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IMPACT OF CRUDE OIL ON RECRUITMENT OF EPIBENTHIC ORGANISMS IN CROSS RIVER ESTUARY, SOUTH EAST NIGERIA

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ABSTRACT

Effects of crude oil on recruitment of epibenthic organisms in Cross River estuary were studied in February and March, 2007 on wooden Panels (15×15×1.5cm). The panels were immersed in Nigerian light crude oil and later suspended in the estuary for six weeks. *Rhizoclonium hieroglyphicum* showed slight resistance to the effect of the crudeoil while species like *Balanus balanoide, Crassostrea gazar, Bugula neritina, Serbellaria intoshi, Catenella opuntia* and *Caloglossa leprieurii* showed slight inhibition. Statistically, there was however no significant difference in the recruitment level of the organisms on both the control panels and oil-polluted panels, ($p>0.05$). This may probably have been as a result of weathering process or bacterial degradation of the crude oil which rapidly diluted the hydrocarbon, thereby reducing its toxicity. The result reveals that widespread oil spill during the reproductive season would reduce larval settlement and impede subsequent recruitment. The ecological implications of these findings are discussed.

KEYWORDS: Crude oil, Epibenthos, Recruitment, Cross River estuary, Nigeria.

INTRODUCTION

Oil contamination, irrespective of its scale, has been recognized as one of the most serious threats to the estuarine environment, particularly on tidal flat. Mangrove wetlands that are commonly found along most low energy shorelines in tropical and sub-tropical regions are well known for their vulnerability to oil spill.

In the Cross River estuary, offshore petroleum facilities are located adjacent to the mouth of the estuary (Enin, 1997). Oil spills and leakages from these facilities are washed into the estuary by tides and waves. These have made the estuarine environment very susceptible to crude oil pollution as a result of reduced wave action and tidal flushing. It also constitutes an additional stress for aquatic organisms (Sindermman, 1982; Ewa-Oboho, 1994; Ewa-Oboho and Oladimeji 2004).

High level of oil pollution in estuary may cause fish stock to decline through adverse effects at the lower trophic level, as well as on the fish themselves by impairing their metabolism and reproductive function. A decline in fish abundance had been reported following an oil spill (Odu, 1977; Adeniyi *et al.*, 1983; Omoregie 2002; Omoregie and Ufodike 2002). Generally, larvae and early developmental stages of fishes and invertebrates in the water column are the most susceptible to crude oil pollution. Ho and Karim (1978) observed that freshly oil-coated panels reduced recruitment of barnacle and oyster spat. Bank and Brown (2002) observed that an oil-contaminated tile showed high recruitment level after three weeks in the field. Ewa-Oboho and Oladimeji (2004) reported that impacted benthic communities usually respond to oiling stress, the extent which depends on the severity of the oiling.

The objective of the present study was to investigate the impacts of crude oil polluted substrate on the recruitment of epibenthic organisms in the Cross River Estuary. This will provide baseline data for future studies since this region continually receives water from the adjacent Gulf of Guinea, and therefore very susceptible to oil pollution.

MATERIALS AND METHODS

The study area

The Cross River estuary which is located in the rainforest belt of South-Eastern Nigeria is also the largest in West African sub-region (Nawa, 1982; Moses, 1988; Enyenihi, 1991). It lies between latitude (4° 00' and 8° 00') and longitude (7° 20' and 10° 00') (Ewa-Oboho, 2006). (Figure 1)

The Cross River estuary has a length of about 42km from the meeting point of the Calabar and Cross River (off Tobacco Island) to the mouth of the estuary. It varies in depth from 1m to 14m (Nawa, 1982) and is approximately 25km wide at the mouth with a tidal flushing of 1.83 billion cm^3 per day (Enyenihi, 1991). The estuary receives seawater from the Atlantic Ocean and freshwater from Cross River and Great Kwa River. It has a mean salinity of 20ppt at dry season and approximately 12ppt at the peak of the rainy season (Udo and Ekpe, 1991).

Owing to the rich mangrove forest that adjoins the shoreline, the estuary is very productive and has a high level of biodiversity supporting a wide variety of

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fishery resources (Ama-Abasi and Holzlohner, 2002). It is the nursery ground for many commercial fishery resources exploited in the Gulf of Guinea.

The estuary has a tropical climate and lies within the Westerlies and the Trade wind zones

Field Sampling Techniques

A total of eighteen wooden panels of 15×15×1.5cm dimension were used for the experiment. Six were used as control while twelve were immersed for 30 minutes in Nigerian light crude oil obtained from Ibeno. The control, rough-polluted and smooth-polluted panels were labeled as Panel A, B, and C respectively. Excess oil was allowed to evaporate into the air until the wooden panels were dry. These wooden panels, together with the control were tied to mangrove roots and suspended horizontally at approximately 1.0m within the intertidal range of the Cross River estuarine environment.

Wooden panels were suspended such that they were covered at high tide and exposed at low tide. They were allowed to remain in the field for a period of six weeks, after which the panels were recovered from the field and taken in estuarine water to the laboratory for analysis.

Laboratory Procedures

In the laboratory, the panels were intermittently submerged for six hours and thereafter exposed for another six hours to simulate the natural estuarine environment throughout the period of the analysis. This was to prolong the lifespan of the organisms during the period of the experiment.

Cross sections were later made on the wooden panels to ease the counting of the encrusted organisms. The encrusted organisms were then identified using standard keys (Newell and Newell, 1977; Barnes *et al*., 1992; Waife and Frid, 2001) while counting was done on the total surface area of each panel using a 10× light microscope.

RESULTS

Seven species of epibenthic organisms were found on the panels. These included: three algal species (i.e., *Catenella opuntia, Caloglossa leprieurii* and *Rhizoclonium hieroglyphicum*) belonging to the class Rhodophyceae and class Chlorophyceae respectively; one Molluscan species belonging to the class Bivalvia (i.e., *Crassostrea gazar*); one Bryozoan's species belonging to the class Gymnolaemata (i.e., *Bugula neritina*); one Arthropoda species belonging to the class Crustacea (i.e., *Balanus balanoide*), and one Annelida species belonging to the class Polychaeta (i.e., *Serbellaria intoshi*). Detail is shown in Table 1.

On Panel A, a total of 188 individual organisms encrusted the panel. Panel A was a non-polluted panel that was used as Control. Of these 188 individual organisms, the most dominant species was the *Rhizoclonium hieroglyphicum* (Chlorophyceae) with a mean density of 5.89 ± 0.66 which made up about 28.19% of the total organisms that encrusted this panel. It was followed by the *Caloglossa leprieurii* (Rhodophyceae) and the *Serbellaria intoshi* (Polychaeta) with a mean density of 2.89 ± 0.54. The least dominant species of organism on Panel A was *Catenella opuntia* (Rhodophyceae) with a mean density of 1.89 ± 0.45 which constitutes only about 9.04% of the total number of organisms on Panel A.

A total of 109 organisms encrusted the Panel B which was a rough oil-polluted panel. The *Rhizoclonium hieroglyphicum* with a mean density of 3.67 ± 0.53 was still the most dominant species. The *Bugula neritina* became the second most dominant species with a mean density of 2.00 ± 0.53. The least dominant species was still the *Catenella opuntia* with a mean density of 0.89 ± 0.42, constituting about 7.34% of the entire encrusted organisms on this panel.

On the Panel C, which was a smooth oil-polluted panel, a total of 119 individual organisms were observed to have settled on it. *Rhizoclonium hieroglyphicum* consisted of about 30.25% of this number, with a mean density of 4.00 ± 0.91. It was followed by *Bugula neritina* and *Caloglossa leprieurii* with a mean density of 1.89 ± 0.56 and a percentage composition of 14.39%. The least dominant species on Panel C was the *Crassostrea garza* which had a mean density of 1.00 ± 0.37 and a percentage composition of 7.56%. The level of recruitment of individual species on the three panels differed according to the panels.

Table 1: Mean Density of Dominant Epibenthic organisms on the Wooden Panel

Taxonomic Class	Species	Panel A *(Non-Polluted)*	Panel B *(Rough polluted)*	Panel C *(Smooth Polluted)*
		X ± S.E	X ± S.E	X ± S.E
Crustacea	*Balanus balanoide*	2.78 ± 0.66	1.78 ± 0.52	1.22 ± 0.43
Bivalvia	*Crassostrea gazar*	2.00 ± 0.41	1.00 ± 0.29	1.00 ± 0.37
Gymnolaemata	*Bugula neritina*	2.56 ± 0.56	2.00 ± 0.53	1.89 ± 0.56
Polychaeta	*Serbellaria intoshi*	2.89 ± 0.54	1.33 ± 0.37	1.78 ± 0.52
Chlorophyceae	*Rhizoclonium hieroglyphicum*	5.89 ± 0.66	3.67 ± 0.53	4.00 ± 0.91
Rhodophyceae	*Catenella opuntia*	1.89 ± 0.45	0.89 ± 0.42	1.44 ± 0.34
Rhodophyceae	*Caloglossa leprieurii*	2.89 ± 0.54	1.44 ± 0.36	1.89 ± 0.45

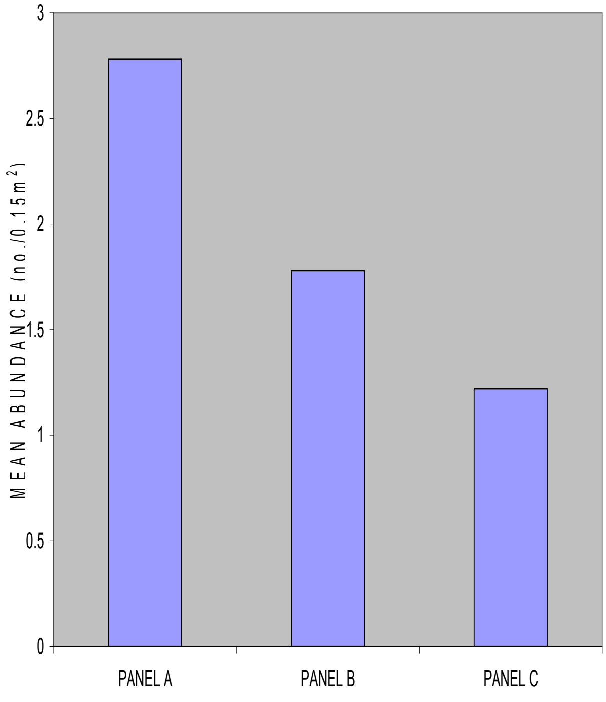

Fig 2: Variation in Mean Abundance of *Balanus balanoide* on Wooden Panels

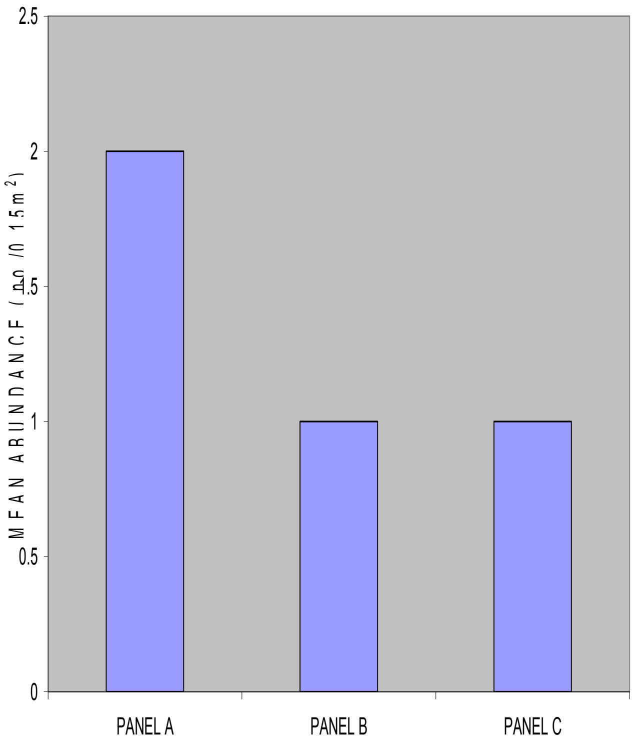

Fig 3: Variation in Mean Abundance of *Crassostrea gazar* on Wooden Panels

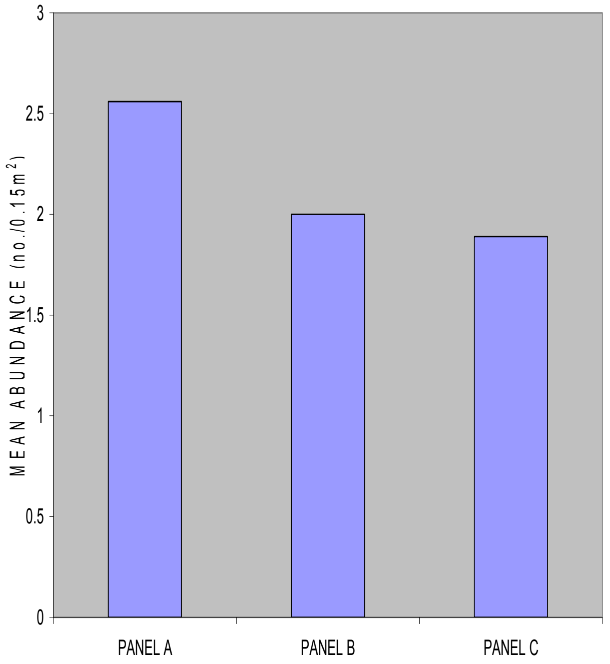

Fig 4: Variation in Mean Abundance of *Bugula neritina* on Wooden Panels

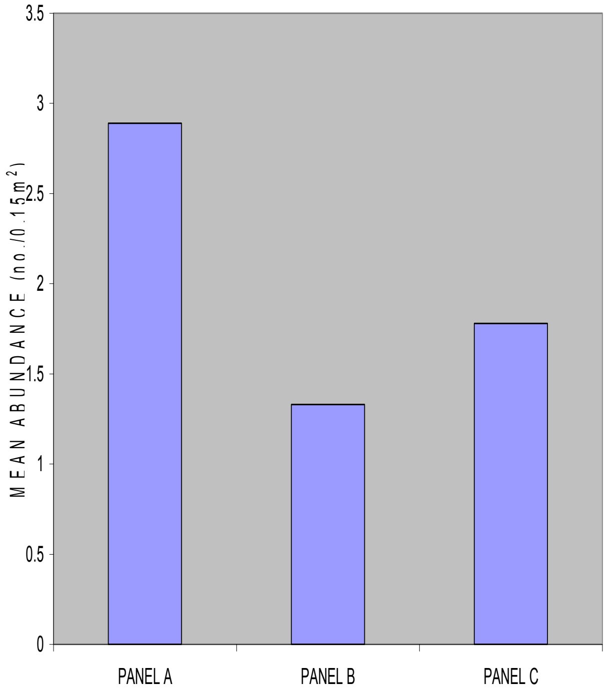

Fig 5: Variation in Mean Abundance of *Serbellaria intoshi* on Wooden Panels

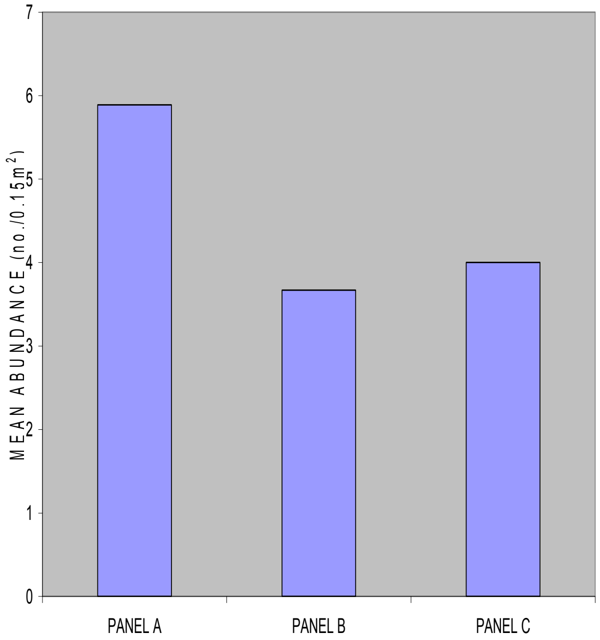

Fig 6: Variation in Mean Abundance of *Rhizoclonium hieroglyphicum* on Wooden Panels

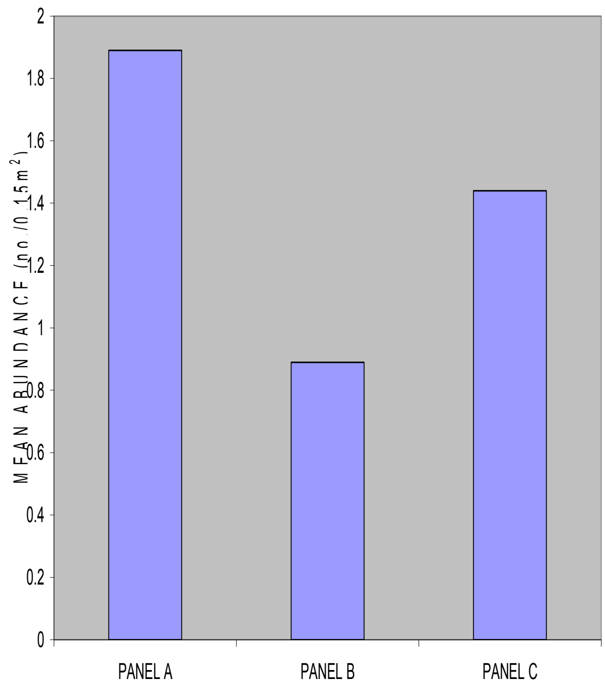

Fig . 7: Variation in Mean Abundance of *Catenella opuntia* on Wooden Panels

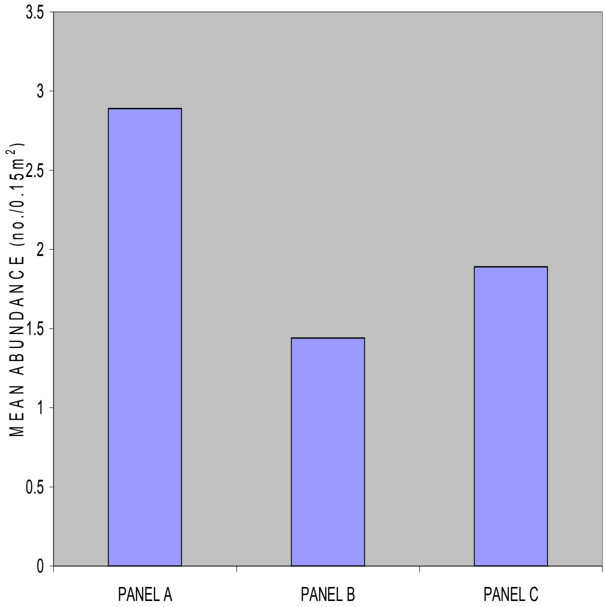

Fig 8: Variation in Mean Abundance of *Caloglossa leprieurii* on Wooden Panels

DISCUSSION

The above results suggest that hydrocarbon pollutant can certainly affect recruitment of epibenthic organisms, but that the effects are taxon specific and tend to reduce with time perhaps, due to the degradation of the hydrocarbon components. Apart from *Rhizoclonium hieroglyphicum* which showed a slight resistance, the effects were strong for other epibenthic organisms whose mean densities showed a slight inhibition in recruitment on the polluted panels when compared to the control panel.

Inhibition could have been caused by an acute toxic response to the crude oil which decreased larval survival and metamorphosis. This was earlier documented by Garrity and Levings (1993) who reported a population reduction of barnacles and other epibenthic organisms on mangrove (*Rhizophora mangle L*.). An alternative hypothesis is that biofilms resulting from oil exposure could have also been the cause of recruitment depression. Support for both hypotheses can be found in literature where oil spill reduced bryozoan percent cover on mangrove roots (Levings and Garrity, 1992); and biofilms inhibit recruitment (Marki *et al.*, 1988; Bryan *et al.*, 1997).

Oil pollution has numerous effects on marine organisms, it has a short-term effect on larval settlement but the effect tends to reduce with time. Result from this study shows that recruitment of some epibenthic organisms was affected by the crude oil on the polluted panel. *Balanus balanoide* and *Crassostrea gazar* also showed a reduction in mean density on the polluted panels when compared with the non-polluted panel. This may be attributed to the toxic effect of the crude oil on these epibenthic organisms because it agrees with the earlier report of Hill and Holand (1985) who reported that hydrocarbon inhibited the settlement of *Balanus balanoide*. Bacterial films might have also grown on the oil-polluted panels. This could also inhibit the recruitment of *Balanus balanoide* by the polluted panels. Marki *et al*. (1988) reported that bacterial films generally inhibited *Balanus amphitrite* larval attachment to a substrate. Ho and Karim (1978) observed that freshly oil-coated panels recruited an average of 0.6 barnacles and oyster spat per 6.5m² whereas the control showed 19/6.5m², a reduction by 31 times as a result of crude oil coating during a two week testing. The population was still half of the control after the residual oil on plate was allowed to weather under room temperature for two weeks before another recruitment test was carried out.

Between the polluted panels B and C, some species of epibenthic organisms such as *Balanus balanoide* and *Bugula neritina* showed a higher density on panel B when compared with panel C. This may be attributed to the fact that some of these organisms prefer rough surfaces for settlement. This has been confirmed by Barnes *et al.,* 1992 who reported that *Balanus spp*. prefer rough surfaces for settlement. The rough surface may also help to reduce the effects of wave action on species like *Bugula neritina*.

For the algal species that were also observed on the panels, *Rhizoclonium hieroglyphicum* settlement seemed not to be severely affected by the crude oil because it was still the most dominant both on the polluted and the control panels. *Rhizoclonium hieroglyphicum* has been reported by many researchers to use crude oil as a source of food. It may appear to be affected by the crude oil (Ewa-Oboho, 1994). The algal species prefer smooth surfaces to rough ones as can be seen in the result where the smooth surface panel had higher recruitment than the rough ones.

Generally, the abundance, as well as the diversity of epibenthic species on the three panels at the time of the present study was not much as expected. The few encrustment on the panels do not mean that larvae of epibenthic organisms were not in the water for settlement. After all, availability of larvae for recruitment does not necessarily determine settlement (Hannan, 1981). The scarcity of epibenthic organisms on the panels may have been that the period of this recruitment test did not correspond to their breeding cycles.

At the time that the experiment was conducted, dredging activities was carried out in the Cross River estuary to deepen the shipping channels. This led to an enormous particulate matter in suspension. Low level of encrustment may have also been promoted by muddy sediment in water since soft mud bottom do not support large epifauna suitable for colonization. It has also been reported by Marki (1988) that diatom films, regardless of cell density were inhibitory to Cypris settlement. Thus, high levels of algal recruitment on the panels may also explain why there was a low rate of *Balanus* recruitment and, the recruitment of other epibenthic organism. It is concluded in this study that the settlement and subsequent recruitment of some epibenthic organisms is usually impeded by the presence of Nigerian light crude on the substrate. This implies that widespread oil spill during reproductive seasons would reduce larval survival and impede metamorphosis, thereby reducing the abundance and diversity of the affected aquatic invertebrate.

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