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Evaluation of some Physicochemical Parameters and Benthic Macroinvertebrates of Ikere Gorge Reservoir in Oyo State, Nigeria

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ABSTRACT: The physico-chemical parameters and benthic macroinvertebrates of Ikere Gorge Reservoir were studied to assess the impact of anthropogenic activities on this man-made lake by collecting surface water and benthic samples. Physico-chemical parameters were within the allowable limits of USEPA for fresh water bodies apart from conductivity (0.055 ± 0.002µS/cm) which was below standard. There were significant differences ($p<0.05$) in the mean values of DO, BOD, TDS, transparency, nitrate and sulphate between the sampling stations. A total of six genera (*Chironomus, Melanoides*, *Cloeon*, *Bulinus*, *Bellamya* and *Hirudo*) of benthic macro-invertebrates belonging to six orders (Diptera, Pelecypoda, Ephemeroptera, Heterobranchia, Caenogastropoa and Hirudinida) were recorded in the reservoir during the study. Pollution tolerant species including *Melanoides tuberculata* and *Chironomus* sp. dominated the benthic macroinvertebrates with a total number and percentage abundance of 674(56.88%) and 435(36.71%), respectively. Ikere Gorge Reservoir is relatively under stress due to dominance of indicators of pollution. © JASEM

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Keywords: Anthropogenic activities, Bioindicator, Ikere Gorge Reservoir, *Melanoides tuberculata*, Water quality.

All over the world, fresh water resources have been subjected to an increasing pollution load from contaminated runoff water originated from manmade activities like domestic and industrial (Banetti and Garrido, 2010). The adverse effects of human impacts on the aquatics include water – borne diseases, alteration of aquatic biota composition, eutrophication and reduction or destruction of ecosystem integrity (Sridhar *et al*., 1981; Egborge, 1991; Oduwole, 1997; Ekpo *et al*., 2012).

Biomonitoring programmes that employ indices and metrics of community structure (Udoidiong and King, 2000) had been used to assess the potential impacts or non-impacts of these alternations on the aquatic ecosystem. The richness of macroinvertebrate community composition in a water body can be used to provide an estimate of water body health (Argerich *et al*., 2004). The physical and chemical qualities of water and of substratum occupied by macro-invertebrates determine their occurrence and distribution (Danes and Hynes, 1980). Macro-invertebrates play an important role in aquatic community which includes mineralization, mixing of sediments and flux of oxygen into sediment, cycling of organic matter and also in assessing the quality of inland water (George *et al*., 2009). In Nigeria, several researchers have used the composition and distribution of macroinvertebrates to indicate the health status of water bodies (including Arimoro, 2007; Ayoade and Olusegun, 2012; Andem *et al*., 2013; Okoroafor *et al*., 2014), however there is paucity of data on the Ikere Gorge reservoir (the only manmade lake on Ogun River).

This study is designed to evaluate the physico-chemical parameters and benthic macroinvertebrates of Ikere Gorge Reservoir and this will provide information on the health status of this water body.

MATERIALS AND METHODS

Study Area: The Ikere Gorge Reservoir lies between longitudes 8°10′35″N and latitudes 3°44′11″E. It is a major earth-fill dam in Iseyin Local Government area of Oyo State in the South west of Nigeria on the Ogun River. Reservoir capacity is 690 million m^3 with surface area of 47 km^2. The reservoir was planned to generate 3750 MW of electricity, and to supply water to local communities and to Lagos and to irrigate 12,000 hectares of land. Neighboring communities depend on this reservoir for various purposes ranging from drinking water and fishing. The reservoir also receives effluents from neighboring communities in the form of domestic wastes waters from washing of clothes, sewage disposal and from non-point sources such as erosion and leaching of chemicals from nearby farm lands.

Three sampling stations were chosen for the study and human activities around these stations includes fishing, farming, washing of clothes and bathing

Determination of Physico-chemical parameters: Water samples were collected monthly (June 2014 - December 2014) from the three sampling stations with plastic containers washed with nitric acid to remove any form of contaminant (Boyd, 1990). The water samples collected were then taken to the laboratory and analyzed immediately. Surface water

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temperature was determined in-situ with a mercury-in-glass thermometer and transparency was determined using a Secchi disc. Other physico-chemical parameters were analysed with a Sper scientific water quality meter AF.33594. Spectophotometric screening according to APHA (2005) was used to determine nitrate, phosphate and sulphate.

Benthic Macro Invertebrates Sampling and Identification: A Van Veen Grab (15 cm×15 cm) was used to collect benthic macroinvertebrates. The sediment collected was emptied into a labelled polythene bag. The samples collected were sieved through a net with mesh size of 0.5 mm to eliminate the excess sediments. Organisms were sorted from the sediments and stored in vials containing 10% formalin solution. In the laboratory, organisms were identified using hand lens/microscope. Aquatic taxonomic keys (Pennak, 1978; Needham *et al*., 2000) were used to identify the collected specimens to species, or at least genus level.

Statistical Analysis: Duncan multiple comparison of mean was used to measure similarities of physico-chemical parameters between sampling stations. Paired t-test was used to determine difference between the seasons for physico–chemical parameters and benthic macroinvertebrates. Taxa richness, diversity and evenness indices were calculated (Margalef, 1949; Shannon and Weaver, 1949; Pielou, 1966). Principal component analysis was use to analyse the interaction between the physico–chemical parameters and benthic macro invertebrates.

RESULTS AND DISCUSSION

The mean Surface Water Temperature (SWT) of the reservoir was 26.91±1.71˚C and it did not differ significantly between stations Table 1. The SWT of wet season months (26.23 ± 1.41˚C) differed significantly from dry season months (28.63±0.77˚C) Table 2. The P^H of the reservoir ranged from 7.66 to 9.01 (8.30 ± 0.61) Table 1. The dry season months P^H (8.94 ± 0.93) was significantly higher than wet season (8.04 ± 0.51).

Table 1: Spatial Variation in the Physico-chemical Parameters of Ikere Gorge Reservoir

	Stations						
Parameters	1	2	3	Mean± SD	Range	US EPA	NESREA
Air Temperature (˚C)	24.50[a]	24.70[a]	24.70[a]	24.60±0.15	24.50-24.70	20-33	30-32
Surface Water Temperature(˚C)	27.00[a]	26.70[a]	27.10[a]	26.90±0.40	26.70-27.10	20-33	30-32
P^H	8.30[a]	8.33[a]	8.31[a]	8.30±0.14	8.30-8.33	6.5-8.5	6.5-9.0
Dissolved Oxygen (mg/L)	5.59[a]	5.36[b]	5.13[c]	5.36±0.29	5.13-5.59	≥4	≥5
Biochemical Oxygen Demand(mg/L)	1.23[a]	0.96[b]	0.67[c]	0.95±0.30	0.67-1.23	≤6.0	≤10
Conductivity (µS/cm)	0.056[a]	0.054[a]	0.054[a]	0.055±0.002	0.054-0.056	240	≤1000
Total Dissolved Solid (mg/L)	37.30[a]	35.60[b]	36.10[ab]	36.3±1.15	35.60-37.30	200	≤200
Transparency (m)	2.63[a]	1.75[b]	1.66[c]	2.01±0.55	1.66-2.63	-	-
Nitrate (mg/L)	0.29[a]	0.49[b]	0.28[a]	0.35±0.12	0.28-0.49	4.0	-
Sulphate (mg/L)	0.09[a]	0.139[b]	0.07[a]	0.10±0.036	0.09-0.139		
Phosphate (mg/L)	0.16[a]	0.15[a]	0.18[a]	0.16±0.024	0.15-0.18	3.5	-

The same alphabet in the same row is not significantly different (P< 0.05); USEPA: United State Environmental Protection Agency; NESREA: National Environmental Safety, Regulatory and Enforcement Agency

Table 2: Seasonal Variation in mean Physico-chemical characteristics (minimum and maximum in parentheses) of Ikere Gorge Reservoir, Southwestern Nigeria

Parameters	Rainy season months	Dry season months	t-test	Probability
Surface Water Temperature(˚C)	26.23 ± 0.36 (24 - 29)	28.63± 0.32 (27.3 – 29.3)	*0.001	p< 0.05
P^H	8.04 ± 0.13(7.43 – 8.89)	8.94 ± 0.038(8.82 – 9.1)	*0.000	p< 0.05
Dissolved Oxygen (mg/L)	5.47 ± 0.27(3.7 – 6.8)	5.07 ± 0.194(4.5 – 5.7)	0.370	p< 0.05
Biochemical Oxygen Demand(mg/L)	0.90 ± 0.09(0.4 – 1.9)	1.08 ± 0.09(0.8 – 1.4)	0.277	p< 0.05
Conductivity (µS/cm)	0.05±0.00(0.05 – 0.06)	0.06 ± 0.001(0.055 – 0.059)	*0.004	p< 0.05
Total Dissolved Solid (mg/L)	36.07 ± 0.36	37.00 ± 0.45	0.159	p< 0.05
Transparency (m)	2.01 ± 0.144	2.02 ± 0.19	0.962	p< 0.05
Nitrate (mg/L)	0.24 ± 0.04	0.64 ± 0.06	*0.000	p< 0.05
Sulphate (mg/L)	0.09 ± 0.014	0.14 ± 0.01	*0.026	p< 0.05
Phosphate (mg/L)	0.16 ± 0.05	0.17 ± 0.10	0.341	p< 0.05

***: significantly different at p< 0.05**

The mean DO was 5.36 ± 0.92 mg L^{-1} (4.9 to 6.63 mg/L) and it differed significantly between the stations. The mean BOD of Ikere Gorge Reservoir was 0.95±0.20 mg L^{-1} and it differed significantly between stations. Conductivity of the reservoir ranged from 0.053 to 0.056µS/cm (0.055 ± 0.001 µS cm^{-1}). The mean transparency (2.01±0.55m) of the reservoir differed significantly between stations. Nitrate concentration of Ikere Gorge Reservoir ranged from 0.100 mg L^{-1} to 0.702 mg L^{-1} (0.35±0.23 mg L^{-1}). The rainy season month concentration was significantly lower than dry season concentration (Table 2).

Sulphate concentration ranged from 0.054 mg L^{-1} to 0.146 mg L^{-1} (0.10 ± 0.04 mg L^{-1}) with the dry season months concentration being significantly higher than rainy season months. The monthly variation of phosphate ranged from 0.149 mg l^{-1} to 0.168 mg L^{-1} (0.16 ± 0.01 mgL^{-1}).

The mean surface water temperature, dissolved oxygen and pH were within the permissible limits of United State Environmental Protection Agency (USEPA) and National Environmental Standards and Regulatory Enforcement Agency (NESREA) standard for rivers/lakes. The mean temperature and pH values for the three sampling stations of Ikere gorge Reservoir studied were comparable with previous studies done on some selected water bodies in the south-western Nigeria (Etim and Adie, 2012). From the findings of the present study, the mean dissolved oxygen of the three sampling stations was not in accordance with studies of Yakub and Ugwumba (2009), who reported low DO in lower River Ogun caused by organic-rich abattoir effluents.

The BOD values of the three sampling stations of Ikere Gorge Reservoir were within the permissible limits of USEPA (≤6.0 mgl^{-1}) and NESREA (≤10) standards. The low mean BOD reported in this study can be attributed to the high flow rate of the reservoir and in such a way it is able to recover from organic load from external sources. Water with biochemical oxygen demand less than 4 mgl^{-1} are termed reasonably clean and unpolluted, while water with level greater than 10 mgl^{-1} are considered polluted since they contain large amount of degradable organic materials (Ohimain *et al*., 2008) . Conductivity was low and this can be attributed to the fact that the substratum of the reservoir comprises mainly of granite (Igneous rock) and granite is composed of more inert materials that do not ionize (dissolve into organic component) when washed into the reservoir. Boyd (1978) stated that natural water normally has conductivity ranges from 20-1500 μScm^{-1}. The result obtained in this study is contrary to a range of 13 - 31 μScm^{-1} in upper Ogun River observed by Adebisi, 1989.

The phosphate concentration of the Ikere gorge reservior was low as compared to the standard guidelines (USEPA, 2008). The result revealed that the nutrient load of Ikere Gorge Reservoir is low. Nitrate is a form of nitrogen and a vital nutrient for growth, reproduction, and the survival of organisms. High nitrate levels (>1 mg L^{-1}) are not good for aquatic life (Johnson *et al*., 2009).

Six benthic macroinvertebrates belonging to three phyla (Arthropoda, Mollusca and Annelida), three classes (Insecta, Gastropoda and Clitellata), six orders (Diptera, Pelecypoda, Ephemeroptera, Heterobranchia, Caenogastropoda and Hirudinida) and six genera (*Chironomus, Melanoides, Cloeon, Bulinus, Bellamya* and *Hirudo*) were recorded from Ikere Gorge Reservoir (Table 3).

Table 3: Checklist of Benthic Macro-invertebrates in Ikere Gorge Dam Reservoir, Iseyin

Phylum	Class	Order	Family	Genus	Species
Arthropoda	Insecta	Diptera	Chironomidae	*Chironomus*	
Arthropoda	Insecta	Ephemeroptera	Ephemeridae	*Cloeon*	*Dipterum*
Mollusca	Gastropoda	Pelecypoda	Thiaridae	*Melanoides*	*tuberculata*
Mollusca	Gastropoda	Heterobranchia	Planorbidae	*Bulinus*	
Mollusca	Gastropoda	Caenogastropoda	Viviparidae	*Bellamya*	*Unicolor*
Annelida	Clitellata	Hirudinida	Hirudinidae	*Hirudo*	

The wet season months recorded higher distribution of benthic macro invertebrates than the dry season months. *Melanoides tuberculata* and *Chironomus spp* were well distributed between seasons (Table 4)

Table 4: Seasonal Distribution of Benthic Macroinvertebrates of Ikere Gorge Reservoir.

	Number of Benthic Macroinvertebrates (Percentage of abundance)					
Season	*Chironomus spp*	*Melanoides tuberculata*	May fly Larvae (*Cloeon dipterum*)	*Bulinus* sp	Leech (*Hirudo species*)	*Bellamya unicolor*
Wet	262 (38.53%)	374 (55%)	4 (0.59%)	25 (3.68%)	1 (0.15%)	11 (1.62%)
Dry	173 (34.02%)	300 (59.06%)	5 (0.98%)	22 (4.33%)	2 (0.39%)	6 (1.18%)

Station 3 (57.55%) recorded the highest abundance of benthic macroinvertebrates and station 1(2.11%) recorded the least. The benthic macroinvertebrates with the highest percentage abundance was *Melanoides tuberculata* (56.88%) > *Chironomus* spp. (36.71%) > *Bulinus* sp. (3.97%) > *Bellamya unicolor* (1.43%) > *Cloeon dipterum* (0.76%) with *Hirudo* (0.25%) having the least (Table 5).

Table 5: Percentage Abundance of Benthic Macroinvertebrates in Different Sampling Stations of Ikere Gorge Reservoir.

	Number of Benthic Macroinvertebrates (Percentage abundance)						
Sampling Stations	***Chironomus* sp**	***Melanoides Tuberculata***	**May fly Larvae (*Cloeon dipterum*)**	***Bulinus* sp**	**Leech (*Hirudo species*)**	***Bellamya unicolor***	**Total**
Station 1	5 (20%)	0	0	20 (80%)	0	0	25(2.1%)
Station 2	173 (36.19%)	285 (59.62%)	1 (0.21%)	14 (2.93 %)	0	5 (1.05%)	478(40.3%)
Station 3	257 (37.68%)	389 (57.04%)	8 (1.17%)	13 (1.91%)	3 (0.44%)	12 (1.76%)	682(57.6%)
Total	435(37%)	674(57%)	9(0.76%)	47(3.97%)	3(0.25%)	17(1.43%)	1185

Spatial variation occurred in the diversity indices with Station 3 being highest in terms of species richness, followed by Station 2 and then Station 1 for the Margalef's and Shannon-Weiner indices. Station 1 had the highest species evenness 0.73 , while species in stations 2 and 3 were equally even (Table 6)

Table 6: Spatial variation in diversity indices of Benthic Macro-invertebrates of Ikere Gorge Reservoir, Iseyin Nigeria

Stations	Margalef's Index	Shannon-Wiener	Evenness
Station 1	1.43	0.22	0.73
Station 2	1.49	0.36	0.52
Station 3	1.76	0.40	0.52

From the Principal component analysis (Fig. 1) showing the interaction between physico-chemical parameters and benthic macroinvertebrates, it was observed that the distribution and abundance of some benthic macroinvertebrates such as Mayfly nymph (*Cloeon dipterum*), *Bulinus* sp., Leech (*Hirudo* species), and *Bellamya unicolor* were determined by changes in some physico-chemical parameters such as pH, DO, BOD, conductivity, transparency, nitrate, sulphate and phosphate. The abundance and distribution of *Chironomus* sp. and *Melanoides tuberculata* were independent of any physico-chemical parameter. Surface water temperature and TDS did not affect the distribution and abundance of any benthic macroinvertebrates.

From the present study, the low number of benthic macroinvertebrates encountered could be due to some ecological imbalance arising from alterations of some important factors (including water quality, immediate substrates for occupation and food availability) governing the abundance and distribution of the benthic communities(Andem *et al*., 2012). Similar results were obtained by Ogbeibu and Egborge(1995) in water bodies in the Okomu forest reserve (sanctuary) in southern Nigeria and they stated that high biodiversity is expected in ecosystems devoid of significant anthropogenic impacts. The occurrence and dominance of pollution tolerant species (*Melanoides tuberculata and Chironomus* larvae) in the study area suggests deterioration of water quality. *Chironomus* larvae are known to thrive in polluted environment probably due to possession of hemoglobin a pigment that transport and store dissolved oxygen (Tyokumbur *et al*., 2002). The presence of these indicator species suggests organic pollution from anthropogenic source.

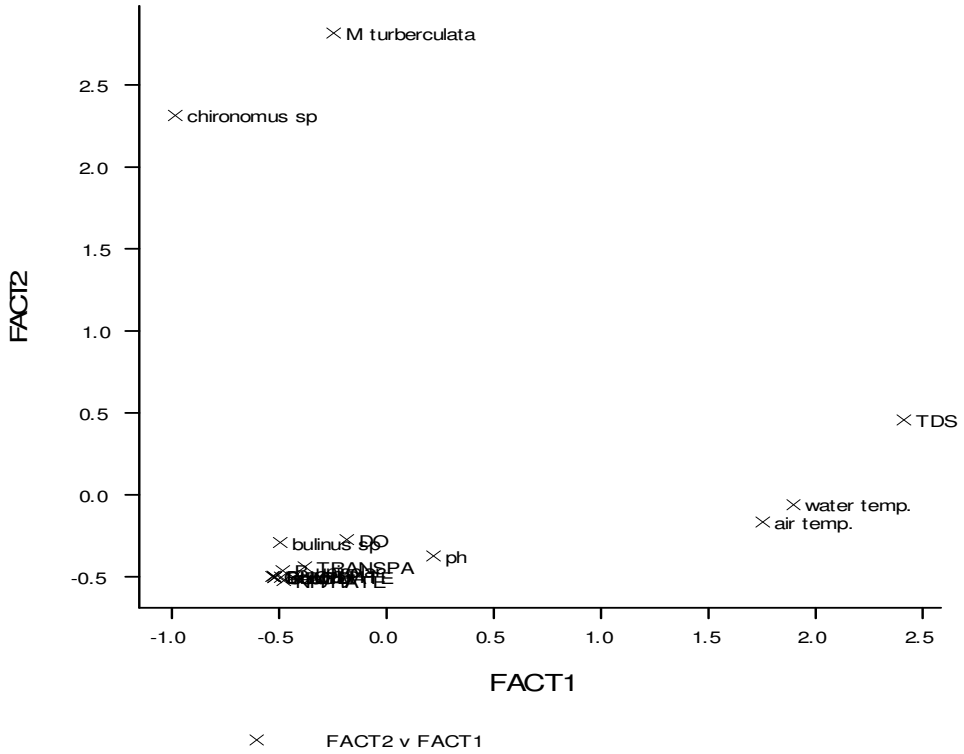

Fig 1: Principal component analysis (PCA) showing the interaction between Physico-chemical parameters and benthic macroinvertebrates of Ikere gorge Reservoir

*Conclusion***:** The physico-chemical parameters of Ikere Gorge Reservoir were within the allowable limits for fresh water bodies apart from conductivity which was below standard. The dominant benthic macroinvertebrates fauna of the reservoir recorded were pollution-tolerant species. The low number of benthic macroinvertebrates of Ikere Gorge Reservoir and the dominant species (*Melanoides tuberculata* and *Chironomus* sp.) being pollution tolerant suggest that the reservoir is relatively under stress. It is relatively polluted with organic pollutants from anthropogenic sources such as the surrounding communities and waterfront dwellers releasing raw human excreta, detergents, and wastewater and cleaning agents from the communities. Therefore regular assessment of the water quality is advised as to checkmate the increasing pollution trend.

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