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INTERTIDAL POLYCHAETES AS INDICATORS OF POLLUTION RESULTING FROM ANTHROPOGENIC ACTIVITIES ALONG THE OKPOKA CREEK, UPPER BONNY ESTUARY, NIGERIA

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ABSTRACT: *The Okpoka river and the Amadi creek are tributaries of the upper bonny estuary. The study is aimed at identifying the intertidal polychaete species and their abundance in these areas, and using them as indicators of pollution. Three stations were sampled for 6 months on a monthly basis at Marine Base, Abuloma and Kalio-Ama. Results gotten from Water samples collected from intertidal pools are as follows; Biochemical Oxygen Demand(BOD) (3.31-4.0)mg/l,, Dissolved Oxygen(DO) (6.40-6.44)mg/l, Conductivity (22.69-25.89)ms/cm, Total Dissolved Solids(TDS) (11.34-12.96)PPT, Salinity (13.65-15.74)PPT, pH (6.58-6.86), Turbidity (45.41-75.11)NTU, Temperature (28.30-31.82)^oC, Nitrate(NO_3) (2.11-4.10)mg/l, Phosphate(PO_4) (0.82-1.10)mg/l, Sulphate(SO_4,) (7.51-15.38)mg/l and Total Petroleum Hydrocarbon(TPH) (0.03-0.13)mg/l. The values of NO_3, pH, Conductivity, TDS, Salinity showed significance in location and time. PO_4 was significantly different between locations ($p<0.05$). BOD, SO_4, TPH and DO showed significance in time while Turbidity and Temperature showed no significance. Results gotten from Analysis done for sediment nutrient parameters such as NO_3(15.50-26.40)mg/l and PO_4(13.32-15.90)mg/l showed significant variations in location and time, TPH(21.93-34.71)mg/l showed significant variations in location and SO_4(15.85-19.71)mg/l had no significance in both location and time. Polychaete family and species identified in this study include: Eunicidae (Lumbrinereis aciculata, Lumbrinereis californiensis), Syllidae (Syllis ramosa, Syllis gracillis, Syllis armata), Capitellidae (Capitella Capitata), Spionidae, Glyceridae and Nereidae (Nereis diversicolor). The dry season witnessed a high number of polychaetes, about 65% of the total number of polychaetes collected from all study locations, while the wet season experienced a low count of about 34% of the total polychaetes collected from all sampled stations. The presence of lumbrinereis sp indicates negatively a poor benthic condition which was present with 25.8% abundance. The high abundance of Nereis sp with 45% abundance indicates heavy metals pollution and the presence of Glycera sp with 4% percentage abundance and Syllid sp with 15.6% percentage abundance indicates unpolluted conditions. In conclusion the abundance and diversity of polychaetes in Marine base, Abuloma and Kalio Ama were generally poor. This is evident by the poor abundance, composition and diversity of benthic fauna of the study area.*

KEYWORDS: Intertidal Polychaetes, Pollution, Anthropogenic Activities, Nigeria

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INTRODUCTION

The Polychaeta also known as the bristle worms or polychaetes, are a paraphyletic class of annelid worms, generally found in the sediment of the marine and brackish environment and having over 10,000 species (Knox 1977). Because the polychaetes are a major component of the sediment in marine and brackish environments they play an important role in the cycling of nutrients and other chemicals between the sediments and the water column. Polychaetes play important roles in the recycling of nutrients by breaking them down to organic particles to enable other life forms to access them for nutritional purposes. They play a vital part in the food chain as over 100 organisms prey on them; they provide food for fishes and their larvae. So it aids the fishing industry that provides food for humans (Fauchad and Jumars, 1979). However, the aquatic environment has been subjected to a drastic pollution during the last few decades due to industrial, agricultural and sewage effluents and runoffs from major rivers along their coasts (Bat *et al.*, 2018). Sediment is the sink for numerous classes of environmental pollutants in the aquatic environment (Ikem et al. 2003) both organic and inorganic and it harbours macrobenthic epifauna and infauna. The sediment in which the benthic organisms live is continuously modified by the introduction of new chemicals. The vast majority of these benthos are sedentary or very slow moving and therefore, susceptible to a variety of pollutants and disturbances. They are species with different tolerances to stress, they have a high sensitivity and tolerance to different environmental conditions and their ability to quickly respond to environmental changes (Knox, 1977). The intertidal layer is highly susceptible to pollutants from various sources of pollution, it generally contains organisms that adapt to difficult environmental conditions. Polychaetes can be used as indicators of quality of marine environment (Surugiu. 2005). The Bonny Estuary is one of the richest estuaries in the Niger Delta aquatic ecosystem, with a network of creeks/tributaries linking various habitats of highly economic and ecological importance. These ecosystems are often the site where many pollution problems exist (Saiz-Salinas and Gonzalez Oreja, 2000, Ekweozor et al., 2004) and where pollution loading caused significant changes in abundance and species composition. A number of studies have been carried out on the benthic communities of the upper Bonny estuary (Ekweozor, 1996; Umesi and Daka, 2004; Ikomah et al., 2005; Moslen et al., 2006; Daka et al., 2007; Daka and Moslen, 2013; Miebaka and Daka, 2013; Moslen and Daka, 2014; Moslen et al., 2015). This study is aimed at accessing the abundance and distribution of the intertidal polychaetes in these locations, hereby using the polychaetes as indicators of pollution caused by anthropogenic activities.

MATERIALS AND METHOD

STUDY SITE: Three sampling stations were located along the Okpoka river and Amadi creek (Marine base, Abuloma and Kalio-Ama). Duplicate samples were collected monthly for 6 months beginning from July to December 2020 from the sampling stations. The sampling stations and their geographical coordinates are as follows: Station 1 ($N04^0$ 46' 07.7", $E007^0$ 01' 49.7") and 2 ($N04^0$ 46' 10.7", $E007^0$ 03' 48.9")and 3 ($N04^0$ 45' 26.9", $E007^0$ 03' 53.5"). All sampling stations were located around the jetties, where boats are being parked and petroleum products are loaded, sewages and domestic waste dumps are being discharged by dwellers of this region. The activities around this region include dredging/sand mining by companies or locals, fishing, navigation by speed boat/vessels, transportation of people and petroleum

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products and recreational activities, parking of large vessels and ships, Boat making by boat making companies.

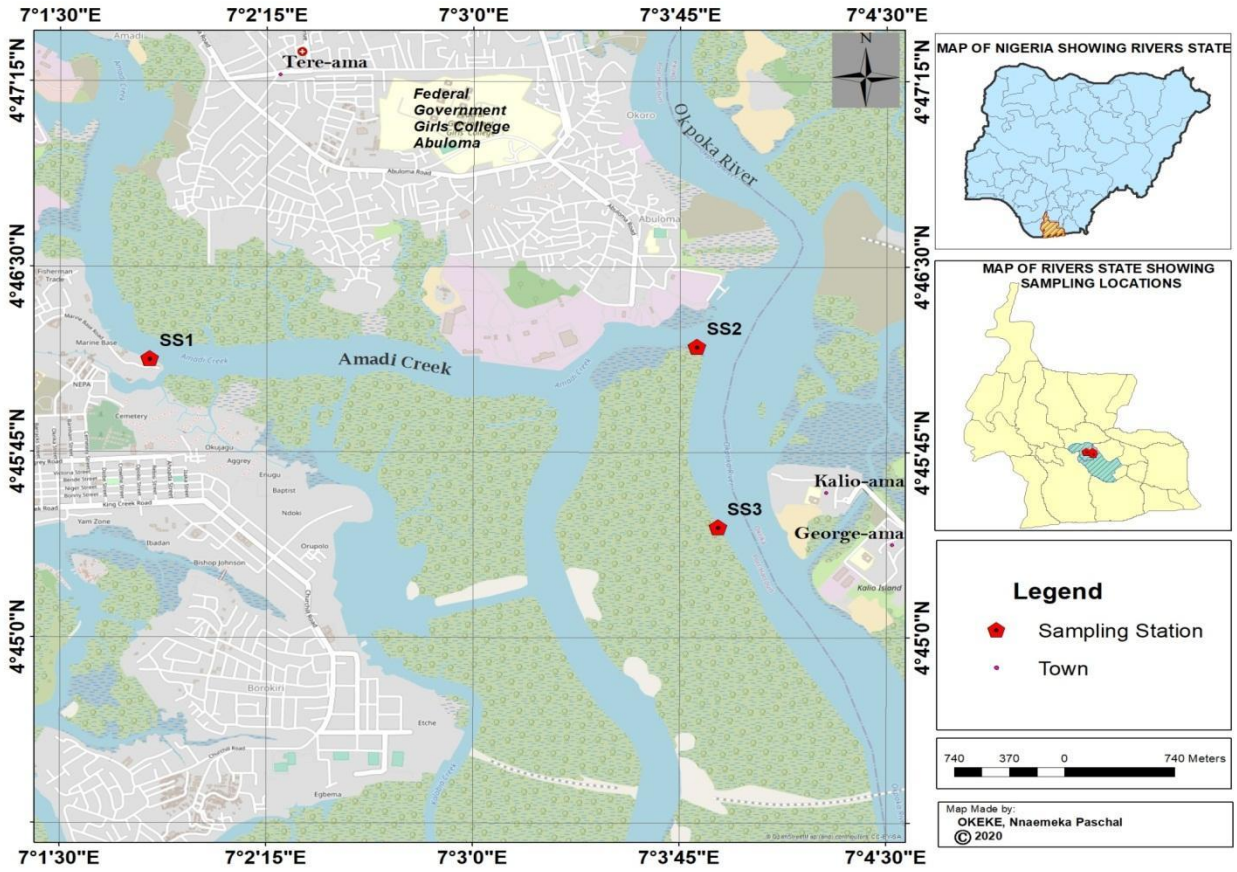

Fig 1: Map of Study area with Sampled Stations

Sample Collection and Analysis

Water and sediment Samples were collected along the shoreline of the Okpoka river and Amadi creek for 6 months. Insitu readings were carried out on the spot using Hanna HI 9829 Multi parameter Water Quality Checker to check for pH, temperature, salinity, conductivity, TDS and turbidity. Intertidal Sediments were collected with the use of a quadrant of 1ft by 1ft (24 cm^2) to a depth of 10 cm. 10 grams of the Sediment Samples were wrapped in properly labeled aluminium foils and put in ice coolers and taken to the laboratory for analysis. Sediment samples were dried at room temperature in the laboratory for the analysis of sediment characteristics. For the analysis of biological samples, sediment samples were washed using 0.5mm mesh sieve to obtain macro fauna. The materials retained by the sieve were placed in a container and preserved with 5% formalin as the preservative and 5% Rosebengal as the stain to facilitate sorting in the laboratory. Laboratory analysis of infauna was carried out shortly after field sampling. Aliquots of the samples were transferred on to a white surgical tray with water for sorting. The detrital sediment samples were then sorted using a pair of forceps and a hand lens. The macro-infanuna found were collected and preserved in small vials containing

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5% formlin water mixture. The contents were later identified to the lowest possible taxonomic level using appropriate keys (Day *et al.*, 1989) and others (Fauchald, 1977). Only the heads of organisms were counted, since the individuals were sometimes fragmented.Water samples were collected from the intertidal pools using plastic containers and stored in an iced cooler before being transported to the laboratory. Physico-chemical parameters were analyzed on sediment and water samples. DO, BOD, Nitrate, Phosphate and Total petroleum hydrocarbon (TPH) were analyzed using the standard method as stated in APHA (2012).

Data Analysis: Anova was used to test for significant differences in the physicochemical parameters that was measured across the three stations and the abundance of polychaetes. Tukey test also was used to analyse results using the Minitab software.

RESULTS

The months of July, August, September represented the wet season, while the months of October, November and December represented the dry season. The result of the physico chemical parameters for the study stations are summarized in Table 1.0. BOD values ranged from 4.0 - 3.3mg/l across stations over the period of study with Marine Base and Kalio-ama having higher BOD values than Abuloma. BOD values were significant ($P<0.05$) across the months of sampling. The mean NO_3 levels ranged from 4.1 – 2.1mg/l. Wet season had higher values. Abuloma had higher values in NO_3 followed by Marine Base and Kalio-Ama with a significant difference between months. The mean PO_4 level ranged from 0.8 to 1.1mg/l with Abuloma having higher value followed by Kalio-ama and Marine base. There was a Significant difference in location. The mean SO_4 levels ranged from 7.5 - 15.3mg/l with significance ($p<0.05$) in months. Kalio-Ama has the highest amount of SO_4 followed by Marine base and Abuloma with the least. TPH levels ranged from 0.0 - 0.1mg/l showing significance ($p<0.05$) in time, with higher values in dry season than in wet season. pH, EC, TDS and Salinity showed significant differences ($p<0.05$) across the time and location with Kalio-ama having higher pH values followed by Abuloma and Marine base. Turbidity and temperature had no significance ($p<0.05$) in both location or time, but had higher values in Abuloma and least values in Marine Base and Kalio-ama respectively. Analysis of physico chemical parameters in the sediment as shown in Table 1.1 showed that NO_3 levels in sediment samples from the study locations showed significance ($p<0.05$) in location and time, with values ranging from 15.5 – 26.4mg/l with Kalio ama having higher values followed by Abuloma and Marine base. PO_4, SO_4, and TPH had higher values in Marine base followed by Kalio-ama and Abuloma, with PO4 showing significance ($p<0.05$) in both location and time, SO4 showing no significant difference ($p<0.05$) in location and Time and TPH showing significance ($p<0.05$) in location. NO_3, PO_4, SO_4 and TPH had higher concentrations in wet season than in dry season

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Table 1.0 Mean Summary Table Of Physico Chemical Parameters Of Surface Water

	MARINE BASE	ABULOMA	KALIO AMA
BOD, mg/l	4.0±0.31	3.31±0.38	3.65±0.12
NO_3, mg/l	2.58±0.80	4.10±1.03	2.11±0.35
PO_4, mg/l	0.82±0.11	1.10±0.29	1.06±0.09
SO_4, mg/l	9.17±4.74	7.51±1.67	15.38±2.15
TPH, mg/l	0.03±0.02	0.04±0.06	0.13±0.16
pH	6.58±0.10	6.83±0.27	6.86±0.31
DO mg/l	6.43±0.59	6.44±0.53	6.40±0.54
EC ms/cm	22.69±1.73	24.15±1.42	25.89±0.83
TDS ppt	11.34±0.88	11.97±0.59	12.96±0.42
Salinity ppt	13.65±1.19	14.50±0.82	15.74±0.59
Turbidity ntu	56.05±15.62	75.11±13.97	45.41±8.12
Temp ^oC	28.30±0.45	31.82±5.25	29.60±2.01

Table 1.1 Mean Summary Table Of Physico Chemical Parameters In Sediment

	MARINE BASE	ABULOMA	KALIO AMA
NO_3, mg/kg	15.50±2.21	21.52±3.42	26.40±7.99
PO_4, mg/kg	15.90±1.77	13.32±2.76	13.59±0.99
SO_4, mg/kg	19.71±4.10	15.85±2.67	18.41±1.18
TPH, mg/kg	34.71±8.16	21.93±8.20	23.39±6.36

A total of 833 polychaetes were collected from sampled locations (Marine Base, Abuloma, and Kalio-ama). The dominant polycheate families are: *Eunicidea (Lumbrinereis aciculata, Lumbrinereis californiensis), syllidea (Syllis ramosa, Syllis gracillis, Syllis armata), Capitellidae (Capitella capitata), Spionidae, Glyceridae and Nereidae (Nereis diversicolor).* A total number of 354 polychaetes were collected from Marine base which constituted 43% of all polychaetes, 241 from Abuloma which was 29%, and 228 from Kalio-ama which was 27% as shown in Fig 1.1. The dry season witnessed a high number of polychaetes collection of 539 making up about 66% of the total number of polychaetes collected from all study locations, the highest counts of polychaetes during the dry season was from Marine base with 259 (31%) followed by Abuloma 149 (18%) and Kalio-ama 131 (15%). The wet season experienced a low count of 284 polychaetes which is about 34% of the total polychaetes collected from all sampled stations. The highest counts of polychaetes in this season was from Kalio-ama with 97 (11.6%) followed by Marine base with 95 (11.3%) and the least was Abuloma with 92 (11.1%) this is shown in fig 1.2 and 1.3. Out of the total number of

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polychaetes species collected from the sampled locations *Capitella capitata constituted* 2.8%, *Lumbrineris aciculata* 13.8%, *Lumbrineris californiensis* 12%, *Nereis diversicolor* 34%, *Nereis* sp 11%, *Spionidae* 6%, *Syllis gracilis* 2.9%, *Syllis ramosa* 3.7%, *Syllis armata* 9%, *and Glycera* sp 4% (Table 1.2). Out of the total number of polychaetes collected during the dry season the families *Capitellidae* constituted <1%, *Eunicidae* 18%, *Nereidae* 28%, *Spionidae* 5%, *Syllidea* 10% and *Glyceridae* 3%. While in the wet season *Capitellidae* constituted 3%, *Eunicidae* 7%, *Nereidea* 17%, *Spionidae* 1%, *Syllidea* 4.6% and *Glyceridae* 1%. During the dry season *Nereis sp* had the highest abundance at 2 locations, Marine base 121 and Kalio ama 100, and *Eunice sp* followed closely with 94 polychaetes at marine base *Syllid sp* followed closely with 67 polychaetes at Abuloma. During the wet season *Nereis* sp had the highest abundance at Kalio ama (76) and Marine base (53) which was followed closely by *Syllid sp* at Abuloma and *Eunice sp* at the same location. Other polychaetes found in this study had lower abundance but some had significant correlation with the nutrient parameters (Table 1.2) *Nereis sp* had no significance with any of the parameters but was more abundant. *Lumbrinereis sp* had a negative significance with NO_3 but had a positive significance with PO_4, SO_4 and Tph. *Capitellidae sp* had a negative significance with NO_3 and Tph but had a positive significance with Phosphate and Sulphate. *Spionidae sp* had a negative significance with all parameters tested. *Glycerides sp* had a negative significance with all parameters and *Syllidea sp* had a negative significance with all parameters tested.

Table 1.2: Monthly Summary of Specie Abundance of Polychaetes Identified in the Intertidal Sediment of the Okpoka River (July 2020 – December 2020)

Identified polychaete species	July	Aug	Sep	% Wet season	Oct	Nov	Dec	% Dry Season	Total (% abundance)
Capitella capitata	12	8	1	2.4%	2	0	0	0.6%	23 (2.8%)
Lumbrineris aciculata	16	5	16	4.4%	49	28	1	9.4%	115 (13.8%)
Lumbrineris californiensis	12	2	11	3%	21	49	5	9%	100 (12%)
Nereis diversicolor	15	19	74	12%	63	25	93	22%	289 (34%)
Nereis sp	3	4	28	4%	17	6	34	7%	92 (11%)
Spionidae	2	0	10	1%	5	33	0	5%	50 (6%)
Syllis gracilis	1	0	4	0.6%	7	7	5	2.3%	24 (2.9%)
Syllis ramosa	4	2	5	1.3%	9	11	0	2.4%	31 (3.7%)
Syllis armata	8	5	10	3%	20	23	9	6%	75 (9%)
Glycera sp	0	0	7	0.8%	14	6	7	3.2%	34 (4%)
Total polychaetes	73	45	166	34%	207	188	154	66%	833

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Table 1.2 Correlation between Sediment Chemistry And Polycheates

	Nitrate	*Phosphate*	*Sulphate*	*TPH*
Phosphate	-0.81013	1		
Sulphate	-0.36404	0.33014	1	
TPH	-0.84508	0.813527	0.555356	1
Syllid sp	0.143687	-0.69168	-0.12881	-0.31453
Nereis sp	-0.09877	0.179214	0.376943	0.11665
Lumbrineris sp	-0.79649	0.776901	0.635035	0.680962
Capitellidae	-0.72375	0.749673	0.648114	0.593869
Spionidae	-0.40296	0.255986	-0.20687	0.547633
Glyceridae	-0.0722	-0.47486	0.13924	0.055152

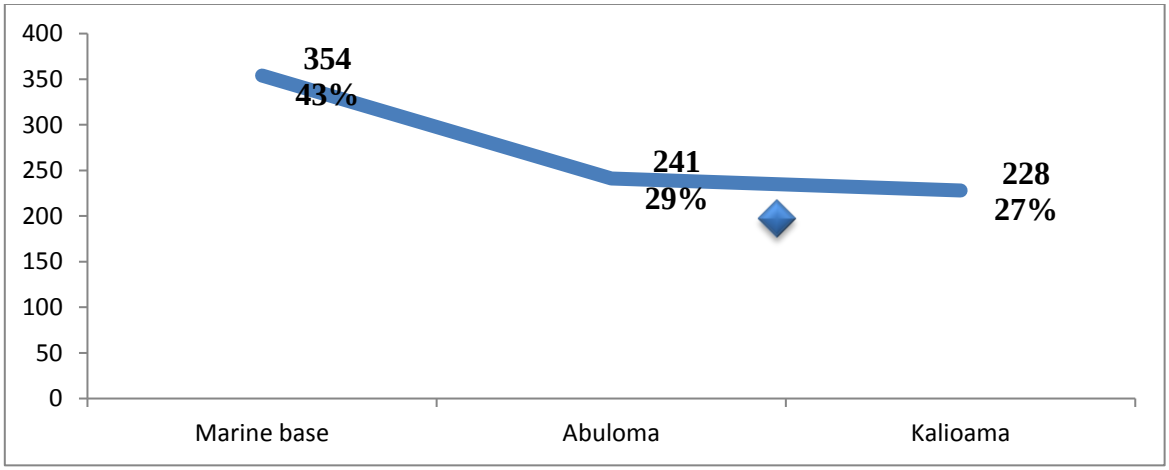

Fig 1.1: Distribution Abundance Of Polychaete Across Sampled Locations

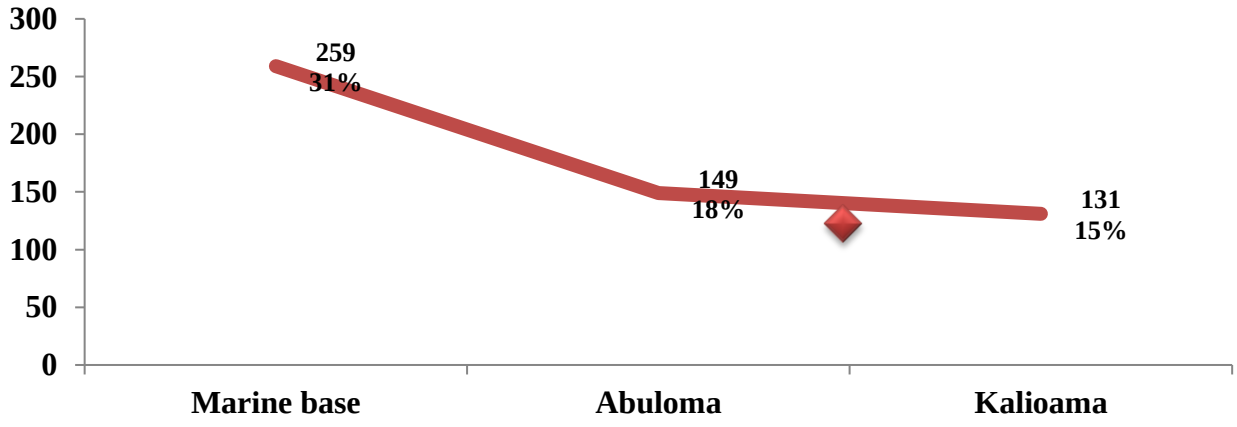

Fig 1.2: Seasonal Abundance Across Sampled Stations (Dry)

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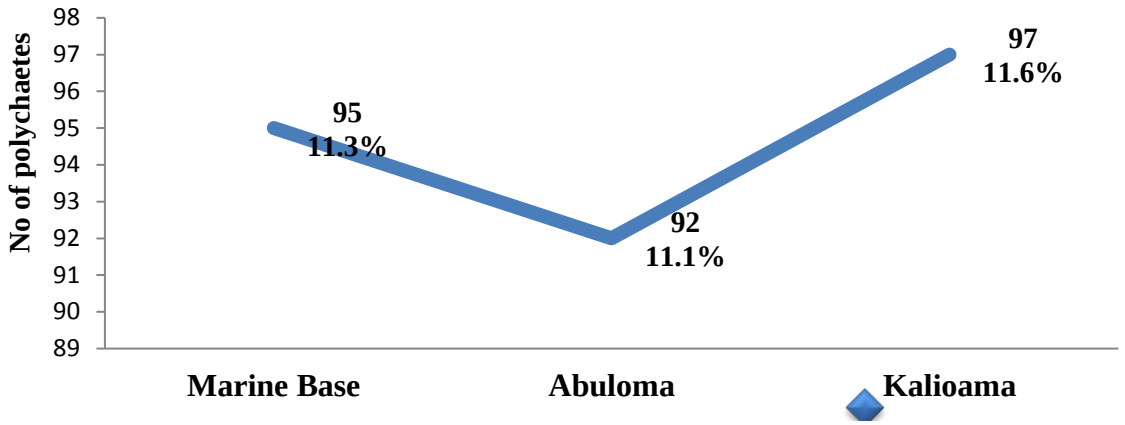

Fig 1.3: Seasonal Abundance Across Sampled Stations (Wet)

DISCUSSION

All analysis carried on water where within the permissible limits of WHO except PO_4, turbidity and temperature. PO_4 had higher concentrations generally which may be as a result of sewage, run offs or industrial effluent discharge in the river which causes organic enrichment in these waters. This result was higher than the results of Oluwayesimi *et al.,* (2016) who analyzed and compared the river waters in Port harcourt based on their physico chemical and microbial properties and PO_4 had values in the Okpoka river ranging from 0.188 - 0.28mg/l. Turbidity also had high values ranging from 45.41 – 75.11NTU which is higher than the WHO permissible limits. This can be as a result of dredging activities, nutrient enrichment (as a result of high PO_4 that eventually leads to eutrophication), navigation by speed boats or large vessels. The works of Oluwayesimi *et al.,* (2016) also stated that Okpoka river had the highest turbidity values ranging from 36.0 – 52.7NTU in comparison with other rivers worked on in Port harcourt. Temperature had slightly high values in abuloma (31.82±5.25)^oC as compared to the WHO limits. TPH had values ranging from 0.03 – 0.13mg/l which was low as compared to the work done by Moslen and Aigberua (2018) on heavy metals and hydrocarbon contamination of surface water at azuabie creek within the bonny estuary which values ranged from 0.07 – 45.20mg/l.

The nutrient parameters analysed on the sediment samples showed that NO_3 had high values ranging from 14.04 - 26.50mg/kg as compared to the work done by Wokoma and Friday (2017) on the sediment physico chemical characteristics in Sombreiro river River state, NO_3 values ranged from 1.34 – 4.0 mg/kg which was lower than the values gotten. An investigation done by Umesi and Daka (2004) showed that NO_3 values ranged from 0.97-6.47 mg/kg. Also the results of PO_4 ranged from 13.32 – 15.90 mg/kg which was higher than the findings of Wokoma and Friday (2017) whose values ranged from 0.39 – 2.97 mg/kg and the findings of Obunwo *et al.,* (2004). Sulphate showed results ranging from 15.85 – 19.71mg/kg in the sediments which was high as compared to the work done by Ogamba *et al.,* (2005). The high sulphate values are attributed to the strong influence of the sea water characterized by its High sulphate concentration (RPI. 1985). In addition, sulphate from effluent sources (leachates from dump sites and municipal runoffs) may possibly also contribute to the high concentrations observed. Tph had results ranging from 21.93 – 34.71mg/kg which was within the DPR permissible limits

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as compared to the results gotten from Chioma and Chioma (2014) that reported a high amount of TPH in the sediment of Bodo, Ogoni Land which ranged from 1007 – 1104mg/kg.

The result of the abundance and distribution of the Polychaetes have shown that the dominant polychaete families in this study area are *Capitellidae, Glyceridae, Nereidae, Eunicidae, Spionidae* and *Syllidae*. In comparison with the studies of George *et al.,* (2009) showed that a total of 19 species of polychaete was identified with *Nereis sp* being the most dominant in Okpoka river of the Bonny estuary. Work done by Anaero-Nweke (2013) who discovered that 6 Nereis species were dominant in the study area. Several other studies have observed negative effect of effluent discharge on the abundance and diversity of benthic community in the niger delta (Ekweozor, 1996; Umesi and Daka, 2004;Ikomah et al., 2005; Wake, 2005; Dean, 2008; Moslen and Daka, 2014). The observed differences in time and location may be attributed to the different anthropogenic activities and environmental differences particular to each area along the creek. Polychaete specie *Capitella capitata* showed lowest abundance both in dry season and wet season in contrast with Work done by Ajao and Fagade (1990), reported that *Capitella capitata* and *Nereis sp* were found associated with sites grossly polluted with organic matter, heavy metals and petroleum hydrocarbon and in conformity with the research done by Dean (2008) who stated that *Capitella capitata* species are more dominant in high organic situations associated with aquaculture facilities and sewage which is often a mixture of high organic materials. Also at one time the *Capitella capitata* was once believed to be indicators of environmental degradation. The works of Dean (2008) found out that *Capitella. capitata* were highly dominant at the most polluted site and were therefore designated as indicators of polluted conditions. The *Eunice sp* showed the second highest abundance both in dry and wet season. The *Eunice sp* have been used as negative indicators of poor benthic conditions, that is, their absence in a community is an indication of poor environmental condition (Olsgard *et al*., 2003). *Nereis sp* have been said to be indicators of highly polluted environments with heavy metals such as Cd, and Hg. Work done by Dean (2008) noted that the family *Nereididae* were found to be very sensitive to Hg while the more Hg tolerant specie was found to be the *Nereis diversicolor* and work done by King *et al.,* (2004) noticed that the family *Nereididae* are sensitive to a very high amount of heavy metal but aren't sensitive to a low amount of heavy metals. *Syllid sp* had only 15% of the total abundance of polychaetes gotten from the study location. Mendez *et al.,* (1998) indicated that the *Syllid sp* were considered tolerant of pollution and not indicators species. *Glycera sp* had only 4% of the total polychaetes obtained from the study location and work done by Pearson (1975) and Rosenberg (1976) indicated that glycerides species are characterized as indicators of unpolluted conditions.

CONCLUSION

The presence or absence of polychaete in Marine base, Abuloma and Kalio ama gives an indication of the possible pollutant present. This is evident by the abundance, composition and diversity of polychaetes present in the study area. . The presence of *Capitella capitata* indicates organic matter and petroleum hydrocarbon pollution which was the least present with 2.8% percentage abundance. The presence of *lumbrinereis sp* indicates negatively a poor benthic condition which was present with 25.8% abundance. The high abundance of *Nereis sp* with 45% abundance indicates heavy metals pollution and the presence of *Glycera sp* with 4% percentage abundance and *Syllid sp* 15.6% percentage abundance indicates unpolluted conditions. The findings of this result has given us a hint on the possible pollutant discharged

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into the aquatic system as a result of anthropogenic activities. The discharge of pollutants into this creek should be discouraged and awareness should be given to the dwellers of this region of the possible side effects these pollutants discharged could cause to this aquatic environment.

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