The Effect of Refinery Effluent on the Plankton and Benthic Composition of Okrika River.

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ABSTRACT
Background: It is evident that Ekerekana Creek in Okrika Local Government Area of Rivers State serves as the reciepient water body (environment) where petroleum Refinery effluent / run off are discharged. A study was conducted on Ekerekana Creek and its adjourning rivers (Okochiri, Okari-Ama and Ogoloma Rivers) to determine the effect of refinery effluent on plankton and benthic composition and distribution of Okrika River. **Methods:** Standard methods were used to ascertain the abundance and richness in population of taxa and species distributed at 4 (four) selected stations; Point of discharge of refinery effluent (S1), Upstream river water (S2), Downstream river (S3) and Ogoloma River (control station). **Result:** The distribution and abundance of phytoplanktons amongst the sampling stations were very poor. A total of 40 taxa were recorded with 3 families namely; Bacillariophycea, Cyanobacteria and Chlorophyceae with Bacillariophyceae dominating the entire phytoplankton distribution. In the same way the distribution and abundance of Benthic Organism were also very poor, a total of 6 (six) species from the family Nereidae were recorded namely; *Leonates decipiens, Dendronereis arborifera*, *Lopdorhynchus ucinatus*, polycheate larvae, *Capitella capitata* and *Arenicola* sp. **Conclusion:** It is evident from the results that the effluents / runoff discharged into the creek impacted negatively and species thriving in the study area especially at the point of discharge were pollution tolerant indicating continuous discharge of the effluents may totally eliminate the benthic fauna of the area, therefore continuous discharge of contaminated effluents into the creek should be discouraged while the development of more effective effluent treatment facility should be pursued.

Keywords: Okrika Creek, Refinery Effluents, Plankton and Bnthic, Composition, Port Harcourt Refinery

1.1 Introduction

Refining of crude oil into petroleum products for energy is essential for human development. The industrial setting requires large volumes of process water which in the process need to be recycled to meet up the demand. Unavoidably large scale contamination by process chemicals / biological additives does occur. The contaminants constitute pollution when discharged into the immediate environment without treatment [2].

It is evident that both the waste water and process water are treated in a water treatment plant, but the level of treatment can only be ascertained through the analysis of the discharged effluent at different points of their exit into the adjoining environment [1].

Similarly, no matter how little the contaminants may be in the discharged waste water, the interactions of such residual chemical / biological contaminants with the existing physical environment would be at risk and may subject the environmental composition therein to partial or outright pollution / loss of environmental esthetics and pollution [1].

The aquatic environment exists in form of running streams, creeks, marine and estuary, lakes/seasonal water bodies. These form natural habitat for a great diversities of fish species, benthos, worms (annelids), plants of all sizes and species, different classes and species of micro-organisms. These species (flora and fauna) interact with one another and also with their immediate environment (water and mudflat/sediment) as well as the atmosphere for a balanced energy transfer / exchange [5]. These interactions are perfect when the environment is natural (ie without pollution).

It is good to also recall that estuaries serve as major sources of dietary protein to man by way of supporting artisanal fishery activities of local fishermen [5]. This occupational support, stem from the fact that such an ecosystem serves as major habitats for several fresh water and marine species.

This study considers the effect of Refinery Effluent on the planktonic and benthic composition of Okrika River in the Upper Bonny Estuary, Niger Delta. The discharge of waste water continues in an unrestricted manner into the aquatic environment without regards to their impact on the aquatic ecology. This is done with the view that water has the capacity of transferring substances from one point to another and allows interactions to occur between solutes without the water been seriously affected [5]. This notion maybe misleading especially if it is accepted that pollution is a gradual process.

Therefore, allowing the toxicants to accumulate overtime may impose serious stress on the environment thereby causing harm or gradual elimination of some important sensitive flora and fauna.

2.0 Materials and Methods

2.1 Description of the study area

The sampling stations were established along Okrika Creek in Okrika Local Government Area, of Rivers State, Nigeria. The creek is brackish as evidenced in their vegetation, which consists mostly of *Rhizophora racemosa* that lined the shores of these stations and *Avicennia nitida* at the inner shoreline. The creek is also naturally tidal. Anthropogenic activities along the creek include sand mining or dredging, fishing, navigation, washing, bathing and recreational activities. A major industrial outfit which is situated in station 1 (Ekerekana) is the Port Harcourt Refinery Company (PHRC) [a subsidiary of the Nigerian National Petroleum Corporation (NNPC)], which generates several volumes of effluents that is channeled into the creek via a drainage system. Three (3) main sampling stations were selected and established for this study as indicated in figure 1 and are described below:

- Ekerekana Creek which served as the Point of Discharge into the river (S.1)
- Okochiri Creek as station 2 (S.2), that represented the Upstream of the River
- Okari-ama Creek as station 3 (S.3): Representing the Downstream of the River
- Ogoloma Creek as Station 4 (S.4) representing the Control station

2.2 Sample Collection and Method

2.2.1 Phytoplankton Analysis

Phytoplankton samples were collected in three sample stations and a control station (S.4). Samples were collected using standard plankton net that was towed for 10 minutes with a slow moving boat. At the end of the tow, phytoplankton filtrate was washed into a vial bottle and preserved with 5% formaline and stained with Rose Bengol solution in the laboratory for microscopy identification and taxonomic grouping.

2.2.2 Benthos analysis

Benthos samples were collected in 3 sampling stations and a control station (S.4). Sampling was done using Eckman's grab and a 0.5mm mesh net for sieving of collected sediment before sieved filtrates were transfered to a well labelled plastic container, fixed with 10% formalin and also stained with Rose Bengol solution in the laboratory before isolating the benthic organisms using a microscope, pairs of forceps and a tray**.**

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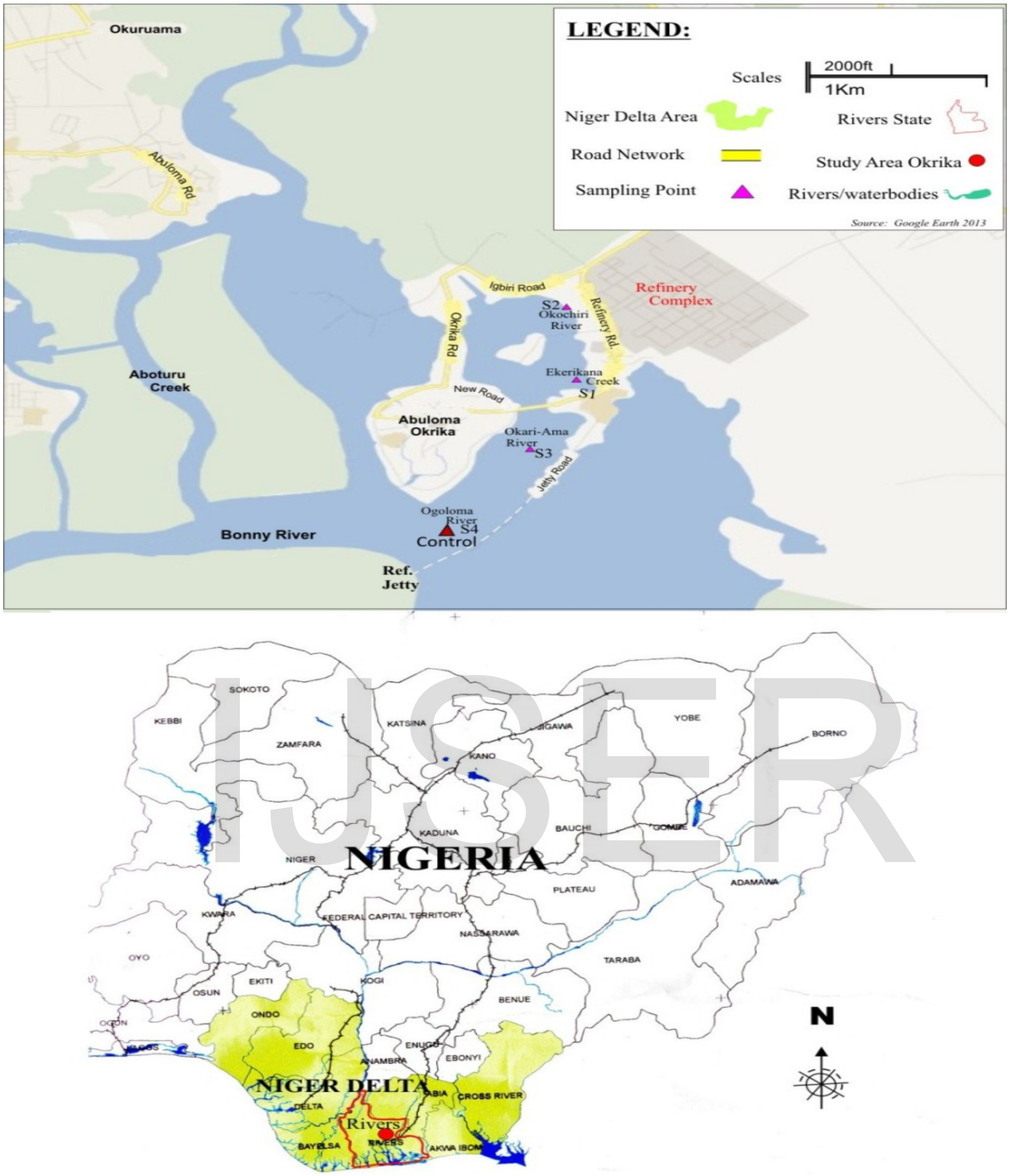

Fig. 1: Map Showing Nigeria, Niger Delta, Rivers State and Okrika the Study Area

3.0 RESULTS

3.1 Level of abundance and distributions of phytoplankton

The level of abundance and distributions of phytoplanktons are shown in Table 1 below:

Table 1: Results for phytoplankton distribution, abundance, density and richness

S/N	Family Bacillariophyceae	POD station 1	Upstream station 2	Downstream station 3	Control station 4	Total

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1	*Nitzschia* sp.	-	1	1	3	5
2	*N. palea*	-	1	3		4
3	*N. sigma*	-	3	1	1	5
4	*N. lanceolata*	-	1	2		3
5	*N. filiformis*	-	3	2	1	6
6	*N. vermicularis*	-	-	-	7	7
7	*N. ricta*	-	1	-	1	2
8	*N. linearis*	-	-	-	2	2
9	*N. denticula*	-	-	-	1	1
10	N. kutzingiana	-	-	-	1	1
11	*N. acicularis*	-	-	-	9	9
12	*N. dissipata*	-	1	-	-	1
13	*N. longissima*	-	1	-	-	1
14	*N. sigmoides*	-	3	-	-	3
15	*N. paleacea*	-	1	-	-	1
16	*Achnanthes* sp.	-	1	1	-	2
17	*Lanceolata*	-	1		-	1
18	*Melosira italic*	-	-	31	-	31
19	*M. granulate*	-	1	4	-	5
20	*M. distans*	-	-	1	-	1
21	*Pinnularia* sp.	-	-	1	-	1
22	*P. viridis*	-	1	-	-	1
23	*Eunotia* sp.	-	1	-	1	2
24	*Stauroneis anceps*	-		-	2	2
25	*Caloneis* sp.	-	3	-	14	17
26	*Diatom* sp.	-	1	-	2	3
27	*Synedra* sp.	1	-	-		1
28	*S. ulna*	-	-	-	2	2
29	*Cymbella* sp.	-	-	-	3	3
30	*C. lanceolata*	-	-	-	1	1
31	*C. cistula*	-	-	-	1	1
32	*Epithemia argus*	-	-	-	1	1
33	*Surirella elegans*	-	-	-	1	1
34	*Cyclotel lacomta*	-	-	-	1	1
35	*Coscinodiscus lacustris*	-	-	-	1	1
	Density (cells/L)	1	25	50	53	129
	No of Species	1	17	12	19	49
	Family Chlorophyceae					
36	*Phytoconis* sp.	45			2	47
37	*Anacystis* sp.	65		11		76
	Density (cells/L)	110	0	11	2	123
	No of Species	2	0	1	1	4
	Family Cyanobacteria					
38	*Lyngbya* sp.	3	1	1		5
39	*L. limnetica*	-	8	-	13	21
40	*Oscillatoria putrida*	-	-	1	-	1
	Density (cells/L)	3	9	2	13	27
	No of Species	1	2	2	1	6
	Density / station	114	34	63	68	279
	Total Species	4	19	15	21	59
	Relative abundance (%)	40.8	12.2	22.6	24.4	100

	Margalef richness index	81.5	11.2	23.0	22.0	

Table 1 represents each of the major families of phytoplankton distribution and abundance during the period of study. A total of 40 species belonging to 3 families were recorded namely; Bacillariophyceae (35), Chlorophyceae (2) and Cyanobacteria (3).

The most diversed family with the highest distribution is Bacillariophyceae which was represented by 35 species and constituted 49 of total species. The dominant genus of the Bacillariophyceae were *Nitzschia* with 15 species though poorly distributed.

Highest density (cells/L) of (53) with 19 species were found in the Control station, followed by Downstream river water which recorded (50) density (cells/l) with 12 species, Upstream river recorded (25) density (cells/l) with 17 species and Only one (1) specie and density (cells/l) (*Synedra* sp.) was found in the POD (Point of Discharge) close to the refinery.

Chlorophyceae recorded 2 species with 123 total number of density (cells/l) and constituted 4 of total species. POD close to the refinery recorded 2 species (*Phytoconis sp.*and *Anacystis sp.*) with the cell counts of 45 cells/L and 65 cells/L respectively which culmulated to dencity (cells/L) of 110, Downstream river recorded 1 specie (*Anacystis sp.)* and 11 density (cells/l), Control station had 1 specie (*Phytoconis sp.*) and 2 density (cell/l) and Upstream river had no specie.

Cyanobacteria had the least number of density (cells/l) 27 and constituted 5 of total specie higher than chlorophyceae. Control station had 13 density (cells/l) with 1 specie (*L. limnetica*), Upstream river recorded 9 density (cells/l) with 2 species (*Lyngbya* sp. and *L.limnetica*) 1 and 8 respectively, POD close to the refinery recorded 3 density (cells/l) with 1 specie (*Lyngbya* sp.*)*, while Downstream recorded 2 density (cells/l) and 2 species (*Oscillatoria putrida* and *Lyngbya* sp.*)*.

Highest relative abundance (40.8%) was in the POD river (station 2), followed by (24.4%) in the control station, (22.6%) in the Downstream river water (station 4), and the least (12.2%) was in upstream river water (station 3), this culminated to the specie richness of 81.5, 23.0, 22.9, and 11.2 respectively.

3.2 Level of abundance and distributions of benthic organisms

Data on benthic organism in respect to distribution and abundance among sampling stations are presented in Table 2. The Table showed very poor distribution and low abundance of benthic organism. A total of 6 species from the family Nereidae were recorded. POD (Point of Discharge) river close to the refinery discharge point had 2 species *Capitella capitata* and *Arenicola* sp. with cell counts of 8 and 2 respectively. No benthic organism was found in the Upstream river. Downstream river recorded 4 species *Arenicola* sp.,*Ceratonereis keiskama*, *Capitella capitata,*and *Dendronereis arborifera* with cell counts of 9, 4, 3, 2 respectively. All the 6 species were however found in the control station with *Ceratonereis keiskama* dominated the control with 72 individuals followed by *Leonates decipiens*, *Dendronereis arborifera*, *Lopdorhynchus ucinatus,* polycheate larvae, *Capitella capitata* and *Arenicola* sp. with cell counts of 49, 38, 13, 11, 7. The Relative abundance in the POD was 4.5% with a corresponding low richness index of 12.8, Downstream 8.0% with richness index of 12.1, and control station 87.3% with richness index of 102.6.

Table 2: Benthos distribution, abundance, density and richness

S/N	Nereidae	POD Station1	Upstream station 2	Downstream station 3	Control station 4	Total

1	*Lopdorhynchus ucinatus*	-	-	-	13	13
2	*Ceratonereis keiskama*	-	-	4	72	76
3	*Dendronereis arborifera*	-	-	2	38	40
4	*Leonates decipiens*	-	-	-	49	49
	Density (organisms/cm^2)	0	0	6	172	178
	No of Taxa	0	0	2	4	6
	Polycheates					
5	*Capitella capitata*	8	-	3	7	18
6	*Arenicola spp.*	2	-	9	6	17
7	Polycheates larvae	-	-	-	11	11
	Density (organisms/cm^2)	10	0	12	24	46
	No of Taxa	2	0	2	3	7
	Density / Station	10	0	18	196	224
	Total Specie	2	0	4	7	13
	Relative Abundance (%)	4.5	0	8.0	87.5	100
	Margalef richness index	13.0	0	12.3	100.2	

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4.0 DISCUSSION

4.1 Phytoplankton distributions and abundance

Phytoplankton distribution and abundance was very poor, and the algal flora of the creek / river water was found to be sparce. The species diversity of phytoplankton was low, and that was why the primary production and productivity was equally low. Phytoplankton density was higher at the unaffected areas of discharge (Downstream and control station) of the river, even though the species diversity was relatively low. The spatial variation was no doubt related to both geographical influences and influx of the discharge. Nevertheless, the general reduction in species diversity must be seen as evidence of the polluting effects of the oil industry effluent discharges on the phytoplankton population. Reduced productivity of phytoplankton and/or algae will have a knock on effect to the other organisms in the environment, such as crustaceans and fish because they provide nutritional base for them and other zooplanktons [4]. However, the dominance of Bacillariophyceae in this study is not an unusual occurrence. Many phytoplankton studies have reported the dominance of Bacillariophyceae in rivers and creeks of the Niger Delta in Nigeria. [6] concluded that the species with the highest self-sustaining natural mechanisms of natural increase usually become dominant. This may account for the widespread dominance of Bacillariophyceae in this study.

4.2 Benthic organism distribution and abundance

Data on benthic organisms with respect to distribution and abundance among sampling stations showed poor distribution and low abundance of benthic organisms (Table 2). The low diversity of benthic organism in this study is not unusual. The dominance of polychaetes at the Point Of Discharge (*Capitella capitata* and *Arenicola* sp.*)* where the refinery effluent is emptied can be attributed to their high level of pollution-tolerance. No benthic organism was seen in the Upstream of the river. Downstream of the river had more species (Table 2) while at the control station all 6 species were present though in low abundance and distribution which could be due to low pollution as compared to other stations. The results showed strong relationship between the results of pollution from physico-chemical contaminant of the discharged effluent [1] and the distribution of organisms along the creek. This is an indication of the ability of the organisms to survive, adapt, migrate or die under favorable and unfavorable environmental conditions. Similar trends in the correlation between the physico-chemical quality and the distribution of organisms have been reported by [7] and [3]. The weak correlation of some of the fauna such as *Lopdorhynch usucinatus, Ceratonereis keiskama, Dendronereis arborifera and Leonates decipiens* to water quality parameters can be attributed to their physiological adaptations to the unfavorable environmental conditions. The differences in species composition and abundance may be attributed to the ecological differences of the different habitat locations and period of investigating the water quality. The diversity of benthic macro-invertebrates in the study areas was generally very low.

5.0 Conclusion

Fauna and flora composition, abundance and distribution in the river water were very low which could be attributed to high concentration of pollutants present in the discharged effluent. However fauna and flora found at the point of discharge into the river were pollution-tolerant but further downstream it was noted that they slowly increased in their numbers.

It was therefore noted at the end of this study that the discharged effluent from Port Harcourt Refinery Company (PHRC) [a subsidiary of the Nigerian National Petroleum Corporation (NNPC)] resulted in pollution of the river water bodies and greatly affected the abundance and distribution of planktons and benthic composition within the creeks.

References

1. Anaero-Nweke, G.N., (2013). Impact of Oil Refinery Effluent on the water quality; case study of Ekerikana creek in Nigeria. M.Sc, Thesis, Kwame Nkrumah University of Science and Technology, Kumasi, Ghana.

2. Basheer, H.D., Wan M.A, A.R. Aziz, A.B.,(2011). Treatment technologies for petroleum refinery effluents. *Process Safety and Environmental Protection,* 89, 95–105.

3. Dean, H.K. (2008). The use of polychaetes (Annelida) as indicator species of marine pollution. *Rev. Biol. Trop.* (*Int. J. Trop. Biol.,* 56 (Suppl. 4), 11-38.

4. Joseph, V., and Joseph, A., (2002). Ecology and seasonal variation of microalgal community in an Oil refinery effluent holding pond: monitoring and assessment. *Environmental Monitoring and Assessment*, 80, 175–185.

5. Nweke, A. A., (2002). Impact of Organic Waste Pollution on the macrobenthos and fish fauna of Elechi creek. Ph.D. thesis, Rivers state University of Science and Technology, Port Harcourt, Nigeria, 287pp.

6. Ogamba, E.N., Chindah, A.C., Ekweozor, I.K.E., and Onwuteaka, J. N., (2004).Water quality and phytoplankton in Elechi creek complex of the Niger Delta. *Journal of Nigerian Environmental Society* (*JNES*), 2(2). 121-130.

7. Wake, H., (2005). Oil refineries: a review of their ecological impacts on the aquatic environment. *Estuar. Coast Shelf Sci.*, 62, 131–140.