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Research Article

The Impact of Consistent Dredging on Heavy Metals Concentration and Benthic Macroinvertebrate of Sediment at Okpare Creek, Delta State, Nigeria

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ABSTRACT
The influence of consistent dredging on heavy metal concentration and benthic macroinvertebrates was investigated at Okpare Creek, Ughelli, Delta State. Fourteen physicochemical parameters were analysed from four stations over one year, covering rainy and dry seasons. Parameters included pH, electrical conductivity (EC), total organic carbon (TOC), total organic matter (TOM), sand%, clay%, silt%, and concentrations of cadmium, chromium, iron, zinc, lead, copper, and nickel. Heavy metals were determined using atomic absorption spectrometry (AAS) after digestion. Sediment samples, collected with an Eckman grab, were sorted for macroinvertebrates, preserved in 5% formalin, and identified to the lowest taxonomic level under a dissecting microscope. The creek was slightly acidic, with pH and EC showing no significant variation ($P>0.05$) among stations. TOC and TOM differed significantly ($P<0.05$). Particle size distribution (sand, clay, silt) varied highly significantly ($P<0.01$). Among heavy metals, Fe, Zn, Cr, and Ni showed highly significant differences ($P<0.01$); Pb differed significantly ($P<0.05$), while Cd and Cu showed no significant differences ($P>0.05$). A total of 42 individual macroinvertebrates were recorded, belonging to two taxa: Diptera (87.5% of total density) and Odonata (12.5%). Margalef's index indicated Station 2 as the richest, followed by Stations 4, 3, and 1. The low abundance and diversity of benthic macroinvertebrates were attributed to disturbances from ongoing dredging, which likely altered sediment composition and heavy metal distribution, adversely affecting habitat quality and organism survival.
Keywords: Benthic Macroinvertebrate; Consistent Dredging; Heavy metals; Impact; Okpare Creek; Sediment

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INTRODUCTION

Dredging is an excavation activity or operation usually carried out at least partly under water in shallow seas or fresh water areas with the purpose of gathering up bottom sediments and disposing them at a different location. This technique is often used to keep waterways navigable. Dredging can affect the aquatic environment in several ways. Suspended sediment is greatly increased, however increase in suspended sediment are typically restricted spatially and are not persistent once dredging has ceased. Acute effect on aquatic organisms occurs at high suspended sediment concentration. Other impact of dredging includes release of nutrients and metals and direct loss of bottom habitat in the area being dredged (Angonesi *et al.,* 2006).

Disposal of dredged materials generally results in an impact on benthic communities; however, recolonization of spoil areas generally occurs. If the dredging actually results in changes in the sediment texture, then the organism recolonization of the area may be very different (Bemvenuti *et al.,* 2005). Also, most studies on the impact of dredging on benthic organisms show that dredging can result in a 30-70% reduction in species variety, a 40-95% reduction in the number of individuals and a similar reduction in biomass in dredged areas (Newell *et al.,* 2004).

Furthermore, dredges can disturb the structure of the substrate, alter the biological community and modify sediment biogeochemistry, the rate of recovery subsequent to dredging varies with habitat and sediment type, composition of the resident biological assemblage and hydrodynamic attributes of the environment. Field experiments have compared a variety of dredges, locations, substrates and habitats at different spatial and temporal scales. Understanding the effects of dredging requires knowledge of the gear- specific impacts on different habitat types, the frequency and geographic extent of harvest disturbance and the biological and physical attributes of affected habitats (Smith *et al.,* 2006). Although dredging initially disturbs benthic habitat, the rate and extent of ecological recovery vary widely. Not all dredged styles produce identical effects on the sediment and so observed impacts are not always consistent across studies.

The impact of dredging might be contradictory when certain effects have both beneficial and detrimental consequences within the benthos (Smith *et al.,* 2006), for example, while dredging may initially damage certain organism, others including scavengers and opportunistic predators benefit by feeding on exposed prey or by colonizing newly exposed bottom surfaces (Bolan *et al.,* 2006). These complex factors have contributed to the variety of conflicting viewpoints associated with dredging impacts. Other researchers discovered that dredging can also perturbs aquatic environments by increasing suspended sediment concentrations, increasing sediment deposition, and increasing turbidity (water cloudiness), resulting in reductions in light and the burial of benthic communities (Chen *et al.,* 2021; Lekomo *et al.,* 2021; Szymelfenig *et al.,* 2006).

Heavy metals are inorganic elements essential for plant growth in traces or very minute quantities, toxic and poisonous in relatively higher concentrations, biologically undegradable but easily assimilated and bioaccumulated in the protoplasm of aquatic organism, Heavy metals are one of the more serious pollutants in our natural environment due to their toxicity, persistence and bioaccumulation problems. They are serious threat to the stability of the biosphere. (Tam and Wong, 2000). They are emitted during natural process between the water, sediments and atmosphere with which is in contact. The concentrations fluctuate as a result of natural hydrodynamic chemicals and biological process and also during human polluting activities which include burning of fossil fuel, mining, smelting, discharge of industrial waste, agricultural, domestic waste into water bodies and deliberate environmental application of pesticides (Lemus *et al.,* 1999).

Heavy metals like Cadmium (Cd), Nickel (Ni), Copper (Cu), Zinc (Zn), Lead (Pb) and Iron (Fe) have been proven to be hazardous when discharged into aquatic environment, and the aquatic environment with its water quality is considered the main factor controlling the state of health and disease in water and sediments. Pollution of the aquatic environment by heavy metals is a major factor due to its resultant effects on aquatic organisms including benthic organism because heavy metals can be incorporated into food chains and concentrated in benthic organisms to a level that affects their physiological state. Of the effective pollutants are the heavy metals which have drastic environmental impact on all organisms. Trace metals such as Zinc, Copper and Iron play a biochemical role in the life processes of all aquatic animals; therefore, they are essential in the aquatic environment in trace amounts. In most cases, the main source of copper and lead are industrial wastes as well as algaecides, while that of Cadmium is the phosphate fertilizers used in crop farms (FEPA, 2001).

Sediments are normally the final pathway of both natural and anthropogenic components produced or derived to the environment. Sediment quality is a good indicator of pollution in water column, where it tends to concentrate the heavy metals and other organic pollutants. And the occurrence of heavy metals in sediments is an indication of man induced pollution and high level of heavy metals is always attributed to anthropogenic influences rather than natural enrichment of the sediment (Uaboi-Egbenni *et al.,* 2010).

Contaminated sediment can cause lethal and sub-lethal effect in benthic and other sediment associated organisms (USEPA, 2001). Also, natural and human disturbances can release pollutants to the overlying water, where pelagic (water column) organisms can be exposed. Sediment pollutants can reduce or eliminate species of recreational, commercial or ecological importance, either through direct effects or by affecting the food supply which the sustainable population requires. The extent and severity of sediment contamination in U.S has been documented in the National Sediment Inventory (NSI). The evaluation of sediment contamination data indicates that thousands of locations have been affected throughout the country (USEPA, 2001).

Macrobenthic fauna are often referred to as macroinvertebrates, macro benthos, benthos or benthic macroinvertebrates and these are organism which are capable of inhabiting the bottom streams, ponds, river, lakes or attached to stones, woods macrophyte or a substrates of a water body(Chatzinikolaou *et al.,* 2006; Rosenberg and Resh 1993) defined macrobenthic invertebrates as organisms over 1mm in size and includes organisms of bottom dwellers which are usually retained by nets or sieve with mesh size of 0.6mm. Egborge (1994), defined benthic organisms as plant and animals which lives on or in bottom sediments or are attached to solid objects floating on or partly or completely submerged in water. Almost every taxonomic group inhabiting the freshwater is represented on the benthos or streams and rivers.

Macrobenthic invertebrates are been used to monitor the level of concentration of heavy metals in bottom sediments because they are the organism that lives on or inside the deposit at the bottom of a water body. In the water body there are several species of organisms, which cut across different phyla including annelids, coelenterates mollusks, arthropods and chordates. These organisms play a vital role in the circulation and recirculation of nutrients in aquatic ecosystems. They constitute the link between the unavailable nutrient in detritus and useful protein materials in fish and shellfish (Chatzinikolaou *et al.,* 2006).

Most benthic organisms feed on debris that settle on the bottom of the water and in turn serves as food for a wide range of fishes. They also accelerate the breakdown of decaying organic matter into simpler inorganic forms such as phosphates and nitrates. All forms of aquatic plants which are the first link of several food chains existing in aquatic environment can utilize their nutrients from benthic organism. These organisms therefore form a major link in the food chain as most fishes, birds and mammals depend directly or indirectly on the benthos for their food supply, hence their usefulness in the assessment of the aquatic environment by providing a more accurate understanding of changing aquatic condition than chemical and microbiological data, which gives short-term fluctuations. Ikomi *et al.* (2005) stated that the most popular biological method in assessment of freshwater bodies receiving domestic and industrial wastewaters is the use of benthic macro-invertebrates. In addition, they are of various taxa and different taxa are associated with different levels of water quality, and because they inhabit a vital position in the food chain of aquatic systems they can be used to make estimates of ecosystem health.

The composition, abundance, and distribution of benthic organisms can be influenced by water quality, which has to do with the differences in environmental conditions. On the other hand, sediments integrate contaminants over time and are in constant flux with the overlying water column and the analysis of heavy metals in the sediments permits detection of pollutants that may be either absent or in low concentrations in the water column. Heavy metals concentrations in the water column may be relatively low, but concentrations in the sediment may be elevated. It has been estimated that about 90% of particulate matter carried by rivers settles at the bottom sediments (Begum *et al.,* 2009).

Furthermore, several studies have shown that water bodies in the Niger Delta region of Nigeria are highly polluted as a result of the commercial activities in the region, activities such as shipping of crude oil, dredging, mining and other recreational activities.

However the river of study is been used for several activities which include fishing, sand mining and a jetty is located at the site of the study area also there is a gas and oil flow station close to station 1 in the study area at Okpare, and there is constant dredging of the area, hence it is highly necessary to perform assessment of the impact of dredging activities in Okpare creek based on Providing useful information on the heavy metals concentration on the bottom sediments of the river, to determine the benthic taxa composition, abundance, distribution and diversity of the sediment and assess the impact of dredging on the benthic fauna of the creek.

MATERIALS AND METHODS

Description of the Study Area

The study was conducted along the Okpare creek in Ughelli South Local Government Area of Delta State, Nigeria. The creek is situated between latitudes 05°27'N and 05°33'N and longitude 5°53'E and 6°04'E flowing northwest to southwest. Originating from Umuaja in Umutu and the River Niger, the Okpare creek empties into the Atlantic Ocean at Forcados, located within the equatorial region, this area experiences two distinct climatic regimes: the wet season, which typically runs from April to October and the dry season, which spans from November to March. However, the timing of these seasons has become increasingly unpredictable due to climate change with fluctuations observed from year to year. The area receives an annual rainfall of 47.1mm to 678.1mm with temperatures ranging from 23 varying between 23^0C and 37^0C during the day and dropping in the afternoon and dropping to 18^0C to 22^0C at night.

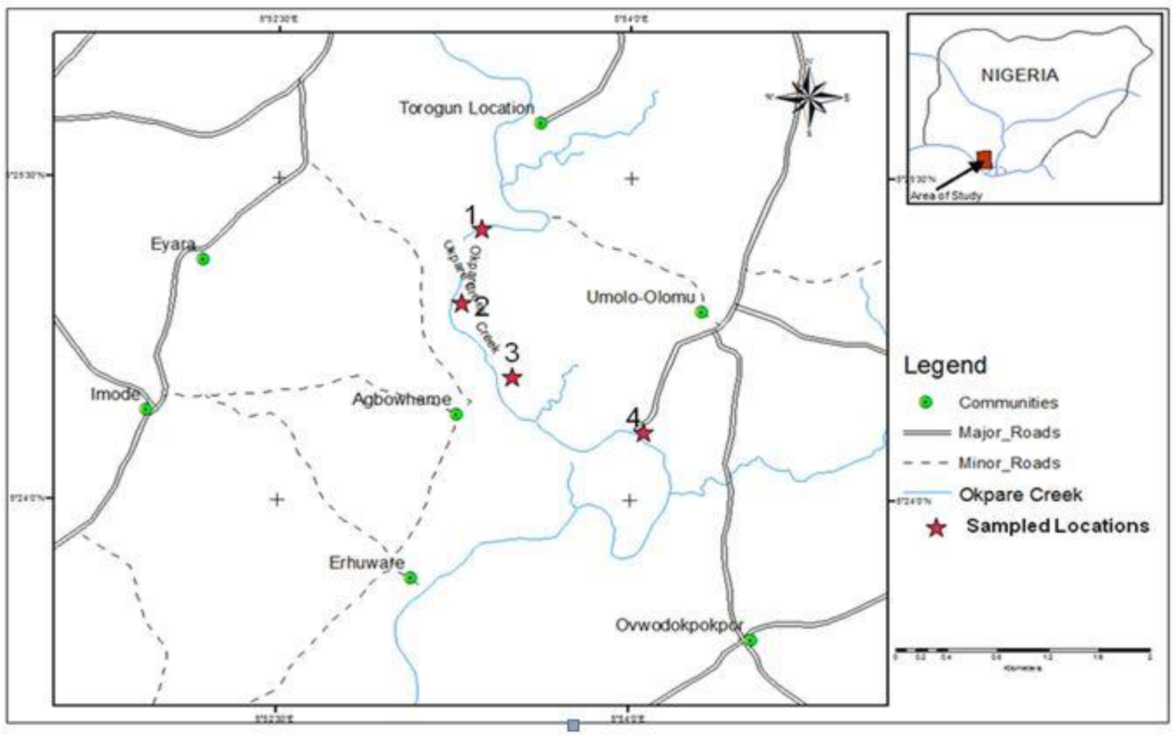

Figure 1: Map of the Study Area Sampled Locations along Okpara Creek

The area's geology is characterized by three main formations at varying depths: the youngest Benin formation at varying depths: the youngest Benue formation, underlain by the Agbada formation and then the oldest Akata formation. These formations are distinguished by their ages and levels of compaction with ages becoming progressively younger in a down dip direction, notably, the Benin formation serves as the primary aquifer in both the study area and the broader Niger Delta region, as reported by Shell Petroleum Development Company (SPDC) (EIA, 2004).

Sampling Stations

Four sampling stations were set up along the creek selected based on their unique ecological characteristics and levels of dredging activity. Despite these differences, the vegetation composition on the banks was similar across all stations.

Station 1: In station 1, substratum is primarily composed of coarse, sharp sand and decaying organic matter from nearby plants and trees. The creek's water depth measures 12 metres, with a flow velocity of 0.8meters per second. Fringed and marginal vegetation characterizes the area.

Station 2: This station is located about 4km from station 1, the substratum is composed of sand, clayey soil, and decaying organic matter. The water depth in the creek is approximately 18 meters, with a water velocity of 0.84 meters per second.

Station 3: This station is located under the Okpare-Olomu Bridge. This site is about 5km from station 2. The water depth is approximately 19.4 metres with a flow velocity of 0.92m/s. The substratum consists mainly of coarse sand in the mid- channel, with some muddy areas near the banks.

Station 4: This station is situated near a jetty, approximately 6km downstream from station 3. The water depth at this location is about 27.6 metres, with a flow velocity of 1.2 meters per seconds.

Sediment Sample Collection for Analyses

The samplings were conducted monthly for 12 months, spanning through February to January, covering rainy and dry season periods. The sediment sampling was collected using an Ekman grab as recommended for sandy and silty substrates. The collected material was processed following the methodology outlined by Olomukoro (2008). The sediment containing macroinvertebrates was preserved in a 10% formalin solution in labelled containers. Taxonomic identification of benthic organisms was facilitated by consulting relevant literatures and identification keys, notably the work of Ogbeibu and Egborge (1995), and Olomukoro (2008) while Composite of sediment samples for physicochemical parameters were stored in a labelled polythene bags and kept in an ice-chest box before transferring to the laboratory. The collected sediments were air dried at room temperature in the laboratory. The dried samples were then crushed to fine texture in a ceramic mortar, re-packaged in labelled polythene bags and stored in the laboratory. The assessed physicochemical parameters including pH, electrical conductivity (EC), percentage (%) total organic carbon (TOC), percentage total organic matter (TOM), % sand, % clay, % silt and heavy metals—cadmium, chromium, iron, zinc, lead, copper, and nickel. The sediment samples were dried to low constant weight, ground to powder and sieved using 2.0 mm mesh sized sieve (pH and particulate size) and 0.5 mm sieve for other analyses and thereafter were digested using the conventional Nitric-perchloric acid digestion method. The digested samples were then analysed for heavy metals using flame atomic absorption spectrophotometer (AAS). Inter-spatial comparisons of the levels of physicochemical parameters determined to test for significant differences in the physicochemical conditions using parametric analysis of variance (ANOVA). If significant value ($P < 0.05$) were obtained in the ANOVA, Duncan multiple range (DMR) test was performed to determine the location of significant differences.

RESULTS

Composition, Distribution and Abundance of Macroinvertebrates

A total of eight taxa of macroinvertebrate belonging to two orders (Odonata and Diptera) were obtained in the course of the sampling. They all belong to class Insecta. Seven of the identified macroinvertebrates belong to the order Diptera while the remaining belongs to order Odonata. The composition, abundance and distribution of the obtained macroinvertebrate are presented in Table 1 while Figure 2 shows the percentage composition of the various taxa. The overall abundance of the macro benthic invertebrates from the study stations shows no significant difference ($p>0.05$).

The order Diptera constituted 78.57% of all macrobenthic invertebrates encountered across the stations. The Diptera is represented by seven species within one family Chironomidae (Table 1). The remaining 21.43% constituted Odonata and its presence was restricted to stations 2, 3 and 4.

Diversity indices

Table 2 shows the summary of the diversity indices adopted in this study. Adopting the Margalef Index was minimal and maximal at stations 2 and 1 respectively. Equitability likewise evenness peaked at station 3. Shannon index of diversity varied across the stations; the minimal and maximal values of this index were recorded in stations 2 and 1 respectively.

Table 1: Composition, Abundance and Distribution of the Macroinvertebrate across the stations

Macroinvertebrates	Station 1	Station 2	Station 3	Station 4
Odonata	-	-	-	-
Libellulidae	-	-	-	-
Libellula sp	-	1	2	6
Diptera	-	-	-	-
Chronomidae	-	-	-	-
Chironomus fractilobus	6	4	1	3
Peutaneura sp	-	5	3	-
Clinotanypus sp	-	-	-	2
Chironomus sp	-	3	-	-
Polypedilum sp	1	-	-	-
Stictochironomus sp	-	-	1	2
Cryptochironomus	-	-	1	1

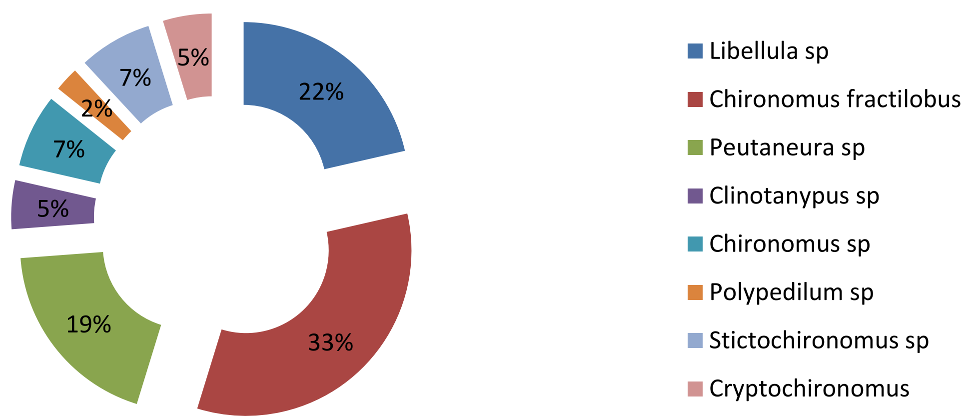

Figure 2: Percentage composition of the various taxa

Table 2: Summary of diversity indices of macroinvertebrate community of Okpare creek

	Station 1	Station 2	Station 3	Station 4
Taxa S	2	4	5	5
Individuals	7	13	8	14
Dominance_D	0.755	0.302	0.250	0.276
Simpson_1-D	0.245	0.698	0.750	0.725
Shannon_H	0.410	1.266	1.494	1.438
Evenness_e^H/S	0.754	0.887	0.891	0.842
Margalef	0.514	1.170	1.924	1.516
Equitability_J	0.592	0.913	0.928	0.893

Variations in the sediment physicochemical Parameters

Table 3 below shows the intraspecific and interspatial variations for the analysed physicochemical parameters in this study. With the exception of pH and cadmium, the other physicochemical parameters differ significantly ($p < 0.05$) across the station. The pH values across the stations were acidic. The mean levels of electrical conductivity in individual stations were generally < 300 µS/cm and intraspecific variations peaked in station 1. The total organic carbon and matter maintained similar variation, the minimum and maximum mean values were recorded in stations 1 and 3 respectively. Iron is the dominant heavy metal and its mean values ranged from 95.49 µg/g in station 2 to 312.40 µg/g in station 1. The trend for other heavy metals showed that zinc > chromium > lead > copper > cadmium. With the exception of copper, the highest values of other heavy metals were recorded at station 1 while the lowest values were generally recorded in station 2. For the intraspecific, the maximum values were recorded in station 1 for all the heavy metals except lead and copper. For the particle matters including sand, clay and silt, their variations complement one another, station 1 recorded the lowest and highest values by sand and silt respectively, opposite of this variation was recorded in station 4.

Table 3: Summary of Some Physical Chemical characteristics and Heavy Metals

Parameters	Unit	N	Station 1		Station 2		Station 3		Station 4		P-values
			Mean ± S. E	Min –Max	Mean ± S. E	Min –Max	Mean ± S. E	Min –Max	Mean ± S. E	Min -Max	
pH		10	4.55 ± 0.10	4.14 – 5.12	5.04 ± 0.13	4.18 – 5.78	5.10 ± 0.17	4.43 – 6.07	4.62 ± 0.24	3.59 – 5.83	P>0.05
EC	µS/cm	10	270.33 ± 50.43	3.89 – 628.00	2020.49 ± 1879.52	101.23 – 18936.00	135.19 ± 7.87	90.30 – 167.40	187.99 ± 21.13	4.09 – 224.00	P>0.05
TOC	%	10	2.66 ± 0.16	1.76 – 3.27	2.09 ± 0.19	1.28 – 3.23	1.66 ± 0.08	1.11 – 2.00	1.94 ± 0.23	1.03 – 2.97	P<0.05
TOM	%	10	4.43 ± 0.24	3.04 – 5.65	3.43 ± 0.25	2.21 – 4.63	2.85 ± 0.13	1.92 – 3.39	3.37 ± 0.34	1.78 – 5.14	P<0.05
Sand	%	10	80.40 ± 1.72	73.80 – 91.80	86.99 ± 1.42	80.40 – 94.50	89.40 ± 0.85	84.90 – 93.20	87.26 ± 0.93	73.80 – 95.40	P<0.01
Clay	%	10	14.67 ± 1.33	6.30 – 20.10	9.37 ± 0.95	3.80 – 13.50	7.61 ± 0.55	5.30 – 10.40	92.26 ± 0.90	87.50 – 95.40	P<0.01
Silt	%	10	4.51 ± 0.47	1.90 – 6.70	3.49 ± 0.43	1.70 – 5.80	2.78 ± 0.35	1.20 – 4.70	2.06 ± 0.15	1.10 – 2.80	P<0.01
Cadmium	mg.kg	10	0.77 ± 0.28	0.07 – 2.25	0.45 ± 0.19	0.02 – 1.43	0.37 ± 0.13	0.04 – 1.04	0.47 ± 0.18	0.06 – 1.33	P>0.05
Chromium	mg.kg	10	2.74 ± 0.27	2.11 – 4.91	1.43 ± 0.20	0.22 – 2.19	1.57 ± 0.16	1.09 - 2.79	1.96 ± 0.08	1.43 – 2.55	P<0.01
Iron	mg.kg	10	308.03 ± 23.19	202.16 – 395.43	92.94 ± 15.28	27.62 – 156.98	176.67 ± 19.19	110.64 – 278.68	243.35 ± 16.44	165.42 – 330.43	P<0.01
Zinc	mg.kg	10	6.43 ± 0.56	3.98 – 9.77	1.94 ± 0.24	0.36 – 2.75	3.05 ± 0.52	0.90 – 5.10	4.37 ± 0.46	1.98 – 6.07	P<0.01
Lead	mg.kg	10	1.47 ± 0.20	0.54 – 2.20	0.45 ± 0.19	0.02 – 1.53	0.81 ± 0.12	0.11 – 1.19	1.17 ± 0.21	0.17 – 2.09	P<0.05
Copper	mg.kg	10	0.69 ± 0.11	0.18 – 1.27	0.29 ± 0.07	0.09 – 0.72	0.57 ± 0.10	0.24 – 1.21	0.80 ± 0.15	0.28 – 1.64	P>0.05
Nickel	mg.kg	10	2.22 ± 0.20	1.28 – 3.29	1.00 ± 0.15	0.10 – 1.78	1.54 ± 0.13	1.00 – 2.13	1.95 ± 0.19	1.19 – 2.96	P<0.01

Similar indices indicate no significant difference

P<0.01 – High significant difference, P<0.05 – Significant difference, P>0.05 – No significant difference

DISSCUSSION

Sediment is usually employed as a pollution indicator by contaminants and it has also been described as a ready sink of pollutants and the level of physic-chemical characteristics in sediments determine the level of introduction of external materials into the aquatic environment rather than natural enrichment of the sediment by geological weathering (Davies *et al.,* 2006). Investigations on the physic-chemical parameters are not new especially in tropical fresh waters. Such studies which help to detail the physic-chemical characteristics of a water body are important for various reasons which may include establishing a database, finding the background pre-impact levels, determining usability by comparing them to standard levels or for impact assessment. This study was aimed basically at investigating comprehensively, the impact of dredging on heavy metals concentration and benthic macro invertebrate of sediment at Okpare creek and using them to draw conclusions on the status of the sediment in the river.

The monthly homogeneity in pH range in Okpare creek shows that the sediment is acidic. A similar trend has been reported by Awachie (1981). Acidic nature of African rivers had earlier been recorded by various workers (Ogbeibu and Victor, 1989; Olomukoro and Egborge, 2003; Egborge, 2001; Davies and Tawari, 2010;). The acidic nature is attributed to the presence of carbonates and biocarbonates in soils. The highest recorded pH (Hydrogen ion concentration) was in the month of February at station 3 and no significant difference ($p<0.05$) was observed between the stations.

Conductivity expresses the total ionic content of liquids and solid and when conductivity increases the concentrations of ions in water sample increases (Chinedu *et al.,* 2011). The electrical conductivity obtained in this study fall within the values obtained in Opete River by Egborge (2001) and similar to the range of 115.71-592.71 µS/cm obtained in Benin River (Ogbeibu and Egborge, 1995). The conductivity of the creek shows that the water is freshwater.

Total organic matter(TOM) values ranged from between 1.78 – 5.65(%wt) in the study stations and there was a significant difference ($p>0.05$) observed among the study stations this shows that total organic matter influenced the other physical and chemical sediment characteristics including reserve of exchanged bases and interaction and dynamics of trace metal, hence maximum soil/sediment capacity for heavy metals are adjusted according to these macro-nutrients (DPR 2002). Organically bound metals may dissociate as free ions and participate in cation exchange reactions with various minerals and leaving organisms, depending on ambient pH, ionic strength and temperature. Hence the organic matter of sediments is known to play a major role in determining the bioavailability of heavy metals (Abduraham 2001)).

The values of total organic carbon (TOC) recorded in this study are similar to values from selected major rivers in south-western Nigeria documented by Etim and Akpan (2012]. Extreme concentrations of TOC levels below 0.05% and above 3% have been implicated in decreased benthic abundance and biomass. The mean TOC obtained in the sediments from the study were within the risk associated values recommended by Hyland *et al.*, 2000].

The analysis of some heavy metals in this study permit detection of pollutants that may be either absent or low in concentrations in the water column. The concentrations of the heavy metals Fe, Zn, Ni, Cr, Pb, Cu and Cd were higher in stations 1 and this is attributed to anthropogenic impact (Davies *et al.,* 2006; Ogundele *et al.,* 2017; Vezzone *et al.,* 2018)

Iron(Fe) concentration were high in all four stations and this is attributed to human activities in the creek, which has been reported by (Olomukoro and Eloghosa, 2009; Olomukoro and Azubuike, 2009; Gielar *et al.,*., 2012) in their different studies but The mean concentration of Fe were lower when compared with the reported values of 28.1-33.7 mg/kg for Orogodo River sediments (Puyate *et al.,* 2007) and 31.19-58.34 mg/kg in the sediments of river Ngada [Akan *et al.,* 2010] . These changes are attributable to the nature of the anthropogenic activities carried out on the river. Fe has been reported to occur at high concentrations in Nigerian soil/sediment (Chukwuogo, 1990; Ezemonye 1992).

The value of Zinc (Zn) accounted for shows a highly significant difference($p<0.01$) among the study stations and it showed no significant correlation with any of the macro benthic invertebrates. It has been known that zinc occurs naturally in air, water and sediment, but the concentration of Zn is rising unnaturally due to addition of Zn through human activities such as dredging, mining, waste combustion and steel processing, Zn may also increase the acidity in the sediment and water and some fish can accumulate zinc in their bodies when they live in zinc contaminated environment and it is able to biomagnify up in food chain (Odu *et al.,* 2011; Muhammad and Hooke 2003).

Lead (Pb) values fluctuate between 0.028 and 2.202 in the study stations. The lead concentration values were higher at station 1 and a significant difference was observed between the stations. The high concentration of lead recorded in station 1 might be due to the nature of anthropogenic activities associated with petroleum products. The range values of lead recorded in this study was lower than the values (3.8-10.00 mg/kg and 4.85-8.52 mg/kg) obtained by Ogbeibu (2011) and Olomukoro and Azubuike (2009) in sediments at Benin River and Ekpan creek respectively.

Akan *et al. (*2010) states in their report that Chromium (Cr) reaches water bodies primarily from the discharge of industrial wastes and disposal of products containing the metal. The values recorded in this investigation were highly significantly different ($p<0.01$) at the stations and it was lower when compared to the mean values of 14.89-21.79 mg/kg for the bottom sediment of Ekpan creek (Olomukoro and Azubuike, 2009).

Cadmium (Cd) was also observed to have low concentrations in the sediments, its value ranges from 2.247 – 0.021. These heavy metals are closely associated with crude oil and its processed products and to extents municipal waste discharge (Chinda and Sibeudu, 2003). Nevertheless, some studies conducted elsewhere in the Niger Delta region reported similar trends as observed in their studies. (Kakulu and Osibanjo, 1988; Kakulu *et al.,* 1987; Davies *et al.,* 2006; Eja *et al.,* 2003)

Copper reaches water bodies primarily from the discharge of industrial wastes and disposal of products containing the metal. Copper has the maximum values of 1.64 at station 4. And it shows no significant difference at the study area. The range obtained in this study was higher than the values of Ekundayo (1998), and much lower than the range obtained in Opete bottom sediment. (Egborge, 2001).

Nickel value ranges between 0.10 – 3.29 in the study stations. A significant difference ($p<0.01$) was observed between the stations. The range obtained in this study was higher than the values obtained at Opete bottom sediment (Egborge, 2001). Consequently, some workers have reported the converse. In this study the general decreasing order of concentration in mg/kg was Fe > Zn > Ni > Cr > Pb > Cu > Cd.

The important factor in this study that affected the abundance of macrobenthic invertebrates is as a result of the dredging activities in the creek which resulted in 95% reduction in the benthic community of the sediment, other factors include: the physio-chemistry of the sediment, immediate substrate of occupation and food availability (Dance and Hynes, 1980). A total of 8 species comprising 42 individuals which belong to two taxa Diptera dominated the faunal composition (78.57%) while the Odonata accounted for 21.43% of macrobenthic invertebrates encountered in the study area and varied from records on earlier studies on pollution of Warri River at Opete (Egborge, 2001; Ogbeibu and Oribhabor, 2001). Also, the overall community composition of the study stretch is not comparable to these earlier studies where more than two taxa in the benthic community were encountered. These differences may be attributed to duration of the various studies, nutrient load, temporal variation and number of areas sampled at the studied stations.

Aquatic dipterans are the most ubiquitous of all the macrobenthic invertebrate groups in the tropics (Ogbeibu and Victor, 1989; Victor and Onomivbori, 1996), having seven species which include; *Chironomous fractilobus* (33.33%), *Peutaneura sp*(19.05%), *Clinotanypus sp* (4.76%), *Chironomus sp* (7.14%), *Polypedilum sp* (2.38%), *Stictochironomous sp* (7.14%) and *Cryptochironomus sp* (4.76%). *Chironomus fractilobus* was the most dominant species and it has been known to show no habitat restriction. It was the most abundant at station 1. Chironomids encountered in this study have been reported in many aquatic bodies within the tropic (Ogbeibu and Victor, 1989; Ogbeibu and Oribhabor, 2001; Olomukoro and Ezemonye, 2006). *Peutaneura sp* was the second most abundant species and it was more at station 2 and *Polypedilum sp* was the least occurred Diptera and it was present only at station 1. The Diptera encountered in this study at station 2 bears the bulk of the organism and station 2 bearing the bulk of the Dipteras is a reflection of the sand mining and fishing activities. All other diptera obtained in this study occurred in the documented taxa in the evaluation of the macro-invertebrate fauna in water bodies of southern Nigeria spanning the rainforest and derived savanna ecozones (Olomukoro and Ezemonye 2006; Ajao and Fagade 2002; Alves *et al.,* 2002).

Investigations revealed that all the species of Diptera indicate a negative insignificant correlation with the physiochemical parameters of the bottom sediment including percentage (%) organic matter and organic carbon.

The Odonata were poorly represented except *Libellula sp* (21.43%) that was encountered in the study. It was observed generally that Station 4 had the highest percentage of 66.67%, and stations 3 and 2 had a percentage of 22.22% and 11.11% respectively. There was no significant correlation between the species of Odonata and the parameters checked in the study. However, the number of taxa recorded from this study was low and have been reported on the studies of some water bodies (Olomukoro and Ezemonye, 2006).

The weak correlation of the macrobenthic fauna of the sediment to the physio-chemical parameters can be attributed to their physiological adaptations to the unfavourable environmental condition which resulted from the dredging activities. This assertion agrees with works by Ehirim *et al.* (2022). They stated that a weak correlation of animal groups such as Diptera and Odonata to temperature could be attributed to their physiological adaptation to anoxic conditions created by high temperatures that reduce oxygen dissolution, for example, *Chironomus* (Diptera) are noted to contain haemoglobin for trapping dissolved oxygen.

Species diversity is known to be highly variable in streams in response to disturbance, resource availability and the presence of suitable habitat (Fowler, 2002; Bemvenuti *et al.,* 2005). Higher diversity also results when many species have equal or near-equal opportunity of co-existence. (Victor and Ogbeibu, 1985), in support of this, observed that in the absence of disturbance, community composition may be strongly influenced by biotic interactions such as competition and predation. A decrease in diversity and corresponding increase in abundance of a limited number of species is a common community response to environmental disturbance. The diversity and evenness of species calculated by Shannon-Wiener function varied among the study stations. The higher diversity in station 2 is a reflection of its ecological heterogeneity and stability. The high evenness and low dominance index justify this situation, since the higher the evenness the higher the diversity, and the lower the dominance index, the higher the diversity (Victor and Ogbeibu 1985).

CONCLUSION

The study has shown that dredging activities has an impact on the community composition of the macro benthic invertebrate within the boundaries of an intensively- dredged site at Okpare creek. Dredging at this creek was associated with a significant suppression of population density, species diversity and biomass of benthic organism. The benthic community was dominated by one order of species within the boundaries of the intensively dredged site. However, the level of heavy metal in these creek calls for constant monitoring in order to safeguard the lives of humans and the organisms that resides in the creek and also to ascertain the true nature of what the environment should be.

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