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Benthic Macroinvertebrates Diversity and Physical-Chemical Parameters as Indicators of the Water Qualities of Ntawogba Creek Port Harcourt Nigeria

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Abstract: The study evaluated the water qualities of Ntawogba creek by utilizing the benthic macroinvertebrates diversity as well as physical-chemical parameters data, to give us an indication of the biochemical condition and health of the river. The research was carried out for twelve (12) months, firstly by establishing three (3) main sampling stations and their co-ordinates along the stretch of the creek based on ecological niche of the stream and human activities on the study area. The physical-chemical parameters measured and analysed include, Temperature, pH, Electrical Conductivity, Salinity, Turbidity, Total Dissolved Solids, Dissolved Oxygen and Biochemical Oxygen Demand, according to APHA 1998 standard methods. Sediment particle size was determined by hydrometer method. Replicate samples of benthic macroinvertebrates were collected from each station randomly with Eckmann's grab. The results of the physical-chemical data were subjected to 2-way analysis of variance and differences among means where separated by Turkey-Honest significant difference at 95% probability. Percentage occurrence and relative numerical abundance of macroinvertebrates were calculated using excel descriptive statistical tool. Diversity of the benthos was determined using Shannon Wiener index hequitability of species. The results showed that pH values ranged from mild acidic to alkalinity (6.42 to 7.63). The values of turbidity, TDS, BOD and DO exceeded limits of World Health Organization in most of the sampling stations. The sediment particles of the stream were significantly dominated by sand fractions with the highest mean recorded in station three (74.08±0.71). The total number of benthic macroinvertebrates individuals in the sampled stations was 28,730 and total number of species was 40. The diversity, taxa richness and evenness recorded at station one were 0.823, 1.934 and 0.683, while station two had 0.605, 1.163 and 0.605 and station three had 0.301, 3.085 and 0.206. The results show that the human activities grossly polluted the stream, and constant monitoring is required to safeguard the waterbody and aquatic ecosystem in the study area.

Keywords: Phyisical-Chemical, Diversity, Macroinvertebrates, Water, Ntawogba, Parameters

1. Introduction

Benthic macroinvertebrates (also known as "benthos") are small animals living among stones, logs, sediments and aquatic plants on the bottom of streams, rivers and lakes [1]. They are large enough to see with the naked eye (macro) and have no backbone (invertebrate), and examples include molluscs, annelids, crustaceans, chordates, arthropods,

coelentrates etc. [2]. The organisms are also found dwelling in or on filamentous algae for some part of their life circle [3]. Different types of macroinvertebrates tolerate different stream conditions and levels of pollution. Their presence or absence are commonly used as indicators of the biological condition of water bodies to indicate clean or polluted water; long enough to reflect the chronic effects of pollutants, and yet short enough to respond to relatively acute changes in water quality.

Figure 1. Variety of benthic macroinvertebrates viewed under a stereo microscope. Source: G. Carter via NOAA/GLERL (2016).

Unlike fish, these populations tend to be relatively immobile, and as a result are continuously exposed to the constituents of the surface water they inhabit. Thus, because of the limited mobility of macroinvertebrates and their relative inability to move away from adverse conditions, the location of chronic sources of pollution often can be pinpointed by comparing communities of these organisms [4]. Generally, waterbodies in healthy biological condition support a wide variety and high number of macroinvertebrate taxa, including many that are intolerant of pollution. Samples yielding only pollution–tolerant species or very little diversity or abundance may indicate a less healthy water body. When the biology of a waterbody is healthy, the chemical and physical components of the waterbody are also typically in good condition [5].

Benthos is utilized as food items for a wide range of organisms in water including fish some of which are consumed by man [6]. Most of the organisms themselves feed on the detritus that settle or grow on the bottom substrate and also shuttle movement between the sediment and the water column thereby accelerating the breakdown of decaying larger organic matters into simpler inorganic forms such as phosphates, nitrates etc.[7].

The composition, distribution and abundance of benthic macrofauna can be influenced by physical, biological and chemical environmental factors [8] and [9]. In Port Harcourt the pace of urban development and industrial activities is fast increasing, so also do the amounts of wastes generation increasing around the city and its environ [10].

Domestic and industrial waste contents of toxic substances are continuously being discharged daily into the aquatic systems with or without proper treatment, thus causing serious water pollution problems [11]. They provide more accurate understanding of the changing aquatic conditions than chemical and microbiological data which at least give short time fluctuations [12]. The inability of the organisms to move effectively away from their habitat pre-supposes that those benthos are deemed to be exposed to ecological danger. These features and other peculiar characteristics of the benthic fauna such as longer life span, abundance and size, render them useful as potential environmental indicators [13].

2. Method

2.1. The Study Area

Ntawogba stream is a tributary of the Bonny River located at the upper reaches off the Bonny river estuary in the Niger delta of Nigeria. It lies between latitude 4°48', 4° 4'7 North and longitude 6° 58', 6° 01'East of Port Harcourt city. It is a meandering stream that traverses almost the entire width of Port Harcourt and harbors several residential communities and industrial companies along its bank with different activities like waste dumps, vehicle repair/car wash, sand mining, boat building/repairs, fishing, recreation and drainage construction, etc.

2.1.1. Sampling Stations

Three main sampling stations were established along the stretch of the stream based on ecological niche of the system. Station 1, is located between *Abacha* and *Okija* street, the stream at this section is none tidal fresh water and flows in one direction, draining through residential and commercial areas (Figure 1).

The main activities here are bathing, car wash, mechanic work, welding and mining of sand and waste dump. This section of stream is walled with concrete embankment (Plate 2 and 3).

The position of station 2 is between *Kaduna* Street and *Aba/Port Harcourt* express way. The area is tidal fresh water zone. The tidal action is minimal, but still drains in one direction through a dense residential and commercial area. The stream is also walled with concrete embankment with floating algal mass (Plates 4 and 5). Human activities are car wash, welding, mechanic work and waste dumping.

Station 3 is located between *Amadi* flats and Eastern by-pass. It is a tidal brackish water ecological zone with mangrove characteristics *(Plates 6 and 7)*. The main human, industrial and commercial activities taking place here are fishing, bathing, car wash, sand mining/dredging, boat building, jetty operations, transportation by the use of canoe and motorized vessels.
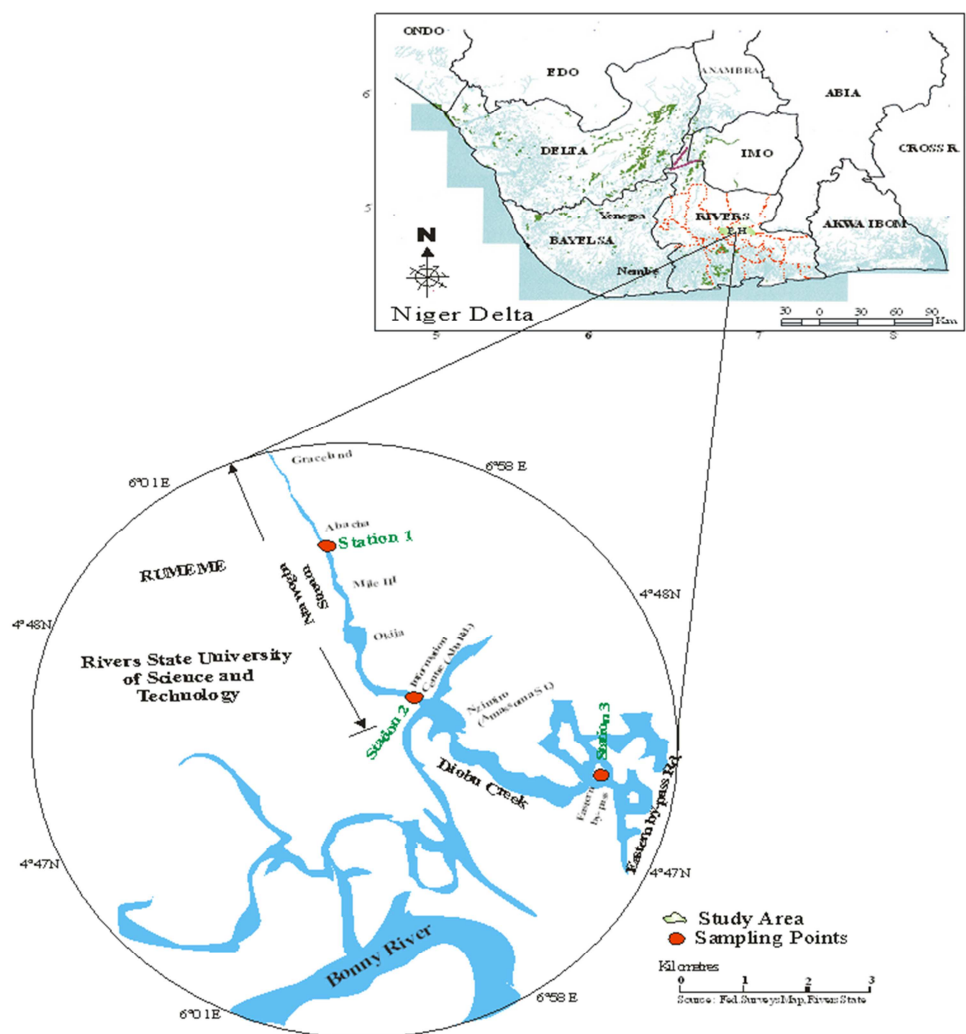
Figure 2. *Map of Niger Delta showing Ntawogba Stream in Port Harcourt Nigeria (The Study Area).*

Figure 3. *Station 1–showing the Upstream part of the study Area (Abacha axis).*

Figure 4. *Station 1-showing the Downstream part of the Study Area (Abacha axis).*

Figure 5. *Station 2-showing the Upstream part of the Study Area (Okija axis).*

Figure 6. *Station 2-showing the Downstream part of the Study Area (Okija axis).*

Figure 7. *Station 3-showing Upstream part of the Study Area (Eastern-Bypass).*

Figure 8. *Station 3-showing the Downstream part of the Study Area.*

2.1.2. Sampling and Analysis

Rainfall data were retrieved from the records of the Federal Ministry of Aviation, department of meteorological services, federal secretariat, Port Harcourt. The physical and chemical parameters studied were Temperature, Hydrogen ion concentration (pH), Electrical Conductivity, Salinity, Turbidity, Total Dissolved Solids, (TDS), Dissolved Oxygen (DO), and Biochemical Oxygen Demand (BOD). The methods used were as described by [14]. The water temperature was measured in situ using mercury in glass thermometer (0-50°C), by immersing the sensitive part of the thermometer directly into the water and, the temperature value read from three readings in the sampling stations and the mean values calculated and recorded. The water pH, electrical conductivity, Salinity, Turbidity and Total dissolved solids were measured in-situ using a multiple-probe Horiba water checker (model U-10$^{\mu}$) by dipping the probe into the water sample after calibration and standardized with reagent and distilled water. The arrow key was positioned on the measured parameters, and the value taken and recorded after the calculation of the mean value. Surface water samples for the measurement of Dissolved Oxygen (DO) were collected and determined according to the modified Azide or Winkler's method [14].

Water sample for Bio-chemical Oxygen Demand (BOD) was collected in the same way as DO, but the samples were left to incubate for 5 days in the dark at temperature of about 20°C. To avoid using all the oxygen by the aerobic micro-organisms during the 5-day period, the BOD samples were diluted before incubation to determine the dilution factor and the BOD$_5$ calculated [14].

2.2. Sediment Study

Sediment particle size was determined by the hydrometer method [14]. The freshly collected sample from the field was air dried under the ceiling fan for a period of five days. The well dried sediment was crushed with laboratory mortar and pestle then sieved through a 2mm mesh size sieve; and transported to the laboratory for further treatment and

analysis.

2.3. Benthic Macro-invertebrate

Replicates samples of benthos were collected from each sampling station randomly, with Eckmann's grab measuring 16cm^2 x 16cm^2 to collect the sediment at the depth of about 15cm. The grab was retrieved by pulling the line after which the grab was opened and sediment sample taken to the laboratory for subsequent treatment and analysis [15].

Benthic macro-invertebrates in the vials were emptied into petri dish and mounted on the microscope for examination and counting the numbers of species of each taxa. The organisms were identified taxonomically to the possible lowest levels using the best keys, such as [16-18].

2.4. Data Analysis

Physico-chemical data from the stations were subjected to 2 way analysis of variance. Differences among means were separated by Tukey Honest significant differences at 95% probability. 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. Diversity of the benthic invertebrates was determined using Shannon Wiener Index, Equitability (E) of species [19, 20] Margalef Diversity index.

3. Result

The rainfall data obtained from Federal Ministry of Aviation, Port Harcourt, showed that the total annual rainfall for the year was 2,852.8mm. Temperature ranged between 26.04°C and 33.05°C and increased spatially in the order 3>2>1 across stations. The pH values of Ntawogba surface water were between 6.54 and 7.83 across stations and values decreased downstream.

Table 1. *Variation in Range, Mean and Standard Deviation in Physico-chemical Parameters of different Stations of Ntawogba Stream.*

Parameters	Stations		
	Stn 1	Stn 2	Stn 3
Temperature °C	26.04-32.52 29.78±0.67[b]	28.04-33.05 30.34±0.50[a]	26.12-31.03 29.88±0.47[b]
Ph	6.59-7.83 7.08±0.15[a]	6.74-7.72 7.07±0.10[a]	6.42-7.63 6.86±0.12[b]
Conductivity (µS/cm)	187.0-8,037.0 1,313.28±673.15c	320.0-20180.0 3,227.09±1,703.62[b]	1,504.0-33,905.0 16,944.29±2,286.65[a]
Turbidity (NTU)	4.0-204.0 47.79±25.29[b]	12.0-782.0 107.92±68.32[a]	1.0-25.0 9.67±2.21[c]
TDS (mg/l)	131.0-5626.0 970.29±457.27[c]	224.0-14126.0 2,252.92±1,190.40[b]	5422.0-24,439.0 14,160.92±1,857.39[a]
Salinity (‰)	0.05-0.5 0.11±0.04[c]	0.1-5.7 1.43±0.55[b]	0.5-19.1 10.50±0.89[a]
Do (mg/l)	1.23-3.65 2.60±0.32[b]	0-2.61 0.62±0.20[c]	2.04-7.11 3.94±0.55[a]
BOD (mg/l)	5.55-19.04 13.29±5.00[b]	66.22-28.07 15.23±6.32[a]	5.34-17.02 11.51±4.28[c]

[a–c] Means with different superscripts in the same column are significantly different at $p > 0.05$ (Tukey HSD).

The mean conductivity values recorded across the stations varied from 725.33±392.28 µS/cm to 20, 734.00±7, 495 µS/cm (Table 1). Turbidity ranged between 1.00 and 782.00 NTU with mean varying significantly from 8.33±5.46 to 332.33±231.63 NTU across the stations. There was spatial variation with a trend that showed higher turbidity values in stations 2 (782.0 NTU) than station 3 (1.0 NTU). The mean total dissolved solids values ranged between 1,939.67±1741.26 mg/l to 14,514.00±5,247.08mg/l across the stations with significant difference at ($p<0.05$).

The range of values for mean salinity recorded varied from 1.47±1.39ppt to 8.08±5.41ppt across the stations with significant difference at $p \leq 0.05$.

Mean values of surface water Dissolved Oxygen concentrations were between 1.56±1.01mg/l and 3.73±1.71mg/l across the stations. Spatial observation showed that a higher dissolved oxygen value was recorded in station 3 (7.11mg/l) than in station 2 (0 mg/l), with values significantly different at $p \geq 0.05$. The mean Biochemical Oxygen Demand ranged between 5.78±0.62mg/l and 22.55±7.81 mg/l across the stations spatially, BOD had maximum value at Station 2 (28.07mg/l) and lowest at Station 3 (5.34mg/l). The relationship between DO and BOD showed an inverse proportionality.

Generally, sediment particles of the stream were significantly dominated by sand fractions ($p \geq 0.05$). There was a tendency of spatial increases in sand content with highest mean values of sand recorded in station 3 (7.4.08±0.7%). The highest mean value (14.09±2.33% was in station 3 and lowest (7.74 CC. 76%) in station 2. The result of the study for the sediment showed that three textural classes were common in the area as follows; station 1 (sandy loam), station 2 (sandy) and station 3 (loamy sand).

Table 2. *Spatial Range, Mean and Standard Deviation in Sediment Particles along Ntawogba Stream.*

Parameters	Stn 1	Stn 2	Stn3
		Stations	
Sand (%)	67.39-78.85	66.33-75.30	69.17-77.19
	73.10±1.12[a]	71.72±0.85[a]	74.08±0.71[a]
Silt (%)	12.68-21.17	14.20-21.24	11.67-15.10
	17.50±0.90[a]	10.98±0.62[c]	13.38±0.48[b]
Clay (%)	5.23-12.33	3.66-12.44	10.70-15.73
	9.29±0.72[c]	8.96±0.81[b]	12.55±0.75[a]
Textural Class	Sandy loam	Sandy	Loamy sand

Means with different superscript letters in the same column are significantly different at $p > 0.05$ (Tukey HSD).

A total of forty (40) species of *benthic fauna* occurred in Ntawogba stream during the period of study. Three phyla: *Annelida, Arthropoda,* and *Mollusca* were recorded in the benthic samples (Table 3); the phylum *Annelida* dominated the community, represented by the classes *Oligochaeta* and *Polychaeta*. The class *Oligochaeta* had three representative families (*Enchytridae, Lumbricidae*, and *Naididae*) with nine species (68.7%). The Polychaeta had ten (10) families (*Arenicolidae, capitellidae, Eunicidae, Glyceridae, Nephthyidae, Nereidae, Sabelidae, Spionidae, Syllidae and Terrebridae* (30.1%).

The crustacean subphylum Malacostraca had 3 representative families (*Taitridae, Gammaridae,* and *Peneidae*), Insecta had 2 families (Chironomidae and Culicidae) and three species (0.4%). Gastropoda was represented by four families (*Bulinidae, Pilidae, Planobidae and Physidae*) which had a total of 5 species (0.7%). Bivalvia was represented by a lone family (Pinnidae) and one taxon.

Table 3. *Checklist of Benthic Macro-invertebrate in Ntawogba Stream During the study period.*

S/N	Phylum	Class	Order	Family	Genus
	ANNELIDA	Oligochaeta	Chaetopoda	Enchytridae	*Lumbricilus sp*
	,,	,,	,,	Lumbricidae	*Eiseniella tetrahidra*
	,,	,,	,,	Naididae	*Chaetogaster diastrophus*
	,,	,,	,,	,,	*Dero obtuse*
	,,	,,	,,	,,	*Ophidonais serpentina*
	,,	,,	,,	,,	*Nais sp*
	,,	,,	,,	,,	*Paranais sp*
	,,	,,	,,	,,	*Stylaria lacustris*
	,,		,,	,,	*Uncinais uncinata*
			,,		
	,,	Polychaeta	,,	Arenicolidae	*Arenicola neamarina*
	,,	,,	,,	Capitellidae	*Capitella capitata*
	,,	,,	,,	,,	*Heteromastus filiformis*
1	,,	,,	,,	,,	*Notomastus tenuis*
	,,	,,	,,	,,	*Notomastus abaraans*
	,,	,,	,,	,,	*Notomastus latricieus*
	,,	,,	,,	Eunicidae	*Diopatra capensis*
	,,	,,	,,	Glyceridae	*Glycinde armingera*
	,,	,,	,,	,,	*Glycera capitata*
	,,	,,	,,	,,	*Glycera convoluta*
	,,	,,	,,	Nephthyidae	*Nephthys hombergi*
	,,	,,	,,	Nereidae	*Nerieis diversicolor*
	,,	,,	,,	,,	*Nereis virens*
	,,	,,	,,	,,	*Nerieis pelagica*
	,,	,,	,,	Sabellidae	*Fabricia capensis*
	,,	,,	,,	Spionnidae	*Polydora capensis*
	,,	,,	,,	,,	*Syllis prolifera*
	''	,,	''	''	*Syllis fulceligera*
	''	,,	''	Terrebridae	*Amphitrite neajohanstoni*
	ARTHROPODA	Malacostroca	Amphipoda	Taiitridae	*Amphithoe rubricata*
	,,	,,	Amphipoda	Gammaridae	*Gammarus lacusta*
	''	,,	Decapoda	Peneidae	*Peneus notialis*
2	,,	Insecta	Diptera	Chironomidae	*Chironomus ablabiesmia*
	,,	,,	,,	Culicidae	*Choaborus corethra*
	,,	,,	,,	,,	*Culex molestus*
	MOLLUSCA	Gastropoda	Pulmonata	Bulindae	*Bullinus globuscus*
	,,	,,	,,	,,	*Bullinus forskali*
3	,,	,,	,,	Pilidae	*Pila ovata*
	,,	,,	,,	Planobidae	*Planobis albus*
	,,	,,	,,	Physidae	*Physa fantinalis*
	,,	Bivalvia	Pelecypoda	Solecurtidae	*Tagelus andasonii*

Table 4. *Density, Distribution and Relative Abundance of Benthic Macro-invertebrates in the Stations at Ntawogba Stream During the study period.*

S/N	Species	1	2	3	Total	% of Organism	% of Class
			STATIONS				
	ANNELIDA						
	Oligochaeta						
1	*Lumbricilus sp*	1,806	627	5	2,438	8.49	

S/N	Species	STATIONS			Total	% of Organism	% of Class
		1	2	3			
2	*Eiseniella tetrahidra*	4,316	132	-	4,448	15.48	
3	*Chaetogaster diastrophus*	670	3	-	673	2.34	
4	*Dero obtusa*	1,719	27	5	1,751	6.09	
5	*Ophidonais serpentina*	258	15	-	273	0.95	
6	*Nais sp*	4,540	294	47	4,881	16.99	
7	*Paranais sp*	529	18	-	547	1.90	
8	*Stylaria lacustris*	181	60	-	241	0.84	
9	*Uncinais uncinata*	3,379	1,104	2	4,485	15.61	68.1
	Polychaeta						
10	*Arenicola neamarina*	-	-	8	8	0.03	
11	*Capitella capitata*	-	-	337	337	1.17	
12	*Heteromastus filiformis*	-	-	11	11	0.04	
13	*Notomastus tenuis*	-	-	38	38	0.13	
14	*Notomastus abarans*	-	-	569	569	1.98	
15	*Notomastus latericieus*	-	-	14	14	0.05	
16	*Diopatra capensis*	-	-	5	5	0.02	
17	*Glycinde armingera*	-	-	10	10	0.03	
18	*Glycera capitata*	-	-	2	2	0.01	
19	*Glycera convoluta*	-	-	3	3	0.01	
20	*Nephthys hombergi*	-	-	21	21	0.07	
21	*Nereis diversicolor*	-	-	62	62	0.22	
22	*Nereis virens*	-	-	26	26	0.09	
23	*Nerieis pelagica*	-	-	3	3	0.01	
24	*Fabricia capensis*	-	-	58	58	0.20	
25	*Polydora capensis*	-	-	7,463	7,463	25.98	
26	*Syllis prolifera*	-	-	5	5	0.02	
27	*Syllis fulceligera*	-	-	15	15	0.05	
28	*Amphitrite neajohonstoni*	-	-	3	3	0.01	30.1
	ARTHROPODA						
	Crustacean						
29	*Amphithoe rubricata*	-	-	8	8	0.03	
30	*Gammarus lacusta*	-	-	8	8	0.03	
31	*Peneus notialis*	-	-	5	5	0.02	0.1
	Insecta						
32	*Chironomus ablabiesmia*	58	15	6	79	0.27	
33	*Choaborus corethra*	-	-	5	5	0.02	
34	*Culex molestus*	17	-	-	17	0.06	0.4
	MOLLUSCA						
	Gastropoda						
35	*Bullinus globuscus*	5	-	-	5	0.02	
36	*Bullinus forskali*	5	-	-	5	0.02	
37	*Pila ovata*	35	-	-	35	0.12	
38	*Planobis albus*	5	-	-	5	0.02	
39	*Physa fantinalis*	165	-	-	165	0.57	0.7
	Bivalvia						
40	*Tagelus andasonii*	-	-	3	-	0.01	0.0
	Total No. of Individuals	17,688	2,295	8,747	28,730	-	-
	Percentage	61.57	7.98	30.45	100	100	100
	Total No. of species	16	10	29	40	-	-
	Diversity	*0.823*	*0.605*	*0.301*			
	Taxa richness	*1.534*	*1.163*	*3.085*			
	Evenness	*0.683*	*0.605*	*0.206*			

The pattern of distribution and relative abundance is presented in Table 4. Oligochaeta species such as *Lumbricilus*, *Nais* sp. and *Uncinata* sp. were present in all the stations. The class Polychaeta, Amphipoda, Crustacea, and Bivalvia species were only recorded in station 3 (brackish water zone), while the Gastropoda species were restricted to station 1, the upstream freshwater zone. Meanwhile the class Insecta had 3 species of which *Chironomus ablabiesmia* was recorded in all stations, *Chaoborus corethra* occurred only in station 3, and *culex molestus* was restricted to upstream freshwater station 1. Generally, station 1 had maximum density (17,688 individuals/m^2), while the lowest density was recorded in station 2 (2,295 individuals/m^2).

As shown in Table 4, species richness peaked at Station 3, followed by Station 1. In contrast, general diversity (Shannon-Wiener Index) was highest at Station 1>2>3. The individuals were also more evenly distributed at Station 1, followed by Station 2.

4. Discussion

The results of the physical-chemical condition of *Ntawogba* stream, Port Harcourt, Nigeria revealed that surface water temperature ranged from 26.04°C to 33.05°C. The observed temperature value in the area agrees with the results from previous works in the Niger Delta [21-24]. pH values of the surface water of Ntawogba Stream showed a transition from mild acidic to mild alkalinity along the various stations investigated. Electrical conductivity values observed in Ntawogba stream indicate transition from fresh water to Marine. The general trend of conductivity values below 1000μS/cm indicates fresh water and higher above 1000μS/cm as brackish and above 40,000m μS/cm as marine. Turbidity range was between 1.00NTU and 782.00NTU across stations. Total Dissolved Solids (TDS) and Turbidity results showed spatial variations along the stretch of the stream. Total dissolved solid concentration increased as one proceeded downstream [25]. They attributed such result to the contribution of industrial effluent and the increased effects of soil erosion. Salinity values of range between 0.05ppt and 19.05ppt indicate that the upstream is a fresh water ecological zone while the downstream is a brackish water ecological system. Dissolved Oxygen (DO) values showed that higher values were recorded in downstream than upstream. Effluent discharge caused a significant decrease in the dissolved oxygen concentration of river water, due to high BOD load [26]. The observed lower values of dissolved oxygen across the stations may be due to discharges of effluent rich in organic matter into the aquatic system which could depress oxygen level to zero, and the impact of oxygen consuming waste discharged into the river system between the points [27]. At the point of the entry of the effluent discharge, there is always a sharp decline in the concentration of oxygen in the water, known as the oxygen sag [28].

Biochemical Oxygen Demand (BOD) **r**esults showed values that were generally high with mean values ranged between 4.72 and 68.21mg/l across stations. High BOD recorded across the stations could be as a result of increase in biodegradable organic substances in the study sites and activities of micro-organisms added to the stream through effluent and those present that utilize available oxygen as they breakdown the organic matter [29, 30]. The particle sizes of sediment in Ntawogba stream revealed three textural groups namely: sandy loam, sandy and loamy sand. The sediment particles were generally dominated by sand fractions. Similar works in the Niger delta such as [31, 32] reported that silt and clay contributed more to the total weight of sediments in the central axis of Bonny estuary than fine sand fractions, and also the sediment particles decreased downstream.

Forty taxa belonging to 23 families and 7 classes of benthic invertebrate were recorded during the study. The study from Eagle Island mangrove swamp of Niger Delta [13] reported forty three species of macrofauna, [33], recorded twenty (23) species of macroinvertebrates in New Calabar River. The study of the zoobenthos of Andoni flats showed twenty eight families, six classes from five Phyla [34]. Thirty taxa belonging to twenty families and five classes of macroinfauna in Woji Creek on the upper reaches of Bonny estuary Niger Delta [13]. Fourteen species representing eleven families of macroinvertebrates were identified in Imo River [35]. Also, another work recorded a dominance of crustaceans, insects, molluscs and annelids in the lower Niger Delta river [36]. From the result of this study it may be suggested that differences in species composition, distribution and abundance recorded may be attributed to both differences in ecological, physiological, adaptations and environmental characteristics. On a station-by-station basis, the distribution pattern of the benthic macroinvertebrates was different. The four species of oligochaetes *(Lumbricilus sp, Dero obtuse, Nais [sp* and *Uncinais uncinata* were recorded from at least two of the three sampled locations. By contrast, all 19 polychaete species encountered were restricted to station 3; amphipodes and crustaceans exhibited same site-specific occurrence.

Gastropods, however, were only recorded in station 1. The Insecta, *Chironomus* occurred in (station 1, 2 and 3), while *Chaoborus Coualitative measurements urethra* was recorded only at station 3. The observed trend may be linked to differences in salinity tolerance; while the widely distributed species were euryhaline, those with limited distribution were oligohaline [37]. These relationships suggest that waterbodies can be fully characterized by three major components: hydrology, physico-chemistry and biology. They can also be described through a range of quantitative and qualitative measurements such as physical-chemical and biological tests, species inventories and biotic indices [38].

5. Conclusion

The findings from the research showed that the composition, distribution and abundance of benthic macro invertebrates were influenced by physical, biological and chemical environmental factors such as total dissolved solids, biochemical oxygen demand, dissolved oxygen, nature of bottom deposits and contaminants entering the aquatic system. Biochemical Oxygen Demand (BOD) **r**esults showed values that were generally high with a sharp decline in the concentration of oxygen in the water, known as the oxygen sag. This might be as a result of presence of and the breakdown of discharged organic matter by micro-organisms, which utilize oxygen to the detriment of the Ntawogba stream biota. Total dissolved solid concentration increased as one proceeded downstream due to the contribution of industrial effluent and the increased effects of soil erosion. The research findings showed paucity in the species richness and general diversity at the study stations which were attributed to pollution along the stretch of the creek. Species diversity of benthos in the study area compared favourably with those of similar environment in the Niger Delta. It is recommended that: periodic studies of benthic macro invertebrates of Ntawogba stream are carried to keep track with the environmental changes overtime. Moreso, stringent

environmental protection measures should be enforced to regulate waste discharges into the integrity of the systems.

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