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Physico-chemical parameters and macro-benthos of Ediene Stream, Akwa Ibom State, Nigeria

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Abstract

Physico-chemical parameters and macro-benthos of Ediene Stream in Akwa Ibom State, Nigeria were studied from January to June 2013. Water and benthic organisms' samples were collected monthly from three sampling stations along the stream. Mean values of air temperature of 27.31± 0.35^{o}C; water temperature of 27.18±0.16^{o}C; transparency 2.51±0.32m; pH 6.54±0.13; Electrical Conductivity (EC) 27.23±7.00µS/cm; Total Dissolved Solid (TDS) 15.90±4.38mg/l; total suspended solid 2.38±0.90mg/l; Dissolved Oxygen (DO) 8.21±0.98mg/L; Biological Oxygen Demand (BOD) 3.45±0.60mg/l; acidity 42.29±5.81mg/l; alkalinity 32.89±5.52mg/l and chloride 42.80±3.79mg/l were recorded. There was no significant ($p<0.05$) spatial variation for all the parameters except for transparency. Of the five parameters that showed significant seasonal variations, air temperature was higher in the dry season than in the wet season while TSS, DO, BOD and acidity, all had higher wet season values than dry season. Three classes of macro-benthos were encountered; comprising of seventeen 17 families and 18 species. Insecta was the most abundant (89.15 %) with 16 species while the least abundant was Clitellata (5.19%). Apart from Insecta, other classes were represented by one species each. The number of individuals and species decreased downstream. Margalef species diversity was highest in station 2 while species evenness was highest in station 3. All the classes of macro-benthos were more abundant in the dry season than in the wet season but Clitellata was the only class that showed a significant ($p<0.05$) seasonal difference.The abundance and diversity of the macro-benthoswere affected by parameters like air temperature, pH, EC, DO and BOD.The decreases of macro-benthos downstream, high DO and BOD may be indications of pollution and stress from anthropogenic sources.

Keywords

Physico-Chemical, Macro-Benthos, Abundance, Ediene Stream, Nigeria

1. Introduction

Water quality plays a vital role in the distribution, abundance and diversity of aquatic organisms. A short-term exposure of benthic organisms to water of poor quality causes an alteration in the community structure due to the elimination of the species that are intolerant to stress and proliferation of stress tolerant species [1]. The physical and chemical characteristics of water are important parameters as they may directly or indirectly affect its quality and consequently its suitability for the distribution and production of fish and other aquatic organisms [2]. Important physical and chemical parameters influencing aquatic environment are temperature, rainfall, pH, salinity dissolved oxygen and carbon-dioxide. Others are total suspended and dissolved solids, total alkalinity and acidity [3]. [4] reported that municipal waste discharges such as human waste, waste from abattoir, refuse dumps, sewage/septic waste, etc affect water quality.

Macro-benthos are animals without backbone that inhabit the bottom substrate (e.g. sediments, debris, logs, aquatic macrophytes, filamentous algae, etc) in aquatic habitat for at least part of their life cycle [5]. They provide a more accurate understanding of changing aquatic conditions than chemical and microbiological data [6, 7]. They include crustaceans, molluscs, aquatic worms and larval forms of aquatic insects. They form part of the aquatic food chain, and are used to

assess water quality [8]. They are good pollution indicators of the aquatic system. Macro-benthos has attracted lots of interest among biologists and environmentalists in view of their importance in food chain of fishes and as long term indicators of water quality (1, 3, 7, 8).

Ediene Stream is an important aquatic system that serves the surrounding communities in various ways: streambed dredging, transportation, domestic purposes, dry season crop production, good protein resource (fish), washings (including cars wash), among others. Despite the importance of this stream and macro-benthos in aquatic environmental sciences, information on their distribution, abundance and seasonality is still lacking. This study, therefore, is aimed at bridging thisvery important gap and providing benchmark information.

2. Materials and Methods

2.1. Study Area

Fig. 1. *Map of the study area showing sampling stations (Insert: Map of Nigeria showing the location of AkwaIbom State) (Google earth, 2014).*

Ediene stream is located in Abak urban 1 in Akwa Ibom State. The stream takes its source from Abiakpo in Otoro clan in Edem Idim Manta and flows through Gospel village into Ediene waterside to Oku Abak and empties in Ibagwa River in Abak Local Government Area. For the purpose of this research work, three sampling stations were selected.

Three sampling stations were selected: station 1 is located at Gospel Village (4.9943^{o}N, 7.8046^{o}E), station 2 is at Midim

water side (4.9848°N, 7.7971°E) and station 3 is located at Ediene Abak (4.9784°N, 7.7973°E). The sediment of the study area is mostly sharp sand, hence its intensive dredging. The vegetation cover here includes guinea grass (*Panicum maximum*), raffia palm (*Raphia hookeri*), plantain (*Musa* sp), banana (*Musa paradisiacal*) and gigantic grass (*Bamboo sp*). Erosion control drainage from Ikot Ekpene Road empties into this water body and there is an on-going bridge construction work across the stream. It is located in the tropical belt with an equatorial climate regime characterized by dry (November - March) and wet (April - October) seasons [9, 10].

The study covered six calendar months from January to March (dry season) and April to June (wet season) in 2013. Twelve physico-chemical parameters were investigated. Temperature, pH, dissolved-oxygen, transparency, and electrical conductivity (EC) were measured in situ. Temperature was measured with a thermometer, transparency with a secchi-disc; DO, BOD, pH, and EC with Hanna H1 98186 meter. Water samples for other physicochemical parameters (total dissolved solid (TDS), total suspended solid (TSS), chloride, acidity and alkalinity) were collected and analyzed according to [11, 12].

Samples of macro-benthos from the bank root biotope [13] were collected by the modified kick method [14, 15]. This method was carried out by using a stick to agitate 1m^{2}area of the substratum. The dislodged macro-benthos that moved downstream were then collected with a 150µm mesh size net held against the water current with the mouth facing upstream. Three replicate samples were collected at each sampled station. . In the laboratory, the sediments collected were washed through graduated sieves of 0.5mm, 1mm, 2mm, and 3mm. The washed sediments with macro-benthos were poured into a white tray and sorted out. The macro-benthos collected from each station were then sorted into different taxonomic groups using a x 10 scanning lens. Sorting of the macro-benthos in the sediment sample was enhanced by staining the washed sediment samples with Rose Bengal solution. Small quantities of 40% formaldehyde were used to kill the invertebrates, which were preserved in 70% ethanol after sorting. Identification with microscope was carried out using identification keys such as [16, 17, 18, 19, 20] were used.

2.2. Statistical Analyses

SPSS (version 19) package was used to determine the means, range, one way Analysis of Variance (ANOVA), Duncan Multiple Range Tests and Spearman's rho correlation coefficient (r). Microsoft Excel 2010 was used for graphical illustrations of all parameters. The community structure/diversity indices (individuals' abundance, species abundance, Margalef species diversity, and species evenness) analysis was done using PAST (version 2.12) software.

3. Results

Table 1 summarized the spatial variations in the physical and chemical parameters of Ediene stream. Mean air temperature ranged from 26.0°C to 30.4°C while mean water temperature ranged from 26.0°C to 28.8°C, thus the water temperature closely following after the air temperature. Spatial variations showed that air temperature was highest in station 1 (27.43± 0.65) and least in station 2 (27.25±0.60); station 3 was 27.23±0.68 while water temperature was highest in station 3 (26.00-30.30) and lowest in station 1 (26.87±0.25); and station 2 (27.03± 0.15). Mean transparency values were between 0.95m and 6m. Though statistically different, highest transparency was observed in station 2 (3.47±0.55) and the least in station 3 (1.24± 0.17); station 1 had 2.83±0.46.pH ranged from 5.1 to 6.9 with spatial variations showing a progressive decrease from stations 1 to 3 as follow 6.65± 0.19,6.56± 0.25 and 6.42± 0.27 respectively. EC was between 11µS/cm and 137µS/cm withspatial variations showing a progressive decrease from stations 1 to 3 as follow 41.35±19.38,21.82±6.62 and 18.53±4.34 respectively.

Table 1. *Spatial variations of physico-chemical parameters in Ediene Stream, Akwa Ibom State, Nigeria.*

Parameters	Station 1 Mean ±SE (Min-Max)	Station 2 Mean ±SE (Min-Max)	Station 3 Mean ±SE (Min-Max)
Air temperature (°C)	27.43± 0.65	27.25±0.60	27.23±0.68
	26.40-30.40	26.11-30.00	26.00-30.30
Water temperature (°C)	26.87±0.25	27.03± 0.15	27.65± 0.33
	26.00-27.60	26.50-27.60	26.50-28.80
Transparency (m)	2.83±0.46^a	3.47±0.55^a	1.24± 0.17^b
	2.00-5.00	2.55-6.00	0.95-2.00
pH	6.65± 0.19	6.56± 0.25	6.42± 0.27
	5.70-6.90	5.30-6.90	5.10-6.80
EC (µS/cm)	41.35±19.38	21.82±6.62	18.53±4.34
	12.00-137.10	14.00-54.90	11.00-39.20
TDS (mg/l)	23.28±12.27	12.80±4.41	11.62±3.00
	5.00-82.70	6.00-33.80	6.00-24.70
TSS (mg/l)	3.37±1.83	1.99±1.58	1.78±1.47
	0.35-10.00	0.18-9.88	0.14-9.10
DO (mg/l)	8.40±2.20	8.03±1.48	8.19±1.67
	1.60-13.80	4.17-13.30	4.17-14.69
BOD (mg/l)	3.39±1.05	3.67±1.08	3.31±1.16
	0.23-5.83	0.77-6.65	0.08-6.30
Acidity (mg/l)	48.14±9.58	37.48±9.70	41.24±12.09
	19.60-68.00	19.99-68-00	17.10-81.40
Alkalinity (mg/l)	31.96±8.11	35.43±13.41	31.28±7.94
	8.00-66.66	6.00-99.99	8.00-66.66
Chloride (mg/l)	37.28±4.72	51.62±8.57	39.50±5.22
	24.00-51.02	22.00-79.40	18.00-51-52

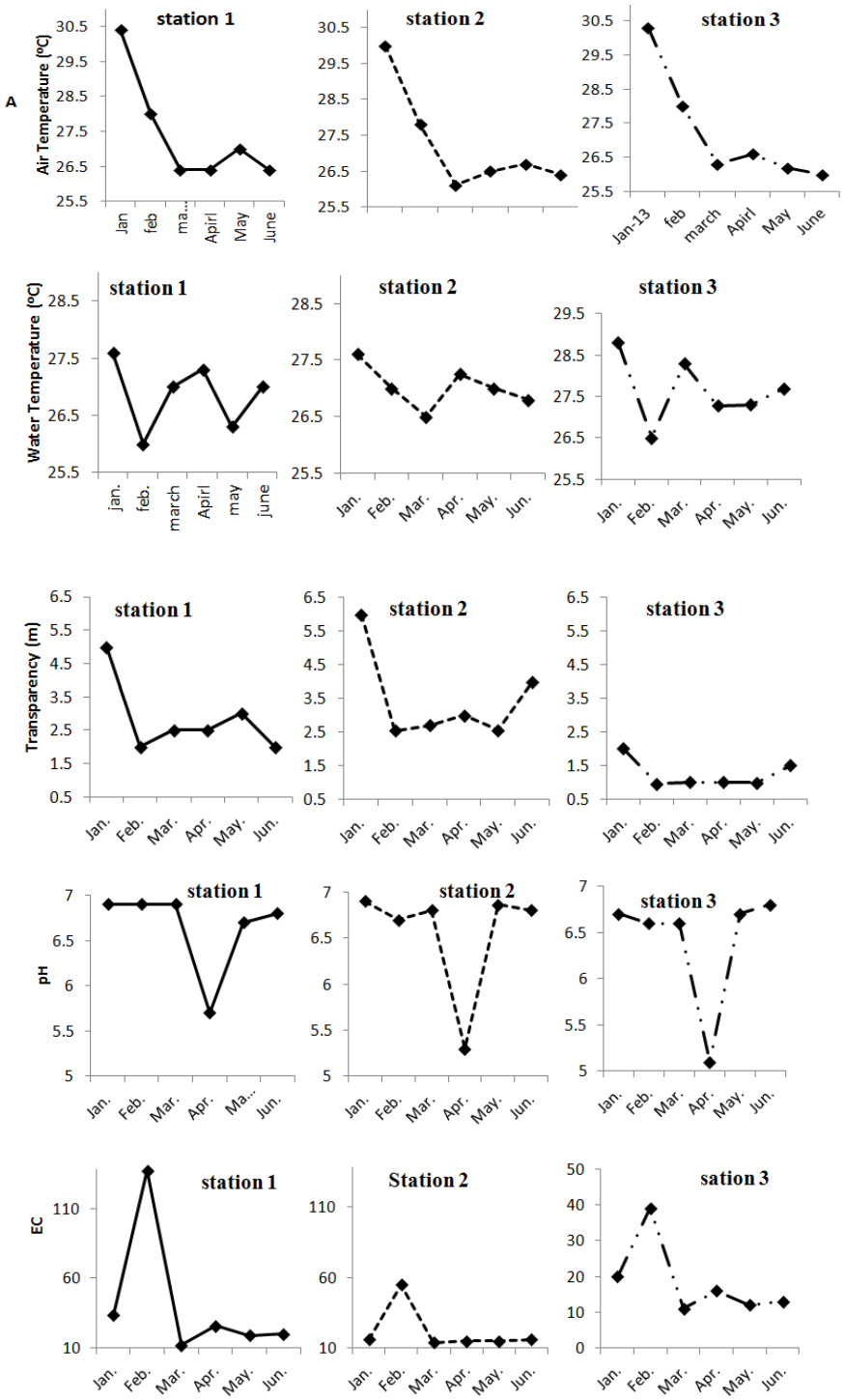
Means with different superscripts along the same row are significantly different $p<0.05$

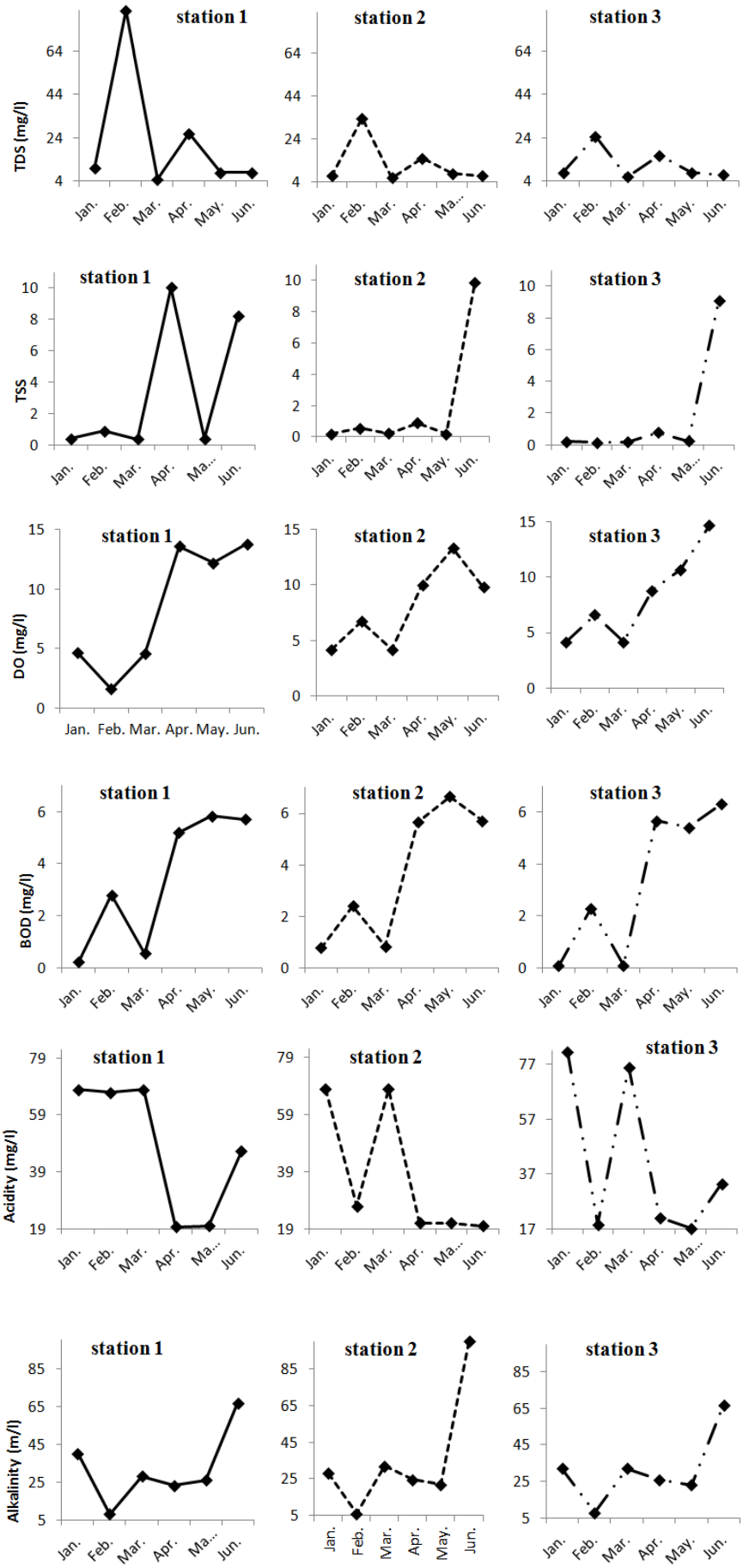
The mean TDS values ranged from 5 mg/l to 82.7mg/l. the highest spatial value was observed in station 1 (23.28±12.27) while the least was in station 3 (11.62±3.00); station 2 had 12.80±4.41. TSS was 0.14mg/l to 10mg/l. Spatial variations among the three stations depicted a progressive decrease from stations 1 – 3 as follow: 3.37±1.83, 1.99±1.58 and 1.78±1.47 respectively. Mean DO values ranged from 1.6mg/l to 14.69mg/l; with the highest observed in station 1 (8.40±2.20) whereas the lowest was in station 2 (8.03±1.48). Station 3 was 8.19±1.67.The mean BOD readings varied

from 0.08mg/l to 6.65mg/l. The highest reading was recorded in station 2 (3.67±1.08) but the least was in station 3 (3.31±1.16); its value in station 1 was 3.39±1.05. Acidity ranged from 17.1mg/l to 81.4mg/l with the highest value of 48.14±9.58 in station 1 whereas the least value of 37.48±9.70 was obtained instation 2; station 3 had the value of 41.24±12.09.

The mean alkalinity values ranged from 6mg/l to 99.99mg/l. Highest concentration of 35.43±13.41 alkalinity was observed in station 2 while the lowest (31.28±7.94) was found in station 3; station 1 had 31.96±8.11.Chloride also varied from 18mg/l to 79.4mg/l; with the highest value depicted in station 2 (51.62±8.57) and the least in station 1 (37.28±4.72). Station 3 was 39.50±5.22.

Monthly variation of the physico-chemical parameters is presented in Fig.2. Air and water temperatures were at their maximum in January in all the stations. Transparencies in all the months in station 3 were low as compared to other stations. The monthly variations of TSS and acidity in the stations did not show any pattern while chloride showed a different monthly pattern in station 2 as compared to stations 1 and 3, which were similar.




station 1
station 2
station 3
TDS (mg/l)
TSS
DO (mg/l)
BOD (mg/l)
Acidity (mg/l)
Alkalinity (m/l)
Jan. Feb. Mar. Apr. May. Jun.

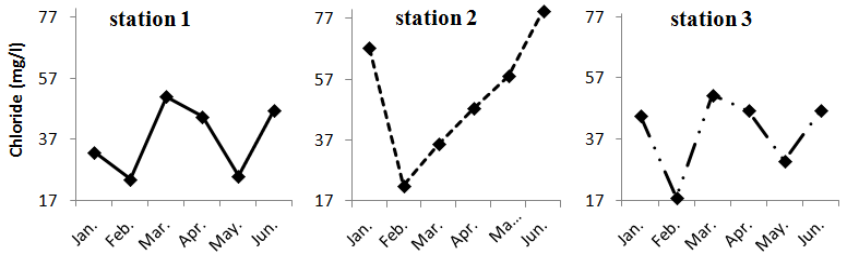


Fig. 2. *Monthly variations in physico-chemical parameters in Ediene Stream (A-L), Nigeria.*

Fig. 3 shows seasonality of physico-chemical parameters. Five of the twelve (air temperature, TSS, DO, BOD and acidity) parameters showed a significant seasonal variation. Of the five parameters that showed significant seasonal variations, air temperature was higher in the dry season than in the wet season while TSS, DO, BOD and acidity had higher wet season values than dry season.

Table 2 showed the abundance and distribution of macro-benthos in terms of number of individuals. Instation 1, a total number of 102 individuals were identified, accounting for 48.11%,68 individuals were identified in station 2, accounting for 32.08% and 42 individuals were identified in station 3, which accounted for 19.81% ofthe total benthos collected during the period of study. *Hesperoperla pacifica* was the most abundant species.

Table 2. *Abundanceand distribution of macro-benthos in Ediene stream, Nigeria.*

Class	Family	Species	No. of individuals		
			Station 1	Station 2	Station 3
Clitellata	Haplotoxidae	*Helodrilus caliginosus*	3	6	2
Insecta	Perlidae	*Hesperoperla pacifica*	24	7	3
”	Baetidae	*Baetis alachua*	5	3	2
”	Isostictidae	*Eurysticta sp*	4	4	2
”	”	*Ameletus bellulus*	2	7	1
”	Gomphidae	*Paragomphus lineatus*	6	4	3
”	*Haplotoxidae*	*Schistosoma sp*	5	2	2
”	Cambaridae	*Orconectes sp*	8	5	5
”	Pscphenidae	*Phanaeus difformis*	3	4	3
”	Ephemerellidae	*Ephemerella sp*	7	2	4
”	Nemovridae	*Ostrocerca* sp	8	5	3
”	Gyrinidae	*Grinus sp*	3	2	0
”	Elmidae	*Narpus sp*	2	0	0
”	Haliplidae	*Adonis phanaeus*	3	5	5
”	Bilostomatidae	*Lethocerus sp*	4	1	2
”	Baetoidae	*Centroptilum triangulifer*	10	4	2
”	Pteronarcyidae	*Pteronarcys dorsata*	2	1	0
Trematoda	Phlopotamidae	*Phylocentropus carolinus*	3	6	3
Total			102(48.11)	68(32.08)	42(19.81)

Table 3. *Number and percentage composition of macro-benthos taxa in Ediene Stream, Nigeria.*

Taxa	Total number (Individuals)	Relative abundance (%)	Total numberof species	Species composition (%)
Clitellata	11	5.19	1	5.56
Insecta	189	89.15	16	88.89
Trematoda	12	5.66	1	5.56
Total	212		18	

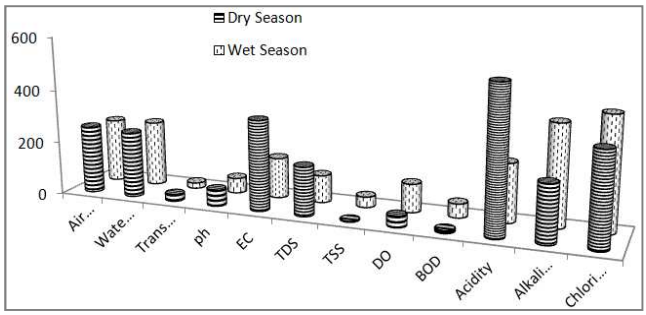


Fig. 3. *Seasonality of physico-chemical parameters in Ediene stream, Nigeria.*

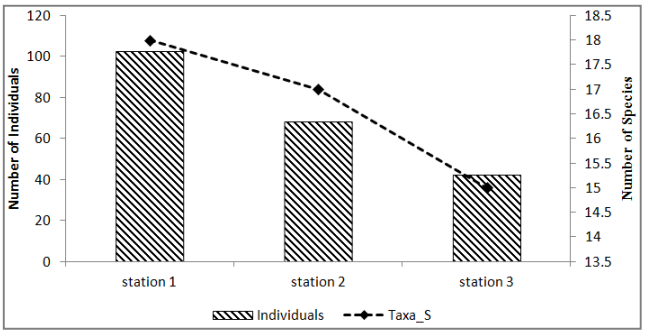


Fig. 4. *Spatial variations in terms of number of individuals and species of macro-benthos in Ediene Stream, Nigeria.*

The number and percentage composition of macro-benthos taxa identified were depicted in Table 3. Three major taxa (Clitellata, Insecta, and Trematoda) were identified. Insecta was the most abundant (189 individuals; 89.15 %) with 16 species while the least abundant was Clitellata (11 individuals; 5.19%). Trematoda had 12 individuals (5.66%). Apart from Insecta, other classes were represented by one species each.

The community structure analyses were illustrated in Fig. 4 and 5.The number of individuals and species decreased downstream. Margalef species diversity (d) was highest in Station 2 while species evenness (j) was highest in station 3.

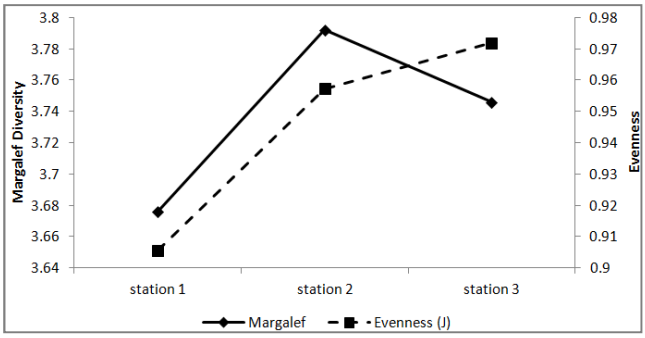


Fig. 5. *Macro-benthos species diversity (d) and evenness (j) in Ediene Stream, Nigeria.*

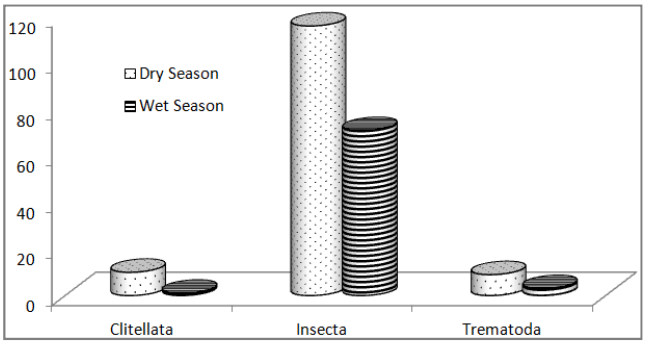


Fig. 6. *Seasonal variation of macro-benthos in Ediene Stream, Nigeria.*

Table 4. *Spearman's rho correlation coefficient (r) between macro-benthos and physico-chemical parameters of Ediene Stream, Nigeria.*

Parameters	Clitellata	Insecta	Trematoda
Air temperature (^{O}C)	0.399	0.408	.538*
Water temperature (^{O}C)	-0.129	0.055	-0.025
Transparency (m)	0.225	0.337	0.448
pH	0.174	.540*	0.146
EC (µS/cm)	0.342	.544*	0.324
TDS (mg/l)	0.263	0.105	0.144
TSS (mg/l)	-0.312	0.211	-0.376
DO (mg/l)	-.627*	-0.306	-0.271
BOD (mg/l)	-.474*	-0.376	-0.289
Acidity (mg/l)	0.317	0.39	0.08
Alkalinity (mg/l)	-0.333	0.189	-0.029
Chloride (mg/l)	-0.267	-0.168	-0.054

*- Significant at 0.05 level (2-tailed).

The seasonal variation of the macro-benthos class was shown in Fig. 6. All the classes of macro-benthos were more abundant in the dry season than in the wet season but Clitellata was the only class that showed a significant ($p<0.05$) seasonal difference.

Table 4 presents the Spearman's rho correlation coefficient (r) between the macro-benthos and the physico-chemical parameters. Insecta showed significant ($p<0.05$) positive correlations with 2 [pH (r= 0.54) and EC (r= 0.54)] physico-chemical parameters while Clitellata showed significant ($p<0.05$) negative correlations with DO (r=-0.62) and BOD (r=-0.47). Trematoda correlated significantly ($p<0.05$) with air temperature (r=0.53).

4. Discussion

The water chemistry of an aquatic ecosystem is dependent on the physical and geological features of its drainage basin [13, 21]. The water chemistry appears homogeneous, with inter-station difference only in transparency.

The temporal variations in some of the physical and chemical parameters of the water samples at the study stations for the period of study were negligible. This is in agreement with the observations of [22, 23]. The result of the study showed that most of the physical and chemical parameters were not significantly different ($p>0.05$) at the study stations.

The water temperature was slightly lower than the air temperature and both were relatively uniform at the three stations throughout the period of study. Air and water temperatures were higher in the dry season than the wet season but only air temperature showed a significant ($p<0.05$) seasonal variation. Higher temperature values recorded in the dry season were expected since heat from sunlight increases temperature of surface water. Similarly, the drop in water temperature in the wet season is attributed to heavy rainfall experienced during the period. [8] recorded relatively uniform temperatures for both surface water and air temperatures in the Lagos lagoon and attributed this to the conservative nature of this parameter in the lagoon. According to [24] temperature was not considered animportant ecological factor in the tropics. The important ecological factors affecting benthic macroinvertebrates in the tropics are salinity and sediment type and salinity is mostly controlled by the rainfall patterns.

Transparency was the only parameter that showed a significant ($p<0.05$) spatial variation. Although, there was no significant ($p>0.05$) seasonal variation observed, higher dry season mean value than wet season was recorded. This is primarily due to the fact that in the wet season, rivers receive runoff from nearby terrestrial environment, thereby increasing the suspended solids load [25]. This trend is consistent with reports from most Nigerian inland waters [26].

The pH range of 5.1 to 6.9 was acidic. [27] reported that pH higher than 7 but lower than 8.5 is ideal for biological productivity, but pH lower than 4 is detrimental to aquatic life. Although low pH values were recorded in this study,

they are not detrimental to aquatic life.[28, 29, 30] attributed variations in pH to evapo-transpiration process, rainfall causing dilution of chemical substances and chemical and biological processes in water.

The EC values range of 11µS/cm to 137.1µS/cm did not exceed the 1,000 µS/cm maximum for fresh waters by [31].

TSS is the sum total of the suspended solid particles and dissolved materials. TSS values ranged from 0.14 mg/l to 10mg/l and can be said to be low when compared to the maximum permissible limit of 2000 mg/l [32], however, the value may be indicative of the physical, geological and biological processes at the position and time of sampling according to [33]. There was a significant ($p<0.05$) seasonal variation with higher wet season values than dry season. The higher wet season mean value may be as a result of the influx of allochthonous materials and organic matter debris into the system through surface run-off. Similar results have been reported by [34, 35, 36].

Dissolved oxygen was higher in the wet season than dry season. Similar higher wet season DO result has been reported by [8]. [37]had attributed high level ofdissolved oxygen to the perturbation of water andthis was prevalent in the wet season. A higherlevel of dissolved oxygen recorded during thewet season could also be linked to floodwaterdilution and reduced resident time of the polluted water.

BOD values followed the trend of DO concentrations. Seasonal variation was significant ($p<0.05$) with higher wet season values than dry season. Similar results were reported by [36, 38]. The wet season increase in BOD values was probably due to the increase input of decomposable organic matter into the river through surface runoff [39]. BOD is a fair measure of the cleanliness of any water on the basis that values less than 1-2 mg/l are considered clean, 3 mg/l fairly clean, 5 mg/l doubtful and 10 mg/l definitely bad and polluted [40]. Lower dry season values (0.29mg/l to 1.95mg/l) in this study; therefore suggest that the stream is clean in the dry seasonbut doubtful in the wet season (5.45mg/l to 6.13mg/l). Alkalinity values ranged from 6mg/l to 99.99mg/l. This range is below the permissible limit of 200 mg/l [41] and therefore does not pose any adverse concern.

A total of seventeen (17) families of macro-benthos encountered in Ediene Stream can be said to be high when compared to 4 families reported by [42] in Ogunpa River in Ibadan and 10 families reported by [43] in Onna River, Ibadan but close to 20 families reported by [44] in Woji creek in the upper reaches of Bonny River in the lower Niger Delta. The difference in the Woji creek may be attributable to the fact that it is a larger and brackishwater system. The macro-benthos in Ediene stream was dominated by insect (89.15%) with 16 species. Other macro-benthos class had only one species each. Similar result of dominance of insect has been reported by [45].The distribution pattern of Insecta shows that they were more abundant in station 1 than 2 and 3. Similar observation was made by [46], where Insecta was restricted to stations 1 and 2. [47] observed that Insecta usually does not show habitat restrictions, but the dominance of *Hesperoperla pacifica* at station 1 compared to other stations may indicate pollution stress in the station. Number of individuals and species decreased downstream. It is apparent that the different human induced sources of pollution increased downstream; which resulted in the defaunisation of the study area. [48] have attributed the low species abundance and diversity of some sites of the Lagoon to the pollution of such sites. The relative abundance of macro-benthos in each station is a reflection of the level of pollution of each station. [49] related the abundance and diversity of the benthic fauna to the health of the water body. Station 1 is a relatively un-impacted site and is reflected in the number of individuals recorded in that station.The relatively lower taxa observed in station 3 could be attributed to the resultant effect of the bridge constructionamong other human activities ongoing at this station and reduced vegetation cover which is the primary source of allochthonous material thatmay be used as food by the benthos. Anthropogenic activities such as dredging; results in substratum instabilityand increased siltation. Suspended silt has the ability of reducing light penetration and primary productivityand can clog the gills of aquatic fauna thereby smothering them [24]. Theoccurrence of relatively higher taxa and individuals' in station 1 may be an indication of lower degree ofanthropogenic activities at this station compared to other stations. Overall diversity has been reported to be the product of all dynamic spatial and temporal changes affecting the community [16]. It could also be a reflection of the extent, to which the ecosystem has been perturbed by human activity.

The abundance and diversity of benthic macro-invertebrates are generally affected by thephysical and chemical characteristics of water, availability of food and substrate occupation. In thisstudy, such parameters like air temperature, pH, EC, DO and BOD influenced the community composition. This is in agreement with earlier observations by workers on the lagoon [23, 50, 24].

5. Conclusion

Most of the physico-chemical parameters measured were within limits. High DO and BOD values in the wet season suggest that the stream could bedoubtful. Three classes of macro-benthos were identified i.e. Clitellata, Insecta and Trematoda; Insecta was the most abundant. Macro-benthos numerical and species abundance decreased downstream. This may be as a result of human anthropogenic perturbation such new bridge construction across the water and stress due to increased anthropogenic activities downstream. The overall diversity may be the product of all spatial and temporal changes affecting the community structure.

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