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Physicochemical Parameters, Heavy-metals and Soil Particle Distribution of Liverpool Axis of Badagry Creek Lagos, South-Western Nigeria

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Abstract

Physiochemical parameters, heavy metals bioaccumulation and soil particle distribution (SPD) in the Liverpool axis of Badagry creek, Lagos state Nigeria was studied with the aim of providing an ecological database for the highly abundant water body. The water parameters studied are: Temperature, Turbidity, Dissolved oxygen, Carbondioxide, Salinity, pH, Total hardness, Conductivity, Nitrite, Nitrate, Ammonia, and Chloride. Heavy metals are: Cu, Zn, Cd and Pb. Three (3) sampling stations along Badagry creek (SS1 - Liverpool, SS2 – Snake-island, & SS3 – Elede village). Composite samples were utilized for the study using atomic spectrophotometer (AAS). Sediment samples were obtained using Eckman grab and SPD analyzed according to International Society of Soil Science (ISSS) classification. Results revealed that Temperature was highest in May (31.0±1.0^{0}C) and lowest (24.0±2.6 C^o) in December, 2019. Turbidity was high in February (118.0±50.9) and lowest in October with 34.0±8.3NTU. Dissolved oxygen was highest in October (27.3±13.9mg/l) but lowest in August (2.6±1.2) Carbondioxide ranged from 16.4±8.5 - 73.9±25.12, Salinity ranged from 0.7 - 31.13‰. pH was steady (6.2±1.5 - 7.2±1.8). Other parameters are temporarily steady. Spatial analysis revealed that water quality values are significantly different ($p<0.05$). Conductivity was 14.8µ/cm and Chloride <0.1mg/l. Heavy metals results in *Callinectes pallidus* and *Penaeus notialis* showed that Mean±SD for cupper was 2.03±0.17mg/l, Zinc was 3.51±0.44. far above the WHO standards (0.1mg/l). Pb and Cd had 0.05 and 0.02mg/l. SPD shows SS1 had 19.05% of coarse sand, 43.91% of fine sand, and 36.74% of clay/silt sediments. SS2 had 13.9% of coarse sand, 35% of fine sand and 19.6% of silt/clay sediment. While SS3 had 16.91% coarse sand, 37.75% fine sand, and 45.29% silt/clay. SS1 has more coarse sand and fine sand than other stations. While SS3 has the highest amount of clay (45.29%) in the environment.

Keywords: water quality, heavy-metals, soil particle sizes, fish fauna and invertebrates

INTRODUCTION

Physico-chemical parameters are usually water quality indices, which are defined as the chemical, physical and biological contents of water. The water quality of any water body changes with the season and geographic areas, even when there is no pollution present. According to Lawson, E.O. (2011). Suitability of water for fish and humans that have their lively-hood on that water is based on urbanizations, anthropogenic pollution activities and the health of the water body as it carries fish (Saliu *et al (*2001), Akintola S.L.*et al* (2009), and Ogungbile *et al* (2017). Physico – chemical parameters influencing the aquatic environment are: Temperature, pH, Salinity, Dissolved oxygen, Carbon dioxide, Turbidity, Conductivity, Total hardness, Chloride, Ammonia, Nitrites, Nitrates and Heavy metals contaminants. These parameters are limiting factors for the growth and survival of organisms (Flora and Fauna).

In Africa, most industrial developments occur along the littoral zone of the aquatic ecosystems. Numerous ecosystems are threatened with heavy metal pollution from mining and petrochemical industries (Oyewo 1998, and Chukwu, 2006). Nigeria as a developing nation and Lagos metropolis which is located along coastal region is experiencing rapid industrial growth. Rapid growth in population and massive industrialization in recent years have resulted in pollution of the biosphere; a situation which pose major hazard and human health problems worldwide (Uttinger, 2005). The rapid urbanization and industrialization of cities and improper environmental planning has resulted in the discharge of sewage and industrial wastes, thereby affecting the physico-chemical properties of water. The importance of physico-chemical studies cannot be overemphasized as it helps to get vital information about the quality of water bodies.

Heavy metals are naturally occurring elements that have a high atomic weight and a density at least 5 times greater than water. Their multiple industrial, domestic, agricultural, medical, and technological applications have led to their distribution in the environment. The presence of heavy toxic metals in environment matrices is one of the major concerns of pollution control and environmental agencies in most parts of the world. Their presence in aquatic ecosystem mainly due to anthropogenic influences has far- reaching implications directly to the biota and indirectly to man. Trace metals have been referred to as common pollutants, which are widely distributed in the environment with sources mainly from weathering of minerals and soils. However, the level of these metals in the environment has increased tremendously during the past decades as a result of human inputs and activities.

Soil particle sizes distribution has a great influence on soil hydraulic properties such as water retention characteristics, saturated and unsaturated hydraulic conductivities, bulk density, permeability, porosity, thus, it is known as the result of geological, chemical and biological processes (Wang *et al* 2008). Characteristics of soil particle size distribution has a good relationship with changes in soil structure, which is affected by management practices and erosion. Therefore, characterizing changes in the soil particle distribution is an inevitable issue in the environment. Zeng *et al.*, (2010) reported that Sediments are important sinks for pollutants, particularly, heavy metals and they play a significant role in re-mobilization of contaminants in aquatic systems when certain conditions prevail. Therefore, it is very appropriate to study it, to know its level of contamination with metals and to determine its interaction with the water body. According to Deng Ji, (2017), The determination of total metal concentration of metals in sediments is often grossly insufficient to providing proper information regarding their bioavailability, mobility, toxicity and reactivity Hence, the need to use speciation analysis (sequential extraction), to investigate their geochemical composition and distribution in the sediments. Whereby, components loosely held in the soil are extracted first, followed by those that are more tightly bonded i.e., the sequential solubilization of the various layers that make up the sediments. It has the following advantages over the determination of total metal concentration as it tells the source of metal, whether natural (lithogenic) or anthropogenic, its toxicity to living organism (biota) and a superior knowledge of metal-sediment interaction.

Lagos metropolis which is situated along the coastal line has become an important city in Nigerian because of the harbor and commercial activities available around it. The Liverpool jetty Apapa of the Badagry Creek is one of the major creeks in Lagos adjoining the Lagos harbor. There are various existing industries, homes and industrial estates in the region, which generate both industrial and domestic wastes. Many Nigerian researchers have investigated the physiochemical of water bodies in the Badagry creeks and other creeks as well Akintola *et al* (2011) carried out study of some physico – chemical characteristic of the Badagry creek, Nigeria and they revealed that variation in the water quality of the creeks is largely influenced by seasonal changes and various instruction from the ocean at different levels. Lawson E.O, (2011) studied the physico-chemical parameter and heavy metals content of water from swamps of the Lagos lagoon Lagos, Nigeria. Ogungbile *et al* (2017) studied the physico – chemicals and heavy metal content of tidal polluted creek, Ijora. They revealed that this part of the creek is the most polluted. Saliu, *et al* (2006) in their preliminary chemical and biological assessment of Ogbe creek, Lagos recorded the hydro-chemistry of the creek as it is strongly influenced by seasonal flood. Physico chemical parameter of this study area; Liverpool axis of the Badagry creek have not been documented in literature before and it is essential just like the other axis of the Badagry creek based on anthropogenic activities going on in that environment.

The aim of the study is to provide primary information, coupled with statistical data on water quality and contributing to the effective monitoring of environmental quality and ecosystem health of the Liverpool axis of the Badagry creek on the following aspects: Status of the physico – chemical parameters; Information on the level of concentration of heavy metals in fish and invertebrates (shrimps) and assessment of the Soil particle sizes monthly variations. The expected results would then be used to give appropriate advice to policymakers on the reduction of devastating consequences of excessive anthropogenic activities on the ecosystem, fish and shellfish and humans.

Materials and Methods

Study Area

Liverpool axis of Badagry lies approximately between latitude: 6.483755N $6^0$26’15.174, longitude: 3.35962E $3^0$21’34.62 (figure 1). It is a brackish/lagoon system and a point where the Badargy creek opens into the Atlantic Ocean. Thus, making the salinity of the water to be high during the inflows of marine water. Liverpool jetty (station A) is situated close to industries and surrounded by neighboring villages. Among them are Olam group of companies, Crown flour, and Honeywell flour. Some of the oil marketers have their oil depots closed the water bodies. All the above-mentioned industries discharge their waste treated or non-treated into the water body. The jetty is polluted through deposition of particulates, organics and cardon gases through transportation activities e.t.c. However, during the rainy season, large amount of runoff brings into the water column lots of domestic waste e.g., oil and grease, pesticides, domestic waste and feces e.t.c. The pollution is significant in the water body where large areas of paved surface result in increased run-off from roads, industrial sites and residential areas. This sample station alongside two other stations was chosen to study the pollution activities and effective monitoring of environmental quality and ecosystem health of the Liverpool axis of Badagry Creek. These areas are shown below.

Water Sampling:

A total of 9 samples were collected from three different locations 1km away (3 samples from each location) from the month of May 2019 to April 2020. Prior to sample collection all the plastic bottles were thoroughly washed and dried. The bottles were rinsed with water sample to be collected at the time of collection. Water samples were collected in a 2lire plastic container with a screw cap. The samples were collected and the temperature and pH were measured at the sampling site (*in situ*) using standard mercury thermometer and pocket pH meter and then preserved at 40C prior further analysis.

Figure 1: Map of Nigeria inset Badagry creeks showing Sample stations in Liverpool axis.
Source: Captured from satellite real-time google maps, 2021.

Physiochemical Analysis:

The physicochemical properties were determined from water samples collected from the Creek in a clean container for the period of one year, May 2019 to April 2020. Samples were collected during morning hours in between 8.00 to 10.00 a.m. using two-liter container. The physical and chemical parameters were analyzed in dry and wet seasons respectively. Parameters including temperature, pH, electrical conductivity, turbidity, total hardness, dissolved oxygen, chloride, sodium, nitrate and nitrite, were analyzed. A standard guideline of water sampling and physico-chemical parameters evaluation was adopted at the laboratory following (APHA, 1998). Parameters such as temperature, transparency and turbidity were directly evaluated in the study area whereas other parameters were analyzed in laboratory.

1. Dissolved oxygen: Reagents: Magnesium sulphate solution (reagent A), Alkali – lodide Azide solution (reagent B), sodiumthiosulphate acid, starch (indicator). 2.0ml of reagent A & B mix was added to water sample in reagent bottles and allow the precipitate to settle. 2.0ml of concentrated sulphuric acid was added and mix till precipitate dissolved. Then, 100ml of solution was taken in conical flask and 1.0ml of starch (indicator) was added and titrated with 0.025ml sodium thiosulphate. DO was determined using the expression below.

$$\textbf{DO in mg/l} = \frac{\textbf{ml of titrant (N) (8) x (1000)}}{\textbf{Sample volume in ml}}$$

2. Carbon dioxide: 100ml of sample water was measured in measuring cylinder and 4 drops of phenolphthalein was added. Sample turned pink showing that the Ph is above 8.34 and free carbon dioxide is essentially absent. (If the sample remains colorless it contains free carbon dioxide). Then, sodium carbonate was titrated till a faint pink was seen which marks the end point.

3. Total hardness: 100ml of water sample was measured into 250ml conical flask. 2.0ml buffer solution was added and mix, 8 drops of EBT was also added and titrated with EDTA solution. At end point, the solution changed from wine red to pure blue. Using the calculation below.

$$\textbf{Total hardness in Mg/l} = \frac{\textbf{ml of EDTA (M) (100.1) (1000)}}{\textbf{Sample volume in ml}}$$

4. Salinity: 10ml of the water sample was added into conical flask. Then 15ml of potassium chromate was added as indicator. The colour changed the sample to yellow and was then titrated with sliver nitrate until colour changed to brick red. The salinity was determined using calculations below.

$$\textbf{Salinity in mg/l} = \textbf{Titer value x 1.8065}$$

5. Nitrite Test (NO_2): A Reagent bottle was shaken very well before usage with the water to be tested, then fill to the 5ml mark. The vial was dried on the outside. 5 drops of reagent 1 &2 was added, and shaken until the liquid is evenly distributed. The colours were compared from a position above under natural daylight.
6. 6 Nitrate (NO_3): A Reagent bottle was shaken very well before usage with the water to be tested, and then fill to 10ml mark. Dry the vial on the outside. 6 drops of reagent was added and shaken. One tea spoonful (red) reagent 3 was added into the vial, covered and shaken vigorously precisely for 15 seconds. The vial was opened and 6 drops reagent 4 was added, and shaken until liquid is evenly distributed. The colours were compared after 5 minutes. the vial was placed on the colour chart and compared from a position above under natural daylight. This same procedure was used for ammonia and chloride.
7. Chloride: This is done using Mohrs's titration method, which is based upon the fact that in solution containing Cl and chromate (Cr). Silver reacts with all the Cl and precipitates before the reaction with chromate begins. The appearance of the brick-red colour of the silver chromate precipitate is the end-point. A suitable aliquot of water sample (10 mL natural water sample) was pipetted into a 250-mL Erlenmeyer flask. 4 drops of potassium chromate solution were added. The solution was then titrated against $AgNO_3$ solution until a permanent reddish-brown color appears in order to standardize the AgNO3 solution used in the determination of Cl. The reading was used to calculate $AgNO_3$ normality:

   $\mathbf{N_{AgN03} = 10 \times N_{Nacl} / V_{AgN03}}$

   Where: $AgNO_3$= Normality of AgNO3 solution, VAgNO3 = Volume of AgNO3 solution used (mL), NNaCl = Normality of NaCl solution Calculation, Cl = V_1 x N x 1000 / V

   Where: V1 = Volume of 0.01 N AgNO3 titrated for the sample (mL), N = Normality of AgNO3 solution, V = Volume of water sample used for measurement (mL)

8. Transparency:_Transparency of water bodies is directly correlated with phytoplankton production thus making fish abundant. It was measured using the secchi-disc.

Heavy metal analysis

For heavy metal determination, concentrated hydrochloric acid was added to the water/ sediment samples and was taken to the laboratory to be analyzed. The concentration of iron (Fe), Zinc (Zn), cadmium (cd), Lead (Pb) and copper (Cu) was determined using the atomic absorption spectrophotometer (AAS).

Determination of heavy metal concentration:

Samples of crab and prawn (5g) was weighed in a 100ml beaker, 25ml of concentrated hydrochloric acid and water was added in ratio 1:1 which were allowed to stay for 20 minutes for oxidation reaction. Then the sample was placed in the hot place at a temperature not more than 120◦ and the heat was monitored. The resulting residues were removed from heat dissolved and washed into 50ml volumetric flasks with 0.1m HNO and made up to mark with distilled de – ionized water and stored for weeks until metal concentrations could be determined using the atomic spectrophotometer (APHA, 1999), after calibration appropriate standards.

Sediment Sample Collection and Treatment for soil particle size analysis:

Sediments samples were collected alongside the water samples using a stainless-steel scoop into a polyethylene bags previously soaked with dilute nitric acid for 24 hrs Rinsed with distilled water and dried. The grab samples of surface sediments were taken at a depth of 0-5 cm for the various months for the dry and wet seasons. These samples were then transported to the laboratory and air dried for about two weeks at room temperature and grinded with mortar and pestle. The ground soil samples were sieved using 0.2mm - pan sieve size to get the soil particle size and kept in a poly ethylene bottle for further analysis.

Statistical Analysis

According to Sena, *et al.*, (2002), statistical analysis procedures as powerful tools, can provide knowledge and assist interpretation of environmental data. Therefore, data obtained was analyzed for mean and standard deviations and graphical charts using MS excel. T-test analysis, analysis of variance (ANOVA), DUNCAN, LSD, and Pearson's correlation analysis were carried out using SPSS 20 version at 95% level of confidence (P<0.05).

RESULTS

Prior to the classification of selected areas, a sub map and coordinates were created for each selected area. These areas description was obtained using the hydrographical, physical appearance and anthropogenic activities been uniquely defined. A sample set was used as representative in triplicate stations labelled as sample station SS1, SS2 and SS3. However, the supervised classification of sample characteristics was done through digital information extraction technique (DIET) in - situ. This is shown in table 1.

The results of the physical and chemical parameters quantified from the analysis of water samples from three (3) sampling stations of Liverpool axis of Badagry creeks is presented in table 3. It shows the mean monthly variations in the study area within the period of study (May, 2019 – April, 2020). Temperature was significantly different from one month to another throughout the period of study with the highest values in May 2019 (31.0±1.0^{0}C) and lowest (24.0±2.6 Cº) in December, 2019. (As shown in figure 2). Mean monthly value for turbidity was high in February (118.0±50.9) and lowest in October with 34.0±8.3NTU. the values varied between months throughout the study period. Dissolved oxygen was highest in October (27.3±13.9mg/l) but lowest in August (2.6±1.2) sharp changes was observed in DO content between months which were connected with temporal variations and anthropogenic influxes. Carbondioxide also varied significantly between months, highest value of 73.9±25.12 was recorded in October and lowest in November (16.4±8.5). Salinity ranged from 0.7‰ to 31.13‰. The temporal variation showed low salinity in raining season when rainwater brought lots of fresh water from channels, rivers and streams, and high salinity in dry season. pH was steady throughout the study period between 6.2±1.5 to 7.2±1.8. Amongst other parameters that are temporarily steady are: Nitrites, Nitrates, Ammonia and Chloride. However, total hardness was the most varied water quality parameter in the study area with 1.02±0.7 in May, 74.4±30.5 in July and rose to 173.0±41.6 in September, and got to its peak in October with 225.0±6.2mg/l. the graphical representations for all the water quality parameters are shown in figures 2 – 4.

Table 1: Description of sample area, coordinates and Characteristics of features

Code	Location name	Ecosystem	Activities /Features	Soil Types	Soil colour	Coordinates
SS1	Liverpool jetty	Transportation, Industries, boats.	Fish market, trucks, bikes, oil plants, human activities, industry effluents e.t.c	muddy	dark	Latitude: 6.48N 6^{0}26'15.174, Longitude: 3.35E3^{0}21'34.62
SS2	Snake island	Mangrove, waterways, crustaceans, oil terminals	Vegetation, oil vessels, dredging.	Soft sand	Clear brownish soil	LATITUDE: 6.428N 6^{0}2542.384", LONGITUDE: 3.39E 3^{0}23'52.548'

SS3	Elede village	Fishing, Trading, dredging & Housing.	Human activities, residences, industrial, planked dug out boats, Nets and fishing.	Partially muddy	Dark	Latitude: 6.40N6^{0}24'0.432", Longitude: 3.39E 3^{0}23'48.048

Physicochemical Parameters	Wet Season				Dry Season				
	Min	Max	Mean	S D	Min	Max	Mean	S D	WHO Limit
Temperature (^{0}C)	27.0	31.0	28.6	1.58	24.0	31.0	28.0	2.3	25
Turbidity (NTU)	47.6	75.3	61.5	9.4	78.5	118.0	100.5	14.5	5
Dissolved Oxygen (mg/l)	2.64	13.0	6.12	3.59	2.7	13.3	5.7	3.8	5.0
Carbondioxide (mg/l)	24.9	67.7	45.56	19.07	16.4	69.1	36.1	18.5	<10
Salinity (‰)	2.7	31.1	12.88	9.63	8.6	23.2	14.3	6.0	0-40
Ph	6.46	8.7	7.55	0.97	6.2	7.6	6.95	0.5	6.5 – 8.5
Nitrite (mg/l)	.0	1.02	0.33	0.46	.0	.4	0.08	0.2	<1.0
Nitrate (mg/l)	.0	.3	0.19	0.11	.0	4.0	0.7	1.6	50
Ammonia (mg/l)	.28	1.4	0.73	0.36	.6	7.0	2.8	2.9	0 – 0.5
Total hardness (mg/l)	1.02	173.0	68.08	63.28	59.3	164.0	127.1	35.8	40 – 400
Conductivity (µS/cm)	5.33	13.83	11.09	3.31	6.3	39.2	21.05	12.2	500
Chloride (mg/l)	0.03	0.09	0.04	0.02	.0	2.0	0.4	0.7	250

Table 2: Temporal Variations of Physicochemical Parameters in Liverpool Axis of Badagry Creek

The result of wet and dry seasons of physicochemical parameters in Liverpool axis of Badagry Creek and compared with world health organization limits (WHO) is shown in table 2. The mean temperature for dry season is 28.0^{0}C and 26.6 in wet season. Turbidity of the creek in this area was 61.5NTU in wet season and 100.5NTU in dry season. Dissolved oxygen was lower in dry season (5.7mg/l) and higher in wet season with 6.12mg/l. pH was virtually similar between the two seasons. Nitrites, Nitrates and Ammonia were low in wet season (0.33, 0.1 and 0.7 mg/l) and slightly higher in dry season (0.08, 0.7 and 2.8 respectively).

The results of the Spatial Mean variation of physical and chemical parameters from three (3) sampling stations from Liverpool axis of Badagry creeks compared with water quality standards established by the Federal Ministry of Environment (FME) and Lagos State Environmental Protection Authority (LASEPA) are presented in Table 4. Water temperature values are significantly different between station 1 and stations 2 and 3. The range of value in the three stations (27.6 – 28.7^{0}C) were within the Federal limits (<35^{0}C). The pH values ranged from 6.7 – 7.2. Carbondioxide ranged from 31.5 – 67.4(mg/l), the highest values were recorded in station 1. Salinity values were stable between 12.8 – 13.7‰ throughout the period of study. Mean dissolved oxygen (DO) values were above standard limits (5mg/l) in stations 1, 2. & 3 (5.3, 8.1 and 8.1mg/l respectively).

The physicochemical parameters were intercorrelated using the Pearson's correlation matrix. The values are shown in table 5. It shows that 6 out of 67 correlation coefficients (8.9%) are most significant (P<0.05). Temperature had negative correlation for most of the parameters; especially with conductivity (r= -0.59*). Turbidity had the highest correlation value (r=0.58*) with conductivity. Dissolved oxygen had its highest correlation values with nitrite (r=0.61*, p<0.05), total hardness (r=0.62*) and CO_2 (r=0.52*) at p<0.05. Carbondioxide was most correlated with nitrate (r=0.68*). Salinity has low correlations with others especially total hardness. p H has the highest correlation value with Carbondioxide (r=0.54*, p<0.05). Total hardness also had a high positive correlation with DO (r=0.62*) but was negatively correlated with nitrite (r=-0.63*) and salinity (r=-0.54). chloride was most negatively correlated with DO (r=-0.52*, p<0.05).

Table 3: Mean Monthly variations in water quality parameters from Liverpool axis of Badagry creek, Lagos

Physiochemical Parameters	May	Jun	July	Aug	Sept	Oct	Nov	Dec	Jan	Feb	Mar	Apr
Temperature (C)º	31.0±1.0^{a}	29.67±2.1^{b}	27.0±0.0^{c}	28.0±1.0^{d}	29.0±0.0^{b}	27.0±2.0^{c}	31.0±1.0^{a}	24.00±2.65^{ab}	27.7±5.5^{c}	27.7±2.08^{c}	29.00±1.0^{b}	28.7±7.1^{d}
Turbidity (cm)	75.3±17.3^{a}	65.67±6.8^{b}	62.7±17.9^{b}	55.3±20.8^{c}	47.1±20.1^{c}	34.0±8.3^{d}	78.5±19.5^{e}	96.83±50.56^{ab}	91.9±40.4^{ac}	118.0±50.9^{ad}	105.0±52.7^{ae}	113.3±20.2^{ad}
Dissolve Oxygen (mg/l)	6.0±6.7^{a}	6.00±6.8^{a}	4.53±3.3^{b}	2.6±1.2^{c}	13.0±12.5^{d}	27.3±13.9^{e}	2.7±0.4^{c}	3.20±2.62^{c}	4.93±1.90^{b}	5.11±4.69^{b}	5.03±2.25^{b}	13.3±7.9^{d}
Carbondioxide (mg/l)	31.6±23.8^{a}	31.57±23.9^{a}	67.7±75.1^{b}	24.9±5.0^{c}	49.9±25.12^{d}	73.9±30.1^{e}	16.4±8.5^{ab}	44.23±35.4^{d}	26.30±6.8^{c}	27.5±8.76^{c}	69.1±30.2^{b}	33.4±20.6^{a}
Salinity (ppt)	31.13±3.4^{a}	12.00±5.8^{b}	9.3±0.9^{c}	13.0±2.7^{b}	2.70±0.5^{d}	0.7±0.2^{e}	8.6±1.5^{c}	23.23±1.9^{ab}	11.9±1.2^{b}	20.3±6.4^{ab}	8.58±7.4^{c}	13.6±2.9^{b}
p H	7.2±0.7^{a}	7.17±0.8^{a}	8.8±2.4^{b}	6.46±0.2^{c}	7.0±0.0^{a}	7.7±1.2^{a}	6.2±1.5^{c}	7.6±1.5^{a}	6.8±0.7^{a}	7.3±0.7^{a}	6.52±1.1^{c}	7.2±1.8^{a}
Nitrite (mg/l)	0.8±1.4^{a}	1.02±0.9^{b}	0.0±0.0^{c}	0.13±0.1^{c}	0.03±0.2^{c}	0.0±0.0^{c}	0.0±0.2^{c}	0.4±0.2^{d}	0.02±0.2^{d}	0.01±0.2^{c}	0.03±0.3^{c}	0.05±0.4^{c}
Nitrate (mg/l)	0.3±0.6^{a}	0.0±0.0^{b}	0.18±0.1^{c}	0.26±0.4^{c}	0.2±0.1^{a}	0.5±0.4^{a}	0.0±0.1^{b}	0.15±0.13^{c}	0.10±0.1^{c}	0.05±0.1^{a}	0.39±0.5^{c}	0.23±0.4^{c}
Ammonia(mg/l)	0.7±0.3^{a}	0.7±0.3^{a}	0.68±0.7^{a}	1.4±0.8^{b}	0.28±0.1^{c}	0.5±0.4^{c}	0.7±0.3^{a}	1.10±0.75^{b}	0.56±0.4^{a}	0.87±0.4^{a}	0.64±0.3^{a}	1.45±0.8^{b}
Total Hardness (mg/l)	1.02±0.7^{a}	3.06±0.4^{b}	74.4±30.5^{c}	82.7±16.4^{c}	173.0±41.6^{d}	225.0±6.2^{e}	133±38.2^{ab}	146.7±66.6^{ab}	59.3±12.7^{c}	132.0±71.4^{ab}	127.3±30.6^{ab}	164.0±7.6^{d}
Conductivity (µS/cm)	9.1±0.9^{a}	12.6±2.1^{b}	13.8±2.6^{b}	11.8±0.8^{b}	5.3±0.9^{c}	0.9±0.3^{d}	6.3±4.9^{c}	39.2±3.1^{e}	30.8±7.9^{ab}	11.9±7.1^{b}	16.3±3.3^{b}	21.70±7.5^{ac}
Chloride (mg/l)	0.04±0.0^{a}	0.06±0.4^{a}	0.3±0.0^{a}	0.1±0.0^{a}	0.03±0.0^{a}	0.0±0.02^{a}	0.2±0.1^{a}	0.26±0.2^{a}	0.07±0.1^{a}	0.05±0.03^{a}	0.04±0.03	0.04±0.03

Note: Values along the same row having the same superscript are not statistically different at 5% probability level using the Duncan multiple range test (P<0.05)

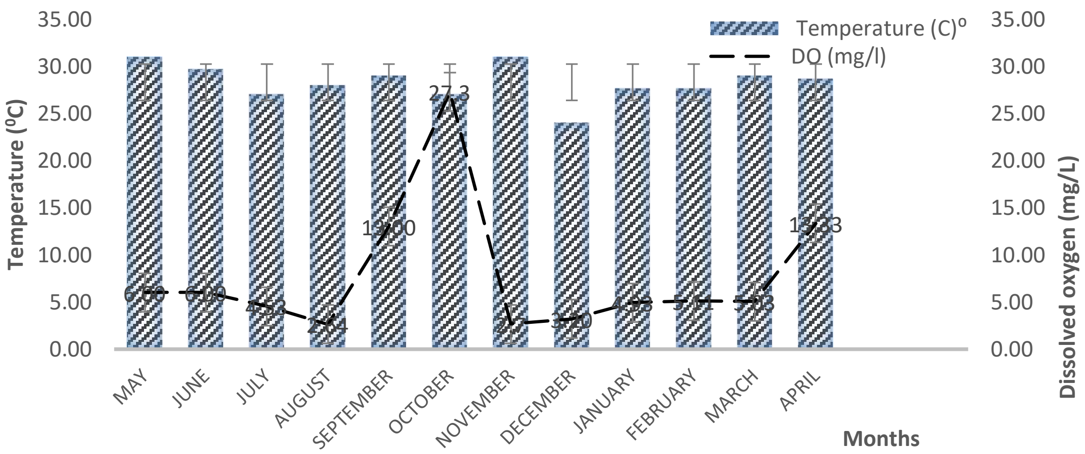

Figure 2: Temporal Mean Values Of Temperature and Dissolved oxygen in water samples of Badagry creek, Lagos.

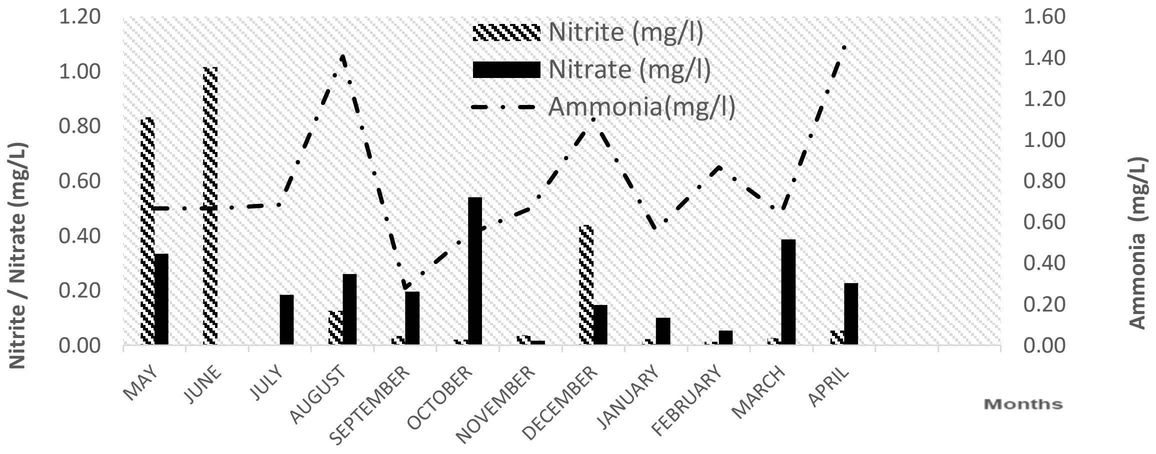

Figure 3: Temporal mean values of Nitrite, Nitrate and Ammonia of analyzed water samples in Badagry creek, Lagos.

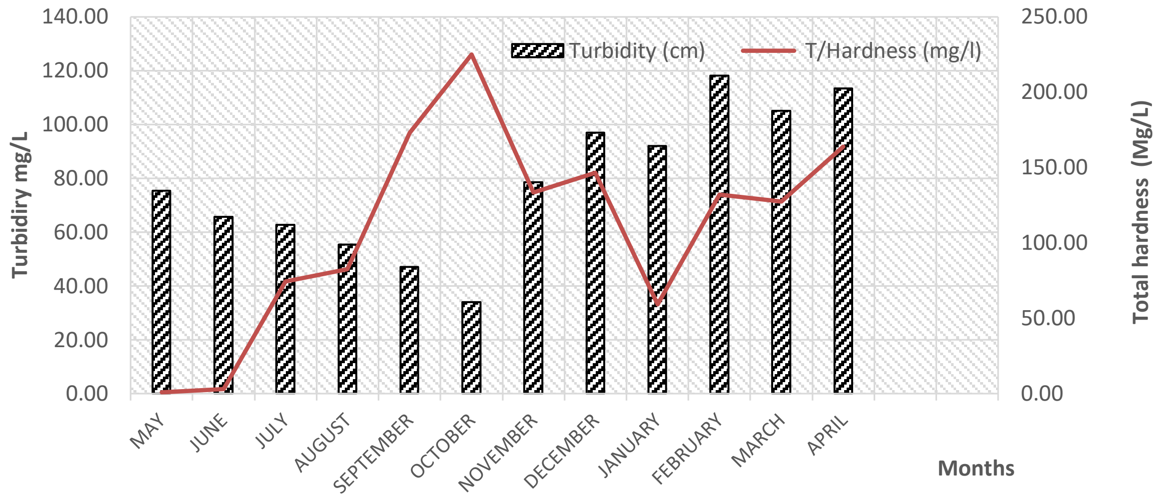

Figure 4: Temporal mean values of Turbidity and Total Hardness of analyzed water samples in Badagry creek, Lagos.

Table 4: Spatial Mean Variation of Water Quality Parameters, Liverpool Axis of Badagry Creek

Physiochemical parameters	Station 1 MEAN ±SD	Station 2 MEAN±SD	Station 3 MEAN±SD	LASEPA/ FME Limit
Temperature (^{0}C)	27.6 ± 3.6	28.6±1.9	28.6±1.9	25 -35^0
Turbidity (NTU)	53.0 ± 23.7	84.9±30.5	84.9±30.5	10NTU
Dissolved Oxygen (mg/l)	5.3 ±4.7	8.1±9.0	8.1±9.0	5mg/l
Carbondioxide (mg/l)	67.4 ±38.7	31.5±13.6	31.5±13.6	<10
Salinity (‰)	12.8 ±7.7	13.7±8.5	13.7±8.5	NS
pH	6.7 ±1.9	7.2±0.6	7.2±0.6	6-8
Nitrite (mg/l)	0.1 ±0.3	0.4±0.8	0.4±0.8	10mg/l
Nitrate (mg/l)	0.2 ±0.4	0.3±0.3	0.3±0.3	10mg/l
Ammonia (mg/l)	1.2 ±0.7	0.6±0.4	0.6±0.4	0.2mg/l
Total hardness (mg/l)	75.5 ±50.2	118.6±85.0	118.6±85.0	
Conductivity (μS/cm)	15.0 ±10.8	14.4±10.0	14.4±10.0	
Chloride	0.1 ±0.1	0.1±0.1	0.1±0.1	250

Note: NS means not specified.

The monthly variation of heavy metals concentration in *Callinectes pallidus* and *Penaeus notialis* from Liverpool axis of Badagry creek are presented in tables 6 and 7 respectively. The graphical trend is also shown in Figures 22 and 23.

Among the metals in the crab, copper was lowest in August (1.74mg/l) and highest in October (2.27mg/l), the mean copper value was 2.03±0.17mg/l. Zinc was lowest in August with 2.69m/l and highest in December (3.91mg/l). Mean zinc values was 3.51±0.44 far above the world health organization standards (0.1mg/l). Lead (pb) and Cadmium (Cd) concentrations were generally lower than other metals studied in the crabs (0.05 and 0.02mg/l respectively), but still higher than the international allowable standards of 0.01mg/l for both metals.

Soil has the tendency to filter out waste, contaminant/pollutants before it gets to the water table due to the physical properties that controls the permeability of the particle sizes. Factors that influence the interconnectivity between the soil particles include; particle shape, density and particle size distribution (PSD). Table 2, shows summary of the mean of sieved particle size analysis data taken for six (6) months from the Liverpool axis of Badargy creek Lagos. Based on the United State Department of Agriculture (USDA) and International Society of Soil Science (ISSS) classification for soil particle distribution. Sieve size for various soil ranges from Silt / clay (< 0.12mm), fine sands = 0.12mm – 0.5mm), sand 0.5 – 2.mm, gravel 0.0075 – 4.75mm, stones (i.e., <2mm). Based on soil particle analysis done, sample station 1 had 19.05% of coarse sand, 43.91% of fine sand, and 36.74% of clay, silt sediments. Sample station 2 had 13.9% of coarse sand, 35% of fine sands and 19.6% of silt/clay sediment.

Table 5: Pearson's correlation matrix for the water quality parameters from Liverpool axis of Badagry creek

Parameters	Temp.	Turb.	DO	CO_2	Salinity	pH	Nitrite	Nitrate	HN^3	Total hardness	Cond.	Cl^{-1}
Temperature	1.0											
Turbidity	-0.073	1.0										
DO	-0.091	-0.450	1.0									
CO2	-0.370	-0.319	0.518	1.0								
Salinity	0.024	0.476	-0.492	-0.440	1.0							
pH	-0.523	-0.164	0.243	0.536	0.038	1.0						
Nitrite	0.251	-0.167	-0.159	-0.217	0.474	0.01	1.0					
Nitrate	-0.105	-0.315	0.606*	0.676*	-0.144	0.116	-0.183	1.0				
Ammonia	-0.246	0.409	-0.260	-0.374	0.355	-0.081	-0.104	-0.057	1.0			
Total hardness	-0.377	-0.049	0.618*	0.409	-0.536	0.035	-0.626*	0.356	0.012	1.0		
Conductivity	-0.594*	0.582*	-0.424	-0.157	0.380	0.073	0.022	-0.260	0.393	-0.123	1.0	
Chloride	-0.402	0.037	-0.519	0.015	0.114	0.397	-0.114	-0.386	0.176	-0.108	0.381	1.0

Table6: Monthly Variation of Heavy metals concentration in Crab (*Callinectes pallidus*) from Liverpool axis of Badagry creek

HEAVY METALS	Aug.	Sept.	Oct.	Nov.	Dec.	Jan.	MEAN±SD	WHO
Copper mg/l	1.74	2.13	2.27	2.02	2.02	2.02	2.03±0.17	1.3
Zinc mg/l	2.69	3.5	3.42	3.86	3.91	3.66	3.51±0.44	0.1
Lead (pb) mg/l	0.14	0.12	0.02	0.02	0.02	0.02	0.05±0.05	0.01
Cadmium (Cd)	0.03	0.01	0.05	0.03	0.01	0.01	0.02±0.02	0.01

Table7: Monthly Variation of Heavy metals concentration in Prawn (*Penaeus notialis*) from Liverpool axis of Badagry creek

HEAVY METALS	Aug.	Sept.	Oct.	Nov.	Dec.	Jan.	MEAN	WHO
Copper mg/l	0.65	0.76	0.64	1.02	0.96	1.01	0.84±0.18	1.3
Zinc mg/l	2.16	2.16	1.71	1.76	2.08	2.08	1.99±0.20	0.1
Lead (pb) mg/l	0.04	0.04	0.04	0.02	0.07	0.05	0.04±0.02	0.01
Cadmium (Cd)	0.01	0.01	0.08	0.01	0.08	0.02	0.03±0.04	0.01

While sample station 3 had 16.91% of coarse sand, 37.75% of fine sand and 45.29% of silt/clay. SS1 has more coarse sand and fine sand than other stations. While SS3 has the highest amount of clay (45.29%) in the environment. From the analysis above and as shown in figure 5 below, there were more fine sands and silt/clay sediment in the sampling stations which showed their increased or higher permeability to retain heavy metals and making them available for bioaccumulation in the biota.

Table 8: Mean Values from Sieve analysis for the soil samples from Liverpool axis of Badagry creek, Lagos-Nigeria

S/n	Sieve Sizes	PSD in Sample station 1	% PSD SS1	PSD in Sample station 2	% PSD SS2	PSD in Sample station 3	% PSD SS3
1	2.0	0.9	0.28	1.3	1.87	2.0	2.84
2	1.4	2.3	3.27	1.7	2.44	0.9	1.28
3	1.0	1.6	2.27	2.2	0.03	1.5	2.13
4	0.11	3.4	4.84	4.0	5.76	3.7	5.26
5	0.5	5.9	8.39	4.7	6.77	3.8	5.40
6	0.35	6.4	9.10	5.4	7.78	5.0	7.11
7	0.25	8.3	0.11	7.4	10.7	3.7	5.26
8	0.18	11.1	15.7	8.0	11.5	4.7	6.68
9	0.12	13.4	19.0	15.1	21.8	13.2	18.7
10	0.09	10.2	14.5	13.6	19.5	22.5	32.0
11	0.06	6.5	9.24	5.6	8.07	8.0	11.3
12	0.04	0.4	0.56	0.4	0.57	1.4	1.99
Total		**70.3**		**69.4**		**70.3**	

Note: PSD mean Particle sizes distribution in mm

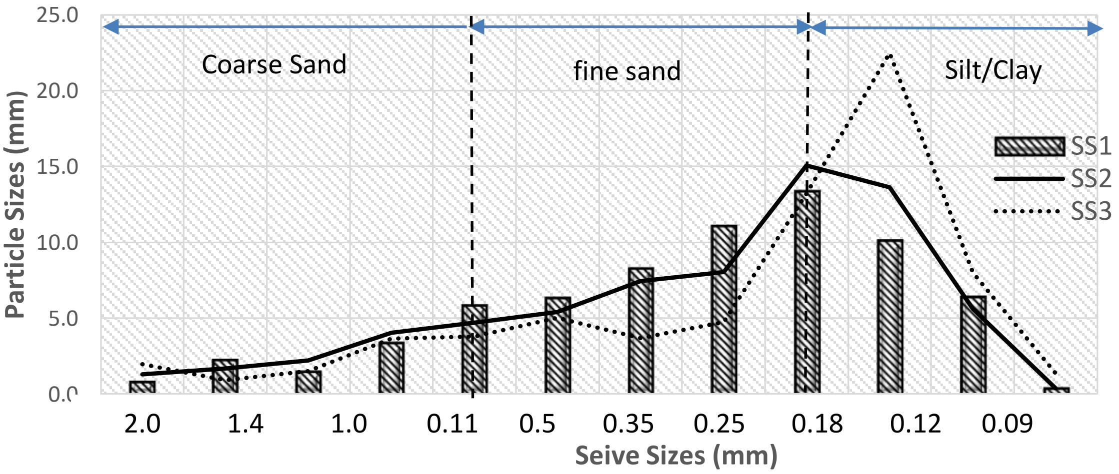

Figure 5: Particle Sizes Distribution (PSD) for Three sample stations (SS1, SS2, & SS3) in Liverpool axis of Badagry creek, Lagos

Discussion

Temporal variations were studied by determining the water quality of the Liverpool axis, of Badagry creeks using analysis of water samples taken between May, 2019 to April, 2020. The dissolved oxygen (DO), temperature (^{0}C), salinity (‰), pH, Ammonia, nitrite, nitrate, conductivity (µS/cm), turbidity, total hardness chloride (Cl^{-1}), and Carbondioxide (CO_2) were studied and compared with LASEPA/WHO/FME limits. Metabolic rate and reproductive activities of aquatic life is controlled by temperature (Agboola, *et al.* 2008). As metabolism increases with increase temperature, fish demand for dissolved oxygen also increases (Boyld and lich koppler (1985). Mean temperature ranged from 24.0 – 31.0 ^{0}C. Mean dissolved oxygen ranged from 2.6 – 27.3mg/l. The results showed that DO was lowest in August which is the peak of rainfall, during which organic compounds and pollutants are washed into the creek from other diffused sources. Adeboyejo *et al* (2009) reported that onset of rainfall leads to introduction of biodegradable and non-biodegradable contaminants which was evident in the dropping of dissolved oxygen in August (2.6mg/l) and November (2.7mg/l). This did not only course complete change of the water quality but also brought pollutant of carcinogenic properties. However, DO remained high in other months (27.3mg/l). Ammonia was lowest in (0.5mg/l) October and highest (1.45mg/l) in April which also coincides with onset of rainfall, the values far exceed the WHO permissible limits for Ammonia in fish (0.0 – 0.5mg/l). Carbondioxide (CO_2) range from 16.4 – 73.9mg/l, also exceeding the WHO limits; Similar trend led to the reduction in dissolve oxygen. Among physicochemical parameters that are within local and international permissible limit are turbidity (34.08 – 118.01 NTU), salinity (0.7 – 31.13‰), pH (6.2 – 8.8), nitrite (0.0 – 0.83mg/l), nitrate (0.0 – 0.39mg/l), and chloride (0.0 – 0.3mg/l).

The spatial distribution of physicochemical parameters as shown in table 4. Twelve water quality factors (12) were assessed in three sample stations from Liverpool axis of Badagry creeks compared with water quality standards established by the Federal Ministry of Environment (FME) and Lagos State Environmental Protection Authority (LASEPA). Mean water temperature values are not significantly different in station 1, stations 2 and 3. it ranged between 27.6 – 28.7^{0}C. and were within the Federal limits (25 - 35^{0}C). turbidity values was lowest in SS1 (53.0±4.7 NTU), 84.9±30.5NTU in SS2 and 84.9±30.5NTU in SS3. The pH values ranged from 6.7 – 7.2. Carbondioxide ranged from 31.5 – 67.4(mg/l), and the highest values were recorded in station 1. Salinity values were stable between 12.8 – 13.7‰ throughout the period of study. Mean dissolved oxygen (DO) values were above standard limits (5mg/l) in stations 1, 2. & 3 (5.3, 8.1 and 8.1mg/l respectively) Water quality is a term used to express the suitability of water to sustain various Uses and processes. It will have several values of physical, chemical and biological characteristics. Megan (2016) opined those physiochemical parameters (water quality) are affected by a wide range of natural and chemical influences. Spatial distribution of physicochemical parameters is shown in table 4. Temperature values in the three sampling stations was Significantly different ranging from (27.6°c - 28.6°c) which are within permissible limit (LASEPA 25-35°c). The highest mean turbidity values was 84.9 in Station 2 and 3, while the lowest recorded was 53.0±23.7; the results thus shows that SS1 (Liverpool) was more siren than others. However, the values obtained were above international standards (10 NTU). This could be attributed to run off water from point and non-pointed sources around the sampling stations. DO values varied from 5.3 – 8.1mg/l. The highest DO value was recorded in Station 2 and 3. The lowest concentration was observed in Station 1. The low DO value may be as a result of anthropogenic activities, which wash in organic and inorganic substances from domestic and industrial sources and thereby consumed appreciable amount of Oxygen as a result of metabolizing activities and decay of organic matters. This agrees with Temesgen and Seyoum, (2018).

Carbondioxide values were significantly different ($p<0.05$) ranging from (31.5 - 67.4 mg/l). 67.4mg/l was observed in Station 1, this must have been because of the decrease in Oxygen level in this sample station. Station 2 and 3 has the same value of 31.5mg/l. Salinity values remained stable throughout the year in all sample stations, The relative differences were insignificant ($P<0.05$). The pH concentration was similar among the sample stations, highest concentration was observed in Station 1 and 2 (7.2±0.6) and Slightly acidic in Station 1 (6.7±1.9) this maybe from the Effluents deposited directly to the water body same report with Samuel *et al* (2007). Mean concentration for Nitrite varied from 0.4 - 0.1mg/l. lowest concentration was observed in station 1 while the highest concentration 0.4mg/l was observed for Station 2 and 3. Nitrate in this present study was high in Station 2 and 3(0.4 mg/l) and extremely low in Station 1 (0.1mg/l) which was considerably lower than the reported value of (Amare etal. 2017). The measured Ammonia values vary between (1.2mg/l - 0.6mg/l) Station 1 showed the highest concentration of 1.2mg/l which may be derived from biodegradation of waste and from domestic and industrial waste in the sampling station, (Chapman and Kimstach 1996) reported that ammonia comes from nitrogen - containing organic material and gas exchange between water and atmosphere. The result of Total hardness under this study ranged from (118.6mg/l - 75.5mg/l) these values was lesser than the prescribed Limits by LASEPA. Conductivity indicates the present of ions within the water body. Electrical conductivity was not significantly different and was within permissible limit, higher concentration was observed in Station 1 (15S/cm) and Lowest on Station 2 and 3 (14.4S/cm). Chloride was not significantly different throughout the present study and was within the prescribed limits.

The Pearson correlation matrix of 12 Physiochemical analyzed variables shows that 6 out of 67 correlated coefficients are most significant. This is presented in table 5. There is a strong and positive correlation between: conductivity and Turbidity (r= 0.58), Dissolved Oxygen and nitrate (r = 0.61), total hardness and Dissolved Oxygen (r =0.62), carbondioxide (r = 0.52), pH and carbon dioxide (r = 0.54) carbondioxide and nitrate (r = 0.68). The correlation of all analyzed variables affected simultaneously by spatial and seasonal variations (Temesgen and Seyoum, 2018). A significant Negative correlation exists between total hardness and nitrite (r = -0.63), total hardness and salinity (r= -0.54) Chloride and Dissolved oxygen (r= -0.52), temperature and conductivity (r = -0.59) and temperature and pH (r = -0.52). The positive correlated values indicate that the increase in one parameter leads to the increase in the other.

The present study shows the concentration of heavy metal in crab (*Callinectes pallidus)* and prawn (*Penaeus Notialis*) from Liverpool axis of Badagry creek in table 6 and 7. Among the metals examined in *C. pallidus*, copper was not significantly different throughout the six months of study. Highest copper values (2.27mg/l), lead (Pb) with 0.14mg/l, highest zinc was 3.91 and cadmium had 0.05mg/l. these concentrations were all higher than WHO limit (Cu_1.3, Pb_0.01 Zn_0.1 & Cd_0.01 respectively). The levels reported in this study were higher than the levels reported in Dzindi River (Cu _0.003mg/l - 0.05mg/l) from Limpopo province of South Africa, according to Edokpayi *et al*, (2016) which were also higher than the WHO permissible limit. While, An Average copper value of (0.65 - 1.02mg/l) was observed in prawn. Highest value was obtained in November (1.02mg/l) and (0.65mg/l) in August, the values are also below WHO Permissible limit. Mean concentration of Zinc in Crab/prawn ranged from (2.69 - 3.91mg/l)/ (1.71 -2.66mg/l) all the values were above the WHO Standard limit. Zinc is an indispensable trace element not only for humans, but also for all organisms. It is a component of proteins as well as a greater number for enzymes (Plum *et al.* 2010). High level of Zinc leads to Phyto-toxicity, reproduction problem, and brain disorder. Highest value of Zinc in Prawn was observed in January (2.08mg/l) and lowest value in October (17.1mg/l) the Obtained mean value concentration was higher than the values gotten in River Nile, Egypt (0.12 -0.69ppm) (Osaman and kloas, 2010). Lawal *et al.* (2014) reported Similar values of Zinc from Kampani river, Plateau State.

Conclusion and Recommendation

The assessment of water quality shows a significant temporal and spatial variation in most of the physiochemical parameters. These variations may be due to several environmental variabilities between sample stations and seasons: biogeochemical fluctuations; run – offs from domestic and industrial sources (point and non – point sources); changes in rainfall pattern; sand mining activities; transportation; dislodged of ballast water from ships amongst others, to the creek. However, the following conclusions were drawn from this assessment:

1. Physiochemical parameters such as carbondioxide and ammonia were extremely high in station 1 above WHO allowable limit which led to high level of water pollution especially from effluent been discharged directly to this area. Total hardness value was high in station 2 & 3 which might have been altered by some anthropogenic activities, sand extractions, mining, transportation and fishing activities in this area.
2. Based on the assessment done, pollution level in the three-sampling station will follow this sequence: SS1>SS3>SS2.
3. Heavy metal analysis done on invertebrate (Cd, Pb, Cu and Zn) had higher values than WHO permissible limit which may be attributed to bioaccumulation of metals and having undesirable effects on the biotic community (i.e., retainment of toxic metals in shell of invertebrates), tendency of some ions to form precipitation, biomagnification along food chain leading to possibility of mutagenicity, carcinogenesis and teratogenicity with its impending impacts in humans (impaired brain functions, renal disorder, constipation, foetal mutation e.t.c.)
4. Soil particle sizes analyzed revealed that SS3 has highest amount of clay, making the environment susceptible to the accumulation and heavy metals retention; thus, being more available to aquatic benthic communities after sedimentation and precipitation. SS1 has more coarse sand than other stations due to anthropogenic activities (e.g. sanding mining and massive boat transportation).

Conclusively, the implication of the above analysis is that fish fauna, invertebrate and benthic communities have been grossly affected negatively in respect to ecological alterations leading to destruction of the stable food chain, primary productivity, gross migrations of endemic species to a more suitable a seine environment occasioned by ecosystem destruction.

Recommendation

The result from the study have revealed that Liverpool axis of Badagry creek is significantly pollution which may affect lives which directly or indirectly depend on this source of water.
The following recommendation is however proposed.

1. Industries and hotels at the upper stream (SS1) should properly and adequately treat their effluent before discharging it into the water.
2. Anthropogenic activities like sand mining should be moderated and minimized.

3. Regular monitoring and control measures should be embarked upon by environmental protection agencies.
4. Continuous assessment and environmental monitoring should be based on international standards and guidelines.

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