



Aquatic Insects Diversity and Water Quality Assessment of a Tropical Freshwater Pond in Benin City, Nigeria

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ABSTRACT: Aquatic insects are species of significant importance to water bodies because they serve various purposes including nutrient cycling, vectors of pathogens and bioindicators of water quality. Analyzing their community structure is a veritable tool in studies of biodiversity and quality of limnetic ecosystems. Therefore, we investigated the health status of a pond in Benin City, Nigeria using insect's abundance, composition, distribution and physicochemical parameters of the waterbody. Insects were sampled using sweep nets and identified to the species level while water samples were collected and analyzed using in-situ and ex-situ methods to determine the physicochemical properties in three sampling stations. The results of the physicochemical assessment of the water indicated that conditions did not differ widely between sites ($P > 0.05$) except for total alkalinity, and the recorded values were well within the ambient FME_{env} permissible limits for surface water except for dissolved oxygen, turbidity and phosphate. A total of 10 insect taxa, comprising of 103 individuals in 2 orders were recorded in the study and among the orders, Hemiptera comprised of 7 species and Coleoptera comprised of 3 species. Majority of the insect fauna found in this study are typically found in similar water bodies in the tropics. However, the observed insect community structure revealed a relatively low taxa richness with a dominance of pollution-resistant species which suggests a moderately polluted condition of the waterbody.

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Aquatic insects are Hexapods that live or spend part of their life cycle in water bodies (Pennak, 1978). Insects undoubtedly form the most successful group in the animal kingdom varying widely in their habits (Smith and Kennedy 2009). They occur in tremendous numbers, and many have become highly specialized and adapted to almost every conceivable habitat (Smith and Kennedy 2009). Nevertheless, as a group, insects have not been particularly successful in colonizing aquatic environment in comparison to the terrestrial environment and it is estimated that less than four percent (4%) of the total number of insect species spend their entire lives in water (Grosberg *et al.*, 2012). Although all of the species in orders (such as Plecoptera, Ephemeroptera, Odonata and Trichoptera) have aquatic stages, these orders are of little numerical significance when compared to large orders like Hemiptera, Lepidoptera, Coleoptera, Hymenoptera and Diptera where only a small percentage of their species are aquatic (Bouchard, 2004). The major problem in becoming adapted to an aquatic environment is dependent on the respiratory mechanism of insects (Pennak, 1978). The air-filled tracheal system is capable of functioning only when

the spiracles are in contact with air. Thus, to overcome this challenge, aquatic insects have become adapted to their environment through a number of processes such as the use of simple diffusion over a relatively thin integument, breathing from a plastron or physical gill, extraction of oxygen from water using a plastron, storage of oxygen in haemoglobin molecules in hemolymph, and taking oxygen from the surface via breathing tubes also known as siphons (Mill, 1974, Pennak, 1978, Barnes, 1980, Graham, 1990, Klowden, 2008). Aquatic insects are of great importance to water bodies and their presence in water serve various purposes. While some are involved in nutrient recycling thereby forming an important component of the natural food web in an aquatic ecosystem, others act as vectors through which disease pathogens are transmitted to both humans and animals (Foil, 1998; Chae *et al.*, 2000). Furthermore, their sensitivity make them very useful sentinels to both natural and man-induced changes in the environment (Ndaruga *et al.*, 2004; Arimoro and Ikomi, 2008). Anthropogenic activities result in the discharge of diverse pollutants into streams and rivers, impairing their quality and health status (Khatri and Tyagi, 2015). The pollution

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of these water bodies have been associated with changes in the physicochemical properties of the water (Amaeze *et al.*, 2012). Such changes might subsequently influence the distribution patterns of aquatic fauna including insects thereby providing insight into the status of the water quality. Thus, the use of Aquatic insects for assessing water quality can provide relevant information to environmental managers and decisions makers to enable them take accurate and justifiable decisions with regards to the state and quality of water bodies as well as to evaluate the effectiveness of legislative regulations already in force (Bauernfeind and Moog, 2000; Arimoro and Ikomi, 2008). Although a good amount of published works on the use of aquatic insects for assessing health and water quality status of streams exist (Ugbogu and Akiya, 2001; Mafuya *et al.*, 2004; Deliz-Quinones, 2005), many have been focused on open water habitats rather than the littoral zone. Littoral zone studies have been hampered largely by difficulties with quantitative sampling of vegetations and sediment substrata, yet diversity is often high in the littoral habitats as compared with the pelagic zone (Pennak, 1966; Wei *et al.*, 2014; Utete *et al.*, 2017). Analysis of insect community structure in littoral vegetations is indispensable for studies of the biodiversity of the limnetic ecosystem and it forms a veritable tool for assessing water quality. This study was therefore undertaken with an objective to assess the composition and relative abundance of the different insect groups associated with the littoral vegetation of a pond.

MATERIALS AND METHODS

Description of Study Area and Sampling Locations: The study was carried out on two separate ponds; a large (Pond A) and a small (Pond B) at a perennially flooded land (Lat.06°22' and 06°23'N and Long. 005°35' and 005°36'E along Uwasota Road, Ugbowo, Benin City, Edo State, Nigeria (Fig 1). The ponds were dug in 2006 as a way of ameliorating the impact of erosion in the area by channelling stormwater into the ponds. Geologically, the area is characterized by the Benin formation consisting mainly of patches of coarse sand interspersed with lignite and patches of lateritic sandy clay. The climate of the area is comparatively stable but not uniform and rhythm of rainfall occurs in conjunction with the movement of the South-West monsoon wind across the Atlantic Ocean, the timing of these movements vary from year to year. Typically, this region has the characteristic features of the humid tropical wet and dry climate governed primarily by rainfall. There are two distinct seasons, the rainy season is from April to November while the dry season is from December to March (Imoobe and Okoye, 2010; Cirella *et al.*, 2019). Three stations were established due to the topography of the

ponds, two stations in pond A (Stations 1 & 2) and one in pond B (Station 3) situated 20m apart. Station One (Lat. 6°22.721'N, Long.5°35.934'E) was located close to the main road and far from residential houses thus, representing the least impacted by humans with dominant littoral weeds such as *Commelina benghalensis*, *Chromolaena odorata* and *Panicum maximum*. Station Two (Lat.6°22.729'N, Long.5°35.933'E) was located in the large pond but adjacent to residential houses thus, served as a spot for indiscriminate refuse disposal with dominant vegetations comprising *Commelina benghalensis* and *Panicum maximum*. Station Three (Lat.6°22.723N', Long.5°35.908'E) was in the small pond also close to residential houses thus, garbage was also disposed of here, its dominant littoral weeds are *Commelina benyhalensis*, *Sacciolepis africana* and *Panicum maximum*.

Sampling Exercise and Analysis: Water samples were collected from all three stations at monthly intervals between 0900 hrs and 1300 hrs, between May to August 2011. Water samples were collected in 1-liter bottles at each station, stored in an insulated cooler containing ice packs (to ensure that the chemical properties of the water were maintained) and delivered on the same day to the laboratory for *ex-situ* analysis using standard analytical methods (APHA, 1992). Parameters measured with these methods include total alkalinity, chlorinity, total hardness, nutrients and cations. Mercury-in-glass thermometer (temperature) and the EXTECH multimeter EC 500 test kit (pH, conductivity, pH, conductivity, turbidity, total dissolved solids and total suspended solids) were used to measure other parameters *in situ*. The water samples for the estimation of dissolved oxygen (DO) were collected with 250ml reagent bottles and analyzed using Winkler's method (Strickland and Parsons, 1968). In collecting the DO samples, bottles were corked under water to avoid trapping air bubbles with the sample. The samples were then fixed immediately by adding 1ml each of Winkler's solution A (Manganese Sulphate) and B (Alkali-Iodine-Azide solution) stoppered well and agitated to mix, which resulted in the formation of a brown precipitate of Manganese hydroxide. Samples for the determination of Biological Oxygen Demand (BOD₅) were collected in 250ml brown reagent bottles in order to prevent light penetration and hence arresting photosynthetic activities of phytoplanktons.

Insects were collected using the kick method; the macrophytes in the three stations were vigorously disturbed using the sweep net, sweeping for about 5 minutes then the content was poured into 10 litres bucket and sieved. The samples were then poured into

properly labelled sampling containers and fixed, using small quantities of 10% formalin. In the laboratory samples were sorted, identified and counted under a binocular dissecting microscope. Identification to the

lowest possible taxonomic level was done using relevant taxonomic keys (Pennak, 1978; Mellanby, 1963).

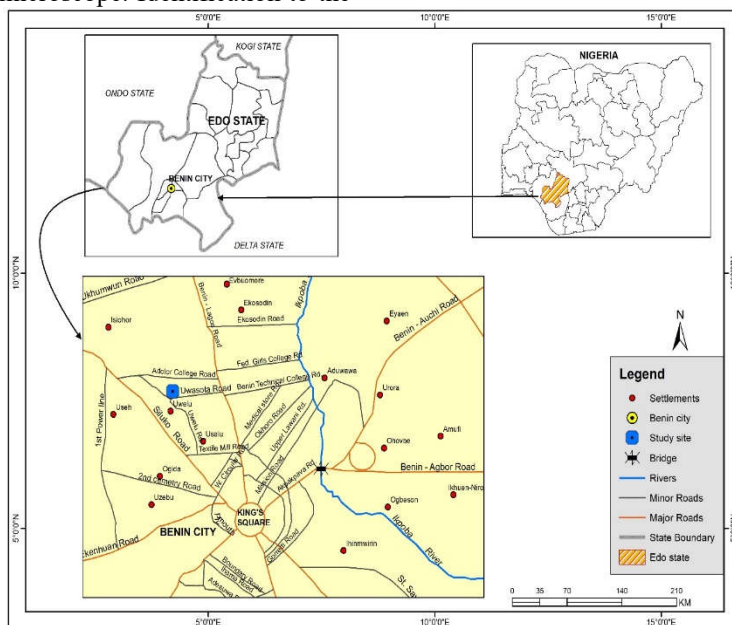


Figure 1: Map of Benin City showing the study pond

Statistical Analysis: All statistical analyses were performed using SPSS software version 17. Basic statistical measurement of mean, min, max and standard error were conducted on the physicochemical parameters while one-way analysis of variance (ANOVA) was used test for statistical differences between the means at $P < 0.05$. Diversity Indices (Margalef's index (d), Shannon Weiner index (H) and Evenness (E)) were computed to ascertain the taxa richness and the degree of uniformity in distributions among the species collected. The Sorenson's index was used to test the association of the sampling stations while Pearson's Correlation coefficient (r) was used to determine the interdependence of the physicochemical parameters as well as between the parameters and the insect fauna abundance.

RESULTS AND DISCUSSION

Physicochemical Analysis: The air temperature ranged between 23°C to 31°C while the water temperature ranged between 22°C to 30°C . The buffering capacity of the water measured as alkalinity was observed to be low with weak acidic to weak alkaline mean pH of 6.55 ± 1.12 , 6.56 ± 1.09 , 6.63 ± 1.18 across the stations except for the month of August which recorded the lowest pH values ranging from 4.9 to 4.95. This can be attributed to low rainfall levels typically associated with the annual "August Break", a relatively dry spell during which the climate temporarily show

characteristic features of the dry season thereafter returning to the raining season in September with its typical high rainfall (Aduwo and Adeniyi, 2019). This low August pH values are in tandem with the work of Offem *et al.*, (2011). Turbidity was generally high with values ranging between 25 to 390 NTU except for the month of August with low turbidity values ranging from 12 to 14 NTU that may be due to the August break which resulted in reduced organic load into the ponds (Offem *et al.*, 2011; Eliku and Leta, 2018). TDS and TSS showed a somewhat inverse relationship, with TSS values being higher throughout the study with mean values of 45.50 ± 19.16 , 41.75 ± 27.78 and $41.50 \pm 31.03 \text{ mgL}^{-1}$ across the study stations. Mean dissolved oxygen concentration (4.13 ± 0.76 , 4.48 ± 1.86 and $4.60 \pm 2.10 \text{ mgL}^{-1}$) and BOD_5 (2.95 ± 0.31 , 2.68 ± 1.24 and $2.73 \pm 0.49 \text{ mgL}^{-1}$) were low across all three stations. The concentration of calcium and magnesium salts combined with various anions particularly carbonates, that constitutes the total hardness of water were also generally low indicating softwater in the ponds (Imoobe, 2011). The primary productivity nutrients with mean values; nitrate (2.41 ± 1.64 , 2.88 ± 1.79 and $3.17 \pm 1.89 \text{ mgL}^{-1}$) and sulphate (20.61 ± 4.67 , 18.32 ± 7.90 and $22.06 \pm 10.75 \text{ mgL}^{-1}$) were low while phosphate (11.63 ± 11.61 , 10.77 ± 9.14 and $14.10 \pm 14.46 \text{ mgL}^{-1}$) was high across the three study stations. The results of the physicochemical assessment as presented (Table 1) indicate that conditions did not differ widely

between sites as there was no significant difference in the parameters recorded within the stations ($P > 0.05$) except for total alkalinity which showed significant difference ($P < 0.05$) in values obtained from the three stations. The findings also revealed that the parameters fell within the ambient FMEnv permissible limits for surface water except for dissolved oxygen, turbidity and phosphate. This can be attributed to high influx organic material from storm water channelled to the ponds and the rather static nature of the ponds, which minimizes rate of refreshing of various parameters. Additionally, being fed with storm water, the pond harbours surface runoffs that are typically high in

materials which impact turbidity (Amaeze *et al.*, 2015).

Fauna Composition, Distribution and Abundance: A total of 103 individuals (Table 2, Plate 2 to 10) from 10 taxa were collected during the sampling period with all belonging to insect orders of Hemiptera (7 Genera) and Coleoptera (3 Genera). Insect's percentage composition of 19.4%, 53.4% and 27.2% were recorded for station 1, 2 and 3, respectively. Most of the taxa recorded in the study had been reported in other inland waters such as the Awba reservoir (Popoola and Otalekor, 2011) and Warri river (Arimoro and Ikomi 2008).

Table 1: Summary of the physical and chemical parameters of the study ponds

Parameter	Station I			Station II			Station III			P-value	FMENV safe limit
	MEAN ± SD	MIN	MAX	MEAN ± SD	MIN	MAX	MEAN ± SD	MIN	MAX		
AT °C	26.50 ± 2.38	23	28	28.5 ± 1.91	27	31	27.75 ± 2.22	25	30	>0.05	
WT °C	24.50 ± 2.08	22	27	26.50 ± 1.73	25	29	26.25 ± 1.73	24	30	> 0.05	
Colour (Pt.Co)	210.50 ± 233.79	17	550	244.25 ± 233.77	20	530	247.75 ± 251.87	15	580	> 0.05	
pH	6.55 ± 1.12	4.9	7.4	6.56 ± 1.09	4.95	7.3	6.63 ± 1.17	4.92	7.6	>0.05	6.5-8.5
Cond. (µS/cm)	147.38 ± 59.77	94.1	230.1	122.33 ± 15.76	98.9	132.8	197.98 ± 89.79	139.9	330	> 0.05	
Turbidity (NTU)	67.00 ± 40.21	13	104	61.50 ± 61.75	14	150	131.00 ± 175.05	12	390	> 0.05	5
TSS (mg/L)	45.50 ± 19.16	19	61	41.75 ± 27.78	15	73	41.50 ± 31.03	16	84	>0.05	0.75
TDS (mg/L)	78.28 ± 23.56	57.9	112	65.90 ± 4.53	60.7	71.7	108.10 ± 39.16	77.3	165	> 0.05	500
DO (mg/L)	4.13 ± 0.76	3.2	4.8	4.48 ± 1.86	2.8	6.7	4.60 ± 2.10	3.1	7.7	> 0.05	> 4
B.O.D (mg/L)	2.95 ± 0.31	2.7	3.4	2.68 ± 1.24	1	4	2.73 ± 0.49	2	3	>0.05	6
TA (mg/L)	51.85 ± 10.57	42.7	67.1	67.10 ± 15.75	48.8	85.4	86.93 ± 21.35	61	109.8	< 0.05	
Chloride (mg/L)	57.27 ± 10.09	47.57	70.9	53.64 ± 16.22	32.67	70.9	57.27 ± 18.81	33.37	75.3	> 0.05	350
TH (mg/L)	47.95 ± 41.89	19.9	108.9	62.58 ± 38.39	12	100.8	95.70 ± 60.83	26	166.1	>0.05	
Nitrate (mg/L)	2.41 ± 1.64	0.2	3.65	2.88 ± 1.79	0.25	4.03	3.17 ± 1.89	0.4	4.39	> 0.05	40
Sulphate (mg/L)	20.61 ± 4.67	16.4	25.94	18.32 ± 7.90	10	25.88	22.06 ± 10.75	12	35.1	> 0.05	500
Phosphate (mg/L)	11.63 ± 11.61	1.85	25	10.77 ± 9.14	1.33	20.2	14.10 ± 14.46	0.64	27	>0.05	3.5
Ca (mg/L)	4.91 ± 6.51	0.69	14.43	5.89 ± 7.41	0.42	16.83	9.12 ± 11.20	0.9	25.65	> 0.05	180
Mg (mg/L)	0.67 ± 0.53	0.39	1.46	1.18 ± 1.48	0.4	3.4	0.80 ± 0.45	0.5	1.46	> 0.05	40

Note: $P > 0.05$: Not Significant; $P < 0.05$: Significant, AT = Air Temperature; WT = Water Temperature; Cond = Conductivity, TA = Total Alkalinity; TH = Total Hardness

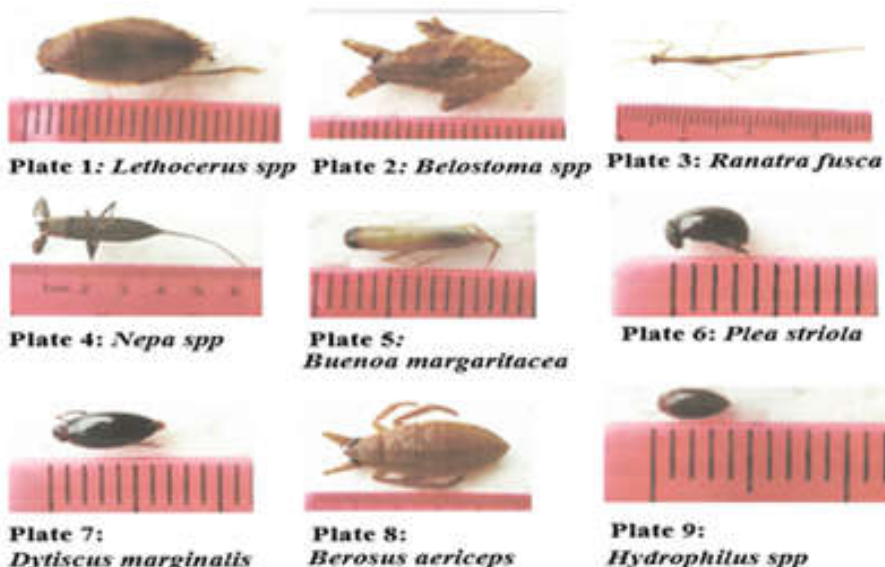
The Order Hemiptera was the most dominated taxa both in abundance (96.12%) and species richness. They were fairly represented in all stations with the families of Belostomatidae and Pliedae accounting for 48.4% and 40.4% of the total Hemipterans observed. The order Coleoptera was generally low in abundance accounting for only 3.88% of the total number of individuals recorded throughout the study. The order Coleoptera was represented by 3 species (*Hydrophilus* spp., *Berosus aericeps* and *Dyticus marginalis*) that were all typically absent in station 1, likely due to the low concentration of dissolved oxygen in this station which agrees with the findings of Ikomi *et al.* (2005), Arimoro *et al.* (2012) and Ikomi and Arimoro (2014). *Lethocerus* spp was the dominant specie in this study with the highest rate of occurrence in all study stations with a total of 42 individuals while *Plea striola* followed closely in abundance recording a total of 40 individuals in all stations with 28 occurring in station two, thus, accounting for the highest number of individuals recorded in any station during the study. Majority of the insect fauna found in this study are

typically found in similar water bodies in the tropics (Adakole and Anunne, 2003; Popoola and Otalekor, 2011). However, the overall insect community structure exhibited relatively low taxa richness across the study stations which tends to deviate from that reported for other lentic systems. An exact comparison cannot be made between the results of this study and those of such previous studies given that there is no existing baseline data on the previous conditions of the ponds and frequency of sampling was restricted to only one season.

Species Composition Similarity Between Sampling Stations: The result of the comparison of sampling station and association of the different insect groups calculated using Sorenson's index is as shown in Table 3 below. The faunal similarity test showed that the values obtained between Station I and III were significantly similar (83.3%) which is a reflection of the low faunal abundance in both sampling stations. Station and I and II were slightly similar recording Sorenson's quotient 50%.

Table 2: Monthly and spatial variation in abundance of insect fauna in the study ponds

Species Composition	Months of Study				Total	Sampling Stations			Total
	May	June	July	August		I	II	III	
Hemiptera									
<i>Lethocerus spp</i>	12	1	20	9	42	11	19	12	42
<i>Belostoma spp</i>	2	4	0	0	6	1	0	5	6
<i>Ranatra fusca</i>	1	0	0	0	1	0	1	0	1
<i>Nepa spp</i>	0	2	0	0	2	1	0	1	2
<i>Buenoa margaritacea</i>	0	3	2	2	7	1	4	2	7
<i>Plea striola</i>	5	8	20	7	40	5	28	7	40
<i>Pelocoris femoratus</i>	0	0	0	1	1	1	0	0	1
Coleoptera									
<i>Dytiscus marginalis</i>	0	0	1	0	1	0	0	1	1
<i>Berosus aericeps</i>	1	0	0	1	2	0	2	0	2
<i>Hydrophilus spp</i>	0	0	1	0	1	0	1	0	1
Total	21	19	45	20	103	20	55	20	103



Plates 2-10: Identified insect fauna from study pond

Table 3: Comparison of sampling station and association of the different insect groups

	Station I	Station II	Station III
Station I	**		
Station II	50%	**	
Station III	83.3%	50%	**

Critical level of significance ≥ 50% for similarity

Diversity Indices: Calculated diversity indices (Table 4) showed diversity ($H = 1.28$) and highest dominance ($d = 1.67$) of aquatic insects in station 1 and station 2 recorded lowest diversity ($H = 1.17$) and lowest dominance ($d = 1.25$) while highest diversity ($H = 1.44$) and dominance ($d = 1.50$) of aquatic insects occurred in station 3. Evenness of distribution of aquatic insects in the three stations ranged from 0.54 to 0.71. The relative abundance of aquatic insects for the three stations was found to be 19.42%, 53.40% and 27.18% respectively. From a statistical standpoint, typical values for Shannon-Weiner's diversity index (H) are generally given to fall between 1.5 and 3.5 in most ecological studies, with the value increasing as

both the richness and the evenness of the community increases (Kerckhoff, 2010). Thus, it can be inferred that the low values recorded in this study show a generally low species diversity across the three stations but also indicate a stronger ecological heterogeneity and stability in station 3 in comparison to the other two stations as a result of its relatively higher diversity (H). Furthermore, with special reference to Margalef's index, values greater than 3 indicates clean water conditions, less than one (1) indicates heavy pollution while values between one to three (1-3) indicates moderately polluted conditions (Lenat *et al.*, 1981; Akindele and Liadi, 2014).

Thus, the generally low Margalef's index values ranging from 1.25 to 1.67 in all three study stations indicate a moderately polluted condition of the study ponds resulting in very low specie richness, diversity and even distribution in the study.

The interrelationship between Physico-Chemical Parameters and Insect Fauna:
The interdependence between water quality parameters at each sampling site in

(Table 5) given by Pearson Correlation Coefficient (r) showed that turbidity had a significant positive correlation with colour, TSS, TDS and conductivity at (p < 0.01) while chloride and nitrate showed a significant negative correlation with calcium and magnesium salts (p < 0.01).

Table 4: Diversity indices of aquatic insects of the study ponds

Parameters	Station I	Station II	Station III
Number of Taxa	6	6	6
Number of individual (N)	20	55	28
Relative abundance (%)	19.42%	53.40%	27.18%
Taxa richness (d) Margalef's Index	1.67	1.25	1.50
Shannon-Weiner's diversity index (H)	1.28	1.17	1.44
Evenness index (E)	0.60	0.54	0.71

Total number of species – 10; Total number of individuals – 103

Table 5: Pearson's correlation (r) of physicochemical parameters of the study pond

	AT.	WT.	Colour	pH	Cond.	Turb.	TSS	TDS	DO	BOD ₅	T.Alk	Chl	TH	NO ₃ ⁻	SO ₄ ²⁻	PO ₄ ³⁻	Ca ²⁺	Mg ²⁺	
AT	1																		
WT.	.695*	1																	
Colour	-0.339	0.070	1																
pH	0.024	0.264	.615*	1															
Cond.	-0.014	0.506	0.246	0.371	1														
Turb.	-0.248	0.412	.709**	0.538	.815**	1													
TSS	-0.166	0.343	0.539	.708*	.630*	.782**	1												
TDS	0.013	0.495	0.406	0.462	.934**	.806**	0.504	1											
DO	0.204	.598*	0.088	0.085	.595*	0.550	0.393	0.511	1										
BOD ₅	-0.127	-0.098	-0.434	-0.402	-0.072	-0.288	-0.044	-0.222	0.121	1									
T.Alk	0.198	-0.098	0.421	0.410	0.341	0.383	0.060	0.551	-0.045	-0.417	1								
Chl	0.072	-0.098	-0.200	-0.095	0.438	0.347	0.456	0.190	0.575	0.232	-0.335	1							
TH	-0.288	-0.098	-0.395	-.581*	-0.235	-0.339	-0.495	-0.286	-0.421	0.216	0.063	-0.175	1						
NO ₃ ⁻	0.072	-0.098	-0.220	0.084	0.559	0.366	.603*	0.259	0.360	0.298	-0.143	.745**	0.081	1					
SO ₄ ²⁻	0.182	-0.098	-0.379	-0.426	0.212	0.060	0.036	0.043	0.440	0.270	-0.352	.880**	-0.023	0.476	1				
PO ₄ ³⁻	0.104	-0.098	.649*	.597*	0.102	0.385	0.187	0.366	0.214	-0.502	0.499	-0.162	-.612*	-0.492	-0.176	1			
Ca ²⁺	0.034	-0.098	0.269	0.086	-0.398	-0.263	-0.533	-0.056	-0.391	-0.268	0.522	-.828**	0.088	-.869**	-.590*	0.529	1		
Mg ²⁺	0.053	-0.098	0.284	0.186	-0.358	-0.188	-0.434	-0.093	-0.417	-.705*	0.382	-.743**	-0.061	-.758**	-.595*	0.457	.734**	1	

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

Table 6: Pearson's correlation (r) of physicochemical parameters and insect faunal abundance of the study pond

	AT.	WT.	Colour	pH	Cond.	Turb.	TSS	TDS	DO	BOD ₅	T.Alk	Chl	TH	NO ₃ ⁻	SO ₄ ²⁻	PO ₄ ³⁻	Ca ²⁺	Mg ²⁺
ST I	-0.630	-0.280	0.622	0.184	0.042	0.379	0.191	0.153	0.193	-0.043	-0.177	0.084	-0.332	-0.328	0.144	0.524	0.138	0.127
ST II	-0.432	0.200	.672*	0.289	0.531	.808**	0.446	0.603	0.607	-0.184	0.152	0.382	-0.289	0.032	0.391	0.549	-0.070	-0.079
ST III	-0.512	-0.199	.704*	0.228	-0.001	0.404	0.122	0.139	0.173	-0.363	-0.037	0.004	-0.340	-0.398	0.060	0.619	0.210	0.364

ST = station; ** Correlation is significant at the 0.01 level (2-tailed). * Correlation is significant at the 0.05 level (2-tailed)

The ecological relationship between mean insect faunal abundance (MFA) and water quality parameter at each station also given by Pearson Correlation Coefficient (r) (Table 6) revealed that in station I, all analyzed water quality parameters were positively correlated with the MFA except temperature (air and water), BOD₅, total alkalinity, total hardness and nitrate, which correlated negatively with the MFA. In station II, air temperature, BOD₅, total hardness, calcium and magnesium ions correlated negatively with the MFA while the remaining analyzed parameters correlated positively with colour and turbidity showing significant positive correlation with the MFA at ($p < 0.05$) and ($p < 0.01$) respectively. In station III air and water temperatures, electrical conductivity, BOD₅, total alkalinity, total hardness and nitrate correlated negatively with the MFA while the remaining analyzed parameters corrected positively with colour showing significant positive correlation with the MFA at ($p < 0.05$).

Conclusion: The findings of this study have provided baseline data and further re-emphasized the role of water quality in the distribution, abundance and diversity of aquatic organisms. The low species abundance and occurrence of majorly pollution-tolerant species of aquatic insects in all stations indicated poor water quality that is reflective of the moderate pollution status of the pond.

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