

A bio- evaluation of the effects of anthropogenic activities around Oguta lake, south – east, Nigeria

Abstract

Oguta Lake serves for several beneficial human uses ranging from Agriculture, sand dredging, cassava fermentation, and washing. Despite these, the Lake receives anthropogenic inputs from the recent channeling of the community waste through erosion, which are capable of causing deteriorating effect on the biota and community at large. Thus the need to assess the likely effects of these wastes using the Macro-invertebrates assemblage to evaluate the habitat stability. Bi-monthly sampling of some physico- chemical parameters and Macro-invertebrates were carried out for three months. Temperature range between 27.00-29.50°C, Ammonia range between 0.32-0.91mg/l and Dissolved oxygen range between 4.60-10.00mg/l. *Chironomus sp* recorded the highest percentage abundance of 34.3%, while *Melanoides tuberculata*, *Sympetrum sp* and *Atoperla sp* have the least abundance. Also, *Chironomus sp* recorded the highest diversity index of 2.344 while Mayfly nymph recorded the least evenness of 0.818. The study revealed that all the physico- chemical parameters measure were within the allowable limit for Aquaculture excepts pH (5.83±0.09), Ammonia (0.63±0.04mg/L), and Total Suspended Solid (3.84±0.51mg/L), while the recorded low mean diversity index in the Macro- invertebrates could be as a result of high suspended solid capable of lowering the dissolve oxygen and also cause destruction of the Macro-invertebrates habitat, thereby making the habitat unstable.

Keywords: physico-chemical parameters, macro-invertebrates, anthropogenic activities, Oguta Lake, Nigeria

Volume 3 Issue 6 - 2019

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Received: November 25, 2019 | **Published:** December 17, 2019

Introduction

The availability of good water is an indispensable feature for preventing disease and improving quality of life, however, Pollution of water ways by organic discharges in Nigeria is presumably a serious threat posed to the Nigerian inland waters.¹ The notable point source arise from the dumping of untreated and partially treated sewage into the river,² brewery effluents into the river,³ discharge of biodegradable wood waste from sawmill located along the river,⁴ which are introduced into aquatic ecosystem as direct discharge from industrial plants or as surface run-off from municipal and Agricultural fields. These wastes cause ecological degradation with the attendant severe adverse consequence on the aquatic biota.¹ A short term exposure of benthic organism to water of poor quality causes an alteration in the community structure due to the elimination of sensitive species, hence the significant of bio-assessment as an evaluation of the condition of water body using biological surveys and other direct measurements of resistant biota in surface water.^{5,6} The concepts of assessment of Oguta Lake become ecological necessary due to the recent channeling of drainage canals in addition to increase irrigation farming along its bank. These can increase waste discharge into the lake which may likely have an adverse effect on the ecological stability of the lake. Though a lot of research have been done on its plankton species diversity,⁷ the origin and study area of Oguta Lake,⁸ heavy metals concentration in water and sediment,⁹ heavy metals in fish species and some physico-chemical parameters of Oguta Lake.¹⁰ But recently, few works is documented about its benthic Macro-invertebrates, thus the need for this research work in order to ascertain its purity level

as well as the composition, abundance and distribution of Macro-invertebrates of the lake.

Materials and methods

Description of the study

Oguta Lake is situated in Oguta local government Area of Imo State; it constitutes the largest natural lake in Imo State, South East Nigeria. It is located between latitude 5°42'24" N and longitude 6°47'33" E and has a maximum depth of 8m and a mean depth of 5.5 and water surface area that varies from 1.8km² in dry season to 2.5km² at the peak of the rainy season. The length of the shoreline is approximately 10km.¹¹ The region is located within the equatorial rain forest, with an average annual rainfall of 3,100mm. Oguta Lake increases in size during the rainy season when it receives overflow and floodwaters from its tributaries (Utu, Awbuna and Njaba River), although river Utu is seasonal, taking its source from river Orashi (an outlet of Oguta lake), and normally empties into Oguta during the high tide (Figure1). Oguta Lake drains into Orashi, a main river on the east- bank flood plain of the Niger and which conveys river Niger's flood waters directly into Niger delta.

Sample Collection and Analysis

Three (3) sampling stations based on anthropogenic activities around the Lake were selected for study. Bi-weekly samples were collected for the period of three months (July-September, 2019) between the hours of 08:00am-10:00am on sampling days. In-situ

measurement of temperature, current, and transparency was carried out using mercury-in-glass thermometer, floater, meter rule, stop watch, secchi disc according to.¹³ Surface water samples for chemical parameters were collected from all sampling stations in pre-sterilized 750ml plastic bottles and transported to the Department of Fisheries and Aquaculture Technology Laboratory, Federal University of Technology Owerri, for analysis.

Water samples for Dissolved Oxygen was collected and fixed immediately using Winkler’s solution A and B as described by Mackereth.¹³ Likewise sediment sample for benthic Macro-invertebrates was collected using kick method and Eckman grab respectively. Two to three hauls of the sediment was collected

using the grab and transferred into a pre-labeled polythene bag and transported to the Department of Fisheries and Aquaculture Technology laboratory, Federal University of Technology Owerri, for analysis. For kick method, the sediments was swept two to three times using a 1mm mesh hand net and transferred in to a bucket half filled with water and transported to the same laboratory for Identification. Water samples for physico-chemical parameters were analysis using a standard method,¹⁴ while the sediments samples were washed through a 0.595mm size sieve. The benthos was collected with forceps into the tray for further sorting, identification, counting and subsequent preservation with 10% formalin. Identification was done using identification guides of APHA/AWWA/WEF,¹⁵ and Hawkin.¹⁶

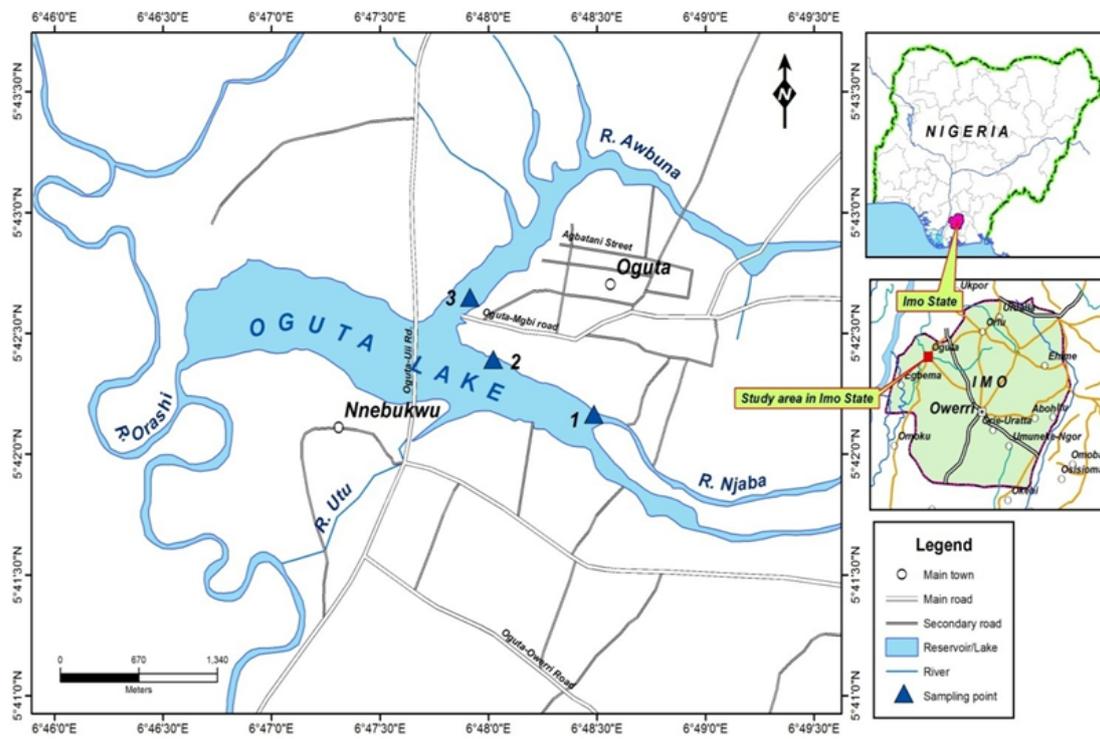


Figure 1 Map of Oguta Lake showing the sampling stations (Source: Cartographic unit, Department of Geography, University of Ibadan, Ibadan. February 2019).

Statistical analysis

Descriptive statistics and Duncan’s Multiple Range Test was used to separate the mean and to check the significant differences in each physico-chemical parameters. One way Analysis of variance (ANOVA) was used to compare the means of various parameters between months, when differences occur. Shannon- wiener (H), Margelef index (D), and evennes (J) was used to determine the species distribution, measure species richness and even distribution of the benthic Macro-invertebratess. Significant level was taken as P<0.05.

Results

Physico-chemical parameters

The results of the physico-chemical parameters of Oguta Lake in Oguta LGA of Imo State, Southeastern Nigeria measured across the sampling locations from July to September 2019 are shown in Tables 1&2, and Figures 2-6 respectively. The lake water was shown to be

slightly acidic in nature. Also, the ammonia concentration of the lake was shown to exceed the recommended limits, while the suspended matters were observed to be on the extreme (Table 1). Ammonia concentrations and the dissolved oxygen were only recorded to vary across the sampling stations (Table 2).

Macro-invertebrates fauna of Oguta Lake

The checklist of the identified Macro-invertebrates fauna in Oguta Lake during the study period is presented in Table 3. A total of 137organismsfrom two classes (Gastropoda and Insecta) in two phyla (phylum Mollusca and Arthropoda) were recorded (Table 4) in the lake. Gastropoda had 2species, while Insecta was represented by 8species. Class Insecta dominated the recorded Macro-invertebratess (Table 5) fauna, and constituted 97.8% of the total Macro-invertebratess populations, while Gastropoda was least abundant accounted for 2.2% of the entire population. The sensitive species was observed to recorded the highest abundance of sixty while tolerant specie had the least abundance of the encountered organism (Figure 7).

Table 1 Descriptive statistics of the Physico-chemical Parameters of Oguta Lake between July and September, 2019

Parameters	Range (Min.–Max.)	Mean±SE	NESREA (2011)	WHO (1998)
Temperature (OC)	27.00 - 29.50	28.00±0.20	A	30-32
Transparency (m)	0.40 - 2.25	1.15±0.11	NS	-
Current (m/s)	4.03 - 24.14	12.08±1.30	NS	-
pH	5.00 - 6.00	5.83±0.09	6.5-8.5	7.0-8.5
Alkalinity (mg/L)	36.00- 132.00	84.78±6.38	NS	-
Conductivity (µS/cm)	9.00 - 37.00	23.39±2.58	NS	≤1,000
Ammonia (mg/L)	0.32 - 0.91	0.63±0.04	<0.1	< 0.1
Total Dissolved Solid (mg/L)	5.00 - 12.00	7.56±0.49	NS	≤200.0
Total Suspended Solid (mg/L)	1.39 - 7.14	3.84±0.51	0.25	≤5.0
Nitrate-Nitrogen (mg/L)	0.05 - 0.05	0.05±0.00	9.1	≥10.0
Dissolved Oxygen(mg/L)	4.60 - 10.00	6.51±0.33	Not<6.0	≥5.0
Hardness (mg/L)	52.00 - 156.00	105.24±6.63	NS	-
Carbon IV Oxide (mg/L)	6.00 - 32.00	17.56±1.82	<20.0	-
Chloride (mg/L)	32.00 - 108.00	68.50±4.06	300	-

SE=standard error of mean, NS=Not Specified, and a³=except in mixing zones, temperature increase by a 7-Day Average of the Daily Maximum temperatures (7-DADMax) shall not be more than 0.3°C above natural background conditions

Table 2 Spatial variation in Physico-chemical parameters of Oguta Lake between July and September, (P<0.05)

Parameters	Stations		
	1	2	3
Temperature (°C)	28.08 ^a	27.92 ^a	28.00 ^a
Transparency (m)	1.29 ^a	1.07 ^a	1.10 ^a
Current (m/s)	10.88 ^a	12.25 ^a	13.12 ^a
Ph	6.00 ^a	5.83 ^a	5.67 ^a
Alkalinity (mg/L)	99.33 ^a	81.33 ^a	73.67 ^a
Conductivity	25.33 ^a	18.50 ^a	26.33 ^a
Ammonia (mg/L)	0.65 ^{ab}	0.51 ^b	0.73 ^a
Total Dissolved Solid (mg/L)	6.83 ^a	7.17 ^a	8.67 ^a
Total Suspended Solid (mg/L)	3.03 ^a	3.14 ^a	5.35 ^a
Nitrate-Nitrogen (mg/L)	0.05 ^a	0.05 ^a	0.05 ^a
Dissolved Oxygen (mg/L)	6.55 ^{ab}	7.57 ^a	5.40 ^b
Hardness (mg/L)	105.40 ^a	109.67 ^a	100.67 ^a
Carbon IV Oxide (mg/L)	18.00 ^a	14.83 ^a	19.83 ^a
Chloride (mg/L)	68.00 ^a	74.00 ^a	63.50 ^a

N.B: Values with the same superscript along same row are not significantly different at P<0.05

Table 3 Checklist of Benthic Macro-invertebrates taxa in Oguta Lake, Between July and September 2019

Phylum	Class	Order	Species
Mollusca	Gastropoda	Sorbeoconcha	Melanoides tuberculata***
		Basommatophora	Gabiella africana****
Arthropoda	Insecta	Diptera	Chironomus sp***
			Crane fly larvae**
			Mayfly nymph*
		Ephemeroptera	Dragonfly**
			Sympetrum sp**
		Coleoptera	Helophorus species*
Riffle beetle adult*			
Plecoptera	Atoperla sp*		

*=Sensitive/ Intolerant species, **=Moderately Intolerant species, ***=Fairly tolerant species, ****=Very tolerant species

Table 4 Relative Abundance of Macro-invertebrates taxa in Oguta Lake Between July and September 2019

Class/order	Species	Abundance			Total abundance	Percentage abundance (%)
		July	August	September		
GASTROPODA	Melanoidestuberculata	-	1	-	1	0.7
	Gabiellaaficana	2	-	-	2	1.5
Total		2	1	-	3	2.2
INSECTA-	Chironomussp	10	19	18	47	34.3
	Crane fly larvae	-	2	-	2	1.5
	Mayfly nymph	10	16	13	39	28.5
	Drangonfly nymph	8	10	6	24	17.5
	Sympetrumsp	-	1	-	1	0.7
	Helophorus sp	2	2	-	4	2.9
	Riffle beetle adult	4	8	4	16	11.7
	Atoperla sp	1	-	-	1	0.7
Total		35	58	41	134	97.8
Grand Total		37	59	41	137	100

Table 5 Diversity index of Benthic Macro-invertebrates in Oguta Lake during the study period

Taxa	H	D	E
Chironomus sp	2.344*	2.873	0.869
Mayfly nymph	2.284	0.919	0.818*
Drangonfly nymph	1.676	1.573	0.891
Gabiellaaficana	0.693	1.443	1
Riffle beetle adult	1.321	1.082	0.937
mean±SE	0.832	0.789	0.952

H=Shanon-Wiener’s index, D=Margalef index, and E=Evenness

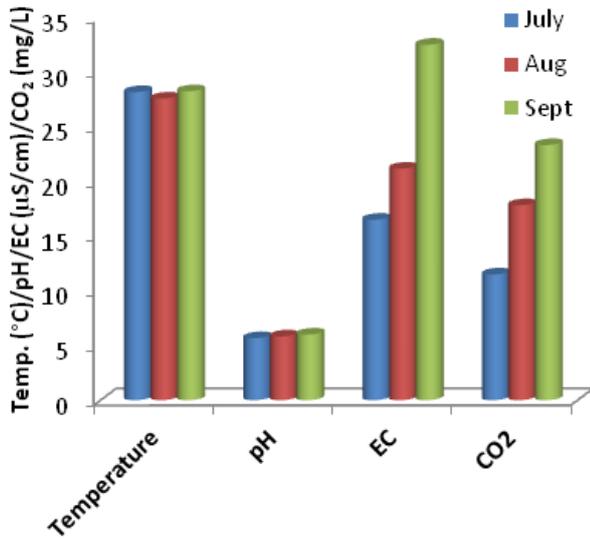


Figure 2 Temporal variations in mean water temperature, pH, Electrical conductivity and Dissolved CO₂ in the Oguta Lake.

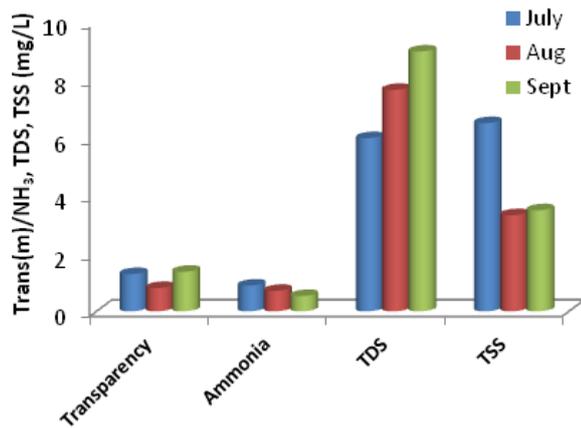


Figure 3 Temporal variations in mean Transparency, Ammonia, Total dissolved and suspended solids in the Oguta Lake.

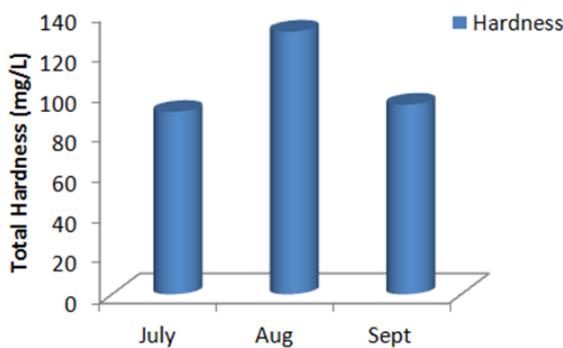


Figure 4 Temporal variations in mean Total Hardness in the Oguta Lake.

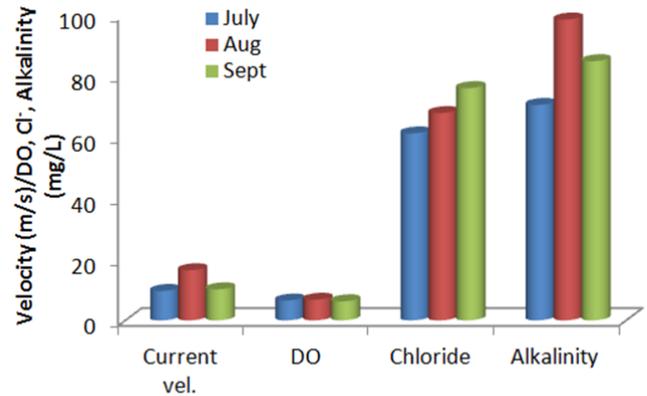


Figure 5 Temporal variations in mean current velocity, Dissolved oxygen, Chloride ions and Total alkalinity of the Oguta Lake.

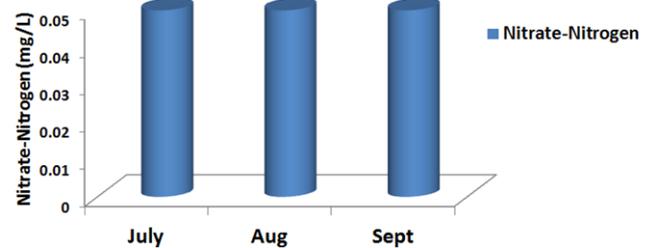


Figure 6 Temporal variations in mean Nitrate-Nitrogen in the Oguta Lake.

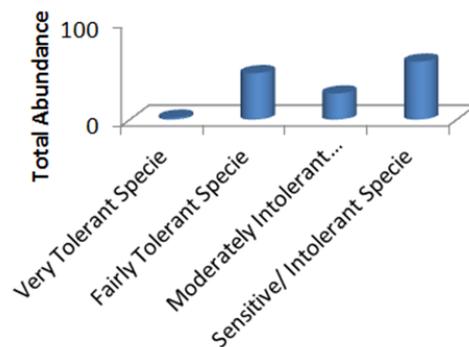


Figure 7 Variations in the indicator species of the Macro-invertebrates of Oguta Lake during the study period.

Macro-invertebrates diversity index

The results of the Macro-invertebrates diversity analysis are presented in Table 6 accordingly. Shannon-Weiner’s index (H) revealed *Chironomus* sp was observed to record higher diversity index (2.34) while Mayfly nymph was least evenly distributed (0.818). The spatial diversity indices for the Macro-invertebrates fauna recorded in the three sampling stations during the study period are presented in. Sampling station 2 recorded the highest diversity index (H=0.768) while station 1 recorded the least diversity index (H=0.399). Sampling

station 2 recorded the overall highest percentage abundance (77%), while station1 recorded the least abundance (15%). The general order of abundance of Macro- invertebrates across the sampling stations were 2>1>3 (Figure 8).

Table 6 Spatial Diversity indices of Benthic Macro-invertebrates in Oguta Lake during the study period

TAXA	Station 1			Station 2			Station 3		
	H	D	E	H	D	E	H	D	E
Chironomussp	0.9	0.961	0.82	1.706	1.47	0.918	1.082	0.962	0.984
Mayfly nymph	1.224	1.038	0.85	1.514	1.412	0.909	1.04	1.443	0.943
Drangonfly nymph	0	0	1	1.516	1.294	0.911	-	-	-
Gabiellaaficana	0	0	1	-	-	-	0	0	1
Riffle beetle adult	0.673	0.434	0.98	0.637	0.558	0.945	-	-	-
Mean	0.399	0.348	0.95	0.768	0.676	0.955	0.707	0.802	0.976

H=Shanon-Wiener's index, D=Margalef index, and E=Evenness

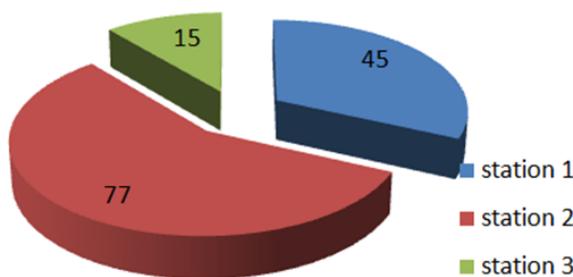


Figure 8 Spatial variation in macro- invertebrate composition and abundance.

Discussion and conclusion

Temperature is an important factor that influences primary production in lakes and it depends on the climate, sun light and depth.^{17,18} Aquatic organisms (from microorganisms to fish) depend on certain temperature range for optimal growth.¹⁴ The mean water temperature of 28.00°C±0.20 recorded in the present study falls within the water temperature in the tropics and the recommended limit for optimum fish growth, as earlier observed by Mustapha,¹⁹ and Usman.²⁰ The observed gradation in Oguta Lake surface water temperature is comparable to that of other fresh water bodies in Nigeria; Adebayo & Ayoade⁹ in Itapaji Reservoir, Edward and Ugwumba²¹ in Egbe Dam, where lower temperature during heavy rains is due to the influx of cooler freshwater and heavy cold cloud covers. Higher surface water temperature of the lake at the onset of the rainy season could be attributed to the solar radiation (insulation) and the reduced water depths a result of reduction in inflow.

The recorded variations in mean transparency values of Oguta Lake could be attributed to high water run-off into the lake. This probably

washed silts, sediments, debris, organic, inorganic and suspended particles into the water body, enhancing the total suspended solid of the lake; subsequently the light attenuation by the particles reduced the Secchi disc visibility that makes the water turbid. Similar observation was reported by Adebayo et al,²² Adebayo & Ayoade,⁹ Mustapha,¹⁹ Mustapha.²³ The authors opined that increased concentration of this parameters decreased light penetration into the water. Though turbidity is not necessarily harmful to fish, the resulting reduction of sunlight intensity in the water column decreases the primary productivity of water body thus, impacting negatively on the entire ecological trophic chains. Additionally, pollutants in turbid waters could be injurious to organisms once they gain entry into their bodies.

Low level of total dissolved solids could be probably due to higher activities of aerobic bacteria causing degradations of the eroded organic particles into the lake. This was further proven in the recorded excess load of total suspended solid of the lake.²⁴ The evidence could also be further confirmed as the station 1 has the least value of DO and it received the highest waste from the major tributaries of the lake. This has tendency of reducing the light penetration into the reservoir which may lead to a reduced photosynthesis and in turn reduce dissolved oxygen of the lake, with consequent effects on both phytoplankton and zooplankton populations of the aquatic environment. The recorded peak value in the TSS of the lake established that the solids originated from the erosion and runoff of the adjoining land. These factors combined could be responsible to the recorded low taxa and number of Macro-invertebrates fauna of the lake.

Habitat destruction due to settling of the recorded high total suspended solid might have influenced the overall composition and abundance of the benthic fauna of the Lake. These factors probably caused disruption of life cycle, reproductive cycle, food chain and migrations or imposed physiological stress on even the tolerant benthic Macro-invertebrates. This observation is not unusual with some earlier report^{22,25,26} in tropical waters. Furthermore, another factor that might be responsible for the recorded low taxa of benthos in the lake might be predators such as fish that exploit invertebrate. The highest diversity index in *Chironomus* sp could be as a result of their ability to utilize more oxygen due to their possession of the oxygen binder pigment- *Haemin* in their red blood cell. Conclusively, owing to the overall mean diversity index of 0.832, Oguta Lake is unstable,²⁷⁻²⁹ this could be linked to the resultant effects of the various organic

and inorganic wastes discharge ranging from municipal waste such as sewage waste, to household waste, and agricultural field run- offs into Oguta Lake that had influenced its physico- chemical parameters, and the diversity of macro- invertebrates. Thus concise efforts should be made by Government to restrict the populace on using water and water ways as their major mean of discharging wastes.^{30,31}

Acknowledgments

None.

Conflicts of interest

The authors declares that there is no conflict of interest.

Funding

None.

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