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WATER QUALITY PARAMETERS AND MACROBENTHIC FAUNA OF BRACKISH WATER SYSTEM, AKWA IBOM STATE, NIGERIA

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ABSTRACT: *A study on water quality and macro-benthic fauna of a brackish water system in Akwa Ibom State, Nigeria was carried out between May 2019 and February 2020. The samples were collected monthly, from three sampling stations across the water body. Standard methods were used to analyze water temperature, dissolved oxygen (DO), hydrogen ion (pH), electrical conductivity (EC) and turbidity in-situ and biochemical oxygen demand (BOD), phosphate and nitrate in the laboratory. Van-veen grab and standard hand net were used to collect the macro-benthos fauna. Ranges of physico-chemical parameters were Water temperature (24.9-25.3 ºC), EC (62.3-70.9 mS/m), pH (6.5-6.7), Turb. (12.0-28.2 NTU), DO (3.8-4.7 mg/L), BOD (2.3-3.2 mg/L), PO_4^- (3.2–5.2 mg/L), NO_3^- (3.0-6.3 mg/L). Statistical analysis showed significant differences in the mean values of turbidity, DO, PO_4^- and NO_3^- ($P<0.05$). Eighteen (18) taxa, 284 individual species of macro-benthic fauna, comprising three (3) phyla and seven (7) taxonomic groups were recorded. Arthropoda was the highest recorded phylum (73.94%); Annelida and Mollusca each accounted for 13.03% of taxonomic group recorded. The dominant taxonomic group was Diptera, accounting 23.9%. Shannon-Wiener index ranged between 1.997 and 2.530, Margalef's index ranged from 1.865 - 3.309, Simpson index ranged between 0.846 and 0.905 and species evenness ranged from 0.908 – 0.923 indicating that the environment has gone through some level of perturbation. Most of the macrobenthic invertebrate species recorded were pollution tolerant species and physico-chemical parameters analyzed revealed that the estuary was polluted due to anthropogenic activities in the watershed.*

KEYWORDS: Water Quality, Macrobenthic, Brackish Water, Anthropogenic Activities

INTRODUCTION

In Nigeria, increases in human activities within aquatic ecosystem could be devastating. These activities together with poor waste management have led to accumulation of pollutants in aquatic ecosystem, causing water pollution, habitat alteration and affecting the structure and composition of aquatic biota, including macro-benthic fauna. However, certain features like topography, climate change, amount of freshwater discharge, intertidal convention current and sediment characteristics influence the ecological system of an estuary. These features, coupled with anthropogenic activities alter the biological community structure. The interaction of both the physical and chemical properties of water plays a significant role in the composition, distribution and abundance of aquatic macro-invertebrates (Michael *et al.*, 2015). Poor water quality affects the composition and abundance of aquatic biota including macro-benthic species (George *et al.*, 2020). Aquatic benthic macro-invertebrates are the animals without vertebral column that inhabit the bottom substrates of water body (George *et al*., 2020). Benthic organisms are relatively sedentary and long-lived with life spans ranging from weeks for some opportunistic worms to months or years for larger taxa (Bamikole *et al.,* 2009); they occupy an important intermediate trophic position and respond differentially to varying environmental conditions. They are used potentially for biological assessment of human impacts in the water bodies (Trigal *et al.,* 2009). Macro-invertebrates constitute a vital link in aquatic food chain, serves as protein materials for fish and shellfish. However, the immediate changes in their habitat structures and physico-chemical characteristics may alter the abundance of these organisms in aquatic ecosystems. Studies have reported the impacts of water quality on macro-invertebrate (Trigal *et al.,* 2009; Caryn, 2010; Mlambo *et al.,* 2011). Low dissolved oxygen, pH, transparency and high water temperature influenced the community structure of invertebrate assemblage (Mlambo *et al.,* 2011). Changes in the water quality and habitat due to anthropogenic activities are the major factors that contribute to poor diversity of macro-invertebrates in aquatic ecosystems (Adeogun and Fafioye, 2011; Adjarho *et al.,* 2013). Andem *et al.* (2015) and Jonah *et al.* (2020a) reported that agrochemicals influenced the survival and distribution of macro-invertebrates of Afi River and Ikpe Ikot Nkon River. Benthic macro-invertebrates also serve as bioindicators in the long-term monitoring of aquatic ecosystem health (Balogun *et al.,* 2011; Abowei *et al.,* 2012; Anyanwu *et al.,* 2019). Some species have physiological adaptations to tolerate organic pollution, low dissolved oxygen, high ionic concentration, temperature and turbidity as well as altered substrate type and flow regime (Buss *et al.,* 2004). Uta Ewa brackish water faces enormous anthropogenic activities and receives waste from the nearby settlements. Other activities observed include fishing, laundry, bathing and boat construction, which could contribute to poor water quality and in turn affect the community structure of aquatic biota. Therefore, the objective of this study is to assess the water quality and macrobenthic fauna characteristics of Uta Ewa brackish water in relation to anthropogenic activities.

MATERIALS AND METHODS

Study area and Sampling stations

Uta Ewa Brackish water is one of the highly utilized water bodies in Akwa Ibom State, Niger Delta, Nigeria. The Estuary is tidal, lying within the Latitude 4º32’44 North and Longitude 7º30’13 East (Figure 1). The Brackish water lie on the Western Bank of Enong Creek, about 12km from the mouth of Imo River (Esenowo *et al.,* 2016); the water receives wastes from the nearby settlements, markets and other domestic activities along the watershed. Vegetations observed were mangrove plants *(Rhizophora racemosa, Nypa fruticans* and *Avicannia africana*). Three sampling stations were selected based on accessibility and observed anthropogenic activities. Station 1 was located upstream and the anthropogenic activities observed were bathing, laundry and fishing. The dominant vegetation was *Rhizophora racemosa* and *Nypa fruticans*; the substrate was muddy and sandy in some sections. Station 2 was located about 2.5 km downstream of station 1. The station was close to human settlements and a market is on the left side. The substrate is muddy. Observed human activities include logging of mangrove plants, boat construction, selling of gasoline, transportation, laundry and fishing. Station 3 was about 3km downstream of station 2 and close to other human settlements. The station was dominated by *Rhizophora sp.* and *Nypa* *fruticans* along the banks with sandy substrate. Observed human activities include logging of mangrove plants, boat construction, water transportation, laundry and fishing.

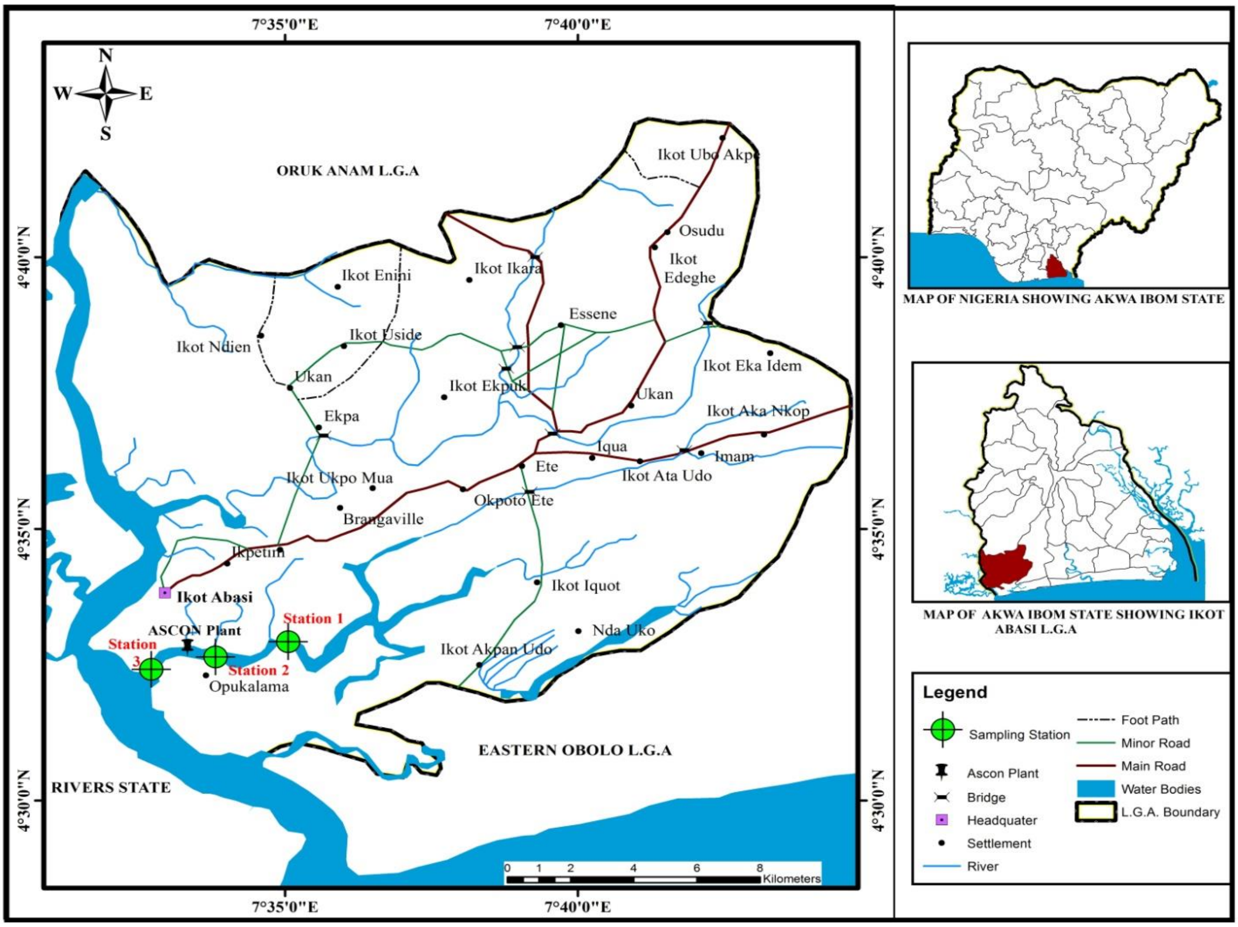

Fig. 1: Map of Ikot Abasi Local Government Area, Akwa Ibom State, Nigeria showing Uta Ewa Estuary Sampling Stations.

Samples Collection

Water samples: The water samples were collected monthly, between May 2019 and February 2020. Sterilized plastic bottles (one litre) were used in sample collections between the hours of 8.00am to 12.00 noon. Some parameters like water temperature, dissolved oxygen (DO), hydrogen ion concentration (pH), electrical conductivity (EC), total dissolved solids (TDS) and turbidity were determined *in-situ* using Hanna portable meter sampler (HI 9811-5 model). Other parameters were analyzed *ex-situ* using standard methods (AOAC, 2000 and APHA, 2005).

Macro-invertebrates samples: Van-veen grab (0.05m^2) and standard hand net (0.5mm mesh size) was used in the benthic macro-invertebrates collection, in four (4) replicates. Some species were handpicked during the low tide at the intertidal shoreline. The pooled sediment samples from each station were thoroughly washed in 0.05mm sieve net. Retained residue were transferred into wide-mouth plastic containers and preserved with 10% formaldehyde. Preliminary identification was carried out in the field before taken to the laboratory for accurate identification and confirmation using appropriate taxonomic keys and materials (Ward and Whipple, 1959; Edmondson, 1959; Pennak, 1978).

Data Analysis

The results obtained were subjected to statistical analysis using the IBM SPSS software. One-way Analysis of Variance (ANOVA) was used to compare means of physico-chemical parameters while Least Significant Difference (LSD) was used to identify the sources of significant differences between the stations. The Pearson's correlation coefficient (r) was used to evaluate relationship between physico-chemical parameters, and between physico-chemical parameters and macro-invertebrates abundance. Analysis was done at significant difference $P<0.05$. Relative and percentage abundance per phylum and taxa were calculated using standard methods. Diversity indices like Shannon-wiener index (H); Margalef's index (D); Simpson's index and Evenness (E) were employed to determine the species diversity, richness and uniformity per station. All the calculations of diversity indices were made using PAST Statistical (Version 3.0) Software.

RESULTS

Physico-chemical Parameters: The summary of mean values of the physico-chemical parameters is shown in Table 1. The temperature values varied slightly across the stations, ranging between 24.9 and 25.3^{o}C. The values were not significantly different across the sampling stations (p > 0.05). Electrical conductivity (EC) had the highest mean value in station 3 (70.9 mS/cm) while the lowest was in station 2 (62.3mS/cm). The values were not significantly different (p >0.05) between the stations. pH values ranged from 6.5 to 6.7 with higher mean value in station 2. Turbidity had its highest mean value in station 2 (28.2 NTU) while the lowest (12.0NTU) was in station 1; ANOVA showed that station 1was significantly different (p < 0.05). Highest mean DO value was recorded in station 1 (4.7 mg/l) and was significantly different (p<0.05) from stations 2 and 3. The highest mean values of nitrate and BOD were recorded in station 2 while highest mean value of phosphate was recorded in station 3. The mean values of phosphate and nitrate was significantly (p<0.05) lower in station 1, compared to the other two stations.

Correlation coefficients between physico-chemical parameters are presented in Table 2. The Pearson's correlation coefficients values of EC gave a significant positive relationship with pH (r = 0.616, p<0.05), PO_4^- (r = 0.819, p<0.05) and NO_3^- (r = 0.741, p<0.05). DO correlate negatively with water temperature (r = -0.894, p<0.01), turbidity (r= -0.763, p<0.01) and BOD (r = -0.763, p< 0.01). BOD value correlates positively with PO_4^- (r = 0.646, p<0.05) and NO_3^- (r =0.509, p<0.01).

Table 1: Mean values and Standard error of physico-chemical parameters of Uta Ewa Estuary

Parameters	Station 1 Mean±SEM	Station 2 Mean±SEM	Station 3 Mean±SEM	Overall Mean±SEM	P-value
Temp.(^oC)	25.1±0.54 (22.8 – 27.5)	25.3±0.55 (23.0 – 28.0)	24.9±0.57 (22.9 – 27.9)	25.2±0.55 (23.0 – 28.0)	P>0.05
EC (mS/m)	63.8±2.99 (45.0 – 75.0)	62.3±3.29 (49.0 – 75.0)	70.9±4.00 (53.0 – 88.0)	65.7±3.43 (45.0 – 88.0)	p>0.05
pH	6.6±0.12 (6.3 – 7.5)	6.7±0.15 (6.3 – 7.6)	6.5±0.05 (6.2 – 6.7)	6.61±0.17 (6.2 – 7.6)	p>0.05
Turb. (NTU)	12.0±2.66^a (3.2 – 30.4)	28.2±2.37^b (18.9 – 45.1)	21.8±2.55^b (12.0 – 35.5)	20.7±2.55 (3.2 – 45.1)	P<0.05
DO (mg/L)	4.7±0.46^a (2.9 – 7.8)	3.8±0.42^b (2.2 – 6.0)	3.9±0.49^b (1.9 – 6.8)	4.12±0.47 (1.9 – 7.8)	P<0.05
BOD(mg/L)	2.3±0.33 (0.2 – 3.6)	3.2±0.39 (1.7 – 5.3)	3.0±0.43 (1.0 – 4.6)	2.8±0.37 (0.2 – 5.3)	p>0.05
Phosphate (mg/L)	3.2±0.40^a (1.5 – 5.4)	4.8±0.55^b (2.3 – 7.7)	5.2±0.54^b (2.8 – 7.8)	4.4±0.51 (1.5 – 7.8)	P<0.05
Nitrate (mg/L)	3.0±0.55^a (1.0 – 5.8)	6.3±0.34^b (4.6 – 8.0)	5.5±0.55^b (2.9 – 8.0)	4.9±0.45 (1.0 – 8.0)	P<0.05

a, b = means with different superscripts across the row are significantly different at P<0.05; SEM = Standard Error of Mean.

Table2: Pearson's Correlation values between the physico-chemical parameters

Param.	Temp.	pH	EC	Tur.	DO	BOD	Phosp.	Nitrate
Temp.	1.00	0.787*	-0.349	-0.415	-0.894**	0.236	-0.401	0.362
pH	-0.152	1.00	0.616*	-0.125	-0.206	0.161	0.669*	0.754*
EC	-0.346	.0.616*	1.00	-0.321	-0.454	0.439	0.819*	-.741*
Tur.	0.415	-0.125	-0.321	1.00	-0.794*	-0.674	-0.434	0.313
DO	-0.894**	-0.206	-0.454	-0.794*	1.00	-0.763**	-0.059	-0.504
BOD	0.236	-0.161	-0.439	-0.467	-0.763**	1.00	0.646*	0.509**
Phosp.	-0.401	0.669*	0.819*	-0.434	-0.059	0.646*	1.00	-0.334
Nitrate	0.362	0.754*	0.741*	0.313	-0.504	0.509**	-0.334	1.00

*Correlation is at significant at P<0.05; **Correlation is significant at P<0.01

Macrobenthos Composition: Species composition, abundance, distribution and its relative abundance are presented in Table 3. A total of 284 macrobenthos species, comprising three (3) phyla, seven (7) taxonomic groups of eighteen (18) taxa were recorded. Phylum Arthropoda had the highest number of individuals (210, 73.94%), Annelida and Mollusca had similar population and relative abundance (37, 13.03%). In relation to taxonomic groups, Diptera had the highest relative abundance (23.9%), followed by Decapoda (22.3%), Coleoptera (17.6%), Gastropoda (13.0%), Oligochaeta (11.6%), Hemiptera (10.2%) and Polychaeta (1.40%) as in Fig. 2. Station 1 recorded the highest number of individuals (118, 41.6%), followed by station 3 (93, 32.7%) and station 2 (73, 25.7%) as shown in Table 4. Higher number of species belonging to Coleoptera, Hemiptera and Decapoda were recorded in station 1; Diptera in station 2 and Gastropoda was high in station 3 (Fig. 3). Percentage composition of the taxa showed that *Turbifex sp.* had the highest abundance (10.5%), followed by *Chiromonus plumosus* and *Cybister larvae* (9.1%) as shown in Table 3.

Table 3: Total population per taxa and its relative abundance (May, 2019-February, 2020)

Phylum	Group (taxa)	STN. 1	STN. 2	STN. 3	TOTAL	RA (%)
ARTHROPODA	**COLEOPTERA**					
	Dysticus marginalis	21	-	3	24	8.4
	Cybister larvae	15	7	4	26	9.1
	HEMIPTERA					
	Ranatra linearis	13	-	1	14	4.9
	Nepa opiculata	14	1	-	15	5.2
	DIPTERA					
	Chiromonus fructilobus	2	11	13	26	9.1
	C. plumosus	4	16	7	27	9.5
	Tabanus larvae	6	6	3	15	5.2
	DECAPODA					
	Caridina Africana	4	-	13	17	5.9
	Cardisoma armatum	-	5	-	5	1.7
	Afruca tangeri	13	-	4	17	5.9
	M. macrobrachion	16	3	5	24	8.4
	Sub-Total	**108**	**49**	**53**	**210**	73.94
ANNELIDA	**OLIGOCHAETA**					
	Turbifex turbifex	4	16	10	30	10.5
	Aulophoru sfurcatus	-	-	3	3	1.0
	POLYCHAETA					
	Glycera dibranchiate	-	-	4	4	1.4
	Sub-Total	**4**	**16**	**17**	**37**	13.03
MOLLUSCA	**GASTROPODA**					
	Littorina punctate	-	-	14	14	4.9
	Hydrobia sp	6	-	5	11	3.8
	Planorbis contortus	-	8	3	11	3.8
	Bullinus sp.	-	-	1	1	0.53
	Sub-Total	**6**	**8**	**23**	**37**	13.03
	Total	**118**	**73**	**93**	**284**	**100**

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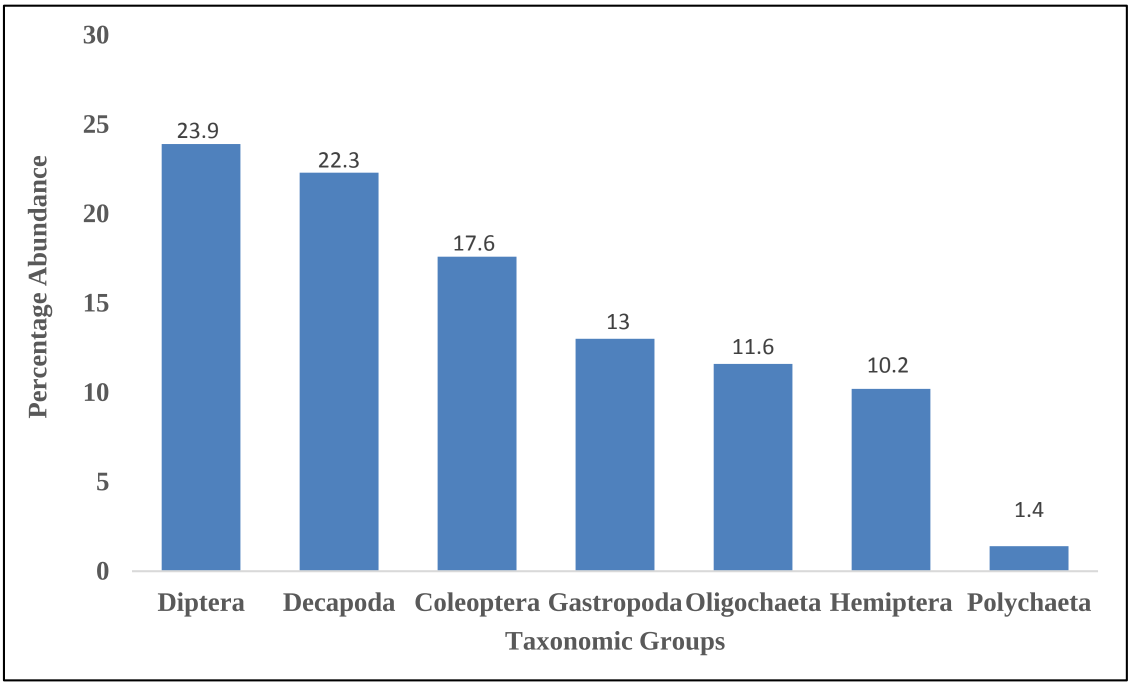

Fig. 2: Percentage abundance of macroinvertebrates taxonomic groups

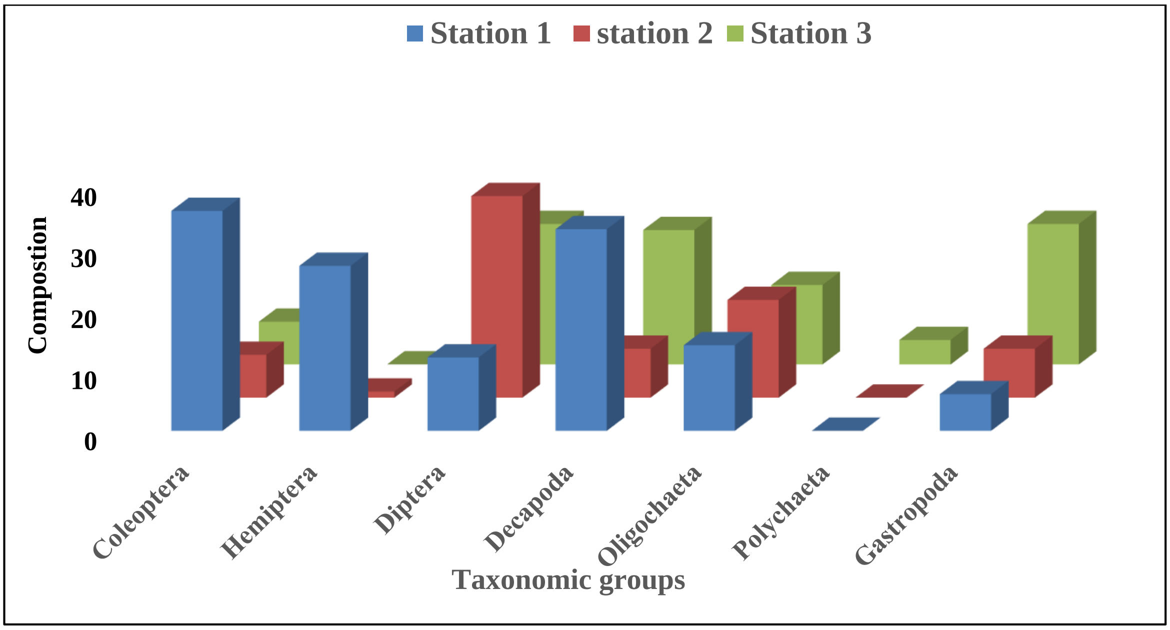

Fig. 3: Composition of macroinvertebrates taxonomic groups per stations

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The species diversity indices of macro-invertebrates revealed that Shannon-wiener index values ranged from 1.997 to 2.530, with the highest value recorded in station 2. Margalef's index values ranged between 1.865 and 3.309; station 2 recorded the lowest value while station 3 had the highest value (3.309). Simpson index values ranged from 0.846 to 0.905 while evenness values was lowest (0.908) in station 2 and the highest value of 0.923 was recorded in station 1 (Table 4)

Table 4: Diversity indices of Macrobenthic Fauna

Indices	Station 1	Station 2	Station 3
No. of taxa	12	9	16
No. of individuals	118	73	93
Relative abundance (%)	41.6	25.7	32.7
Shannon-wiener index (H)	2.295	1.997	2.530
Margalef's index (D)	2.306	1.865	3.309
Simpson index (D)	0.886	0.846	0.905
Evenness index (E)	0.923	0.908	0.912

The correlation values between physico-chemical parameters of water and macro-invertebrates are shown in Table 5. The coleoptera correlated positively with EC (r= 0.935, p<0.05) and negatively with DO (r = -0.888, p<0.05), BOD (r= -0.874, p<0.05). Species belonging to Hemiptera correlated positively with water temperature (r= -0.674, p<0.01), pH (r= 0.832, p<0.05) and inverse relationship with turbidity (r= -0.947, p<0.01), BOD (r= -0.749, p<0.05), DO (r= -0.854, p<0.01). Diptera correlated positively with turbidity (r= 0.613, p<0.05), DO (r= 0.994, p<0.05), BOD (r=0.612, P<0.05), PO_4^- (r= 0.562, p<0.05), NO_3^- (r=0.905, p<0.05). Oligochaeta correlated positively with turbidity (r= 0.651, p<0.05), DO (r= 0.803, p<0.01), BOD (r= 0.931, P<0.01), PO_4^- (r= 0.893, p<0.01), NO_3^- (r= 0.940, p<0.01) and Gastropoda correlated positively with turbidity (r= 0.543, p<0.05), DO (r= 0.919, p<0.01), PO_4^- (r= 0.814, p<0.01), NO_3^- (r= 0.722, p<0.05).

Table 5: Pearson's Correlation coefficients (r) values between physico-chemical parameters of water and macro-invertebrates

Macro/param.	Temp.	pH	EC	Tur.	DO	BOD	Phosp.	Nitrate
Coleoptera	-0.342	-0.514	0.935*	-0.266	-0.888*	-0.874*	-0.158	-0.318
Hemiptera	0.674**	0.832*	-0.749	-0.947**	-0.854**	-0.749*	-0.562	-0.415
Diptera	-0.38	-0.545	0.462	0.613*	-0.994**	-0.912*	0.562*	0.905*
Decapoda	-0.584	-0.483	0.314	-0.153	0.414	-0.441	.0.360	0.571
Oligochaeta	0.240	0.076	-0.451	0.651*	0.803**	0.931**	0.893**	0.940**
Polychaeta	-0.078	0.951*	-0.431	-0.436	-0.243	-0.211	-0.104	-0.223
Gastropoda	0.286	-0.153	-0.217	0.543*	-0.918**	-0.243	0.814**	0.722**

**Correlation is at significant at P<0.05, **Correlation is significant at P<0.01*

DISCUSSION

The mean values of surface water temperature recorded in this study were within the ranges of 20-30°C recommended for aquatic lives in tropical rainforest rivers by Okorafor *et al.* (2014). Slight variations in the water temperatures could be as a result of fluctuations in climatic conditions during sample collection. DO is an important parameter that determines the survival of aquatic organisms. The low values of DO recorded in stations 2 and 3 suggest high loads of organic pollutants discharged from the nearby settlements. The decomposition of these organic pollutants by microorganisms resulted in the depletion of DO in these stations (Jonah *et al*., 2020b). This is in line with George *et al*. (2020) that recorded low values of DO in stations exposed to organic pollutants. The negative correlations of DO with temperature, turbidity, and BOD indicated that these parameters influence the availability of oxygen in the water. The pH values recorded could be attributed to wastes discharged into the water body via surface runoffs. Similar values were reported by Jonah *et al*. (2020b), which attributed it to influx of more acidic substances into the water body through surface runoff. High values of EC recorded in station 3, could be attributed to anthropogenic activities resulting in high concentration of ions and inorganic dissolved salts in the station (Muhammad *et al.*, (2013). This is in line with the studies of Okorafor *et al*. (2014) in lower Qua Iboe River and Fakayode (2005) in Alaro River. Low values of EC were attributed to low concentrations of ions and dissolved salts in both studies. The positive correlation with pH, nitrate and phosphate suggests that increase of these parameters resulted in corresponding increase of EC values (Adeogun and Fafioye, 2011). High turbidity values recorded in stations 2 and 3 suggests the effects of indiscriminate dumping of discarded solid wastes, high level of turbulence during fishing and other domestic activities in the stations. Phosphate and nitrate had similar trend, with high concentrations in stations 2 and 3. This could be as a result of discharge of organic pollutants into the water in the stations through point and non-point sources. Wastes from nearby shores and anthropogenic activities inside the water could also contribute to the increased values in stations 2 and 3. Chapman (1996) reported that surface waters could have nitrate values up to 5 mg/L when influenced by human activities. On the other hand, Mandal *et al.* (2012) associated high phosphate values with human activities. Okorafor *et al*. (2014) reported that leaching of fertilizer residues from cultivated farmlands and household effluents could contribute to high concentrations of phosphate in water. High BOD values were also recorded in stations 2 and 3 compared to station 1; suggesting difference in pollutant concentrations within the stations occasioned by anthropogenic activities. Increase of decomposable organic matters in stations 2 and 3; require oxygen for biodegradation, which will result in high BOD values (Mahre *et al*., 2007). Unpolluted waters usually have BOD values of 2 mg/l or less (Chapman, 1996). These results agreed with Jonah et *al*. (2019) that recorded high values of BOD in stations with high organic pollution resulting from anthropogenic activities in Ikpe Ikot Nkon River, Nigeria.

The variability in physico-chemical characteristics, substrate type, food availability and anthropogenic perturbations in water body of Uta Ewa Estuary influenced the abundance of benthic macro-invertebrates. Human activities resulted in rapid deterioration of the habitats, which in turn affected the wellbeing of the aquatic communities. The eighteen taxa recorded in this study was higher than the 10 taxa reported by Adeogun and Fafioye (2011) and Andem *et al*. (2012) in Awba Stream and Reservoir and Ona river both in Nigeria, respectively. The observed variations in composition and abundance of benthic species of macro-invertebrates could be as a result of the ecological instability arising from anthropogenic activities and sediment characteristics. The occurrence of *Chiromonus* species in all the stations was in line with Emere and Narisu (2009) in an urbanized stream in Kaduna and Anyanwu *et al*. (2019) that recorded non-biting Midge (*Chiromonus* species) as the most dominant species from Ossah River, Umuahia, Nigeria. High nutrient enrichment favour the increase of tolerant species like Chironomidae, Mollusca and Oligochaeta at the expense of Hemiptera (Quinn *et al*., 1997; Masese, *et al*., 2009). This could be the reason for the high occurrences of these groups of macro-invertebrates in station 3. The presence of *Turbifex turbifex, Chironomus fructilobus* and *Chironomus plumosus* is an indication of organic pollution (Tyokumbur *et al.*, 2002; Ogidiaka *et al*., 2012; Adjarho *et al*., 2013). This was also affirmed by Sharma and Chowdhary (2011) that recorded *Turbifex turbifex* at the stations where anthropogenic activities and pollution were high. The presence of the gastropods *Littorina punctata*, *Hydrobia* sp. and *Planorbis contortus* also suggests organic pollution because of their pollution tolerant status (Adeogun and Fafioye, 2011; Jonah *et al*. 2020a). The low number of Coleopterans and Hemipterans in stations 2 and 3 suggests poor water quality. Masese *et al.* (2009) and Arimoro and Keke (2017) described Coleoptera and Hemiptera as bioindicators of poor water quality. High number of individuals of species belonging to these groups was recorded in station 1, when compared with stations 2 and 3; suggesting low degree of pollution and human activities. The low number recorded in station 2 could be as a result of imbalance in the prevailing environment due to dredging activities, domestic wastes discharge, and unfavorable water quality. Gubbay (2003) reported that alteration of aquatic environment caused by sand excavation, would lead to alteration of aquatic biota as they tend to adapt to the prevailing condition. High diversity of species was recorded in station 3 despite the level of anthropogenic activities. Point and non-point pollution sources upstream may have resulted in the abundance of vegetation cover, which provided favorable habitation to aquatic biota (Masese *et al*., 2009). The finding is in line with Runuru (2003) in Nyando River, that reported high macro-invertebrate diversity in stations with high anthropogenic activities and attributed it to riparian vegetation cover and substrate quality. The high occurrence of Decapoda species *Macrobrachium macrobrachion, Afruca tangeri* and *Caridina africana* is because they have the ability to cope with perturbations and survive in unstable environment (Mariantika and Retnaningdyah, 2014) and grow in large numbers (Kucuk, 2008). Polychaeta, *Glycera dibranchiata* recorded in station 3, also suggest unfavourable conditions in the station.

The significant correlation between hydrological parameters and macro-invertebrate further explain the status of the environment. The negative correlation of Coleoptera with DO, BOD, phosphate and nitrate indicated that these parameters hindered the abundance of coleopterans. The negative association of Hemiptera with turbidity, DO and BOD also suggest that these species do not thrive well in polluted water. This further explains that the species of Hemiptera recorded in this study are inhabitants of clean water environment and are very sensitive to pollution. The relationship of Diptera and Oligochaeta with turbidity, DO, BOD, phosphate and nitrate indicated that these groups are pollution tolerant and can survive in polluted and nutrient contaminated water bodies with low DO levels. This is in line with reports of Adeogun and Fafioye (2011) and Sharma and Chowdhary (2011).

The diversity structure of macro-invertebrates showed that the water quality of Uta Ewa Estuary has been adversely impacted by the anthropogenic activities. Comparison of communities to identify biotic disturbances or level of stability can be done with species diversity indices as useful tools (Olawusi-Peters and Ajibare, 2014) and the indices increase as the complexity or stability of the habitat increases (Leinster and Cobbold, 2012). The Shannon-Weiner diversity values recorded in all the stations was of the range indicating moderate polluted environment. The index categories indicated that values of < 1 is for heavily polluted conditions, values of 1 to 2 is for moderate polluted conditions and values of > 3 for stable environmental conditions (Mason 2002). The Margalef indices was high in stations 3; indicating some level of environmental stability which could be attributed to the presence of almost all the macroinvertebrates recorded in this study. The low value recorded in station 2 is an indication of instability; fewer numbers of species and individuals were recorded in stations due to anthropogenic impacts. This revealed environmental variability attributed to environmental degradation (Mason 2002; Yeom and Kim, 2011; Shah and Pandit, 2013). Station 3 had highest value of Simpson diversity index, followed by stations1 and 2; indicating dominance of tolerant groups in station 3. The pielou's evenness values were high, closer to one (1) in all the stations, indicating that there was no dominance of any particular species or group of species; though station 1 was higher than the rest. According to Leinster and Cobbold (2012), evenness is an important aspect of diversity indices showing how evenly distributed the individuals are within the different species. The low diversity recorded as reflected in the community structure (Shannon-wiener, Margalef, Simpson and Evenness indices) may be attributed to anthropogenic impacts (Anyanwu *et al*., 2019).

CONCLUSION

Certain anthropogenic activities, associated wastes and discharges contribute to the deterioration of water quality. The low species composition, distribution, abundance and community structure of macro-invertebrates recorded in this study could be attributed to perturbation of the water body. There were nutrient enrichment, pollution and habitat fragmentation caused by agricultural activities and other anthropogenic activities such as sand mining, logging, etc in Uta Ewa Estuary. There is need for continuous monitoring of our water bodies for the protection of the environment, sustenance of the biota and full utilisation of ecosystem services derivable from them.

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