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# THE EFFECT OF CRUDE OIL SPILL ON PLANKTON ABUNDANCE IN SANTA BARBARA RIVER, NEMBE, BAYELSA STATE

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## ABSTRACT

Plankton are the main varied group of aquatic organisms that play major roles in the aquatic environment as primary producers. The study focused on the effect of crude oil Spill on Plankton composition in Santa Barbara River, Nembe, Bayelsa State. Samples were collected and preserved in 5% formalin from ten (10) water sampling locations with one serving as control in four replicates. Standard plankton net of 55µm mesh size was used for sample collection. Data recovered from the study showed the occurrence of 61 species of plankton belonging to two (2) classes, 8 families and genera. A total of 486 organisms were recovered from the surface water out of which 394 (81.06%) were phytoplankton and 92 (18.93%) were zooplankton. The families of planktons identified were Bacillariophyceae, Cyanophyceae, Chlorophyceae, Xanthophyceae, Euglenophyceae, Dinophyceae, Copepod, and Cladocera. The family Bacillariophyceae had the highest species diversity (144) within WO/SW1 having the highest species richness of (96) which represented (19.75%) of the total plankton population recovered in the study. Sampling station WO/SW2 had a species richness of 64 (13.16%) while BA/SW8 had the lowest species richness of 32 representing (6.58%) of the recovered plankton population in the study. The result shows a decrease in the distribution and abundance of the plankton species in the Santa Barbra River. The results indicate pollution caused by hydrocarbon spillage. There was phytoplankton bloom when compared to zooplankton. The zooplanktons were more sensitive to the hydrocarbon spill than phytoplanktons this is linked to hypoxic nature of surface water following the hydrocarbon spill incident significantly affecting zooplankton abundance and diversity in the Santa Babra River.

**Keywords:** Phytoplankton, Zooplankton, Oil spill, Hydrocarbons, Hypoxic nature

  

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## 1. INTRODUCTION

The Niger Delta Gas Province is the largest in the world with an estimated 34.5 billion barrels of recoverable oil and 93.8 trillion cubic feet of gas and hosts Nigeria's most prolific oil deposits (Tuttle *et al.,* 1999). Since the discovery of petroleum in Nigeria, there has been an increase in oil exploration, prospecting, and mining in the Niger Delta region of the country. Nigeria has heavily relied on petroleum as the mainstay of her economy and foreign exchange. However, this has not come without health and environmental consequences due to oil spillage occasioned by the oil and gas industry's activities in the region. These activities by operators in the oil industry have caused pollution that had adversely impacted the ecosystem and lives of the inhabitants of the region (Angela and Ikenna, 2021).

Afinotan and Ojakorotu (2009) assert that in over 40 years of oil exploration and production in Nigeria, an estimated 60,000 spills have occurred. According to UNDP (2006), oil spills have been recurrent in the last 30 years, emptying into creeks and soils of southern Nigeria, with about 70% of these recovered while, 30% is lost to the environment. Similarly, oil exploitation had resulted to environmental pollution evident in the general degradation of water quality and resources in the Niger Delta region (Efe, 2001). These oil spills have resulted in heavy metal contamination of vegetation and the uptake of toxins through the trophic chain due to bioaccumulation in cultivated and wild crops. It has been established that ecosystem processes expose humans generally to heavy metals and threaten human health (McLaughlin *et al.,* 2000). This is because the ingestion of accumulated heavy metals by living systems and the physical resources are unsafe at unacceptable levels if consumed result to acute and chronic effects to living organisms such as impaired growth (Tietenberg, 2006).

Plankton are sensitive to pollutants due to their non-motility in relation to water current thus, drift with the surface water (Ikpeme *et al.,* 2013). They are the most varied groups of aquatic organisms that play a major role as primary producers in the aquatic environment (Khoirunnisaa and Juniato, 2010). These microscopic organisms are affected by both biotic and abiotic conditions of the aquatic ecosystem. The relative abundance of plankton communities is influenced by prevailing abiotic and biotic conditions of the ambient environment, thus, exhibit seasonality in their speciation, abundance, occurrence, richness (Arimoro *et al.,* 2018). Plankton are bioindicators of environmental quality and can comfortably give a snapshot of the pollution status, oceanographic complexity and organismal stress in a particular environment (Wilson and Hayek, 2019). Considering the sensitivity of the plankton community to minute ecological alterations occasion by disturbances such as oil spillage, this study, therefore seeks to determine the post impact status of the plankton community in Santa Barbara River, Nembe, Bayelsa State.

  

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## 2. THE STUDY AREA

The study area is in Bassambiri, lies within South Brass and East Odiama Creeks of Nembe Southeast of Bayelsa State, Nigeria. The geographical coordinates are within longitude 6'24'0"E and 6'34'30"E and latitude 4'34'30"N and4'28'30"N. The Santa Barbara River meanders through the thick brackish mangrove forest terrain of Bayelsa State of Nigeria, intersected by interconnected secondary tributaries and empties into the Atlantic Ocean (Figure 1).

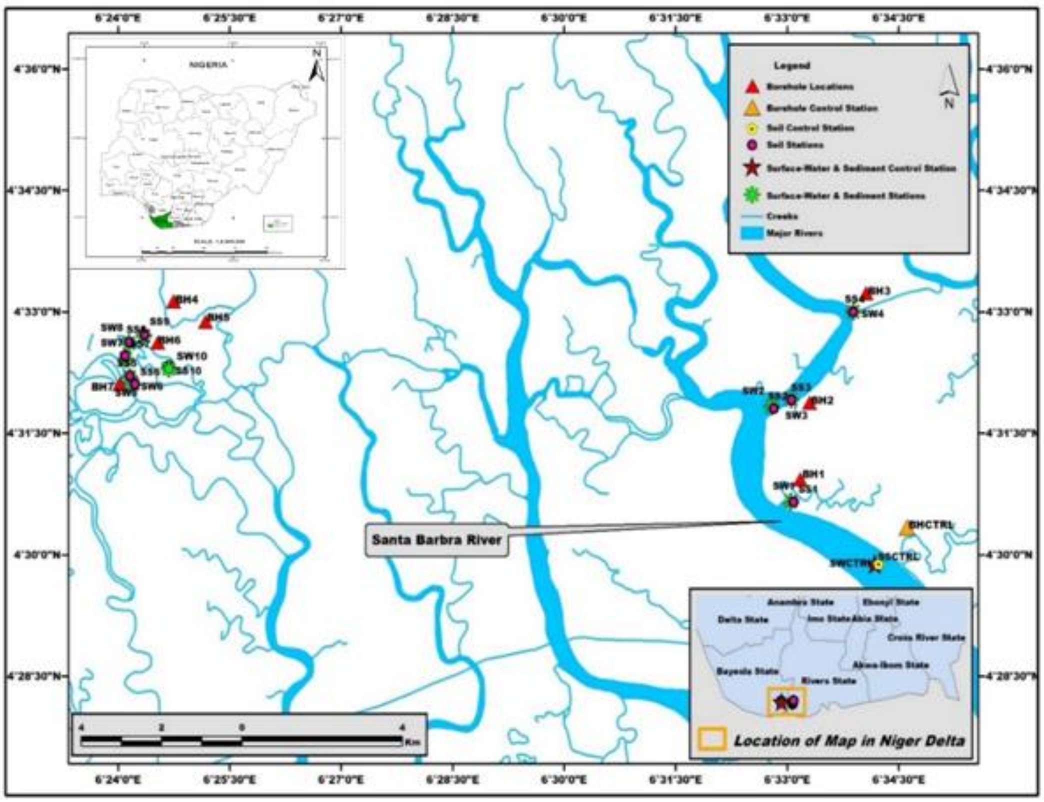


**Fig.1: Map of Study Area showing Santa Barbara River**

## 3. MATERIALS AND METHOD

### 3.1. Sample Collection

Samples for phytoplankton and zooplankton were collected and preserved in 5% formalin from ten (10) water sampling locations with one serving as the control. These samples were collected using standard plankton net of 55$\mu$m mesh size (Waife and Frid, 2001). Both qualitative and quantitative samples were collected. While, the qualitative samples were collected by towing the net at about 3 knots for 5 minutes at every station, quantitative samples were collected by

  

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filtering 50 litres of water through the net. These were composed and the concentrated aliquots were preserved in buffered 5% formalin in appropriately labelled plankton bottles for further analysis in the hydrobiology laboratory of the Department of Animal and Environmental Biology, Faculty of Science, University of Port Harcourt, Rivers State, Nigeria.

### 3.2. Plankton Analysis

Five drops (using a dropping pipette) of the concentrated sample aliquote (10ml) were observed using a grease free slide and a cover slip. 0.1ml of the concentrate was examined at different magnifications (x50, x100 and x400) using a binocular microscope with calibrated eye piece and the average recorded. The Drop Count Microscope Analysis Method described by Lackey (1938) and modified by Onyema (2007) was used to estimate the plankton flora and fauna. Each sample drop from the dropper accounts for 0.1 ml, the results on the abundance/occurrence of species were multiplied accordingly to give the values as numbers of organisms per ml which is the standard unit of measurement. To create a suitable plankton sample mount, a dropper was used to take in at least 1.5 ml of the sample after shaking properly. This was then allowed to stand for at least 3 minutes. After which one or two drops of concentrated sample from the dropper was then gently dropped on a glass-slide (7.5 cm by 2.5 cm) while, placed on a flat laboratory table and covered with a glass-slide (2cm by 2cm). The mount was then placed on the microscope stage, fitted in and all transects thoroughly observed for phytoplankton (cells, filaments and colonies) and zooplankton species (e.g. adults and juvenile stages alike). Final data were presented as number of organisms (cells, filaments, colonies and whole organism) per ml. Identification of the species was done using the keys as found in Whitford and Schmacher, (1973), Nwankwo, (1990), Barnes et. al., (1993), Waife and Frid, (2001).

**3.3. Data Analysis:** Percentage occurrence and relative numerical abundance of macro benthos were calculated using Excel Descriptive Statistical Tools. Densities of the abundant species were analyzed for each of the sampled stations.

## 4. RESULT

### 4.1. Planktons in the Santa Barbara River

Data recovered from the study showed the occurrence of 61 species of plankton belonging to two (2) classes, 8 families and genera. A total of 486 organisms were recovered from the surface water out of which 394(81.06%) were phytoplankton and 89(18.93%) were zooplankton (Table 1.0). Out of the 8 families, six (6) were phytoplankton and two (2) were zooplankton (Fig. 2). The families of plankton identified were Bacillariophyceae, Cyanophyceae, Chlorophyceae, Xanthophyceae Euglenophyceae, Dinophyceae, Copepod, and Cladocera. The family Bacillariophyceae, 144(29.7%) had the highest species diversity while Dinophyceae, 23 (4.73%)

  

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had the least occurrence within the sampling stations. The copepods were the most abundant zooplankton, 70 (14.40%) followed by the Cladocera, 22 (4.5%).

**Table 1: Community Distribution of Planktons in the Santa Barbara River**

| Class | Family | **Abundance (%)** | |
|---|---|---|---|
| Phytoplankton | Bacillariophyceae | 144(29.7) | 394(81.06) |
| | Cyanophyceae | 105(21.6) | |
| | Chlorophyceae | 54(11.11) | |
| | Xanthophyceae | 30 (6.17) | |
| | Euglenophyceae | 38(7.81) | |
| | Dinophyceae | 23(4.73) | |
| Zooplankton | Copepod | 70(14.40) | 92(18.93) |
| | Cladocera | 22(4.5) | |
| **Total (%)** | | | **486** |

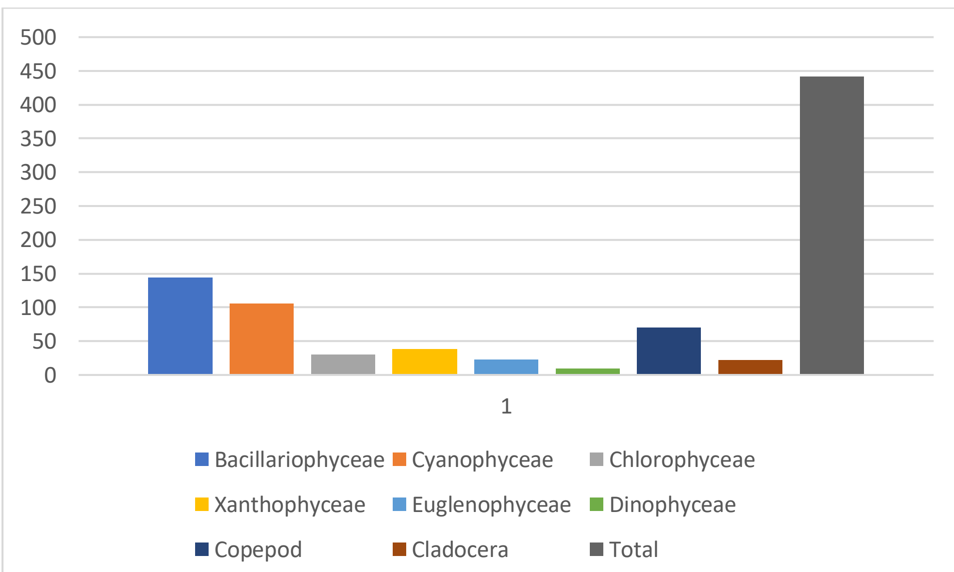


**Fig. 3: Community Distribution of Plankton in The Study Area**

### 4.2 Distribution of Plankton Across Sampling Stations

Plankton distribution and occurrence in relation to the sampling stations showed great variability (Figure 4). Sampling station, WO/SW1, 96 (19.75%) had the highest occurrence while stations BA/SW8 and BA/SW9 had the least abundance in relation to biomass (Figure 3). Sampling

  

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station WO/SW2 had a species richness of 64 (13.16%) while, sampling station; BA/SW8 had the lowest species richness of 32 representing (6.58%) of the recovered plankton population in the study. Similarly, Cyanophyceae had an abundance of 105 species across the study stations with sampling station; WO/SW2 recording the highest species richness of 18 representing (17.1%) of the Cyanophyceae encountered in the study while, sampling station; BA/SW9 and BA/SWC had the lowest species richness with 8 (7.61%) and 7 (6.66%) species respectively. Chlorophyceae recorded 54 species across the stations with highest and lowest population occurring in sampling stations WO/SW1 and BA/SWC respectively. Similarly, Xanthophyceae had a total of 30 species, Euglenophyceae had 38 species, Dinophyceae had 23 species, Copepod recorded 70 species and Cladocera had 22 species.

**Table 2: Plankton, Distribution and Abundance in Santa Barbara River**

| | Plankton Abundance and Diversity (%) | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|
| SPECIES | WO/SW1 | WO/SW2 | SAN/SW3 | SUN/SW4 | SEL/SW5 | ORU/SW6 | BA/SW7 | BA/SW8 | BA/SW9 | BA/SWC | Abundance |
| Bacillariophyceae | 33 | 18 | 15 | 11 | 16 | 15 | 12 | 11 | 8 | 5 | 144(29.7) |
| Cyanophyceae | 18 | 15 | 14 | 9 | 10 | 9 | 8 | 7 | 8 | 7 | 105(21.6) |
| Chlorophyceae | 13 | 9 | 7 | 8 | 7 | 5 | 1 | 2 | 2 | 0 | 54 (11.11) |
| Xanthophyceae | 8 | 4 | 3 | 0 | 5 | 2 | 5 | 2 | 0 | 1 | 30 (6.17) |
| Euglenophyceae | 11 | 7 | 5 | 4 | 0 | 3 | 5 | 1 | 0 | 2 | 38 (7.81) |
| Dinophyceae | 9 | 4 | 2 | 3 | 1 | 2 | 0 | 0 | 2 | 0 | 23(4.73) |
| Copepod | 3 | 4 | 3 | 3 | 8 | 9 | 7 | 9 | 10 | 14 | 70(14.40) |
| Cladocera | 1 | 3 | 0 | 3 | 0 | 0 | 3 | 0 | 5 | 7 | 22(4.5) |
| Total | 96 | 64 | 49 | 41 | 47 | 45 | 41 | 32 | 35 | 36 | 486 |

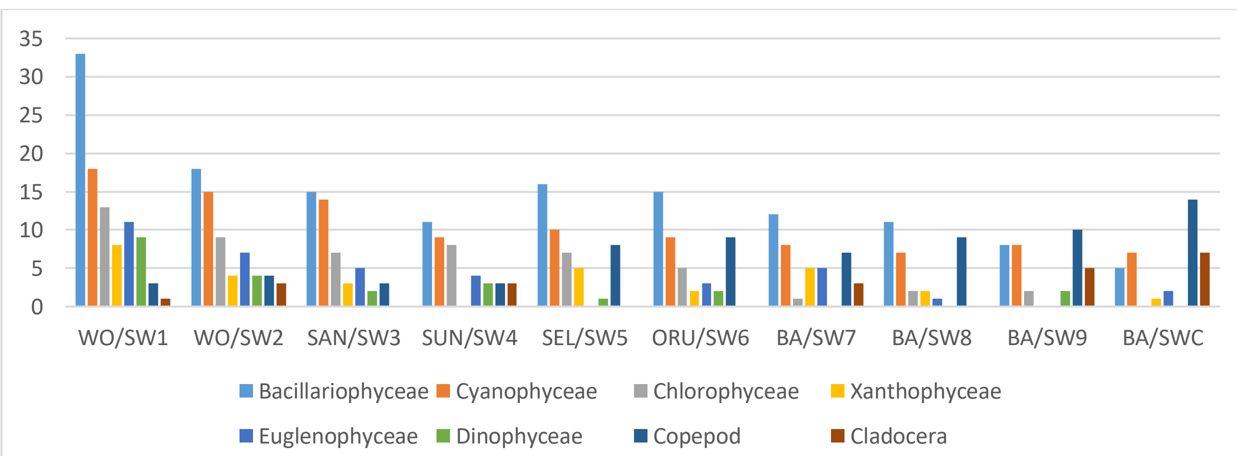


**Fig. 4: Plankton Distribution and Abundance in Santa Barbara River**

  

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### 4.3 Variation and Distribution Pattern of Plankton Families in the Study

Figure 4 to 11 showed the species abundance and prevalence of plankton groups in each family across the study stations. In the family Bacillariophyceae *Pleurosigma angulatum* recorded the highest number (19) representing 13.01% abundance followed by *Diatoma elongatum* (11) while *Navicula cryptocephala* (1) was the least abundant (Fig. 4). Similarly, *Lynbgya martensiana* (18) was the most abundant in the family Cyanophyceae followed by *Lynbgya limmetica* (15) while, *Oscillatoria limosa* (5) was the least abundant (Figure 5). In the Chlorophyceae family *Closterium ehrenbergii* was the most abundant (9) representing (16.67%) abundance followed by *Closterium kuetzingii* (8) representing (14.81%) abundance (Figure 6) while, *Gonatozygon monotaenium* (2) recorded the least abundance representing (3.70%) abundance (Figure 6). The family Xanthophyceae recorded only two species *Tribonema viride* (12) and *Tribonema utriculosum* (17) representing (41.38%) and (58.62) abundance respectively (Figure 7). Furthermore, Euglenophyceae recorded 5 species with *Euglena* gracilis (8) as the most abundant representing 21.05% while *Trachelomonas hispida* was the least abundant (Figure 8).

Dinophyceae had 4 species with *Ceratium tripos* (8) as the most abundant representing 34.78% while, *Cryptomonas erosa* (7) was the least abundant (Figure 9). The result shows that *Tropodiaptomus processifer* is the most ab undant zooplankton species in the family copepod while *Thermocyclops neglectus* is the least abundant. Similarly, the family Cladocera had only two species *Bosmina longirostris* and *Bosminopsis dertersi* (Figure 10 and 11).

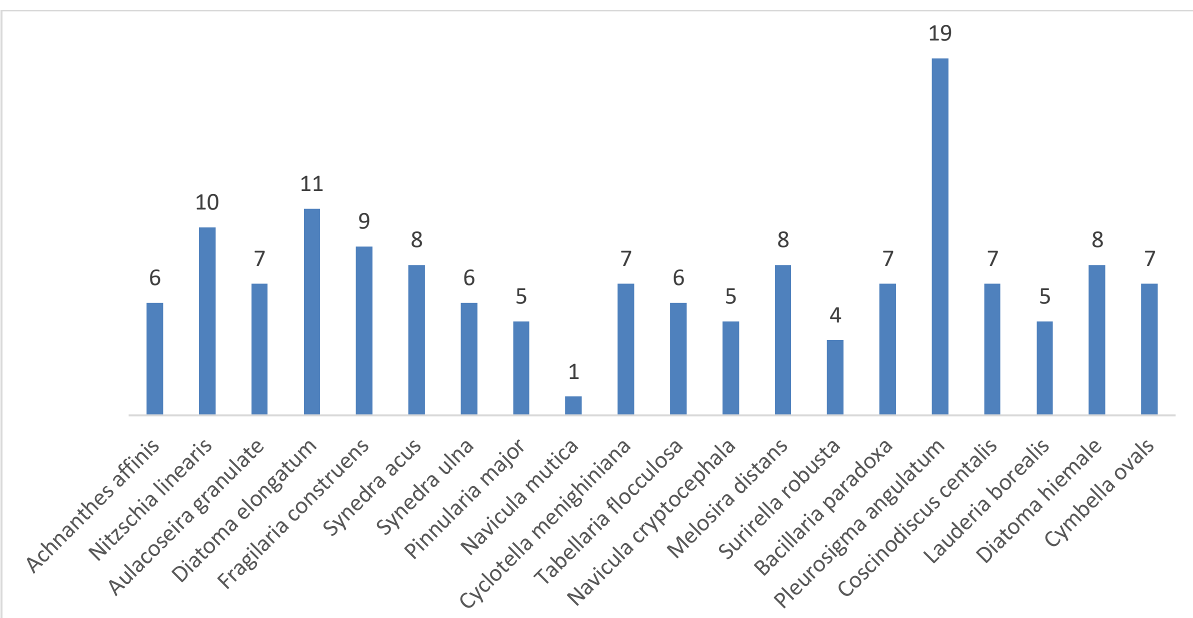


**Fig 4: Species Abundance of the Family- Bacillariophyceae**

  

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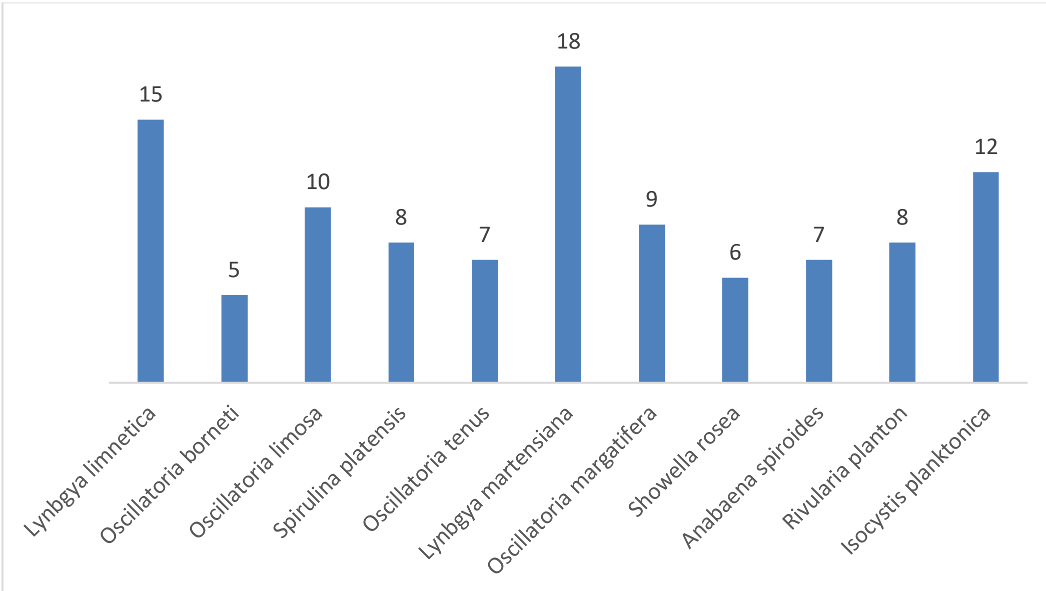


**Fig 5: Species Abundance of the Family- Cyanophyceae**

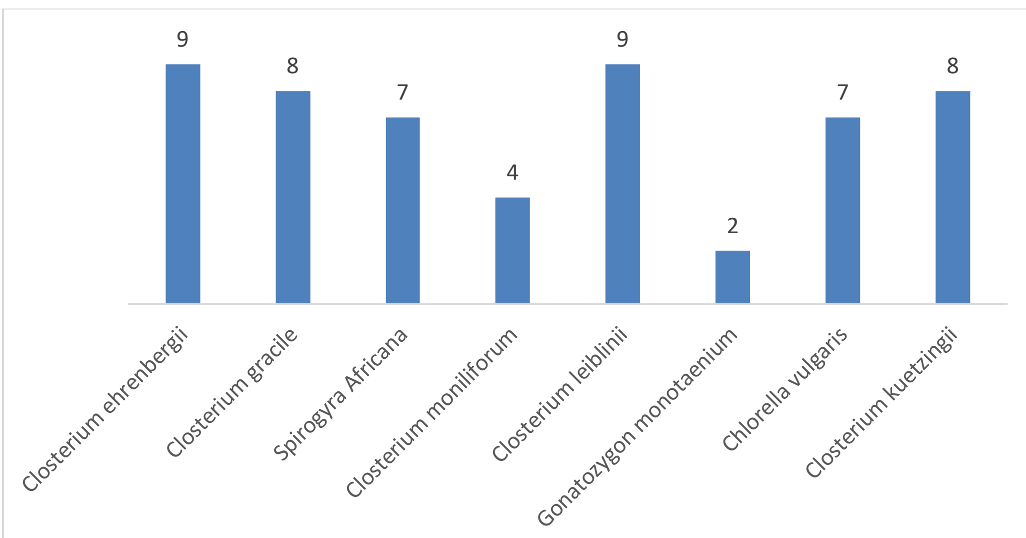


**Fig 6: Species Abundance of the family Chlorophyceae**

  

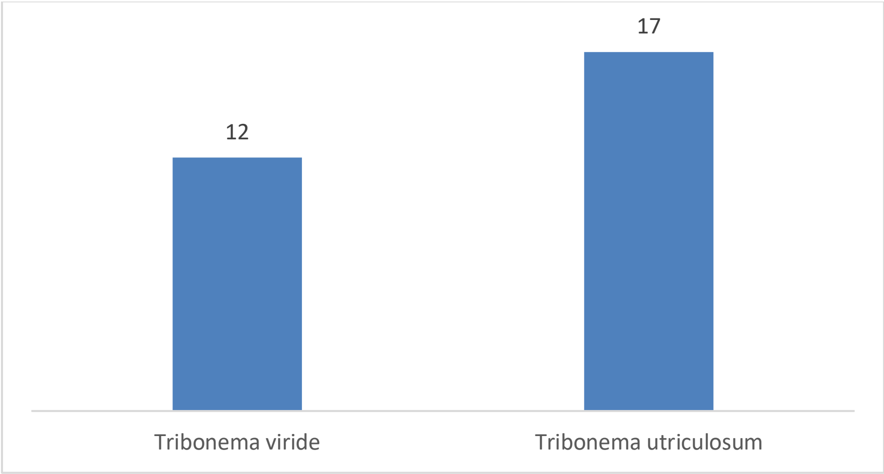


**Fig 7: Species Abundance of the Xanthophyceae**

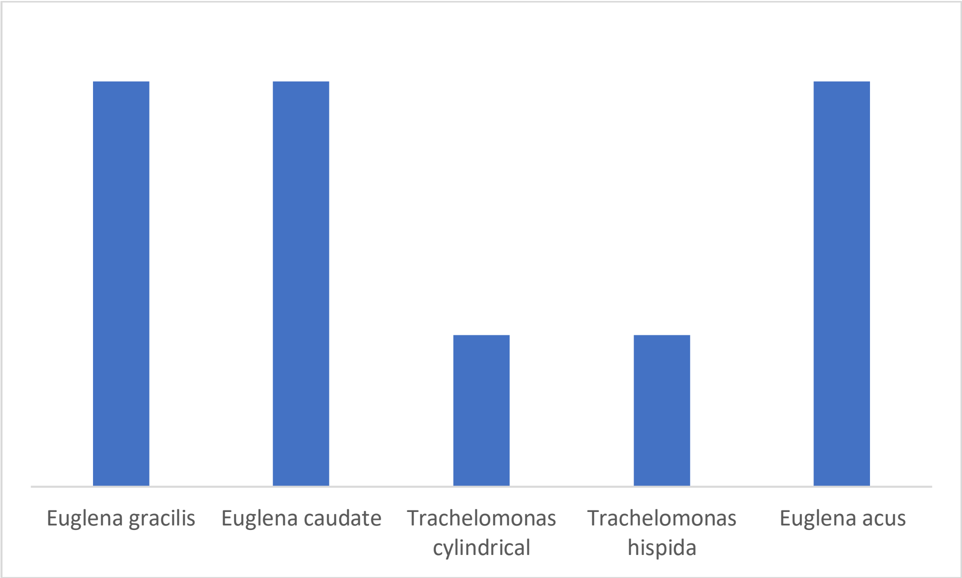


**Fig. 8: Species Abundance of the Euglenophyceae**

  

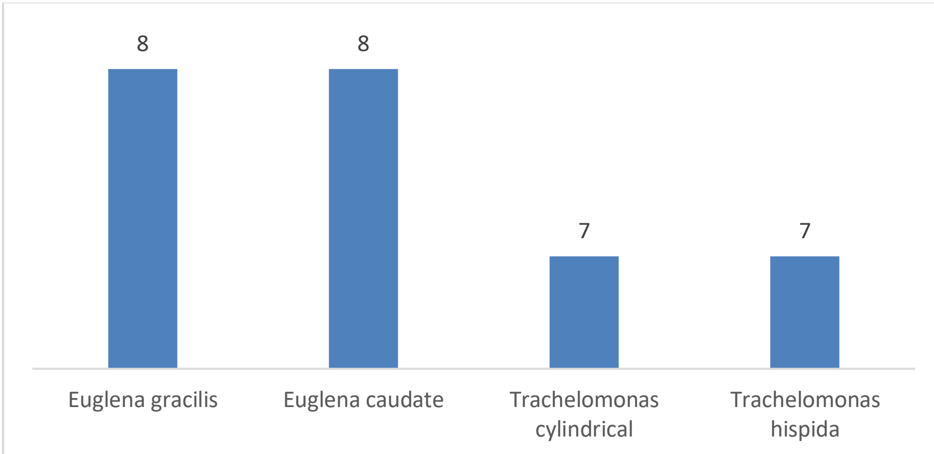


**Fig 9: Species Abundance of the Dinophyceae**

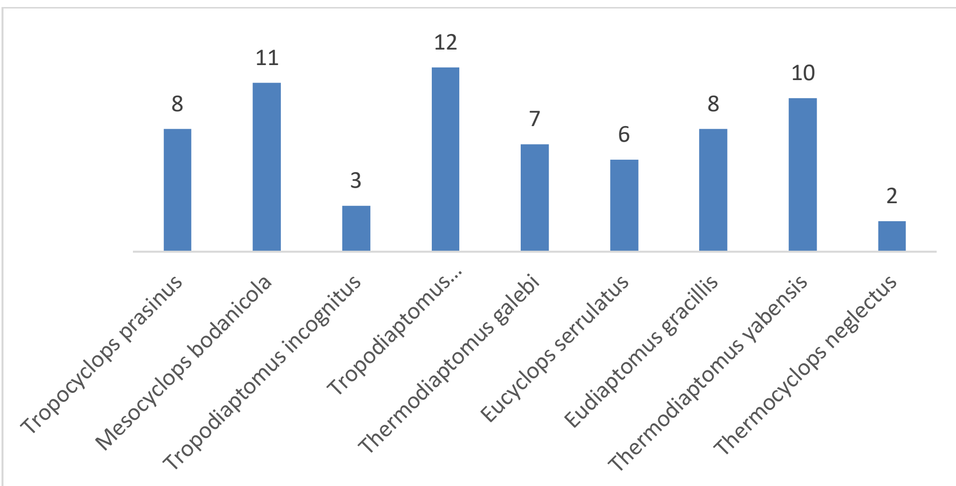


**Fig 10: Species Abundance of the family COPEPOD**

  

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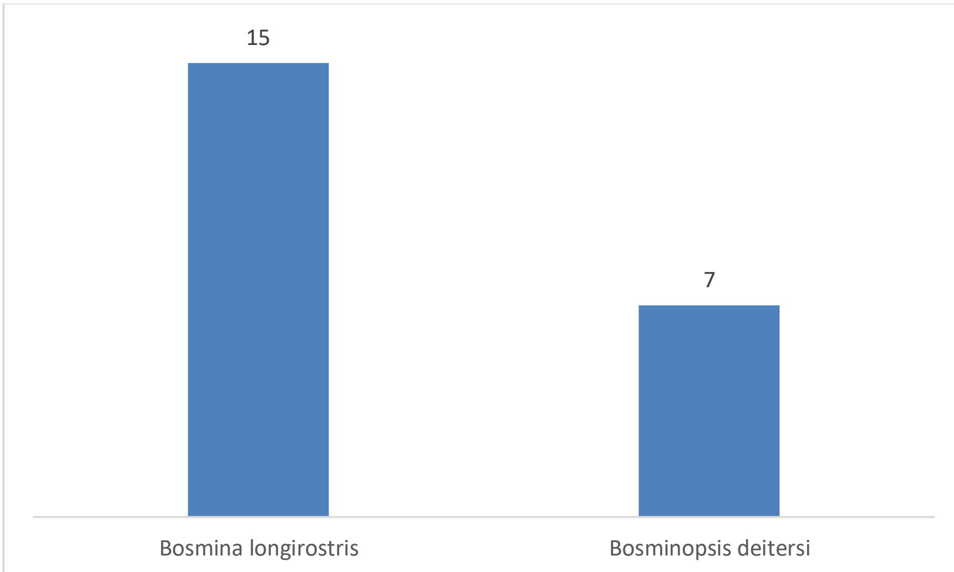


**Fig 11: Species Abundance of the family CLADOCERA**

## 5.0. DISCUSSIONS

### 5.1. Hydrocarbon impact on Planktons in the Study Area

The results of the study show that the plankton were affected by the hydrocarbon spill. Lewis and Pryor (2013) noted that hydrocarbon spills are harmful for microbes (phytoplankton, bacteria, protozoa). Decrease in algal boom and primary productivity have been reported following hydrocarbon spills (Gonzaleez et al. 2009). Planktons are highly susceptible to natural changes in diverse ecosystem, they could monitor aquatic ecosystem under high phosphorus and nitrogen existence. Studies have shown that the chemical properties of oil can affect the cellular membranes of planktonic organisms by increasing permeability to toxic chemicals, disrupting respiration, and causing membrane lysis (Singer et al., 1991). The occurrence of some species that can be found in polluted areas (impacted sites) and non –polluted (non-impacted sites) environment is an indication of the ubiquitous nature of planktons in the aquatic environment. The presence of *Lynbgya martensiana*, *Lynbgya limmetica* and *Oscillatoria limosa* in the family Cyanophyceae shows the pollution status of the water. Thakur, et. al. (2013) reported that planktons of the family cyanophyceae and chlorophyceae are known biological indicator of rapid eutrophication of aquatic ecosystem caused by pollution.

### 5.2 Hydrocarbon impact on Phytoplanktons

The results of abundance, distribution, and diversity of phytoplanktons in the Santa Babra River show more resilience than the zooplankton and signifying local adaptation to the hydrocarbon

  

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spill. The result is consistent with similar studies carried out, which argue that planktonic communities exhibit an encouraging level of resilience in the presence of hydrocarbons, whilst adapting to preexisting conditions (Abbiano et al., 2011). Phytoplankton booms following hydrocarbon spills is often linked to reduced predation from zooplanktons (Ozhan et al., 2014; Abbiano et al., 2011). Often following hydrocarbon spills rapid recovery of phytoplankton populations occur. High reproduction rates of marine organisms, circulation as well as mixing, dispersion, and degradation of oil in surface seawater are linked to rapid recovery of phytoplanktons in oceans (Abbiano et al., 2011). Similarly, phytoplankton community and structure is known to shift in response to conditions such as temperature, nutrient availability and grazing pressure (Quigg et al., 2021)

Previous studies have shown that plankton growth responses vary as some studies find growth increase while others find growth decrease in the presence of contaminants (Bretherton, *et al*., 2018, Ozhan, *et al*., 2014 and Bretherton, *et al*., 2020). Hence, the plankton community response in the event of a hydrocarbon spill may be influenced by site- or species-specific conditions. The result of this study establishes that the hydrocarbon spill in the Santa Barbara River and aquatic organisms were affected. There was significant decrease in the plankton composition and structure particularly zooplanktons. The phytoplanktons were less impacted due to reduced predation by zooplanktons. The phytoplankton boom within the hydrocarbon spill shows resilience and local adaptation by the phytoplanktons in the presence of hydrocarbons. The results demonstrated that a relationship between the impacted and non-impacted spill sites exists.

A comparative analysis of impacted sites and non-impacted areas showed significant variance in the community distribution and abundance of phytoplankton species with a descending trend from upstream to downstream of the Santa Barbara River (See Table 3). In the more impacted sites where the hydrocarbon spill occurred located upstream of the river phytoplankton boom was evident particularly with the Bacillariophyceae, Cyanophyceae showing greater dominance. In the less impacted sites with no hydrocarbon spill located downstream of the river particularly the control point, there was reduced abundance of phytoplanktons species as demonstrated by fewer numbers of Bacillarophyceae, Cyanophyceae and Chlorophyceae species. This may be attributed to presence of zooplanktons downstream, increased predation and favourable conditions for zooplankton growth and productivity. The hydrocarbon spill impacted sites had greater species abundance and richness levels of phytoplanktons when compared with the less impacted sites with lower species abundance and richness levels. The results showed there was a significant effect of hydrocarbon spill on phytoplankton and abundance and diversity at the impacted and non-impacted sites.

  

**Table 3: Variation of Plankton and Distribution of Species in the Santa Barbaras River**

| | Plankton Abundance and Diversity (%) | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|
| SPECIES | WO/SW1 | WO/SW2 | SAN/SW3 | SUN/SW4 | SEL/SW5 | ORU/SW6 | BA/SW7 | BA/SW8 | BA/SW9 | BA/SWC | Abundance |
| Bacillariophyceae | 33 (22.9) | 18 (12.5) | 15 (10.4) | 11 (7.63) | 16 (11.1) | 15 (10.41) | 12 (8.3) | 11 (7.63) | 8 (5.55) | 5 (3.42) | 144 (29.7) |
| Cyanophyceae | 18 (17.1) | 15 (14.3) | 14 (13.3) | 9 (8.57) | 10 (9.52) | 9 (8.57) | 8 (7.61) | 7 (6.66) | 8 (7.61) | 7 (6.66) | 105(21.69) |
| Chlorophyceae | 13 (24.07) | 9 (16.66) | 7 (12.96) | 8 (14.81) | 7 (12.96) | 5 (9.29) | 1 (1.85) | 2 (3.7) | 2 (3.7) | 0 (0) | 54 (11.16) |
| Xanthophyceae | 8 (26.66) | 4(13.33) | 3 (10) | 0 (0) | 5 (1.66) | 2 (6.66) | 5 (1.66) | 2 (6.66) | 0 (0) | 1 (3.33) | 30 (6.17) |
| Euglenophyceae | 11 (28.94) | 7 (18.42) | 5 (13.15) | 4 (10.52) | 0 (0) | 3 (7.89) | 5 (0.13) | 1 (2.63) | 0 (0) | 2 (5.26) | 38 (7.81) |
| Dinophyceae | 9 (39.13) | 4 (17.39) | 2 (8.69) | 3 (13.04) | 1 (4.37) | 2 (8.69) | 0 (0) | 0 (0) | 2 (8.69) | 0 (0) | 23 (4.73) |
| Copepod | 3 (4.28) | 4 (5.71) | 3 (4.28) | 3 (4.28) | 8 (11.4) | 9 (12.85) | 7 (10) | 9 (12.85) | 10 (14.28) | 14 (20) | 70 (14.40) |
| Cladocera | 1 (4.54) | 3 (13.63) | 0 (0) | 3 (13.63) | 0 (0) | 0 (0) | 3 (13.63) | 0 (0) | 5 (22.72) | 7 (31.81) | 22 (4.5) |
| Total | 96 (19.75) | 64 (13.16) | 49 (10.08) | 41(8.43) | 47 (9.67) | 45 (9.25) | 41(8.43) | 32 (6.58) | 35 (7.20) | 36 (7.40) | 486 |

## 5.3. Hydrocarbon impact on Zooplankton in the Study Area

The results showed the zooplankton had low abundance, sparse distribution, and diversity in all the sampled stations in the Santa Babra River following the hydrocarbon spill. Zooplankton were more severely affected than the phytoplankton. The result is consistent with other research that suggest zooplankton species are sensitive to chemicals found in hydrocarbons (Abbiano et al., 2011). However, Fefilova (2011) argued that zooplankton are more susceptible on exposure to hydrocarbon spill than phytoplankton due to lack of oxygen in the water surface. Zooplankton (Copepods) in direct contact with hydrocarbon spills are likely to experience increased mortality and decreased feeding and reproduction (Suchanek, 1993), potentially allowing blooms of phytoplankton (Abbiano et al., 2011). Generally, the of resilience and response of plankton to hydrocarbon spills varies. Studies show that in zooplankton communities mortality tends to be more dependent upon exposure time than concentration of oil, although higher oil concentrations lead to the higher mortalities (Lee and Nicol, 1977). However, in the immediate vicinity of hydrocarbon spill, thick buoyant oil slicks inhibit air-sea gas exchange and light penetration both essential to photosynthesis and phytoplankton growth (Gonzalez et al., 2009). Harrison et al. (1986) argued that PAHs in the oil also affect phytoplankton growth, with responses ranging from stimulation at low concentrations of oil (1 mg L–1) to inhibition at higher concentrations at 100 mg L–1. In the study area no PAH were detected in the Santa Babra River, hence the phytoplanktons were not affected or influence by PAH. Comparisons of impacted sites and non-impacted sites showed significant variance in the community distribution and abundance of zooplankton species particularly the Copepods species with an increasing trend from upstream to downstream of the Santa Barbara River. In the more impacted areas located upstream of the river there were fewer Copepods, however the Cladocera specie did not follow this trend. In the less impacted areas downstream the Cladocera which showed a sinusoidal trend in community structure and downstream. Dispersion of hydrocarbons downstream of a meandering river may lead to build up of hydrocarbons along the river which may have affected zooplanktons as they are sensitive to hydrocarbons leading to zero count of Cladocera in some sampling stations downstream. The impact of the hydrocarbon spill affected the zooplanktons leading to increased species at sampling stations downstream including the control (See Table 3). In the non-impacted sites greater number of species were present, increased predation of phytoplanktons leading to reduced number of phytoplanktons downstream. Less impacted areas promoted zooplankton productivity and affected community structure of both zooplanktons and phytoplanktons.

## CONCLUSION

There was significant variance in the community distribution and abundance of phytoplankton species with a descending trend from upstream to downstream of the Santa Barbara River. In the more impacted areas located upstream of the river phytoplankton boom was evident and in the less impacted areas downstream there was reduced abundance of phytoplankton's species. The zooplanktons demonstrated an increasing trend from upstream to downstream of the Santa Barbara River. In the more impacted areas located upstream there were fewer Copepods when compared to downstream; however the Cladocera specie did not depict this trend rather a sinusoidal trend was observed. The hydrocarbon spill impacted sites affected distribution and species abundance of both zooplanktons and phytoplanktons but varied from upstream to downstream of the Santa Barbara River. The study demonstrated that a relationship between the impacted and non-impacted spill sites exist. This affected plankton distribution and structure in the Santa Barbara River.

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