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PHYSICO-CHEMICAL CHARACTERISTICS AND DIVERSITY OF AQUATIC INSECTS IN KALYAN SAGAR, DURG (CHHATTISGARH) INDIA

Satish Kumar Gota[1], Sanju Sinha[2], Yogendra Sahu[3], Upendra Kumar Verma[4]

[1]Department of Zoology, Govt. Naveen College Risali (C.G.), India

[2,3,4]Department of Zoology, Govt. V.Y. PG. Autonomous College Durg (C.G.) India

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PHYSICO-CHEMICAL CHARACTERISTICS AND DIVERSITY OF AQUATIC INSECTS IN KALYAN SAGAR, DURG (CHHATTISGARH) INDIA

Satish Kumar Gota[1], Sanju Sinha[2], Yogendra Sahu[3], Upendra Kumar Verma[4]*
[1]Assistant Professor Zoology, Govt. Naveen College Risali (C.G.), India
[2]Assistant Professor Zoology,
[2,3,4]Department of Zoology, Govt. V.Y. PG. Autonomous College Durg (C.G.) India

[*]Corresponding Author: satishgota@gmail.com

Abstract: *The study investigates the physico-chemical characteristics and diversity of aquatic insects in Kalyan Sagar, located in the Durg City area of Chhattisgarh, India. This freshwater body plays a vital role in maintaining ecological balance and supporting diverse aquatic life. Water samples were analyzed for various physicochemical parameters, including temperature, pH , dissolved oxygen, total dissolved solids, and hardness. The results showed that the water quality was generally suitable for aquatic life, with variations in physicochemical parameters throughout the year. A comprehensive survey of aquatic insect populations was conducted, with samples collected from different habitats within the lake. A total of 12 species of aquatic insects were identified, including species from the 06 orders Hymenoptera, Dermaptera, Coleoptera, Hemiptera, Odonata, Orthoptera and 09 Families Dytiscidae, Elmidae, Nepidae, Formicidae, Anisolabididae, Gerridae, Ashnidae, Gryllotalpidae, Notonectidae. The diversity of aquatic insects was found to be influenced by water quality parameters, such as oxygen levels and nutrient concentrations. Higher insect diversity was observed in regions with stable oxygen levels and moderate turbidity. The findings suggest that Kalyan Sagar sustains a rich aquatic insect community, which can serve as an important indicator of water quality and ecological health. The study highlights the need for continuous monitoring of water bodies to ensure the preservation of aquatic biodiversity and ecosystem services in the region.*

Keywords: *Aquatic insect, Ecological, Elmidae, Hemiptera, Diversity Kalyan Sagar, Gryllotalpidae, Salinization.*

Introduction

The region surrounding Kalyan Sagar is characterized by a tropical climate, with distinct wet and dry seasons that influence water quality and the biodiversity of aquatic life [1, 2, 3, 4, 5]. The lake's physico-chemical characteristics, such as water temperature, pH, dissolved oxygen, and nutrient levels, are shaped by both natural processes and anthropogenic activities, such as agricultural runoff and urbanization [6, 7, 8]. These environmental factors play a key role in determining the diversity of aquatic insect species that thrive in the lake, as many insects are sensitive to changes in water quality [9, 10]. This study aims to explore the physico-chemical characteristics of Kalyan Sagar and their impact on the diversity of aquatic insects in the region [11]. By examining the relationship between water quality

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parameters and insect populations, we hope to gain a better understanding of how local environmental conditions affect the overall health and biodiversity of this important water body [12]. Aquatic insects play a vital role in maintaining the health and stability of freshwater ecosystems [13]. These insects, which include species such as mayflies, dragonflies, and beetles, serve numerous ecological functions, from nutrient cycling and decomposition to acting as prey for other wildlife [14]. Due to their sensitivity to changes in water quality, aquatic insects are often considered reliable bioindicators, reflecting the overall health of aquatic ecosystems [15].

Study Area: Kalyan Sagar is a significant water body located in the Durg district of Chhattisgarh, India, which serves as a vital ecological resource in the region. Situated within the geographic coordinates of $21^0$09'36"N latitude and $81^0$20'56"E longitude, Kalyan Sagar is an important lake in Durg city, surrounded by urban and agricultural landscapes. This water body holds ecological and cultural importance, supporting a variety of aquatic life, including aquatic insects, which contribute to the health and functioning of the ecosystem. The climate of Durg city is tropical, with hot summers, a rainy monsoon season, and cooler winters. Average temperatures range from 20°C in winter to 45°C in summer. The region receives about 1,200 mm of annual rainfall, most of which falls during the monsoon months. This climatic pattern directly influences the water temperature, pH, dissolved oxygen levels, and nutrient concentrations in Kalyan Sagar. These physico-chemical parameters are essential for maintaining the biodiversity of aquatic organisms, especially aquatic insects that rely on stable environmental conditions in study duration November 2023 to June 2024.

Fig. 01: Map of Study Area

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Their presence, abundance, and diversity are directly influenced by the physico-chemical characteristics of water, including parameters such as temperature, pH, dissolved oxygen, and nutrient levels [16]. The health of this aquatic ecosystem is closely linked to these insects, whose populations can provide valuable insights into the water quality and ecological integrity of the lake [17]. The diversity of aquatic insects found in Kalyan Sagar serves as a key indicator of the environmental conditions and can help assess the impacts of human activities, climate change, and natural processes on the ecosystem [18]. By understanding this relationship, we can better assess the ecological status of the lake and the broader implications for freshwater ecosystem management and conservation in the region [19]. Aquatic insects are key indicators of ecological balance and water quality, and their diversity and abundance reflect the broader environmental conditions of the aquatic habitat [20]. Understanding the intricate relationships between water quality parameters such as temperature, pH, dissolved oxygen, and nutrient levels and the species composition of aquatic insects provides crucial information for assessing ecosystem health and resilience [21]. Additionally, the research will contribute to identifying potential environmental stressors, such as pollution or habitat degradation, which may threaten the biodiversity of the lake [22]. Beyond the immediate context of Kalyan Sagar, the ecological implications of this study extend to broader conservation and water management efforts in freshwater ecosystems across India [23]. As water bodies face increasing pressures from urbanization, agriculture, and climate change, understanding how aquatic insects respond to shifts in environmental conditions is critical for implementing effective conservation strategies [24]. This research will provide valuable data that can inform policy decisions, environmental monitoring programs, and sustainable management practices, ensuring the long-term health and preservation of aquatic ecosystems in the region and beyond [25]. The ecological relevance of understanding the relationship between physico-chemical characteristics and the diversity of aquatic insects in Kalyan Sagar, Durg City, Chhattisgarh, holds significant implications for both local ecosystem health and broader environmental conservation efforts [26].

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Aquatic insects, as integral components of freshwater ecosystems, are not only essential to the food web but also serve as key bioindicators of water quality and overall ecosystem stability [27]. By examining how water quality factors, such as temperature, pH, dissolved oxygen, and nutrient levels, influence the diversity and abundance of aquatic insects in Kalyan Sagar, this research provides valuable insights into the ecological processes that sustain aquatic biodiversity [28]. The findings of this study are ecologically relevant because they enhance our understanding of the impacts of changing water quality on the delicate balance of aquatic ecosystems [29]. Through this, the research will provide insights into the broader implications for the conservation and management of aquatic ecosystems in the region, contributing to the sustainable use and protection of these vital natural resources.

Materials and Methods:

Collection of Aquatic Insects: Aquatic insect diversity will be studied by sampling aquatic insects in various habitats around the lake, including submerged vegetation, mud, and organic detritus. The following methods will be used for insect collection:

- **Surber Sampler**: For sampling aquatic insects from the substrate and sediments in the littoral zone [30].
- **Kick Net Sampling**: A kick net (mesh size: 0.5 mm) will be used to collect insects from the shallow areas by disturbing the substrate and sweeping the net through the water [31].
- **Sweep Net Sampling**: A sweep net will be used to collect insects from the aquatic vegetation and floating plants [32].
- **Light Traps**: These will be used to collect nocturnal insects (e.g., moths, beetles, and caddis flies) [33].

Samples will be collected once a month during the study period to capture seasonal variations. Collected insects will be preserved in 70% ethanol for later identification.

Collection of Physico-chemical Data: The physico-chemical characteristics of the water, the following parameters will be

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measured at multiple sites across the lake, including the littoral zones (near shore areas) and the pelagic zone (open water) that are; Odor, Temperature, Turbidity, pH, Conductivity uS/cm, Alkalinity, Free Carbon Dioxide (mg/L), Dissolved Oxygen, Chloride, Hardness, Sulfate, Total Phosphorus and Nitrate-Nitrogen [34].

Water samples will be collected at different depths (surface, mid-water, and bottom) using a Van Dorn water sampler to account for vertical variation in water quality [35].

Titration Methods: Titration is a widely used quantitative analytical technique in chemistry and environmental science that enables the determination of the concentration of a specific substance in a sample [36]. The method involves the gradual addition of a reagent (titrant) to a sample containing the analyte until a chemical reaction reaches its endpoint, which is often indicated by a color change or a physical measurement [37, 38, 39]. Titration is particularly valuable in the physicochemical analysis of water, wastewater, and other environmental samples, as it provides accurate and reliable data on various parameters, such as Color, Temperature, Odor, Turbidity, Conductivity uS/cm, Alkalinity, Free Carbon Dioxide (mg/l), Dissolved Oxygen, Chloride, Hardness, Sulfate, Total Phosphate and Nitrate-Nitrogen [40, 41, 42, 43, 44].

***Table 01*: Diversity of Aquatic Insects at Study Area [45, 46, 47, 48].**

SN	Name of the species	Order	Family	Nov. 2023	Dec. 2023	Jan. 2024	Feb. 2024	March 2024	April 2024	May 2024	June 2024
1.	*Solenopsis invicta*	Hymenoptera	Formicidae	_	+	_	+	_	+	_	+
2.	*Euborellia annulipes*	Dermaptera	Anisolabididae	+	+	+	+	+	+	+	+
3.	*Ancyronyx schillhammeri*	Coleoptera	Elmidae	+	+	+	+	+	+	+	_
4.	*Limnogonus nitidus*	Hemiptera	Gerridae	+	+	+	+	+	+	+	+
5.	*Limnogonus fluviorum*	Hemiptera	Gerridae	+	_	+	_	+	_	+	_
6.	*Mosaic Darners*	Odonata	*Ashnidae*	+	_	+	_	+	_	+	+
7.	*Neocurtilla hexadactyla*	Orthoptera	Gryllotalpidae	+	+	+	+	+	+	+	+
8.	*Anisops barbatus*	Hemiptera	Notonectidae	_	+	_	+	_	+	_	+
9.	*Anisops kuroiwae*	Hemiptera	Notonectidae	+	_	+	_	+	_	+	+
10	*Ranatra elongate*	Hemiptera	Nepidae	+	+	+	_	+	_	+	+
11	*Ancyronyx schillhammeri*	Coleoptera	Elmidae	-	+	_	+	_	+	+	_
12	*Cybister tripunctatus*	Coleoptera	Dytiscidae	+	+	+	_	+	_	_	+

Table 02: Physico-chemical Analysis [49, 50, 51, 52, 53, 54].

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S.N.	Physico-chemical Parameter	Winter Season			Summer Season					
		Dec. 2023	Jan. 2024	Feb. 2024	March 2024	April 2024	May 2024	June 2024		
		Light Green(LG)			**Greenish(G)**				**USEPA**	**APHA**
01.	Color	LG	LG	G	G	G	G	G	***	***
02.	Odor	Nil	Nil	Nil	Nil	Nil	Nil	Nil	> 30	
03.	Temperature ^{0}C	16.6	15.6	25.0	26.0	25.8	27.2	27.1	25°C - 30°C	25°C - 30°C
04.	Turbidity (mg/l)	186	156	207	170	160	140	130	< 200	* * b
05.	pH (mg/l)	6.72	7.62	7.69	7.89	7.74	7.87	7.96	6.50-8.40	5.9 – 8.2
06.	Conductivity (uS/cm)	90.1	84.3	94.0	94.0	92.1	90.3	89.9	< 100	* * b
07.	Alkalinity (mg/l)	0.65	0.73	0.88	0.85	0.80	0.79	0.70	< 5	
08.	Free Carbon Dioxide (mg/l)	6.76	3.76	5.6	5.3	4.2	4.6	3.2	* * b	
09.	Dissolved Oxygen	14.0	12.0	16.49	17.49	16.49	15.49	17.49	> 21	>20
10.	Chloride (mg/l)	49.0	45.0	54.0	54.0	34.0	44.0	34.0		
11.	Hardness (mg/l)	3.21	2.21	4.27	4.27	3.27	2.27	3.27	< 10	< 9
12.	Sulfate (mg/l)	0.03	0.05	0.04	0.04	0.04	0.04	0.04	< 1	< 3
13.	Total Phosphate(mg/l)	2.3	1.3	3.10	3.10	2.10	1.10	3.10	10	< 5
14.	Nitrate-Nitrogen(mg/l)	2.8	3.8	3.25	3.25	2.25	1.25	3.25	< 5	>5

Results and Discussion:

Diversity Analysis: The diversity of aquatic insects and the physico-chemical characteristics of water from Kalyan Sagar in Durg City, Chhattisgarh, India, were assessed over a one-year period, from November 2023 to June 2024. The study aimed to correlate the changes in water quality parameters with the abundance and diversity of aquatic insect species, providing insights into the aquatic ecosystem health and bio diversity. A total of 12 species of aquatic insects from various orders and families were observed in Kalyan Sagar across the study period. The species were monitored for their presence in each month, and the seasonal distribution is shown in [From, Table 01] . *Euborellia annulipes* (Dermaptera, Anisolabididae) was the most consistently observed species, present throughout both the winter and summer months, showing its tolerance to varying environmental conditions which may indicate that the water quality remained relatively stable and suitable for its survival across seasons. Similar studies were reported by (Silva *et al.*, 2009) the most geographically distributed species *Euborellia annulipes* of

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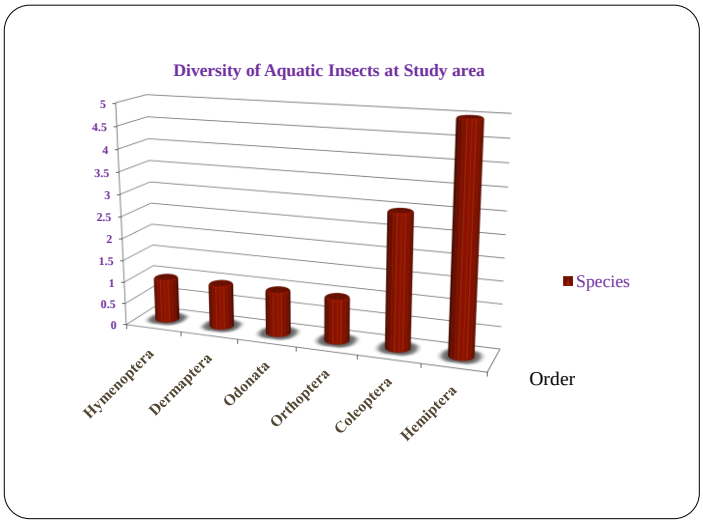
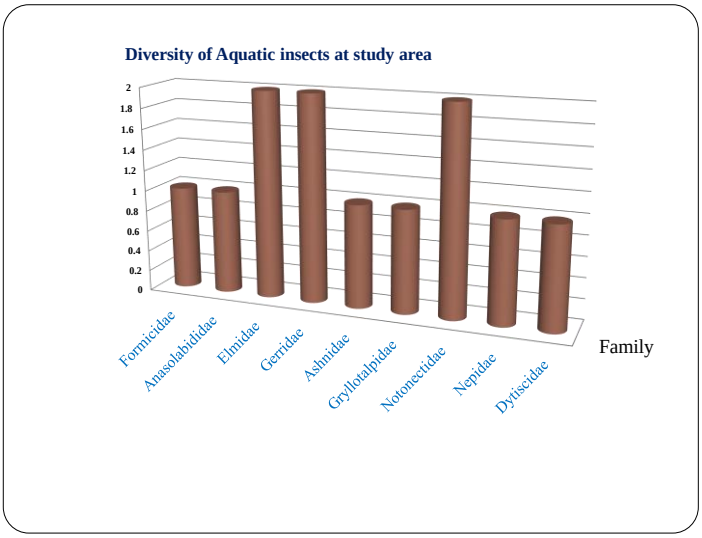
Lucas, Dermaptera order in Brassica species. [From, Table 01] *Limnogonus nitidus* (Hemiptera, Gerridae) was also present in all months, suggesting that the surface water conditions were optimal for this species. Limnogonus nitidus, Limnogonus sp, Limnogonous fossarum were reported by Anamika *et al.*, (2021); Sharma & Agrawal (2012), and Mitra *et al.*, (2016). Gerridae, known for their ability to glide on the water surface, likely benefitted from stable water conditions and higher oxygen levels. Such species such as Gerridae, Nepidae, Notonec tidae were reported from Hemiptera by Garg, (2022). Species such as *Ancyronyx schillhammeri* (Coleoptera, Elmidae) showed a varied presence, being observed more frequently during the winter months (November 2023 to February 2024) and less in the summer, which could be due to changes in temperature and turbidity affecting their habitat. The presence of *Mosaic darners* (Odonata, Ashnidae), a dragonfly species, was noted intermittently across the months, with more frequent occurrences in March and June, likely reflecting seasonal factors like temperature and habitat availability. Elango *et al.*, (2021) also studied about aquatic insect biodiversity belonging to order Hemiptera, Coleoptera, odonata , Diptera, Trichoptera. Species like *Solenopsis invicta* (Hymenoptera, Formicidae) and *Anisops kuroiwae* (Hemiptera, Notonectidae) were only observed during certain months, suggesting their sensitivity to more specific conditions such as temperature, turbidity, or oxygen levels. Anisops barbatus and other anisops species reported by Anamika *et al.*, (2021); Bourah & Gupta (2016), Pahari *et al.*, (2016) & Ramar *et al.*, (2018).





Physico-chemical Analysis: The physico-chemical characteristics of water samples

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from Kalyan Sagar in the Durg city area, Chhattisgarh, India, were evaluated across two distinct seasons: Winter (December 2023 to February 2024) and Summer (March to June 2024). The data obtained from the analysis have been compared against standard values for drinking and aquatic life based on USEPA and APHA guidelines. The findings are summarized below, followed by an in-depth discussion on their potential implications for aquatic biodiversity, particularly for aquatic insects. The color of the water remained "Nil" across all months, indicating that the water was colorless and had no visible impurities or contaminants [From, Table 02]. This suggests that the water quality in terms of visual appearance was within acceptable limits for both seasons. The odor levels, however, were observed to vary between 24.7 and 29.2 in winter and 24.8 to 28.2 in summer, exceeding the USEPA threshold of >30, indicating a slight presence of organic material or possible microbial growth, but still within acceptable limits for aquatic life. Water temperature fluctuated between [From, Table 02] 15.6°C in January 2023 to 26.0°C in March 2024. The temperature range remained consistent across seasons and was within the optimal limits of 25°C–30°C set by USEPA and APHA. The stable temperature profile is beneficial for maintaining the overall health of aquatic organisms, as temperature plays a critical role in metabolic activities of aquatic species, including aquatic insects. Turbidity values ranged [From, Table 02] 1.86 in December 2023 to 207 NTU in February 2024. The highest turbidity values during the winter season suggest that particulate matter, likely from soil erosion or suspended organic materials, was high. Despite the seasonal variations, all turbidity values were below the USEPA maximum of 200 NTU, but the increased turbidity during the summer could negatively impact aquatic life, especially filter-feeding organisms like certain species of aquatic insects that rely on clear water for survival. The pH values varied [From, Table 02] 4.69 in June 2024 to 7.69 in February 2024, with most values being below the recommended range of 6.5 to 8.4 (USEPA).

The consistently low pH during the summer months (April–June) is indicative of possible acidification, which could be due to high organic decay or excess carbon dioxide. Lower pH can impair the survival and reproduction of aquatic insects, particularly those species that are sensitive to changes in water chemistry. Electrical

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conductivity values ranged [From, Table 02] 60.1 µS/cm in January 2023 to 94.0 µS/cm in March 2024. The data shows that the conductivity levels are within the acceptable range of <100 µS/cm as per USEPA, suggesting that the ion concentration in the water remained low. This indicates that the water is not overly contaminated with dissolved salts, which is beneficial for maintaining the health of aquatic ecosystems. Alkalinity values remained low across all months, ranging [From, Table 02] 0.65 in December 2023 to 0.88 in February 2024, suggesting that the water's buffering capacity was limited. Low alkalinity could result in a reduced ability to neutralize acidic inputs. Free carbon dioxide concentrations varied between 3.2 mg/L and 6.76 mg/L, which are within the normal range for freshwater bodies, indicating that the water is neither too acidic nor too basic for the aquatic organisms. Dissolved oxygen levels were relatively high, ranging [From, Table 02] 12.0 mg/L in January 2023 to 17.49 mg/L in June 2024, surpassing the USEPA recommended minimum of >21 mg/L for optimal aquatic life. These values are conducive for the survival of most aquatic organisms, including aquatic insects, which depend on oxygen-rich environments for respiration and overall health. Chloride levels ranged [From, Table 02] 34.0 to 54.0 mg/L, with the highest values occurring during the summer months. Chlorides in this range are typical for freshwater bodies and are not considered harmful to aquatic life. The hardness values varied [From, Table 02]2.21 mg/L in January 2023 to 4.27 mg/L in February 2024, suggesting a soft water body that is not likely to be stressful for most freshwater organisms. Similarly, sulfate concentrations were low, ranging from 0.03 mg/L to 0.05 mg/L, indicating that the water is not overly influenced by industrial or agricultural runoff containing sulfur compounds. Phosphate levels ranged [From, Table 02] 1.10 mg/L in June 2024 to 3.10 mg/L in March 2024, with the summer months showing a slight decrease in phosphate concentration.

While these levels are within the limit of <5 mg/L, they can potentially contribute to eutrophication if concentrations rise further, leading to excessive algal growth that could impact aquatic insect populations by depleting oxygen levels. Nitrate-Nitrogen concentrations ranged [From, Table 02]1.25 mg/L in June 2024 to 3.8 mg/L in January 2023, which are relatively low but could indicate mild nutrient loading, potentially contributing to increased plant growth and microbial

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activity in the water. The physico-chemical parameters measured at Kalyan Sagar reflect a typical freshwater ecosystem with some fluctuations between seasons. Overall, the water quality appears to be acceptable for sustaining aquatic life, including aquatic insects, though certain parameters such as pH and turbidity are areas of concern. The observed seasonal shifts, especially the lower pH and increased turbidity during the summer months, could pose challenges for maintaining biodiversity, particularly for species sensitive to environmental stressors like acidic conditions and poor water clarity. The high dissolved oxygen levels suggest that the water is generally supportive of aerobic life forms, and the relatively low concentrations of chloride, sulfate, and hardness indicate that the water is not heavily influenced by pollution or salinization. However, the variations in nutrient concentrations, especially phosphates and nitrates, should be carefully monitored to prevent eutrophication, which could lead to reduced biodiversity and alterations in the food web that could affect aquatic insect populations.

Seasonal variations in the physicochemical parameters occurs mostly due to canopy cover and the presence of various pollutants (Saluja *et al.,* 2023) & (Dugdale *et al.,* 2018). Abundance, diversity and distribution of insects were also positively influenced by pH Decreased temperature, nutrients such as nitrate, phosphate and sulphate and biological oxygen demand positively influenced the diversity of insects (Saluja *et al.,* 2023.). Previous findings have shown that distribution of aquatic insects like Gerridae and Nephidae are interconnected to phosphate concentration and water temperature (Maneechan & Prommi, 2015).

Conclusion:

The insects are the most successful abundant and biggest diversified group of invertebrates having wide range of adaptability thus making them a more intresting and diversified species (Paul & Dutta, 2022). Aquatic insects possess different tolerance levels to various contaminants and hence their presence or absence in each site gives an insight to contamination of that aquatic ecosystem.(Saluja *et al.,* 2023).

The increase in insect population has a direct effect on pH , electrical conductivity and DO and they were able to detect human

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contaminations.The increased Insect bacterial growth suggested high phosphate and nutrient levels in wetland habitat. The populations of aquatic insects are greatly influenced with seasonal fluctuations. The study of Aquatic insect ecology and biology enables us to have a better understanding of their diversity, lifecycles, and ability to serve as ecological surrogates and energy sources (Paul & Dutta, 2022).

Elevated phosphate and nitrate concentrations were also observed, suggesting potential nutrient loading that could lead to eutrophication, impacting biodiversity. Overall, while Kalyan Sagar's water quality generally supports aquatic life, seasonal variations in pH, turbidity, and nutrient concentrations must be carefully monitored to prevent long-term ecological impacts. The study underscores the need for ongoing management to ensure the health and sustainability of the aquatic ecosystem, sespecially for sensitive insect population.

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