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World Rural Observations

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Assessment of Water Quality and Benthic Macroinvertebrates Assemblage of Etim Ekpo River, Niger Delta, Nigeria.

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Abstract: Assessment of Water Quality and Benthic Macroinvertebrates Assemblage of Etim Ekpo River, Niger Delta, Nigeria were investigated from November, 2018 to August, 2019. Samples were collected from three sampling stations along the river course. Benthic macro-invertebrates were collected using Van-Veen Grab sampler. Three to four hauls were made per sampling station for collection of benthic sediments for isolation of macro-benthic invertebrates. Three phyla of macro-benthic invertebrates were encountered during the study period. They were Arthropoda, represented by five species, *chironomus larvae* (diptera), *Macromia magnifica*, *Progomphus larvae* (odonata), *Callibaetis pictus* (ephemeroptera), *Isoperla ornate* (plecoptera); Annelida were represented by two species, *Turbifex larvae* (oligochaeta), *Glycera* (polychaeta) and Mollusca were represented by two species of gastropoda, *Pila ovata* and *Physa species*. The phylum Arthropoda had the highest percentage composition (73.7%) followed by Annelids (21.9%), while Mollusca was the least (4.4%) in terms of numerical abundance. *Macromia magnifica* dominated the macro-benthic invertebrates with a total relative abundance of 27.97%, while *Pila ovata* were the least abundance recording 1.63% by number. Surface water temperature, Dissolved oxygen, pH, conductivity and Total dissolve solids were determined *in situ* using standard laboratory procedures. The mean value of surface water temperature ranges from 26.3- 26.5ºC, DO 3.18-4.94 mg/L, EC 11.34 – 17.14 us/cm, pH 6.2 – 6.8, TDS 96.19 – 126.40 mg/L, TSS 29.5 – 37.3 mg/L, BOD 3.95 – 4.52 mg/L, Alkalinity 6.62 – 6.90 mg/L, Phosphate 5.7 – 8.7 mg/L and Nitrate 11.32 – 18.19 mg/L. Analysis of variance (ANOVA) showed significant difference ($P<0.05$) in the mean values of DO, TDS, Phosphate and Nitrate. The results showed that the river is moderately polluted based on the benthic macro-invertebrates encountered during the study, which were dominated with pollution tolerant species.
[George, U. U., Jonah, U. E., Nkpondion, N. N., Akpan, M. M. **Assessment of Water Quality and Benthic Macroinvertebrates Assemblage of Etim Ekpo River, Niger Delta, Nigeria.** *World Rural Observ* 2020;12(1):16-24]. ISSN: 1944-6543 (Print); ISSN: 1944-6551 (Online). http://www.sciencepub.net/rural. 3. doi:10.7537/marswro120120.03.

Keywords: Benthic, Macro-invertebrates, Pollution Assessment, Physico-chemical Parameters Etim Ekpo River, Nigeria.

1.0 Introduction

We are of the recognition that pollution is happening here and is happening now; it's not a nightmare or dream but real resulting from the nefarious activities of humans in the environment. It is in the light of this that we see pollution as a terrible monster which should be given top priority and proper management approach should be put in place to curb this menace. Let's not be more economical oriented but more environmentally oriented (George and Effiom, 2018).

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). Water quality is a key economic and environmental problem in developing countries. With proliferation in human population, our interactions with the water resources on which we are completely reliant on become more and more acute (George and Atakpa, 2015).

It is important to note that the major cause of environmental / water quality degradation is as a result of human induced activities which include mining, agriculture, house hold waste production, road construction and other human related activities that is capable of increasing the concentration of heavy metal and pathogenic organisms in the environment, thereby altering the status of the aquatic ecosystem which may in turn affects resident organisms (George and Atakpa, 2015).

Aquatic benthic macro-invertebrates are those animals without vertebral column, that inhabit the bottom substrates of water body. Benthos organisms have been reported by previous scholars in related researches to serve as bio-indicators of water quality and constitute a vital link in aquatic food chain, which higher animal like fishes fed on (Wallace and Webster, 1996; Oben *et al.,* 2003). They also help in long-term monitoring programme relating to anthropogenic impacts on water quality (Simboura *et al.,* 1995; Williams *et al.,* 2009; Sharma *et al.,* 2010; Balogun *et al.,* 2011 and Abowei *et al.,* 2012).

According to Williams *et al.,* (2009), benthic organisms are relatively sedentary and long-lived, they occupy an important intermediate trophic position and also respond differentially to varying environmental conditions. However, the abundance of these organisms in any given environment is affected by the immediate changes in their habitat structures and physico-chemical characteristics of water quality associated with pollution, erosion and siltation. Some species according to Simboura *et al.* (1995) are relatively tolerant to organic pollutants and low dissolved oxygen.

However, there is paucity of report on the water quality and composition of benthic macro-invertebrate of Etim Ekpo River. Therefore, the objective of this study is to assess the water quality and benthic macro-invertebrate's assemblage of Etim Ekpo River.

2.0 Materials And Methods

2.1 Study Area

Etim Ekpo River is located in Akwa Ibom State, south-south geopolitical zone of Nigeria, lies between Latitude 5°017°N and Longitude 7°617°E. It is a major tributary of Qua Iboe River (Figure 1). The river receives wastes from point and non-point sources through surface runoff. The anthropogenic activities here include agricultural activities using fertilizers and pesticide, dredging and indiscriminate disposal of domestic waste**.** Station 1 is upstream, located in Uruk Ata Ikot Isemin, it characterized by slow water current and high human activities. Station 2 was sited at Utu Etim Ekpo, behind the head bridge; it's characterized with high human activities, slow water current with muddy bottom substrate. Station 3 is downstream, located in Uruk Ata Ikot Ekpor characterized by muddy substratum in some section and also with high anthropogenic activities ranging from dredging, fishing and domestic activities such as bathing and cloth washing.

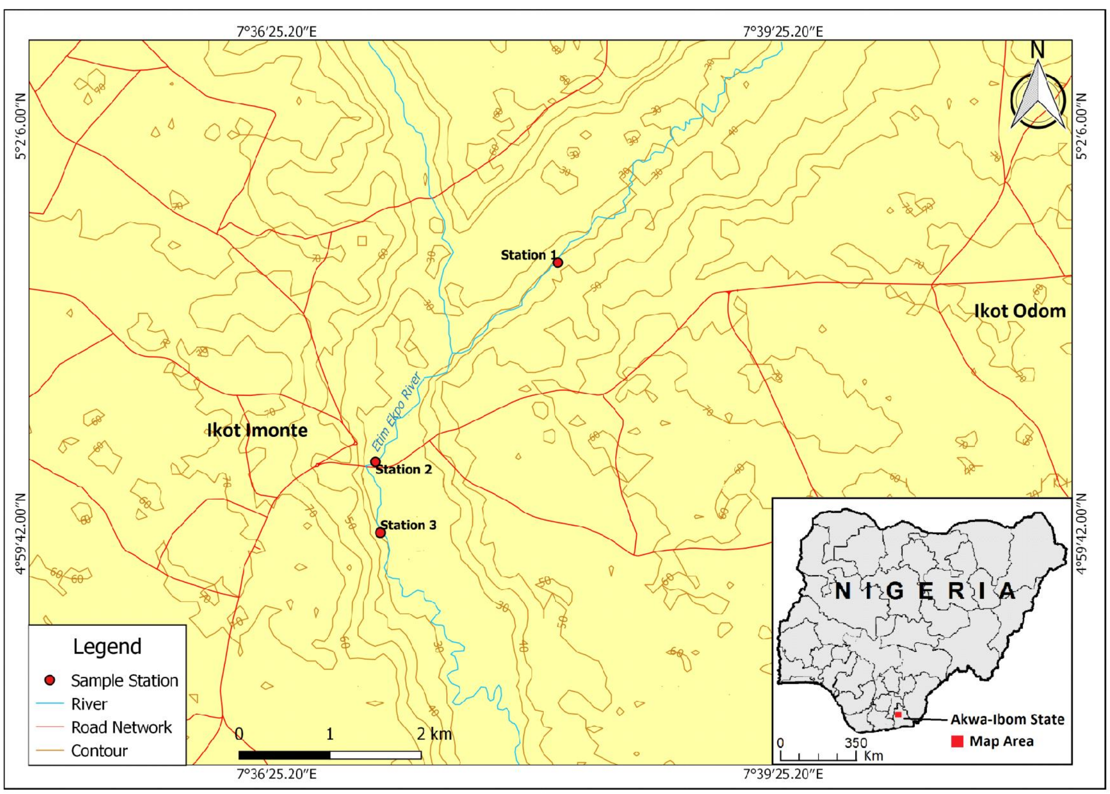

Figure 1: Map of the study area showing sampling Locations along Etim Ekpo River

2.2 Samples Collection

Water samples were collected on monthly basis from November, 2018 to August, 2019; and between the hours of 8.00am and 11.00am on each sampling day. Water samples were collected using sterilized plastic bottles (one litre). Water temperature, DO, pH, EC and TDS were determined *insitu* using Hanna portable meter sampler (HI 9811-5 model). The meter was used by submerging the probe into the water and switching it on, the values and readings of water temperature, DO, pH, EC, TDS were taken while the meter probe was still submerged. Other parameters were determined *ex-situ* in the Laboratory of the Ministry of Science and Technology, Uyo, Akwa Ibom State, according to Standard Methods for Examination of water and Waste water (APHA, 2005 and AOAC, 2000).

Macro-invertebrate's samples were collected using a van-veen grab sampler of $0.05m^2$ surface area in four replicates. The sediment samples from each station were collected with the aid of a van-veen grab sampler and emptied into polythene bag with little water, and the sediments were sieved with mesh sizes nets of 2mm, 1mm and 0.5mm in order to remove the clay particles. The residual retained on the screen of the sieves were washed into a white enamel tray with moderate volume of water to improve the visibility for sorting. The concentrated samples were stored in a small glass jars, labeled and preserved in buffered 4% formalin. In the laboratory, identification of the macro-invertebrates was made based on the identification guides of ward and whipple (1959), Edmondson (1959), Willoughby (1976) and Pennak (1978). The macro-invertebrates encountered were counted according to their respective phylum, classes and species in their respective stations.

2.3 Statistical Analysis

Statistical package for social sciences (SPSS) version 20 was employed to compute mean, variance and standard error in the data. Also, two-way analysis of variance (ANOVA) and least significant difference (LSD) test were employed to separate significance in mean values computed for stations. The probability level was set at p = 0.05.

2.4 Macro-invertebrates Diversity

Benthic macro-invertebrate's diversity was determined using ecological indices such as, Shannon-weiner index (H), Margalef's index (d) and Evenness or equitability index (e) according to Ogbeibu (2005).

Shannon-Weiner index (H) takes into account species richness and proportion of each species within the stations. It express as:

$$H = -\sum_{i-1}^{s} \text{PiInPi}$$

Where; S = Number of individuals in each species.

Pi = Proportion of number of individuals in each species to the total number of individual of all species.

Margalef's species index (d) measure the species richness. It express as:

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

Where; S = the number of species

N = the total number of individual's species

Evenness index (e) measured the degree of uniformity of species. It express as

$$E = \frac{H}{\text{InS}}$$

Where; H = the number derived for Shannon-Weiner

S = the number of species in the sample

In = the natural Logarithm.

3.0 Results

3.1 Physico-chemical Parameters

Spatial variation in the physico-chemical parameters of Etim Ekpo River during the study period are presented in Table 1. The mean surface water temperature ranged from 26.3 to 26.5°C, spatial mean temperature value shows slightly difference across the stations, statistically there was no significant difference across the stations. The temperature values recorded in the study are within the acceptable limit of 24 – 30°C set by WHO (2011).

The spatial mean value of DO was higher in station 2 (4.94 mg/L), while the least was observed in station 3 (3.18 mg/L). There was a significant difference at ($P < 0.05$) across the stations. DO values recorded were below the recommended limit set by WHO (2011).

Electrical conductivity values ranged from 11.34 – 17.14 µs/cm; the highest mean value was recorded in station 3, while station 2 had the lowest value (11.34µs/cm). There was no significant difference between station 1, 2 and 3. The conductivity values recorded in this study are within the acceptable limit of WHO (2011).

The pH values recorded are slightly acidic to moderately alkaline ranging from 5.3 to 8.9. Low spatial mean value of pH was recorded in station 1 and 3 (6.2) respectively. There was no significant difference in pH value across the stations.

The spatial mean values of TDS were recorded higher in station 3 (126.40 mg/L), while the lowest was recorded in station 2 (95.19 mg/L). The TDS values recorded were within the recommended value set by WHO (2011). There was a significant difference in TDS values across the stations at ($P<0.05$).

Total suspended solids (TSS) values ranged from 29.5 – 37.3 mg/L. Highest mean value was recorded in station 2 (37.3 mg/L), while station 1 recorded the lowest mean value of 29.5 mg/L, with no significant difference across the sampling stations.

Biochemical oxygen demand values ranged between 3.95 and 4.52 mg/L. The mean highest value was recorded in station 3 (4.52 mg/L) while the lowest was in station 2 (3.95 mg/L). There was no significant difference in BOD values across the stations.

The highest mean value of alkalinity was recorded in station 1 (6.90 mg/L) and the lowest was in station 2 (6.62 mg/L), and there were no significant differences observed in all the stations.

Phosphate values were observed to be higher in station 1 and 3 (8.3 and 8.7 mg/L) and the lowest was recorded in station 2 (5.7 mg/L). Statistically, there was significant difference in station 1, 3 and 2 respectively, at ($p < 0.05$).

The values of nitrate ranged from 11.32 to 18.19 mg/L. The highest value was recorded in station 3 while the lowest was in station 2. The mean values recorded in all the stations were above the recommended value set by WHO (2011). Statistically, significant difference across the stations at ($p < 0.05$) were observed.

Table 1: The Spatial Mean and Standard error of Physico-Chemical Characteristics during the Sampling Period (November, 2018 – August, 2019)

Parameters	**ST1**	**ST2**	**ST3**	**WHO Std. (2011)**
Temp. ^{o}C	26.4 ± 0.12^{a}	26.5 ± 0.24^{a}	26.3 ± 0.31^{a}	24 – 30^{o}C
DO mg/L	3.38 ± 0.37^{a}	4.94 ± 0.42^{b}	3.18 ± 0.12^{a}	> 5.0 mg/L
EC (us/cm)	13.38 ± 0.19^{a}	11.34 ± 0.31^{a}	17.14 ± 0.27^{a}	1200 us/cm
pH (mg/L)	6.2 ± 0.16^{a}	6.8 ± 0.27^{a}	6.2 ± 0.20^{a}	6.5 – 9.0
TDS (mg/L)	102.16 ± 0.34^{a}	96.19 ± 0.18^{a}	126.40 ± 0.28^{b}	0 – 500 mg/L
TSS	29.5 ± 0.13^{a}	37.3 ± 0.14^{a}	30.1 ± 0.17^{a}	50 mg/L
BOD	4.21 ± 0.49^{a}	3.95 ± 0.34^{a}	4.52 ± 0.38^{a}	< 3.0 mg/L
Alkalinity	6.90 ± 0.26^{a}	6.62 ± 0.25^{a}	6.86 ± 0.19^{a}	NI
Phosphate	8.3 ± 6.81^{a}	5.7 ± 6.81^{b}	8.7 ± 6.95^{a}	< 5 mg/L
Nitrate	16.40 ± 0.65^{a}	11.32 ± 0.39^{b}	18.19 ± 0.25^{a}	10 mg/L

± Standard error, WHO = World Health Organization, NI = Not Indicated; Means with different super scripts across the same rows are significantly different at $p < 0.05$, Means with the same super scripts across the same rows are not significantly different at $p < 0.05$.

3.2 Benthic Macro-invertebrates

Composition, relative abundance and diversity of benthic macro-invertebrates encountered during the sampling period are presented in Table 2, while Figure 2 shows the percentage composition of benthic macro-invertebrate' phyla obtained during the study. Nine (9) species belonging to three phyla from a total of 429 individual benthic macro-invertebrates were collected from all the sampling stations. Station 2 accounted for the highest abundance (39.4%), followed by station 1 which accounted for 32.2%, while station 3 accounted for the least abundance (28.4%) by number. The phylum Arthropoda accounted for the highest percentage abundance (73.7%), followed by Annelida and Mollusca (21.9% and 4.4%) respectively. The highest number of species (9) was recorded in station 2, while station 1 and 3 recorded the least number of species (7). In terms of species abundance, the following order was observed; *Macromia magnifica* accounted for the highest percentage abundance of 27.97% > *Glycera spp.* 15.85% > *Progomphus larvae* 14.68% > *chironomus larvae* 10.98% > *callibaetis pictus* 10.96% > *Isoperla ornate* 9.09% > *Turbifex larvae* 6.06% > and the least was *Pila ovata* (1.63%).

All the sampling stations were dominated by Arthropods and the least was Mollusca. The order Odonata recorded the highest number of individual (183) with the relative abundance of 42.6%, followed by Polychaeta (68) with relative abundance of 15.85% and the least was Gastropoda (19) with relative abundance of 4.4% (Figure 3).

The diversity indices show that station 2 had the highest Margalefs index value of 1.36 and Shannon-Weiner value of 0.68, followed by station 1 (1.21) and (0.56), the least values were recorded in station 3 (1.04) and (0.52) respectively. Slight variations in values of equitability were observed in station 1 and 2 (0.287 and 0.290), the highest value was recorded in station 2 (0.327).

Table 2: Composition, Relative Abundance and Diversity of Benthic Macro-Invertebrate of Etim Ekpo River during Sampling Period (November, 2018 – August, 2019)

SPECIES COMPOSITION	ST. 1	ST. 2	ST. 3	TOTAL	%
Phylum: Arthropoda					
Class: Insecta					
Order: Diptera					
Chironomus larvae	16	31	-	47	10.96
Order: Odonata					
Macromia magnifica	38	46	36	120	27.97
Progomphus larvae	18	33	12	63	14.68
Order: Ephermeroptera					
Callibaetis pictus	27	20	-	47	10.96
Order: Plecoptera					
Isoperla ornate	-	7	32	39	9.09
Phylum: Annelida					
Class: Clitellata					
Order: Oligochaeta					
Turbifex larvae	4	10	12	26	6.06
Order: Polychaeta					
Glycera spp.	32	12	24	68	15.85
Phylum: Mollusca					
Class: Gastropoda					
Pila ovata	-	5	2	7	1.63
Physa sp	3	5	4	12	2.80
Total no. of species	7	9	7	9	100
No. of individuals	138(32.2%)	169(39.4%)	122(28.4%)	429	100
Margalef's index (d)	1.21	1.36	1.04		
Shannon-wiener (H)	0.562	0.680	0.521		
Equitability (e)	0.287	0.327	0.290		

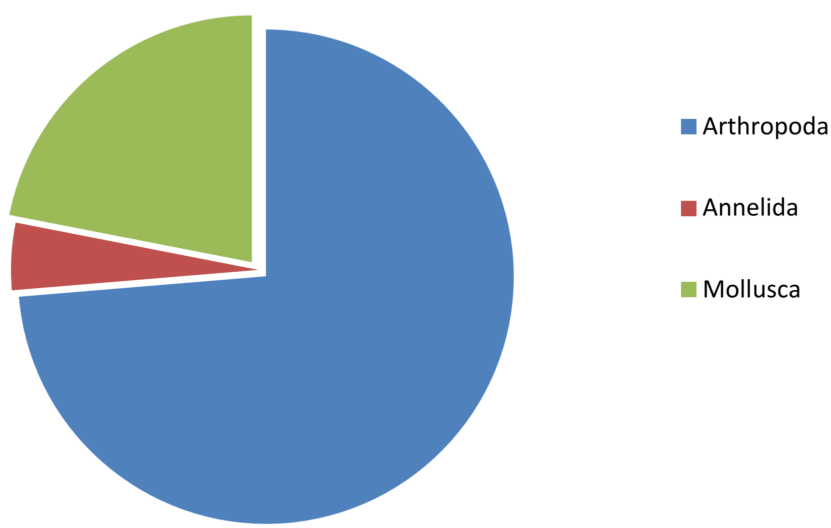

Figure 2: The percentage composition of benthic macro-invertebrate's phyla of Etim Ekpo River

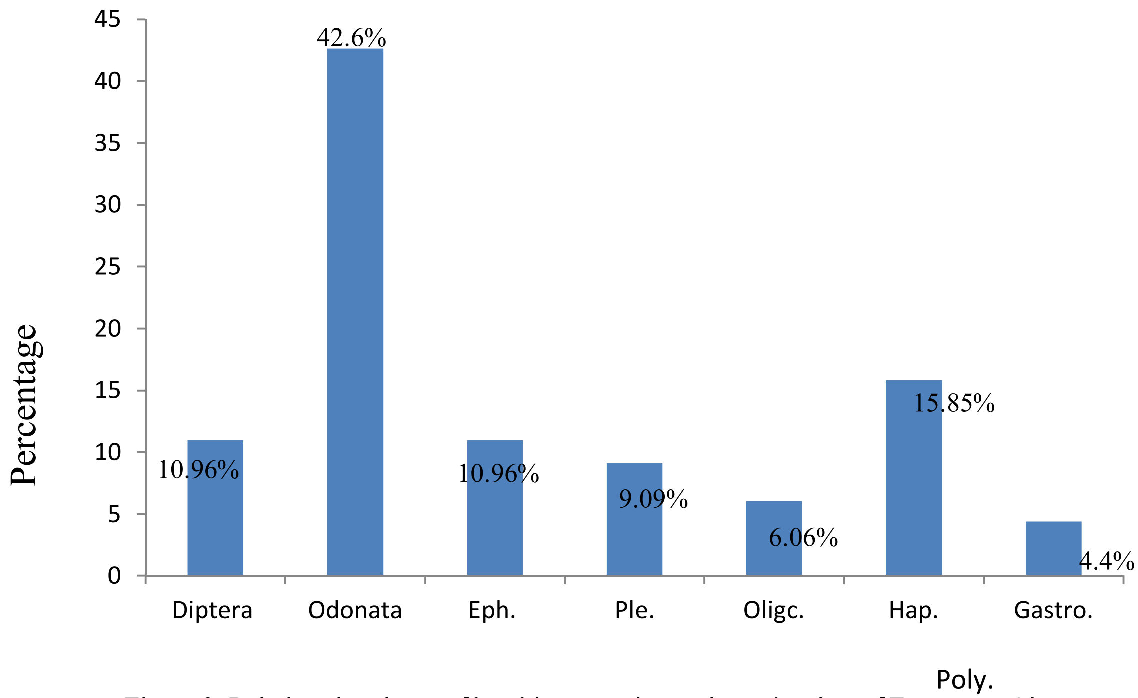

Figure 3: Relative abundance of benthic macro-invertebrates' orders of Etim Ekpo River

4.0 Discussion

Physico-chemical characteristics of a water body generally determine the biological productivity of aquatic ecosystems. The surface water temperature recorded in this study was within the stipulated range of 24 – 30^{o}C for aquatic organisms (WHO, 2011). The slight variation observed in water temperature values may be attributed to climatic condition and time of sampling period.

Dissolved oxygen was observed to be higher in station 2 and low in station 1 and 3. High value recorded in station 2 probably may be attributed to low discharge of organic and inorganic pollutants during the study period. Lower values of this parameter in station 1 and 3 account for intensive human activities such as farming and dredging in these stations. This result corroborates with the findings of Ayobahan *et al.* (2014) who posit that fluctuations of dissolved oxygen level is attributed to the presence of organic pollutants in water body majorly through human activities.

High value of electrical conductivity and total dissolved solids in station 3 as recorded when compared with other stations could be traceable to the discharge of dissolved constituents in this station during the study period, majorly through human activities, including surface runoff from nearby town and the surrounding. Ohimain, *et al.* (2008) posit that high TDS may arise from car wash activities and discharge of dissolved polluted substances which is in line with the present findings. Ewa *et al.* (2011) reported that high level of EC could be corresponding with high value of TDS as affirmed in this study.

The pH value recorded in this study were observed to be low in station 1 and 3, the values recorded in these stations are below the acceptable limit for the growth of aquatic organisms. Low pH values in station 1 and 3 could be attributed to constant dredging activities. This report is in line with the findings of Ohimain, *et al.* (2008) and Amah-jerry *et al.* (2017). Seiyaboh *et al.* (2013) posit that dredging lowers the pH level of water bodies.

High value of TSS in station 2 may be attributed to high runoff of surface water transporting allochthonous materials and organic debris from upstream and the surrounding vegetation into the river.

The mean values of biochemical oxygen demand (BOD) were observed to be high in station 1 and 3 when compared with station 2. This could be attributed to high discharge of organic and inorganic pollutants into these stations through surface runoff. This may also be attributed to high precipitation which increases inputs of decomposable organic matter into the station, requiring oxygen for their biodegradation, which resulted in increased values of BOD. This assertion is in agreement with Adesalu, *et al.* (2010), who reported that increase in rainfall increases the BOD of aquatic ecosystems.

The mean values of phosphate and nitrate in all the stations were high compared to the required range as specified by WHO (2011). High values of these parameters were recorded in stations 1 and 3. This may be linked to the fact that these stations were exposed to organic and inorganic wastes containing phosphate and nitrate in high concentration during the study period. Fertilizer like NPK used to grow plant for rapid growth is the main agro-chemical used at the river bank for agricultural purpose. The chemical might have leached or washed into the river at this stations through the impact of precipitation, which resulted in an increased in these parameters. The result obtained in this study is in line with the finding of Akubugwo and Duru (2011) who reported high levels of phosphate, sulphate and nitrate in water body due to anthropogenic activities. The lower mean value of these parameters in station 2 may be attributed to the fact that station 2 was devoid of much organic and inorganic wastes during the study period.

The number of macro-benthos identified in this study were generally low when compared with the reports of Edokpayi and Osimen (2001); Adekole and Annune (2003), and Andem *et al.* (2015). A total of nine (9) species comprising of a total of 429 individual's species, belonging to 3 phyla were recorded. Arthropoda were the most abundant group accounted for 73.7% in number, followed by Annelida (21.9%) and the least was Mollusca (4.4%). Similar trends in abundance of macro-benthos groups were reported by Avoaja *et al.* (2007) and Andem *et al.* (2012). In this study, the low species diversity recorded could be attributed to the alterations of habitat structure and physico-chemical characteristics of the water body by anthropogenic activities such as dredging, removal of riparian zones, farming, and other domestic activities within the river. These phenomena probably contribute to the disruption of life cycle, reproductive cycle and food chain; also imposed physiological stress on even the tolerant macro-benthos species as reported by Adekole and Annune (2003). Agricultural activities with the use of organic fertilizers rich in nitrate and phosphate near the water body increases the amount of nutrients entering the water and this lead to a corresponding increase in nutrient concentration such as phosphate and nitrate, reduction in dissolved oxygen and subsequent increases in biochemical oxygen demand.

All the species of macro-invertebrates recorded in this study were pollution tolerant classes, which reveal that the river is impacted with organic pollutants as affirm in the BOD and DO values of this study. Presence of *chironomus sp*, *callilbaetis pictus*, *tubifex sp.* and *physa sp.* can be traceable to the fact that these organisms has the capacity to withstand high level of organic pollution (Perkasky *et al.*, 1990). Ogidiaka *et al.* (2012) reported the presence of pollution indicator species in stations of high BOD in Ogunpa River, Abadan. The relative low species recorded in station 1 and 3 in this study could be traceable to the resultant effect of continuous dredging and intensive farming activities in these stations.

The application of diversity indices in macro-invertebrate studies is to assess the pollution status of environment. According to Shekhar *et al.* (2008) the Shannon-wiener diversity index for clean fresh water bodies are proposed as diversity index greater than 4; between 3 – 4 is proposed as mildly polluted water, while less than 2 as heavily polluted water. The Shannon-wiener diversity index in this study ranged between 0.521 and 0.680, margalef's index ranged between 1.04 and 1.36 and equitability ranged between 0.287 and 0.327. The low values of Shannon-wiener diversity index in this study especially in station 1 and 3 indicate severe stress of pollution emanated mainly from anthropogenic activities. The high diversity value of Shannon and margalef's index in station 2 may entail that this station was less stressed. However, the high evenness (equitability) value observed in station 2 may reflect that there was uniformity in the distribution of macro-benthos in this station.

5.0 Conclusion

Benthic macro-invertebrates have been used as bio-indicator organism to monitor the changes in water quality. All the species recorded in this study were dominated by pollution tolerant species. The low diversity of macro-invertebrate fauna could partly be due to the stress imposed on the river and physico-chemical condition during the study period. This study therefore, recommend constant monitoring of the river in order to forestall any changes that may further lead to the alteration of water quality.

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3/12/2020