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# Aquatic Insects Biodiversity and Water Quality Assessment of Ala Stream Located in Roadblock, Akure, Ondo State, Nigeria

[1]Richard Olajide Owaseye, [2,3]Balogun Aliyu and [1]Babasola Williams Adu
[1]Department of Biology, Federal University of Technology Akure, Nigeria
[2]Department of Biology, Federal College of Education, Okene, Nigeria
[3]Department of Biotechnology, University of Salford, Manchester, United Kingdom

## ABSTRACT
**Background and Objective:** Water quality is a crucial determinant of aquatic ecosystem health, yet it is increasingly threatened by anthropogenic activities. Bioindicators such as aquatic insects provide valuable insights into the ecological integrity of freshwater bodies. This study aimed to assess the water quality of the Ala Stream in Akure, Nigeria, using aquatic insect biodiversity and physicochemical parameters as indicators. The objective was to determine the diversity and abundance of aquatic insects and evaluate their relationship with key physicochemical parameters to infer the ecological health of the stream. **Materials and Methods:** Sampling was conducted over six months at three designated sites along the stream (upstream, midstream, and downstream). Aquatic insects were collected using a 200 mm mesh dip-net, preserved in 70% ethanol, and identified to the family level using standard taxonomic keys. Physicochemical parameters, including pH, dissolved oxygen, temperature, turbidity, electrical conductivity, and nutrient levels, were analyzed using standard field and laboratory methods. Data were statistically analyzed using ANOVA, Pearson correlation, and diversity indices to determine variations across sites. The $p<0.05$ indicates the level of significance. **Results:** A total of 815 aquatic insect individuals from 19 genera and 11 families were recorded, with Chironomidae being the most abundant (36.32%). Diversity indices indicated the lowest taxa richness and diversity at Station 1 (upstream), while Station 3 (downstream) exhibited the highest diversity. Physicochemical analysis revealed variations in water quality across the stations, with some parameters exceeding WHO-recommended limits, indicating potential pollution. **Conclusion:** The study highlights significant correlations between aquatic insect diversity and specific physicochemical parameters, reinforcing their role as bioindicators. Findings provide critical insights into the ecological health of road block stream, emphasizing the need for integrated biological and physicochemical assessments in freshwater monitoring. This research contributes to sustainable water resource management in Nigeria.

## KEYWORDS
Aquatic insects, biodiversity, monitoring, physicochemical parameters, streams, water quality



## INTRODUCTION
Water is a vital resource essential for sustaining life and supporting ecosystems[1]. However, anthropogenic activities, urbanization, and industrialization often lead to the degradation of water quality in various water

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bodies worldwide[2]. In Nigeria, like many developing countries, the impact of human activities on water quality is a growing concern, particularly in urban areas. Aquatic insects have been recognized as a reliable bioindicator of water quality due to their sensitivity to environmental changes and relatively stationary life stages in aquatic ecosystems[1]. Their abundance and diversity can reflect alterations in water quality, making them valuable tools for ecological assessments.

Concurrently, physicochemical parameters such as pH, dissolved oxygen, temperature, turbidity, and nutrient levels provide crucial information about the overall health of aquatic environments[3]. Several studies have successfully employed aquatic insects as bioindicators for water quality assessment and physicochemical parameters have also been extensively studied for water quality assessment[4,5].

However, the integration of both aquatic insect biodiversity and physicochemical parameters in monitoring water quality in specific Nigerian water bodies, such as the Ala Stream, remains a gap in the existing literature.

This study aims to bridge this gap by adopting a comprehensive approach that combines biological and physicochemical assessments. The findings are expected to contribute not only to the understanding of the water quality in the Ala Stream but also to the broader field of freshwater resource management in Nigeria and beyond.

## MATERIALS AND METHODS

**Study area and sampling locations:** This study was carried out in the Ala Stream located in the Roadblock area of Akure, Ondo State, Nigeria. The study was carried out for a period of 6 months between March to August, 2023. The stream is a moderately fast-flowing stream but is slow in some areas of the stream due to blockage of the route of the water. The stream cuts across the road and passes through residential areas. It is located at 7°29'2"N; 5°1'32"E. The stream is polluted by improper disposal of waste, agricultural activities, and the use of pesticides by the inhabitants around the stream. There was also a poultry farm near the stream. Three study sites were studied from the stream. The study stations were picked with a station from the top, middle, and down of the stream and were labeled Stations 1, 2, and 3, respectively (Fig. 1).

### Sampling procedure

**Sampling and identification of aquatic insects:** At each sampling station, aquatic insects were collected using a dip net with a mesh size of 200 mm. The contents collected were put in a sorting bucket and the net was properly checked for insects clinging to the mesh. Insects collected were preserved in 70% ethanol in specimen bottles labeled according to the sample stations, description, and collection date. Subsequently, the collected insects were identified using a hand lens and dissecting microscope in the Biology Research Laboratory at the Federal University of Technology, Akure. Aquatic arthropods taxonomic keys were used to identify the collected specimens to family level[6,7].

**Water sampling and analysis (physicochemical parameters):** Water samples were gathered from different sites using 1000 mL plastic containers that were carefully rinsed with the stream water to ensure they were free from any potential contaminants. Ten key physicochemical parameters (pH, temperature, total dissolved solids, electrical conductivity, dissolved oxygen, water depth, flow rate, nitrate, sulfate, and phosphate) were investigated. The pH was measured with a portable HANNA pHep® pH meter, temperature with a thermometer, TDS with a HI96303, EC-3 TDS meter, EC with a HANNA DiST conductivity meter, and dissolved oxygen with a HANNA meter. Water depth was measured with a calibrated stick, and the flow rate was estimated by observing the time it took for a floating object to cover a 5 m distance, timed with a stopwatch. Nitrate, sulfate, and phosphate levels were determined using a UV-visible spectrophotometer (Jenway).

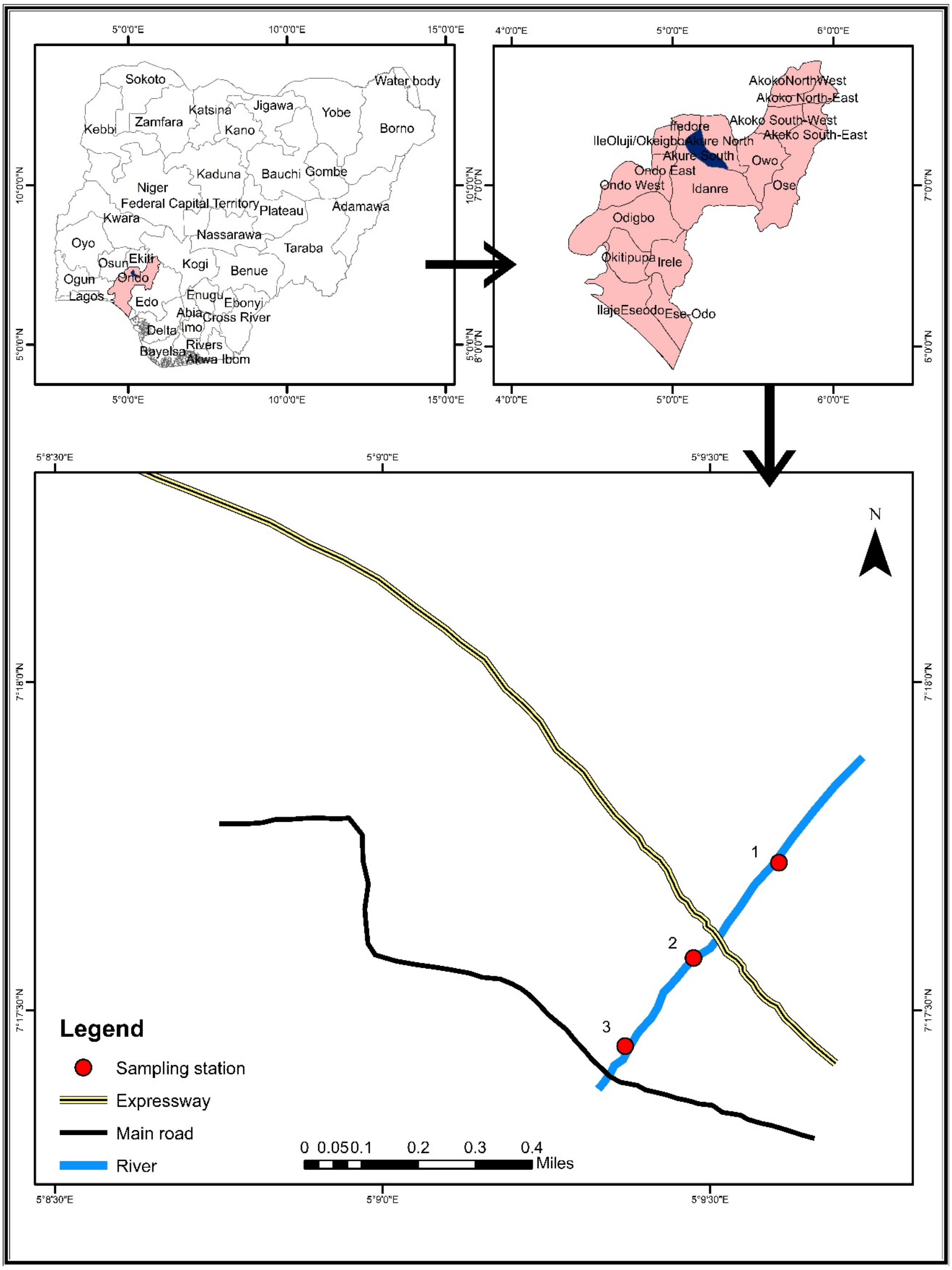


Fig. 1: Ala Stream located in Roadblock area, Akure, Ondo State, Nigeria

**Data analysis:** All data collected from the study stations were compiled and analyzed statistically using inferential and descriptive statistics. Data on physicochemical parameters were subjected to One-way Analysis of Variance (ANOVA) ($p<0.05$), and where significant differences existed, means were separated using Tukey's test. The ANOVA was done using the SPSS 21.0 software package. Pearson correlation analysis was done to determine the relationship between physicochemical parameters and aquatic insect biodiversity. Data on taxonomic composition and diversity of aquatic insects at the three study sites were subjected to diversity indices using the Palaeontologist Statistical Software Package (PAST). All graphs were plotted using Microsoft Excel 2016.

## RESULTS

**Abundance of aquatic insects:** The occurrence of aquatic insects across three sampling stations at Ala Stream, Akure, Nigeria is presented in Table 1. The study recorded a total of 815 individuals representing 19 genera and 11 families. The family Chironomidae contributed the highest number of individuals with 296 (36.32%), predominantly from the genus *Chironomus*. Libellulidae followed with 191 individuals (23.44%), represented by the genera *Branchithemis* (77 individuals, 9.45%), *Orthetrum* (73 individuals, 8.96%), *Plathemis* (25 individuals, 3.07%), and *Trithemis* (16 individuals, 1.96%).

Culicidae recorded 124 individuals (15.22%), with contributions from *Culex* (66 individuals, 8.10%) and *Anopheles* (58 individuals, 7.12%). Gerridae accounted for 87 individuals (10.67%), predominantly from *Gerris* (56 individuals, 6.87%). Coenagrionidae had 73 individuals (8.96%), primarily from *Ceriagrion* and *Pseudagrion*. Other families, including Nepidae, Corixidae, Elmidae, Dytiscidae, and Hydrophilidae, each contributed less than 3% to the total population. Station 2 recorded the highest number of individuals with 532, followed by Station 3 with 215, and Station 1 with the least at 68 individuals.

**Diversity indices of the aquatic insects:** The diversity indices of insects recorded across the three stations at Ala stream is shown in Table 2. Station 1 recorded the lowest taxa richness (6 taxa) and the fewest individuals (68), while Stations 2 and 3 both had higher taxa richness (16 taxa each) and individual counts of 532 and 215, respectively. Simpson's diversity index (1-D) was lowest at Station 1 (0.3997), indicating lower diversity, and highest at Station 3 (0.8551). Similarly, the Shannon-Wiener index (H') showed an increasing trend from Station 1 (0.8803) to Station 3 (2.339). Margalef's index, which reflects species richness, was highest at Station 3 (2.793) and lowest at Station 1 (1.185). Equitability (J) and Evenness (^H/S) indices also followed similar patterns, with Station 1 having the lowest values (0.4913 and 0.4019) and Station 3 the highest (0.8437 and 0.6484), indicating a more even distribution of species in Stations 2 and 3 compared to Station 1.

Table 1: Aquatic insect occurrence at the three study stations at Ala Stream, Akure, Nigeria

| | | | Station | | | | |
|---|---|---|---|---|---|---|---|
| | Family | Genus | 1 | 2 | 3 | Total | Occurance (%) |
| Odonata | Libellulidae | Brachythemis | 0 | 58 | 19 | 77 | 9.45 |
| | | Orthetrum | 0 | 55 | 18 | 73 | 8.96 |
| | | Plathemis | 0 | 15 | 10 | 25 | 3.07 |
| | | Trithemis | 0 | 7 | 9 | 16 | 1.96 |
| | Coenagrionidae | Ceriagrion | 0 | 33 | 12 | 45 | 5.52 |
| | | Pseudagrion | 0 | 12 | 5 | 17 | 2.09 |
| | | Ischnura | 0 | 8 | 3 | 11 | 1.35 |
| | Gerridae | Aquarius | 3 | 10 | 7 | 20 | 2.45 |
| | | Gerris | 7 | 35 | 14 | 56 | 6.87 |
| | | Metrobates | 1 | 6 | 4 | 11 | 1.35 |
| | Nepidae | Nepa | 2 | 0 | 0 | 2 | 0.25 |
| | Corixidae | Sigara | 0 | 3 | 2 | 5 | 0.61 |
| Coleoptera | Elmidae | Macrelmis | 0 | 0 | 5 | 5 | 0.61 |
| | Dytiscidae | Cybister | 3 | 14 | 4 | 21 | 2.58 |
| | Hydrophilidae | Hydrobius | 0 | 11 | 0 | 11 | 1.35 |
| Diptera | Chironomidae | Chironomus | 52 | 175 | 69 | 296 | 36.32 |
| | Culicidae | Anopheles | 0 | 43 | 15 | 58 | 7.12 |
| | | Culex | 0 | 47 | 19 | 66 | 8.10 |
| Total | | | 68 | 532 | 215 | 815 | 100 |

Table 2: Diversity of insects found in each station

| Diversity indices | Station 1 | Station 2 | Station 3 |
|---|---|---|---|
| Taxa-S | 6 | 16 | 16 |
| Individuals | 68 | 532 | 215 |
| Simpson (1-D) | 0.3997 | 0.8434 | 0.8551 |
| Shannon Wiener (H') | 0.8803 | 2.248 | 2.339 |
| Margalef | 1.185 | 2.390 | 2.793 |
| Equitability-J | 0.4913 | 0.8107 | 0.8437 |
| Evenness (^H/S) | 0.4019 | 0.5917 | 0.6484 |

Table 3: Physicochemical parameters of Ala Stream

| Parameters | Station 1 | Station 2 | Station 3 | Recommended standard (WHO) |
|---|---|---|---|---|
| pH | 6.83±0.03[a] | 6.88±0.03[a] | 6.83±0.03[a] | 6.50-8.5 |
| Temperature (°C) | 27.87±0.30[a] | 27.83±0.21[a] | 27.85±0.16[a] | |
| Water depth (m) | 0.15±0.01[a] | 0.39±0.05[b] | 0.13±0.01[a] | None |
| Flow rate (m/s) | 0.34±0.02[a] | 0.29±0.03[a] | 0.29±0.02[a] | None |
| EC (µS/cm) | 261.89±1.66[a] | 316.39±1.07[b] | 305.44±0.75[b] | <1000 |
| TDS (mg/L) | 129.44±1.30[a] | 172.39±1.19[c] | 156.94±1.15[b] | <500 |
| DO (mg/L) | 5.04±0.02[b] | 4.85±0.02[a] | 5.00±0.02[b] | >5 |
| Nitrate (mg/L) | 13.70±0.55[a] | 20.80±0.58[c] | 19.10±0.37[b] | <50 |
| Phosphate (mg/L) | 16.39±0.53[a] | 16.33±0.52[a] | 16.31±0.53[a] | |
| Sulphate (mg/L) | 51.57±1.61[a] | 64.23±2.19[b] | 61.77±2.02[b] | <100 |

[abc]Statistically significant differences between stations for a given parameter, while the same letter denotes no significant difference

**Physicochemical parameters:** The physicochemical parameters of Ala Stream across the three stations are outlined (Table 3), showing that pH ranged between 6.83±0.03 and 6.88±0.03, within the WHO recommended standard of 6.50-8.5. Temperature remained relatively constant, varying from 27.83±0.21 to 27.87±0.30°C. Water depth was highest at Station 2 (0.39±0.05 m) compared to Stations 1 (0.15±0.01 m) and 3 (0.13±0.01 m). Electrical conductivity (EC) values were 261.89±1.66 µS/cm at Station 1, 316.39±1.07 µS/cm at Station 2, and 305.44±0.75 µS/cm at Station 3, all below the WHO limit of <1000 µS/cm. Total dissolved solids (TDS) ranged from 129.44±1.30 mg/L at Station 1 to 172.39±1.19 mg/L at Station 2, also within the WHO limit of <500 mg/L. Dissolved oxygen (DO) was lowest at Station 2 (4.85±0.02 mg/L) but remained slightly below the recommended standard of >5 mg/L, while nitrate concentrations ranged from 13.70±0.55 mg/L at Station 1 to 20.80±0.58 mg/L at Station 2, all within the WHO limit of <50 mg/L. Phosphate concentrations were consistent across the stations, ranging from 16.31±0.53 to 16.39±0.53 mg/L, while sulfate levels were higher at Stations 2 (64.23±2.19 mg/L) and 3 (61.77±2.02 mg/L) compared to Station 1 (51.57±1.61 mg/L), remaining below the WHO standard of <100 mg/L.

**Correlation coefficient between aquatic insects and physicochemical parameters:** The Pearson correlation coefficient values between aquatic insect families and physicochemical parameters of Ala Stream indicate varying degrees of relationships. For Libellulidae, water depth showed a strong positive correlation (r = 0.675), while other parameters showed low to moderate correlations Coenagrionidae exhibited strong positive correlations with temperature (r = 0.714) and a strong negative correlation with pH.

Dytiscidae showed weak correlations across parameters, with the highest positive value observed for temperature (r = 0.394). Elmidae displayed a positive correlation with pH (r = 0.589). Hydrophilidae had moderate positive correlations with water depth (r = 0.552) but negative correlations with flow rate (r = -0.405) and other parameters.

Gerridae revealed a significant negative correlation with pH (r = -0.863, $p<0.05$), and Culicidae showed a significant negative correlation with flow rate (r = -0.962, $p<0.01$). Nepidae correlated positively with dissolved oxygen (r = 0.682) and negatively with nitrate (r = -0.719). Chironomidae and Corixidae exhibited weak to moderate correlations across parameters shown in Table 4.

Table 4: Pearson (r) correlation coefficient values of aquatic insect families with physicochemical parameters at Ala Stream

| Parameters | pH | Temperature (°C) | WD (m) | Flowrate (m/s) | EC (mg/L) | TDS (mg/L) | DO (mg/L) | $NO_3$ (mg/L) | $PO_4$ (mg/L) | $SO_4^{2-}$ (mg/L) |
|---|---|---|---|---|---|---|---|---|---|---|
| Libellulidae | -0.394 | 0.062 | 0.675 | 0.139 | -0.101 | -0.198 | 0.364 | -0.566 | -0.488 | -0.394 |
| Coenagrionidae | -0.702 | 0.714 | 0.211 | -0.431 | 0.503 | 0.497 | -0.348 | 0.205 | 0.498 | 0.511 |
| Dytiscidae | -0.380 | 0.394 | -0.004 | -0.027 | 0.294 | 0.207 | -0.133 | 0.043 | 0.253 | 0.240 |
| Elmidae | 0.589 | -0.354 | -0.391 | 0.166 | -0.091 | -0.148 | 0.025 | 0.210 | 0.106 | -0.024 |
| Hydrophilidae | -0.362 | 0.133 | 0.552 | -0.405 | -0.310 | -0.023 | 0.185 | -0.274 | -0.009 | 0.015 |
| Gerridae | -0.863* | 0.789 | 0.537 | -0.652 | 0.459 | 0.530 | -0.301 | 0.124 | 0.478 | 0.508 |
| Nepidae | 0.133 | -0.382 | 0.129 | 0.609 | -0.607 | -0.629 | 0.682 | -0.719 | -0.506 | -0.551 |
| Corixidae | -0.108 | -0.061 | 0.569 | 0.125 | -0.080 | -0.229 | 0.370 | -0.413 | -0.318 | -0.337 |
| Chironomidae | -0.426 | 0.133 | 0.622 | -0.134 | 0.055 | 0.043 | 0.065 | -0.291 | -0.434 | -0.248 |
| Culicidae | -0.766 | 0.792 | 0.410 | -0.962** | 0.579 | 0.760 | -0.613 | 0.476 | 0.604 | 0.689 |

*Correlation is significant at the 0.05 level (2-tailed) and **Correlation is significant at the 0.01 level (2-tailed)

## DISCUSSION

The occurrence of aquatic insects across three sampling stations at Ala Stream, Akure, Nigeria, showed significant variations in diversity and abundance. A total of 815 individuals, representing 19 genera from 11 families, were identified. Chironomidae was the most dominant, followed by Libellulidae and Culicidae. The high abundance of Chironomidae aligns with findings from similar studies in freshwater ecosystems, where chironomids are often indicators of organic pollution. Previous research in Nigerian freshwater bodies[8] reported the dominance of Chironomidae in streams with moderate pollution levels.

Libellulidae, comprising Branchithemis, Orthetrum, Plathemis, and Trithemis, was the second most abundant family. Similar observations were reported by Adu *et al.*[9] in a study of dragonfly diversity in southwestern Nigeria, where Libellulidae was among the most frequently encountered groups due to their preference for slow-moving waters. The presence of Culicidae, particularly Culex, and Anopheles, is consistent with studies in other tropical regions, where these genera thrive in stagnant or low-flow environments with organic matter accumulation.

Among the sampling stations, the second station recorded the highest number of individuals, followed by the third, while the first station had the lowest count. This pattern is similar to Ganguly *et al.*[10] that insect diversity and abundance tend to be higher in areas with more stable water quality and vegetation cover. The first station, with the lowest abundance, could be influenced by higher anthropogenic activities, as suggested by studies in similar urban-influenced streams[11].

Diversity indices reflected variations across the sampling stations. The Shannon-Wiener and Simpson indices were lowest at the first station, indicating lower diversity, while the highest values were observed at the third station. These results are in line with earlier findings in freshwater bodies, where pollution and habitat disturbance negatively impact species richness[12]. The higher diversity at the third station suggests a relatively stable environment, supporting findings from studies that associate increased species richness with improved water quality and habitat complexity[13].

Physicochemical parameters varied across the stations. The pH remained within the recommended range, consistent with studies in similar freshwater environments where pH stability supports diverse aquatic life[14]. Temperature showed minimal variation, aligning with previous studies that report relatively stable temperature conditions in tropical freshwater ecosystems[15]. Electrical conductivity and total dissolved solids were highest at the second station, a pattern observed in other urban-influenced water bodies[16]. Dissolved oxygen was slightly lower at the second station, which may have influenced insect distribution, as documented by earlier studies linking low oxygen levels to reduced macroinvertebrate diversity[17].

Correlations between aquatic insect families and physicochemical parameters revealed important trends. Libellulidae showed a positive correlation with water depth, similar to findings of Olomukoro and Dirisu[18], that dragonflies prefer deeper waters with moderate flow. Coenagrionidae had a strong positive correlation with temperature, aligning with studies indicating that damselflies thrive in warmer conditions[19]. Gerridae exhibited a significant negative correlation with pH, a trend also observed in studies where, pH fluctuations affected surface-dwelling insects[16]. These relationships highlight how physicochemical factors shape insect distribution, reinforcing previous research findings in tropical freshwater ecosystems.

Overall, the study's findings align with previous research on aquatic insect diversity and environmental influences. Variations in diversity across stations are consistent with patterns observed in similar ecosystems, where anthropogenic activities and water quality fluctuations impact insect distribution. The correlations between insect families and physicochemical parameters further support established ecological relationships in freshwater environments.

## CONCLUSION

The study assessed the biodiversity of aquatic insects and water quality of Ala Stream at Roadblock, Akure, Ondo State, Nigeria. Results revealed variations in insect diversity and abundance across sampling stations, with Chironomidae being the most dominant family. Differences in diversity indices and physicochemical parameters indicated that water quality influenced insect distribution. Higher diversity was associated with better water conditions, while lower diversity corresponded with signs of pollution. The findings highlight the potential of aquatic insects as bioindicators for freshwater ecosystem health and emphasize the need for continuous monitoring and conservation efforts to maintain the ecological integrity of Ala Stream.

## SIGNIFICANCE STATEMENT

Freshwater ecosystems are increasingly threatened by anthropogenic activities, necessitating effective monitoring strategies to assess water quality. This study highlights the use of aquatic insects as bioindicators alongside physicochemical parameters to evaluate the ecological health of the Ala Stream in Akure, Nigeria. The findings reveal significant variations in insect diversity and water quality across different sampling stations, indicating localized pollution impacts. By demonstrating the strong correlation between aquatic insect assemblages and key water quality parameters, this study reinforces the importance of biomonitoring in freshwater assessment. The results provide critical baseline data for policymakers, conservationists, and water resource managers, supporting the implementation of sustainable strategies for freshwater ecosystem management and pollution control in Nigeria.

## REFERENCES

1. Adu, B.W. and R.O. Owaseye, 2023. Assessment of water quality utilizing insect biotic indices and physicochemical parameter in Awule and Ala Streams in Akure, Ondo State, Nigeria. Adv. J. Sci. Eng. Technol., 8: 1-12.
2. Komolafe, B.O. and T.O.T. Imoobe, 2020. Aquatic insects diversity and water quality assessment of a tropical freshwater pond in Benin City, Nigeria. J. Appl. Sci. Environ. Manage., 24: 1129-1136.
3. van Nguyen, H., C. van Duong, N. Sareein, C.J.C. Uy-Yabut, A.D. Tran and V. van Nguyen, 2024. Biodiversity of aquatic insects and water quality parameters in Thac Bac Stream, Tam Dao National Park, Vietnam. Chiang Mai J. Sci., Vol. 51. 10.12982/CMJS.2024.092.
4. Arimoro, F.O. and W.J. Muller, 2010. Mayfly (Insecta: Ephemeroptera) community structure as an indicator of the ecological status of a stream in the Niger Delta area of Nigeria. Environ. Monit. Assess., 166: 581-594.
5. Payakka, A. and T.O. Prommi, 2014. Aquatic insects biodiversity and water quality parameters of receiving water body. Curr. World Environ. J., 9: 53-58.
6. Umar, D.M., J.S. Harding and M.J. Winterbourn, 2013. Freshwater Invertebrates of the Mambilla Plateau, Nigeria. University of Canterbury-School of Biological Sciences, New Zealand, ISBN: 9780473254896, Pages: 86.

7. Subramanian, K.A. and K.G. Sivaramakrishnan, 2005. Habitat and microhabitat distribution of stream insect communities of the Western Ghats. Curr. Sci., 89: 976-987.
8. Adu, B.W. and E.A. Oyeniyi, 2019. Water quality parameters and aquatic insect diversity in Aahoo Stream, Southwestern Nigeria. J. Basic Appl. Zool., Vol. 80. 10.1186/s41936-019-0085-3.
9. Adu, B.W., S.S. Ogbogu and K.A. Kemabonta, 2015. Dragonflies and damselflies (Insecta: Odonata) as tools for habitat quality assessment and monitoring. FUTA J. Res. Sci., 1: 36-45.
10. Ganguly, I., L. Patnaik and S. Nayak, 2018. Macroinvertebrates and its impact in assessing water quality of riverine system: A case study of Mahanadi River, Cuttack, India. J. Appl. Nat. Sci., 10: 958-963.
11. Nayak, S.B., K. Elango and K.S. Rao, 2021. Insect Biodiversity and Their Conservation for Sustainable Ecosystem Functioning. In: Biological Diversity: Current Status and Conservation Policies, Kumar, V., S. Kumar, N. Kamboj and T. Payum (Eds.), Agriculture Environmental Science Academy, Haridwar, India, ISBN: 978-81-954996-4-9, pp: 304-314.
12. Onyenwe, E., E.D. Anyanwu and G.I. Nnyama, 2018. Preliminary assessment of aquatic insects biodiversity and water quality parameters of Anya River, Umudike, South East, Nigeria. Anim. Res. Int., 15: 3041-3047.
13. Majumder, J., R.K. Das, P. Majumder, D. Ghosh and B.K. Agarwala, 2013. Aquatic insect fauna and diversity in urban fresh water lakes of Tripura, Northeast India. Middle-East J. Sci. Res., 13: 25-32.
14. Patil, P.N., D.V. Sawant and R.N. Deshmukh, 2012. Physico-chemical parameters for testing of water-A review. Int. J. Environ. Sci., 3: 1194-1207.
15. Abdel Shakour, M.A., R.A. Abdel Salam, G.M. Hadad and D.T.A. Youssef, 2019. Assessment of physicochemical parameters of freshwater and tap water in Suez Canal Region, Egypt. Rec. Pharm. Biomed. Sci., 3: 69-80.
16. Jarjees, F.Z., N.S. Hanna and J.J. Toma, 2019. Biodiversity of aquatic insects in relation to physico-chemical parameters of Shekh Turab Stream. Passer J. Basic Appl. Sci., 2: 12-16.
17. Prommi, T. and A. Payakka, 2015. Aquatic insect biodiversity and water quality parameters of streams in Northern Thailand. Sains Malaysiana, 44: 707-717.
18. Olomukoro, J.O. and A.R. Dirisu, 2014. Macroinvertebrate community and pollution tolerance index in Edion and Omodo Rivers in derived Savannah Wetlands in Southern Nigeria. Jordan J. Biol. Sci., 7: 19-24.
19. Gupta, N., R.C. Sharma and A.K. Tripathi, 2008. Study of bio-physico-chemical parameters of Mothronwala Swamp, Dehradun (Uttarakhand). J. Environ. Biol., 29: 381-386.