Science World Journal Vol 14(No 1) 2019
www.scienceworldjournal.org
ISSN 1597-6343
Published by Faculty of Science, Kaduna State University

SAND DREDGING IMPACT ON MACROBENTHIC INVERTEBRATES OF A HALLOWED RIVER IN DELTA STATE OF NIGERIA

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ABSTRACT

River Ethiope is one of the most revered water bodies in Delta State by communities along its course. Macroinvertebrate samples were collected from threes communities; Obi- Iloh, Ebedei-Adonishaka, Ebedei Obi-Ukwuole designated as Station 1, 2 and 3 respectively, that forbids women entrance but allows men folk to sand dredge. The survey conducted between March and April, 2015, identified 17 taxa of macro invertebrate with 219 individuals. Of the nine order, Hemiptera constituted the most abundant set 42.25%, followed by Decapoda 16.90%, Coleoptera 11.74%, Plecoptera and Arachnida 6.57%, Odonata 5.16%, Diptera 4.23%, Annelida(Lumbriculida and Arhynchobdelida) 3.76% and the least Trichoptera 2.82%. However, non-statistical significant richness exists among these organisms at the stations ($p \geq 0.05$). Computed biological indices and lower macro invertebrates census revealed that the macro invertebrates were more abundant in stations 3 and 1 than in station 2, identifying the last two stations as unstable and moderately deteriorated. The enlisted significant correlated variables expressed manifold hydrological factors pinpointing human disturbance as impact.

Keywords: Water Quality, Macroinvertebrates, Diversity indices and Culture

INTRODUCTION

Accessible safe freshwater is a basic human right for people of all race and social class, hence sustainable and safe management of freshwater and its resources is pertinent to the actualization of regional and global safe freshwater. In the aquatic ecosystem, freshwater and its associated organisms are most impacted by different pollution entry point from anthropogenic activities in the watershed. Water quality problems and their effects vary, in type and magnitude along different coastal communities, particularly in in the rural areas of Niger- delta region in Nigeria. Poor water quality has a direct impact on the quantity of available water to users in a variety of ways (UN-waters 2011). Continuous monitoring of freshwater bodies and its resources by collecting good data are important efforts towards improving water quality and increasing the quantity of water available to sustain life.

Macrobenthic invertebrates are regarded as one of the most representative taxa for identifying the health plight of aquatic ecosystem as they reflect changes in the environment in an integrative and continuous manner and have been widely used for ecological water quality monitoring (Guareschi *et al.* 2017). The Ethiope River is an important natural resource for communities located around its shorelines, as it provides water for domestic, agricultural, industrial, recreational, educative purposes and importantly as a symbol of worship (Iloba 2012). It is also especially important for its diverse freshwater fauna and flora and economic value. There is no comprehensive hydrobiological study on the quality and macroinvertebrate community of Ethiope River particularly in this River spectrum. Available works includes Ikomi *et al.* (2005); Omo-Irabor & Olabaniyi, (2007); Kaizer & Osakwe (2010); Ikomi & Arimoro (2014); Iloba (2017). This study was done to provide previously unavailable information on the water quality and macroinvertebrate diversity at the Ebedei axis of Ethiope River, with a strong taboo of being assessed by women and as such lacks hydrological information, until male indigenous researchers joined the project band. This information will provide the previously unavailable data about this head region of Ethiope River.

Description of Study Area

River Ethiope is tributary-less river and the second tributary of the Benin Rivers. It flows in a south-western direction from its source at Umuaja over a distance of about 96.6km through the dense rainforest to Sapele in Delta state where it empties its water into Benin River. It is located within Longitude 5.30˚-6.05˚ east and Latitude 5.53˚-6.05˚ north. The river although, although a freshwater body is tidal around the lower reach between Aghalokpe to Sapele. The area around this river is characterized by two metrological seasons (rainy and dry). The rainy season characterized by heavy rainfalls occurs between May- November, while the dry season characterized by low precipitation occurs between December and April. The river has been discussed extensively in Ikomi *et al.* (2005); Omo-Irabor & Olabaniyi (2007); Kaizer & Osakwe (2010), Iloba (2012); Ikomi & Arimoro (2014) and Iloba (2017). With an aim of this study, three sampling stations were mapped out and identified for effective sample collection at the Ebedei axis of River Ethiope. These areas lack hydrobiological information following the stringent culture that forbids women and sometimes strangers assess.

Station 1

This station is located at Obi- Iloh. The substratum is covered with coarse sand, fast flowing and an average depth of 0.22m. Transparency is 100% as various fish species can be seen swimming around in the water. The river is surrounded by vegetation includes, Azolla *Africana, Commelina sp. Pistia stratiotes, Bambusa vulgaris* etc. Human activities at this station include dredging, swimming, washing and fetching of water domestic use.

Station 2

This is at Ebedei-Adonishaka. This station is similar to station 1 above. However, human activities here include sand dredging. The station is surrounded by tree such as *Elaeis guinensis, Anacadium occidentalis, Havea bransilliensis.* There are farmlands around this station and also evidence cattle coming to drink at this station.

Station 3
This station is located at Ebedei Obi-Ukwuole. Aquatic macrophytes here include *Bambusa vulgaris, Azolla Africana, Lemna pausicostata* etc. The river here is wide than stations 1 and 2, slightly deeper and flows faster. Notable human activities here include swimming, washing and fetching of water for domestic use.

Physico-chemical Parameters
The prevailing physico-chemical conditions at each station were measured during each sample collection period. These parameters include, air temperature, water temperature, dissolved oxygen, biochemical oxygen demand, pH, conductivity, acidity, alkalinity, total dissolved solids, phosphorus and chloride, were measured using standard methods by APHA, 1992.

Macroinvertebrate sampling
Kick sampling method described by Lenat *et al*. (1981) and adopted by Ikomi & Arimoro (2014) was employed in this study. The macroinvertebrate samples were kept in 70 % ethanol, before transferring it to the laboratory for sorting and identification. In the laboratory, the samples were sieved to remove sand and excess silt, while the macroinvertebrate were then picked out and counted. Identification was done using pictorial keys by Water and Rivers Commission (2001), Arimoro & James (2008) and Barber-James & Lugo-Oritz (2003).

Analysis of Results
ANOVA was used to statistically analyze the water quality data among the various stations sampled Biological diversity indices; Margalef richness index, Shannon-weiner index, Evenness, Simpson dominance index, Menhinick index as well as Kruskal-Wallis test of equal medians used to analyze the macroinvertebrates community structure by the application of PAST statistical package (Hammer *et al*,. 2001). The relationship between the water variables and the macroinvertebrates were investigated using Pearson correlation analyze using Statistix 8.

RESULTS
The daily atmospheric temperatures were fairly similar, and ranged between 24.9˚C to 30.2˚C. The highest value was recorded at station 2 on the 8th day while the least value was recorded at station 3 on the 5th day. Water temperature ranged from25.9˚C to28.0˚C. The highest value for water temperature was recorded in station 1 on the 9th day, while the lowest value was recorded on the 8th day in station 1. The mean pH value recorded was 6.87, while the highest pH values (8.03 mg/L) were recorded at stations 1 and 2 on the 4th and 8th days respectively and the least value was recorded at station 1 and 2 (6.4 mg/L) on the 3rd and 9th day. Dissolved oxygen had a mean value of 23.83mg/L. The highest value recorded (60.80mg/L) for dissolved oxygen was at station 1 on the 6th day while the least value recorded was 0.00mg/L at station 2 on the 9th and 10th day. Biochemical Oxygen demand recorded the highest value (80mg/L) at station 1, on the second day and the least value (0.00mg/L) in all the stations sampled. The Alkalinity had a mean value of 5.67mg/L. The highest value (12mg/L) was recorded on the 8th day in station 2, while the least value was recorded at station 1 on the 5th day. Acidity values in the study had a mean of 188.8mg/L, with the highest value (358mg/L) recorded in station 1 on the 9th day, and the least value (78mg/L), recorded on the 4th day in station 1 also. Conductivity values had a mean of 14.04µS/cm. the highest value (18.34µS/cm) was recorded in station 3 on the 8th day, while the least value (11.40µS/cm) was recorded in station 1 on the 4th day. Phosphorus value had a mean value of 0.98mg/L, with the highest value (2.5mg/L) recorded on the 4th day in station 1 and the least value (0.2mg/L) in station 3 on the 10th day. Chloride values had a mean of 75mg/L. the highest value (135mg/L) was recorded on the 6th day in station 3, while the least value (1.15mg/L) on the 9th day in station 1. The P-values (ANOVA) revealed that there was no significant difference between the stations for all physico-chemical parameters studied (Table 1).

Macroinvertebrate Distribution, Composition and Abundance
Taxa composition, distribution and abundance of macroinvertebrates in the study are shown in Table 2. Nine taxa represented by sixteen (16) families, namely *Hydroschide, Leutridae, Perlidae, Culicidae, Chironimidae, Libellulidae, Notonectidae, Naucoridae, Nepidae, Pleidae, Belostomatidae, Aranneae, Hirudinae, Lumbricullidae, Gyrinidae, Elmidae and Carinidae*. The total number of taxa and individuals present in stations 1, 2 and 3 were 16(71), 12(56) and 17(86) respectively. Hemiptera constituted the most abundant order in this study 42.25%, this was closely followed by the order Decapoda 16.90%, Coleoptera 11.74%, Plecoptera and Arachnida 6.57%, Odonata 5.16%, Diptera 4.23%, Annelida(Lumbriculida and Arhynchobdelida) 3.76% and the least Trichoptera 2.82%.

Table 1: The rundown of the physicochemical results of the studied stations.

Parameters	Station1	Station2	Station 3	Anova P-Value	Mean±SE
Alkalinity (mg/L CaCO3)	5.40±0.79 (2.00-10.00)	5.4±0.90 (2.0-12.00)	6.20±0.7572 (4.00-10.00)	0.73	5.67±0.46 (2.00-12.00)
Acidity (mg/L CaCO3)	189.2±24.81 (78.00-358.0)	193.4±21.75 (88.00-278.0)	183.8±21.62 (102.0-293.0)	0.96	188.8±12.71 (78.00-358.0)
Chloride (mg/L)	54.02±11.72 (1.15-112.0)	86.67±12.88 (1.720-131.0)	84.30±12.36 (14.00-135.0)	0.13	75.00±0.7401 (1.15-135.0)
Atmospheric Temp. °C	27.16±.46 (24.90-29.00)	26.69±.5677 (24.90-30.20)	27.11±.5699 (24.90-30.10)	0.79	26.81±0.27 (24.9-30.2)
Water Temp.	26.63±0.21 (25.90-28.00)	26.57±.1375 (26.10-27.20)	26.67±0.1239 (26.10-27.20)	0.9	26.62±0.09 (25.90-28.0)
B.O.D (mg/L)	28.24±8.96 (0.0-80.00)	9.920±4.09 (0.0-39.20)	11.52±3.046 (0.0-24.80)	0.072	16.56±3.66 (0.0-80.0)
D.O (mg/L)	24.32±4.714 (8.80-60.80)	22.48±5.23 (0.9-48.00)	24.72±3.995 (8.00-45.60)	0.94	23.83±2.61 (0.0-60.8)
pH	7.12±0.18 (6.04-8.03)	6.837±0.19 (6.040-8.000)	6.641±0.1563 (6.050-7.060)	0.18	6.87±.11 (6.04-8.03)
ConductivityµS/cm	13.36±.47 (11.40-15.93)	14.12±0.51 (11.50-16.77)	14.64±.533 (13.24-18.34)	0.21	14.04±.30 (11.40-18.34)
TDS (mg/L)	6.40±.31 (5.00-8.00)	5.90±.18 (5.000-7.000)	6.9000±.3480 (6.000-9.000)	0.06	6.40±.18 (5.0-9.0)
Phosphorus (mg/L)	1.01±.22 (.08-2.50)	0.93±.15 (.26-1.81)	.9930±.2700 (.11-2.40)	0.96	0.98±0.12 (0.08-2.5)

Hemiptera were found in all the stations studied and were equally most abundant, accounting for four families. The *Naucoridae* were the most abundant family of the hemipterans, with the *Naucoris sp*. contributing the highest number of individuals. The order *Decapoda* contributed the highest number of macroinvertebrate individuals *(36)* in the study. Trichoptera represented by a single species, *Macrostemum capense (6)* was the least occurring in the entire study. The daily relative abundance of macroinvertebrates revealed that day 1 had the highest abundance, followed by day 10, while day 6 had the least abundance.
Inter- macrobenthic population differences exist between the three communities (Stations) as shown in Fig. 2. The characterization of

the benthic organisms in station 1 is of this sequence; Hemiptera>Decapoda> Coleoptera> Arachnida> Plecoptera> Diptera>Trichoptera> Odonata >Annelida. While station 2 presents Hemiptera >Coleoptera> Decapoda> Odonata >Plecoptera>Arachnida> Annelida and the Trichoptera, no Diptera and finally station 3 had Hemiptera > Decopda > Plectoptera > Odonata = Arachnida > Diptera = Annelida = Coeleoptera > Trichoptera. Despite the inter-station population differences no statistical significant difference was indicated between them ($F=0.2596$; $p=0.7732$). The correlation tested relationship between macro invertebrates and water properties are shown in Table 3.

Diversity, dominance and similarity indices

Table 4, shows the summary of the diversity and dominance indices calculated for River Ethiope at the three stations. Margalef index (d) calculated was highest in station 3(3.60), this was closely followed by station 1 (3.28), while station 2 (2.42) had the least value. Berger-Parker dominance values were similar in stations 2 and 3, while the least value was in station 1. Equitability values revealed that the macroinvertebrates were equitably distributed as shown by the closely related values recorded in this study. Kruskal-Wallis test for equal medians revealed, there is no significant difference between sample medians. Shannon-Weiner diversity (H) and Simpson diversity showed similar trends in the study, both showed highest values in station 3, followed closely by station 1 and recorded the least values in station 2. The macroinvetebrates found at the various stations were not different statistically ($F= 0.25$; $P= 0.7839$, grand mean- 7.89 and coefficient of variation (CV) is equal 115.19%**.**

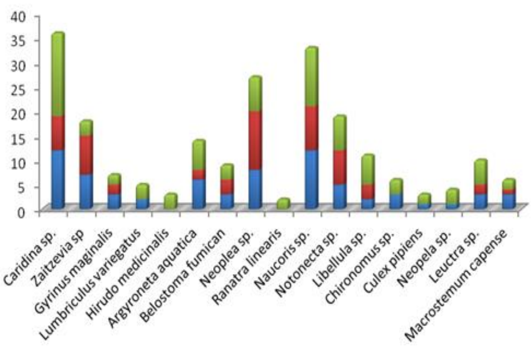
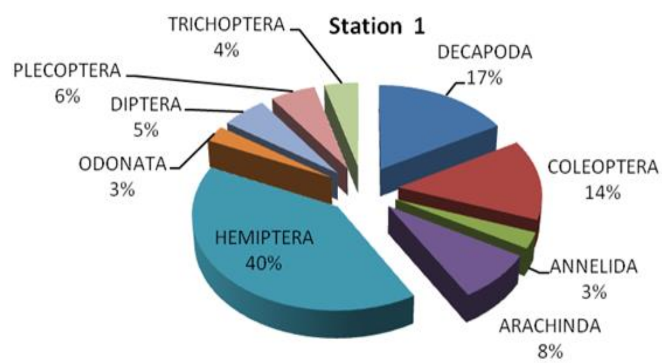


Fig. 1: Species Abundance of Macroinvertebrates Samples at the three studied stations

Table 2: The structure, pattern and relative number of Macroinvertebrates at the sampling stations

Order	Family	Species	Station1	Station 2	Station 3	Total	%
Decapoda							**16.90**
	Family Atyidae	*Caridina sp.*	12	7	17	36	
Coleoptera							**11.74**
	Family Elmidae	*Zaitzevia sp*	7	8	3	18	
	Family Gyrinidae	*Gyrinus maginalis*	3	2	2	7	
Lumbriculida							**2.35**
	Family Lumbriculidae	*Lumbriculus variegatus*	2	0	3	5	
Arhynchobdelida							**1.41**
	Family Hirududae	*Hirudo medicinalis*	0	0	3	3	
Arachnida							**6.57**
	Family Araneae	*Argyroneta aquatica*	6	2	6	14	
Hemiptera							**42.25**
	Family Belostomatidae	*Belostoma fumican*	3	3	3	9	
	Family Pleidae	*Neoplea sp.*	8	12	7	27	
	Family Nepidae	*Ranatra linearis*	0	0	2	2	
	Family Naucoridae	*Naucoris sp.*	12	9	12	33	
	Family Notonectidae	*Notonecta sp.*	5	7	7	19	
Odonata							**5.16**
	Anisoptera Family Libellulidae	*Libellula sp.*	2	3	6	11	
Diptera							**4.23**
	Family Chironomidae	*Chironomus sp.*	3	0	3	6	
	Family Culidae	*Culex pipiens*	1	0	2	3	
Plecoptera							**6.57**
	Family Perlidae	*Neopela sp.*	1	0	3	4	
	Family Leuctridae	*Leuctra sp.*	3	2	5	10	
Trichoptera							**2.82**
	Family Hydropsychidae	*Macrostemum capense*	3	1	2	6	
Grand Total			71	56	86	213	**100**



Science World Journal Vol 14(No 1) 2019
www.scienceworldjournal.org
ISSN 1597-6343
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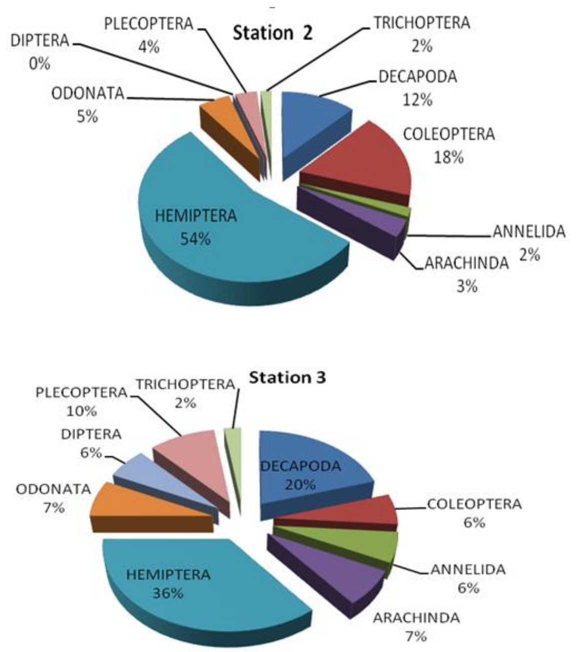

Fig 2: relative abundance of macro invertebrates order at the three communities during the period studied

Table 3: Pearson Correlation results of Water Parameters and macroinvertebrates population, significant at 5% probability level

Correlated Parameters	Station 1	Station 2	Station 3
Acidity vs Arachnida	-0.7142; 0.0203		
Acidity vs Decapoda			0.6809; 0.0302
Acidity vs Hemiptera		-0.6873; 0.0281	
Acidity vs Plecoptera		0.6829; 0.0495	
Air Temperature vs Arachnida		0.6869; 0.0282	
Air Temperature vs Odonata		0.8850;0.0007	
Alkalinity vs Plecoptera	0.7579; 0.0111		
Conductivity vs Arachnida			0.6464; 0.0435
Chloride vs Arachnida		0.6567;0.0321	
Chloride vs Diptera			-0.7109; 0.0212
Chloride vs Trichoptera		-0.7329;0.0159	
Phosphate vs Annelida	0.7613;0.0105		
Phosphate vs Arachanida		0.6567;0.0392	
Phosphate vs Odonata		0.7511; 0.0123	
pH vs Trichoptera		0.6689; 0.0344	
TDS vs Coleoptera		0.6776;0.0313	
TDS vs Hemiptera	-0.6417;0.0455		

Table 4: Diversity Indices of Macroinvertebrate Communities of Ethiope River

Diversity Indices	Stations		
	1	2	3
Taxa_S	15	11	17
Individuals	71	62	86
Dominance_D	0.1026	0.1243	0.09438
Simpson_1-D	0.8974	0.8757	0.9056
Shannon_H	2.461	2.2	2.593
Evenness_e^H/S	0.7808	0.8206	0.7863
Margalef	3.284	2.423	3.592
Equitability_J	0.9086	0.9175	0.9151
Berger-Parker	0.169	0.1935	0.1977

DISCUSSION

The combination of the influences of anthropogenic activities, geological and physical conditions of the watershed determines the physico-chemical condition of an aquatic ecosystem, which further determines the quality of the water body and distribution and structure of available aquatic communities (Ikomi & Arimoro, 2014). There were relatively, no variations of any significance in the result of physico-chemical conditions of Ethiope River among the stations in this study. However, when compared with previous studies (Ikomi & Arimoro, 2014 and Iloba, 2017), in Ethiope River, air and water temperature all fell within similar range were significantly correlated(r= 0.6729; p= 0.03). This is attributed to the similarity in the prevailing climatic conditions of the study stations of earlier studies in this River. High water temperatures distraught self-purification capacity of freshwaters, by reducing its oxygen carrying capacity which could have be used for biodegradation (Morrison *et al*., 2002). Dissolved oxygen values recorded were found to be generally high. This could be attributed to the combined action of water temperature and the swift flowing nature of the river at these stations. This view has been corroborated by Ikomi *et al*., (2005) in Ethiope River and Niusha Amri *et al*. (2014) in Jajroud River in Iran. Arimoro *et al*., (2015) reported that, a river losses its ability to purify itself if the BOD value exceeds 4 mg l-1. The BOD values recorded were disturbingly high, however this could be an indication of high nutrient loading resulting from the fermentation of cassava in Ethiope River and an ambient temperature, which provides a favourable environment for the growth and abundance of phytoplankton and bacteria, which makes use of oxygen for the breakdown of organic material. This high BOD is an indication of high burden organic effluents in Ethiope River. This view is further corroborated by the high values of phosphates in this study and conforms to Arimoro *et al*., (2007).17 taxa of macroinvertebrates with 219 individuals were identified and recorded in this study. This number is less than those reported by Ikomi *et al*. (2005) and Arimoro & ikomi (2008) in Ethiope River, Iloba *et al*., (2018) in Agbarha-otor River, This difference could be attributed to difference in changes in the physico-chemical parameters of the sampling environment and/or in the sampling effort. Low abundance of macroinveretebrate organisms could also be associated with rumbling of the environment due to dredging. Shannon and Margalef's indices revealed that the macro invertebrates were more abundant in stations 3 and 1 than in station 2. These are indications that the substratum at stations 3 and 1 had remained relatively consistent as against that of station 1, the major dredging site, irrespective of changing environmental conditions. The hemiptera were the most diverse group in this study. However, hemipterans have a higher tolerance for lower dissolved oxygen concentration in freshwater than Ephemeropterans, Plecopterans and Trichopterans. According to Locke *et al*. (2015), lower sensitivity of hemiptera to water quality (dissolved oxygen) can be explained by the fact that all adults with the exception of A. aestivalis depends on atmospheric oxygen for respiration. Similar to the present, a vast number of hemipterans have been identified moderately pollution tolerant (Archna *et al*., 2015). There abundance can be ascribed to surface tension on the water surface and habitat complexity. Surface tension, Structural and habitat complexity affords gerridae and velidae the ability to stride quickly on water and a diversity of habitat to occupy on the water surface (Kovalenko *et al*., 2012; Flores *et al*., 2016). Ikomi *et al*. (2005) reported the dominance of decapod species in the upper reaches of River Ethiope. This study corroborates their findings, however; Caridina sp. instead of Potamalpheops sp. is the only decapod recorded here. Their presence in this study can be explained by the high values of dissolved oxygen recorded here (0.8-60.40)mg/L. C. africana and other Atyidae abundance have shown positive correlation with dissolved oxygen concentration as well as high canopy coverage (Foto *et al*.,2013 and Tchakonte *et al*., 2014). According to Rogowski & Stewart (2016) Trichoptera particularly Hydropsychidae are especially low in running water with high temperature and good oxygen water quality as observed in our present study. Their low number therefore indicates a compromised aquatic system. Trichoptera abundance was low despite recording high temperature and dissolved oxygen. The reason for this low record indicts the open nature of the habitat in association with leaf litter from tropical trees result in relatively high temperature unacceptable to their survival

The present study identified few parameters influencing the macroinvertebrates population. In the order population score, the most abundant taxon Hemiptera was negatively influenced by acidity in Station 2 and also negatively in Station 1 correlation with only two parameters(acidity and TDS),the second had include Decapoda (positively with acidity) in station 3, Plectoptera also with acidity positively in station 2 while TDS influenced Coleoptera positively in station(Table 3). By interpretation, several factors marking sources of influence in the studied sites and the macroinvertebrates; acidity and pH (gas emission within Ebedei community) (Ramseur 2017); air temperature (whether), conductivity, alkalinity and TDS (ions and sum of ions from geological origin, soil, clay through mining) (Phyllis *et al*., 2007: Boyd *et al*., 2016); Chloride (human induced sewage, fertilizers (farm operations) (Hunt et al., 2012); phosphate (nutrients) (Belal *et al*., 2016). The present study, enlisted significant correlated variables with pronounced manifold hydrological factors pinpointing human disturbance as impact (Kim *et al*., 2016)).

Ghosh & Biswas (2015) reporting stated that diversity values of real communities fall within a range of values from 1.0-6.0, where values of 1 and below represent a polluted water bodies. Moderately polluted water bodies have values that are above 1 but less than 3, while non-polluted water bodies range from 3-6. Shannon's index of diversity of the studied portion of River Ethiope all fell had values below 3; hence it is safe to conclude that the studied portion of River Ethiope is moderately polluted or perturbed due to the effects of dredging, an allowable tradition.

Conclusion

Low fauna density, particularly the EPT group, high B.O.D and high nutrient levels recorded are all indications that Ethiope River is perturbed. The low density of Diptera bothers on the fast flowing nature of the river which prevents silts and debris which are important for the abundance of dipteran fauna to settle. It is therefore important that river remediation processes should be initiated in no distance future to prevent further decay of the river system.

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