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BIODIVERSITY SURVEY OF THE MACROBENTHIC INVERTEBRATE COMMUNITY OF AN OIL DRILLING ENVIRONMENT IN THE MARINE WATERS OF NIGERIA.

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ABSTRACT

The effect of drilling activities on the macrobenthic community of an oil drilling environment was monitored. Physichemical parameters were determined and macrobenthic specimens were collected. The data collected were used to measure biological integrity and reflect the health of the marine ecosystem investigated. Pollution due to oil drilling activities was the primary determinant of the biodiversity of the macrobenthic community. There was gross organic contamination of the seabed around the oil drilling area. Dissolved oxygen levels were generally low, while ammonia and phosphate levels, and suspended solids were generally high in the oil drilling area. Diversity indices and biotic quality were equally generally low around the drilling area and there was a positive correlation between the two indices. Macrobenthic fauna showed a pattern of distribution centred as distances farther away from the oil drilling area. Capitella capitata exhibited the largest gradient relative to drilling activity. There were altered distribution of species diversities, densities and percentage population abundance and biomass indicating that the stations (stations 1 – 4) closed to the drilling area are characterized by degraded biodiversity communities, compared with the control stations (stations 5 – 7) which are 10000 metres away from the drilling environment.
***Keywords**: Biodiversity, Community, Drilling activities and pollution.*

INTRODUCTION

Biodiversity surveys are important tools for the assessment of any damage done to biological resources due to human activities (Thomas, 1993). For ecological surveillance, it is important and necessary to study the benthic facet of biological community in the marine ecosystem. Fauchald and Jones (1978) reported that benthic communities are the most useful tools for auditing a surveyed marine environment.

The survey of the macrobenthic species of an oil drilling environment is important because the organisms live in contact with the sediments and often ingest sediments and suspended particulars which may contain organic food or contaminants. However, benthic invertebrates may show changes in diversity due to pollution of the seabed, which may lead to enhancement of species and degradation of the community. Environmental variables such as organic production, temperature, pH, dissolved oxygen, among others and variation in general physiocochemical properties of the marine waters are usually influenced by

drilling and other operational activities and benthic organisms therefore respond to the gradients and the variation of these environmental variables. The correlation of benthic organisms distribution and physical and chemical variables, provide insight into the processes that influence the composition of the community assemblage. The purpose of this investigation is to assess the impact of drilling operations on the macrobenthic biodiversity and community of the seabed environment.

STUDY AREA

The study area is located at Latitude 4° 3'; Longitude 7° 34' off the shore coast of Ibeno in Akwa-Ibom state (Figure 1). The depth of the reference point is 108.83 metres. The area is characterized by bimodal rainfall pattern. (Annual range 1278-3008 mm) and prevailing south-west winds.

MATERIALS AND METHODS

Field Studies

Physicochemical Parameters

Water samples from a depth of 0.3m, 5m, 10m and 20m were taken using a Khalisco water sample. Five aliquots of samples were taken per station and this constitutes one composite sample. The samples were refrigerated pending laboratory analysis. The pH was determined using the a digital glass electrode pH meter, while the temperature was determined using a mercury-in-glass thermometer of celcius scale. Dissolve oxygen was determined, using Beckman portable field meter. Ammonia levels were measured using Mackereth (1963) methods of Ammonia estimation, while phosphate levels were determined using the klet colorimeter. The total suspended solids were measured by weight determination, and standard four day biochemical oxygen demand was analysed by a modified Winkler technique (Asterberg, 1975).

Sampling of Macrobenthic Fauna

Seven sampling stations were established around an oil drilling area. Station one was made the reference point and other stations were selected at various distances to the shore from the oil drilling area. A transect direction was chosen shore-wards because the net movement of water and tides were towards the shoreline. The selected stations were station 1 (500m), station 2 (800m), station 3 (2,500m) and 4 (5,000m). Three control stations: stations 5, 6 and 7, which were presumed not to be affected by pollution were selected approximately 10,000m along the transect direction and away from the oil drilling area. Sampling was carried out aboard a vessel, and the Magellan GPS NAV 50000 PRO™ handled receiver was used for absolute location and geodetic positioning of the locations. Macrobenthic specimens were collected, using an $0.1m^2$ van-Veen grab sample of 15.0 cm diameter. The bottom sediment collected by the grab sampler was searched manually and the benthic fauna were removed using a pair of long forceps. The remaining sediment in each grab sample was washed in 0.5mm mesh sieve with sea-water. The retained fauna in the sieve and the ones removed with forceps were preserved in 5% formalin and labeled in each sampling station.

Laboratory Studies

In the laboratory, the samples were sorted, counted and identified using illustrations in Olaniyan (1968); Yoloye (1988); Segun (1989) and standard designed by Bellinger, (1992).

Data Analyses

In order to remove the effect of heterogeneity of variance, data collected during this study were normalised using long (x + 1) transformation. Community species diversity indices (D) was determined using Lioyd and Kar equation.

$$D = C/N(\log 10N - \text{nilog } 10ni)$$

Where C = 3.321928; N = total number of individuals in each station; and ni = total number of species in a particular station. The index takes into account richness of species and distribution of individuals among the stations. Biotic quality index (BQI) was also determined using Chutter (1972) formula:

$$BQI = \frac{\sum(ni \times q)}{N}$$

Where q = value of water quality rating of the stations in terms of number of species, ni = number of individuals in a station and N = Total number of individuals in the sample. The index shows the horizontal distribution of macrobenthic fauna on the seabed, which reflects the health of the environment in terms of species distribution with reference to the source of pollution. This indicates a lower BQI values near the oil drilling area and higher values with increase in distance away from it. The population densities of benthic fauna numbers grabbed per unit area of the seabed touched by the cylinder vanVeen grab sampler of 15.0cm diameter during collection of bottom sediments were expressed as absolute density estimates (number per m^2) for fauna numbers collected by the sampler in each station. Cluster analysis was used to identify species assemblage with similar physicochemical properties to denote species assemblages in the different sampling stations.

RESULTS AND DISCUSSIONS

Physicochemical Properties

The results of the physicochemical analyses are presented in Table 1. There is a general variation in data collected among the stations. pH was slightly basic within the range of 7.9-8.6. Water temperature was between the range of 27.2°C to 28.8°C. Dissolved oxygen levels were generally high in the control stations (stations 5, 6 and 7), but stations 1 to 4 recorded lower values in an increasing trend away from the drilling area. BOD_4 levels were low between stations one to four. This reflects the low oxygen available for the degradation of organic matter of the water body in the area. However, the low biological oxygen demand recorded after five days, implies that much organic matters are present and undegraded between stations 1 to 4. This tends to reflect the unsatisfactory water quality of the oil drilling environment (stations 1 to 4), while relatively higher values were recorded in the three control stations (stations 5, 6 and 7). Also, ammonia and phosphate levels were high in the stations close to the drilling area. However, the low percentage of organic carbon and the high values of suspended solids, high ammonia and phosphate level recorded between stations one to four indicates a gross organic contamination of the seabed around the drilling area. Biotic quality and species diversities (Table 2) were lower around the oil drilling environment indicating the low distribution

of species with reference to the poor water quality between stations 1 to 4. Generally, Biotic and species diversity values were relatively higher at the control stations (stations 5, 6 and 7) than stations close to the oil drilling area (stations 1, 2, 3 and 4). The significant positive correlation of species diversity indices with the biotic quality ($r = 0.94$, $n = 5$ at 5% level of significance) implies that both indices are associated, with low BQI being associated with low biological diversity.

Biodiversity Measures

The macrobenthic fauna community of the study area was determined by analysing various biodiversity measures. These include: percentage fauna abundance, species diversity, fauna density, and the biomass (Table 2). In this study, a total of 515 individuals from 3 taxa (Annelids, Arthropods and Molluscs) comprising 12 species were collected. Molluscs were the predominant taxonomic group, representing 56.96% of the taxa and 46.67% of the individuals, followed by polychaetes (26.67% and 25.23%), while the minor taxa (crustaceans) contributed 26.67% and 17.76% of the total taxa and individuals collected in this study.

Polychaetes collected in this study include: an errant polychaete *(Diopatrâ monroi)*, a typical sediment dweller (Nereis sp) and a sediment burrower *(Capitella capitata)*. Species of crustaceans collected in this study are the hermit crab *(Clibernarius africana)*. Some species of the hermit crab were found inhabiting empty shells of the dog whelk *(Semifusus morio)*, while others were found in the shells of carnivorous whelk *(Thais haemastoma)*. This biological relationship has been described as a phoretic association between the hermit crab and the molluscs (Segun, 1989). Other crustaceans collected are an amphipod *(Gammarus neglectus)* and a malacostran of the order stomapoda *(Squilla mantis)*.

Among the molluscs, three species of the class bivalvia collected including *Egeria radiata*, the West Africa bloody cockle Selilia senils *(=Anadara senilis)* and two deep sand borrowers *(Donax rogosus* and *Dabia Mutela)*. Gastropods collected were mainly marine opistobranchs. They include the dog whelks *(Thais haemastoma* and *Semifusus morio)* and an auger shell of the family Terebridae *(Terebra micans)*.

Fauna densities and percentage abundance showed a pattern of distribution centred at the diffuser stations (stations 5, 6 and 7). There is a general increase in densities and percentage abundance of macrofauna with increase in distance away from the drilling area. The lower densities and percentage abundance recorded in the drilling area reflects the impoverished status of the species composition and the simplification of macrobenthic fauna community. Biomass was depressed at the stations near the drilling area. Stations 1, 2, 3 and 4 had lower biomass compared with higher biomass values recorded at Stations 5, 6, and 7. The lower biomass that occur at the stations near the drilling area reflect the impact of drilling activities on the sessile macrobenthic communities. The effect was less on the benthic species collected at the far stations (stations 5, 6 and 7). This is reflected in the high densities, percentage abundance, species diversities and biomass values recorded at the control stations (stations 5, 6 and 7), which were farther away (10,000m) from the drilling area.

The summary dendrogram for species cluster groups and contribution of each group to the observed results is presented in Figure 1. Cluster analysis identified species assemblages with the same station groupings. Species assemblages formed four groupings two major groupings and two minor groups. Species group 1 (A and B) comprise of a minor grouping of similar species composition. It contributed about 13.6% to the total species clustering and comprises of species with low abundance at stations close to the oil drilling area (stations 1 and 2). This pattern could be due to drilling activities effect which might have degraded the benthic communities around the oil drilling environment. Species in the cluster in this group include: *Diopatra monroi, Capitella capitata* and *Thais haemastoma*. Others are *Semifusus morio, Squilla mantis, Nereis sp* and *Gammarus neglectus*. However, drilling effect was also apparent on species groups 2 (a major cluster grouping C and D), which contributed 42.11% of total species clustering. These species were recorded in lower numbers at stations 1 and 2, but at the control stations (stations 5, 6 and 7) higher numbers were collected. This further supports the contention that oil drilling effect was devastating on the macrobenthic communities around the drilling area. Species that clustered into this group are *Capitella capitata, Terebra micans, Egeria radiata and Gramarus neglectus*. Another major similar species cluster grouping was constituted by Species group 3 (E and F). The group accounted for about 36.14% of total species clustering. Species in this group were distributed at the stations 3 and 4; 1 and 2 and the control stations (stations 5, 6 and 7). Among the species in this group was the polychaete *(Capittela capitata)* which was collected in six of the seven stations sampled. The species shows an increasing pattern in population with increase in distance away from the drilling area. This reflects the sensitivity of the organisms to organic pollution of the bottom sediment, which is the burrowing medium for the species. Another species of ecological interest in species group 3 is the West African bloody clam *(Anadara senilis)*, a bivalve molluscs and an opportunistic species with the highest distribution among other species collected in this study. The bloody clam was collected in all the seven station sampled. It contributed 37.28% to the total number of individuals collected in this study. The fourth and a minor species cluster grouping (G) contributed 28.12% of the total species clustering group. This group comprises of species that showed strong preference for stations 3, 4 and the control stations.

However, the fact that species assemblages defined by species group 4 contained unbiquitous species which were confined to the middle stations (stations 3 and 4) and the control stations (stations 5, 6 and 7) farther away from the oil drilling area further supports the contention that drilling activities affected the biodiversity of the benthic communities of the studies area.

The occurrence of pollution sensitive species *(Capittela capitata)* along with opportunist species in the same group indicate the polymorphic nature of benthic community of the investigated area. However, the distribution of the major clustering groups to station farther away from the drilling area, (stations 3, 4, 5, 6 and 7) and few species of a minor group at stations 1 and 2 (close to the drilling area suggest that altered abundance patterns in

benthic fauna distribution could reflect degraded community.

CONCLUSION

This study reveals that the main determinant of the biodiversity of the investigated area is pollution due to drilling operations. Drilling activities stress the macrofauna community leading to its degradation particularly in the drilling area's vicinity. This is reflected in the general decrease of individuals, diversities, densities and biomass values with the corresponding decrèase in dissolved oxygen and biological oxygen demand values and increase in ammonia, phosphate levels and total suspended solids around the drilling area.

Environmental impact of drilling operations on macrobenthic biodiversity occurs at all stages of drilling operations. During drilling operation, there is the discharge of drill and mud cuttings which cause smothering of the sea-bottom as well as degradation of the benthic communities. This survey shows that the continous exploitation of the non-renewable resources of the marine environment without adequate management measures could lead to the degradation of the living communities of the seabed.

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Table 1: Physicochemical parameter of the sampling stations (means ± sd are in mg l^{-1})

Parameters	STATIONS						
	Oil Drilling Area →				Control Stations →		
	1	2	3	4	5	6	7
Temp. (°C) Mean	28.2	28.4	28.2	27.4	27.2	27.8	28.8
PH	8.4	8.2	8.0	8.5	7.8	8.6	7.9
Dissolved Oxygen	5	7.3	6.2	12	18.30	19.0	21.3
BOD (4-day)	0.4	0.8	0.3	0.8	5.6	4.2	8.3
Ammonia (level)	1684 ± 27.6	550 ± 20.2	79 ± 24.2	30 ± 16	15 ± 8	18 ± 4	13 ± 4
Phosphate (Level)	62 ± 2.0	57 ± 6.2	42 ± 12.3	23 ± 4	18 ± 2	17 ± 0	21 ± 4
Suspended Solids	73.0	75 ± 26.4	43 ± 162	32 ± 4	8.2 ± 4	1.0 ± 2	1 ± 0
Organic carbon (%)	12.0	11.8	8.8	14.6	21.9	24.6	28.9

Table 2: Species of macrobenthic fauna collected at the studied area.

Benthic Species	SAMPLING STATIONS						
	Oil Drilling Area →				Control Stations →		
	1	2	3	4	5	6	7
Phylum Annelida							
Nereis sp		2	1		3	6	4
Diopatra monroi	1		2	2		3	6
Capitella capitata		3	4	6	8	11	15
Phylum Arthropoda(Class Crustaceans)							
Clibernarius aficana		3	1		2	6	3
Squilla mantis	1		2			3	6
Gammarus neglectus				3	2	1	2
Phylum Mollusca							
(Class Gastropoda)							
Thais haemastoma		2			6	14	18
Terebra micans				5	1	10	19
Semifusus morio			3	7	6	12	11
Class Bivalvia							
Egeria radiata	2	1		6	12	13	15
Donax rugosus	1		5	9	6	9	18
Anadara senilis	2	4	6	19	33	59	69
Total Number of Species	5	6	8	8	10	12	12
Total Number of Individuals	7	15	24	57	79	147	186

Table 3: Total Densities, Percentage abundance, Species Diversities, Biomass and the Biotic quality of the Studied Area.

	1	2	3	4	5	6	7
Total Densities	330	406	369	546	4192	5480	6690
Abundance (%)	11.2	25.2	18.9	32.3	46.5	59.6	68.6
Biomass (g)	8.2	6.2	7.4	6.3	14.3	11.9	15.3
*Species Diversity	0.44	0.36	1.08	3.84	4.46	3.96	5.46
*Biotic Quality	0.34	0.21	0.81	1.32	2.64	2.73	2.81

• = Significant (P = <0.05)

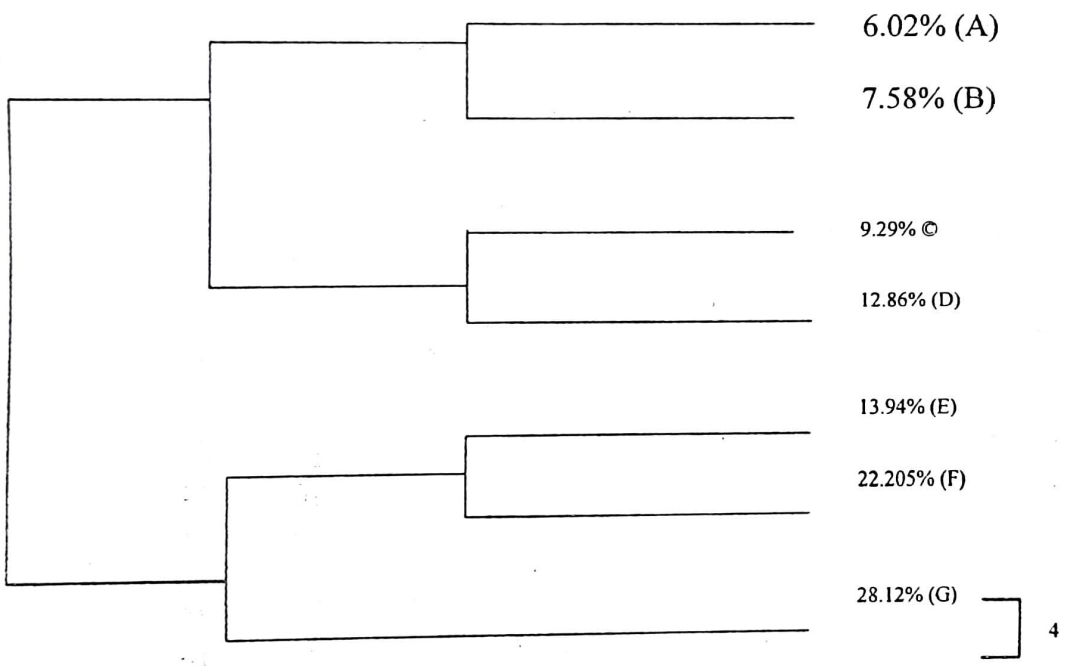

Fig 2: Summary of species dendrogram generated from hierachial cluster analysis for the study area.

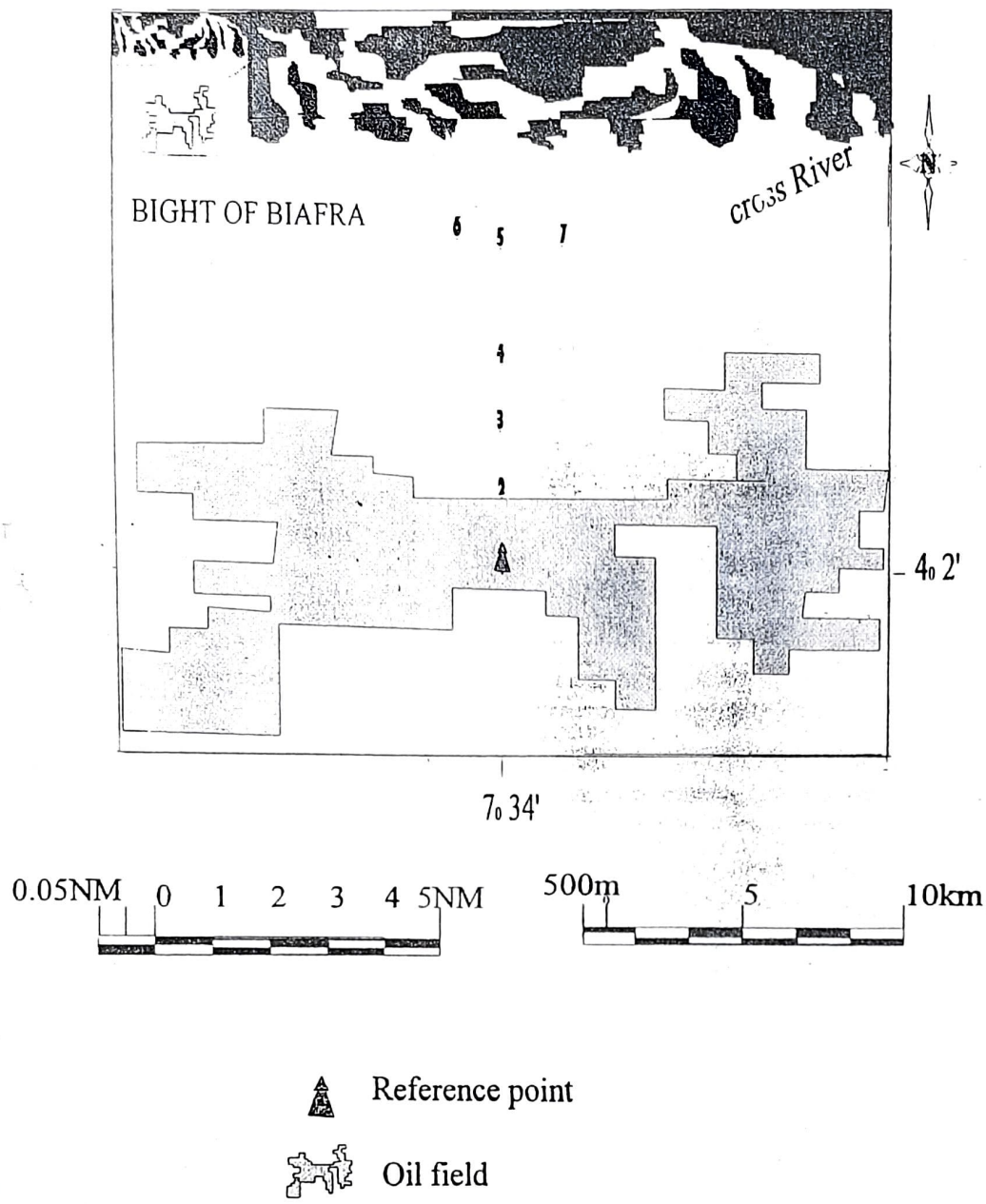

Fig. 1: Map of study area showing location of stations