

Original Research Article

Spatio-temporal Dynamics of Physico-Chemical Parameters and Aquatic Insect Assemblages in a Western Nigerian River: An Approach to Water Quality Assessment

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Abstract: Purpose: This study evaluated the interconnected dynamics of water physico-chemical parameters and aquatic insects within Omi River, a perennial lotic system in Iwajowa Local Government Area of Oyo State, Western Nigeria, to assess its water quality and biological integrity. Methodology: Sampling was conducted at five stations over an annual cycle from December 2024 to September 2025 to capture seasonal variations. Physico-chemical parameters were monitored alongside aquatic insect communities. Spatial and seasonal variations were assessed, while Canonical Correspondence Analysis (CCA) was used to examine relationships between environmental variables and aquatic insect distribution. Findings: A total of 1,040 individuals belonging to six orders, 19 families, and 44 genera were recorded, with *Rhagovelia* sp. dominating (24.04%). Environmental conditions were highly uniform spatially, with BOD being the only parameter showing significant spatial variation ($p < 0.05$), reflecting mild downstream organic enrichment at Station 5. Seasonal variation was pronounced, with river width, depth, volumetric discharge, turbidity and dissolved oxygen (DO) significantly higher during the wet season ($p < 0.001$), whereas TDS and electrical conductivity (EC) were significantly higher during the dry season ($p < 0.001$). Total abundance and diversity metrics were higher during the stable dry season, whereas EPT abundance increased during wet-season aeration. Although CCA was not statistically significant, it indicated that discharge, depth, stream width and turbidity were the primary ecological variables structuring species distribution, outweighing nutrient gradients. Contribution: The study demonstrates that Omi River retained high biological integrity during the study period and provides an important baseline framework for water-quality assessment and freshwater conservation in Western Nigeria and the wider West African region.

Keywords: Aquatic Insect, Bioindicator, Physico-Chemical Parameters, Water Quality Assessment, Omi River.

1.0 INTRODUCTION

Freshwater ecosystems are vital planetary life-support systems that provide critical ecological goods and services, regulate regional climate regimes and harbour exceptional global biodiversity (Edegbene *et al.*, 2024). Despite their ecological and socio-economic value, lotic systems such as rivers and streams are increasingly vulnerable and degraded. Under the Anthropocene epoch, global river networks face unprecedented pressures from rapid urbanization, agricultural expansion and industrial effluent discharge. In tropical developing sub-Saharan African nations, these stressors are magnified by weak environmental regulation and demographic pressures, leading to alterations in river hydrology and degradation of ecological integrity (Mohammed, 2026).

In West Africa, the guinea savanna and transition forest zones of Western Nigeria are critical regions where aquatic systems face severe environmental strain (Olatunji and Odedeyi, 2023). The Omi River, flowing through Iwajowa Local Government Area (LGA), Oyo State, Nigeria, experiences anthropogenic pressures associated with its agrarian landscape. Extensive rain-fed cassava, yam and maize cultivation, riparian forest clearing and cattle grazing contribute non-point nutrient loads and siltation, altering dissolved oxygen, electrical conductivity, pH, nitrate and phosphate concentrations and creating fluctuating conditions for aquatic life (Olowo *et al.*, 2025). These pressures interact with strong spatio-temporal variations associated with the tropical climate. The river experiences an intense wet season from April to October and a dry season from November to March. Heavy wet-season rainfall generates storm-water runoff, bank erosion, increased sediment loads and dilution of chemical parameters (Akawo, 2023), whereas dry-season reductions in discharge and flow velocity may concentrate nutrients, lower dissolved oxygen and alter benthic microhabitat availability (Mohammed, 2026).

Traditional isolated chemical water sampling is insufficient for assessing the ecological health of such dynamic systems because it provides only a snapshot of water quality and may fail to capture transient pollution events. Biological monitoring using aquatic macroinvertebrates, particularly aquatic insect assemblages, has therefore become a foundational approach in tropical limnology (Adeleke and Amusan, 2024). Aquatic insects are effective bioindicators because of their relatively sedentary lifestyles, documented sensitivity to environmental stress and diverse functional roles within aquatic food webs (Arimoro *et al.*, 2024). Changes in assemblage structure, taxonomic richness and functional traits reflect the long-term, integrated effects of water-quality degradation and physical habitat alteration (Enabulele and Olomukoro, 2024; Mohammed, 2026).

Although macroinvertebrates are widely recognized as bioindicators, their spatial and temporal responses to interacting hydrological variations in Western Nigerian rivers,

particularly the Omi River, remain insufficiently integrated into regional conservation frameworks. Previous studies have often relied on descriptive, univariable statistical indices that do not adequately map complex relationships between community structure and environmental variables (Akindele *et al.*, 2023; Edegbene *et al.*, 2023; Olowo *et al.*, 2025). Canonical Correspondence Analysis (CCA) provides a robust constrained approach for relating biological assemblages to environmental matrices. However, a critical gap remains in quantifying how localized agricultural pressures and seasonal flow changes reshape the niche space of sensitive orders such as Ephemeroptera, Plecoptera and Trichoptera relative to tolerant taxa such as Chironomidae. Addressing these multidimensional socio-ecological relationships is essential for developing effective localized biotic indices for Nigerian river management (Edegbene, 2021; Edegbene *et al.*, 2024).

This study therefore, investigates the spatio-temporal dynamics of physico-chemical hydrology and aquatic insect assemblages across anthropogenic gradients in the Omi River, Iwajowa LGA, Oyo State, Nigeria, using a Canonical Correspondence Approach. Specifically, it aims to: (i) characterize seasonal and spatial variations in hydrological and nutrient parameters; (ii) inventory the taxonomic composition, abundance and functional structures of aquatic insect communities; and (iii) apply CCA to identify environmental drivers of insect distribution. By linking environmental matrices with biological indicators, the study seeks to assess ecological integrity and provide a statistically validated framework for targeted river restoration, water policy formulation and biodiversity conservation in West African lotic ecosystems.

2. Materials and Methods

2.1 Study Area

The study was conducted on the Omi River, which originates from the mountainous headwaters of Inanyin settlement and traverses Iwere-Ile in Iwajowa Local Government Area (LGA), Oyo State, Nigeria. Iwajowa, located in the Oke-Ogun region of northwestern Oyo State near the Benin Republic border, lies between Latitude 7°30'–8°00'N and Longitude 2°45'–3°30'E, covering about 2,529 km² (Figure 1). Its vegetation is predominantly Derived Savanna, with a tropical savanna climate (Koppen Aw) characterized by distinct wet and dry seasons. The wet season occurs from April to October, contributing about 90% of annual rainfall (1,100–1,400 mm), while the dry season extends from November to March (IITA, 2010; Akinbode *et al.*, 2008). Relative humidity ranges from 80–88% during the wet season and 30–40% during the dry season (NiMet, 2025). The forest-savanna zone supports diverse flora, including *Vitellaria paradoxa*, *Parkia biglobosa*, *Anogeissus leiocarpus*, *Daniellia oliveri*, *Triplochiton scleroxylon*, *Milicia excelsa*, *Khaya senegalensis* and *Ceiba pentandra*, alongside diverse fauna (Ogidan *et al.*, 2023). Omi River flows from Ayetoro to Ilaji-Ile and extends toward the Nigeria-Benin border. It is perennial and supports domestic, agricultural and fishing activities. Anthropogenic pressures include farming, grazing, charcoal production, deforestation, cassava processing, effluent discharge, washing, bathing and fishing. The substratum

consists mainly of fine sand, mud, pebbles, debris and decaying organic matter, contributing to aquatic insect composition.

2.2 Sampling Programme

To evaluate seasonal dynamics and spatial heterogeneity within the Omi River, a spatio-temporal survey design was employed. Five sampling stations were selected along the river stretch, covering representative reaches and distinct microhabitats. Sampling was executed tri-monthly across a 12-month duration, capturing both the wet and dry seasons over an annual cycle. This systematic framework ensured that structural variations in water quality and aquatic insect communities were robustly accounted for.

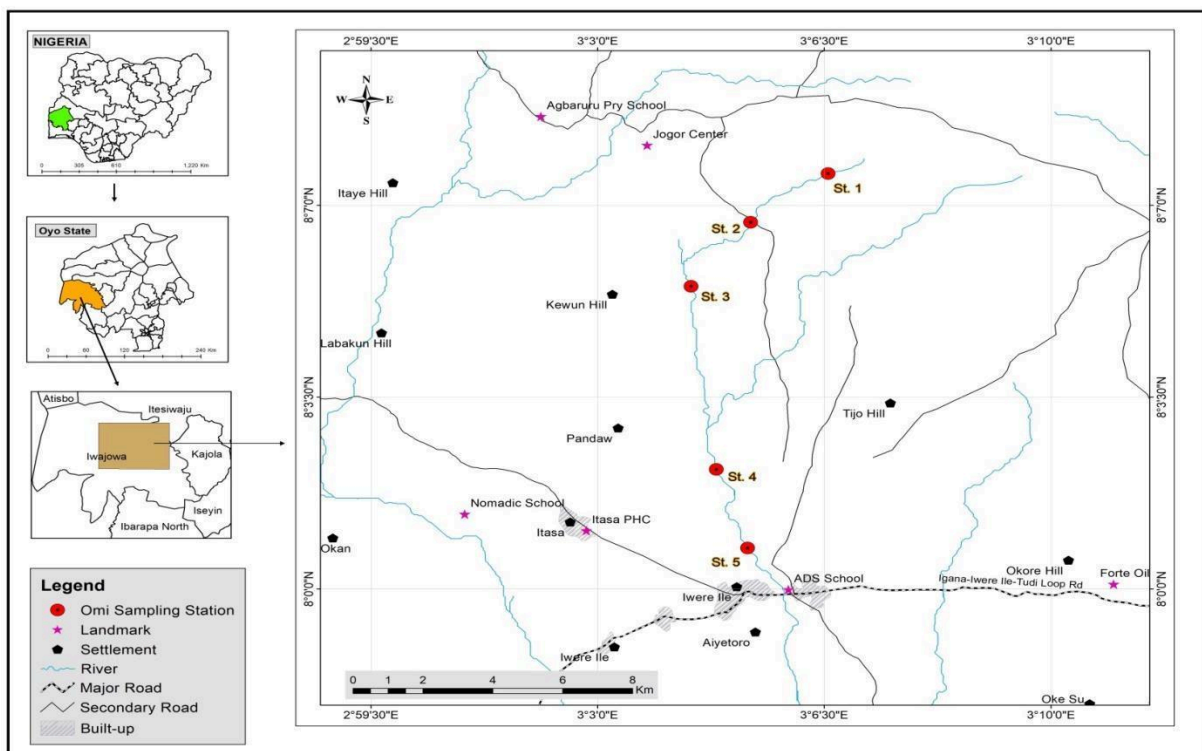


Figure 1: Map of the study area showing the selected sampling points on the Omi River, Iwajowa Local Government Area, Oyo State, Nigeria, from December 2024 to September 2025

2.3 Collection of Water Samples

Prior to water and biological sampling, *in-situ* physico-chemical parameters were determined directly to prevent disturbance-induced bias. Surface water temperature, dissolved oxygen (DO), pH, electrical conductivity (EC) and total dissolved solids (TDS) were measured using a dissolved oxygen meter (Precision DO-9100), a 7-in-1 professional water quality tester (SKU-GE779IP6), and turbidity was quantified on-site using a calibrated turbidity tube (10-400 NTU-1103018). Concurrently, channel width and depth were measured using a standardized steel measuring tape to calculate cross-sectional area and subsequent river discharge, while flow velocity was determined via the float method by

timing a buoyant object over a pre-measured distance. Following these measurements, sub-surface water samples were collected at a depth of approximately 20–30 cm in sterile 1 L polyethylene bottles for laboratory analysis using standard techniques. Samples for biochemical oxygen demand (BOD₅) were collected in specialized 250 ml amber glass bottles. All collected samples were stored in an ice-filled cooler box at approximately 4°C and transported to the laboratory for analysis within 24 hours.

2.4 Collection, Sorting and Identification of Aquatic Insects

Aquatic insects were collected thrice per sampling station using a long-handled D-frame net and the direct hand-picking method. This net was used to scoop the open water, submerged and emergent vegetation zones in the river. The sorting of the collected specimens was done on a white enamel tray. Sorted specimens were preserved in specimen bottles containing 70% ethanol solution (APHA, 2005) and appropriately labeled. In the laboratory, the preserved samples were thoroughly rinsed through a 500 µm sieve to remove fine sediment and taxonomically identified to the possible lowest level using standard dichotomous regional identification keys (Voshell, 2002; De Moor and De Moor, 2003) under a digital microscope (TEMLOV-DM9PRO).

2.5 Statistical Analysis

Statistical analyses were performed to evaluate the spatio-temporal and seasonal variations in water quality parameters and aquatic insect assemblages. Prior to parametric testing, data were subjected to the normality test. A one-way Analysis of Variance (ANOVA) was executed to determine significant spatio-temporal variations in the mean values of physico-chemical parameters across the sampling stations, while an independent-samples t-test was employed to evaluate seasonal variations between the wet and dry seasons. To assess community structure, structural attributes were quantified using standard diversity indices including the Shannon-Wiener diversity index (H'), Margalef's richness index (d), Simpson's dominance index (D), and Pielou's evenness index (J') alongside the Biological Monitoring Working Party Scoring System (ISO-BMWP) to determine the biotic integrity of the waterbodies. The relationships between environmental conditions and the aquatic insect communities were established using Canonical Correspondence Analysis (CCA). The significance of the extracted canonical axes and species-environment correlations was validated using a Monte Carlo permutation test with 999 permutations. All univariate and multivariate statistical procedures were executed using PAST (Paleontological Statistics, Version 4.13) and R software environments (R 4.5.1), with statistical significance established at $p < 0.05$.

3. Results

3.1 Spatial Dynamics of Water Quality and Environmental Uniformity

The spatial analysis of physico-chemical and nutrient properties of the Omi River across five sampling stations revealed longitudinal fluctuations in mean concentrations (Table 1). Water temperature was highest at Station 2 and lowest at Station 4. Stream width peaked at Station 3, while channel depth was highest at Station 1 and lowest at Station 4.

Discharge was highest at Station 5 and lowest at Station 2, whereas flow velocity peaked at Station 4. Turbidity was highest at Station 4 and lowest at Station 3. Total dissolved solids and electrical conductivity showed identical trends, peaking at Station 5 and lowest at Station 2. Dissolved oxygen was highest at Station 2 and lowest at Station 5, while biochemical oxygen demand showed the reverse trend. Nitrate peaked at Station 2 and phosphate at Station 5. pH was highest at Station 4 and lowest at Station 3. Calcium, magnesium, and total hardness showed localized variation, with calcium, magnesium, and hardness highest at Station 4 and lowest at Station 5.

Table 1: Spatial Variation of Physico-chemical Parameters along Omi River, Iwajowa Local Government Area, Oyo State, Nigeria from December 2024 to September 2025

Parameter	Station 1	Station 2	Station 3	Station 4	Station 5	F-value	p-value
Temperature (°C)	28.52 ± 0.52	28.70 ± 0.61	28.00 ± 0.63	27.10 ± 0.84	28.23 ± 0.48	0.995	0.4402
Width (m)	13.00 ± 3.54	11.75 ± 2.93	14.25 ± 2.66	11.75 ± 3.71	14.00 ± 3.92	0.124	0.9716
Depth (m)	1.52 ± 0.37	1.23 ± 0.34	1.18 ± 0.38	1.10 ± 0.34	1.45 ± 0.39	0.255	0.9024
Flow Velocity (m s ⁻¹)	0.55 ± 0.03	0.55 ± 0.06	0.55 ± 0.03	0.62 ± 0.05	0.55 ± 0.03	0.628	0.65
Discharge (m ³ s ⁻¹)	12.79 ± 5.61	8.12 ± 3.01	10.74 ± 4.41	9.19 ± 4.14	13.39 ± 5.75	0.232	0.9158
Turbidity (NTU)	21.50 ± 5.95	22.00 ± 5.67	20.75 ± 6.49	23.25 ± 7.47	21.00 ± 6.49	0.024	0.9988
Dissolved Oxygen (mg L ⁻¹)	7.31 ± 0.40	7.36 ± 0.28	7.15 ± 0.37	6.85 ± 0.50	6.79 ± 0.43	0.42	0.7918
pH	6.91 ± 0.29	7.12 ± 0.08	6.85 ± 0.24	7.54 ± 0.05	7.42 ± 0.05	2.94	0.0559
TDS (mg L ⁻¹)	64.00 ± 6.75	62.75 ± 6.69	74.75 ± 13.24	67.50 ± 9.36	76.75 ± 8.62	0.466	0.7598
EC (μS cm ⁻¹)	136.50 ± 11.32	124.50 ± 14.13	151.75 ± 28.75	148.75 ± 24.94	150.50 ± 23.18	0.296	0.8758
BOD (mg L ⁻¹)	1.10 ± 0.18	1.17 ± 0.07	0.91 ± 0.08	1.21 ± 0.12	1.73 ± 0.30	3.3	0.0396
Nitrate (mg L ⁻¹)	1.34 ± 0.66	2.92 ± 2.62	1.57 ± 1.22	0.65 ± 0.58	0.64 ± 0.56	0.461	0.7635
Phosp.hate (mg L ⁻¹)	0.10 ± 0.04	0.07 ± 0.03	0.11 ± 0.04	0.06 ± 0.03	0.21 ± 0.09	1.488	0.2552
Calcium (mg L ⁻¹)	13.24 ± 1.86	13.74 ± 1.86	13.84 ± 2.57	14.81 ± 1.75	11.57 ± 1.00	0.403	0.8034
Magnesium (mg L ⁻¹)	18.89 ± 4.42	30.14 ± 9.35	30.43 ± 15.93	30.96 ± 18.05	16.14 ± 4.48	0.366	0.8291
Water Hardness (mg L ⁻¹)	111.00 ± 22.74	158.25 ± 36.70	159.75 ± 61.04	164.50 ± 78.73	97.50 ± 15.97	0.41	0.7984

Significance: * indicates p<0.05, **indicates p<0.01 and *** show significant at P<0.001

3.2 Seasonal Variations in Tropical Catchments

The seasonal assessment of Omi River environmental metrics revealed strong temporal fluctuations between dry and wet seasons (Table 2). Water temperature was highest in the dry season and lowest in the wet season, although not significantly. Stream

width, channel depth and volumetric water discharge were highest in the wet season and lowest in the dry season ($p < 0.001$), while flow velocity showed the opposite pattern. Turbidity and dissolved oxygen were highest during the wet season and lowest during the dry season ($p < 0.001$). Conversely, total dissolved solids and electrical conductivity peaked in the dry season and declined in the wet season ($p < 0.001$). Water pH and biochemical oxygen demand were highest in the wet season but showed no significant seasonal variation. Nitrate and phosphate were highest in the wet season. Calcium peaked in the dry season and was significantly different ($p < 0.01$), whereas magnesium and total water hardness were highest in the wet season but showed no significant variation.

Table 2: Seasonal Variation of Physico-chemical and Nutrient Parameters along Omi River, Iwajowa Local Government Area, Oyo State, Nigeria from December 2024 to September 2025

Parameter	Dry	Wet	T-test	p-Value
Temperature ($^{\circ}\text{C}$)	28.12 ± 0.53	28.10 ± 0.23	0.035	0.9729
Width (m)	7.80 ± 0.80	18.10 ± 1.16	-7.314	0.001***
Depth (m)	0.73 ± 0.09	1.86 ± 0.12	-7.46	0.001***
Flow Velocity (m s^{-1})	0.60 ± 0.03	0.53 ± 0.02	2.09	0.0516
Discharge ($\text{m}^3 \text{s}^{-1}$)	3.70 ± 0.72	17.99 ± 1.93	-6.944	0.001***
Turbidity (NTU)	11.90 ± 1.22	31.50 ± 2.24	-7.685	0.001***
Dissolved Oxygen (mg L^{-1})	6.50 ± 0.19	7.69 ± 0.05	-5.931	0.001***
pH	7.15 ± 0.14	7.19 ± 0.14	-0.233	0.8184
TDS (mg L^{-1})	81.20 ± 5.18	57.10 ± 2.23	4.273	0.001***
EC ($\mu\text{S cm}^{-1}$)	169.60 ± 11.67	115.20 ± 5.67	4.191	0.0011***
BOD (mg L^{-1})	1.16 ± 0.10	1.30 ± 0.16	-0.75	0.4644
Nitrate (mg L^{-1})	0.37 ± 0.15	2.48 ± 1.07	-1.956	0.081
Phosphate (mg L^{-1})	0.09 ± 0.03	0.13 ± 0.04	-0.672	0.5108
Calcium (mg L^{-1})	15.31 ± 0.78	11.57 ± 1.10	2.767	0.0136**
Magnesium (mg L^{-1})	19.21 ± 2.36	31.41 ± 9.46	-1.251	0.239
Water Hardness (mg L^{-1})	118.20 ± 10.63	158.20 ± 39.75	-0.972	0.3533

Significance: * indicates $p < 0.05$, ** indicates $p < 0.01$ and *** show significant at $P < 0.001$

3.3 Compositions and Relative Abundance of Aquatic Insects of the Omi River

The taxonomic assessment of aquatic insects along the Omi River recorded 1,040 individuals belonging to Insecta, comprising 6 orders, 19 families and 44 genera (Table 3). Total abundance was highest at Station 1 and lowest at Station 4. *Rhagovelia* sp. was the dominant taxon, with highest density at Station 1 and lowest at Station 4. *Pseudagrion* spp. and *Orthetrum* sp. peaked at Station 2, with lowest abundance at Stations 3 and 5, respectively. *Orectogyrus* spp. and *Dineutus* sp. were most abundant at Station 1; *Orectogyrus* spp. was lowest at Station 3, while *Dineutus* sp. was absent at Station 4. *Hydrochara* sp. peaked at Station 2 and was lowest at Station 1. *Elassoneuria* sp. peaked at Station 3 and was lowest at Station 1. *Sphaerodema* sp. and *Eurymetra* sp. peaked at Station 4, with *Eurymetra* absent at Stations 3 and 5. *Neoperla* sp. peaked at Station 5 and was absent at Station 4. *Potamodytes* sp. and *Limnichus* sp. occurred only at Station 5, *Chironomus* sp. and *Caenis* sp. only at Station 2, and *Adenophlebia* sp. only at Station 1.

Table 3: Compositions and Relative Abundance of Aquatic Insects along Omi River, Iwajowa Local Government Area, Oyo State, Nigeria from December 2024 to September 2025

Order	Family	Taxa	St 1	St 2	St 3	St 4	St 5	Tot.Abu.	Rel. Abu %)
Coleoptera	Dytiscidae	<i>Derovatellus</i> sp.	0	2	1	0	0	3	0.29
		<i>Philodytes</i> sp.	0	1	1	0	0	2	0.19
		<i>Hydrocanthus</i> sp.	0	0	0	0	1	1	0.10
	Gyrinidae	<i>Aulonogyrus</i> sp.	16	16	1	0	0	33	3.17
		<i>Orectogyrus</i> spp.	62	19	1	4	6	92	8.85
		<i>Dineutus</i> sp.	42	2	24	0	8	76	7.31
		<i>Amphiops</i> sp.	4	0	2	0	0	6	0.58
	Hydrophilidae	<i>Helochaeres</i> sp.	1	1	3	0	0	5	0.48
		<i>Hydrochara</i> sp.	1	46	4	1	2	54	5.19
		<i>Philaccolus</i> sp.	3	2	2	0	0	7	0.67
	Elmidae	<i>Potamodytes</i> sp.	0	0	0	0	4	4	0.38
	Limnichidae	<i>Limnichus</i> sp.	0	0	3	0	0	3	0.29
	Scirtidae	<i>Elodes</i> sp.	0	0	2	0	0	2	0.19
	Belostomatidae	<i>Sphaerodema</i> sp.	0	1	0	0	0	1	0.10
Hemiptera	Gerridae	<i>Eurymetra</i> sp.	1	6	4	8	6	25	2.40
		<i>Limnogonus</i> sp.	9	4	0	11	0	24	2.31
		<i>Tenagonus</i> sp.	3	0	1	3	0	7	0.67

	Hydrometridae	<i>Hydrometra sp.</i>	4	1	2	2	1	10	0.96
	Naucoridae	<i>Laccocoris sp.</i>	2	6	0	4	1	13	1.25
	Nepidae	<i>Laccotrephes sp.</i>	2	5	6	0	3	16	1.54
		<i>Ranatra sp.</i>	2	3	7	1	3	16	1.54
		<i>Anisops sp.</i>	3	2	2	3	2	12	1.15
	Notonectidae	<i>Enithares sp.</i>	2	2	2	3	2	11	1.06
		<i>Nychia sp.</i>	2	1	1	1	0	5	0.48
	Veliidae	<i>Rhagovelia sp.</i>	3	7	4	1	2	17	1.63
	Chlorocyphidae	<i>Chlorocypha sp.</i>	73	42	46	28	61	250	24.04
	Coenagrionidae	<i>Agriocnemis sp.</i>	8	2	3	0	3	16	1.54
		<i>Pseudagrion spp.</i>	0	3	3	3	1	10	0.96
		<i>Lestinogomphus sp.</i>	13	38	11	24	16	102	9.81
	Gomphidae	<i>Paragomphus sp.</i>	0	0	3	0	3	6	0.58
		<i>Phyllogomphus sp.</i>	1	2	0	1	1	5	0.48
Odonata		<i>Bradinopyga sp.</i>	0	1	0	0	0	1	0.10
		<i>Nesciothemis sp.</i>	2	0	0	0	1	3	0.29
	Libellulidae	<i>Orthetrum sp.</i>	0	5	0	0	6	11	1.06
		<i>Olpogastra sp.</i>	26	41	19	9	0	95	9.13
		<i>Trithemis sp.</i>	1	3	2	5	2	13	1.25
		<i>Zygonoidea sp.</i>	1	0	2	2	0	5	0.48
	Platycnemididae	<i>Elatoneura sp.</i>	0	2	0	0	1	3	0.29
Diptera	Chironomidae	<i>Chironomus sp.</i>	0	0	3	0	0	3	0.29
	Caenidae	<i>Caenis sp.</i>	0	1	0	0	0	1	0.10
Ephemeroptera	Leptophlebiidae	<i>Notonurus spp.</i>	2	1	0	0	1	4	0.38
		<i>Adenophlebia sp.</i>	2	0	0	0	0	2	0.19
	Oligoneuriidae	<i>Elassoneuria sp.</i>	1	6	33	1	8	49	4.71
Plecoptera	Perlidae	<i>Neoperla sp.</i>	1	2	5	0	8	16	1.54
Total			293	276	203	115	153	1040	100

Note: Tot. Abu. Means Total Abundance and Rel. Abu. Means Relative Abundance.

3.4 Spatial Diversity and Biological Indices of Aquatic Insects of the Omi River

The analysis of community structure and biotic integrity metrics of aquatic insects across five monitoring stations revealed distinct spatial gradients along the Omi River (Table 4). Total abundance was highest at Station 1 and lowest at Station 4, while generic richness peaked at Station 2 and was lowest at Station 4. Shannon–Wiener diversity was highest at Station 3 and lowest at Station 5, whereas Simpson’s diversity peaked at Station 2 and was lowest at Station 5. Pielou’s evenness was highest at Station 4 and lowest at Station 1. Margalef richness was highest at Station 2 and lowest at Station 4. Family richness was highest at Stations 2, 3 and 5 and lowest at Station 4. The Biological Monitoring Working Party (BMWP) score peaked at Station 3 and was lowest at Station 4. Average Score Per Taxon (ASPT) was highest at Station 1 and lowest at Station 4. Both EPT abundance and percentage EPT were highest at Station 3 and lowest at Station 4.

Table 4: Spatial Diversity indices of Aquatic Insects in Omi River, Iwajowa Local Government Area, Oyo State, Nigeria from December 2024 to September 2025

Diversity Index	St 1	St 2	St 3	St 4	St 5
Total abundance (N)	293	276	203	115	153
Taxa richness (S)	30	33	31	20	26
Shannon–Wiener Index (H')	2.403	2.672	2.702	2.419	2.397
Simpson's Diversity (1 – D)	0.857	0.896	0.890	0.869	0.814
Pielou's Evenness (J')	0.706	0.764	0.787	0.808	0.736
Margalef Richness Index (d)	5.105	5.694	5.646	4.004	4.970
N0. of Families	16	17	17	12	17
BMWP	107	106	110	74	107
ASPT	6.69	6.24	6.47	6.17	6.29
Individual EPT	6	10	38	1	17
% EPT	2.05	3.62	18.72	0.87	11.11

3.4 Seasonal Diversity and Biological Indices of Aquatic Insects of the Omi River

The seasonal comparison of community attributes and biotic scores revealed temporal shifts in the aquatic insect assemblage between the dry and wet seasons of the Omi River (Table 5). Total individual abundance and generic richness were highest during the dry season and lowest during the wet season. Shannon–Wiener and Simpson’s diversity indices similarly peaked in the dry season and declined in the wet season. Pielou’s evenness and Margalef richness also reached their highest values during the dry season and lowest during the wet season. Family richness followed the same pattern, being highest in the dry

season and lowest in the wet season. The Biological Monitoring Working Party (BMWP) score peaked during the dry season and declined during the wet season, whereas Average Score Per Taxon (ASPT) remained identical across both seasons. Conversely, both EPT abundance and percentage EPT were highest during the wet season and lowest during the dry season.

Table 5: Seasonal Diversity indices of Aquatic Insects in Omi River, Iwajowa Local Government Area, Oyo State, Nigeria from December 2024 to September 2025

Diversity index	Dry season	Wet season
Total abundance (N)	529	511
Taxa richness (S)	36	29
Shannon–Wiener Index (H')	2.670	2.460
Simpson's Diversity (1 – D)	0.901	0.841
Pielou's Evenness (J')	0.745	0.731
Margalef Richness Index (d)	5.581	4.490
N0. of Families	12	11
BMWP	77	73
ASPT	6.4	6.4
Individual EPT	1	71
% EPT	0.19	13.89

3.5 The Relationship between Physico-chemical Parameters and Aquatic Insects of the Omi River

The Canonical Correspondence Analysis (CCA) outlines the structural partitioning of variance between the measured physico-chemical water parameters and the aquatic insect assemblages of the Omi River across the first four ordination axes (Table 6). The first two canonical axes account for the majority of the constrained inertia, capturing a substantial cumulative proportion (63.50%) of the total explained variation. This demonstrates that a two-dimensional ordination space is structurally robust enough to represent the primary gradient patterns of the dataset, with Axes 3 and 4 explaining minor remaining components of the variance. Crucially, the Monte Carlo permutation tests reveal that none of the canonical axes reach statistical significance at the conventional alpha level ($p > 0.05$ across all axes). This clearly indicates that the observed linear combinations of environmental variables do not exert a statistically structured, deterministic control over aquatic insect distribution across the spatial-temporal sampling grid. Consequently, the

CCA triplot (Figure 2) is utilized as an exploratory and descriptive tool to evaluate the directional trends and underlying relationships between specific insect taxa and environmental gradients.

Table 6: Eigenvalue and Percentage of Total Inertia for the first four Axes of Canonical Correspondence Analysis of Physico-chemical parameters of water and Aquatic Insects of the Omi River in Iwajowa Local Government Area, Oyo State, Nigeria, from December 2024 to September 2025

Axix	Eigenvalue	% of total inertia	Monte Carlo permutation test (p-value)
1	0.22096	33.09	0.706
2	0.20304	30.41	0.262
3	0.13692	20.51	0.163
4	0.10231	15.32	0.309

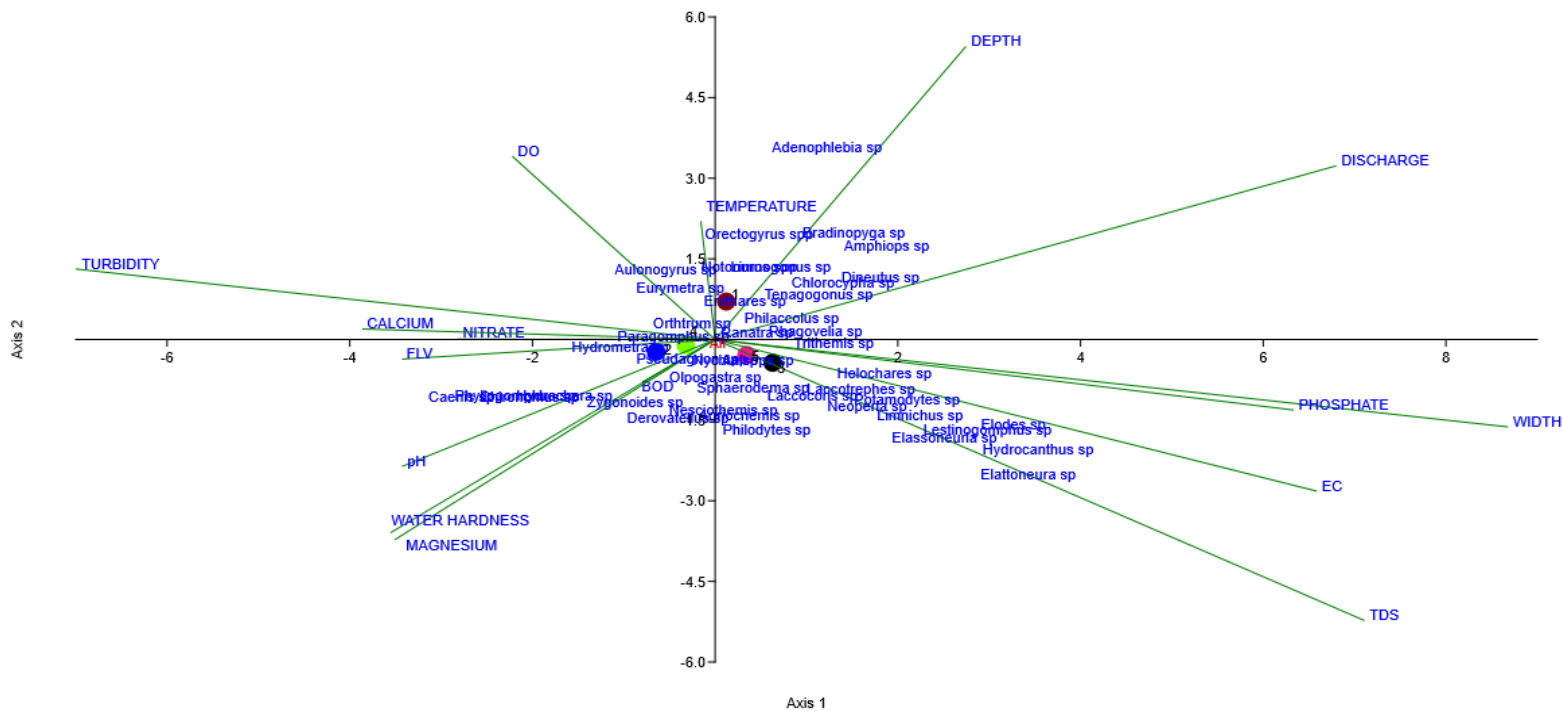


Figure 2: Canonical Correspondence Analysis (CCA) triplot showing the relationships between aquatic insect taxa and physico-chemical variables in the Omi River, Iwajowa Local Government Area, Oyo State, Nigeria, from December 2024 to September 2025.

Discussion

The physico-chemical characteristics of the Omi River indicated relatively uniform environmental conditions across the five sampling stations, with limited localized disturbance and a stable hydrological regime, consistent with tropical rivers with homogeneous catchment characteristics and limited anthropogenic activities (Forio et al., 2021; Tampo et al., 2021). Water temperature remained narrow (27.10–28.70°C), reflecting the tropical climate of southwestern Nigeria and buffering against extreme thermal fluctuations (Oso and Olutona, 2023), with stability likely favouring diverse aquatic insect assemblages (Jerves-Cobo et al., 2020; APHA, 2023). The absence of significant spatial differences in river width, depth, flow velocity and discharge indicated comparable hydromorphological conditions among reaches (Okoye and Eyo, 2021), potentially promoting habitat continuity and macroinvertebrate persistence through reduced physical disturbance (Masese et al., 2020). Turbidity was spatially uniform and moderate, suggesting relatively even sediment inputs and limited adverse effects on aquatic insects (Forio et al., 2021), while seasonal rainfall may constitute the principal source of suspended sediments in tropical African rivers (Tampo et al., 2021). Dissolved oxygen remained above 6.7 mg L⁻¹, providing favourable conditions for freshwater macroinvertebrates, particularly pollution-sensitive taxa requiring concentrations above 5 mg L⁻¹ (WHO, 2022; USEPA, 2022). The occurrence of pollution-sensitive Ephemeroptera and Plecoptera further supports this interpretation (Aina et al., 2022). pH remained near neutrality and within acceptable freshwater ranges (WHO, 2022), while EC and TDS showed no significant spatial differences, indicating consistent ionic composition, relatively low mineralization and limited domestic or industrial pollution (Nkwoji, 2023; Forio et al., 2021). BOD was the only parameter showing significant spatial variation, being highest at Station 5 and lowest at Station 3, possibly reflecting localized domestic activities, vegetation decay or agricultural runoff (Ibrahim and Suleiman, 2022); however, values remained below levels associated with serious organic pollution and high DO indicated adequate assimilative capacity.

Nitrate and phosphate remained low without significant spatial variation, indicating minimal nutrient enrichment and low eutrophication risk, consistent with high DO and favourable biological indices (Aina et al., 2022). Calcium, magnesium and total hardness were relatively stable, with moderate hardness potentially improving buffering capacity and reducing physiological stress associated with soft water, while spatial stability suggested consistent geological controls on water chemistry (APHA, 2023). Seasonally, rainfall, catchment hydrology and discharge influenced several physicochemical variables (Jerves-Cobo et al., 2020; Tampo et al., 2021), although temperature and pH remained relatively stable (Oso and Olutona, 2023; Masese et al., 2020; WHO, 2022). Wet-season increases in river width, depth and discharge reflected increased rainfall and runoff (Ibrahim and Suleiman, 2022), affecting habitat availability, sediment transport, nutrient cycling, benthic disturbance, drift and substrate instability (Allan and Castillo, 2022). Turbidity increased during the wet season because of overland flow and bank erosion, particularly from exposed soils and agricultural areas (Edegbene et al., 2021), but its

association with rainfall rather than nutrient enrichment or increased BOD suggested a predominantly natural hydrological influence (Forio et al., 2021). Wet-season DO increased through enhanced reaeration caused by greater turbulence (Jerves-Cobo et al., 2020), maintaining favourable conditions for sensitive taxa such as Ephemeroptera and Plecoptera (Aina et al., 2022). BOD remained low with no significant seasonal difference, suggesting limited organic pollution and effective assimilation of naturally occurring organic matter (Nkwoji, 2023). EC and TDS were higher during the dry season because reduced discharge, evaporation and diminished dilution concentrated dissolved ions, whereas increased wet-season volumes promoted dilution (Ibrahim and Suleiman, 2022; APHA, 2023; Allan and Castillo, 2022). Nitrate and phosphate remained low without significant seasonal enrichment, while calcium varied significantly, possibly because of groundwater contribution, weathering and rainfall-induced dilution; stable magnesium and hardness suggested limited ecological consequences.

The aquatic insect assemblage comprised 44 taxa and more than 1,000 individuals, indicating a relatively rich community supporting multiple trophic interactions under favourable water-quality conditions (Forio et al., 2021; Tampo et al., 2021). *Rhagovelia* sp. dominated (24.04%), suggesting suitable surface habitats, DO and prey availability, consistent with tropical African streams with relatively intact habitat and low organic pollution (Masese et al., 2020). High abundances of *Pseudagrion* spp. and *Orthetrum* sp. further indicated favourable ecological conditions associated with well-oxygenated waters, submerged vegetation and stable breeding habitats (Omokunle and Adebayo, 2024; Tampo et al., 2021). The occurrence of pollution-sensitive *Elassoneuria* sp. and *Neoperla* sp., particularly 49 *Elassoneuria* individuals (4.71%) concentrated at Station 3, corresponded with high DO (6.79–7.36 mg L⁻¹) and low BOD, reinforcing evidence of low organic pollution (Aina et al., 2022). Conversely, the single *Chironomus* sp. individual (0.10%) indicated limited conditions for pollution-tolerant dominance (Nkwoji, 2023). Station 4 had substantially fewer individuals despite acceptable physicochemical conditions, suggesting that substrate composition, riparian cover, habitat complexity or localized human disturbance may have constrained abundance (Okoye and Eyo, 2021). Overall, the coexistence of predatory Hemiptera and Odonata, diverse beetles and pollution-sensitive taxa indicated relatively good ecological integrity and active trophic interactions (Forio et al., 2021; Masese et al., 2020).

Seasonally, aquatic insect abundance differed only slightly (528 dry-season versus 512 wet-season individuals), whereas richness and diversity indicated greater ecological complexity during the dry season. Richness declined from 36 to 28 taxa, probably because stable dry-season hydraulic conditions reduced substrate scouring, whereas wet-season rainfall increased current strength, disturbance and downstream drift (Omokunle and Adebayo, 2024; Masese et al., 2020; Forio et al., 2021). Shannon diversity declined from 2.670 to 2.460 and Margalef richness from 5.572 to 4.487, confirming that hydrological disturbance affected taxonomic richness more than total abundance. BMWP declined slightly from 77 to 73, while ASPT remained constant at 6.40, indicating maintained average pollution sensitivity and biological quality (Bonada et al., 2020; Tampo et al.,

2021). Thus, seasonal rainfall primarily modified community structure rather than ecological condition. Canonical Correspondence Analysis showed associations with discharge, depth, stream width, EC, TDS, DO and turbidity, suggesting that habitat characteristics and flow conditions were dominant ecological drivers (Eriksen et al., 2021; Edegbene et al., 2021). *Adenophlebia*, *Orectogyrus*, *Hydrodipnoya*, *Amphiops* and *Dineutus* were associated with discharge and depth (Edegbene et al., 2021; Okoye et al., 2021), while *Hydrocanthus*, *Elodes*, *Elattonneura* and *Lestinogomphus* were associated with EC, TDS and phosphate (Edegbene et al., 2021; Nkwoji, 2023). *Aulonogyrus*, *Notonecta* and *Hydrometra* were associated with DO (Oso et al., 2023; Omokunle, 2024). Overall, the findings agreed with relatively protected West African rivers, where hydromorphological influences were stronger than nutrient influences (Edegbene et al., 2021; Nkwoji, 2023; Oso and Olutona, 2023; Ibrahim and Suleiman, 2022; Omokunle and Adebayo, 2024; Aina et al., 2022; Okoye and Eyo, 2021).

Conclusion

The Omi River represents a highly functional, resilient tropical lotic ecosystem characterized by excellent dissolved oxygen levels, low organic enrichment and neutral pH. The water chemistry remains highly uniform across the river, with only localized, mild organic loading at Station 5 that is successfully processed by the river's self-purification capacity. Seasonal hydrology is the primary driver of physical and chemical variations, causing elevated turbidity and structural dilution during the wet season and concentrated mineral ions during the dry season. The river supports a diverse, biologically complex aquatic insect community dominated by sensitive taxa (e.g., *Elassoneuria* and *Neoperla*), confirming its high biological integrity. Hydromorphological conditions played a major role in the community structure of aquatic insects while seasonal high flows act as a natural physical filter that temporarily redistributes communities without degrading water quality. Future research should focus on how different river bed substrates interact with changing tropical rainfall patterns. This will provide critical insights into how microhabitat availability and insect communities will adapt to climate-induced shifts in hydrology.

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Author Contributions

S. O. Adeleke performed the practical laboratory work, collected the field samples, analyzed the data and drafted the manuscript. R. O. Sanni identified the botanical species found at the study site while both B. O. Amusan and R. O. Sanni supervised the project,

read the manuscript and provided critical corrections. All authors have read and approved the final version of the manuscript.

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