



MACROINVERTEBRATE-BASED BIOMONITORING AND PHYSICO-CHEMICAL CHARACTERIZATION OF WATER QUALITY IN A TROPICAL RIVER SYSTEM: A CASE STUDY OF OLORI RIVER, SOUTHWESTERN NIGERIA

Adeleke S. O.¹; Amusan B. O.²; Adeosun O. J.^{2*}; Adeleke N. A.³; Okeowo O. P.⁴

¹*Department of Biology, Adeyemi Federal University of Education, Ondo State, Nigeria.*

²*Department of Zoology, Obafemi Awolowo University, Ile-Ife, Osun State, Nigeria.*

³*Department of Biology, Osun State University, Osogbo, Osun State, Nigeria.*

⁴*Salford Business School, University of Salford, United Kingdom*

Abstract

Assessment of freshwater ecosystems using biological indicators provides valuable insights into their ecological integrity and pollution status. This study evaluated the water quality and macroinvertebrate assemblages of Olori River, Oke-Igbo, Southwestern Nigeria, to determine the ecological condition of the river. Water and macroinvertebrate samples were collected bi-monthly from six sampling stations between December 2023 and October 2024. Physico-chemical parameters including temperature, dissolved oxygen (DO), pH, total dissolved solids (TDS), electrical conductivity (EC), and biological oxygen demand (BOD) were measured using standard methods. Macroinvertebrates were sampled using a D-frame net and direct hand-picking technique and preserved in 70% ethanol for identification. The results showed that most physico-chemical parameters did not vary significantly among sampling stations ($p > 0.05$), except for temperature. A total of 2,002 macroinvertebrate specimens belonging to 12 orders, 31 families, and 51 genera were recorded. *Melanoides* sp. was the most dominant species, while *Philaccolus* sp. was the least abundant. Station 1 exhibited the highest taxa richness and diversity indices, whereas the lowest diversity was observed in Station 6. The dominance of pollution-tolerant taxa, particularly dipterans and gastropods, alongside moderate BOD levels, suggests that Olori River is experiencing moderate anthropogenic pollution, likely from agricultural runoff and domestic waste inputs. Despite this, the presence of some pollution-sensitive taxa indicates localized areas of relatively good water quality. The study highlights the importance of integrating physico-chemical analysis with macroinvertebrate bioassessment for effective monitoring and management of freshwater ecosystems. Appropriate conservation and pollution control strategies are recommended to safeguard the ecological integrity and biodiversity of Olori River.

Keywords: Water Quality, Macroinvertebrate, River, Abundance, Diversity

*Correspondence email:
Adeosunolamide112@gmail.com
ORCID: 0000-0002-1096-7050

INTRODUCTION

A major concern in several regions of developing countries has been the contamination of water resources. Polluted waters pose serious risks to human health and the environment. The necessity of water in biota as the fulcrum of biological and chemical metabolism relies on its remarkable characteristics. Many developing countries have hugely suffered the opportunity to assess potable water brought about by factors such as human's expansion in population, industrialization, in-depth agricultural practices, discharge of enormous amount of toxic waste water and refuses into the lotic and lentic water and poor management (Adeyemo *et al.*, 2008). These anthropogenic impacts are responsible for the worsening status of water quality of many inland water waterbodies in developing countries. The pollution of inland waterbodies have not only deprived humans the access to potable water but it has led to a great reduction in the global aquatic biodiversity (Taiwo *et al.*, 2012).

Water quality plays a major role in the distribution range, composition, abundance and diversity of aquatic organism (Adebayo and Ayoade, 2019).

The exposure of aquatic organisms to polluted water may alter their community structure due to the elimination of intolerant species and proliferation of tolerant species (Adeogun and Fafioye, 2011). As such, monitoring of water quality is a basic tool in the management practices of inland water resources. Aquatic macroinvertebrates have been identified as useful indicators of water quality because they are important components of all aquatic ecosystem and they exhibit differential tolerance to environmental changes (Adu and Oyeniyi, 2019). The distribution of most aquatic macroinvertebrates is nevertheless thwarted by several biotic and physico-chemical factors occurring in both running and stagnant water ecosystem. As a result, they are known to be very intolerant to specific changes, such as nutrients enrichment or metal pollution. Some species are moderate in their sensitivity to contamination while others can withstand a wide range of pollution effects (Payakka and Prommi, 2014). The ability of most macroinvertebrates to reflect changes in their environment coupled with their high distribution has therefore significantly contributed to their enormous importance as a tool for monitoring the effects of anthropogenic impact on water quality. Furthermore, biological indicators such as

species abundance and diversity also help to provide a better understanding of the ecological status of waterbodies. As such, changes in the health of a waterbody will most likely result in changes in biological composition and structure of the waterbody.

The use of physico-chemical parameters in the assessment of water quality is also one of the traditional methods that have been commonly used. The reliability of this method is based on the fact that the composition and distribution of macroinvertebrates is influenced by the physico-chemical qualities of the substratum on which they are found. This implies that changes in the physico-chemical parameters of water may lead to distortions in biological activities, the transfer of energy and migration of certain species (Amusan & Balogun, 2019). Furthermore, the nature of the distribution of physico-chemical parameters of water provides first-hand information on the ecological processes and environmental variables that govern the populations and community structure of macroinvertebrates in a given waterbody (Kumar *et al.*, 2022). A more objective and widely acceptable approach in water quality protocols is one that combines physico-chemical and biological assessment. According to Camargo (1993), biological monitoring gives a better picture of pollution indication than the physico-chemical parameters of the water alone. However, a combination of

both the assessment of the physico-chemical parameters and bio-monitoring has provided more accurate information on the health status of waterbodies.

Olori River is one of the oldest and important waterbodies in the Southwestern Nigeria as it provides many essential benefits to the surrounding communities. The river supports municipal water supply, artisanal fishing, agricultural practices, recreational and domestic uses. In spite of these enormous benefits, the river is being constantly subjected to anthropogenic impacts which could potentially undermine the ecological integrity of the waterbody. Similarly important waterbodies around this part of the country have been assessed for their health and the ability to continue to support the ecological services which they provide. Such studies include; Adu and Oyeniyi (2019), Olusola (2020) and Onoyima and Ibraheem (2021) but no information is available on the assessment of the water quality of Olori River. Hence, this study which seeks to assess the water quality of the river using the physico-chemical parameters and macroinvertebrate assemblage as indicators of the overall ecological status of the waterbody. This will provide information about the water quality and pollution status of the river which will enable necessary management measures by the relevant stakeholders

MATERIALS AND METHODS

Study Area

This study was conducted on Olori River, one of the largest river in Oke-Igbo, Southwestern Nigeria. The river provides potable water and serves other axillary functions such as fishing, water for irrigation and recreation to the inhabitants of the community. Oke-Igbo is a town located in Ondo State, Southwestern Nigeria. It is situated within Ile-Oluji/Oke-igbo Local Government Area of Ondo State. Olori River lies between Latitude 07°04.532'N to 07°04.596'N and Longitude 004°49.362'E to 004°49.49'E and an average altitude of 761 amsl (Figure 1). Oke-Igbo area is characterized by gently sloping terrain and experiences tropical climate with two distinct seasons in the annual cycle; a wet season (April to October)

and a dry season (November to March). Fishing and farming are the major occupation of the residents of the community. The river basin is characterized by with tropical rainforest vegetation and notable trees and crops found around the basin include; *Bambusa sp.*, *Heliconia sp.*, *Raphia sp.*, *Tectona grandis*, *Theobroma cacao*, *Elaeis guineensis*, *Cocos nucifera* and *Nemphaea spp.* Cocoa is the major crop cultivated in the area but other important agricultural crops cultivated in the area include; Yam, Cassava and Palm Produce. Olori River flows all year round and the flow runs through almost the entire length of the town. Olori River is visibly impacted by varying degrees of anthropogenic and other stress factors such as run-off from agricultural lands, fishing and domestic sewage from homes.

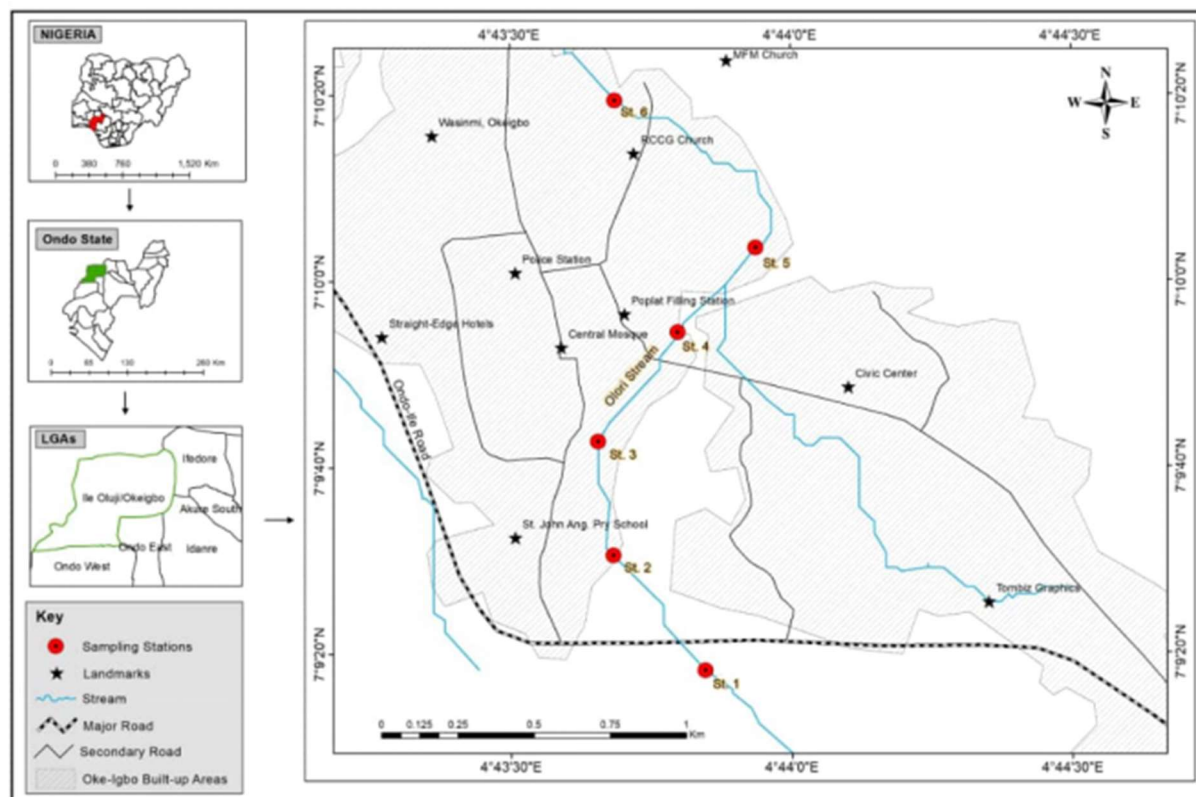


Figure 1: Map showing the sampling stations on Olori River, Oke-igbo, Southwestern Nigeria.

Sampling programme

Six sampling stations were chosen for the collection of water and macroinvertebrate samples. The selected sampling stations cover the various microhabitats and reaches of the river.

Samples were collected bimonthly, thus amounting to a total of 6 sampling periods between December, 2023 and October, 2024. The grid locations and other details about the sampling stations are as contained in Table 1.

Table 1: Some details about the sampling stations in Olori River, Southwestern Nigeria

Stations	Latitude (N)	Longitude (E)	Elevation (M)	Mean depth (M)	Site Description
1	07°04.532	004°49.362	814	0.1	Muddy, not transparent, vegetated and shaded
2	07°04.544	004°49.352	762	0-3	Sandy, forested, deep and shaded.
3	07°04.550	004°49.303	772	0.43	Pebbled, shallow, transparent, surrounded by bamboos.
4	07°04.567	004°49.280	740	0.3	Rocky, exposed, washing, farming and fewer vegetations
5	07°04.582	004°49.250	786	0.5	Sandy, near dumping site, vegetated, shallower and transparent.
6	07°04.596	004°49.49	693	0.6	Rocky, forested, near oil milling plant and liable to receive domestic wastes.

Collection of water samples

Surface water samples were collected in clean and sterilized 1L plastic bottles usually between the hours of 7:00 a.m. and 11:00 a.m. Temperature, Dissolved oxygen, pH, TDS, and Electrical conductivity were determined *in situ* using water analysis meters (Multifunction: pH-03/618/k13, TDS/EC: EZ-99001/986 and precision DO meter). The probes meant to determine respective parameter were inserted into a 250 ml conical flask containing about 20 ml of the water samples collected. The readings were taken three times in order to attain accuracy. Adequate precautions were taken on the water analysis kits before and after readings for each parameter. The water sample for the determination of BOD was collected in 300 ml amber bottles which were properly sealed and wrapped with foil paper. The water samples were kept in the dark cupboard for Biological Oxygen Demand (BOD₅). The BOD₅ was obtained by subtracting DO₁ from DO₅ ($DO_1 - DO_5 = BOD_5$).

Collection of macroinvertebrate samples

Macroinvertebrates were sampled across the six (6) sampling stations using appropriate methods for the collection of aquatic macroinvertebrates, including D-frame net made of 0.05 µm mesh-size net of 40 cm in diameter with an aluminum handle of about 1.5 m in length. Employing the standard techniques, the net was lowered to the margin of the river to scoop the substratum and the littoral vegetation in order to collect the adult and larvae attached to the riparian corridors. Direct search by hand picking was also employed where appropriate. The collected specimens were transferred into a well labeled specimen bottle and preserved in 70% ethanol. Following standard methods, each specimen bottle was emptied into a white tray and sorted based on their morphological resemblances for onward observation and

examination under the dissecting microscope. The specimens were identified to the lowest possible taxonomic level using standard keys and guides such as; Dickens and Graham (2002), Voshe (2002), Danladi *et al.* (2013) Orozco-Gonzalez and Ocasio-Torres (2023).

STATISTICAL ANALYSIS

All data were subjected for normality tests. The dataset showed normality distribution. The mean distribution for the physico-chemical parameters was determined for its significant differences using analysis of variance (ANOVA). Species abundance, taxa richness and species diversity were determined using Shannon Wiener, Simpson (1-D), Margalef and Evenness indices respectively. All statistical tests were carried out using Microsoft excel and PAST (Paleontological Statistical package, version 4.0).

RESULTS

Physico-chemical parameters

The mean values recorded for the physico-chemical parameters of Olori River is as presented in Table 2. Except for the water temperature, the variations in the values recorded for the physico-chemical parameters determined in this study did not show significant difference ($P > 0.05$). The mean temperature values range from 25.6 - 31.2 °C with the lowest mean value recorded in station 1 (27.4 ± 1.39) while the highest was in station 5 (29.9 ± 1.10). The Dissolved oxygen concentration values range from 5.7 - 7.8 mg/l with the lowest mean value (6.42 ± 0.50) recorded in station 2 while the highest was observed in stations 4 and 5 (6.83 ± 0.53). The mean values for pH, BOD, TDS and EC range from; 7.0 - 8.2, 1.4 - 3.2 mg/l, 48 - 77 mg/l and 68 - 90 µm/cm respectively. The lowest mean pH value recorded in station 6 (7.50 ± 0.09) while the highest was recorded in station 5 (7.83 ± 0.33). BOD, TDS and EC had their

lowest concentrations in stations 1 and 2 in stations 3, 6 and 5 respectively as shown in respectively while the highest were obtained Table 2.

Table 2: Mean ($\pm$ SE) results of the physico-chemical parameters of Olori River, Oke-Igbo, Southwestern Nigeria

Sites	Tem. $^{\circ}$ C	DO mg/l	pH	BOD mg/l	TDS mg/l	EC μ s/cm
Station 1	27.4 $\pm$ 1.39	6.8 $\pm$ 0.71	7.73 $\pm$ 0.35	2.02 $\pm$ 0.43	55 $\pm$ 5.85	76 $\pm$ 3.24
Station 2	28 $\pm$ 1.42	6.42 $\pm$ 0.50	7.63 $\pm$ 0.43	2.15 $\pm$ 0.27	50 $\pm$ 1.87	72 $\pm$ 4.80
Station 3	28.4 $\pm$ 1.20	6.47 $\pm$ 0.58	7.55 $\pm$ 0.10	2.55 $\pm$ 0.48	52 $\pm$ 3.16	77 $\pm$ 0.99
Station 4	28.4 $\pm$ 1.40	6.83 $\pm$ 0.58	7.58 $\pm$ 0.18	2.10 $\pm$ 0.32	54 $\pm$ 5.12	77 $\pm$ 5.82
Station 5	29.9 $\pm$ 1.10	6.83 $\pm$ 0.26	7.83 $\pm$ 0.33	2.47 $\pm$ 0.45	58 $\pm$ 3.14	80 $\pm$ 6.38
Station 6	30.3 $\pm$ 1.25	6.62 $\pm$ 0.46	7.50 $\pm$ 0.09	2.23 $\pm$ 0.48	63 $\pm$ 7.63	77 $\pm$ 10.27
Range	25.6 - 31.2	5.7 - 7.8	7.0 - 8.2	1.4 - 3.2	48 - 77	68 - 90
ANOVA: F P	7.213	1.253	0.533	0.3377	1.195	0.7305
	0.0002*	0.3097	0.7496	0.886	0.3357	0.6062
WHO, 2011	10 - 30	6 and above	6.5 - 8.5	0 - 4	0 - 600	0 - 1000
EPA, 2019	10 - 30	5 and above	6.5 - 8.5	0 - 5	0 - 500	0 - 1000
NESREA, 2011	10 - 30	5 and above	6.5 - 8.5	0 - 5	0 - 500	0 - 1000
NAFDAC, 2018	10 - 30	0 - 5	6.5 - 9.0	0 - 5	0 - 500	0 - 1000

Significant level, $p < 0.05^*$; 0.01^{**} ; 0.001^{***}

Taxonomic composition of macroinvertebrates

The taxonomic composition, abundance and percentage distribution of aquatic macroinvertebrates recorded in this study are as presented in Table 3. A total of 2,002 specimens of aquatic macroinvertebrates were recorded in Olori River. The macroinvertebrates recorded are distributed into 12 orders, 31 families and 51 genera. *Melanoides* sp. (Thiaridae) was the most abundant species as it accounted for about 29.27% of the entire macroinvertebrate collection. This was closely followed by the *Orectogyrus* sp (Gyrinidae) which accounted for 26.12% of the macroinvertebrates while the least abundant species was *Philaccolus* sp. (Dytiscidae) which accounted for 0.05% of the total collection. Other species that occurred with low abundance are *Laccotrephes* sp (0.05%), *Sapho ciliate* (0.05%), *Microgomphus* sp (0.05%) and *Neurogomphus* sp (0.05%) and *Zygonyx* sp (0.05%). The relative abundance based on the Orders of macroinvertebrates recorded in this study is as shown in Figure 2. Hemiptera was the order with the highest abundance as it accounted for 29.27% while Odonata had 26.77% but Lymnaeida was the least order with 0.20%. The spatial distribution of macroinvertebrates recorded in this study is

presented in Table 4. It is quite interesting to note that some species were recorded in just one station while some were recorded in all the six stations. For instance, the following macroinvertebrates were recorded in station 1 only; *artherix* sp, *Adenophlebiodes* sp, *Laccotrephes* sp, *Sapho ciliate*, *Chlorocypha selysi*, *Pseudagrion hamoni*, *Ictinogomphus ferox*, *Neurogomphus* sp and *Palpopleura lucia*. The following macroinvertebrates were recorded in station 2: *Philaccolus* sp, *Chironomus* sp, and *Zygonyx* sp. while *Limnogonus* sp, *Rhagadotarsus* sp and *Microgomphus* sp were recorded in station 4 only. *Melanoides tuberculata*, *Orectogyrus* sp, *Pseudagrion* sp, and *Lestinogomphus* sp were recorded in all the sampling stations.

The species diversity across the sampling stations is as presented in Table 5. Station 1 was the most diverse station as indicated the diversity indices which all had their highest values recorded for station 1 (Simpson - 0.83; Shannon-weiner - 2.58; Margalef - 6.57). The least diverse station was station 6 with the least values of diversity indices recorded for the station ((Simpson - 0.56; Shannon-weiner - 1.08; Margalef - 2.01). Taxa richness was highest in station 1 (40) while the lowest was recorded in station 6 (12).

Table 3: Taxonomic composition and abundance of macroinvertebrates in Olori River, Southwestern Nigeria.

Order	Family	Genus	No. of Individual	Percentage (%)
Opisthopora	Lumbricidae	<i>Lumbricus sp</i>	8	0.40
Unionidea	Iridinida	<i>Aspatharia sp</i>	25	1.25
Architaenioglossa	Ampullaridae	<i>Lanistes sp</i>	27	1.35
Lymnaeida	Planorbidae	<i>Bulinus sp</i>	4	0.20
Sorbeoconcha	Thiaridae	<i>Melanoides sp</i>	586	29.27
Decapoda	Potamonautidae	<i>Sudanonautes sp</i>	28	1.40
Araneae	Pisauridae	<i>Dolomedes sp</i>	14	0.70
Coleoptera	Dytiscidae	<i>Laccophilus sp</i>	2	0.10
		<i>Philaccolus sp</i>	1	0.05
	Gyrinidae	<i>Orectogyrus sp</i>	523	26.12
	Hydrophilidae	<i>Amphiops sp</i>	4	0.20
		<i>Helochares sp</i>	4	0.20
	Limnichidae	<i>Afrolimnichus sp</i>	2	0.10
Diptera	Athericidae	<i>Atherix sp</i>	2	0.10
	Chironomidae	<i>Chironomus sp</i>	2	0.10
	Limoniidae	<i>Hexatoma sp</i>	2	0.10
Ephemeroptera	Heptageniidae	<i>Notonurus sp</i>	11	0.55
	Leptophlebiidae	<i>Adenophlebiodes sp</i>	5	0.30
Hemiptera	Belostomatidae	<i>Sphaerodema sp</i>	33	1.65
	Hydrometridae	<i>Hydrometra sp</i>	10	0.50
	Naucoridae	<i>Neomacrocoris sp</i>	5	0.30
	Nepidae	<i>Laccotrephes sp</i>	1	0.05
		<i>Ranatra sp</i>	9	0.45
	Gerridae	<i>Eurymetra Africana</i>	22	1.10
		<i>Eurymetra natalensis</i>	16	0.80
		<i>Eurymetropsiella schoutedeni</i>	4	0.20
		<i>Limnogonus sp</i>	2	0.10
		<i>Rhagadotarsus sp</i>	2	0.10
		<i>Tenagogonus sp</i>	6	0.30
	Mesovelidae	<i>Mesovelis sp</i>	2	0.20
	Veliidae	<i>Rhagovelia sp</i>	402	20.08
Odonata	Calopterigidae	<i>Sapho ciliate</i>	1	0.05
	Chlorocyphidae	<i>Chlorocypha sp</i>	3	0.15
		<i>Chlorocypha selysi</i>	8	0.40
	Coenagrionidae	<i>Pseudagrion hamoni</i>	2	0.10
		<i>Pseudagrion sp</i>	65	3.25
	Platycnemididae	<i>Agriocnemis machlachlani</i>	7	0.35
		<i>Mesocnemis singularis</i>	5	0.30
	Gomphidae	<i>Lestinogomphus sp</i>	58	2.90
		<i>Ictinogomphus ferox</i>	4	0.20

		<i>Microgomphus sp</i>	1	0.05
		<i>Neurogomphus sp</i>	1	0.05
		<i>Paragomphus genei</i>	12	0.60
		<i>Phyllogomphus sp</i>	2	0.10
	Macromiidae	<i>Phyllomacromia sp</i>	10	0.50
	Libellulidae	<i>Orthetrum sp</i>	33	1.65
		<i>Palpopleura lucia</i>	8	0.40
		<i>Trithemis arteriosa</i>	5	0.30
		<i>Trithemis sp</i>	9	0.45
		<i>Zygonoides sp</i>	3	0.15
		<i>Zygonyx sp</i>	1	0.05
Total = 12 orders	31 families	51 genera	2,002	100

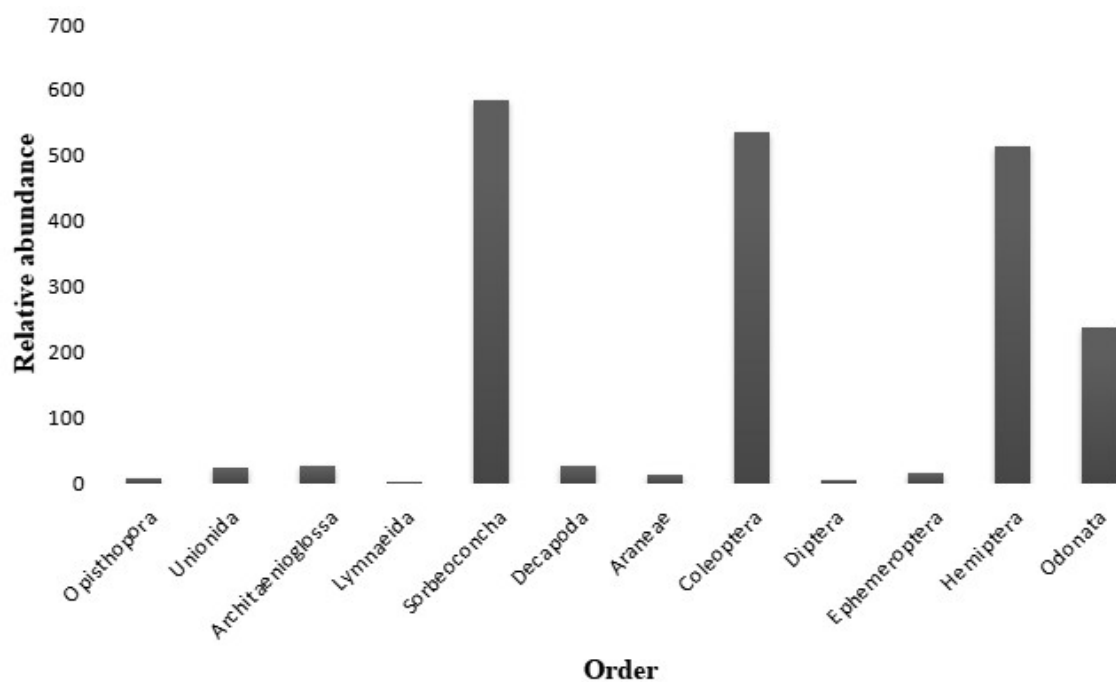


Figure 2: Relative abundance of aquatic macroinvertebrates (Order) in Olori River, Oke-Igbo, Southwestern Nigeria.

Table 4: Spatial Distribution of Macroinvertebrates in Olori River, Oke-Igbo, Southwestern Nigeria.

GENUS/SPECIES	Station 1	Station 2	Station 3	Station 4	Station 5	Station 6	Total
<i>Lumbricus</i> sp.	3	1	1	2	1	0	8
<i>Aspatharia dahomeyensis</i>	3	13	4	3	0	2	25
<i>Lanistes varicus</i>	11	6	7	2	1	0	27
<i>Bulinus</i> sp.	1	2	0	1	0	0	4
<i>Melanoides tuberculata</i>	137	68	96	84	106	95	586
<i>Sudanonautes</i> sp.	11	1	10	0	5	1	28
<i>Dolomedes</i> sp.	2	5	3	2	1	1	14
<i>Laccophilus</i> sp.	1	1	0	0	0	0	2
<i>Philaccolus</i> sp.	0	1	0	0	0	0	1
<i>Orectogyrus</i> sp.	7	197	95	55	43	126	523
<i>Amphiops</i> sp.	1	0	2	1	0	0	4
<i>Helochaeres</i> sp.	1	1	2	0	0	0	4
<i>Afrolimnichus</i> sp.	1	1	0	0	0	0	2
<i>Atherix</i> sp.	2	0	0	0	0	0	2
<i>Chironomus</i> sp.	0	2	0	0	0	0	2
<i>Hexatoma</i> sp.	0	1	0	0	1	0	2
<i>Notonurus</i> sp.	5	2	2	2	0	0	11
<i>Adenophlebiodes</i> sp.	5	0	0	0	0	0	5
<i>Sphaerodema</i> sp.	19	5	7	1	1	0	433
<i>Hydrometra</i> sp.	0	4	6	0	0	0	10
<i>Neomacrocoris</i> sp.	1	3	1	0	0	0	5
<i>Laccotrephes</i> sp.	1	0	0	0	0	0	1
<i>Ranatra</i> sp.	1	2	5	1	0	0	9
<i>Eurymetra Africana</i>	7	11	1	1	0	2	22
<i>Eurymetra natalensis</i>	7	4	0	0	2	3	16
<i>Eurymetropsiella schoutedeni</i>	0	0	0	1	0	3	4
<i>Limnogonus</i> sp.	0	0	0	2	0	0	2
<i>Rhagadotarsus</i> sp.	0	0	0	2	0	0	2
<i>Tenagogonus albovittatus</i>	2	4	0	0	0	0	6
<i>Mesovelgia</i> sp.	0	1	0	0	1	0	2
<i>Rhagovelgia</i> sp.	59	170	79	11	83	0	402
<i>Sapho ciliate</i>	1	0	0	0	0	0	1
<i>Chlorocypha</i> sp.	1	0	0	0	2	0	3
<i>Chlorocypha selysi</i>	8	0	0	0	0	0	8
<i>Pseudagrion hamoni</i>	2	0	0	0	0	0	2
<i>Pseudagrion</i> sp.	8	10	16	22	6	3	65
<i>Agriocnemis machlaclani</i>	1	1	2	2	0	1	7
<i>Mesocnemis singularis</i>	2	1	2	0	0	0	5

<i>Lestinogomphus</i> sp.	17	24	9	6	1	1	58
<i>Ictinogomphus ferox</i>	4	0	0	0	0	0	4
<i>Microgomphus</i> sp.	0	0	0	1	0	0	1
<i>Neurogomphus</i> sp.	1	0	0	0	0	0	1
<i>Paragomphus genei</i>	1	4	1	6	0	0	12
<i>Phyllogomphus</i> sp.	1	1	0	0	0	0	2
<i>Phyllomacromia</i> sp.	5	1	1	2	1	0	10
<i>Orthetrum</i> sp.	21	5	3	4	0	0	33
<i>Palpopleura lucia</i>	8	0	0	0	0	0	8
<i>Trithemis arteriosa</i>	5	0	0	0	0	0	5
<i>Trithemis arteriosa</i>	2	1	2	3	0	1	9
<i>Zygonoidea</i> sp.	0	0	1	1	1	0	3
<i>Zygonyx</i> sp.	0	1	0	0	0	0	1
Total	376	555	358	218	256	239	2002

Table 5: Diversity of Macroinvertebrates in Olori River, Oke-Igbo Southwestern Nigeria.

Diversity Indices	Station 1	Station 2	Station 3	Station 4	Station 5	Station 6
Taxa Richness	40	34	25	25	16	12
Taxa Abundance	376	555	358	218	256	239
Dominance	0.1682	0.2373	0.1939	0.2244	0.3032	0.4343
Simpson Index	0.8318	0.7627	0.8061	0.7756	0.6968	0.5657
Shannon Index	2.58	1.978	2.088	2.083	1.495	1.087
Evenness	0.33	0.2126	0.3228	0.3212	0.2787	0.247
Margalef Index	6.577	5.222	4.081	4.457	2.705	2.009

DISCUSSION

Physico-chemical parameters

The physico-chemical properties of water are crucial for both living organisms and environmental processes. They determine water's ability to act as a solvent, regulate temperature, participate in chemical reactions, and influence the behavior of other substances. As such, the understanding of these properties is essential for assessing water quality, managing resources, and

addressing environmental challenges. The levels of the physico-chemical parameters of Olori River compares favourably with those of similar waterbodies in this region. Such studies in which similar levels of physico-chemical parameters have been reported include; Adu *et al.* (2019), Amusan and Balogun (2019), Komolafe and Imobe (2022) and Adeleke and Amusan (2024). Furthermore, the values of physico-chemical parameters recorded in this study fell within

the range recommended by standards for water quality such as; NESREA (2011), NAFDAC (2018) and EPA (2019). Although, there were variations in the concentrations of the parameters, but the variations were not statistically significant ($p > 0.05$) except for water temperature which varied across the sampling stations significantly ($p < 0.05$). Temperature is known to be a fundamental property of water like other environmental variables and it influences the distribution of other physico-chemical parameters such as Dissolved oxygen (DO), pH and Electrical conductivity. Infact, McCaffrey (2018) reported that water at 0°C will retain up to 14.6 mg/l⁻¹ of oxygen while at 30°C it will hold about 7.6 mg/l⁻¹. This described the relationship between temperature and DO. The significant variation in the water temperature observed in this study may be attributed to variations in the vegetation cover along the river stretch. For instance, station 1 was characterized by abundance of riparian vegetation with canopy cover which provided shade for the water and this may account for the low temperature around the sampling station.

The pH is a measure of the rate of acidity or alkalinity of water. The pH value below 7 is acidic, and value above 7 is alkaline (Ben-Chioma *et al.*, 2015). High pH can minimize the effectiveness of chlorine disinfection, potentially permitting toxic microscopic organisms such as bacteria and viruses to thrive. The non-significant variation observed in the pH values recorded for the sampling stations indicated that there is high buffering capacity which may cause the water to resist changes. The insignificant variations in the pH values could also be as a result of consistent introduction of pollution loads to the various sampling stations ((Khaliq *et al.*, 2024). Dissolved oxygen (DO) levels recorded across the sampling stations suggested effective aeration in the river and a

fairly good level for aquatic life. The level of Dissolved oxygen also suggested minimal organic pollution in the river, as excessive organic matter can potentially deplete oxygen level during decomposition (Edegbene and Arimoro 2012). The Biological oxygen demand (BOD) values recorded in this study suggested moderate pollution in the water. According to Adakole and Anune (2003)'s classification of rivers with respect to BOD values, rivers were classified as follows; unpolluted ($BOD < 1.0 \text{ mg l}^{-1}$), moderately polluted (BOD between 2 and 9 mg l^{-1}) and heavily polluted ($BOD > 10 \text{ mg l}^{-1}$). The moderate pollution in Olori River may be traceable to agricultural run offs and domestic sewage.

Macroinvertebrates Composition

Most of the aquatic macroinvertebrate groups recorded in this study have been earlier reported to be widely distributed in tropical inland waters (Rotimi and Iloba, 2002; Edegbene and Arimoro, 2012; Amusan, 2023). Based on the richness and diversity of species recorded in this study, Olori River can be considered to be fairly rich in terms of macroinvertebrate taxa composition and the assemblages compares favourably with similar waterbodies in this region (Kamtambe *et al.*, 2019; Amusan, 2023). The abundance and diversity of macroinvertebrate species in Olori River may be attributed to the presence of diverse habitats and adequate food sources ((Balázs, *et al.*, 2022). The dominance of *Melanoides sp* is not suprising as this species have been reported to be dominant in many waterbodies in Nigeria. The abundance and dominance of this species in many waters have been attributed to its ecological flexibility, as the species is known to have the ability to tolerate a range of water quality conditions, thus making them well-suited to various aquatic environments (Vogler *et al.*, 2012; Balázs, *et al.*, 2022). The muddy nature

of the river substrate is another factor that could account for the abundance of the *Melanoides* sp in Olori River as *Melanoides* sp have been reported to have preference for muddy substrates (Ben-Ami and Heller, 2005; Raw *et al.*, 2016). Hence, Olori stream provided enabling environment for *Melanoides* sp.

Odonata is another group that occurred with high abundance and diversity in this study. The dominance of the Odonata have been attributed to their preference for areas with diverse vegetation and other features that provide shelter and suitable breeding grounds (Adu *et al.* 2019). Odonates are also known to have the ability to tolerate a wide pH range and they also thrive in area with abundant nutrients. Most of the Odonata species recorded in this study are referred to as generalists which have been reported to be commonly found in and around aquatic environment. Although, two species of Ephemeroptera, which is a sensitive insect order was recorded in this study. The occurrence of these sensitive insect species may possibly indicate the presence of localized areas with better water quality in the river (Agra *et al.*, 2021; Amusan, 2023).

However, the occurrence of Dipterans in this study was an indication of elements of pollution in the water. The members of the Order; *Atherix* sp., *Chironomus* sp. and *Limoniidae* sp. recorded in this study are all known to be tolerant of pollution and can survive in aquatic environments with low level of dissolved oxygen (Solimini *et al.*, 2003). Furthermore, their presence could be an indication of point source pollution due to influx of domestic sewage into the river. This group of macroinvertebrates are also known to thrive in water with elevated temperature which can accelerate their development and reproduction. Availability of food is another important factor that favours the abundance of this tolerant group of organisms. Dipterans

feed on a variety of food sources, including algae, detritus and small invertebrates and all these food sources were found in abundance in the study area.

The diversity indices obtained for the sampling stations also suggested Olori River as a fairly diverse and moderately polluted freshwater ecosystem as at the time this study was conducted.

CONCLUSION

The combined assessment of physico-chemical parameters and macroinvertebrate assemblages revealed that Olori River is a moderately impacted freshwater system. Although most physicochemical parameters fell within acceptable limits and the river supported relatively high macroinvertebrate diversity, the dominance of pollution-tolerant taxa and the presence of dipteran species indicate increasing anthropogenic pressure on the waterbody. Agricultural runoff, domestic sewage, and other human activities within the river basin are likely contributors to the observed ecological conditions. Continuous monitoring and the implementation of effective management and conservation strategies are therefore essential to prevent further degradation, maintain water quality, and preserve the biodiversity and ecological services provided by Olori River.

ACKNOWLEDGEMENTS

The authors gratefully acknowledges Prof. E. O. Akindele for granting access to his laboratory equipments and Dr. Adedapo Matthew Abiodun for assistance with specimen identification. Appreciation is also extended to all team members for their support during field sampling and laboratory work.

Funding: This is Self-sponsored research

Conflict of Interest: The authors declare that there is no conflict of interest regarding the publication of this paper.

REFERENCES

- Agra, J., Ligeiro, R., Heino, J., Macedo, D.R., Castro, D.M.P., Linares, M.S., et al. (2021). Anthropogenic disturbances alter the relationships between environmental heterogeneity and biodiversity of stream insects. *Ecological Indicators*, 121(2): 107079. DOI:10.1016/j.ecolind.2020.107079
- Amusan, B.O. (2023). Ecological assessment of a tropical river using aquatic insects assemblage and water quality as indicators. *Entomology and Applied Science Letters*, 10(3): 1-9.
- Arimoro, F.O. and Ikomi, R.B. (2009). Ecological integrity of Upper Warri River, Niger Delta using aquatic insects as bioindicators. *Ecological Indicators*, 9(3): 455-461.
- Arimoro, F.O., Ikomi, R.B. and Iwegbue, C.M.A. (2007). Water quality changes in relation to Diptera community patterns and diversity measured at an organic effluent impacted stream in the Niger Delta, Nigeria. *Ecological Indicators*, 7(6): 1-552.
- Balázs, A., Šipoš, J., Matúšová, Z., Hamerlík, L., Novíkmec, M. and Svitok, M. (2022). Comparison of conservation values among man-made aquatic habitats using Odonata communities in Slovakia. *Biologia*, 77(9): 2549-2561.
- Ben-Ami, F. and Heller, J. (2005). Spatial and temporal patterns of parthenogenesis and parasitism in the freshwater snail *Melanoides tuberculata*. *Journal of Evolutionary Biology*, 18(1): 138-146.
- Ben-Chioma, A.E., Jack, A.S. and Philipokere, G.K. (2015). A comparative study on the measurement of pH of water, using pH meter and water testing kit [test-tube method] in Port Harcourt. *Hard-International Journal of Applied Chemistry*, 1(3): 1-6.
- Berry, A.J. and Kadri, A.B.H. (1973). Reproduction in Malayan freshwater cerithiacean gastropod *Melanoides tuberculata*. *Journal of Zoology*, 172(3): 369-381.
- Chieshire, K., Boyero, L. and Pearson, R.G. (2005). Food in tropical Australian streams: shredders are not scarce. *Freshwater Biology*, 50(4): 748-769.
- Edegbene, A.O. and Arimoro, F.O. (2012). Ecological status of Owan River, Southern Nigeria using aquatic insects as bioindicators. *Journal of Aquatic Sciences*, 27(2): 99-111.
- Edema, C.U., Ayeni, J.O. and Aruoture, A. (2002). Some observations on the zooplankton and macrobenthos of the Okhuo River, Nigeria. *Journal of Aquatic Science*, 17(2): 145-149.
- Ikomi, R.B., Arimoro, F.O. and Odihirin, O.K. (2005). Composition, distribution and abundance of macroinvertebrates of the upper reaches of River Ethiope, Delta State. *The Zoologist*, 3: 68-81.
- Kamtambe, K., Banda, J., Kaphuka, B. and Msiska, O.V. (2019). The abundance, distribution and diversity of benthic invertebrates of Lake Malombe. *International Journal of Fisheries and Aquaculture*, 11(2): 13-22.
- Lenat, D.R., Smock, L.A. and Penrose, D.L. (1980). Use of benthic macroinvertebrates as indicators of environmental quality. In: *Biological Monitoring for Environmental Effects*. Lexington Books, Toronto, Canada. pp. 7-114.

- Merritt, R.W. and Cummins, K.W.** (1996). *An Introduction to the Aquatic Insects of North America* (3rd ed.). Kendall-Hunt, Dubuque. 862pp.
- Nelson, S.M. and Roline, R.A.** (2003). Effects of multiple stressors on the hyporheic invertebrates in a lotic system. *Ecological Indicators*, 13: 65-79.
- Ogbeibu, A.E. and Oribhabor, B.J.** (2002). Ecological impact of river impoundment using benthic macroinvertebrates as indicators. *Water Research*, 36(10): 2427-2436.
- Olumukoro, J.O. and Egborge, A.B.M.** (2004). Hydrobiological studies of Warri River. Part II: seasonal trend in the physicochemical limnology. *Tropical Freshwater Biology*, 12: 9-23.
- Raw, J.L., Perissinotto, R., Miranda, N.A.F. and Peer, N.** (2016). Feeding dynamics of *Melanoides tuberculata* (Müller, 1774). *Journal of Molluscan Studies*, 82(2): 328-335. DOI:10.1093/mollus/eyv070
- Rotimi, J. and Iloba, B.N.** (2002). Ecological studies of insect communities in temporary ponds in southern Nigeria. *Tropical Journal of Environmental Science and Health*, 5: 27-32.
- Sana, U., Muhammad, A., Fawad, A., Sana, U. and Karim, J.K.** (2014). Hand pumps' water quality analysis for drinking and irrigation purposes at District Dir Lower, Khyber Pakhtunkhwa Pakistan. *European Academic Research*, 2(1): 1560-1571.
- Šigutová, H., Pyszko, P., Valušák, J. and Dolný, A.** (2022). Highway stormwater ponds as islands of Odonata diversity in an agricultural landscape. *Science of the Total Environment*, 837: 155774.
- Solimini, A.G., Ruggiero, A., Bernardini, V. and Carchini, G.** (2003). Temporal pattern of macroinvertebrate diversity and production in a new man-made shallow lake. *Hydrobiologia*, 506-509: 373-379.
- Vogler, R.E., Núñez, V., Gutiérrez Gregoric, D.E., Beltramino, A.A. and Peso, J.G.** (2012). *Melanoides tuberculata*: The history of an invader. In: Hämäläinen, E.M. and Järvinen, S. (Eds.), *Snails: Biology, Ecology and Conservation*. Chapter 3, pp. 65-85.
- Walsh, C.J., Gooderham, J.P.R., Grace, M.R., Sdraulig, S., Rosyidi, M.L. and Lelono, A.** (2002). The relative influence of diffuse and point source disturbances on a small upland stream in East Java, Indonesia: a preliminary investigation. *Hydrobiologia*, 487: 183-192.