Physiochemical Factors Affecting Macrobenthic Invertebrates Disribution in the Bottom Sediments of Okhuo River

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Abstract
Nigerian benthos has been concentrated on the benthic fauna of urban and semi urban areas; consequently, the rural waters have been abandoned. The taxonomy of Nigerian streams is poorly known and this probably contributes to the reluctance to carry out researches in these areas. The macrobenthic invertebrates of a perturbed urban section of the Ikpoba River, showed that the stress caused by human activities affected species diversity and abundance on the benthic fauna of New Calabar River, in Cross River State. The study showed that the diversity of the fauna was low, with only 23 taxa recorded. The fauna was dominated by Annelid (Polychaete and Oligochaete) that constitutes 54% of the population. Investigation shows the effect of salinity and other physicochemical factors in abundance and distribution of littoral invertebrates in a coastal lagoon of southern examined flora and fauna associated with water hyacinth in Yewa River, in Ondo State. Studies of the benthic fauna associated with different microhabitats in mangrove forest of the Bonny Estuary, Niger Delta, Nigeria showed that the number of species associated with a particular habitat was similar but the community structure differed distinctly.
Keywords: Macrobenthic Invertebrates, Polychaete, Oligochaete, Environmental Impacts, Habitat

1.0 INTRODUCTION

Almost every taxonomic group inhabiting the fresh water is represented on the macrobenthos of streams and rivers (Hynes, 1972). Aquatic dipterans are the most ubiquitous of all the macrobenthic invertebrate groups in the tropics (Ogbeibu and Victor, 1989). Many macrobenthic invertebrates are mostly the larval forms of flying insects such as May flies, Stone flies and Caddis flies. Others are small animals that spend their lives in the stream, such as water mites and planarians. Some can travel between water and moist terrestrial environments such as fresh water snails. The invertebrate communities of streams provide a more sensitive index of realistic changing conditions than chemical and microbiological data, which only indicate short-term alterations (Hynes, 1960, 1965; Brinkhurst, 1965). Therefore, benthic invertebrates have been widely used as bioindicators of aquatic impacts related to stream pollution (Tsui and McCart, 1981). The benthic community is affected differently varying with latitude, depth, local current regimes, substrates, geography and site exposure resulting in a high variability both on spatial and temporal scales (Tsui and Mc Cart, 1981). North East Local Government Area of Edo State, a rural community in Southern Nigeria, with pollution sources coming from human activities such as washing and bathing; with the specific objectives of investigating:

1. The species composition, distribution, taxa richness and diversity of the benthic communities in the bottom sediment of the river.
2. Some physicochemical properties of water that affect the macrobenthic invertebrates.
3. Spatial variations among the parameters, and seasonal variations

It is quite important that a baseline investigation of macrobenthic fauna in the bottom sediment of this river is recorded and used for future reference of bioindicators. It is hoped that the information provided here would be a study guide for future reference.

2.0 MATERIALS and METHODS

SAMPLING LOCATION

The study was carried out in Okhuo River about 20.5km away from Benin City off Lagos-Benin Express Road (Ovia North-East Local Government area) and lies within coordinates 06 33’N and 05 37’E as shown in Fig-1. Okhuo is located within the tropical forest belt of Southern Nigeria with the mean annual rainfall of >60cm and mean annual temperature fluctuates between 31.8^0C and 34.2^0C.

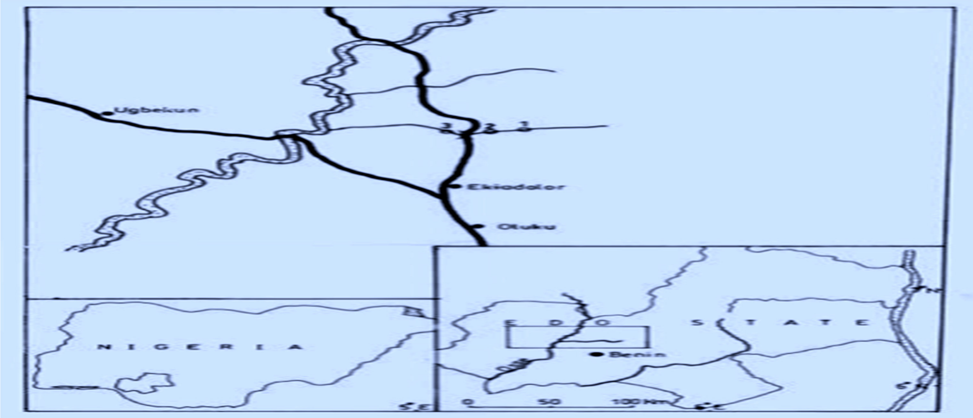


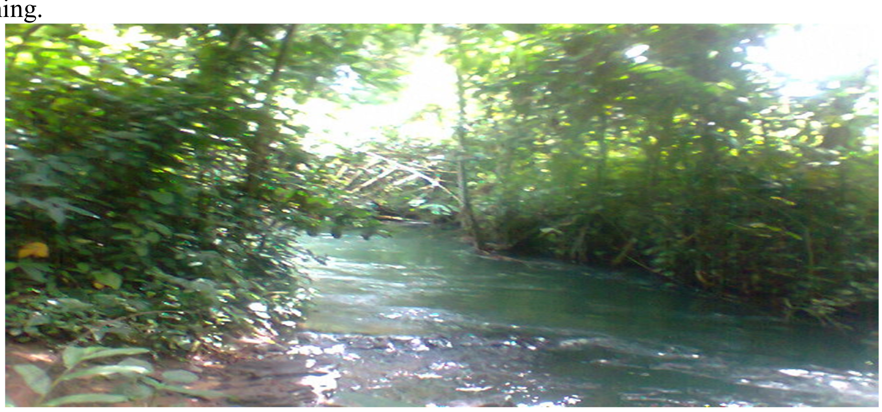
Fig-1: Map of Okhuo River and the Sampling Stations

2.2 Sampling Stations:

Three sampling stations were selected: upstream, mid-stream and a downstream station.

2.2.1 Station 1

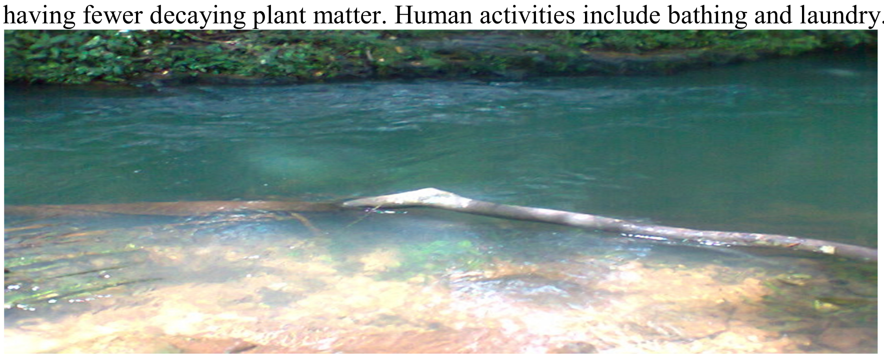
Station 1 is located upstream approximately 4km from a bridge across the river. It is partially shaded by trees forming a canopy over it. The substratum is clay, mud and decaying plant matter. Human activity is restricted to occasional bathing.



Station 1: Sampling station 1

2.2.2 Station 2:

Station 2 is about 2km downstream of station 1. Major part of the sub-stratum is covered with stones but the bank area is sandy. The sampling station is surrounded by trees of Indian bamboo, *Bambusa* sp. with clear water and the bottom having fewer decaying plant matter. Human activities include bathing and laundry.



Station 2: Sampling station 2

2.2.3 Station 3

Station 3 is 2km downstream of sampling station 2 and immediately after the bridge across the river. The dominant vegetation at the bank is *Bambusa* sp. The sub-stratum is sandy, with decaying plant matter.

Station 3: Sampling station 3

2.3 Sample Collection:
Water samples for checking water quality were collected once in a month from January to June 2013 and twice a month for macro-benthic fauna. Sampling was done in Uniben water bottles with tight corks. At each station, air temperature, surface water temperature, water depth and flow rate were determined in-situ and the values were recorded.

2.4 Determination of Physicochemical Parameters
2.4.1 Physical Parameters:
Temperature: Air and water temperature was measured in the field with mercury glass thermometer (Molded Valon model) ranging from 0^0C to 110^0C.
Flow Rate: Water flow rate or current velocity was determined as demonstrated by (APHA 1988)
Total Dissolved Solids: TDS was measured using Total Dissolved Solids meter (512T10-Myron) by dipping the probe into a beaker containing water samples, and readings were recorded.
2.4.2 Chemical Parameters
Dissolved Oxygen (DO): The dissolved oxygen of the given water samples was determined by Winkler's method (APHA 1988).
Biochemical Oxygen Demand (BOD): Water samples were incubated at 20^0C for 5 days and at the end of fifth day BOD was measured by the Winkler's method (APHA 1988).

2.5 Macro Invertebrates
Random sampling was done on the macro habitats of the various sampling sites on a monthly basis.
Sorting: The organisms were sorted using the American Optical Dissecting Microscope (LB-570, Bausch & Lomb Optical Co.). Sorted organisms were preserved in 4% formalin in labeled specimen bottles for identification and counting.
Identification and Counting: Identification of the organisms was done using the dissecting microscope described above and binocular Olympus (WF 10x, Olympus Global). Most of the organisms were identified using some texts with identification keys of organisms (Olomukoro, 1983; Ogbeibu, 1984).
Estimation of Fauna Diversity: This is the qualitative relationship between taxa species and individuals or between total numbers of components. Margalef's Index (d) was used to calculate for species or taxa richness:

$$d = \frac{S-1}{\text{In}N}$$

Where,
S = Number of species

N = Total number of individuals
I_n = Natural logarithm
Shanon-Weinner's Index (H) was used to calculate the general diversity. This index is a function of the relative abundance of the species in the macrobenthic community.

$$H = \frac{\text{NlogN} - \sum_{i=i}^{S} \text{f1logf1}}{\text{N}}$$

Where,
N = Total number of individuals
F_1 = Number of individuals in species
S = Number of species

Evenness Index (S) was used to calculate the degree of uniformity in the distribution of individuals of each taxon collected.

$$E = \frac{H}{Hmax} \text{ or } \frac{H}{logS}$$

Where,
H = General diversity
H_{max} or logs = Maximum expected diversity
The index for estimating the similarities (Sorenson's Quotient ($^{Q}/_{S}$)) between fauna at different stations was calculated to evaluate the similarity between the fauna of the three stations. It is expressed as:

$$Q/S = \frac{2C}{a+b} \text{X} \frac{100}{1}$$

Where,
a = Number of the species at one station
b = Number of species in the other station
c = Number of species common to both stations
Q/S Value less than 50% indicates dissimilarity in the fauna while Q/S value more than 50% indicates similarity in the species composition between the stations.

3.0 RESULTS

The results of the physicochemical characteristics of the three study stations of Okhuo River are represented along with the macrobenthic invertebrate fauna that were collected during the study period.

3.1 Physical and Chemical Characteristics

The summary of the physicochemical characteristics of the three study stations are presented in Table-1 below.

Table-1: Summary of Physical and Chemical Characteristics:

PARAMETERS	Units	Station 1		Station 2		Station 3	
		Min-Max	Mean ±SE	Min-Max	Mean± SE	Min-Max	Mean ± SE
Air temperature	°C	25– 30	28.33±1.75	24–30	28.16±2.14	23–30	28±2.53
Water Temp.	°C	25– 27	26 ±0.63	25–26	25.83±0.41	25–27	26±0.63
Depth	M	1.60–1.75	1.69.5±0.058	1.50–1.67	1.59±0.072	0.56–0.79	0.67±0.083
Flow rate	m/s	1.56–4	2.61±0.96	1.14–2.1	1.66±0.35	1.53–3.31	2.22±0.78
Turbidity	NTU	0–12	5±4.82	2–9	5.66±2.42	1–11	4.5±3.45
Suspended solid	mg/l	0–7	3.16±2.99	0–4	2.16±1.72	0–5	2.83±1.72
pH	mg/l	6.2–6.5	6.36±0.10	6.2–6.9	6.45±0.24	6.2–6.4	6.28±0.09
Conductivity	µS/cm	14.9–16.6	16.1±0.75	18–34.3	21.55±6.58	15–18.1	16.03±1.25
Total solid	mg/l	8–16	11.82±2.64	8–25.25	15.20±5.65	9–14	12.23±1.98
Total dissolve solid	mg/l	8–11.9	9.32±1.33	8–25.25	13.71±6.15	7–13.4	8.73±2.41
Dissolve oxygen	mg/l	4.8–7.5	5.66±1.27	2.4–7.35	5.51±1.96	6.3–8	6.8±0.87
BOD	mg/l	4.44–9.55	5.63±1.97	4.1–7.1	4.78±1.19	4.9–6.5	5.45±0.67
Alkalinity	mg/l	3 –16	10.3±6.23	3–24	10.16±7.36	3–22	10.33±6.74
Hardnesss as $CaCo_3$	mg/l	3–16	7.5±4.76	4–10	7.17±2.71	4–11	6.67±2.50
Nitrate	mg/l	0.26–0.2	0.19±0.17	0.26–0.5	0.41±0.27	0.45–1.62	0.54±0.56
Chloride	mg/l	14.1–35.4	25.8±10.63	14–28.4	21.02±6.12	17.75–28.3	21.86±5.21
Phosphate	mg/l	0.07–1.76	0.33±0.69	0.06–3.1	0.57±1.26	0.02–0.47	0.12±0.17
Sulphate	mg/l	1–7	3.83±2.23	1–8	3.38±2.40	2–5	3.33±1.03
Calcium	mg/l	0.8–5.21	2.50±1.55	1.2–3.61	1.71±0.96	1.2–3.21	1.64±0.81
Magnesium	Mg/l	0.24-0.73	0.36±0.21	0.97-1.2	0.72±0.46	0.73-1.23	0.77±0.36

3.2 Air and Water Temperature

The air and water temperature range, Flow rate d between 23 °C and 30 °C for the three sampling stations while the mean values of air temperature for stations 1 to 3 are 28.33°C, 28.16°C and 28°C respectively. This is as shown in fig. 2. The water temperature values ranged between 25 and 27 °C. The least value of water temperature was recorded in the month of January in all the stations while the highest value was recorded in the month of May in stations 1 and 3. This is shown in fig. 3.

3.3 Flow Rate (m/s)

The flow rate ranged between 1.14 and 4.00 m/s with the least value being recorded at station 2 in the month of January and the highest value in the month of May in station 1. The mean values for flow rate at the three stations were 2.61, 1.66 and 2.22 m/s respectively for stations 1, 2 and 3. This is as shown in fig. 4.

3.4 pH

The pH ranged between 6.2 and 6.9 in the three stations. The highest pH value was recorded in the month of March at station 2. The mean values were 6.36, 6.45 and 6.28 for stations 1, 2 and 3 respectively. There were little variations between values recorded throughout the duration of the study with the river being slightly acidic, basic or neutral by approximation. This is represented in fig.5.

3.5 Total Dissolved Solid (mg/L)

The value of total dissolved solid ranged between 7 and 25.25mg/L in all the stations. The lowest value in the months of February and June at station 3 and the highest value were recorded in the month of January at station 2. The mean values for total dissolved solid were 9.32, 13.71 and 8.73 for station 1, 2 and 3 respectively and this is well represented in fig.6.

3.6 Dissolved Oxygen (DO) (mg/L)

Dissolved Oxygen values for the three stations ranged between 2.4 and 8mg/L with the least value being recorded at station 2 in the month of May and highest value at station 3 in the month of January. Higher values were recorded in the months of January and February and lower values were recorded in the rest of the months. This shows that DO reflected the two seasons and this is shown in fig.7.

3.7 Biological Oxygen Demand (BOD) (mg/L)

The BOD values ranged from 4.44 and 9.55 mg/L with the highest and lowest value being recorded at station 1 in the months of January and March respectively. The mean values for the three stations were 5.63, 4.78 and5.45mg/L for station 1, 2 and 3 respectively. This is shown in fig. 8.

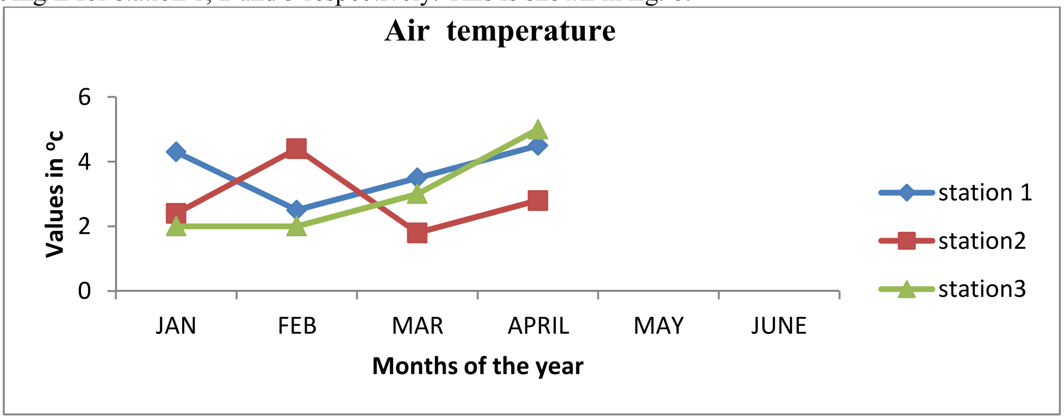


Fig-2: Monthly variation in Air Temperature in Okhuo River, Edo State.

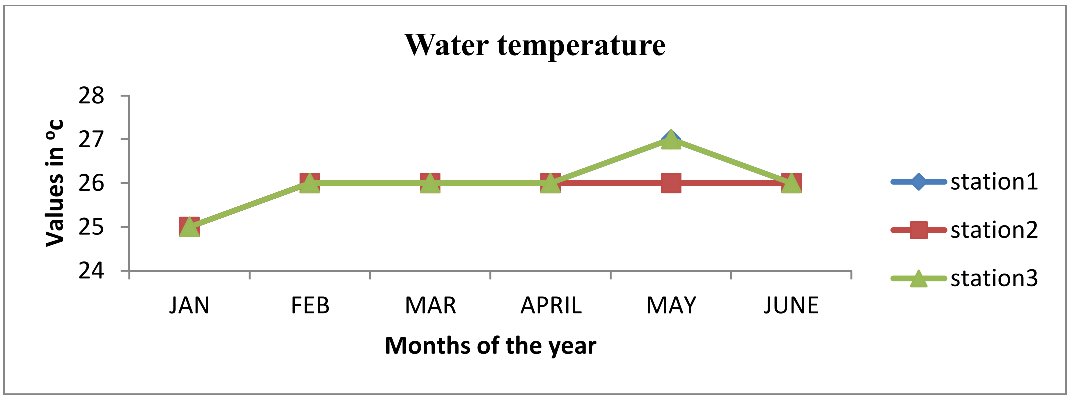


Fig-3: Monthly variation in Water Temperature in Okhuo River, Edo State.

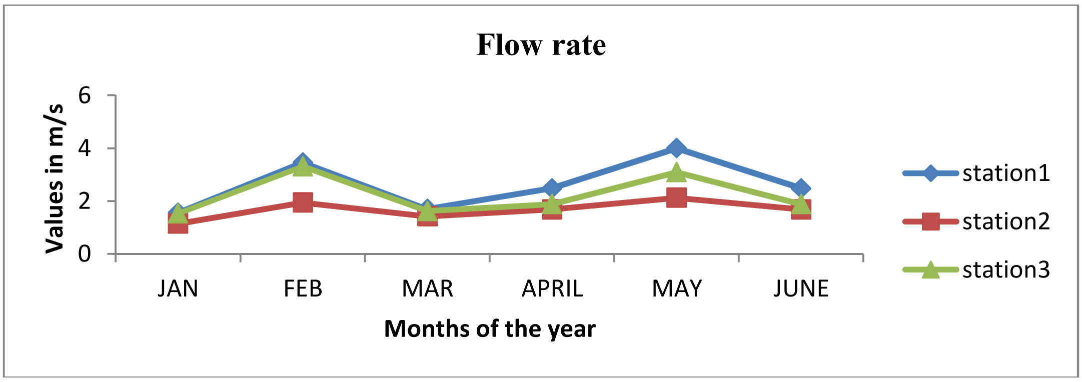


Fig-4: Monthly variation in Flow rate in OKhuo River, Edo State.

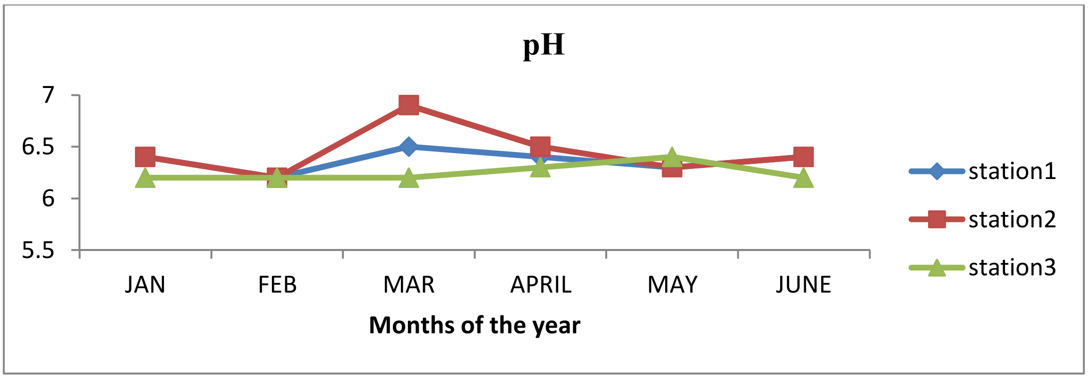


Fig-5: Monthly variation in pH of Okhuo River, Edo State.

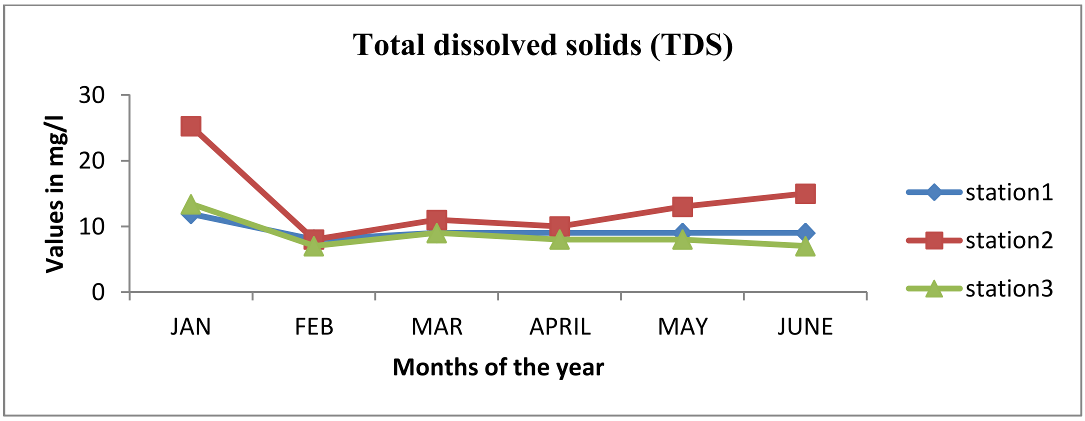


Fig-6: Monthly variation in Total Dissolved Solid of Okhuo River, Edo State.

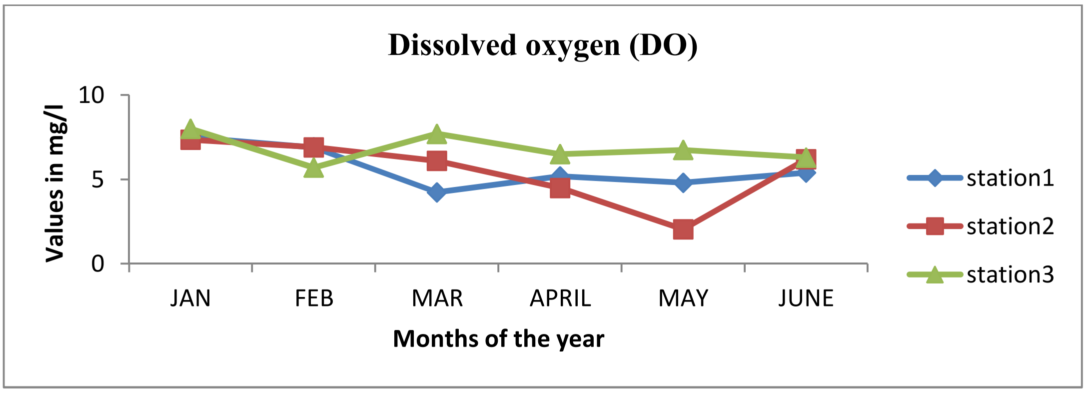


Fig-7: Monthly variation in Dissolved Oxygen of Okhuo River, Edo State.

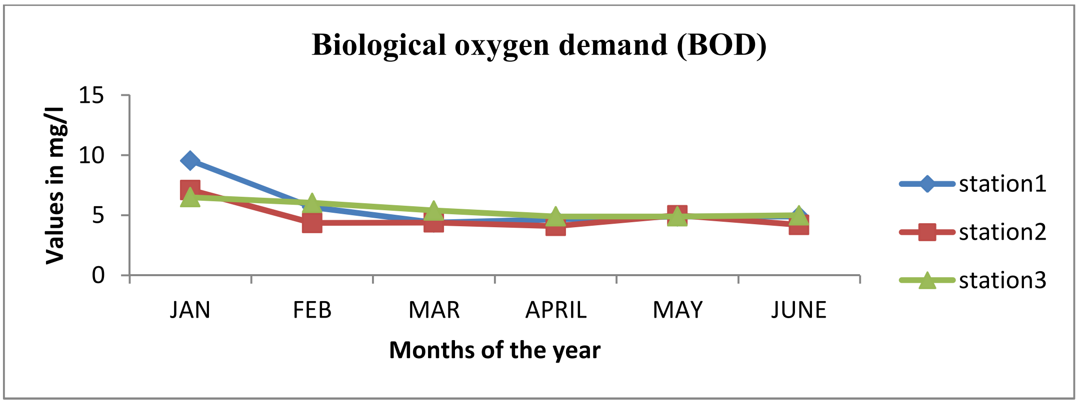


Fig-8: Monthly variation in Biological Oxygen Demand in Okhuo River, Edo State.

4.0 MACROBENTHIC INVERTEBRATE FAUNA COMPOSITION, DISTRIBUTION AND ABUNDANCE

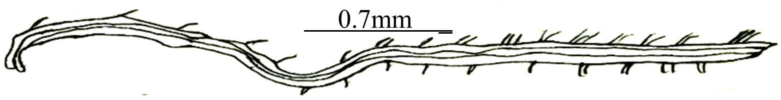
A total of 26 macroinvertebrate taxa comprising of 348 individuals which include 11 species of Diptera, 4 species of Ephemeroptera, 3 species of Odonata, 1 species each of Plecoptera, Coleoptera, Crustacea (Decapoda), Tricoptera, Hemiptera and 4 species of Oligochaeta was recorded.

4.1 Check List

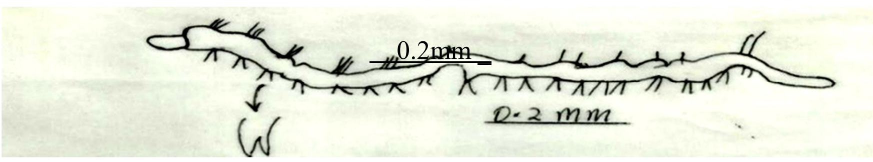
Phylum Annelida
Class Oligochaeta
Species *Pristina sp*
Nadium breviseta
Nais communis
Nais obtuse

Phylum Arthropoda
Class Crustacea
Subclass Malacostraca
Order Decapoda
Family Atyidae
Genus Caridina
Species *Caridina Africana*

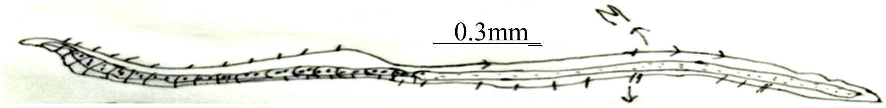
Class Insecta
Order Diptera
Family Chironomidae
Subfamily Chironomina



(a) *Nadium breviseta*



(b) *Nais communis*



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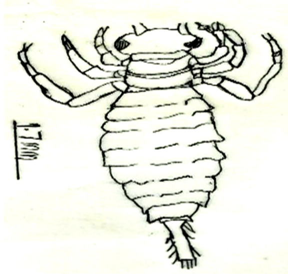

(c) Nais obtuse

Table-2: The taxa and individuals of the Macrobenthic Fauna.

GROUP	No. of Taxa	No. of individual	% Taxa	% Individual
DIPTERA	11	307	40.7%	88.2%
EPHEMEROPTERA	4	13	14.8%	3.7%
ODONATA	3	6	11.1%	1.7%
PLECOPTERA	1	1	3.7%	0.29%
COLEOPTERA	1	1	3.7%	0.29%
TRICHOPTERA	1	1	3.7%	0.29%
HEMIPTERA	1	1	3.7%	0.29%
OLIGOCHAETA	4	17	14.8%	4.89%
CRUSTACEA	1	1	3.7%	0.29%
TOTAL	**27**	**348**		

The macrobenthic fauna collected during this study was dominated by members of the order Diptera (88.2%). All the other groups are rare groups. Taxonomic groups or genera comprising 15% or more of the total number of individuals collected are considered as dominants, those comprising 5-14% are considered as sub-dominants. All other groups below 5% are considered rare groups (Slack *et al*, 1977).

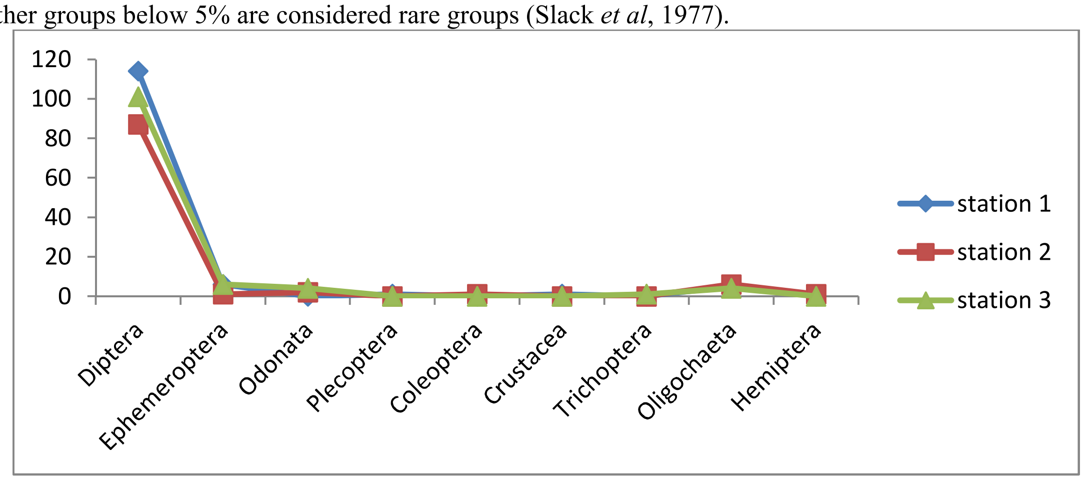

Fig 9: Relative Abundance of the macrobenthic fauna at the three stations

4.3 Biodiversity
The indices calculated for taxa richness (d), Shanon-Weinner's index (H) and Evenness index in the study stations are shown below

Table 3: Diversity of macrobenthic fauna of the study stations

Indices	STATION 1	STATION 2	STATION 3
Number of taxa	14	17	15
Number of individual	57	69	58
Relative abundance (%)	31.0%	37.5%	31.5%
Taxa richness using Margalef's Index (d)	3.215	3.779	3.448
Diversity using Shanon-Weinner's Index (H)	2.157	2.426	2.252
Evenness index (E)	0.6175	0.6654	0.634
Simpson's Dominance Index	0.8347	0.8851	0.8496

Station 2 had the highest taxa richness with 17 taxa represented in 69 individuals when compared to 14 taxa among 57 individuals in station 1 and 15 taxa among 58 individuals in station 3.
However, there was no significant or distinct difference in the diversity and evenness in all three stations.

4.4 Physical and Chemical Characteristics of the Bottom Sediment.
The summary of the physico-chemical characteristics of the three study stations including the particle size distribution, organic carbon and organic matter are shown in graphs below.

4.4.1 Organic carbon
The organic carbon content ranged from 0.37 to 1.35 for station 1, 0.01 to 1.21 for station 2 and 0.28 to 1.19 for station 3. The mean values were 0.947, 0.6625 and 0.38 respectively for the three stations. The only significant difference worthy of note in the values recorded is seen in station 2 in the month of February were the lowest value was recorded. This is shown in fig. 10.

4.4.2 Organic matter
The organic matter content ranged from 0.10 to 0.14 for station 1, 0.09 to 0.16 for station 2 and 0.09 to 0.21 for station 3. The mean values for the three stations were 0.125, 0.1163 and 0.12 respectively. There was no significant difference in the values recorded. This is well represented in fig. 11.

4.4.3 Sand
The sand content of the river ranged from 84.54 to 90.54 for station 1, 88.11 to 89.64 for station 11 and 88.56 to 91.04 for station 3. The mean values for the three stations were 87.36, 88.845 and 89.88 respectively. There was no much significant difference in the values recorded except for station 1 in the month of April were the lowest value was recorded. Fig.12.

4.4.4 Silt
The silt content ranged from 7.53 to 11.68 for station 1, 6.79 to 19.34 for station 2 and 8.26 to 9.54 for station 3. The mean values for the three stations were 9.715, 12.808 and 8.32 respectively. There was really no significant differences in the values recorded except for station 2 in the month of March were the highest value was recorded. Fig. 13.

Clay
The clay content ranged from 1.93 to 3.78 for station 1, -8.98 to 3.04 for station 11 and 1.9 to 1.98 for station 3. The mean values were 2.775, 0.0013 and 1.94 for the three stations respectively. There was a significant difference in the values recorded, especially for the month of March in station 2 were a significantly low value (-8.98) was recorded as shown in fig.14.

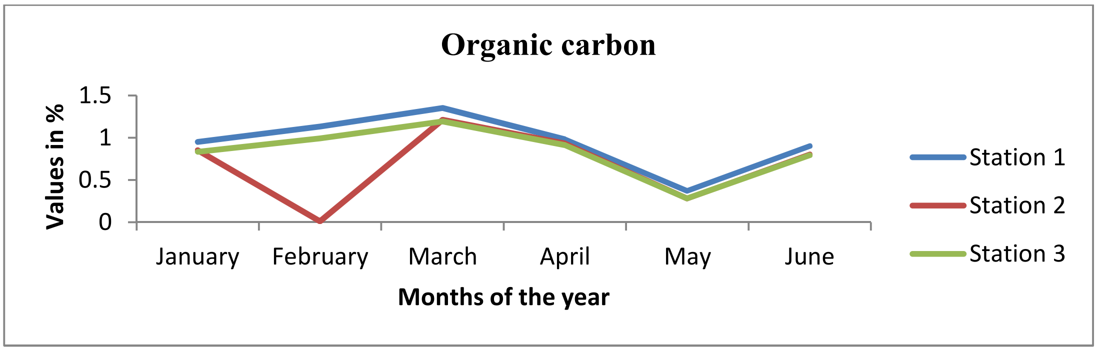

Fig. 10: Monthly variation in organic carbon of Okhuo River, Edo State.

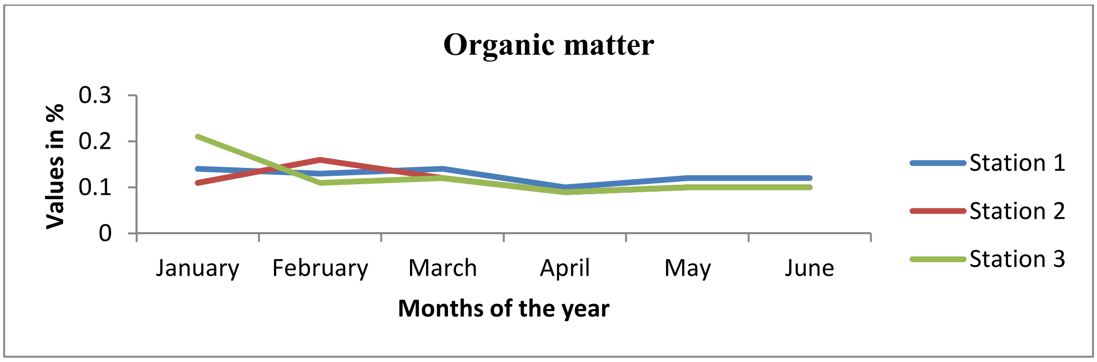

Fig. 11: Monthly variation in Organic Matter in Okhuo River, Edo State.

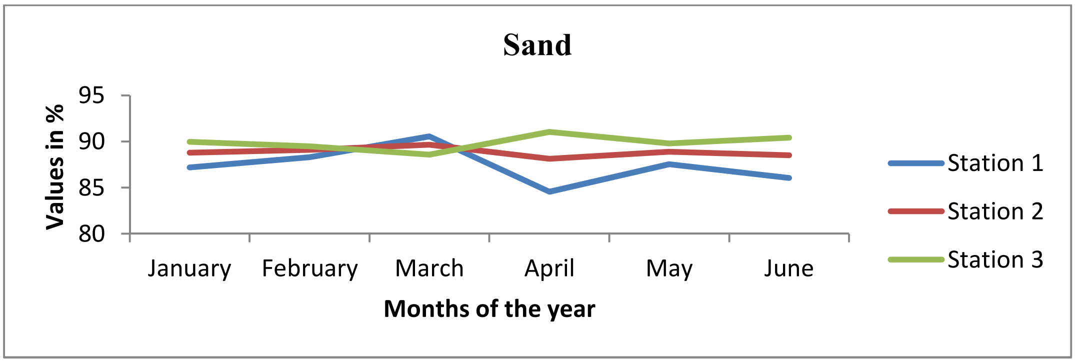

Fig.12: Monthly variation in Sand in Okhuo River, Edo State

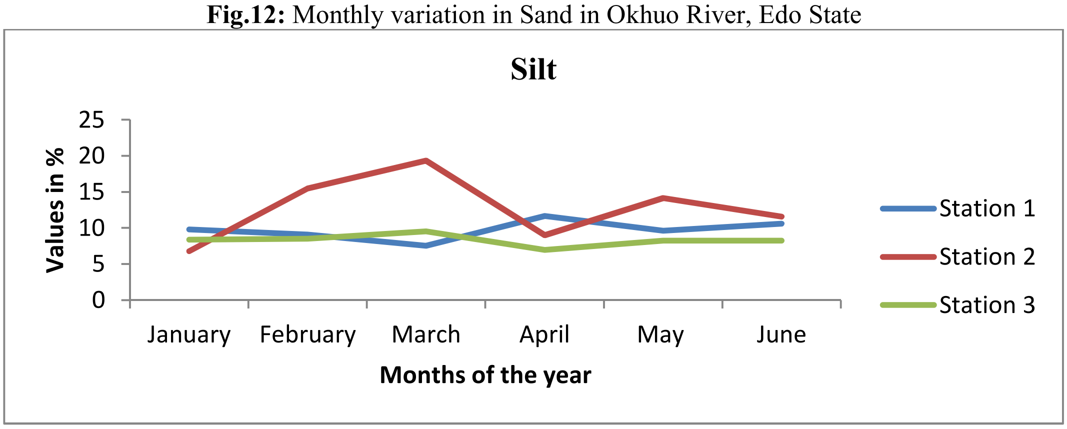

Fig.13: Monthly variation in Silt of Okhuo River, Edo State.

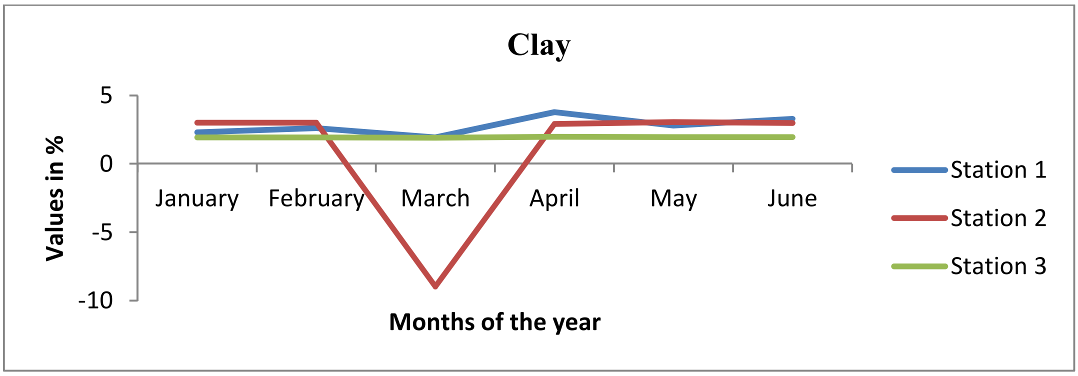

Fig. 14: Monthly variation in Clay of Okhuo River, Edo State.

5.0 DISCUSSION

Physical and Chemical Parameters

The physical and chemical parameter results in Okhuo River conforms with previous works that they are important factors governing the occurrence and distribution of macrobenthic invertebrates and any severe alteration of these factors will significantly affect the benthic organisms (Victor and Ogbeibu, 1985). Life cycles and population densities of many streams organisms are very much dependent on temperature and any alteration of the average stream temperature by a few degrees could alter the flora and fauna of the river (Jackson *et al.,* 1989).

The pH of the river ranged between 6.20 and 6.90 shows very low acidity to slightly alkaline conditions all through the study period, indicating that the water is unpolluted and well buffered (Pennak, 1978). pH values in the sampling stations showed no significant difference.

Dissolved oxygen values fluctuated between 2.04mg/l and 8.00mg/L with the lowest value observed in station 2 in the month of May which falls into the rainy season. This could be due to a better aeration and exposure of station 3 to the atmosphere resulting in high photosynthetic activity and therefore higher dissolved oxygen.

Biochemical oxygen demand values ranged between 3.49mg/l and 9.55mg/l. The pressure of pollutants, particularly organic pollutants in the water through human activities (mainly the domestic activities which are highest during the dry season) bring about the high level of bacterial and other microorganisms feeding on the organic materials thereby reducing the dissolved oxygen concentration while it is being used up. The low levels of B.O.D at the three stations during the rainy season may be accounted for by the presence of oil films on surface waters; this may hinder re-aeration at the water surface and may reduce the biochemical activity of microrganisms (Jackson *et al.,* 1989).

The bottom sediments showed no much difference in value only that the river is very sandy with values greater than 84.54% in all the stations. In station 2, percentage clay recorded the lowest of values (-8.98) in the month of March. Organic carbon, organic matter and percentage silt showed no significant difference in their values. The high values of the sand could be due to erosions from the surrounding community directed to the river.

The non-significant difference in most of the parameters across the study stations suggests a uniform disturbance, similar vegetation, domestic and occupational activities across the three stations.

5.1 Macrobenthic Invertebrates

The community structure reveals the qualitative nature of the macrobenthic fauna associated with the bottom sediment of Okhuo River. A total of 26 macrobenthic invertebrate taxa comprising 348 individuals were recorded. They include Diptera (11 species), Ephemeroptera (4 species), Odonata (3 species), Plecoptera (1 species), Coleoptera (1 species), Crustacea (1 species), Trichoptera (1 species) Hemiptera (1 species) and Oligochaeta (4 species).

Macrobenthic distribution is often affected by the availability of food and shelter rather than the physical and chemical parameters. The root of aquatic macrophytes is known to serve as shelter or direct and indirect food source for macrobenthic invertebrates (Lodge, 1991; Newman, 1991). The number of taxa recorded from this study is quite high and this is supported by the fact that tropical streams generally harbor a large number of taxa compared to temperate streams (Hynes, 1970; Bishop, 1973). Furthermore, tropical rivers tend to recover rapidly; the rate of reproduction and relatively high primary production has been suggested as factors responsible (Wallace and Hynes, 1981).

The dominant groups from this study include, Diptera, Ephemeroptera and the Oligochaets. The rare groups include, Crustacea, Coleoptera, Trichoptera, Hemiptera and Plecoptera. Station 2 had the highest relative abundance (37.5%) and station 1 had the lowest abundance (31.0%) of macrobenthic fauna. Sensitive species of the orders Odonata, Trichoptera and Coleoptera which indicate unpolluted water with low organic waste were not present in all the study stations, indicative of pollution. The occurrence of insects throughout the sampling stations confirms their ubiquitous nature and the knowledge that they do not show habitat restriction. The presence of *Chironomous sp*; pollution-tolerant taxa, is an indication of the deteriorating water quality and the impact of perturbation stress on the organisms (Saliu and Ekpo, 2006).

Diversity and Evenness indices show that there are no significant differences in species composition between the stations. The organisms are similar to a great extent in all three stations. Diversity has been considered as a measure of community stability where low diversity is an indication of stress in the environment while high diversity is a reflection of a stress free environment (MacArthur, 1965, Olomukoro, 1996). The three stations had a high diversity index and this infers that the three stations are relatively stable and stress free.

6.0 CONCLUSION

In conclusion, in the cause of studying the macrobenthic invertebrates in the bottom sediments of Okhuo River according to Sorenson's quotient of fauna similarity shows that there is no significant difference in the fauna between stations. Also, there was no significant difference ($P>0.05$) in the physic-chemical parameters between the three stations ($P<0.05$). Different factors (physical and chemical) including availability of food significantly affect the abundance and diversity of benthic organisms. Macro invertebrates are useful in indicating environmental changes in the aquatic environment in relation to human and industrial activities.

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