the sampling sites was 0.67±0.015m. There was significant difference in water transparency across the hydrological cycles ($P<0.05$) in the present study.

The mean pH of the coastal waters was 6.35± 0.036 ppm. The highest pH of 7.83 ±0.16mg/l was observed in the month of February and lowest at 5.60 ±0.29mg/l in September. High turbidity in the rains coupled with decomposing organic matter like Eichornia crassipes which infestation was massive in the study area at the period of study. There was no significant difference in the value of pH across the seasons (P<0.05).Temperature ranged from 27^{o}C – 30^{o}C. The highest value of 30^{o}C was observed in the dry month of December and lowest at 27.33 ±1.16l^{o}C in July and September, the rainiest months of the years.

The interaction effect of season and sites were significantly different for temperature at P>0.05. There was no seasonal variations in water temperature of the coastal waters across the seasons, hence the insignificant difference at p<0.05.

Salinity ranged from the lowest at 1.36 ±0.13ppt observed in the rainy month of September to 5.27 ± 0.21ppt in January, the driest month (Table 1). The mean value was 2.55±0.109. Of all the sampling sites, Mahin was the least saline with a mean value of 2.46±0.11ppt as against 2.64ppt and 2.84ppt for Ode-Ugbo and Ugbo-Nla respectively.

Conductivity ranged from the lowest at 80.8 ± 1.56µhomscm-1 in December to highest at 93.6±1.35µhomscm-1 in the mostrainy month of July. The mean value of the coastal waters was 85.81 ± 0.597µhomscm-1 There was significant difference in the value of conductivity across the seasons at P< 0.05.

The mean value of phosphate of the coastal water ranged from the lowest at 1.17 ± 0.15ppm in December to the highest in July at 5.67±0.13ppm. There were seasonal variations in the phosphate level. There was significant difference in phosphate level across the seasons at P<0.05. There was no significant difference among the three sampling sites in the coastal waters at P > 0.05. Higher phosphate value was observed during the rainy season than the dry season.

Nitrate value was lowest in July, the most rainy month at 0.26±0.015mg/l and highest at 4.15±0.127mg/l in the dry month of February. The mean value was 1.34±0.074mg/l (Table 1) This trend cuts across all the three sampled sites representing the coastal waters. Seasonal variation was significant at P<0.05 though there was no significant difference across the three sampling sites of the coastal waters.The mean Nitrite concentration of the coastal waters was 0.27 ±0.005mg/l The lowest value of 0.14 ± 0.006mg/l was recorded at the onset of the rainy season and highest at 0.46± 0.12mg/l in January, the peak of the dry season The difference was significant across the season at P<0.05 but not significantly different across the sampling sites

Table1. *Physico-chemical Parameters of the Coastal waters of Ondo State, Nigeria(June 2011 – December, 2012)*

	Dissolved oxygen (mg/l)	Water transparency (m)	pH (mg/l)	Salinity (ppt)	Conductivity(uhoms/cm)	Phosphate (ppm)	Nitrate (ppm)	Alkalinity (ppm)	Nitrite (ppm))	Silicate (ppm)	Water depth (m)
Mahin	7.27	0.65	6.41	2.47	85.45	3.55	1.36	56.41	0.28	11.68	2.48^{b}
Ugbo	7.47	0.68	6.29	2.64	86.18	3.61	1.33	56.21	0.26	11.92	2.73^{b}
Ugbonla	7.63	0.70	6.33	2.84	87.49	3.80	1.12	55.22	0.27	12.37	3.41^{a}
Mean	7.37	0.67	6.35	2.55	85.81	3.58	1.34	56.31	0.27	11.80	2.73
SEM	0.104	0.015	0.036	0.109	0.597	0.075	0.074	0.368	0.005	0.201	0.279

Mahin	Rainfall(mm)	Temperature(oC)
Ugbo	244.61	28.29
Ugbonla	244.61	28.01
Mean	244.61	28.67
SEM	0.000	0.190

Source: *Field Survey (June, 2011-December,2012)*

DISCUSSION

The dissolved oxygen measurement, a key test in water pollution control activities and waste treatment process control was observed to be highest in May with mean value of 8.43±0.21mg/l, thus coinciding with the onset of rains and lowest in November at 6.51 ±1.47 mg/l which coincides with the beginning of the dry season.This corroborates with the findings of Odulate (2010) who observed higher dissolved oxygen during the wet season probably due to better aeration and mixing of the marine front of Ode-Omi in Ogun State water side. Olawusi-Peters also observed higher value of

dissolved oxygen during the dry season in Agboyi Creek, Lagos lagoon, Nigeria.The lower dissolved oxygen of the dry season could be due to chemicaloxidation of humid organic matter decomposition like water hyacinth as a result of inundation of the forested creeks

Solubility of dissolved oxygen is affected non-linearly by water temperature. The amount of flora, level of organic pollution, population density of fauna, local rainfall and wind strength are reported as having effect on dissolved oxygen (Yab, 1992).

Oxygen is a growth-limiting factor especially in the tropics. Ammonia, in an unionized form is very toxic during period of high photosynthetic activities. When the pH of water is alkaline at high temperature, the ammonium ions $NH4^+$ would volatilize to ammonia and water (Adeosun, 2007).

Secchi-disc Water transparency of the coastal waters was observed to be highest in the month of February at 0.83 ±0.03m and lowest in the wet month of June with value of 0.45 ± 0.06m. This corroborates with the findings of Adeosun (2007) who observed higher transparency of water in Ikere Gorge during the dry season probably due to the absence of flood water, surface runoffs, resident time of suspended particles at the bottom following rain. There is a resultant increase in photosynthetic, euphotic zones which varied directly with rainfall. The euphotic zone is affected by rainfall because turbidity reduces photosynthesis and hence primary conductivity (Adeyemo, 2007; APHA,1992)

Akegbejo-Samsons(1995) also observed higher secchi disc transparency in Ondo coastal waters in the months of April, may and June which was characterized by scanty rains attributing the differences in the secchi disc reading to more light penetration or greater angle of incidence due to speed of river flowing. With increase in water level, transparency decreases was reported by Akegbejo-Samsons (1995) who found the water transparency of the coastal waters of Ondo State to range from 0.82-1.10m during the wet season and mean value 1.07 ±0.33m in the dry season. There was significant difference in water transparency across the hydrological cycles ($P<0.05$) in the present study. Woke and Wokoma (2007) reported that gradual decrease in transparency coincided with plankton build-up.

The highest pH of 7.83 ±0.16ppm was observed in the month of February and lowest at 5.60 ±0.29ppm in September. High turbidity in the rains coupled with decomposing organic matter like Eichornia crassipes which infestation was massive in the study area at the period of study. There was no significant difference in the value of pH across the seasons ($P<0.05$). Bello-Olusoji (1998) reported that very high pH could result in mortality of African prawn, *Macrobrachium vollenhovenii* in Asejire Dam because of high solubility of waste ammonia at high pH (which is often caused by dense phytoplankton bloom). Low pH was associated with low depth and found to be probably due to decomposition of organic matter near the mud sediments in tropical lakes (Adebowale *et.al*, 2008). Boyd (1981) reported that pH ranging from 6.6- 9.3 is conducive for aquatic life. pH range of 6.5 -8.5 is indicative of good quality water. pH of seawater ranging from 7.5- 8.5 is good for photosynthesis and respiration (Ude, 2012)

Temperature ranged from 27°C- 30°C. The highest value of 30°C was observed in the dry month of December and lowest at 27.33 ±1.16l °C in July and September, the most rainy months during the period of study in 2012 and 2011. The temperature range observed in Ondo coastal waters compared well with that recorded for tropical water bodies (Obasohan, 2005; Adeniji *et.al*, 2007).The temperature range recorded is within tolerable level for tropical waters. Tropical fishes can tolerate wide range of temperature from 28°C–31°C . Tilapia species tolerates temperature range between 18-30 °C. (Adefemi *et, al*, 2007).

Akegbejo-Samsons (1995) recorded mean annual temperature value of 26.23±1.68 °C in December and highest value of 28.7°C in March in the study of the coastal waters of Ondo State. There was no seasonal variations in water temperature of the waters across the seasons, hence the insignificant difference at $p< 0.05$.Temperature is a stable environmental factor in the shallow brackish environment in West Africa (Abowei and Sikoki, 2005; Bolarinwa, 2013).

Salinity ranged from the lowest at 1.36ppt±0.13 observed in the rainy month of September to 5.27ppt±0.21 in January, the driest month. Decreased salinity during the rainy season might be as a result of dilution factor of intense rainfall especially during the months of June, July and September. This is similar to the findings of Odiko (2011) who observed a higher salinity level of River Ovie in the dry season attributing it to higher concentration of salts in lower volume of water. Higher level of Cl- ions >100mg/l is said to be responsible for physiological damage apart from impacting salty taste on fish flesh according to Boyd (1983).

Salinity range of 7.8 ppt-25.75 ppt can be tolerated by most brackish water fish. Survival of life is within certain salinity range (Sikoki and Otobokere, 1999). Salinity varies in the brackish habitats depending on the tide, amount of freshwater entering from rivers or as rain and rate of evaporation. Salinity values are influenced by evaporation, precipitation, river inflow and melting of sea ice. There must be a balance between precipitation and evaporation (Akegbejo-Samsons, 1995; Odulate, 2010).

Conductivity is based on the capacity of water to conduct current was measured by a portable conductivity meter on the field. The more the ions in the water, the more the conductivity. Presence of ionic solutes is responsible for electrical conductivity. Though the effect is negligible except under condition of low salinity, free carbon (IV) Oxide and ammonia could also impact electrical conductivity (Ademoroti, 1996). Conductivity ranged from the lowest at 80.8±1.56 µhomscm -1 in December to highest at 93.6±1.35 µhomscm -1)in the most rainy month of July. There was significant difference in the value of conductivity across the seasons at P< 0.05. Akegbejo-Samsons (1995) recorded that chloride content varied during in seeping of sea water under freshwater during high tide in Ondo coastal waters. Conductivity recorded in the wet season might be due to water runoffs (carrying a lot of decomposed organic matter and high mineralization), tidal influx from the salty waters of Aiyetoro, Orioke Iwamimo, and better mixing of bottom ionic nutrients with top. This corroborates with the findings of Adeosun (2007) in Ikere gorge, Ibadan, Nigeria who recorded 90.6 µohms cm^{-1} in August which happened to be the peak of rainfall during the study. Odulate (2010) also observed higher conductivity in the rainy month of July in his study on Ode-Omi marine water front in Ogun State attributing it to tidal influx, mixing of bottom sediments, and up swelling. The lower value in the dry season was attributed to concentration effect as a result of reduced volume of water.

The mean value of Phosphate of the coastal waters ranged from the lowest at 1.17± 0.15mg/l in December to the highest in July and September at 5.67±0.13mg/l and 5.28±0.021mg/l respectively. There was seasonal variations in the phosphate level. There was significant difference in phosphate level across the seasons at P<0.01=0.05. Higher phosphate value was observed during the rainy season than the dry season probably due to flooding, runoffs and bioturbation (by bottom-dwelling fishes). Bolarinwa (1984) in his study of the brackish water of Buguma, Niger Delta observed higher phosphate level during the wet season. This is similar to the findings of Odulate (2010) who recorded the highest value of phosphate in the rainy month of July in the marine front of Ogun State waterside.

Nitrate value was lowest in July, the most rainy month at 0.26±0.015mg/l and highest at 4.15±0.127mg/l in the dry month of February The higher value of nitrate NO_3-N (a major form of nitrogen used by phyto planktons) in the wet season might be due to organic decomposition and mineralization through evaporation. At the period of study, there was a high infestation of the water bodies by water hyacinth (*Eichornia crassipes)* especially in Mahin. This was aggravated by the high sewage disposal as a result of anthropogenic activities. Human wastes are directly disposed in the open waters of the Ondo State coast. Seasonal variation is significant at P<0.05 though there was not any significant difference across the three sampling sites.

This finding negates the findings of King (1998) in the study of rainforest pond where nitrate was observed to be highest in the wet month of July. Odulate (2010) also recorded a higher value of nitrate (0.29ppm) in July, the rainiest month of the wet season. However, my findings corroborates that of Odiko (2011) in River Ovie where a higher level of nitrate was observed in the dry season attributing it to higher organic decomposition and mineralization and runoffs from agricultural farms around the river. Olawusi-Peters (2008) in the study of physicochemical parameters of Agboyi creek in Lagos State recorded nitrate value of 3.62±0.45 ppm, phosphate value of 0.38±0.23ppm which exceed the recommended limit by World Health Organisation for drinking and bathing, hence the need for FEPA intervention.

Nitrate and phosphates are essential nutrients for phytoplankton growth. The high value of nitrate could be due to runoffs from upland area into coastal waters thus supporting fish production in open seas. The low level of nitrate in water could be due to microbial action and uptake of nitrate for protein synthesis and denitrification (UNEPGEM, 2006).

The lowest value of 0.14 ± 0.006 mg/l was recorded at the onset of the rainy season and highest at 0.46± 0.12mg/l in January, the peak of the dry season.Nitrite is the least desirable of all formsof nitrogen when NH_3 and NO_3 are not high, NO_2 would be under control. There is always increase in NH_3 with decreasing nitrate and nitrite, hence the need for control of NH_3 accumulation in water bodies (Akpan and John, 1993).

Bacterial decomposition of organic matter like water hyacinth and the mangroove roots under low oxygen could lead to accumulation of ammonium ions in water. This could be indicative of organic pollution. In the presence of dissolved oxygen. Nitrification process could convert the ammonia to nitrate, hence the need for adequate dissolved oxygen in water bodies. Oxygen is a growth-limiting factor especially in the tropics (Egborge, 1994; Yab, 2005).

Alkalinity values ranged from 30.53 ±0.503 mg/l in July, the peak of rainfall to 81.67 ±1.225mg/l in the driest month of January.The mean value of 58.34 ±0.348mg/l. The lower alkalinity of the wet season could be due to dilution factor of the rains. This finding agrees with that of Adebisi (1981) who observed increasing alkalinity with decreasing water level. There was a negative correlation between alkalinity and water depth in Upper Ogun River. However, my findings negate that of Boyd (1981) who reported higher alkalinity in the dry season attributing it to low water level and its attendant concentration of salts. Alkalinity data indicates changes in water quality or pollution load only when results vary significantly from known normal levels (Sikoki and Otobokere,1999).

Silicate content of the coastal waters ranged from1.68±0.035mg/l in February to 18.43 ±0.21mg/l in October. The mean value of 10.88 ± 0.232mg/l was recorded.Silicate was lowest before the onset of rainfall in April. The highest value was recorded in the peak of late and early rains in the months of October and July. This might be due to leaching out of silicates from the bottom soil and large water runoffs**.**

CONCLUSION AND RECOMMENDATIONS

The study revealed the that quality of the coastal waters of Ondo State was within tolerable limits according to standards set by the World Health Organisation and various environmental protection agencies despite the high anthropogenic pressure, high incidence of water hyacinth infestation and crude oil exploration in the area. The mean values recorded for all the parameters could support aquatic life. However there is a need for regular water quality monitoring in view of the importance of Ondo State coast in artisanal fish production in Nigeria. Poor water quality could lead to loss of biodiversity. Enforcement of environmental laws and obeisance of maritime law of the Sea should be taken more seriously in the coastal maritime States to avoid loss of aquatic life. More funds should be channelled to researches on water quality, biomass estimate and Suivellance survey. Training and sensitization of fisherfolks on responsible fisheries and basic record-keeping habits should be conducted at regular intervals.

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