DISTRIBUTION OF TRACE METALS IN WATER, SEDIMENT AND BIOTA FROM IKPUKULU-AMA CREEK PORT HARCOURT, RIVERS STATE, NIGERIA

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Abstract
The distribution of trace metals (Lead (Pb), Iron (Fe), Copper (Cu), Zinc (Zn) and Cadmium (Cd) were assessed from three stations in water, sediment and biota (Fish and plankton) from Ikpukulu-ama creek in Rivers State, Nigeria from March to August,2017. The physico- chemical parameters in water that affect metal concentrations were analyzed using standard methods and the metals were analyzed using Atomic Absorption Spectrophotometer (AAS) after acid digestion. Concentrations of metals in water were in the order of Cd<Cu<Pb<Zn<Fe, in sediments Cd<Cu<Pb<Zn<Fe, in fish Cd<Cu<Pb<Zn<Fe while in plankton the order of concentration were Cu<Zn<Fe, while Cd and Pb were below detectable limit. The mean concentrations of metals in surface water (mg/L) were 5.2, 0.83, 0.03, 0.46, and 0.01 for Fe, Zn, Cu, Pb and Cd respectively, in sediments (mg/g) the values were 16.0, 0.65, 0.09, 0.32, and 0.01 for the same metals. The mean concentrations of metals in fish (mg/g) were Fe (2.96), Zn (1.87), Cu (0.03), Pb (0.08) and Cd (<0.001), while for plankton (mg/L) were Fe (13.2), Zn (2.09), Cu (0.06), Pb (<0.001) and Cd (<0.001). Trace metal concentrations in water, sediment and biota were below the maximum permissible levels recommended by National standards.
Keywords: Fishing; Urbanization; Pollution Load Index; Marine ecosystem.

INTRODUCTION

In recent decades, high rate of population growth, urbanization and industrialization at the coastal regions have frequently introduced toxic pollutants particularly metals into the marine ecosystem (Montalvo *et al*., 2014; Conceição *et al*., 2013; Adekola *et al*., 2003; Anikwe and Nwobodo 2002). Pollution causes unfavourable changes in the environment which could affect the components of the ecosystem. Some of the sources of pollution include industrial effluents, sewage, agricultural discharge and household residue. Most aquatic environments have been influenced by a number of stressors which significantly destroys the biodiversity. These stressors include pollution from industries, mining, oil and gas activities, erosion, sea rising, sand storm, drought, desertification etc. Environmental protection is a major global concern. According to (Palaniappan *et al.*, 2010) in recent times, it has become more challenging to maintain the quality of the aquatic ecosystem. Water pollution is the introduction of contaminant by physical, chemical, biological or radioactive agents in the natural water body (Hogan, 2013). Hossain *et al.*, (2012) said there are pollutants that naturally enter the aquatic system e.g. from natural fires, volcanoes and oil seeps etc. Some non-natural sources of water pollution include underground storage leakages, industrial waste, marine dumping, (Gambhir *et al*., 2012). The coastal and brackish water environment is usually identified with large industrial settlements and urbanization with resultant effluent discharge which results in the accumulation of heavy metal (Ridgway and Shimmield, 2002). The brackish water environment is endangered by discharges of untreated waste and industrial effluent. This eventually causes harm to the sustainability of the living resources and public health. The waste transports high level of toxicants, especially the heavy metals which have the ability to accumulate in the basic food chain and also move up to the higher trophic level. Trace metals are important environmental pollutants and their toxicity is a challenge because of their ecological, nutritional, environmental and evolutionary effects (Nagajyoti *et al*., 2010; Jaishankar *et al*., 2013). Activities of human and industries have caused various discharge of pollutants into the marine environment endangering the health of the population and destroying the quality of the environment by making the water bodies unfit (Abowei and Sikoki, 2005). Sediments are commonly used as indicators for the degree of pollution in the aquatic environment (Opuluwa *et al*., 2012). According to (Davies *et al*., 2006), trace metal concentrates more in sediment than in water. According to Issa *et al*., (2011), sediment is an integral part of the aquatic environment that can be used for spawning and feeding. The main entry routes of toxic substances into the surface water are normally via point source and non-point source. Fish are vital food that supplies essential elements and certain vitamins; nevertheless, most current health risks are connected with seafood safety from the environment (Otitoju and Otitoju, 2013) (Nwani *et al*., 2010). Mudskipper *Periophthalmus Papilio* is an amphibious fish that is highly active during low tides and spend most of its time out of water in mangrove habitats. According to Akinrotimi *et al*., (2018) they form a high density on tidal mud flats in the coastal areas of Niger Delta. This species is widely distributed and notably present in many riverine communities in Niger Delta, Nigeria, therefore, it is essential to evaluate the bioaccumulation and toxicity of these metals in the fish, as many research activities in coastal environment have been focusing on other species. The consequences of trace metal pollutants in aquatic environment can be looked at from two perspectives with respect to their impact. First, trace metal has the potency to persist in natural aquatic ecosystems for an extended period. Secondly, they have the ability to accumulate in successive levels of the biological chain.

Several studies have reported the accumulation of these metals in water, sediments and tissues of aquatic biota from contaminated areas in Niger Delta (Akinrotimi *et al.*, 2018; Unyimadu *et al*., 2004; Ayotunde *et al*., 2012). Despite these, paucity of information that exists on Ikpukulu-Ama Creek, which is one of the polluted sites along the Bonny Estuary and these pollutants have a tendency to accumulate in biota (Landrum *et al.*, 2003; Anyakora and Coker, 2007) and undergo food chain magnification (James *et al.*, 1998). Illegal bunkering activities have been set up in and around the Ikpukulu-ama creek banks during the recent years which has led to the discharge of these effluents into the creek. Therefore, the aim of this project is to assess the concentrations of trace metals (Pb, Fe, Cd, Zn and Cu) in water, sediments and biota (fish and plankton) commonly found in Ikpukulu-ama Creek.

Study area

The Ikpukulu-ama Creek is a small tidal creek in the Niger Delta region (Figure1.0) that flows through a small fishing settlement behind Government Comprehensive Secondary School, Borikiri in Port Harcourt City Local Government Area of Rivers State. The creek is a tributary of the Bonny River that flows into the Atlantic Ocean. Some industries Nigerian Liquefied Natural Gas (NLNG) Dock, Almarine base, Federal Fishing Terminal, Dredging Company and John Holt Plc located within this area are involved in oil and gas servicing, marine technology, fishing, transportation and other anthropogenic activities.

Materials and methods

Study stations

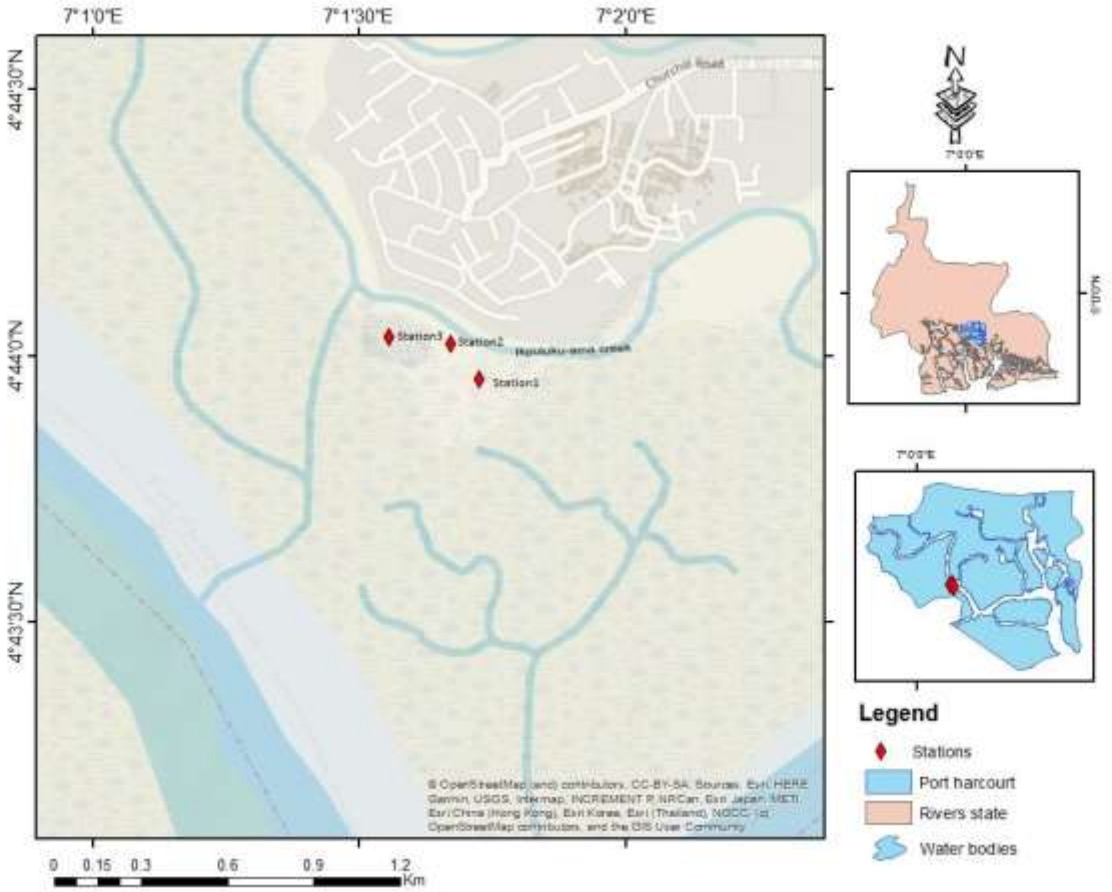

Figure 1.0: Map showing sampling stations

Three sampling stations where located along the creek. The vegetation of Ikpukulu-ama creek are sparse, full of dead roots of mangrove trees (*Rhizophora racemosa*, *Avennicia africana*)with few pockets of Nipa palms (*Nypa fruticans*) trees found in some stations.

Station 1 is located upstream at latitude $04^{o}44'01.4''$ N and longitude $007^{o}01'40.4''$ E. It has no vegetation at all. The major activities of this station includes; bathing, washing and human waste discharge.

Station 2 is located midstream at latitude of $04^{0}44'02.2''$N and longitude of $007^{0}1'33.4''$E. The station lacked vegetation. Human waste discharge, illegal bunkering discharge and waste discharge, also effluents from Bile Creek are found there. The surface of the water is filled with oil film.

Station 3 is located downstream at latitude of $04^{0}43'57.4''$N and longitude of 00701'43.6″E. It has good vegetation Nipa palms (*Nypa fruticans*), some dead roots of mangrove trees and fresh *Rhizophora racemosa, Avecinnia africana.* Human waste discharge is the major activity of this station.

Sample collections

Composite sampling method was used in collection of sample in each sampling station during high tide. Sample collections were carried out monthly covering a period of March to August, 2017. Replicate samples were collected from each location. Water samples were collected from under the surface of the water using amber bottles while sediment samples were collected using the Ekmann grab sample rat the same stations for water collection. Sediment was put in sampling bottles (Schott glass bottles) and transported with the water on ice to the laboratory. In the laboratory samples were stored at 4°C until analysis. Fish (*Periopthalmus papilio*) commonly known as the mudskipper were collected from the local fishermen and stored in a cooler packed with ice block in order to maintain the freshness and later transported to the laboratory. Plankton (zoo- and phytoplankton) samples were collected with the help of a plankton net (mesh size: 20 µm) through vertical hauls from the upper layer of 10 cm. Filtered plankton samples were kept in sampling bottles and preserved in ice packs.

Analysis of samples

All water samples were analyzed directly while sediment samples were oven dried, homogenized and sieved to remove large particulates. Three grams (3 g) of each powdered sample was weighed into conical flasks dissolved in 2 ml of Sulphuric acid, 2 ml of Nitric acid and 1ml of Perchloric acid, then allowed to digest for 5 minutes. The solution was filtered using Whatmann No. 1 cellulose filter paper and the filtrate was made up to 100 ml using deionised water.

The fish samples were wrapped with Aluminum foil and oven dried at 105 ºC. After drying to constant weight, the dried fish samples were crushed in a small porcelain mortar and pestle to a homogenized powder. Three grams (3 g) of the dried fish powder was heated in a muffle furnace temperature of 630 ºC for 3hours. The ash was dissolved in 2ml of Sulphuric acid, 2 ml of Nitric acid and 1ml of Perchloric acid was heated on an electro-thermal heater hotplate. The solution was filtered using Whatmann No. 1 cellulose filter paper and solution was diluted to 100ml with distilled water and the trace metal contents were determined using an atomic absorption spectrophotometer (AAS) Agilent technologies 4210 MP-AES model as described in Standard Methods (APHA, 1995). Plankton samples were acidified with 1 ml of concentrated HCL analyzed according to the method described by (Kalay *et al*., 1999). The concentration of the individual metal ions of the samples were extrapolated from the standard graph of the calibrated curves of the individual metal ions and was presented in parts per million.

Quality control

Each sample was analyzed in triplicate, and a blank determination was carried out with every batch of samples. All reagents used were of AnalaR grade, all glassware and polyethylene were properly cleaned with acid – cleansing reagents and rinsed thoroughly with distilled deionized water. The blank values were low generally and below the detection limits of the instrument for the metals.

Statistical analysis

Statistical package for social sciences (SPSS version 22) IBM 2013 were used. Two way-ANOVA and Duncan Multiple Range Test were used to determine the significant difference at $p < 0.05$. Microsoft EXCEL was used to illustrate graphs for the physicochemical parameters.

Pollution load index (PLI): Pollution load index for each site was evaluated as indicated by Tomilson *et al.,* (1980). Pollution load index= (CF1 * CF2 *.....* CFn) 1/n Where, n is the number of metals (five in the present study) and CF is the contamination factor. The contamination factor can be calculated from; Contamination factor (CF) = metal concentration in sediments/Background values of the metal. The PLI value > 1 is polluted while PLI value < 1 indicate no pollution (Chakraborty *et al*., 2013; Seshan *et al*., 2010). The background value used is that of average shale (Turekian and Wedepohl, 1961).

Bioaccumulation Factor (BAF): Bioaccumulation Factor is the ratio of the concentration of the chemical in the organisms C_B to that in the sediment $C_{s.}$

<u>Mean concentration of metal in fish</u>
Mean concentration of metal in sediment

Results

Temperature (^{0}C):

Apart from March with high temperature, months April to August showed little variations. Temperature ranged from 24.9 - 29.4 ^{0}C throughout study period (figure1). The highest temperature in March occurred at 29.4 ^{0}C and the lowest temperature occurred in April at 24.9 ^{0}C. With overall mean for station 1 as 25.7 ± 0.11^{0}C, station 2 as 25.7 ± 0.11^{0}C and station 3 as 25.8 ± 0.11 ^{0}C (Table 1). Two way analysis of variance revealed that temperature had no significant difference across the stations at $p<0.05$ (Table 1). The mean temperature across the stations is in the following descending order Station 3 < Station 1=Station 2, while for the months; March < April=May=June=July=August.

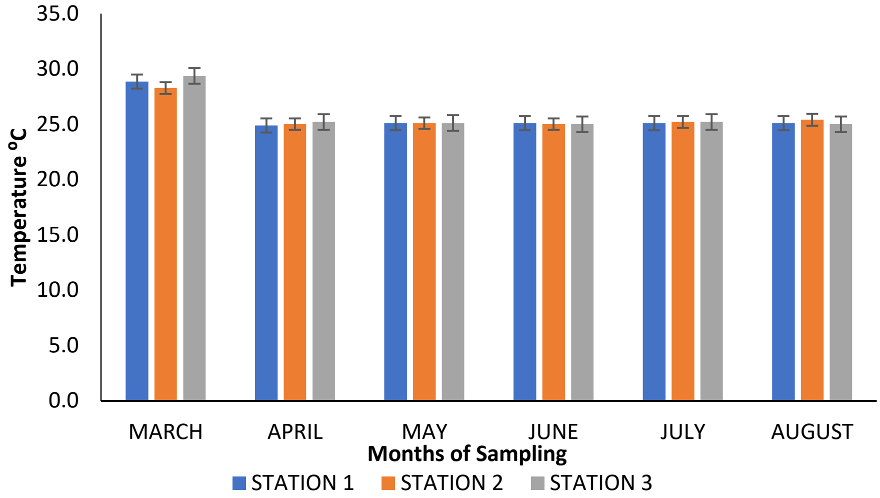

Figure 1. Graph of Mean Temperature of Water from Ikpukulu-Ama Creek

pH:

pH across the stations showed high range of variation from 4.1-7.8 throughout the study period (Figure 2). The lowest pH occurred in June 4.1 indicating high acidity while the highest pH occurred in August 7.8 indicating alkalinity. With overall mean for station 1 as 6.02 ± 0.03, station 2 as 6.28 ± 0.03 and station 3 as 6.22 ± 0.03 (Table 1), two way analysis of variance indicated significant difference between station1 and station 2 and 3 but no significant difference across station 2 and station 3 at $p > 0.05$ (Table 1). The mean pH across the stations is in the following descending order Station 3< Station 2 < Station 1, while for the months; August <March < July = April < May < June.

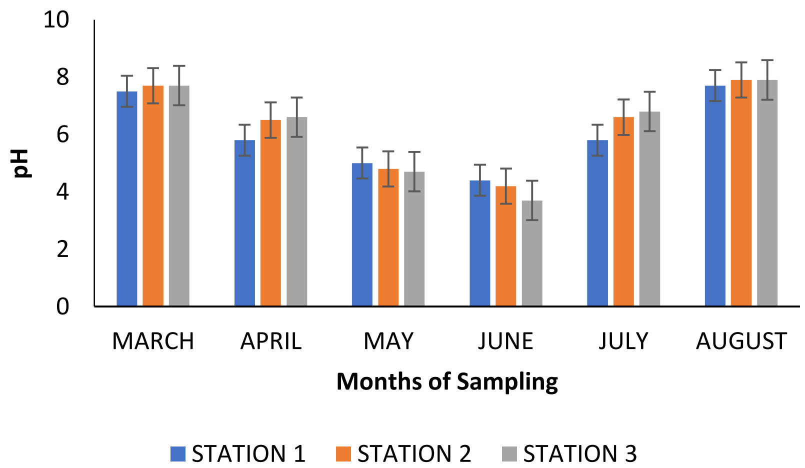

Figure 2. Graph of Mean pH of Water from Ikpukulu-Ama Creek

Dissolved Oxygen (mg/L):

Dissolved Oxygen across the stations showed little variation, ranging from 3.1-4.7 throughout the months of the study period (Figure 3). The maximum dissolved oxygen occurred in March 4.7 and the minimum occurred in June 3.1 (Figure 3), with the overall mean for station 1 as 3.9 ± 0.27, station 2 as 3.9 ± 0.27 and station 3 as 4.02 ± 0.27 (Table 1). Two way analysis of variance revealed that there was significant difference between station 3 and stations 1 & 2 but no significant difference across stations 1 and station 2 at $p > 0.05$ (Table 1). The mean dissolved oxygen across the stations is in the following descending order Station 3< Station 1=Station 2, while for the months; March<August <July < May < April < June.

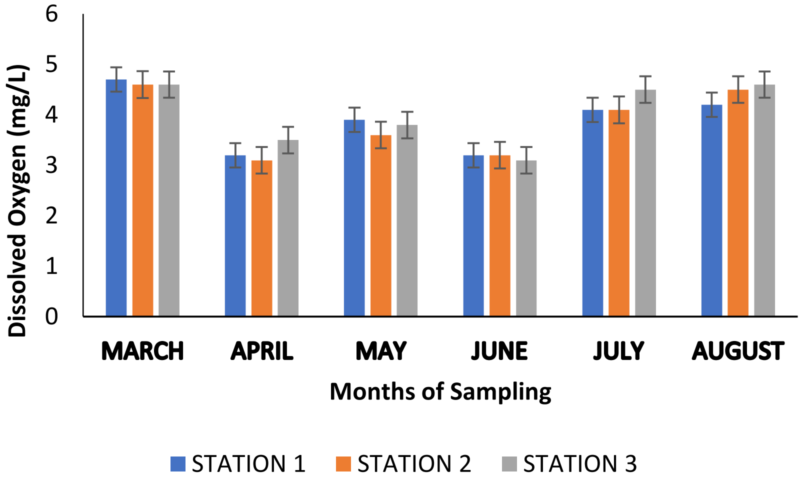

Figure 3. Graph of Mean Dissolved Oxygen of Water from Ikpukulu-Ama Creek

Salinity (ppt):

Salinity across the stations showed variation, ranging from 18.4-22.9 ppt throughout the months of the study period (Figure 4). The maximum salinity occurred in March 22.6 ppt and the minimum occurred in July 20.9 ppt (Figure 4), with the overall mean for station 1 as 21.1 ± 0.09 ppt, station 2 as 21.5 ± 0.09 ppt, and station 3 as 22.3 ± 0.09 ppt. Two way analysis of variance revealed significant difference between station 1, station 2 and station 3 at $p > 0.05$ (Table 1). The mean salinity across the stations is represented in the following descending order Station 3< Station 2 < Station 1, while for the months; March = April < May < August < July = June.

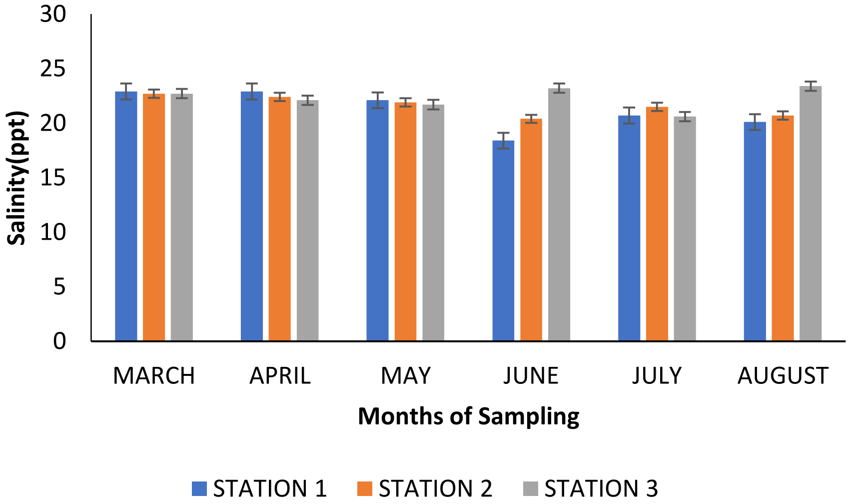

Figure 4.Graph of Mean Salinity of Water from Ikpukulu-Ama Creek

Total Dissolved Solid-TDS (ppt):

Total Dissolved Solid across the stations showed little variation, ranging from 17.7-18.8ppt throughout the months of the study period (Figure 5). The maximum TDS occurred in March 18.8ppt and the minimum occurred in June 17.7 ppt (Figure 5), with the overall mean for station 1 as 18.4 ± 0.04 ppt, station 2 as 18.3 ± 0.04 ppt and station 3 as 18.3 ± 0.04 ppt. Two way analysis of variance revealed no significant difference across the stations at $p > 0.05$ (Table 1). The mean TDS across the stations is in the following descending order Station 2 < Station 3 < Station 1, while for the months; March < August < April < July < May < June.

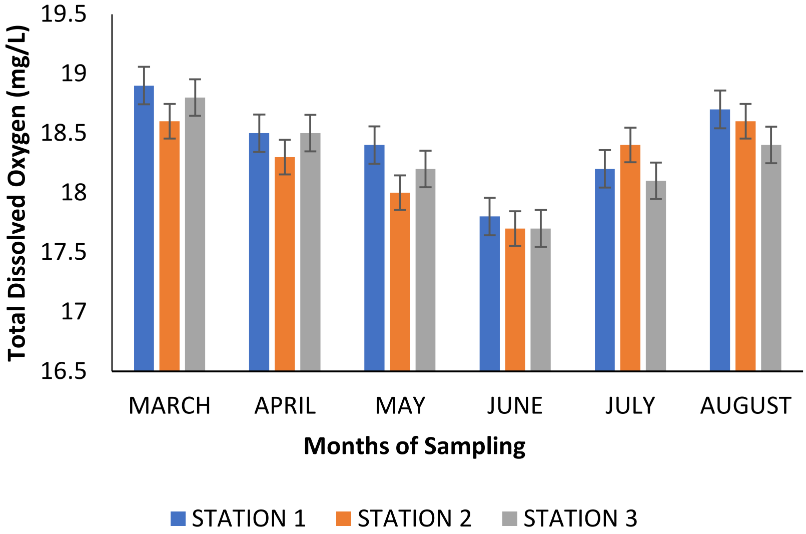

Figure 5. Graph of Mean Total Dissolved Solid of Water from Ikpukulu-Ama Creek

Conductivity (µS/cm):

Conductivity across the stations showed little variation, ranging from 22.6-37.4µS/cm throughout the months of the study period. The maximum conductivity occurred in March 37.4µS/cm while the minimum level of conductivity occurred in August 23.1µS/cm (Figure 6); with the overall mean for station 1 as 32.4 ± 0.13, station 2 as 32.7 ± 0.13µS/cm, and station 3 as 32.0± 0.13µS/cm. Two way analysis of variance revealed significant difference between station 3 and stations 1 and 2 but no significant difference across station 1 and station 2 at $p > 0.05$ (Table 1). The mean conductivity for the stations is in the following descending order Station 2< Station 1< Station 3, while for the months; March < April < May < June < July < August.

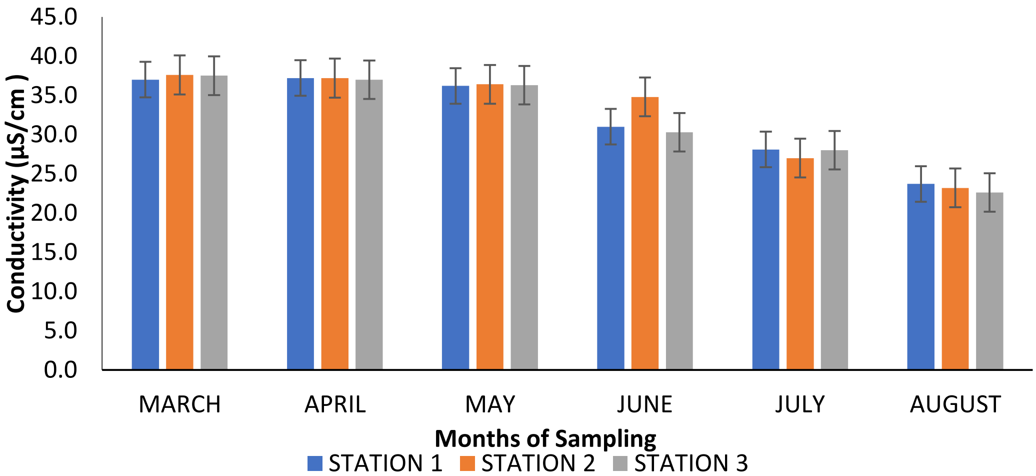

Figure 6. Graph of Mean Conductivity of Water from Ikpukulu-Ama Creek

The mean trace metal concentrations in mg/L with standard error of the water samples from the study area is recorded in Table 1. These values were compared with those of Nigerian Industrial Standard (NIS) and World Health Organization (WHO). The concentration of Fe varied significantly across the stations, ranging from 4.1986 – 6.1955. Fe was highest in station 2 and least in station 1. The concentration of Zn varied significantly across the stations, ranging from 0.4371– 1.4051. Zn was highest in station 2 and least in station 3. The concentration of Cu varied significantly across the stations ranging from 0.0264 – 0.0414. Cu was highest in station 2 and least in station 1. The concentration of Pb varied significantly across the stations. Pb was highest in station 1 and least in station 2. Concentration of Cd had no significant difference across the stations. In station 1, the order of concentration of metal for the water samples was Cd<Cu<Pb<Zn<Fe and stations 2 and 3 were: Cd<Cu<Zn<Pb<Fe.

Table 1. Spatial mean concentrations of trace metal in water (mg/L) of Ikpukulu-Ama Creek during the March (2017) to August (2017) compared with standards

METALS	STATION 1	STATION 2	STATION 3	WHO (2011)	NIS (2007)
Fe	4.1986±0.02[a]	6.1955±0.02[c]	5.0838±0.02[b]	-	-
Zn	0.6332±0.00[b]	1.4051±0.00[c]	0.4371±0.00[a]	15.0	3.0
Cu	0.0291±0.00[b]	0.0414±0.00[c]	0.0264±0.00[a]	2.0	1.0
Pb	0.5063±0.01[c]	0.4288±0.01[a]	0.4523±0.00[b]	0.01	0.01
Cd	0.0149±0.00[b]	0.0108±0.00[b]	0.0108±0.00[b]	0.003	0.003

With same superscript there is no significant difference ($p < 0.05$).
NIS- Nigerian Industrial Standard, WHO- World Health Organization

The mean trace metal concentration in mg/g with standard error in the sediment samples from the study area are recorded in Table 2. These values with those of the Department of Petroleum Resources (DPR) Nigeria. The concentration of Fe varied significantly across the stations ranging from 13.801 – 19.023. Fe was highest in station 2 and least in station 3. The concentration of Zn varied significantly across the stations ranging from 0.409 - 0.993. Zn was highest in station 2 and least in station 3. The concentration of Cu varied significantly across the stations ranging from 0.019 – 0.202. Cu was highest in station 3 and least in station 1. The concentration of Pb varied significantly across the stations ranging from 0.270 – 0.389. Pb was highest in station 3 and least in station 1. The concentration of Cd showed little variation across the stations, ranging from 0.012 – 0.018. Cd was highest in station 2 and least in station 1 and 3. The result revealed trace metal distribution in sediment to be the same in all stations Cd<Cu<Pb<Zn<Fe. The PLI values revealed station 1< station 2= station 3.

Table 2. Spatial mean concentrations of trace metals in sediments (mg/g) of Ikpukulu-Ama Creek during March (2017) to August (2017) compared with standards

METALS	STATION 1	STATION 2	STATION 3	DPR (2002)
Fe	15.2098±0.04[b]	19.0233± 0.04[c]	13.8014±0.04[a]	20
Zn	0.5319±0.00[b]	0.9932±0.00[c]	0.4085±0.00[a]	50-300
Cu	0.0189±0.00[a]	0.0418±0.00[c]	0.2022±0.00[b]	35/20
Pb	0.2701±0.08[a]	0.3145±0.08[b]	0.3891±0.08[c]	2-20
Cd	0.0121±0.00[a]	0.0183±0.00[b]	0.0121±0.00[a]	0.03-0.3
PLI	0.0033	0.0052	0.0052	
Pollution condition	(<1)	(<1)	(<1)	

PLI= Pollution Load Index; with same superscript there is no significant difference, with different superscript there is a significant difference ($p<0.05$). DPR-Department of Petroleum Resources

The mean trace metal concentration in mg/g with standard error in the fish samples from the study area is recorded in Table 3. These values with those of Federal Environmental Protection Agency (FEPA) Nigeria. The concentration of Fe varied significantly across the stations ranging from 2.404 – 3.471. Fe was highest in station 2 and least in station 3. The concentration of Zn varied significantly across the stations ranging from 1.538 – 2.385. Zn was highest in station 2 and least in station 3. The concentration of Cu varied significantly across the stations ranging from 0.026 – 0.041. Cu was highest in station 2 and at least in station 1. The concentration of Pb varied significantly across the stations ranging from 0.061 – 0.094. Pb was highest in station 1 and least in station 2. The concentration of Cd across the stations from 0.000-0.001, this is below detectable limit (<0.001), hence was not detected. The result revealed trace metal distribution in fish to be the same in all stations Cd<Cu<Pb<Zn<Fe.

Table 3. Spatial mean concentrations of trace metals in fish (mg/g) of Ikpukulu-ama Creek during March (2017) to August (2017) Compared with standards

METALS	STATION 1	STATION 2	STATION 3	WHO/FEPA (2003)
Fe	3.0068±0.00[b]	3.4709±0.00[c]	2.4037±0.00[b]	0.5
Zn	1.6883±0.01[b]	2.3849±0.01[c]	1.5381±0.01[a]	30.0(FAO 1983)
Cu	0.0291±0.00[b]	0.0414±0.00[c]	0.0264±0.00[a]	3.0
Pb	0.0938±0.00[c]	0.0609±0.00[a]	0.0767±0.00[b]	2.0
Cd	ND	ND	ND	0.5

ND: Not detected; with same superscript there is no significant difference, with different superscript there is a significant difference at ($p<0.05$). WHO- World Health Organisation, FEPA-Federal Environmental Protection Agency

The mean trace metal concentrations in mg/L with standard error in the plankton samples from the study area are recorded in Table 4. The concentration of Fe varied significantly across the stations ranging from 11.798 –15.821. Fe was highest in station 2 and least in station 3. The concentration of Zn varied significantly across the stations, ranging from 1.465 – 2.705. Zn was highest in station 2 and least in station 1. The concentration of Cu varied significantly across the stations, ranging from 0.0156 – 0.0163. Cu was highest in station 1 and least in station 3. The concentration of Pb and Cd ranges across the stations from 0.000-0.001, this is below detectable limit (<0.001), hence was not detected. The result revealed trace metal distribution in plankton to be the same in all stations Cd=Pb<Cu<Zn<Fe.

Table 4. Spatial mean concentrations of trace metals in plankton (mg/L) of Ikpukulu-ama Creek during March (2017) to August (2017)

METALS	STATION 1	STATION 2	STATION 3
Fe	12.0309 ± 0.11^{b}	15.8214 ± 0.11^{c}	11.7982 ± 0.11^{a}
Zn	1.4654 ± 0.04^{a}	2.7046 ± 0.04^{c}	2.1261 ± 0.04^{b}
Cu	0.1583 ± 0.00^{a}	0.0163 ± 0.00^{b}	0.0156 ± 0.00^{a}
Pb	ND	ND	ND
Cd	ND	ND	ND

ND: Not detected; with same superscript there is no significant difference, with different superscript there is a significant difference ($p < 0.05$)

It follows this order Station 3 > Station1 > Station 2 as in Table 4. Accumulation of the metals in biota can either be through the sediment or water which will get to man.

Table 5. Spatial bioaccumulation factor in fish (Lkg^{-1})

	STATION 1	STATION 2	STATION 3
Fe	0.2	0.2	0.2
Zn	3.2	2.4	3.8
Cu	1.5	1.0	1.0
Pb	0.4	0.2	0.2
Cd	0.1	0.1	0.1

Discussion

Metals occur naturally in low concentrations. According to (Bakarat *et al*., 2012), metals enter into the water via oxidation-reduction reactions, adsorption-desorption reaction, sedimentation re-suspension and degrading organisms. This study reveals that metals in the water when compared with WHO (2011) and NIS (2007) values are in a satisfactory level for drinking and surface water. Fe (Iron) is the highest because it is one of the most abundant metals in nature. It is required as one of the essential metals in nature and also a toxicant. Fe (Iron) is the highest because it is one of the most abundant metals in nature. High concentration of iron is a characteristic of the Niger Delta environment and has been attributed to geological processes (Angaye *et al*., 2015). This is in agreement with the work of Vincent-Akpu *et al.,* (2015) that Iron concentration was higher than all metals in her work in Bodo creek Niger Delta. This study reveals low values of trace metals compared with other water bodies in Port Harcourt, and according to (Chindah *et al*., 2004), this could be the result of high energy of current, volume of water that dilutes and adequate flushing of the system. Nonetheless, high concentrations of trace metals were observed in Woji River which receives effluent from domestic, industrial and agricultural site (Leton and Akpila, 2008). According to (Bader *et al.,* 2015), the reason why metal concentrations found in water do not indicate the relative contributions of pollution from activities in the creek might be as a result of some physicochemical processes such as tapping, precipitation, settling and storage of pollutants in the sediments and bioaccumulation in the aquatic organisms. The effect of water physiochemical parameters on heavy metal concentration are consistent with that of (Yi *et al.,* 2012); that temperature affect the concentration of heavy metal in the aquatic environment. Sediment has been known to be the major depository of metals holding more than 99 percent of total amount of a metal present in the aquatic system (Demirak *et al.,* 2006; Ozturk *et al.,* 2009; Aderinola *et al.,* 2009). This study revealed that sediment contained higher metal concentration when compared with their concentrations in water. Higher concentration of metals in the sediment more than in surface water may be connected with the fact that pollutants discharged into the aquatic environment does not remain in aqueous phase but instead are adsorbed onto the sediments. (Kaizer and Osakwe, 2010) observed that when heavy metals are discharged into the aquatic environment they can be absorbed by suspended solid and they strongly accumulate in the sediment. Moreover the sediment acts as a sink and also as a source of heavy metal (Suresh *et al.,* 2012). Sediments are commonly used as indicators for the degree of pollution in the aquatic environment (Fernandes *et al.,* 2007). Obire *et al.,* (2003) reveals that metal concentration in sediment affects water quality and bioaccumulates in aquatic organisms which causes long-term effect on the human health and the environment. The results indicated that low concentrations when compared with (DPR, 2002) where Fe as 20 ppm, Zn as 50-300 ppm, Cu as 35/20 ppm, Pb as 2-20 ppm and Cd as 0.03-0.3 ppm . Asaolu and Olaofe, (2004) and Belize *et al.,* (2003) also confirms high metal concentration in sediments than in water. Vincent-Akpu and Babatunde, (2014) states that when there is high pH, absorption of metals is promoted while low pH stops metal retention by sediment. Copper (Cu) is one of the metals, which are vital to human health. It's presence in the aquatic environment may be as a result of accumulation of domestic and agricultural wastes. It combines with certain proteins to produce enzymes that act as catalyst to help in the body functions and it's also essential for the synthesis of haemoglobin (Sivaperumal *et al*., 2007). Cadmium is biotoxic elements and one of priority pollutant. It is not an essential metal and its occurrence in sediments is mainly by human activities (Montalvo *et al*., 2014). In man, Cd poisoning could lead to anaemia, renal damage, bone disorder and cancer of the lungs (Ademoroti, 1996). Low levels of cadmium is seen in previous works done in the Niger Delta as reported by (Otitoju and Otitoju, 2013; Ideriah *et al.,* 2012; Vincent-Akpu and Mmom, 2012). Similar results are in agreement with previous findings for the Niger Delta (Otitoju and Otitoju, 2013; Adeleye *et al*., 2011; Vincent-Akpu and Mmom, 2012; (Issa *et al*., 2011; Chindah *et al.*, 2009). Low levels of Pb in recorded in this study (0.27-0.39 mg/g) are consistent with previous results in Niger Delta (Adeleye *et al.*, 2011; Chindah *et al.*, 2009; Vincent-Akpu and Yanadi, 2014). This result is in consonance with reports from those who identified sources of Pb contamination in the Nigerian environment to include batteries, metal plating, painting and mining industries and reported that about 200 tonnes of Pb were lost annually from fishing gears at mouths of rivers in Sweden (Gunner *et al*., 2001) and Pb used as weights for fishing nets (Aroke *et al*., 2016). Metals that usually thrives into solution first would be the metals within the top of the surface sediment, this will give an indication of current heavy metal concentration in the sediment. Pollution Load Index (PLI) were below 1 which indicated that the sediment was not contaminated. This is in line with the studies of (Salah *et al*., 2012) who recorded PLI values between 0.45 - 1.15 at all sampling sites which they suggested no overall pollution of site quality. The present study revealed that sediment accumulated more heavy metals than water. By comparing the accumulation of heavy metals in water and sediments, it can be concluded that heavy metals are highly accumulated in sediments than water, given that sediments act as reservoir for all contaminants and dead organic matter descending from the ecosystem above. Similar findings were reported by other authors (Hamed, 1998 and Nguyen *et al*., 2005).

The present study indicates that heavy metals in fish (mg/g) have mean values lower than (WHO, 2003) and (FEPA,2003) where Fe is 0.5ppm, Cu is 3.0ppm, Pb is 2.0ppm and Cd -0.5 while Zn -30ppm (FAO, 1983), and recommended limits in fish except that of Fe which was higher than the permissible standard (WHO/FEPA 2003). According to (Eneji *et al.,* 2011), the age of fish, lipid content in the tissue and feeding habits could also affect the accumulation of heavy metals in fisheries. Low levels of cadmium in fish is in concordance with (Davies *et al.,* 2006). According to Adeyeye (1996) difference in metal concentration in fish could be dependent on the fish species, while Idodo-Umeh (2002) said bigger fishes accumulate high metal concentrations than smaller ones. Fe is necessary for red blood formation and also plays a vital role in some metabolic processes. Iron is an essential trace metal, but can be harmful to living organisms even at low exposure. The bioaccumulation results indicated that fish in station 3 accumulated more metals followed by station 1 and station 2. This could be as a result of the waste deposit is very high in station 3 when compared to other stations. The Bio-contamination factor results of the heavy metals analyzed in this study revealed that there was bioaccumulation in the fish but at a low rate. This is in line with works of (Bower, 1979; Fabris *et al.*, 1994; Lau *et al*., 1996, 1998; Besada *et al*., 2001; Chindah and Braide, 2003 and Eja *et al*., 2003). In most cases sediment is the main sink of metals, with more than 99% of the sum amount of metals present in the aquatic system (Odiete, 1999).

According to Elamci *et al*., (2007), heavy metal concentration in plankton is dependent on absorption properties of the plankton species, metal content in water and partially from the sediment. Also, (Kerrison *et al*., 1998; Radwan *et al*., 1990; Elmaci *et al*., 2007), stated other factors, which includes productivity and the physicochemical properties of the water, quantitative and qualitative species composition of zoo- and phytoplankton, the capacity of heavy metal absorbance, and the seasons. The present study revealed low concentrations in plankton when compared with the metal concentrations in sediment and water.

The reason for the low values of metals have been affirmed to high energy of current and the volume of water that ensures proper flushing of the system (Chindah *et al*., 2004).

Conclusion

Pollution load index in Ikpukulu-Ama Creek was low, this implies that the concentrations of the metals analyzed were not high enough to suggest serious contamination in the sediment because the creek is tidal with continuous ebb and flows which guarantees adequate flushing of the creek. However, the higher concentration of metals in Ikpukulu-Ama Creek suggests that it is not fit for domestic use. The trace metals results obtained indicated that these metals from this creek are within the permissible limit but the risk of deleterious effects after long period cannot be exempted. This is due to the fact that this water body acts as a receptor for domestic, effluents from illegal bunkering activities and industrial wastes including agricultural run-offs. It is very important to control the level of discharge of the pollutants from non-point and point sources. Ensuring healthy status of the creek will improve the quality of the water and protect the biodiversity of the water body without putting-on health risk to humans who eat aquatic products from the water body. Public enlightenment on the significance of not depositing waste in the water bodies and drainage ways is very important. This will help in reducing occurrence of water pollution and permit adequate use of water resources.

Conflict of Interests

The authors have not declared any conflict of interests.

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