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Ecological Factors Favouring Mosquito Breeding in Akure South Metropolis, Ondo State

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ABSTRACT: Mosquitoes are major vectors of many infectious diseases, and they strongly relate their abundance to the ecological attributes of their breeding sites. With a focus on the physico-chemical and physical characteristics of larval habitats and their correlation with larval density, abundance, and species distribution, this study examined the ecological factors that favour mosquito breeding in Akure South Metropolis, Ondo State, Nigeria. Field sampling was done across selected wards where mosquito larvae could be collected from identified breeding sites using standard dipping techniques, reared to adulthood, and identified morphologically. Water temperature, pH, dissolved oxygen, electrical conductivity, total dissolved solids, habitat length, breadth, depth, and distance to the nearest building were measured on-site. A total of 4,001 adult mosquitoes belonging to four genera (Culex, Aedes, Anopheles, and Toxorhynchites) were recorded, with Culex species being the most abundant and widely distributed Isikan showed the highest mosquito distribution, larval abundance, and dissolved oxygen, whereas Odopetu showed the highest electrical conductivity and total dissolved solids, reflective of higher ionic and organic enrichment. Correlation analysis revealed that larval density was positively associated with pH and dissolved oxygen, indicating preference for moderately acidic to near-neutral and well-oxygenated waters, but negatively correlated with temperature, total dissolved solids, and electrical conductivity, suggesting that excessive heat and chemical enrichment may limit larval survival. Physical habitat characteristics further influenced larval distribution, as larval density was positively correlated with habitat length and proximity to buildings, but negatively correlated with habitat breadth and depth, demonstrating that shallow, narrow, elongated water bodies close to human dwellings are more favourable for mosquito breeding than wider and deeper habitats. The study shows that mosquito breeding in Akure South Metropolis is strongly driven by an interaction of water quality, habitat structure, and anthropogenic activities, highlighting the need for improved environmental sanitation, drainage management, and targeted larval source reduction to effectively control mosquito populations and reduce the risk of mosquito-borne diseases.

KEYWORDS: Ecological Factors, Mosquitoes, Breeding, Akure South, Ondo State

INTRODUCTION

Mosquitoes are small, midge-like flies of the family Culicidae; the female species are hematophagous, whose tube-like mouthparts, called the proboscis, pierce the hosts' skin to consume blood (Adeyekun *et al*., 2025). Thousands of species feed on the blood of various kinds of hosts, mainly vertebrates, including mammals, birds, reptiles, amphibians, and even some kinds of fish (Adeogun *et al*., 2023). Many species of mosquito act as vectors of diseases; some transmit extremely harmful infections such as malaria, yellow fever, West Nile virus, dengue fever, filariasis, and other arboviruses, rendering this dipterous insect family the deadliest animal family in the known world of diseases (Adeyekun, 2021). Good understanding of the breeding ecology of these organisms, including the types and preferences for larval habitats as well as the physical, biological, and chemical characteristics of the habitats, is required to make vector control measures successful (Adeyekun *et al.*, 2021).

All types of lentic aquatic habitats can be used for breeding, and mosquito larvae have been found to thrive in aquatic bodies such as fresh or salt water marshes, swamps, plantations, grassy ditches, streams, lakes and rivers, and small, temporary rain pools, while some breed in habitats with vegetation cover and some breed in open, sunlit pools (Oniya *et al*., 2019). Various studies of larval habitats of mosquitoes in Nigeria found that abandoned vehicle tires, used and abandoned containers, stagnant pools, unused septic tanks, etc. contained high numbers of these nuisance organisms that act as vectors of debilitating diseases (Idowu *et al*., 2014; Afolabi *et al*., 2019). The oviposition preferences of gravid females and the ability of immature stages of mosquitoes to survive both biotic and abiotic environmental conditions of a given aquatic habitat determine the abundance and distribution of mosquito larvae (Day, 2016). Breeding sites of *Aedes aegypti* are closely related to macro- and micro-ecological factors that are determined by human behaviors such as individual, collective, and institutional ones and their related social, economic, and political status (Quintero *et al*., 2014). *Anopheles* mosquitoes, which are vectors for malaria, often breed in clean, sunlit water, making areas with such conditions more prone to malaria transmission, while *Culex* spp. have been observed to breed in polluted water (Adeyekun, 2021).

The intricate relationship between mosquitoes and their habitat environments has long been recognized as a crucial determinant of mosquito population dynamics and disease transmission patterns (Ferraguti *et al*., 2021). Rapid urbanization, poor waste management practices, deforestation, agricultural expansion, and increased human activities have contributed to changes in the quality of water bodies and the creation of numerous artificial breeding habitats (Bartilol *et al*., 2021). These environmental modifications often result in stagnant pools, drainage channels, household containers, gutters, and polluted sites that serve as productive larval habitats (Gbaye *et al*., 2017). The concentration and distribution of mosquito breeding sites can significantly influence the geographical spread of diseases, impacting public health measures and resource allocation (Foster and Walker, 2019).

The physico-chemical characteristics of mosquito breeding sites may have some effect on mosquito vectors' oviposition, survival, and spatial distribution, and of these physico-chemical properties, temperature, dissolved oxygen, pH, turbidity, total dissolved solids, water hardness, and the presence of various ions such as chloride and nitrate were known to influence the presence and abundance of larval mosquito species (Seal and Chatterjee, 2023). These factors must also successfully support the development of the immature stages, from the first-instar larvae to the emergence of the adult stage of the mosquitoes (Agyekum *et al*., 2022). The immature stages of mosquitoes have body temperatures that vary depending on the outside temperature; this makes them depend on the temperature of the aquatic habitat (Abiodun *et al.*, 2016). The electrical conductivity is an important parameter used to estimate the level of dissolved salts in water and soil (Corwin and Yemoto, 2017). An increase in conductivity of the aquatic environment may be an indicator that pollutants have been discharged into the habitat (Emidi *et al*., 2017). Mosquito larvae have been found to adapt to ranges of ambient pH that are higher than those tolerated by other aquatic organisms (Ukubuiwe *et al*., 2020). Larvae of mosquitoes are not affected by reduction of dissolved oxygen since atmospheric oxygen is readily accessible, and in the absence of atmospheric oxygen, mosquito larvae use dissolved oxygen (Yamada *et al*., 2020). The diversity of mosquito species and their ability to thrive under varying physico-chemical conditions demonstrate the need for continuous research on the relationship between water quality and mosquito breeding (Owolabi and Bagbe, 2019).

Shallow water depth is especially critical, as most mosquito larvae are surface feeders and rely on frequent access to atmospheric oxygen; consequently, higher larval densities are often reported in sites with depths less than 30 cm compared to deeper water bodies (Adeyekun *et al.*, 2025). Adeyekun *et al.* (2022) reported that *Aedes* mosquitoes adapt to a wide range of depths, as they nominated most of the habitats, revealing that depth is a major factor in the distribution of mosquitoes. Length also has a significant effect on the breeding of *Culex* species, as the higher the length values, the greater the reduction of their presence (Adeyekun *et al.*, 2025). The objective of this study is to understand the ecology of breeding sites of mosquitoes in Akure South Metropolis in order to identify larva preferences of different mosquitoes across the study area.

MATERIALS AND METHODS

Study Area

Akure South (Fig. 1) is one of the 18 local governments of Ondo State, Nigeria, which lies between latitude 5° 45′ and 8° 15′ North and longitude 4° 45′ and 6° East (Olugbamila, 2018). The state is bounded in the northwest by Ekiti State, in the west-central by Osun State, in the southeast by Ogun State, in the southeast by Delta State, and in the south by the Atlantic Ocean. The state lies in the tropical rainforest biome with excellent vegetation that spawns almost all year round, indicative of a good breeding environment for all sorts of fauna and flora. The local government area has a landmass of 331 km² and comprises a total of 360,268 people at the 2006 census, and with an annual growth rate of 3.03%, the projected population of the LGA in the year 2015 is put at 471,100. The increase in annual growth of the population is as a result of the administrative role of the town as well as its longstanding role as a center of economic activities, which keeps attracting a large number of immigrants into it. The area thus encompasses various sectors of the workforce: the government house, various manufacturing companies, educational institutions, small firms, etc. (Afolabi *et al*., 2019). The climate in the study area is tropical with two distinct seasons, the rainy season (April–October) and the dry season (November–March), with slight variations from year to year. The annual rainfall varies from 1150 mm in the northern parts to 2000 mm in the southern area; the area generally enjoys luxuriant vegetation. The LGA comprises eleven (11) wards, such as Apomu, Gbogi/Isikan I, Gbogi/Isikan II, Ijomu/Obanla, Lisa, Oda, Odopetu, Oke-Aro/Uro I, Oke-Aro/Uro II, Oshodi/Isolo, and Owode/Imuagun.

Study Method

This research was conducted for two weeks, from October 13 to October 29, 2025. Advocacy visits were paid to the heads of the communities before samplings. Samplings were done randomly during the day between 6:30am and 10am by searching for breeding sites at the four cardinal areas, starting from the epicenter of the communities. Apparatus used on the field included Surveying tape was used to measure the length and breadth of the breeding sites as well as the nearest building; a Garmin GPS (USA) device was used to determine the coordinates of each location and the breeding sites; a meter rule was used for measuring the depth of the breeding sites; a hand-held multimeter by Yieryi, China, was used for measuring the physico-chemical parameters (pH, temperature, electrical conductivity, and total dissolved solids); and a dissolved oxygen meter by Lutron Electronic Enterprise Co., Ltd., Taiwan, was used to determine the dissolved oxygen of the breeding sites. These parameters were chosen based on the direct effects they have on Dipterous breeding. The Multimeter was calibrated

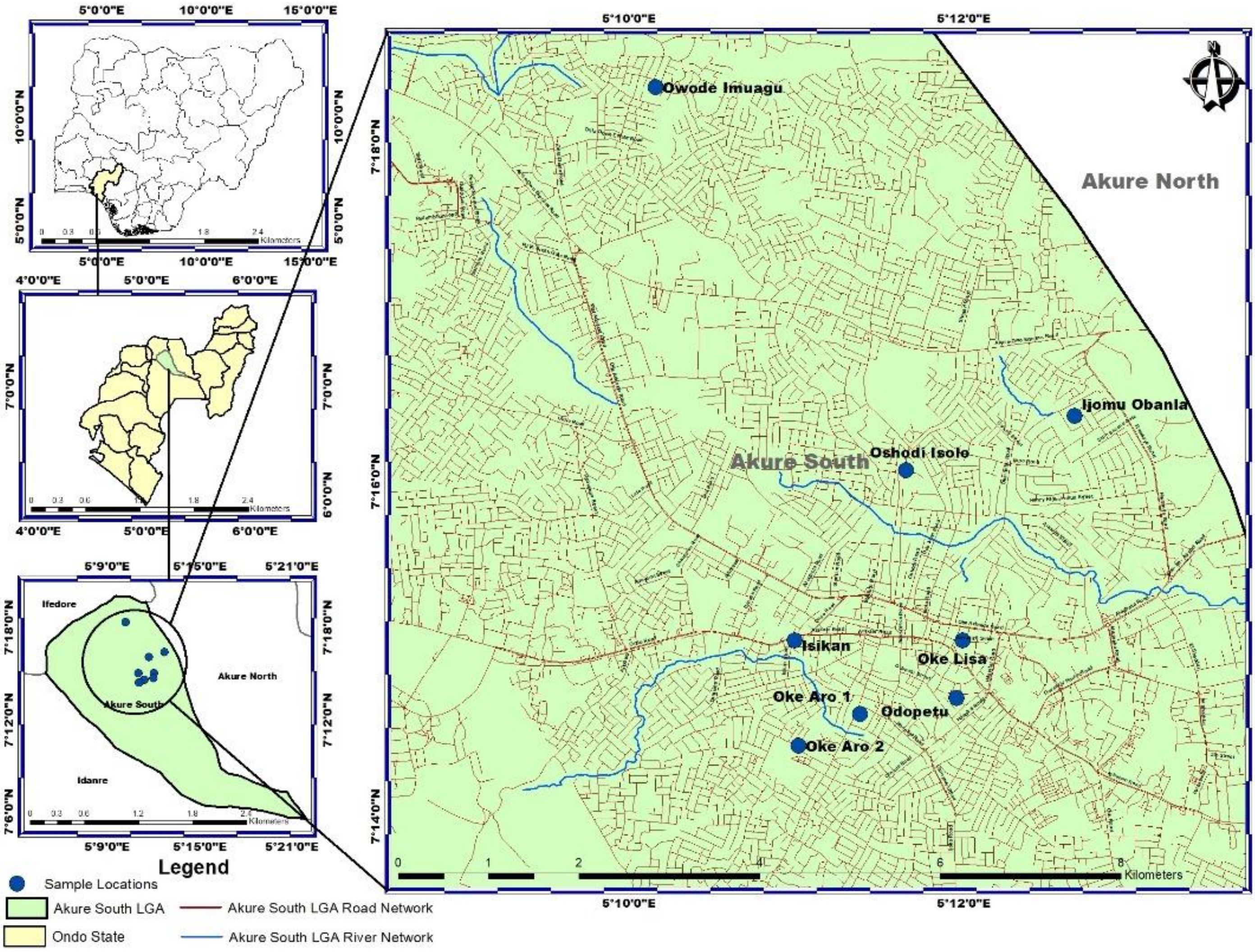

Fig. 1: Administrative Map of the Study Area

before usage based on manufacturers' instructions and reagents. 2–10 dips of water samples were taken with standard dipping techniques, and the mosquito larvae collected were transferred into the transportation containers. Experimental gloves and safety boots were worn to prevent contact with the polluted water. Other equipment used were Pasteur pipettes used for suctioning fauna, white handkerchiefs, and sieves. Collected larvae samples from each site were taken to the laboratory and placed in rearing cages for rearing into the adult stage. Adult mosquitoes thereafter were preserved in 1.5 ml Eppendorf tubes containing prepared silica gel and were identified with the aid of a digital microscope.

Statistical Analyses

Larvae density and larvae abundance were calculated immediately at the study site to determine the number of larvae collected per site and community.

$$\text{Larvae density} = \frac{\text{Total number of larvae per site}}{\text{Total volume of water, in ml}}$$

$$\text{Larvae Abundance} = \frac{\text{Total number of larvae in a location}}{\text{Total number of positive sites}}$$

The means of physico-chemical parameters and physical descriptions, correlation coefficients between physico-chemical parameters, physical description of sites and larvae density were determined by correlation analysis and comparison of the means using SPSS (Statistical Package for Social Science) version 24.0.

RESULTS

Table 1 showed the means of larvae density, larvae abundance, emerged adults, and the colour of the breeding water. The result revealed that Oke-Aro I had the highest mean larvae density (1.08 ± 1.11), followed by Isikan (0.99 ± 1.05), and the lowest mean larvae densities were recorded in Odopetu (0.22 ± 0.07) and Oke-Aro II (0.23 ± 0.18). Isikan had the highest mean larvae abundance (461.43 ± 544.56), followed by Oke-Aro II (292.5 ± 388.53) and Oke-Lisa (277.5 ± 203.70), while Oke-Aro I had the lowest mean larvae abundance (85.00 ± 15.03). The mean of emerged adults was seen to be highest in Isikan (155.875 ± 270.97), followed by Oke-Aro I (117.88 ± 219.80), and the lowest mean of emerged adults was recorded in Oshodi/Isolo (13.13 ± 27.47). The results revealed significant differences across the means of larvae density, larvae abundance, and emerged adults. The result also indicated that most of the water in each breeding site sampled was highly polluted, green and black in colour, and turbid.

Table 2 revealed the means of physico-chemical parameters and larvae density of water samples in the study area. It was seen that the highest temperature of the breeding sites was recorded in Ijomu/Obanla (39.00 ± 26.43), followed by Oke-Lisa (34.33 ± 1.86). Oke-Aro I, Isian, Owode/Imuagun, and Odopetu had a moderate temperature; Oshodi/Isolo had a low water temperature (24.53 ± 1.17), while Oke-Aro II had the lowest mean temperature in the study area (23.23 ± 1.79). The pH of the breeding sites recorded in Oke-Aro II, Isikan, Owode/Imuagun, Oke-Aro I, and Odopetu were all acidic, while Oshodi/Isolo revealed a neutral pH (7.01 ± 0.64). The pH recorded was within the required limit for mosquito breeding except for Ijomu/Obanla (5.71 ± 0.33) and Oke-Lisa (5.52 ± 0.12), which had the lowest pH recorded. The highest total dissolved solid was recorded in Odopetu (1128.64 ± 5.64), followed by Isikan (793.10 ± 8.37), and the lowest was

Table 1: Means of Larvae Density, Larvae Abundance, Emerged Adult and Colour of Water

Locations	Geo-Reference	Mean of Larvae Density	Mean of Larvae Abundance	Means of Emerged Adult	Colour of the Water
Isikan	7.15058^0, 5.1096^0	0.99 ± 1.05^a	461.43 ± 544.56^a	155.875 ± 270.97^a	Green, Polluted
Oke-Aro I	7.1462^0, 5.11361^0	1.08 ± 1.11^a	85.00 ± 15.03^d	117.88 ± 219.80^{bc}	Black, Turbid
Oke-Aro II	7.14394^0, 5.11009^0	0.23 ± 0.18^c	292.5 ± 388.53^{ab}	43.00 ± 79.22^d	Black, Turbid
Ijomu/Obanla	7.15374^0, 5.11909^0	0.32± 0.05^b	135.25 ± 116.75^{bc}	25.5 ± 41.20^e	Polluted
Oke-Lisa	7.15098^0, 5.12162^0	0.31 ± 0.16^b	277.5 ± 203.70^{ab}	52.75 ± 93.14^{cd}	Polluted, Turbid
Owode/Imuagun	7.15532^0, 5.11416^0	0.37 ± 0.25^b	172.5 ± 73.65^{bc}	50.75 ± 94.19^{cd}	Green, Polluted, Turbid
Odopetu	7.1486^0, 5.11717^0	0.22 ± 0.07^c	140.00 ± 96.70^{cd}	19.875 ± 32.87^e	Green, Black, Polluted
Oshodi/Isolo	7.16097^0, 5.11653^0	0.48 ± 0.06^{ab}	176.00 ± 48.87^{bc}	13.13 ± 27.47^e	Black, Turbid

Means having the same alphabet down the column are not significantly different from one another at p >0.05.

Table 2: Means of Physico-Chemical Parameters Measured in the Study Area

Locations	TEMP (°C)	pH	TDS (mg/L)	EC (µS/cm)	DO (mg/L)	Larvae Density
Isikan	26.80 ± 2.63^{c}	6.73 ± 0.73^{ab}	793.10 ± 8.37^{c}	1745.69 ± 1.52^{b}	25.58 ± 2.60^{a}	0.99 ± 1.05^{a}
Oke-Aro I	28.65 ± 2.46^{bc}	6.45 ± 1.03^{b}	170.91 ± 2.49^{e}	337.28 ± 4.94^{e}	22.10 ± 0.99^{a}	1.08 ± 1.11^{a}
Oke-Aro II	23.23 ± 1.79^{c}	6.93 ± 0.36^{a}	578.70 ± 5.08^{d}	1158.22 ± 1.01^{c}	21.15 ± 9.82^{a}	0.23 ± 0.18^{c}
Ijomu/Obanla	39.00 ± 26.43^{a}	5.71 ± 0.33^{c}	175.53 ± 2.34^{e}	354.47 ± 4.70^{e}	7.10 ± 2.35^{b}	0.32 ± 0.05^{b}
Oke-Lisa	34.33 ± 1.86^{ab}	5.52 ± 0.12^{c}	68.51 ± 5.84^{f}	157.13 ± 1.16^{f}	6.60 ± 0.67^{b}	0.31 ± 0.16^{b}
Owode/Imuagun	26.20 ± 2.21^{c}	6.68 ± 0.47^{ab}	454.31 ± 6.69^{d}	906.86 ± 1.34^{cd}	6.73 ± 1.27^{b}	0.37 ± 0.25^{b}
Odopetu	25.43 ± 1.44^{c}	6.19 ± 0.76^{b}	1128.64 ± 5.64^{a}	2234.66 ± 2.45^{a}	6.20 ± 1.54^{b}	0.22 ± 0.07^{c}
Oshodi/Isolo	24.53 ± 1.17^{c}	7.01 ± 0.64^{a}	309.28 ± 5.38^{de}	626.05 ± 1.09^{d}	5.23 ± 1.47^{c}	0.48 ± 0.06^{ab}

Means having the same alphabet down the column are not significantly different from one another at p >0.05.
KEY:
TEMP: Temperature
TDS: Total Dissolved Solid
EC: Electrical Conductivity
DO: Dissolved Oxygen

recorded in Oke-Lisa (68.51 ± 5.84). Odopetu also recorded the highest electrical conductivity in the study area (2234.66 ± 2.45), followed by Oke-Aro II (1158.22 ± 1.01), while the lowest electrical conductivity was recorded in Oke-Lisa (157.13 ± 1.16). The highest dissolved oxygen was recorded in Isikan (25.58 ± 2.60), followed by Oke-Aro I (22.10 ± 0.99) and Oke-Aro II (21.15 ± 9.82), and the lowest was recorded in Oshodi/Isolo (5.23 ± 1.47). There exist significant differences among the means of the physico-chemical parameters in the study area. Figs. 2-6 showed the physico-chemical parameters of the study area. Table 3 revealed the correlation of physico-chemical parameters and larvae density of water samples in the study area. The result showed that larvae density had negative correlations with temperature (-0.084), total dissolved solids (-0.110), and electrical conductivity (-0.063) but showed positive correlations with pH (0.265) and dissolved oxygen (0.695).
Table 4 showed the means of physical parameters and larvae density of water samples in the study area. The result revealed that Oke-Lisa had the highest mean length value (7.38 ± 4.15), followed by Isikan (6.81 ± 7.87), and the lowest mean length value was recorded in Oke-Aro II (3.02 ± 3.19). Oke-Lisa was also recorded to have the highest mean breadth value (2.03 ± 0.47), followed by Isikan (1.33 ± 1.41), and Oke-Aro I was seen to have the lowest mean breadth value (0.07 ± 0.01). The highest mean depth value was recorded in both Ijomu/Obanla (0.25 ± 0.25) and Oke-Lisa (0.25 ± 0.17), followed by Owode/Imuagun (0.21 ± 0.26), and the lowest mean depth value was recorded in Oke-Aro I (0.04 ± 0.03), Oke-Aro II (0.05 ± 0.02), Oshodi/Isolo (0.06 ± 0.02), and Odopetu (0.08 ± 0.03). The highest mean nearest to the building was recorded in Isikan (7.23 ± 7.03), followed by Oke-Lisa (5.48 ± 1.58), and the lowest mean nearest to the building was recorded in Owode/Imuagun (1.30 ± 0.24). There exist significant differences among the means of the physical parameters in the study area. Table 5 showed the correlation of physical parameters and larvae density of water samples in the study area. It was revealed that larvae density had positive correlations with length (0.141) and nearest to building (0.226) and showed negative correlations with breadth (-0.174) and depth (-0.390).
Table 6 showed the diversity of mosquito species in the study area. The result revealed that out of the total 4001 adult mosquitoes that emerged, Isikan had the highest diversity of mosquito species (1418), followed by Oke-Aro I (943), Oke-Lisa (422), Owode/Imuagun (406), Oke-Aro II (344), Ijomu/Obanla (344), and Odoptu (159), and the least mosquito diversity was recorded in Oshodi/Isolo (105). The result also revealed that the *Culex* mosquito was most prevalent in the study area. Fig. 7 showed the diagrammatical representation of the mosquito species diversity in the study area.

DISCUSSION

Water characteristics of breeding places are important for oviposition and development of mosquitoes. The majority of the sites encountered were permanent breeding sites and supported mosquito larvae breeding. The findings revealed significant variability among communities and provide insight into how these factors may influence mosquito habitat suitability (Oniya *et al*., 2019; Mbanzulu *et al*., 2022). Temperature is a critical factor influencing mosquito breeding, as it affects the metabolic rate and developmental stages of mosquito larvae. The breeding temperature observed during the study suggested that mosquitoes breed at water temperatures of 23.23 to 39.00°C, which was supported by the work of Adeyekun *et al*. (2025). Asare *et al*. (2016) reported that the temperature of the larval habitat had a significant influence on the development of the aquatic stages of mosquito species. It was also reported that the development of many mosquito species critically decreases when the temperature of the larval habitat goes below 14–16°C (Reinhold *et al*., 2018). Higher temperatures, such as those in Ijomu/Obanla and Oke-Lisa, typically accelerate larval development and can increase the frequency of mosquito breeding cycles. Conversely, the lower

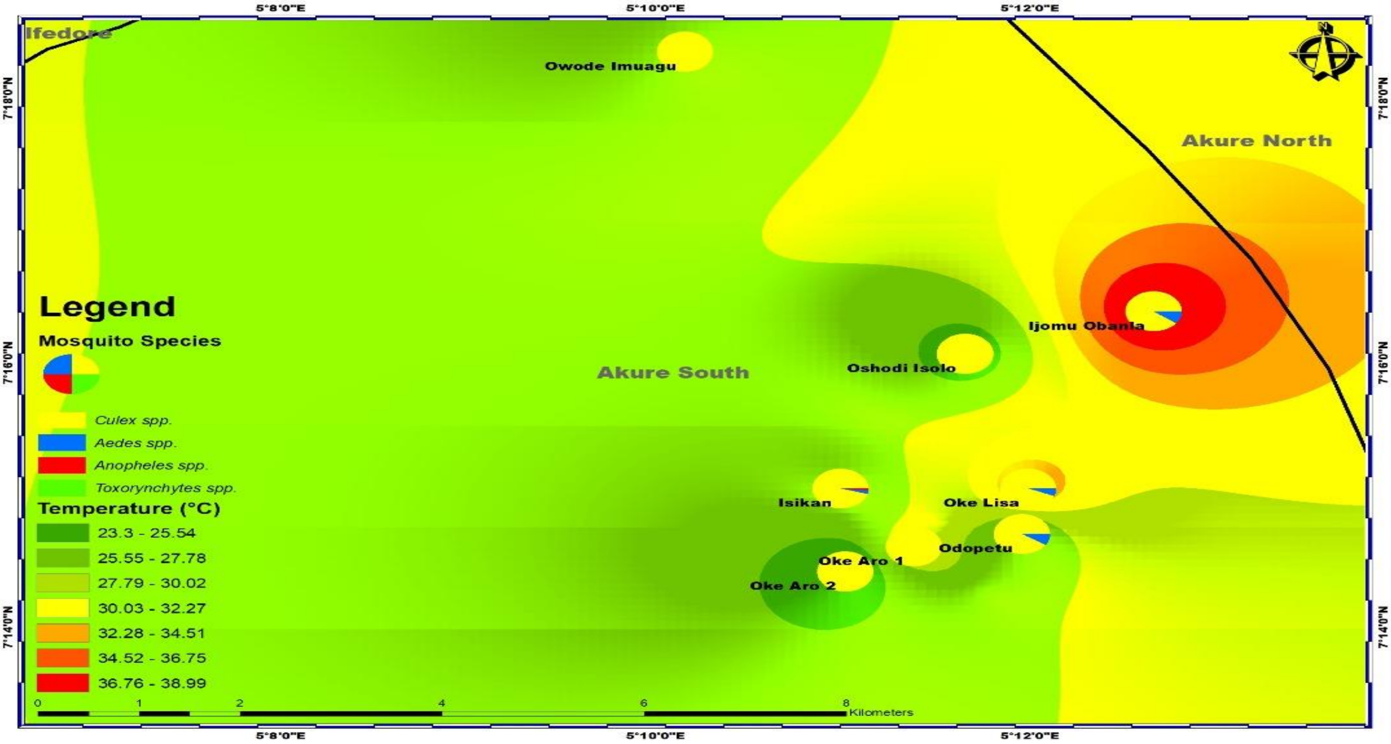

Fig. 2: Temperature (°C) Range in the Breeding Sites

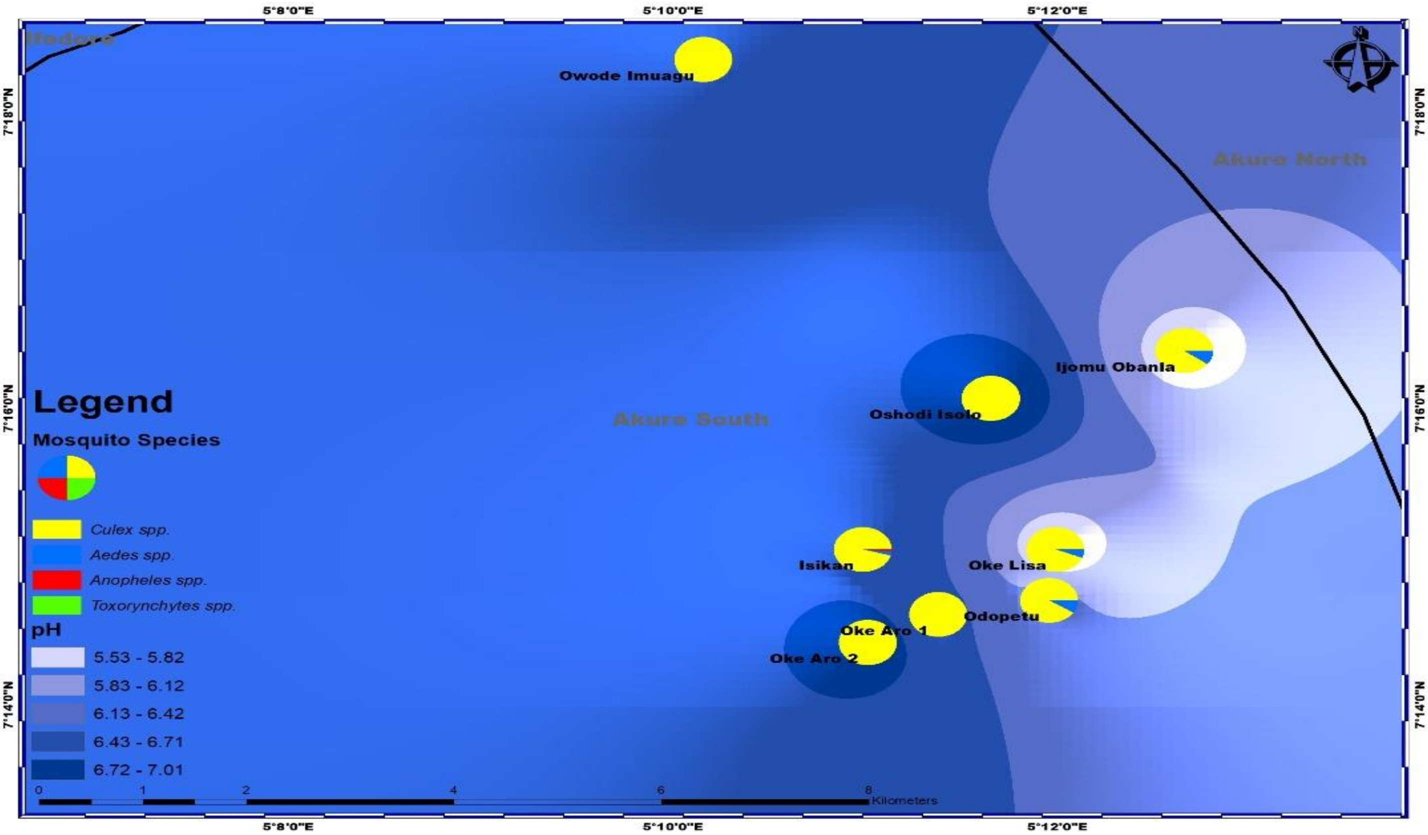

Fig. 3: pH Range in the Breeding Sites

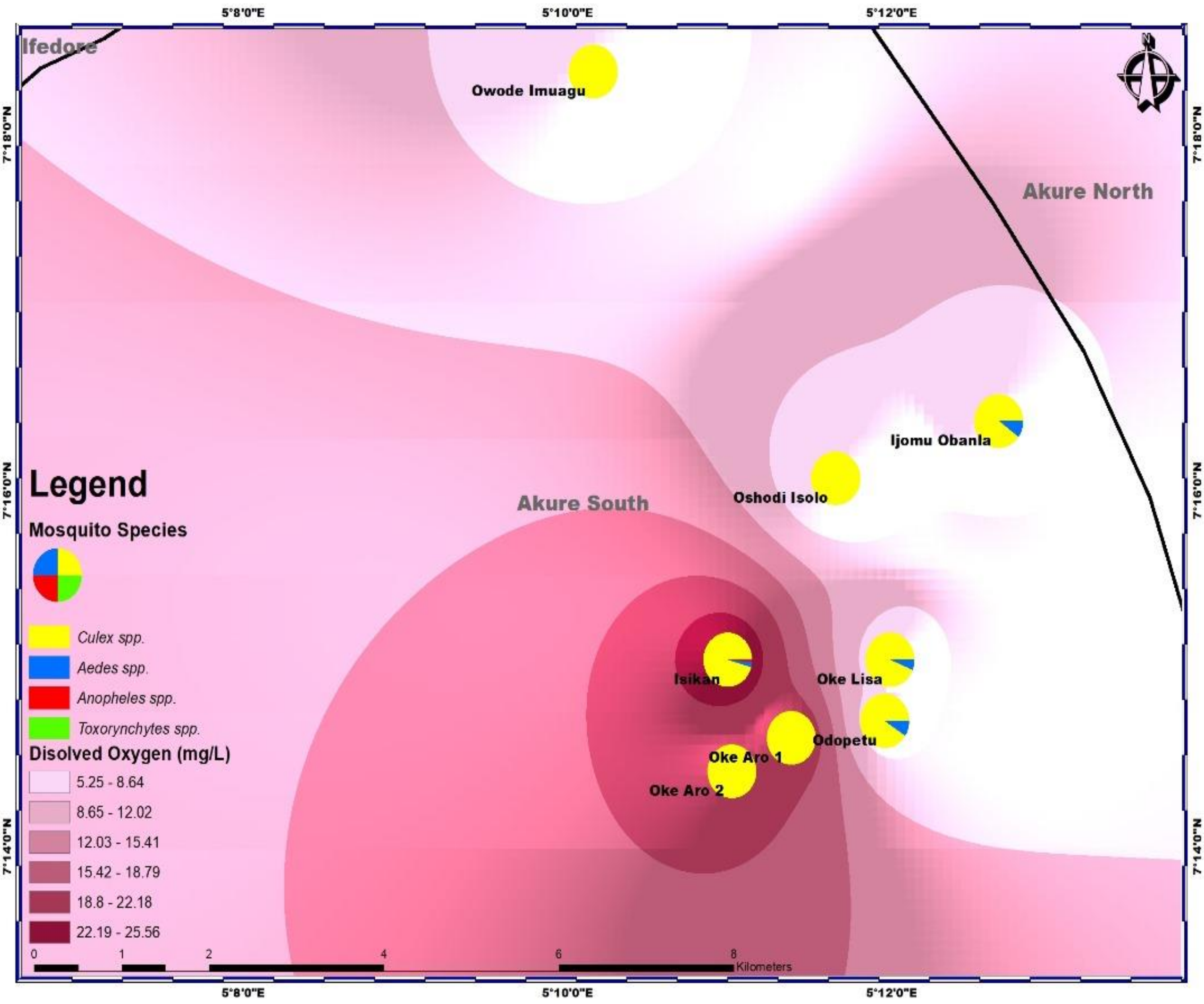

Fig. 4: Dissolved Oxygen (mg/L) Range in the Breeding Sites

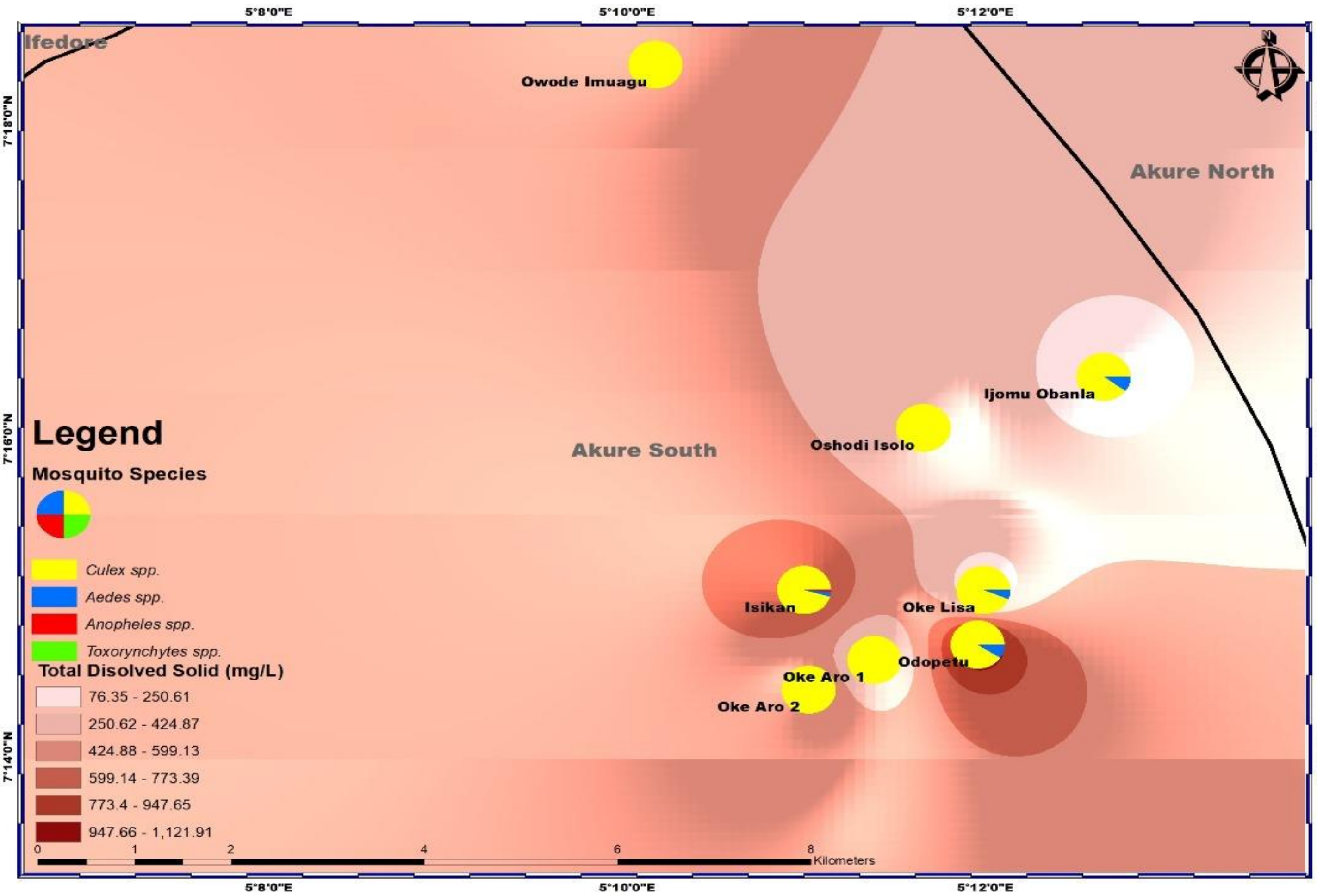

Fig. 5: Total Dissolved Solid (ppm) Range in the Breeding Sites

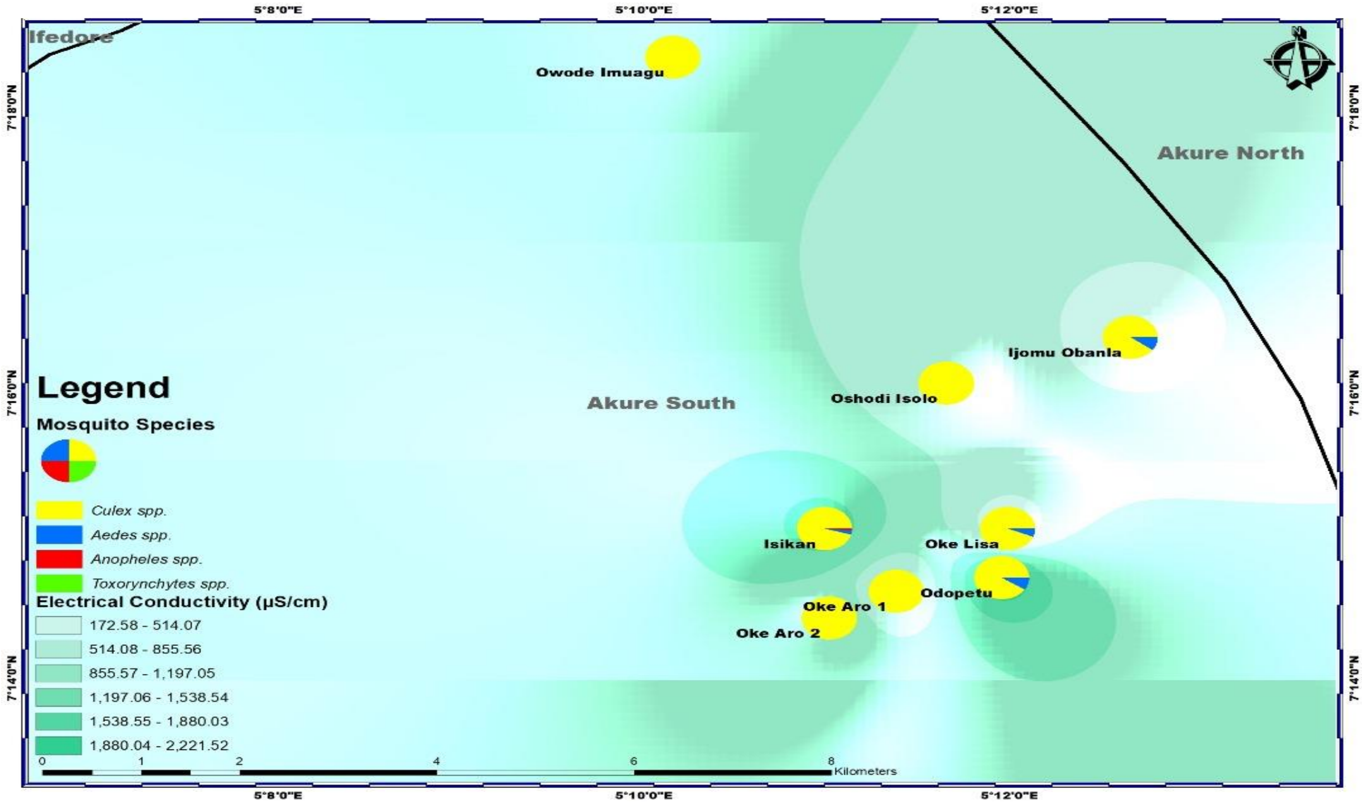

Fig. 6: Electrical Conductivity (µS/cm) Range in the Breeding Sites

Table 3: Correlation between Water Physico-Chemical Parameters and Larvae Density

Parameters	TEMP	pH	TDS	EC	DO	Larvae Density
TEMP	1.000					
pH	-0.866	1.000				
TDS	-0.580	0.333	1.000			
EC	-0.572	0.341	0.997	1.000		
DO	-0.292	0.404	0.154	0.195	1.000	
Larvae Density	-0.084	0.265	-0.110	-0.063	0.695	1.00

KEY:
TEMP: Temperature
TDS: Total Dissolved Solid
EC: Electrical Conductivity
DO: Dissolved Oxygen

Table 4: Means of Physical Parameters Measured in the Study Area

Locations	Length (m)	Breadth (m)	Depth (m)	NTB (m)	Larvae Density
Isikan	6.81 ± 7.87^{ab}	1.33 ± 1.41^{b}	0.10 ± 0.11^{b}	7.23 ± 7.03^{a}	0.99 ± 1.05^{a}
Oke-Aro I	3.37 ± 4.43^{c}	0.07 ± 0.01^{e}	0.04 ± 0.03^{c}	2.32 ± 0.84^{d}	1.08 ± 1.11^{a}
Oke-Aro II	3.02 ± 3.19^{c}	0.50 ± 0.53^{d}	0.05 ± 0.02^{c}	3.40 ± 1.91^{c}	0.23 ± 0.18^{c}
Ijomu/Obanla	3.95 ± 3.12^{c}	0.58 ± 0.25^{d}	0.25 ± 0.25^{a}	3.83 ± 1.54^{c}	0.32 ± 0.05^{b}
Oke-Lisa	7.38 ± 4.15^{a}	2.03 ± 0.47^{a}	0.25 ± 0.17^{a}	5.48 ± 1.58^{b}	0.31 ± 0.16^{b}
Owode/Imuagun	5.43 ± 2.05^{b}	0.57 ± 0.35^{d}	0.21 ± 0.26^{ab}	1.30 ± 0.24^{e}	0.37 ± 0.25^{b}
Odopetu	3.64 ± 2.61^{c}	0.80 ± 0.23^{cd}	0.08 ± 0.03^{bc}	3.56 ± 4.45^{c}	0.22 ± 0.07^{c}
Oshodi/Isolo	4.70 ± 2.04^{bc}	0.93 ± 0.11^{c}	0.06 ± 0.02^{c}	2.30 ± 0.95^{d}	0.48 ± 0.06^{ab}

Means having the same alphabet down the column are not significantly different from one another at $p > 0.05$.

Table 5: Correlation between Physical Parameters and Larvae Density

Parameters	Length	Breadth	Depth	NTB	Larvae Density
Length	1.000				
Breadth	0.861	1.000			
Depth	0.517	0.439	1.000		
NTB	0.596	0.690	0.152	1.000	
Larvae Density	0.141	-0.174	-0.390	0.226	1.000

KEY:
NTB: Nearest to Building

Table 6: Distribution and Diversity of Mosquito Species in the Study Area

Locations	Male *Culex*	Female *Culex*	Male *Aedes*	Female *Aedes*	Male *Anopheles*	Female *Anopheles*	Male *Toxorynchytes*	Female *Toxoryncyhytes*	TOTAL (4001)
Isikan	564	624	20	17	110	80	2	1	1418
Oke-Aro I	520	423	0	0	0	0	0	0	943
Oke-Aro II	160	182	0	0	0	0	1	1	344

Ijomu/Obanla	84	99	12	9	0	0	0	0	204
Oke-Lisa	152	244	12	14	0	0	0	0	422
Owode/Imuagun	215	191	0	0	0	0	0	0	406
Odepetu	83	61	8	7	0	0	0	0	159
Oshodi/Isolo	27	77	0	1	0	0	0	0	105

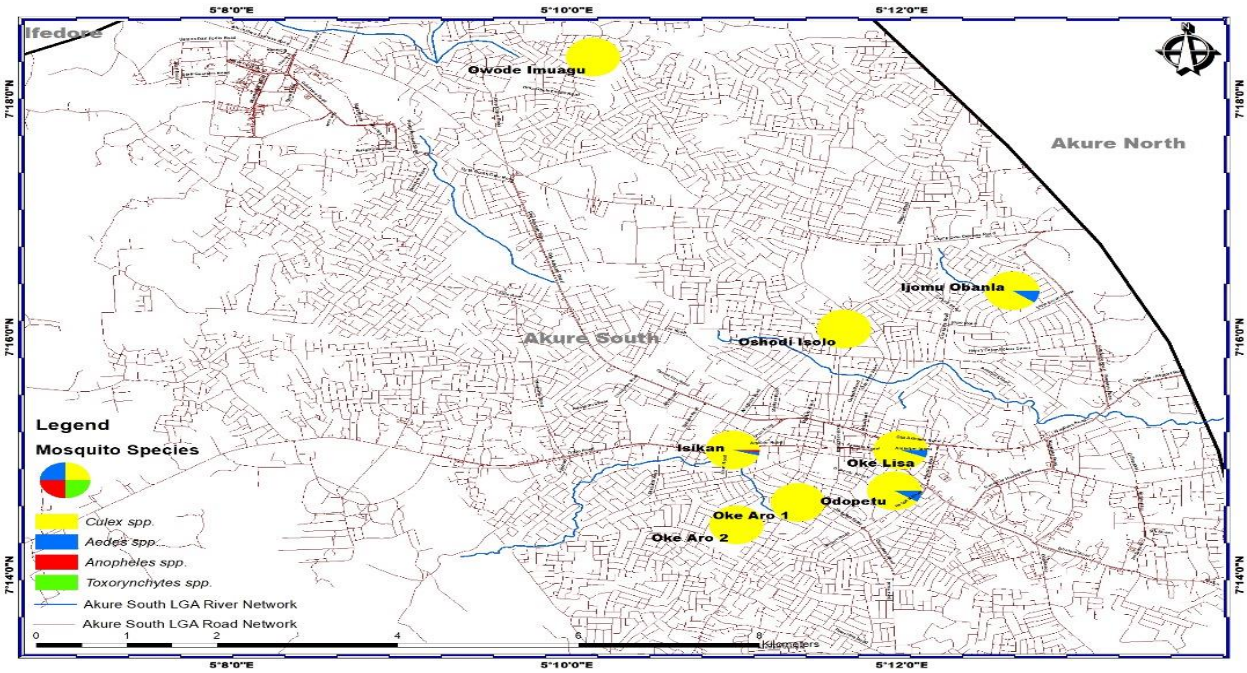

Fig. 7: Distribution and Diversity of Mosquito Species in the Study Area

temperatures in Oke-Aro II and Oshodi/Isolo might result in slower development and fewer breeding events, potentially leading to a lower mosquito population in those areas (Adeyekun *et al*., 2025).

The pH levels in the study area ranged from acidic to more neutral in Oshodi/Isolo (7.01 ± 0.64). Acidic conditions are generally less favourable for mosquito larvae compared to neutral or slightly alkaline conditions. The pH range of 5.52 to 7.01 supported breeding in all the habitats sampled, which concurred with the findings of Oniya *et al.* (2019) and Adeyekun *et al.* (2025). Both authors agreed that mosquitoes, especially *Aedes*, breed in water with pH less than 5.0 and higher than 7.4. Afolabi *et al*. (2019), in their findings, showed that water near these pH values was suitable for the weakening of the eggshells for the first instar larvae to emerge. The findings of Getachew *et al*. (2020) reported that the pH of mosquito species larval habitat could be slightly acidic or slightly alkaline. This was in agreement with the report of a previous study, where the pH of the larvae habitat was found to be acidic and neutral (Akeju *et al*., 2022).

The TDS was highest in Odopetu (1128.64 ± 5.64 mg/L) and lowest in Oke-Lisa (68.51 ± 5.84 mg/L). Higher TDS levels suggest a greater concentration of dissolved substances, which can indicate a more nutrient-rich environment (Adeyekun *et al*., 2025). High TDS levels in Odopetu may contribute to a more conducive habitat for mosquito larvae by providing ample nutrients and supporting a diverse microbial community. The study of Ramayanti *et al.* (2025) reported that higher TDS indicates increased mineral salts, organic matter, and dissolved ions in the aquatic habitats, which can strongly influence mosquito breeding dynamics. Elevated TDS in Odepetu is likely associated with organic pollution from domestic waste, surface runoff, decomposing vegetation, and soil leachates, all of which enrich breeding waters with dissolved nutrients. Such conditions are particularly favourable for pollution-tolerant mosquito species, especially *Culex*, whose larvae thrive in organically enriched and chemically loaded waters (Akeju *et al*., 2022). High TDS enhances microbial and algal growth, which serves as a major food source for mosquito larvae, thereby supporting larval survival and development. Previous studies have shown that breeding sites with high dissolved solids often arise from poor sanitation, indiscriminate waste disposal, and limited water flow, all of which are common in peri-urban settlements (Obi *et al*., 2020; Eze *et al*., 2022).

High electrical conductivity values recorded in Odopetu suggest higher concentrations of dissolved ions in the water, potentially indicating more nutrient-rich environments. This nutrient enrichment could create favourable conditions for mosquito larvae development, as these environments often support more abundant microbial growth and organic matter, which serve as food for larvae (Faiman *et al.*, 2019). The study by Mbanzulu *et al*. (2022) reported that the ecological implication of high EC by increased ionic concentration enhances microbial and algal productivity, providing abundant food resources for mosquito larvae and supporting their development. Similar observations have been reported in studies by Obi *et al*. (2020) and Eze *et al*. (2022), where high EC was positively correlated with mosquito larval abundance in polluted breeding habitats. The highest

EC recorded in Odepetu suggests strong anthropogenic influence on water quality and highlights the role of physico-chemical parameters in shaping mosquito breeding ecology.

The highest mean DO was recorded in Isikan, and the lowest in Oshodi/Isolo. Dissolved oxygen is crucial for the survival of aquatic organisms, including mosquito larvae. Higher DO levels in Isikan could support a more robust aquatic ecosystem, potentially including a larger population of mosquito larvae. Adequate oxygen levels are essential for healthy larvae development, making high DO levels a factor that could enhance breeding conditions despite other potentially less favourable conditions (Dickson *et al*., 2017). Adeyekun *et al*. (2025) reported that high DO levels may be attributed to the presence of relatively cleaner and less polluted breeding habitats, with better water circulation, reduced organic load, and possible photosynthetic activity from aquatic vegetation. Similarly, high DO is known to support a wider range of aquatic organisms and can improve mosquito larval survival and development, particularly for species such as *Anopheles*, which prefer cleaner, well-oxygenated waters (Service, 2012). The low DO recorded in Oshodi/Isolo may likely be a consequence of high organic pollution and stagnant water conditions resulting from domestic waste disposal, sewage inflow, and poor drainage. Decomposition of organic matter by microorganisms increases biological oxygen demand (BOD), leading to oxygen depletion in breeding waters. Studies have consistently shown that mosquito larval habitats with low DO are associated with poor sanitation and high organic enrichment (Faiman *et al*., 2019).

The result revealed positive correlations of larvae density with pH and DO and negative correlations with temperature, TDS, and EC. The positive association with pH suggests that mosquito larvae thrive better in near-neutral to slightly alkaline waters, which enhance microbial activity and food availability while supporting optimal physiological processes for larval growth (Adeyekun *et al*., 2025). Service (2012) has reported increased larval density in breeding habitats with moderate pH levels, as extreme acidity or alkalinity can impair larval metabolism and survival. Similarly, the positive correlation with DO indicates that well-oxygenated waters favour larval development, particularly for species such as *Anopheles*, which prefer cleaner and less polluted habitats. Kumar *et al*. (2024) reported that high temperatures have been shown to reduce larval abundance by accelerating development beyond sustainable limits and increasing vulnerability to predation and desiccation. The inverse relationship of larvae density with TDS and EC indicates that increased ionic concentration and organic pollution in breeding waters may suppress larval density by creating physiologically stressful conditions. Although pollution-tolerant species such as *Culex* can survive in such environments, excessively high TDS and EC can reduce overall larval abundance by limiting oxygen solubility and increasing osmotic stress (Onyido *et al*., 2011).

Physical descriptions of each of the sites showed that larvae were found in shallow and muddy habitats. The distance between the breeding sites and residential abodes ranged from 1.30 to 7.23 m, a distance that can easily be covered by the vectors and can allow effective transmission of mosquito-borne diseases in the study area. Length, breadth, depth, and nearest to building were found to be the main variables influencing the abundance and distribution of mosquito larvae and predators in habitats investigated. Depth had a significant effect on all the mosquito species' larvae, as higher depth values increased the number of these species. The depth in all breeding sites ranged from 0.04 to 0.25; mosquito larvae were seen in breeding sites with depth as low as 0.04 at Oke-Aro I. Most of the larvae sampled adapt to a wide range of depths, as they dominated most of the habitats, revealing that depth is a major factor in the distribution of mosquitoes (Adeyekun *et al.*, 2022). Adeyekun *et al.* (2025) reported that length had a significant effect on the breeding of *Culex* species, as higher length values reduced their presence. Nearness to the building had a significant effect on the breeding of mosquito species, as greater nearness to the building reduced its presence but had no effect on the other species. The positive association with habitat length suggests that elongated water bodies, such as roadside drains, gutters, and narrow channels, provide extensive margins that favour oviposition and larval aggregation. These habitats often have reduced water flow and increased organic accumulation along the edges, creating ideal microhabitats for mosquito larvae (Service, 2012). Similarly, the findings of Onyido *et al*. (2011) reported that the positive correlation with proximity to buildings indicates that human settlements strongly influence larval abundance, as areas close to houses are more likely to contain artificial breeding sites, receive organic waste inputs, and experience frequent human water storage and disposal activities. The negative correlation with habitat breadth and depth suggests that larger and deeper water bodies are less favourable for mosquito larval proliferation. This is in line with the findings of Adeyekun *et al.* (2025), who reported that deeper habitats often support higher water movement, increased predator presence (fish and aquatic insects), and lower water temperatures at depth, all of which can reduce larval survival. Wider water bodies also tend to have less sheltered margins and greater exposure to wind and wave action, which can disrupt oviposition and larval development. Service (2012) reported that shallow, narrow, and elongated breeding sites located close to human dwellings are more conducive to high mosquito larval density than broad and deep water bodies.

The effects of the ecological factors on the density of mosquito larvae were examined in this study. The result of the study revealed that Oke-Aro I and Isikan had the highest larvae density in the study area. This suggests that there is a high density of stagnant water and water-holding containers such as plastics, cans, and clay pots, and these containers serve as habitats for mosquito breeding, especially during the rainy season. This corresponded with the study of Bartlett-Healy *et al*. (2012), who reported that the higher mean mosquito larvae density can be attributed to a combination of favourable environmental, ecological, and anthropogenic factors that enhance mosquito breeding and survival. Oniya *et al*. (2019) also reported that areas with higher larvae density are characterized by the presence of numerous permanent and semi-permanent water bodies, including poorly drained gutters, stagnant pools, discarded containers, and water-holding domestic receptacles. Such habitats provide stable oviposition sites and allow uninterrupted larval development, leading to increased larval density. Previous studies have shown that mosquito larvae are significantly more abundant in areas with persistent stagnant water and poor drainage systems, especially in peri-urban and semi-rural communities (Service, 2012; Onyido *et al*., 2011). Organic pollution from household waste and surface runoff commonly observed in these locations increases nutrient availability, which enhances microbial growth and serves as a food source for mosquito larvae, particularly *Culex* species. Vegetation cover around homes and water bodies in these locations may also provide shade and protection from predators and extreme temperatures, conditions known to favour larval survival (Martínez-Barciela *et al*., 2025).

The result also revealed that the mean larvae abundance seems to be highest in Isikan and lowest in Oke-Aro I. The result corresponded with the finding of Adeyekun *et al*. (2025), who reported that in areas with higher larvae abundance, mosquito breeding sites are likely to be numerous, stable, and nutrient-rich, such as stagnant pools, blocked drainage channels, and organically polluted water bodies. These conditions favour continuous oviposition and high larval survival, resulting in a consistently high mean abundance. Several studies have demonstrated that mosquito larvae attain higher densities in permanent habitats with high organic content, which support microbial growth that serves as larval food (Onyido *et al*., 2011; Service, 2012). The low mean larvae abundance in Oke-Aro I suggests that breeding habitats in this location may be less stable or more frequently disturbed. Water bodies in Oke-Aro I may experience periodic drying, flushing, or human interference, which disrupts larval development and reduces mean abundance per sampling unit. The result is in line with the study of Collins *et al*. (2019) also reported that biotic factors such as increased presence of predators (e.g., tadpoles, insect larvae, and fish) or competitive fauna could significantly suppress mosquito larval populations. Predation pressure has been identified as a key regulator of larval abundance in disturbed or semi-natural habitats.

In this study, Isikan had the highest distribution of mosquitoes compared to other locations, as this location was known for heavy social and anthropological activities. This finding was in accordance with the work of Simon-Oke and Ayeni (2015), who observed that mosquito distribution and abundance were related to population, land use, and human activities. This significant difference from other locations may be due to the difference in social and anthropological activities, as areas with high activities may have high population density of mosquitoes and vice versa. The high distribution of mosquitoes in Isikan can also be related to the findings of Adeyekun *et al*. (2025), who reported that numerous permanent and semi-permanent water bodies, including stagnant pools, blocked drains, water-filled depressions, and domestic water containers, provide stable oviposition sites for mosquitoes. Such habitats allow continuous breeding and higher survival rates of immature stages, leading to increased mosquito abundance. Similar observations have been reported in earlier studies where areas with persistent stagnant water and poor drainage supported higher mosquito populations (Afolabi *et al*., 2019; Oniya *et al*., 2019).

Of the 4 genera of mosquito observed in this study, *Culex* species had the highest abundance and distribution in all locations. This suggests that these species are cosmopolitan and breed indiscriminately in all habitats. In a study by Nikookar *et al*. (2017) across Mazandaran Province, *Culex* spp. was the dominant species. Compatibility of *Culex* spp. to different types of oviposition sites in the vicinity of human places with various degrees of physico-chemical factors and suitable vegetation can probably be important in their interspecific interactions and justify their wide distribution in different locations of the study area (Bashar *et al*., 2016). On the contrary, *Anopheles*, *Aedes,* and *Toxorhynchites* species were observed to be sparsely distributed and with relatively low abundance. This low abundance of the various species might be due to their innate characteristics of endophagy (indoor feeding) and endophilic (indoor resting) (Afolabi *et al*., 2019). Their association with human dwellings might suggest that *Anopheles* mosquitoes are selective breeders that breed in containers with clean water within and around human houses for easy accessibility to hosts (Afolabi *et al*., 2019).

CONCLUSION

Ecological parameters of water play a crucial role in determining the suitability of breeding sites for mosquitoes. This study, conducted across different locations in the Akure South Metropolis, has highlighted significant variations in key water quality indicators, including electrical conductivity, temperature, pH, total dissolved solids (TDS), dissolved oxygen (DO), and the water's physical parameters, such as length, breadth, depth, and nearest to buildings. Isikan recorded the highest mosquito distribution and larval density, reflecting the availability of stable breeding habitats, favourable pH and dissolved oxygen levels, and close proximity to human settlements. In contrast, locations such as Oke-Aro I and Oshodi/Isolo exhibited lower larval abundance, likely due to habitat disturbance, unfavourable physico-chemical conditions, or reduced habitat suitability. These variations impact mosquito larvae density and abundance, and consequently, the potential risk of mosquito-borne diseases. There is a need for improving drainage systems, reducing stagnant water, improving sanitation, and larval source reduction as effective strategies for controlling mosquito populations and reducing the risk of mosquito-borne diseases in the study area.

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