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IMPACT OF LOCALLY REFINED DIESEL ON MACROINVERTEBRATE COMMUNITY OF EKEHUAN AND GELEGELE RIVER, EDO STATE

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ABSTRACT: *This study was carried out between April 2013 and January 2014 to investigate the impact of locally refined diesel on the abundance and diversity of macroinvertebrate fauna in Ekehuan and Gelegele Rivers in Edo State. Water and macroinvertebrate samples were collected from three sampling points in the study area. The water samples collected were analysed for total hydrocarbon concentration (THC) among other environmental parameters like air and surface water temperature, pH, conductivity, dissolved oxygen (DO), biological oxygen demand (BOD), and chemical oxygen demand (COD). While, Dissolved Oxygen (DO), Water and Air Temperatures were significantly lower at sampling station 1, THC was considerably higher at the same sampling station 1. A total of 16 species comprising 510 individuals were encountered in this study. The class of macroinvertebrates encountered in this study were Class Insecta, Malacostraca, Phasmidea, Oligochaeta and Gastropoda. The diversity and abundance of macroinvertebrates were significantly (P<0.01) lower at sampling station 1 than at the other sampling stations 2 and 3, which were themselves very similar with respect to species diversity and composition. There was a high correlation between the abundance of macroinvertebrates and the level of hydrocarbon in the water. Therefore, it is evident that the presence of locally refined diesel has significantly reduced the diversity and abundance of macroinvertebrate.*

KEYWORDS: Macroinvertebrates, Diesel, Ekehuan, Illegal Refineries.

INTRODUCTION

Oil theft in Nigeria has reached an unprecedented level, with approximately 100,000 – 150,000 barrels of crude oil stolen every day. Although most of this oil is sold internationally, 25% stays in the Niger Delta region for local refining (SDN, 2013). The illegal refining activities taking place in the creeks of the Niger Delta region of Nigeria are alarming. The activities have led to pipeline vandalism, river and land pollution and general environmental degradation, and loss of revenue to the Federal Government (Odiete, 1999; Asimiea and Omokhua, 2013). The growing crude oil bunkering and siphoning into barges, wooden boats or erecting illegal depots and illegal refining outlets have been going on with attendant spills on the waterways and the shorelines (SDN, 2013). The majority of the shorelines have lost most of their vegetation, while spilt crude oil continually spread on the water surface (Asimiea and Omokhua, 2013).

The transport of locally refined petroleum products, particularly diesel by boats, constitutes a serious environmental risk to the water. However, the extent of damage to stream fauna that has been reported following accidental spills of oil and petroleum products is diverse. Lytle and Peckarsky (2001) reported that diesel spill in a small trout stream in New York, USA significantly reduced the density of macroinvertebrates by 90% and taxonomic richness by 50%, within a distance of about 5km downstream of the spill. The fauna density immediately after the spill point recorded poor species abundance, and Optioservus dominated it due to their tolerance of petrochemicals. The impacts of oil exploration and production on the macrobenthic invertebrate fauna of Osse River in Edo State Nigeria conducted by Omoigberale and Ogbeibu (2010) revealed that the overall abundance of macrobenthic invertebrates was significantly different in the five stations of the study. The abundance and taxa richness were significantly lower in the sampling points where exploration and production of oil took place. The control stations harboured more species and had the highest abundance. Ikpeme *et al.*, (2013) investigated the effects of crude oil spill on diversity and abundance of plankton in Njaba River, Imo State, Nigeria, reported that species composition and abundance were similar at the spill point and downstream sections of the river. According to the study results, many species, particularly arthropod larvae and polychaetes, encountered in the upstream sampling points, were absent at the spill point and downstream sampling points.

The impact of local refineries and crude oil bunkering on the vegetation of the Niger Delta and the economy of Nigeria has been extensively investigated (Uzoekwe and Achuume, 2011). However, no investigation has taken into cognisance the impact of the contamination of locally refined diesel on macroinvertebrates, particularly that of Ekehuan River that serves as an evacuation point of this product from the illegal refineries in the swamps. This study aims to determine the impact contamination of Ekehuan River with locally refined diesel has on the species composition, Spatio-temporal distribution and abundance and diversity of macroinvertebrates.

MATERIALS AND METHODS

The study was carried out on a section of Ekehuan River designated as sampling station I, representing the highly oil impacted section of the river where drums filled with locally refined diesel are rolled along the shallow portions of the river. Two other sampling stations designated as sampling stations 2 and 3 were also chosen along the Gelegele River. Ekehuan River is a tributary of Ovia River, flowing from Northeast to Southeast direction and empties into Gelegele River. The entire study area lies within latitude 06^0 $10'$ N and 06^0 $12'$ N and longitude 005^0 $20'$E and 005^0 22' E in Ovia North East Local Government Area of Edo State, Nigeria (Figure 1).

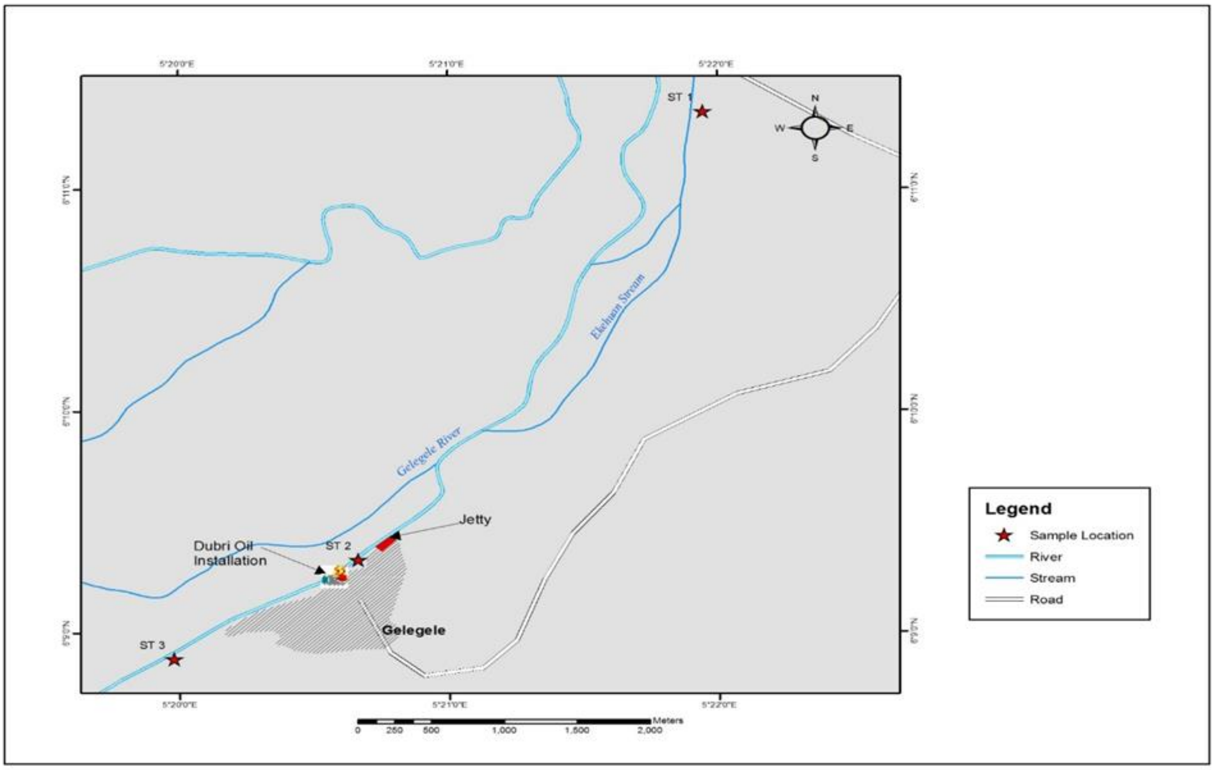


Fig 1: Map of the study area.

Sampling for both water and macroinvertebrates in the study area was carried out every month for 10 months beginning April 2013 to January 2014. Sampling was done between the hours of 0900hrs and 1200hrs on each sampling day. Macroinvertebrates were collected from roots of *Eichhornia crassipes* (water hyacinth) and by kick sampling method as described by Hynes (1970). Five water hyacinth plants were randomly collected from the stations and vigorously dusted in a water bucket containing 10% formaldehyde to dislodge macroinvertebrates attached to the roots. At each station, the air and surface water temperature was taken in-situ using a Mercury-in-glass thermometer. In contrast, water samples for the analysis of total hydrocarbon and some other physicochemical parameters were collected in line with acceptable standard methods and instrumentations procedures (APHA, 1998). Surface water samples for total hydrocarbon were collected into thoroughly cleaned 750 cl glass bottles, while water for other physico-chemical parameters were collected in 2 L polyethene containers. For dissolved oxygen (DO) determinations, separate samples were collected in 300 ml plain glass bottles and the samples fixed using the azide modification of Winkler's method (APHA, 1998). Samples for biochemical oxygen demand (BOD) were collected into dark glass bottles for incubation, and subsequent DO determination after five days. Each container was rinsed with the appropriate sample before the final sample collection. The samples were placed in a cooler box and then taken to the laboratory for analyses. In the laboratory, pH, electrical conductivity, dissolved oxygen, biochemical oxygen demand (BOD_5), chemical oxygen demand (COD) and total hydrocarbon were determined according to procedures outlined in the Standard Methods for the Examination of Water and Wastewater (APHA, 1998).

Data was analyzed statistically, using PAST (Paleontological Statistics) software package (Hammer et. al. 2001) to compute the diversity indices (Shannon-Weiner (H) and Margalef (D) indices), compare the similarities or differences among the stations using Bray Curtis similarity index and to test for significant differences using One-way analysis of variance (ANOVA). Where significant values ($p < 0.05$) were obtained in a One-way analysis of variance, 'A posteriori' Duncan Multiple Range Test was subsequently applied to all pairs of means to detect the location of difference.

RESULTS

The summary of result of the physical and chemical parameters of water quality in Ekehuan and Gelegele Rivers is presented in table I. The Total Hydrocarbon (THC) concentration was significantly higher ($P<0.01$) at sampling station 1 with up to 10.53 mg/L as against the < 0.12 mg/ L reported from sampling stations 2 and 3. The mean dissolved oxygen (DO), air and surface water temperature were however, significantly lower ($P<0.01$) at sampling station 1.

Table I: Summary of some physicochemical parameters result

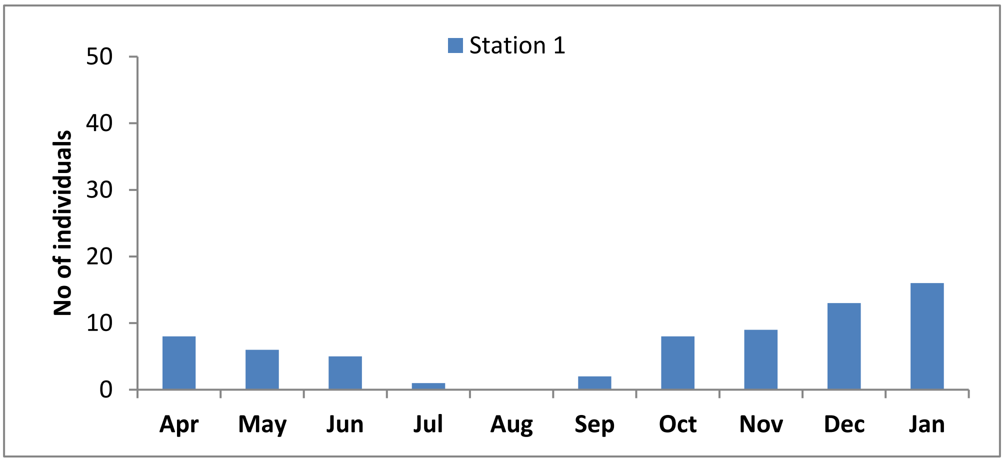
Parameters	Station 1 Mean±SE (Min, Max)	Station 2 Mean±SE (Min, Max)	Station 3 Mean±SE (Min, Max)	P-Value
Air Temperature	22.98^{b}±0.79 (20,27)	26.61^{a}±0.76 (23,30.5)	26.31^{a}±0.7 (23.5,29.2)	**P<0.01**
Water Temperature	18.66^{b}±0.33 (17,21)	21.27^{a}±0.51 (19.5,23.5)	21.43^{a}±0.78 (18,25.8)	**P<0.01**
pH	5.69±0.28 (4.66,7.25)	6.1±0.23 (4.86,7.09)	6.18±0.16 (5.29,6.82)	P>0.05
Conductivity	87.75±25.21 (29,300)	134.42±59.81 (49.2,670)	126.81±72.11 (20,770)	P>0.05
DO	5.80^{b}±0.49 (3.96,8.85)	7.18^{a}±0.37 (5,9.05)	6.24^{b}±0.25 (5.1,7.36)	**P<0.05**
BOD	2.48±0.19 (1.62,3.64)	2.48±0.25 (1.68,4.1)	2.76±0.15 (1.7,3.4)	P>0.05
COD	38.98±7.6 (6.4,72.59)	31.34±8.96 (4,106.4)	29.52±15.24 (4,164.8)	P>0.05
THC	3.34^{a}±1.08 (0.02,10.53)	0.02^{b}±0.01 (0.001,0.12)	0.03^{b}±0.01 (0.001,0.11)	**P<0.01**

The macroinvertebrate species encountered during this study belong to five Classes of invertebrates, namely, Insecta, Malacostraca, Oligochaeta, Phasmidea and Gastropoda consisting of sixteen (16) species with 510 individuals (Table II). In the sampling station I, only 11 species out of the 16 species recorded made up of 68 individuals were found. However, all the 16 species were represented in sampling station 2 with 201 individuals, while 15 species were represented in sampling station 3 with 240 individuals (Table II).

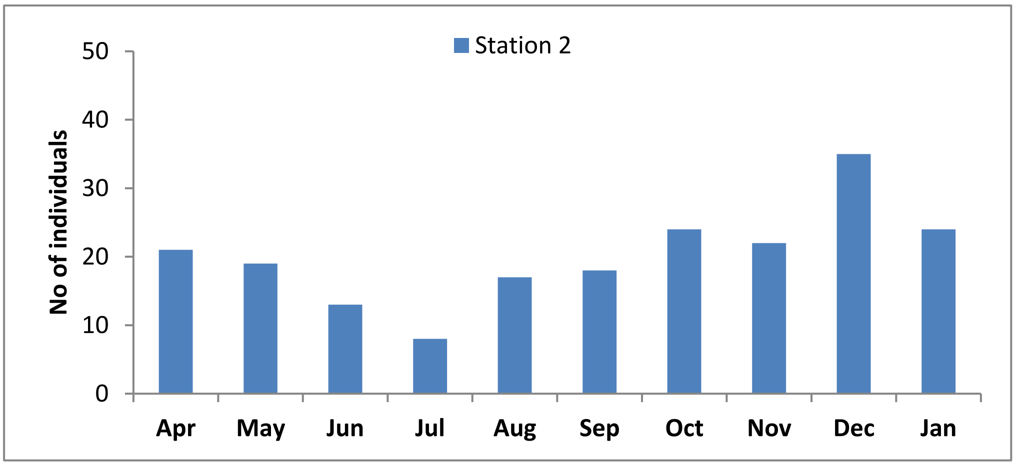
Table II: Composition and distribution of species across the study stations

SPECIES COMPOSITION	STN I	STN 2	STN 3
Phylum: Arthropoda			
Class: Insecta			
Subclass: Pterygota			
Order: Ephemeroptera			
Family: Baetidae			
Baetis sp.	2	5	13
Cloen sp.	0	3	12
Centroptilium sp	0	15	21
Order: Coleoptera			
Family: Gyrinidae			
Gyrinus natalor	0	3	0
Order: Diptera			
Family: Chironomidae			
Cardiocladius sp	6	7	13
Crptochironomous sp	9	11	13
Pentaneura sp	10	12	11
Palpomyia sp	9	11	20
Class: Malacostraca			
Order: Decapoda			
Family: Atyidae			
Caridina africana	4	30	26
Family: Desmocaridae			
Desmocaris sp	8	23	28
Family: Aipheidae			
Potamalpheops monody	4	32	34
Order: Odonata			
Family: Agrionidae			
Enallagma sp	3	11	12
Lestes sp	0	12	15
Phylum: Annelida			
Class: Oligochaeta			
Family: Naididae			
Nais simplex	7	14	12
Phylum: Nematoda			
Class: Phasmidea			
Family: Diplogasteridae			
Diplogaster sp	6	9	9
Phylum: Mollusca			
Class: Gastropoda			
Family: Neritidae			
Neritina glabrata	0	3	2
Total	**68**	**201**	**241**

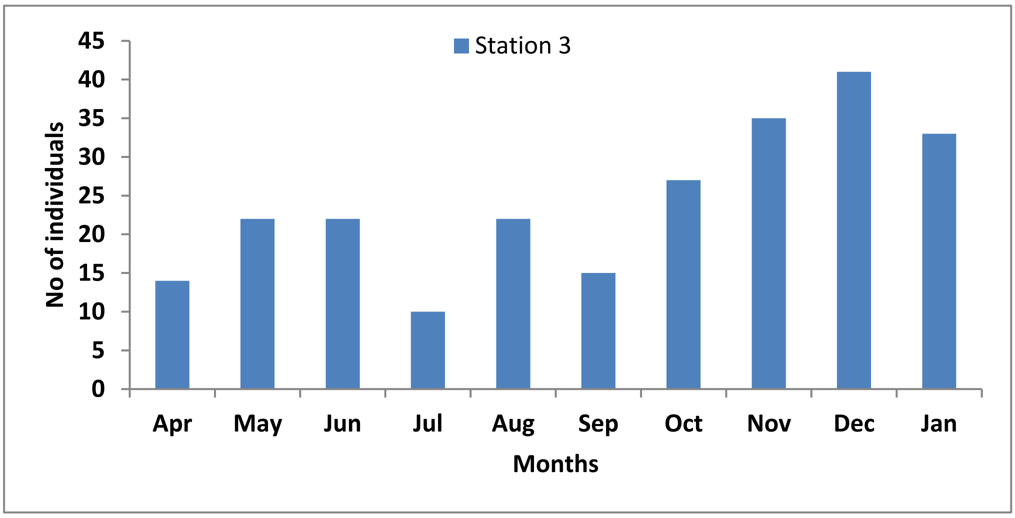
In sampling station I, the number of individuals encountered decreased steadily from the month of April, 2013 to July 2013. No species was encountered in August 2013; thereafter, the number of individuals increased steadily in September 2013 over the next four months till January 2014 (Figure 2a). No species in the Class Gastropoda was recorded from this station. Macroinvertebrates were encountered in all the months of the study in sampling stations 2 and 3. The lowest abundance was recorded in both stations in July 2013 while the highest was in December, 2013. The number of individuals decreased steadily from April 2013 to July 2013 in sampling station 2. This was followed by a sharp increase in August 2013; subsequently, there was a slight increase in the abundance of macroinvertebrates, which again decreased slightly in November 2013 followed by another sharp rise in December 2013 ((Figure 2b). In station 3, the number of individuals encountered incresed from April 2013 to June 2013 before experiencing a decrease in July, 2013, followed by another increase in August same year. The number of individuals increased consistently from October 2013 to December 2013 after a decline in September 2013 (Figure 2c).



(a)



(b)



(c)

Fig 2a-c: Spatial distribution of macroinvertebrates in all study stations.

The computed diversity indices, namely, Margalef's species richness and Shannon-Wiener diversity indices, showed that stations 2 and 3 were the richest and more diverse and least was station 1 (Table 3).

Table III: Summary of Macroinvertebrates richness and diversity indices

	Station 1	Station 2	Station 3
Species (S)	11	16	15
Individuals (N)	68	201	241
Margalef's Index (d)	2.37	2.828	2.553
Shannon-Wiener Index (H)	2.306	2.553	2.583

Generally, the macroinvertebrate abundance and diversity were significantly lower ($P<0.01$) at sampling station 1 relative to sampling stations 2 and 3, which were more similar in both species composition and abundance (Fig. 3).

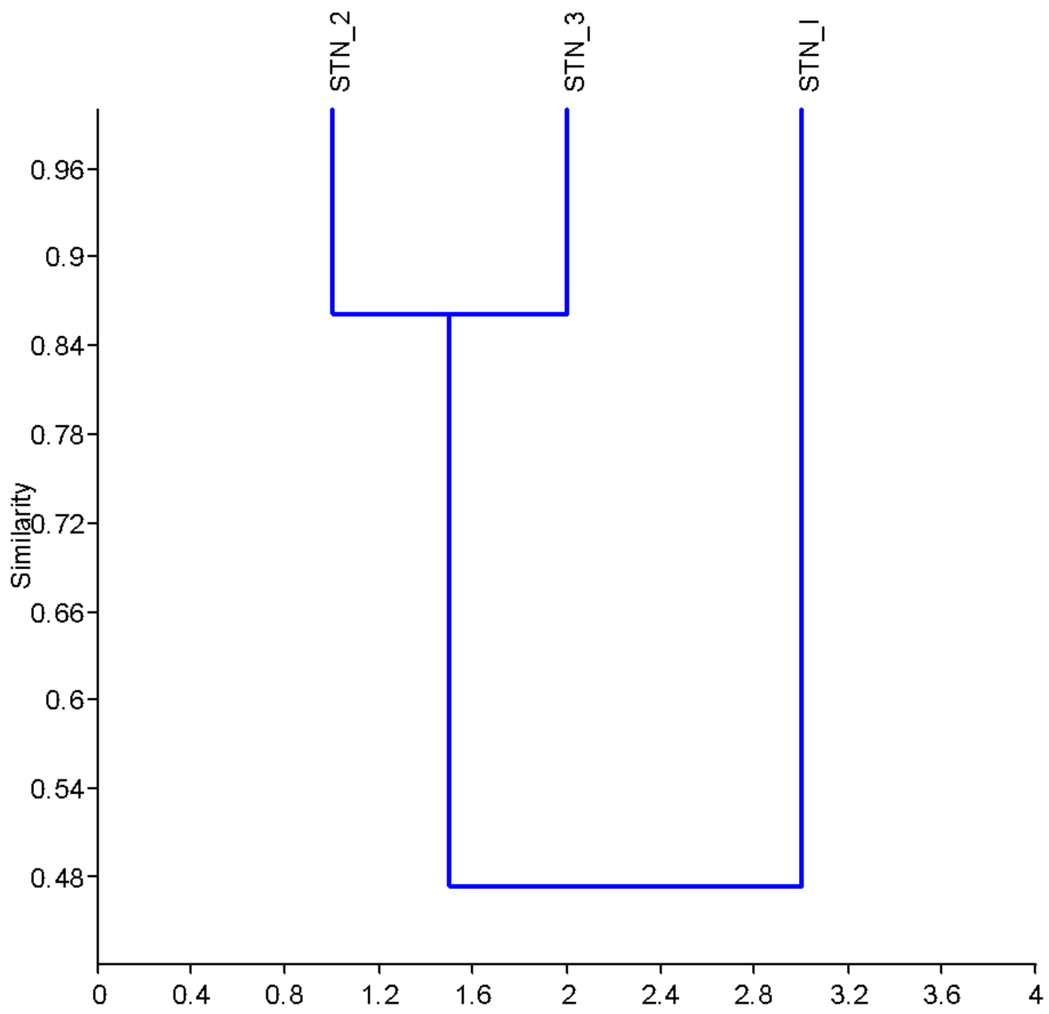


Figure 3: Bray Curtis similarity index of the macroinvertebrate at the sampling stations in Ekehuan and Gelegele rivers (STN_1 = Sampling station I, STN_2 = Sampling station II, STN_3 = Sampling station III)

DISCUSSION

Total Hydrocarbon (THC) concentration was significantly higher in station 1, which was the direct result of accidental spills of locally refined diesel in moving the products to the river bank for onward transportation to their eventual buyers.

The 16 species made up of 510 individuals of macroinvertebrates encountered in this study are grossly low compared to the previous work by Omoigberale and Ogbeibu (2010) that reported a total of 55 taxa with 6,262 individuals. The decline in abundance of macroinvertebrates directly relates to the high concentration of Total Hydrocarbon (THC) at sampling station 1 can be attributed to the pollution of Ekehuan River by operators of illegal refineries where crude oil is locally refined to diesel.

The number of imacroinvertebrates individuals was particularly low in the station I, as compared to stations 2 and 3, following the heavy contamination of the station with diesel, especially between June 2013 and September 2013, when the activities of the illegal refineries were high. Sampling stations 2 and 3 had similar species composition and abundance because the effect of the spilled diesel waned with distance from station 1 and because the abundance of Water hyacinth in these stations. Water hyacinth forms a stable substrate that assorted groups of macrofauna easily colonize,. Generally, floating macrophytes provide protection for macroinvertebrates from fish predators and serve as a substrate for grazing, hunting and breeding (Soszka, 1975; Ogbeibu and Aganmwonyi, 2005). Consequently, macroinvertebrates abundance is usually higher in an area with a dense growth of floating macrophytes (Rooke, 1986; Friday, 1987).

CONCLUSION

The impact of an accidental spill of locally refined diesel on macroinvertebrate fauna was evident in sampling station I, the section of Ekehuan River, which unfortunately serves as the route for the refinedproducts'ts movement their end-users. Consequently, only a few representative species of macroinvertebrate fauna were recorded in this station.

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