Assessment of Macrobenthic Invertebrate Fauna and Physicochemical Characteristics of Etim Ekpo River, South-South, Nigeria

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Abstract: The benthic macroinvertebrate fauna and the physicochemical characteristics of Etim Ekpo River in South-South, Nigeria were investigated from November 2018 to August 2019 in three stations. The aim was to relate the water quality and benthic macroinvertebrate fauna to the anthropogenic activities in the river. Standard methods were used in the collection and analyses of the water samples while Van veen grab was used to collect the benthic macroinvertebrates fauna. The mean values of physicochemical parameters were: water temperature (26.3-26.5ºC), dissolved oxygen (3.18– 4.83 mg/L), electrical conductivity (109.4– 112.4 µS/cm), pH (6.2 – 6.9), total dissolved solids (68.1–73.4 mg/L), total suspended solids (29.5 – 37.5mg/L), biochemical oxygen demand (3.6 – 4.5 mg/L), phosphate (5.7 – 8.7 mg/L) and nitrate (11.3 – 18.2 mg/L). Higher values in most of the parameters were recorded in Stations 1 and 3. Three phyla of macrobenthic invertebrates were recorded; Arthropoda, represented by five species; Polychaeta represented the annelids while mollusca was represented by two gastropod snails. Arthropoda had the highest percentage of abundance (73.7%), followed by Annelids (21.9%) while Mollusca had the least (4.4%). *Macromia magnifica* was the dominant species with a relative abundance of 27.97% while *Pila ovate* was the least abundant (1.63%). Most of the benthic macroinvertebrates recorded were pollution-tolerant species, while the biodiversity indices indicated a disturbed environment. The benthic macrofauna and the physicochemical characteristics showed that the river has been seriously impacted by some of the anthropogenic activities going on in the watershed.

Keywords: Anthropogenic, Assessment, Benthic, Macroinvertebrate, Physico-chemical parameters, Pollution

Introduction

Water is an indispensable natural resource on earth; all life forms including human beings depend on water. Freshwater systems have now become the dumping site of wastes and other pollutants emanating from anthropogenic activities (Amah-Jerry *et al.*, 2017; Anyanwu and Ukaegbu, 2019). Studies (Esoka and Umaru, 2006; Adebayo *et al.*, 2007; Jonah *et al.*, 2019) have shown that freshwater bodies in Nigeria are witnessing a rising trend in water pollution attributed to human activities. Human activities such as industrial processes, mining, agriculture, household waste production and urbanization contribute to the pollution load of the aquatic ecosystems altering the physicochemical status and community structure of aquatic organisms including macroinvertebrates fauna (Kucuk, 2008; Anyanwu *et al.,* 2013; Arimoro *et al.,* 2015; Anyanwu and Jerry, 2017).

In freshwater, the macrobenthic invertebrates are mainly made up of insects, others include crustaceans, gastropods, bivalves and oligochaetes (Allan, 1995; Thorp and Covich, 2001; Merritt *et al.*, 2008). These groups of organisms also play critical roles in the

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ecology as decomposers, nutrient recyclers, consumers, and preys in aquatic ecosystem (Wallace and Webster, 1996; Covich *et al.,* 1999; Vanni, 2002; Moore, 2006). Benthic organisms are relatively sedentary, long-lived and respond differently to varying environmental conditions (Williams *et al.,* 2009).

Benthic organisms serve as bio-indicators and have been extensively used in long-term monitoring of aquatic ecosystem health (Simboura *et al.,* 1995; Williams *et al.,* 2009; Sharma *et al.*, 2010; Balogun *et al.,* 2011; Abowei *et al.,* 2012). Some species have physiological adaptations to tolerate organic pollution and low levels of dissolved oxygen (Simboura *et al.,* 1995).

Etim Ekpo River is one of the highly utilized rivers in Akwa Ibom State, South-South Nigeria; the area is subjected to various illicit human activities such as dredging and sand mining. Other activities include indiscriminate disposal of sewage and domestic waste, laundry and washing cars. Various levels of farming activities were also observed along the banks of the river. These activities may have a direct and indirect impact on the water quality and on the diversity of macroinvertebrate fauna and other biocoenosis.

Several studies have been carried out on macroinvertebrates' assemblage and water quality characteristics in Nigeria. Ibemenuga *et al.,* (2017) studied the influence of abattoir wastes on macroinvertebrates' distribution in River Idemili, South-Eastern Nigeria, while Iyagbaye *et al.,* (2017) studied the diversity and seasonal variation of the benthic macro-invertebrates of Ovia River (Iguoriakhi), Edo State, Southern Nigeria. Edegbene *et al.,* (2019) on the other hand, developed and applied a macroinvertebrate-based multimetric index for assessing water quality condition of impacted urban river systems in the Niger Delta, Nigeria, whereas Olaniyan *et al.,* (2019) studied the macroinvertebrate fauna of Oluwa River, Ilaje Local Government Area, Ondo State, Southwest Nigeria. Recently, Aliu *et al.,* (2020) assessed three major tributaries (Obudu, Opa and Esinmirin rivers) of a tropical reservoir in Ile-Ife, Southwest Nigeria and Edegbene (2020) studied the probable menacing effects of the Typha grass and some selected environmental variables on the composition and diversity of benthic macroinvertebrates of Kalgwai Dam, Jigawa State, Northwest Nigeria. Among all these, there is no study concerned with the Etim Ekpo River.

The aim of this study is to assess the benthic macroinvertebrate fauna and physicochemical characteristics of the Etim Ekpo River, South-south, Nigeria vis-à-vis anthropogenic activities.

Materials and Methods

Study Area and Sampling Stations

Etim Ekpo is one of the highly utilized rivers in Etim Ekpo Local Government Area of South-Southern Nigerian State of Akwa Ibom. The section of the river studied lies within the Latitude (5º17"34' - 5º34"20' North) and Longitude (7º60"11' - 7º64"10' East); receiving runoffs from the activities in the watershed (Figure 1). Accessibility and the observed anthropogenic activities were the criteria used for selecting the sampling stations.

The river takes its source from Udoawangwo River in Ikot Ekpene Local Government Area and discharges into the Ukanafun River in the Ukanafun Local Government Area of Akwa Ibom State, Nigeria. The two major tributaries, Ikot Akpan and Itung Achan Ika stream drain into the river and play a major role in the hydrology of the river.

Station 1 (5º17"34'N, 7º60"11'E) was upstream, and the Control Station was located in Nkwot Ikono. The anthropogenic activities were intense and include mining and the selling of sand, farming, bathing, laundry and indiscriminate disposal of sewage and domestic waste. Station 2 (5º30'16N, 7º39'15E) was about 6km downstream of Station 1, and was located between Uruk Ata Ikot Isemin and Utu Etim Ekpo before the head bridge. Human activities were moderate and include farming, dredging, bathing,

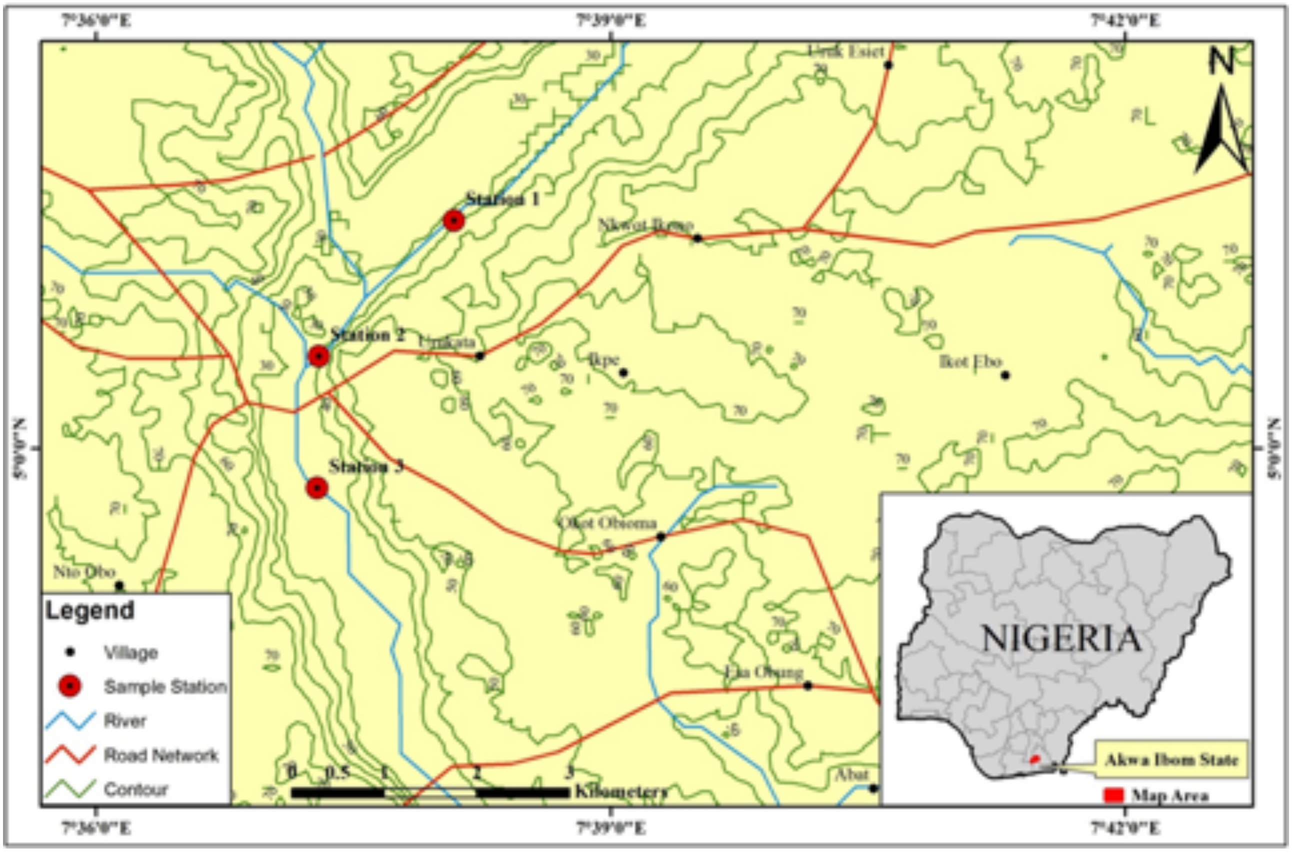

Figure 1. Map of Etim Ekpo River, South – south Nigeria showing the sampling stations.

laundry, and the washing of cars. Sandy and muddy sediments were observed in some sections, while the dominant vegetation was *Paniculum maximum*. Station 3 (5º34"20'N, 7º64'10E) was located at Uruk Ata Ikot Ekpo, It was about 2.5km downstream of Station 2. The substrate was muddy and sandy and the vegetation was mostly *Bambusa vulgaris* and P*aniculum maximum*. The human activities were also intense and included an indiscriminate disposal of sewage and domestic wastes, dredging, fishing, bathing, laundry, extensive farming, and washing of cars. Runoffs from the settlements are also discharged into the river at this Station.

Sample Collection

Water Samples

The water sampling was carried out monthly between November 2018 and August, 2019. A 1litre water sampler was used in the sample collections, and the samples were transferred to sterilized plastic bottles. Some parameters including water temperature, dissolved oxygen, hydrogen ion (pH), electrical conductivity, and total dissolved solids were determined *in-situ*. Water temperature was determined using mercury-in-glass thermometer, and dissolved oxygen with DO meter (Lutron DO-5509 Model), while pH/ EC/TDS Meter (HANNA 3100 Model) was used for the determination of hydrogen-ion concentration, electrical conductivity and total dissolved solids. Other parameters were analysed in Akwa Ibom State Ministry of Science and Technology Laboratory, Uyo, using standard methods (AOAC, 2000; APHA, 2005).

The data obtained were summarized using Microsoft Excel, while the significant difference ($P<0.05$) among the stations was determined by One-way Analysis of Variance (ANOVA). Significant variations were isolated using the Least Significant Difference (LSD) test.

Macroinvertebrates Samples

Van-veen grab ($0.05m^2$) was used in the macro-invertebrates sampling; collected in four replicates. The pooled sediment samples from each station were thoroughly washed in a 0.05mm sieve and the retained residues were transferred into wide-mouth plastic containers and preserved with 10% formalin solution.

A preliminary identification was carried out in the field before the samples were taken to the laboratory for accurate identification and confirmation. Taxonomic keys and materials (Willoughby, 1976; Pennak, 1978; Merritt and Cummins, 1996; Merritt *et al*., 2008; Umar *et al.,* 2013) were used for the identification and confirmation of the isolated organisms. The relative abundance (%) of the groups and species were calculated. The community structure of the macroinvertebrates was determined using ecological indices (Shannon-weiner index (H), Margalef's index (d) and Evenness index). PAST Statistical Software Package (Version 3.24) was used to determine ecological indices (Hammer *et al.,* 2001).

Results

Physicochemical Characteristics

Mean values of physicochemical characteristics are presented in Table 1. Mean water temperatures were between 26.3 and 26.5^{o}C. The temperature values were within the acceptable limits set by FMEnv (2011). The highest temperature (28.8^{o}C) was recorded in Station 1 in December 2018.

The mean values of Dissolved Oxygen (DO) ranged between 3.18 mg/L and 4.83 mg/L. Station 3 had the lowest value. All the DO values were below the acceptable limit (>6 mg/L) set by FMEnv (2011) except for 7.0 and 6.6 mg/L recorded in December 2018 and August 2019 respectively in Station 2. The lowest value (1.6 mg/L) was recorded during the early rains in May 2019. One-way ANOVA showed that Station 2 was significantly higher than Stations 1 and 3 (P<0.05).

The mean values for Electrical conductivity ranged from 109.4 to 112.4 µS/cm; Stations 2 and 3 had the higher mean values, while the least was recorded in Station 1. The highest EC value (172.1µS/cm) was recorded in May 2019 after early rains in Station 1. The mean pH values were slightly acidic; ranging between 6.2 and 6.9. One-way ANOVA also showed that Station 2 had significantly higher pH values than Stations 1 and 3 (P<0.05). The lowest values (6.0) were recorded in Stations 1 (May 2019) and 3 (December 2018, January and June 2019). The Total Dissolved Solids (TDS) followed the same trend with electrical conductivity; though the highest value (97.3 mg/L) was recorded in April 2019 (Station 3). The mean TDS values were between 68.1 mg/L and 73.4 mg/L. ANOVA showed that Station 3 differed significantly from Stations 1 and 2 (P<0.05). The highest TDS value was recorded in Station 3 in April 2019. The mean values for total suspended solids (TSS) ranged between 29.5 and 37.5 mg/L. The lowest mean value was recorded in Station 1, while Station 2 had the highest. The highest TSS value was recorded in Station 2 in May 2019 after early rains.

A mean value range of 3.6 to 4.5 mg/L was recorded for Biochemical Oxygen Demand (BOD). All the mean values exceeded the acceptable limit of 3.0 mg/L set by FMEnv (2011), especially in station 3. The highest values were recorded between May and June 2019 in all Stations.

The mean concentrations of phosphate exceeded the acceptable limit (3.5 mg/L); ranging from 5.9 to 8.7 mg/L. Higher mean values were recorded in Stations 1 and 3. The highest value (21.4 mg/L) was recorded in Station 3 also in May 2019 after early rains.

The mean nitrate values ranged from 11.3 to 18.2 mg/L. Higher mean values were also recorded in Stations 1 and 3 as in phosphate. The highest value (34.1 mg/L) was also recorded in Station 3 after early rains in May 2019. All values were within the acceptable limit (50mg/L) set by FMEnv (2011).

Macroinvertebrate Fauna

The composition, abundance, and distribution of macroinvertebrate fauna are presented in Table 2. Three phyla, nine species, and

Table 1. A summary of the physicochemical characteristics of the Etim Ekpo River, South – south Nigeria

Parameters	Stn 1 X±SEM	Stn 2 X±SEM	Stn 3 X±SEM	P-Value	FMEnv (2011)
Temp. °C	26.4±0.47 (24.0 – 28.8)	26.5±0.62 (24.3 – 29.2)	26.3±0.45 (24.0 – 28.6)	P>0.05	<40°C
DO mg/L	3.42 ± 0.31[a] (2.4 – 5.0)	4.83 ± 0.47[b] (2.8 – 7.0)	3.18 ± 0.33[a] (1.6 – 5.0)	P<0.05	> 6.0 mg/L
EC (uS/cm)	109.4±10.69 (59.5 – 172.1)	111.6±8.55 (64.8 – 140.2)	112.4±8.86 (67.7 – 147.9)	P>0.05	-
pH	6.2±0.04[a] (6.0 – 6.4)	6.9±0.13[b] (6.8 – 7.8)	6.2±0.06[a] (6.0 – 6.5)	P<0.05	6.5 – 8.5
TDS (mg/L)	68.1± 5.60[a] (42.5 – 95.6)	73.2±5.18[a] (44.7 – 90.5)	73.4±5.96[b] (43.4 – 97.3)	P<0.05	-
TSS (mg/L)	29.5±3.35 (15.5 – 46.0)	37.5±3.86 (22.8 – 53.7)	30.1±4.09 (14.2 – 47.0)	P>0.05	-
BOD (mg/L)	3.6±0.52 (1.9 – 6.1)	3.7±0.42 (1.5 – 5.5)	4.5 ± 0.39 (2.6 – 6.9)	P>0.05	3.0 mg/L
Phosphate (mg/L)	8.3±1.65 (1.7 – 16.1)	5.9±1.03 (2.1 – 12.6)	8.7±1.62 (3.8 – 21.4)	P>0.05	3.5 mg/L
Nitrate (mg/L)	16.4±2.62 (7.4 – 33.3)	11.3 ±1.60 (3.8 – 18.4)	18.2±2.36 (8.0 – 34.1)	P>0.05	50 mg/L

a, b = Means with different superscripts across the rows are significantly different at p<0.05; SEM= Standard Error of Mean; FMEnv (2011) - National Environmental (Surface and Groundwater Quality Control) Regulations

a total of 429 benthic macroinvertebrates individuals were recorded. Arthropoda accounted for the highest group relative abundance (73.7%), followed by Annelida (21.9%) and Mollusca (4.4%). *Macromia magnifica* accounted for the highest species relative abundance (27.97%), followed by *Glycera* spp. (15.85%), *Progomphus* larvae (14.68%), C*hironomus* larvae (10.98%), *Callibaetis pictus* (10.96%), *Isoperla ornate* (9.09%), *Turbifex* larvae (6.06%) and the least was *Pila ovate* (1.63%).

Some of the species (*Chironomus* spp., *Progomphus larva,* C*allilbaetis pictus*, *Turbifex* spp., *Glycera* spp., *Pila ovate and Physa* spp.) recorded belong to the tolerant group. Most of the tolerant species recorded higher numbers in Station 2. All the sampling stations were dominated by Arthropods and the least was Mollusca; the order Odonata had the highest number (183 individuals, 42.6%), followed by Polychaeta (68 individuals, 15.85%) and the least was Gastropoda (19 individuals, 4.4%).

Spatially, the highest number of individuals (169 individuals, 39.4%) was recorded for Station 2, Station 1 followed with 138 individuals (32.2%) and Station 3 with 122 individuals (28.4%). Station 2 accounted for the highest number of species, which were 9, while seven species each were recorded for Stations 1 and 3. The highest number of individuals (60) was recorded during the early rains in June 2019, while the lowest (24) was recorded during one of the peaks of the wet season in July 2019.

In terms of community structure, the highest Margalef's species richness index (1.559) was recorded for Station 2, and decreased in the order of 1.249 and 1.218 in Stations 3 and 1 respectively. On the other hand, Station 2 also had highest (1.932) Shannon-Weiner index, Station 1 was the next with 1.715, and Station 3 with the lowest value of 1.667. The highest Evenness Index value (0.7935) was recorded in Station 1, while the lowest (0.7564) was recorded in Station 3.

Discussion

The productivity of the aquatic ecosystems in terms of biota is generally determined by the physicochemical characteristics of the water body (Wu *et al*., 2017; Arimoro, *et al.,* 2018; Anyanwu *et al.,* 2019).

The surface water temperature values were lower than the acceptable limit. The highest water temperature was recorded during the peak of the dry season in December 2018 (station 1). Air temperatures influence water temperatures (Mohseni and Stefan, 1999; Webb *et al*., 2003). Naturally, water bodies exhibit daily changes in temperature due to different activities or phenomena that can influence such changes (Gebreyohannes *et al.,* 2015).

All the dissolved oxygen values were lower than the acceptable limit except in December 2018 and August 2019 in Station 2, which may be attributed to the small perturbation and seasonal influence. Relatively higher DO values were recorded in Station 2 throughout the study. Dissolved oxygen usually increase with less precipitation, improved clarity, and photosynthesis (Kale, 2016) as may be the case in August and December. The high discharge of organic and inorganic pollutants into Stations 1 and 3 from the nearby farms and communities might have been responsible for the poor dissolved oxygen content. Ayobahan *et al.,* (2014) observed that fluctuations in the dissolved oxygen level are attributed to the presence of organic pollutants in the body of water through human activities. The degradation of organic matters in water by bacteria results in the depletion of dissolved oxygen (Mahre *et al.,* 2007). The lowest DO value recorded during early rains (May 2019) in Station 3 might have been influenced by the season. DO contents of a river were mainly influenced by the decomposition of organic matter inputs from the increased runoff after rain (Ling *et al.,* 2017) especially after a period of dryness.

The values of electrical conductivity and total dissolved solids were slightly varied across the stations; the higher values recorded in Stations 2 and 3 might have been as a result of discharges into the Stations from two major tributaries (Ikot Akpan and Itung Achan Ika), human activities, and surface runoffs from the nearby communities along Etim Ekpo River. The highest EC value was recorded in Station 3 during early rain in May 2019 and might have been influenced by the season, while the highest TDS value recorded also in Station 3 in April 2019 before the onset of rains may be attributed to anthropogenic activities. Girardi *et al.,* (2016) recorded the highest EC values after four hours of rainfall, which was attributed to runoff transporting substances rich in ions and polar molecules. Ewa *et al.,* (2011) reported that a high level of EC usually corresponds to a high value of TDS. Ohimain *et al.,* (2008), Seiyaboh *et al.,* (2013) and Rehman *et al.,* (2016) reported that dredging and sand mining contribute to the increase in both EC and TDS values as observed in Stations 2 and 3.

Low pH values were observed especially during some months in Stations 1 and 3, which might have been caused by the constant dredging and some unregulated sand-mining activities. Studies including Ohimain *et al.,* (2008), Seiyaboh *et al.,* (2013) and Amah-Jerry *et al*., (2017) have reported that human activities, such as the dredging and mining of sand, lower the pH levels of water bodies. Studies have established a strong relationship between water pH and the composition of the macroinvertebrate community (Winterbour and Mc Diffett, 1996; Earle and Callaghan, 1998; Varner, 2001). Tripole *et al.,* (2006) reported changes such as the decrease in abundance and richness and the replacement by more tolerant species in the macroinvertebrate community due to decreased pH values. Tripole *et al.,* (2008) also reported a total absence of macroinvertebrates in the stations with pH values lower than 5.5.

The high TSS values observed in Station 2 especially in May 2019 may be attributed to the high runoffs transporting large amounts of sediment from upstream (Station 1) and the Ikot Akpan stream discharging into Station 2 in addition to the season. Ling *et al.,* (2017) reported higher TSS values after early rain events.

The entire mean BOD values exceeded the limits especially in Station 3; with the highest values recorded between May and June 2019 in all stations. This might have been resulted from the discharge of organic and inorganic pollutants through runoffs from the surrounding farmlands and re-suspension and circulation of organic matters through the dredging and sand-mining activities influenced by the season (Akankali *et al*., 2017; Ling *et al.,* 2017). According to Nwankwo *et al.,* (2014), BOD is one of the indicators of organic pollution in a river, therefore, BOD affects water quality. The high value of BOD is reflected in the corresponding low value of DO observed in Station 3. Mahre *et al.,* (2007) reported that when BOD is high, the DO is reduced because the available oxygen in the water is being consumed by bacteria in the process of degrading organic matters.

Phosphate had mean values that exceeded the limits, and significantly higher values were recorded in Stations 1 and 3. Organic and inorganic wastes (including fertilizer) with a high phosphate content might have been responsible for the higher phosphate values observed in Stations 1 and 3. The highest value was recorded in Station 3 (May 2019), which is attributable to the seasonal influence. Mandal *et al.,* (2012) observed that the phosphate contamination comes from anthropogenic activities including runoffs laden with fertilizers and pesticides. Zhang *et al.,* (2019) reported that both of the taxonomic and functional beta diversities of the macroinvertebrate assemblages were regulated by total phosphorus, which acted as the major environmental factor. This regulation resulted in the abundance of pollution-tolerant species.

Nitrates on the other hand, followed the same trend of phosphate. All the mean values were within the acceptable limit; it was observed that Stations 1 and 3 were relatively higher than Station 2 suggesting an anthropogenic impact. Chapman (1996) reported that nitrate values above 5 mg/l are indications of pollution resulting from organic sources. The highest nitrate value was also recorded during early rains in May 2019, and was attributed to the season similar to the case of phosphate.

The macrobenthos recorded was generally low in number when compared with the findings of Andem *et al.,* (2015) and Anyanwu *et al.,* (2019). The order of abundance was arthropoda > annelida > mollusca as observed in Avoaja *et al*., (2007) and Andem *et al.,* (2012). Arthropoda was also the dominant group recorded in Anyanwu *et al.,* (2019), while mollusca was the dominant group recorded in Anyanwu and Jerry (2017). Alterations in the habitat structure and the physicochemical characteristics of the river through dredging and sand mining might have been responsible for the low species diversity observed in Stations 1 and 3. Lawal (2011) reported that the river bed and channel degradations as well as the lowered water levels are some of the destructions caused by river sand mining in the aquatic habitats. On the other hand, Gubbay (2003) reported that when the environment of a river has been altered as a result of sand excavation, the biota are also altered because they tend to adapt to the prevailing conditions rather than recover from their poor conditions. Anthropogenic activities as observed in this study may lead to the homogenization of environmental conditions, which in turn will result in biotic homogenization (Zorzalalmeida *et al.,* 2017).

The highest number of macroinvertebrates was recorded in June 2019, while the least was recorded in July 2019; such variance is attributed to the seasonal influence. Ling *et al.,* (2017) reported a high input of nutrients coming with the early rains of May and June, which supports the growth and development of aquatic biota. On the other hand, July is among the peaks of the wet season in the region, which usually has a negative impact on aquatic biota. Reductions in macroinvertebrate abundances, by more than a half, usually occur after heavy rainfalls (McCabe, 2010).

Most of the recorded species (*Chironomus* sp., C*allilbaetis pictus*, *Turbifex* sp., *Glycera* spp., *Pila ovate and Physa* sp.) belong to the tolerant group that is capable of surviving in a degraded environment (Adeogun and Fafioye, 2011; Adebayo *et al*., 2019; Anyanwu *et al.,*, 2019). Chironomidae taxa are known to be tolerant to water pollution (Dalu and Chauke, 2020) and most tolerant to a low pH (Tripole *et al.,*, 2006; 2008). The presence or occurrence of *Chironomus* and *Tubifex* spp are indications of organic pollution (Aina and Fafioye, 2011; Chanazah *et al*., 2018). Khalil *et al.,* (2016) reported the dominance of oxygen depletion tolerance species (including *Physa* spp) which is attributed to low dissolved and high BOD values. Ogidiaka *et al.,* (2012) also linked the presence of tolerant species in the stations to the high BOD levels in the Ogunpa River, Ibadan. Station 2 had higher numbers of the tolerant species, which may be attributed to an ecological phenomenon known as the invertebrate drift from Station 1 and Ikot Akpan stream discharging into the river before Station 2. Naman *et al.,* (2016) described the invertebrate drift as a basic process in streams whereby aquatic invertebrates exhibit a passive or active downstream movement. According to Koehnken *et al.,* (2020), sand mining affects the macroinvertebrate drift, species abundance, and community structures among others things.

Biodiversity indices have been applied in macroinvertebrate assessments in order to evaluate the environmental conditions of the waterbodies. Shekhar *et al.,* (2008) proposed a Shannon-wiener diversity index classification; values > 4 were for clean fresh waterbodies; values 3 – 4 were for slightly-polluted waters, while values for the severely-polluted waters fall below 2. All the Shannon-wiener index values recorded were < 2; though, a higher value was recorded in Station 2. The Margalef taxa richness index followed the same trend of the Shannon-wiener index. The Shannon-wiener diversity and Margalef species richness indices were low especially in Stations 1 and 3 indicating a severe stress of anthropogenic impacts (Zorzalalmeida *et al.,* 2017). The relatively higher values of the Shannon-wiener and Margalef indices recorded in Station 2 suggested less environmental disturbances. Evenness values were low though Station 1 has a relatively higher value. These values were slightly higher than the values recorded by Anyanwu *et al.,* (2019) and Edegbene (2020) suggesting unstable environmental conditions. When species in a community are not evenly distributed, the evenness index will be low indicating an unstable environment and the presence of dominant species (Victor and Ogbeibu, 1991).

Conclusion

Benthic macroinvertebrates have been used as bio-indicator organisms to evaluate the drastic changes in water quality arising from human activities. Most of the species recorded were pollution-tolerant. The poor water quality and the low diversity of macroinvertebrate fauna can be partly explained by the impacts of the different anthropogenic activities on the river. The impacts of the anthropogenic activities are better explained by the community structure of the macroinvertebrates which was not fully captured by the water quality parameters as in some cases. This study, therefore, recommends a constant monitoring of the river in order to forestall a further degradation of the water quality and the diversity of the biota.

Conflict of interest

The authors hereby state that this research and the manuscript production comply with ethical standards, and none of the authors has any potential conflict of interest. The authors further declare that this research was not been funded by any agency.

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