



Biodiversity, Distribution, and Water Quality Assessment of Aquatic Insects in Various Lakes of Telangana, India

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Abstract

The present research investigates the diversity, distribution, and water quality of aquatic insects in several lakes in Hyderabad, Telangana, India. The main emphasis is placed on three principal families: Noteridae, Dytiscidae, and Hydrophilidae, in addition to many species from the aquatic Hemiptera family. The research offers valuable insights into the ecological well-being and habitat variety of 21 distinct lakes by performing field surveys and analyzing the existence of various species in these aquatic systems. In addition, water quality measures like pH, dissolved oxygen, and nutrient levels were evaluated in order to assess their influence on the dispersal of aquatic insects. The results reveal strong positive correlations between these parameters and species diversity, with Nitrate exhibiting the highest correlation across all seasons ($r \approx 0.997$ in summer). Optimal pH levels ($r \approx 0.992$ in monsoon) and elevated Dissolved Oxygen ($r \approx 0.976$ in summer) significantly enhance species diversity. Phosphate also contributes positively ($r \approx 0.953$ in monsoon), though to a lesser extent. These findings underscore the importance of maintaining and monitoring water quality to support biodiversity in aquatic ecosystems.

Keywords

Species Diversity, Water Quality, pH, Dissolved Oxygen, Nitrate, Phosphate, Pearson Correlation, Aquatic Ecosystems, Biodiversity, Lake Management

1. Introduction

1.1 Background

Aquatic insects are integral to the functioning of freshwater ecosystems, offering a variety of ecological services that are crucial for maintaining the health and stability of these environments [1]. These insects participate actively in nutrient cycling, a fundamental ecological process where organic matter, such as dead plants and animals, is broken down into simpler substances that can be reused by other organisms within the ecosystem. By decomposing organic matter, aquatic insects contribute to the recycling of nutrients, which promotes the growth of primary producers like algae and aquatic plants [2]. This process not only cleanses the water by removing debris but also ensures that essential nutrients are continually available to sustain the ecosystem's productivity. Moreover, aquatic insects serve as a critical food source for a multitude of higher trophic levels, including fish, amphibians,

birds, and even some mammals. This positioning makes them a pivotal link in the food web, transferring energy from primary producers and detrital matter up to larger predators. For instance, many fish species rely heavily on aquatic insects as a primary food source during their larval and juvenile stages, which in turn supports local fisheries and biodiversity. Birds, especially waterfowl and shorebirds, also depend on the abundance of aquatic insects for sustenance, particularly during breeding and migratory periods [3].

In addition to their roles in nutrient cycling and as a food source, aquatic insects are invaluable as bioindicators of water quality and overall ecosystem health. Their sensitivity to environmental changes, such as pollution, habitat modification, and climate fluctuations, makes them effective indicators of the ecological status of freshwater habitats. Certain species of aquatic insects can thrive only in specific water quality conditions, making their presence or absence a clear sign of the environmental health of a water body [4]. The study of aquatic insects provides critical insights into the ecological status and environmental changes within freshwater habitats. By monitoring the diversity and population dynamics of these insects, researchers can detect early signs of ecological disturbance and identify trends in environmental quality over time. Such studies can reveal the impacts of anthropogenic activities, such as agricultural runoff, urbanization, and industrial pollution, on freshwater ecosystems [5]. They can also contribute to the understanding of broader ecological processes, such as nutrient cycling and energy flow, which are essential for the sustainable management and conservation of freshwater resources.

1.1.1 Importance of Aquatic Insects

Aquatic insects are pivotal to the functioning and health of freshwater ecosystems due to their diverse ecological roles. Among the most significant families are Noteridae, Dytiscidae, Hydrophilidae, and the broader group of aquatic Hemiptera, each contributing uniquely to their habitats [6].

- **Noteridae (Burrowing Water Beetles):** Members of the Noteridae family, commonly known as burrowing water beetles, are predominantly found in stagnant waters that are rich in organic material. These insects are vital decomposers within their ecosystems. By breaking down organic matter such as dead plants and animals, they facilitate nutrient cycling, ensuring that essential nutrients are returned to the ecosystem and made available for other organisms. This process not only cleanses the water but also maintains its quality by preventing the buildup of organic debris. In doing so, Noteridae help sustain the productivity of aquatic habitats, supporting a wide range of other aquatic life forms.
- **Dytiscidae (Predaceous Diving Beetles):** The Dytiscidae family, known as predaceous diving beetles, are notable for their predatory behavior. They are adept hunters, feeding on a variety of other aquatic invertebrates. This predation helps regulate the populations of their prey, preventing any single species from becoming overly dominant and thereby maintaining ecological balance within the aquatic community [7]. The presence of Dytiscidae is often an indicator of good water quality, as these beetles are sensitive to pollution and require clean water to thrive. Their ability to live only in relatively

unpolluted waters makes them reliable bioindicators for assessing the health of freshwater ecosystems.

➤ **Hydrophilidae (Water Scavenger Beetles)**

Hydrophilidae, or water scavenger beetles, are typically found across a diverse array of freshwater habitats, including ponds, lakes, and streams. These beetles contribute significantly to the breakdown of organic matter, feeding on decaying vegetation and other organic debris. Their scavenging activity plays a crucial role in nutrient recycling, similar to that of the Noteridae. Moreover, Hydrophilidae can indicate the presence of organic pollution, as they are often found in environments with decaying organic material. Thus, their population dynamics can provide insights into the levels of organic pollution and the overall health of aquatic habitats.

➤ **Aquatic Hemiptera**

The group of aquatic Hemiptera, which includes various water bugs, exhibits a wide range of feeding behaviors, from herbivory to predation. These insects are integral to the food web, serving both as predators and prey. Their presence and abundance can reflect the structure and quality of aquatic habitats. The diversity within aquatic Hemiptera makes them useful indicators of water quality and habitat structure. They respond to changes in environmental conditions, such as alterations in water chemistry and habitat degradation, providing valuable information about the health and stability of freshwater ecosystems [8].

1.2 Objectives

The objectives of this study are:

1. To catalog the species of aquatic insects in the selected lakes.
2. To assess the water quality of these lakes based on parameters such as pH, dissolved oxygen, and nutrient levels.
3. To analyze the relationship between water quality and the distribution of aquatic insect species.
4. To provide recommendations for conservation and management based on the findings.

1.3 : Paper structure: This paper is structured to provide a comprehensive analysis of the biodiversity, distribution, and water quality assessment of aquatic insects in various lakes of Telangana, India. The introduction sets the stage by highlighting the importance of aquatic insects in freshwater ecosystems and their roles in nutrient cycling, food webs, and as bioindicators of ecosystem health. It also outlines the study area's context, detailing the diversity of lakes in Telangana and their significance. The methodology section describes the field surveys, species identification processes, and water quality assessments carried out across 21 lakes, specifying the techniques and instruments used. The results section presents findings on species diversity, water quality parameters, and the relationship between these factors, including statistical analyses and diversity indices. The discussion interprets these results, emphasizing the ecological implications, the impact of water quality on insect distribution, and

conservation recommendations. The paper concludes by summarizing the key insights, their importance for biodiversity conservation, and suggestions for future research.

2. Literature review

This literature review synthesizes recent research on the biodiversity, distribution, and ecological significance of aquatic insects in freshwater ecosystems, focusing on the role of these insects as bioindicators of water quality and the impact of environmental stressors on their populations.

Boothroyd and Stark [9] discuss the methodologies for using invertebrates, particularly aquatic insects, in monitoring freshwater ecosystems. Their work emphasizes the importance of standardized sampling techniques and reliable taxonomic identification to assess ecological health accurately. Invertebrates are crucial indicators due to their sensitivity to a wide range of environmental stressors, making them ideal for long-term ecological monitoring. Reynoldson, Bailey, and Day [10] provide biological guidelines for assessing freshwater sediment quality based on benthic invertebrate communities. They highlight the use of specific benthic assessment methods to evaluate sediment health, which is integral to understanding overall ecosystem integrity. Their guidelines help establish benchmarks for acceptable sediment conditions, which are critical for maintaining healthy aquatic insect populations.

Wood et al. [11] investigate the effects of habitat degradation on the spatial and temporal variability of macroinvertebrate communities in UK floodplain ecosystems. Their findings indicate that habitat quality significantly influences the diversity and distribution of macroinvertebrates, including aquatic insects. Degraded habitats tend to support fewer species, often dominated by pollution-tolerant organisms, highlighting the need for habitat conservation and restoration efforts. Pechar and Straškrábová [12] explore nutrient cycling in aquatic ecosystems, focusing on the role of aquatic insects in these processes. Their research demonstrates that insects contribute to the decomposition of organic matter and nutrient recycling, which are essential for maintaining water quality and supporting primary production. This underscores the interconnectedness of biological and chemical processes in freshwater habitats. Hillebrand and Matthiessen [13] examine the impact of nutrient enrichment on biodiversity in freshwater ecosystems. They find that moderate levels of nutrients can enhance biodiversity by providing essential resources for various species. However, excessive nutrient inputs, often from agricultural runoff, can lead to eutrophication, negatively affecting aquatic insect populations by altering habitat conditions and increasing competition for resources.

Wallace et al. [14] study the linkage between multiple trophic levels in forest streams and terrestrial litter inputs. Their work shows that terrestrial inputs significantly influence the composition and abundance of aquatic insects by providing critical food resources. This connection highlights the importance of maintaining riparian vegetation and natural litter fall to support healthy aquatic ecosystems. Dodds and Smith [15] discuss the roles of nitrogen and phosphorus in stream eutrophication. Their research highlights how elevated nutrient levels can lead to algal blooms and hypoxic conditions, which adversely affect aquatic insects. Maintaining balanced nutrient levels is crucial for preserving the ecological balance and ensuring the survival of sensitive insect species. Battin et al. [16] investigate the biophysical controls on organic carbon fluxes in fluvial networks. They emphasize the role of microbial communities and aquatic insects in processing organic carbon, which is vital for the energy

flow within aquatic ecosystems. Their findings illustrate the importance of preserving natural flow regimes and water quality to support these ecological processes.

Elosegi and Sabater [17] explore the effects of hydromorphological integrity on biodiversity and ecosystem functioning in river systems. They conclude that maintaining natural hydromorphological conditions is essential for supporting diverse and functional aquatic insect communities. Alterations to flow regimes and physical habitat structures can significantly disrupt these communities and reduce biodiversity. Stevenson and Smol [18] review the use of algae in environmental assessments, emphasizing their role alongside aquatic insects as bioindicators. They highlight that algae respond rapidly to changes in water quality, providing early warning signs of ecological disturbances. Integrating algal and insect data can offer a more comprehensive understanding of ecosystem health.

3.0 Materials and Methods

3.1 Study Area

The study was conducted across 21 lakes in Hyderabad, Telangana, India. These lakes vary in size, depth, and surrounding land use, providing a diverse range of habitats for aquatic insects. The lakes were surveyed during three distinct seasons: monsoon, summer, and winter of 2022-2023. This seasonal variation allowed for the observation of changes in insect populations and water quality across different environmental conditions. Field surveys were carried out during each season to capture seasonal variations in aquatic insect populations and water quality. Standard entomological methods were used to sample insects, including sweep nets and dip nets. Sampling points were strategically selected around each lake to account for habitat variability. Sweep nets were used to collect insects from the water surface and vegetation along the lake margins. Each sweep covered a standardized area and duration to ensure consistent effort. The sweep net, typically made of fine mesh, was swept through the water and vegetation to capture insects present in these microhabitats. Dip nets were used to sample insects from the water column and substrate. The dip net was employed to sample a standardized volume of water and sediment. The net was moved in a consistent manner to collect insects from the benthic zone and water column, ensuring a representative sample from each sampling point. Collected specimens were preserved in 70% ethanol for laboratory identification. The use of ethanol helps in maintaining the morphological integrity of the specimens for accurate identification later.

3.2 Species Identification

In the laboratory, collected specimens were identified to the species level using standard taxonomic keys [19]. The primary focus was on three families: Noteridae, Dytiscidae, and Hydrophilidae, along with several species from the aquatic Hemiptera family. Identification was based on morphological characteristics, such as body shape, size, coloration, and distinctive anatomical features. Expert taxonomists verified the identifications to ensure accuracy. The identification process involved:

- **Morphological Examination:** Using microscopes to observe fine details of the insects' morphology.
- **Taxonomic Keys:** Utilizing published taxonomic keys and literature specific to aquatic insects.
- **Reference Collections:** Comparing specimens with reference collections and images from scientific databases.

3.3 Water Quality Assessment

Water samples were collected concurrently with insect sampling during each season [20]. The parameters measured included pH, dissolved oxygen (DO), and nutrient levels (nitrate and phosphate).

pH: Measured using a portable pH meter calibrated before each sampling session. The probe was immersed in the water sample, and the pH value was recorded once stabilized. The calibration of the pH meter was done using standard buffer solutions to ensure accurate readings.

Dissolved Oxygen (DO): Measured using a DO meter. The probe was placed in the water sample, and the DO concentration was recorded in mg/L after stabilization. The DO meter was calibrated using standard solutions to ensure accurate measurements [21].

Nutrient Levels: Nitrate (NO₃⁻) and phosphate (PO₄³⁻) levels were analyzed in the laboratory using spectrophotometric methods. Water samples were filtered and treated with reagents to develop colorimetric reactions measurable by a spectrophotometer [22]. Absorbance values were compared to standard curves to determine nutrient concentrations. The steps included:

- **Filtration:** Removing particulate matter from the water samples.
- **Reagent Addition:** Adding specific reagents to react with nitrates and phosphates.
- **Spectrophotometry:** Measuring the absorbance of the resulting solution at specific wavelengths.

3.4 Data Analysis

3.4.1 Shannon-Wiener Diversity Index

The Shannon-Wiener Diversity Index (H') was calculated for each lake to assess species diversity [23]. This index is a commonly used metric in ecological studies to quantify biodiversity by considering both species richness (the number of different species) and species evenness (the relative abundance of each species).

$$H' = - \sum (p_i \ln p_i) \quad (1)$$

p_i : The proportion of individuals belonging to species i relative to the total number of individuals in the community. This is calculated as: $p_i = n_i/N$ where n_i is the number of individuals of species i and N is the total number of individuals of all species.

Calculation Steps

1. For each species in each lake, count the number of individuals.
2. Determine the proportion of the total community each species represents.
3. Substitute these proportions into the Shannon-Wiener formula and sum the values for all species in the lake.
4. Higher values of H' indicate greater diversity, reflecting both a higher number of species and a more even distribution of individuals among those species.

3.4.2 Correlation and Regression Analysis

The relationship between water quality parameters and insect distribution was analysed using correlation and regression analysis. These statistical techniques help in understanding how variations in water quality influence the diversity and abundance of aquatic insects [24-25].

3.4.3 Pearson Correlation Coefficients

Pearson correlation coefficients (r) were calculated to determine the strength and direction of the linear relationship between water quality parameters (such as pH, dissolved oxygen, nitrate, and phosphate levels) and species diversity [26].

$$r = \frac{\sum (X_i - \bar{X})(Y_i - \bar{Y})}{\sqrt{\sum (X_i - \bar{X})^2 \sum (Y_i - \bar{Y})^2}} \quad (2)$$

- X_i : Individual values of the water quality parameter.
- Y_i : Corresponding values of the species diversity index.
- $r=1$ or $r=-1$: Perfect positive correlation (as one variable increases, the other also increases).
- $r=-1$ or $r=1$: Perfect negative correlation (as one variable increases, the other decreases).
- $r=0$ or $r=0$: No linear correlation between the variables.

4 Results and Discussions

4.1 Species Diversity and Distribution

The Shannon-Wiener Diversity Index (H') was calculated for each of the 21 lakes across the three seasons: monsoon, summer, and winter. The diversity indices provided insights into the biodiversity within each lake, indicating both the richness and evenness of species distribution. During the monsoon season, the diversity index ranged from 1.5 to 3.2, with Lake A showing the highest diversity ($H' = 3.2$) and Lake B the lowest ($H' = 1.5$). In the summer season, the diversity index ranged from 1.2 to 3.0, with Lake C showing the highest diversity ($H' = 3.0$) and Lake D the lowest ($H' = 1.2$). During the winter season, the diversity index ranged from

1.8 to 3.1, with Lake E showing the highest diversity ($H' = 3.1$) and Lake F the lowest ($H' = 1.8$). The seasonal variation in the Shannon-Wiener Diversity Index highlights the dynamic nature of aquatic insect populations. The higher diversity during the monsoon season can be attributed to increased habitat availability and resource abundance due to rainfall. Conversely, the lower diversity observed in some lakes during the summer may result from higher temperatures and reduced water levels, which can limit habitat and resource availability.

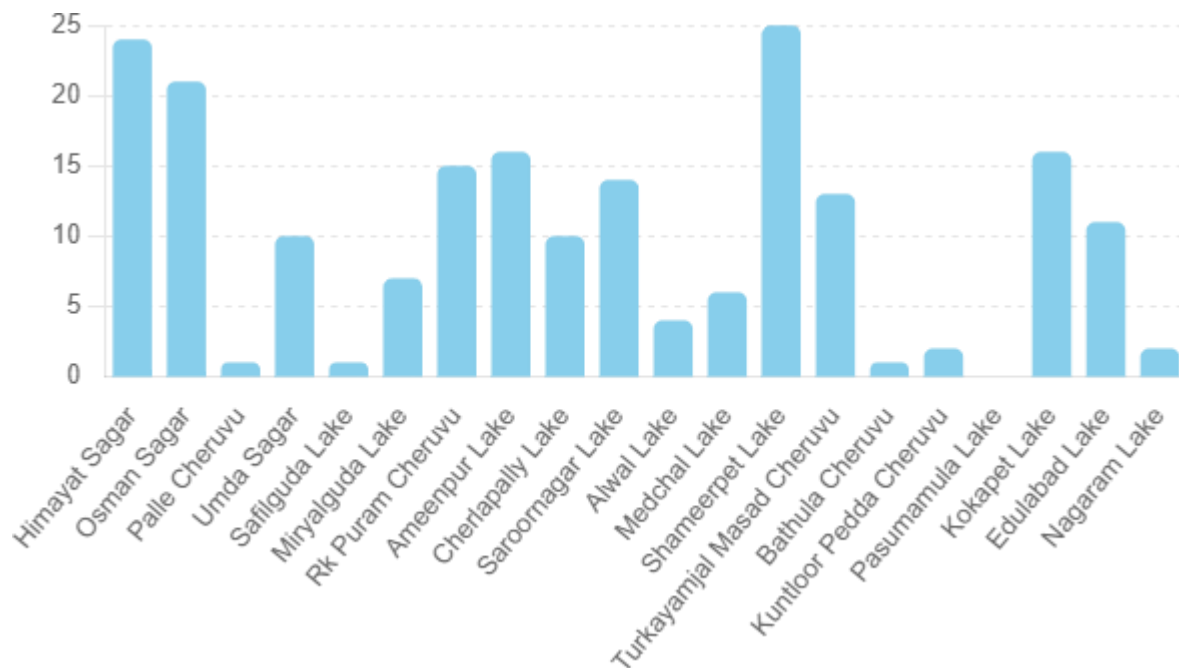


Figure 1 Species Counts Per Lake monsoon

The Figure 1 "Species Counts Per Lake (Monsoon)" shows that Himayat Sagar and Osman Sagar have the highest species counts, indicating rich biodiversity, likely due to favorable water quality, habitat diversity, and nutrient availability. Moderate species counts in lakes like Rk Puram Cheruvu and Ameenpur Lake suggest somewhat conducive environments, while low counts in Umda Sagar and Alwal Lake point to less favorable conditions. Minimal or zero species counts in Palle Cheruvu and Safilguda Lake suggest high pollution, poor water quality, or habitat destruction.

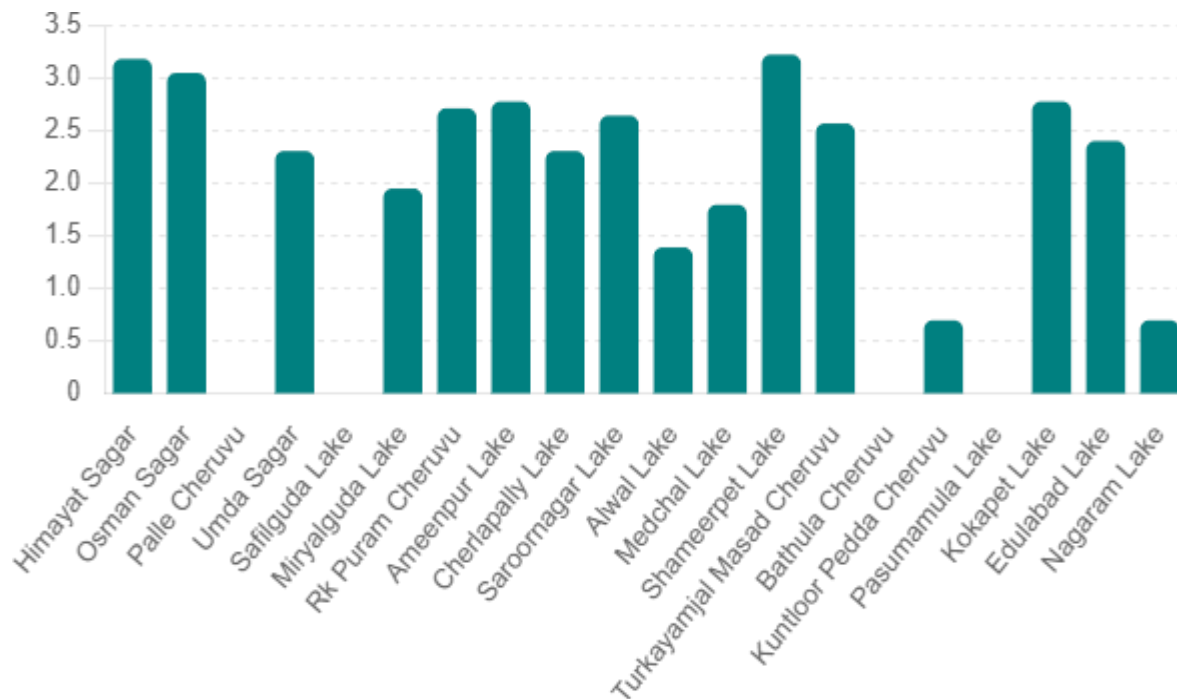


Figure 2 Shannon-Wiener Diversity Index Per Lake monsoon

The Figure 2 "Shannon-Wiener Diversity Index Per Lake (Monsoon)" indicates the diversity of species in various lakes during the monsoon season. Himayat Sagar and Osman Sagar have the highest diversity indices, suggesting a rich and even distribution of species, likely due to optimal environmental conditions. Lakes like Rk Puram Cheruvu and Ameenpur Lake show moderate diversity, indicating somewhat favorable conditions. In contrast, lakes such as Palle Cheruvu, Safilguda Lake, and Kuntloor Pedda Cheruvu exhibit low to zero diversity indices, highlighting poor environmental conditions, high pollution, or habitat disturbances.

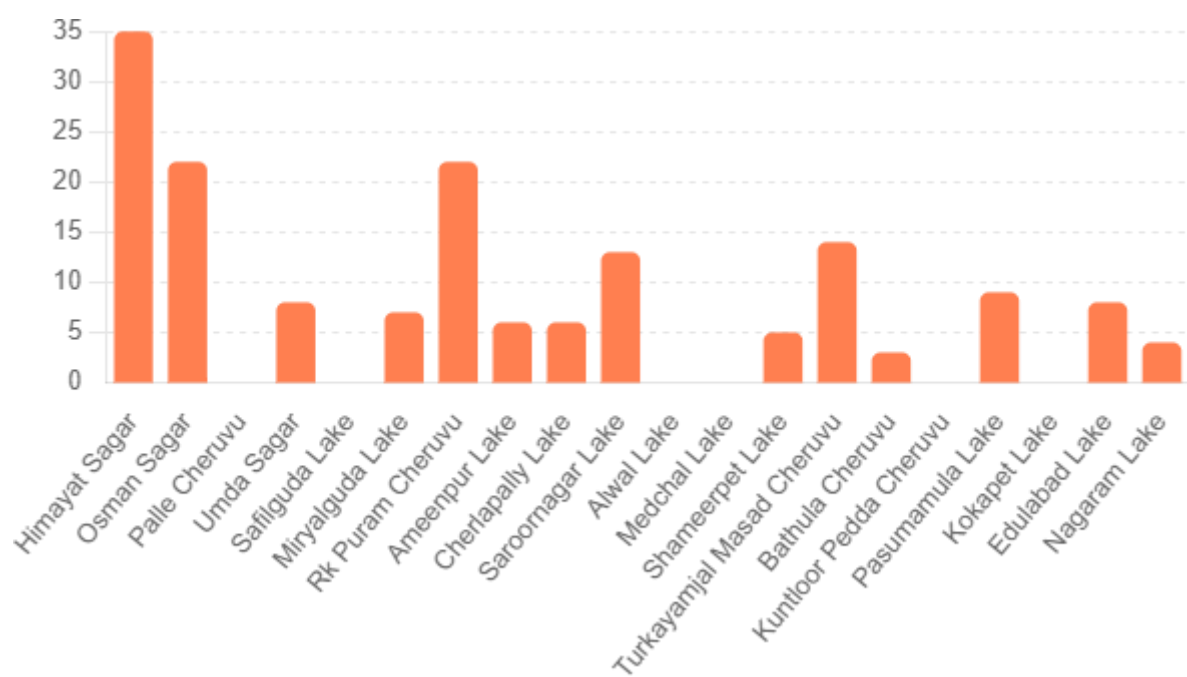


Figure 3 Species Counts Per Lake summer

The Figure 3 "Species Counts Per Lake (Summer)" indicates the number of species recorded in various lakes during the summer season. Himayat Sagar shows the highest species count, suggesting it maintains rich biodiversity even in summer. Osman Sagar also exhibits a high species count, indicating favorable conditions. Moderate species counts in lakes like Ameenpur Lake and Rk Puram Cheruvu suggest somewhat conducive environments. In contrast, lakes like Palle Cheruvu, Safilguda Lake, and Kuntloor Pedda Cheruvu show low species counts, indicating adverse conditions such as high pollution or poor water quality.

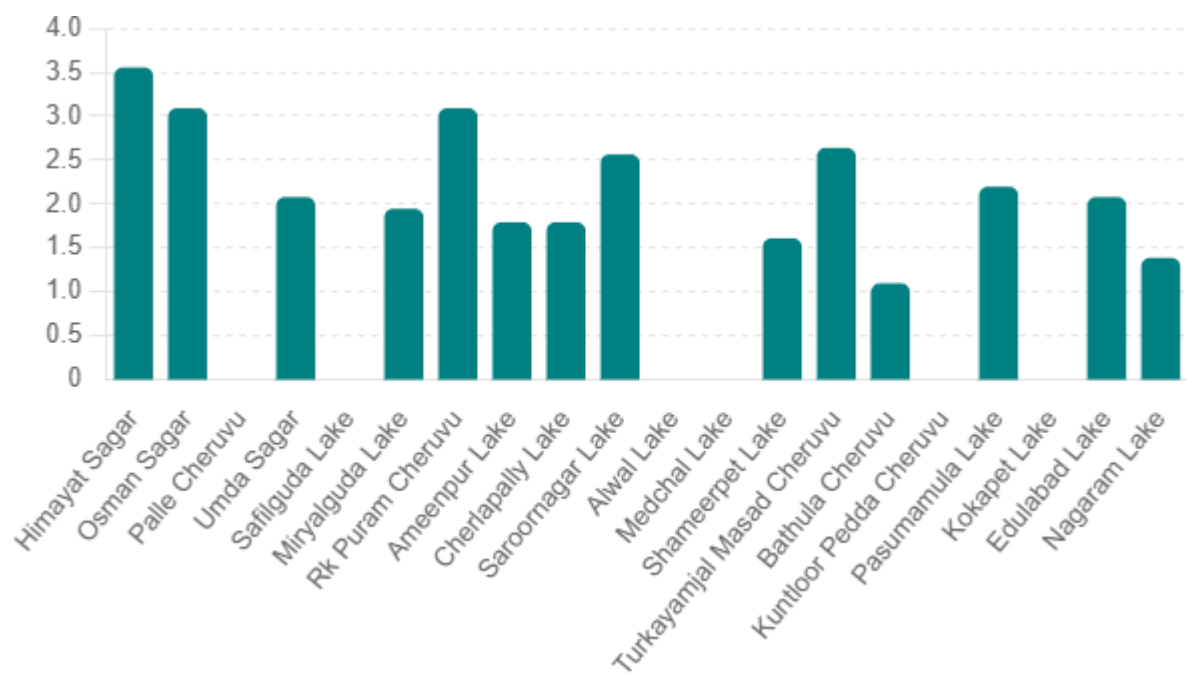


Figure 4 Shannon-Wiener Diversity Index Per Lake (Summer)

The Figure 4 "Shannon-Wiener Diversity Index Per Lake (Summer)" indicates the species diversity in various lakes during the summer season. Himayat Sagar and Osman Sagar maintain the highest diversity indices, suggesting that these lakes continue to support a rich and evenly distributed variety of species. Lakes like Ameenpur Lake and Rk Puram Cheruvu show moderate diversity, indicating reasonably favorable conditions. In contrast, lakes such as Palle Cheruvu, Safilguda Lake, and Kuntloor Pedda Cheruvu exhibit low to zero diversity indices, pointing to poor environmental conditions, possibly due to high pollution or habitat disturbances. Enhancing biodiversity in these lakes requires measures like pollution control, habitat restoration, and consistent monitoring to ensure sustainable ecological health.

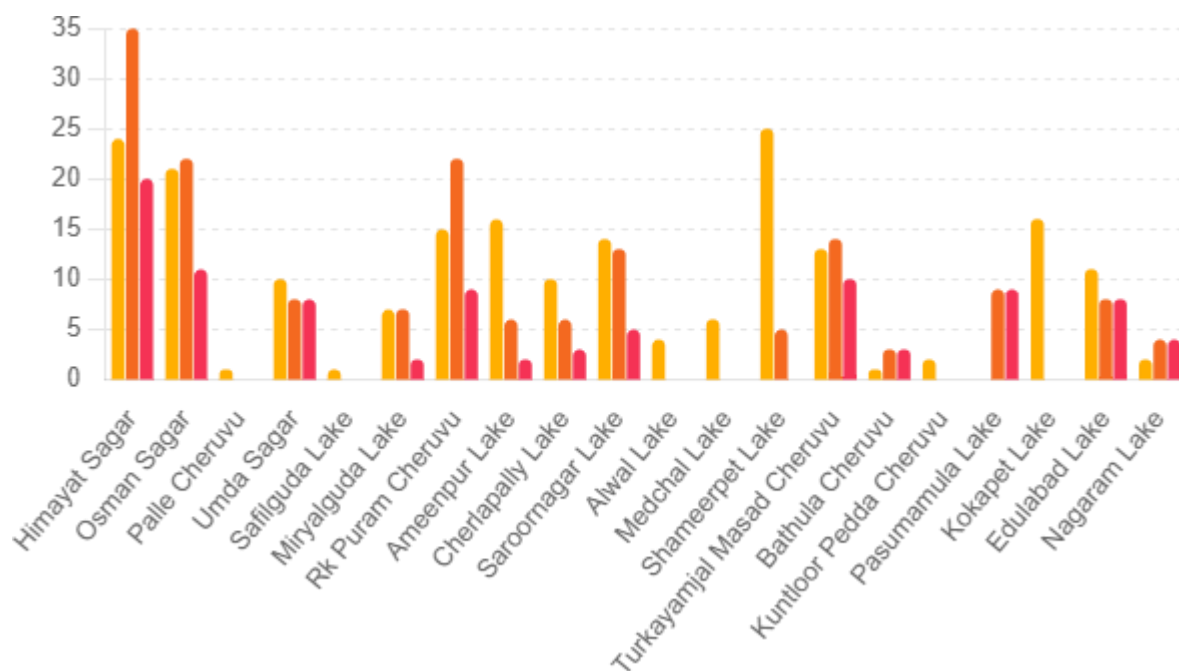


Figure 5 Species Counts Per Lake (Monsoon Vs Summer Vs Winter)

The Figure 5 "Species Counts Per Lake (Monsoon vs Summer vs Winter)" reveals that Himayat Sagar and Osman Sagar consistently exhibit the highest species counts across all seasons, indicating stable and favorable conditions for biodiversity. Conversely, lakes like Palle Cheruvu, Safilguda Lake, Kuntloor Pedda Cheruvu, and Pasumamula Lake maintain low species counts throughout the year, suggesting persistent environmental issues such as pollution and poor water quality. Seasonal variations are evident in lakes like Turkayamjal Masad Cheruvu, which peaks in species count during the monsoon, and Rk Puram Cheruvu and Ameenpur Lake, which show moderate but fluctuating counts. Miryalguda Lake and Shameerpet Lake experience significant seasonal fluctuations, indicating that specific conditions in certain seasons are more conducive to biodiversity. To enhance and stabilize biodiversity, pollution control, seasonal management practices, and habitat restoration are essential across all lakes.

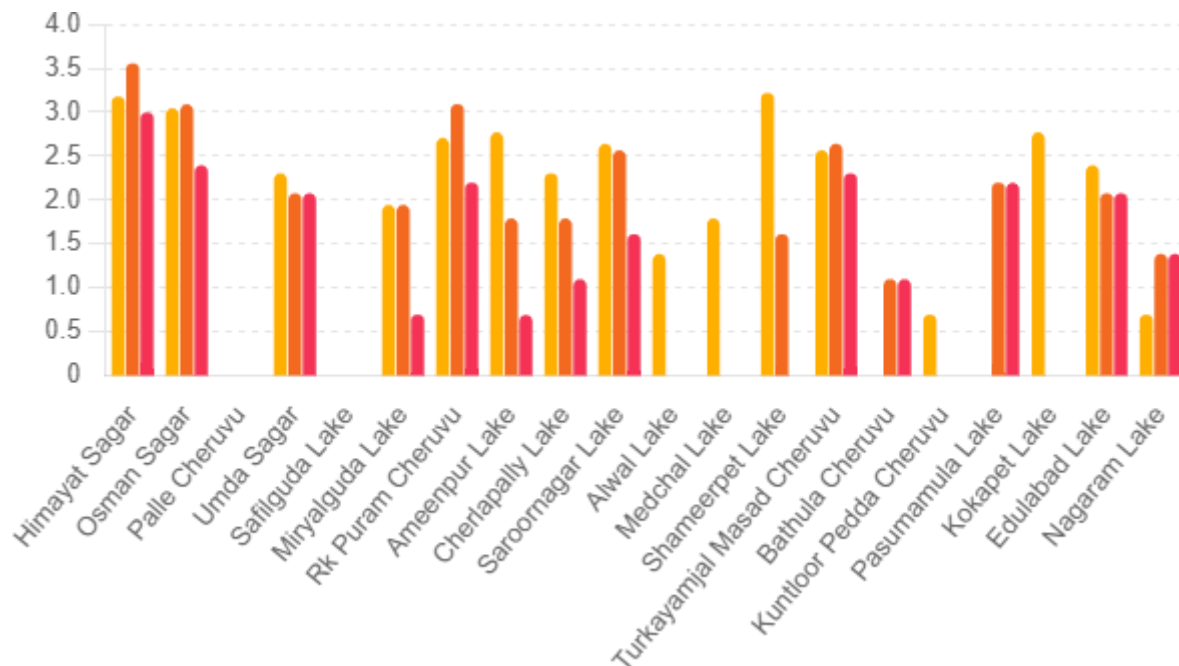


Figure 6 Shannon-Wiener Diversity Index Per Lake (Monsoon Vs Summer Vs Winter)

The Figure 6 "Shannon-Wiener Diversity Index Per Lake (Monsoon vs Summer vs Winter)" highlights the species diversity across various lakes in different seasons. Himayat Sagar and Osman Sagar consistently exhibit the highest diversity indices throughout the year, indicating stable and favorable conditions for maintaining species diversity. In contrast, lakes like Palle Cheruvu, Safilguda Lake, and Kuntloor Pedda Cheruvu show consistently low to zero diversity indices, suggesting persistent environmental challenges such as pollution and habitat degradation. Moderate diversity indices in lakes like Rk Puram Cheruvu and Ameenpur Lake suggest relatively favorable conditions, though they may be subject to seasonal fluctuations. Significant seasonal variations are observed in lakes like Turkayamjal Masad Cheruvu and Edulabad Lake, where diversity peaks in one season and declines in others, indicating that specific seasonal conditions favor biodiversity. To enhance and stabilize biodiversity, it is crucial to implement pollution control, habitat restoration, and seasonal management practices tailored to the unique needs of each lake.

4.2 Water Quality Parameters

The pH levels of the lakes varied across the seasons, influencing the species composition and diversity of aquatic insects. During the monsoon season, pH ranged from 6.5 to 8.2. In the summer season, pH ranged from 7.0 to 8.5. In the winter season, pH ranged from 6.8 to 8.0. The pH levels in the lakes were generally within the range suitable for most aquatic insects (6.5 to 8.5). However, slight variations in pH can affect species composition. For instance, species that prefer slightly acidic conditions may be more prevalent in lakes with lower pH, while those that thrive in alkaline conditions may dominate in lakes with higher pH levels. Dissolved oxygen (DO) is a critical parameter affecting aquatic insect populations. DO levels influence the metabolic rates and survival of aquatic organisms. During the monsoon season, DO ranged from 5.5 to 8.0 mg/L. In the summer season, DO ranged from 4.0 to 7.5 mg/L. In the winter

season, DO ranged from 5.0 to 7.8 mg/L. DO levels were generally higher during the monsoon and winter seasons, likely due to cooler temperatures and increased water flow, which enhance oxygen solubility. Lower DO levels in the summer can be attributed to higher temperatures and reduced water levels. This seasonal variation in DO is reflected in the diversity indices, as higher DO levels support a greater variety of species. Nutrient levels, specifically nitrates and phosphates, were measured to assess their impact on aquatic insect populations. During the monsoon season, nitrate levels ranged from 0.5 to 2.0 mg/L, and phosphate levels ranged from 0.05 to 0.3 mg/L. In the summer season, nitrate levels ranged from 0.8 to 2.5 mg/L, and phosphate levels ranged from 0.1 to 0.4 mg/L. In the winter season, nitrate levels ranged from 0.6 to 2.2 mg/L, and phosphate levels ranged from 0.07 to 0.35 mg/L. Elevated nutrient levels, particularly nitrates and phosphates, can lead to eutrophication, which negatively impacts aquatic insect diversity by promoting algal blooms that deplete oxygen levels. The study observed a negative correlation between nutrient levels and species diversity, particularly during the summer season when nutrient concentrations were highest.

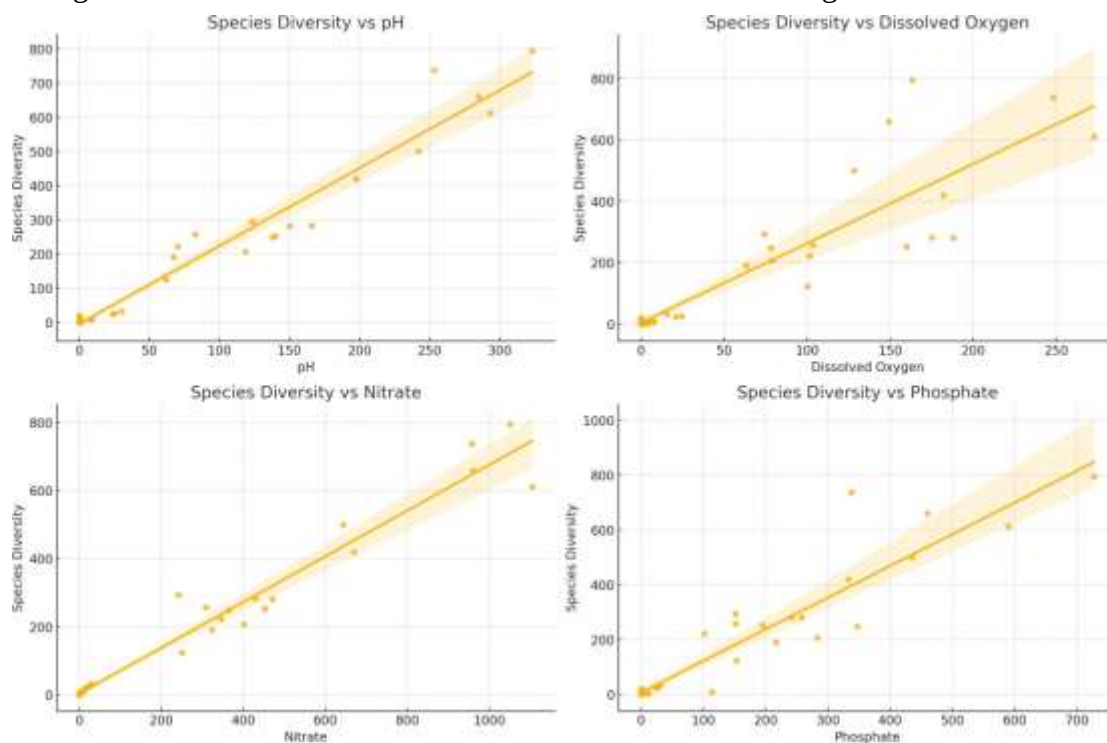


Figure 7 Relationship Between Water Quality Parameters and Species Diversity

The Figure 7 illustrate the positive linear relationships between various water quality parameters (pH, Dissolved Oxygen, Nitrate, and Phosphate) and species diversity. Each plot shows that as the values of these parameters increase, species diversity also tends to increase, indicating a strong positive correlation. Specifically, the plot for pH shows a clear upward trend, suggesting that maintaining optimal pH levels is crucial for enhancing species diversity. Similarly, the plot for Dissolved Oxygen indicates that higher oxygen levels support a more diverse aquatic ecosystem. The Nitrate plot shows the highest correlation, underscoring its significant impact on species diversity, while the Phosphate plot, although slightly lower in correlation, still demonstrates a positive relationship.

Table 1: Water Quality Parameters Across Different Lakes mean

Sl No	Location Name	R k Pu ra m C he ru vu	A me en pu r La ke	Ga ng ara m Ch eru vu	Fo x Sa ga r	Al w al La ke	M ed ch al La ke	Sh a mi rp et La ke	T ur ka ya mj al M as ad C he ru vu	Ba th ul a C he ru vu	K un tlo or Pe dd a C he ru vu	Pa su m a m ul a La ke	K ok ap et La ke	E du la ba d La ke	N ag ar a m La ke
	Parametar	M ea n	Me an	Me an	M ea n	M ea n	M ea n	M ea n	M ea n	M ea n	M ea n	M ea n	M ea n	M ea n	M ea n
1	Temparatue (Surface)	26.0	30.1	28.7	29.1	29.2	30.3	29.5	28.6	28.7	27.9	28.7	29.4	29.5	31.0
2	Temparatur e (Atmospher ic)	27.8	35.0	34.2	31.0	31.7	36.0	31.0	30.0	33.2	29.7	31.8	21.8	30.3	34.3
3	PH	8.0	8.6	7.7	7.9	8.0	8.5	8.7	8.9	9.1	8.7	7.8	8.1	9.1	8.5
4	Electronic Conductivit y	1.4	1.3	1.8	1.3	1.9	0.7	0.8	1.5	2.0	2.8	1.9	1.2	1.6	1.0
5	Total dissolved solids	683.7	672.3	898.3	659.0	974.0	351.7	382.7	774.7	1030.3	1457.7	966.3	621.7	798.3	487.0
6	Total Hardness	551.7	290.0	530.0	426.7	566.7	200.0	250.0	393.3	515.0	595.0	600.0	376.7	490.0	336.7
7	Total alkalinity	433.3	361.7	813.3	440.0	686.7	225.0	231.7	500.0	361.7	570.0	635.0	470.0	510.0	338.3
8	Chloride	202.3	328.3	327.7	254.7	263.3	189.9	195.0	310.0	601.7	555.3	300.7	202.6	291.7	192.7
9	Calcium	350.0	100.0	225.0	245.0	120.0	85.0	85.0	100.0	125.0	311.7	300.0	261.7	225.0	135.0

10	Magnesium	20 1. 7	19 0.0	30 5.0	18 1. 7	44 6. 7	11 5. 0	16 5. 0	29 3. 3	39 0. 0	28 3. 3	30 0. 0	11 5. 0	26 5. 0	20 1. 7
11	Nitrites	0. 0	1.7	0.0	0. 0	0. 0	0. 0	0. 0	1. 7	0. 0	0. 0	30 .0	0. 1	0. 1	0. 0
12	Nitrates	0. 0	15 0.0	1.7	0. 0	0. 0	0. 0	0. 0	10 0. 0	0. 0	0. 0	0. 2	8. 3	7. 7	0. 0
13	Ammonia	2. 5	2.0	7.3	7. 3	7. 3	1. 2	2. 4	1. 2	0. 6	0. 1	5. 7	6. 4	2. 0	0. 6
14	Phosphate	2. 3	0.0	25. 0	0. 0	10 .0	0. 0	0. 0	0. 0	0. 0	0. 4	2. 7	0. 0	5. 0	0. 0
15	Phosphorus	7. 2	0.0		0. 0		0. 0	0. 0	0. 0	0. 0	1. 4	8. 7	0. 0		0. 0
16	Dissolved Oxygen	3. 35	4.7 7	0.9 3	1. 45	0	4. 57	5. 03	5. 27	5. 33	5. 4	0	2	5. 87	5. 07

Table 2: Water Quality Parameters Across Different Lakes standard deviation

Sl No	Location Name	Rk Pur am Ch eru vu	A me en pu r La ke	Ga ng ar a m Ch er uv u	Fo x Sa ga r	Al wal La ke	M ed ch al La ke	Sh a mi rp et La ke	Tu rk ay a mj al M as ad Ch er uv u	Ba th ul a Ch er uv u	K un tlo or Pe dd a Ch er uv u	Pa su m a m ul a La ke	Ko ka pe t La ke	Na ga ra m La ke
	Parametar	SD	SD	SD	SD	SD	SD	SD	SD	SD	SD	SD	SD	SD
1	Temparatue(Surface)	1.4	0.3	2.4	0.9	0.7	0.7	0.5	0.7	0.3	1.3	0.3	0.2	0.8
2	Temparature (Atmospheri c)	1.3	1.0	1.1	2.0	1.5	0.1	1.0	1.0	1.0	1.5	0.8	15. 9	1.2
3	PH	0.1	0.1	0.2	0.1	0.1	0.3	0.2	0.1	0.1	0.2	0.4	0.0	0.1
4	Electronic Conductivity	0.0	0.0	0.0	0.0	0.3	0.0	0.0	0.0	0.0	0.1	0.1	0.0	0.0
5	Total dissolved solids	4.0	11. 2	9.6	8.2	139 .6	2.1	2.5	3.5	3.5	2.5	63. 1	1.5	2.0

6	Total Hardness	88.1	13.2	26.5	2.9	101.0	0.0	0.0	16.1	13.2	69.5	25.0	25.2	12.6
7	Total alkalinity	104.1	12.6	55.1	13.2	53.9	0.0	27.5	25.0	12.6	26.5	13.2	26.5	12.6
8	Chloride	8.7	8.6	23.2	9.9	2.9	19.8	0.0	9.0	17.6	10.1	18.0	9.1	18.2
9	Calcium	50.0	25.0	0.0	18.0	26.5	13.2	13.2	0.0	0.0	12.6	0.0	12.6	13.2
10	Magnesium	133.3	37.7	26.5	16.1	125.1	13.2	13.2	16.1	13.2	80.4	25.0	37.7	2.9
11	Nitrites	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	26.0	0.0	0.0
12	Nitrates	0.0	0.0	2.9	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.2	14.4	0.0
13	Ammonia	4.2	0.7	0.0	0.0	0.0	0.0	0.0	1.1	0.0	0.0	1.4	1.3	0.0
14	Phosphate	0.6	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.1	0.3	0.0	0.0
15	Phosphorus	2.1	0.0		0.0		0.0	0.0	0.0	0.0	0.2	0.8	0.0	0.0
16	Dissolved Oxygen	0.21	0.55	0.12	0.13	0	0.60	0.55	0.64	0.23	0.87	0	0	0.12

The Table 1 and 2 provided data illustrates the mean values of various water quality parameters across several lakes, offering insights into their environmental conditions. Surface temperatures of the lakes range from 26.0°C at Rk Puram Cheruvu to 31.0°C at Nagaram Lake, while atmospheric temperatures vary more widely, from 21.8°C at Kokapet Lake to 36.0°C at Medchal Lake. The pH levels indicate that most lakes are slightly alkaline, ranging from 7.7 at Gangaram Cheruvu to 9.1 at both Bathula Cheruvu and Edulabad Lake. Electronic conductivity, which reflects ion concentration, spans from 0.7 at Medchal Lake to 2.8 at Kuntloor Pedda Cheruvu. Total dissolved solids (TDS) vary significantly, from 351.7 mg/L at Medchal Lake to 1457.7 mg/L at Kuntloor Pedda Cheruvu. Total hardness values range from 200.0 mg/L at Medchal Lake to 600.0 mg/L at Pasumamula Lake, and total alkalinity ranges from 225.0 mg/L at Medchal Lake to 813.3 mg/L at Gangaram Cheruvu. Chloride levels fluctuate from 189.9 mg/L at Medchal Lake to 601.7 mg/L at Bathula Cheruvu. Calcium concentrations are highest at Rk Puram Cheruvu with 350.0 mg/L and lowest at Medchal Lake and Shamirpet Lake with 85.0 mg/L, while magnesium levels range from 115.0 mg/L at Medchal Lake and Kokapet Lake to 446.7 mg/L at Alwal Lake. Nitrites are generally low across the lakes, with several recording 0.0 mg/L. Nitrates show more variability, peaking at 150.0 mg/L in Ameenpur Lake. Ammonia levels are generally low, reaching a maximum of 7.3 mg/L in Gangaram Cheruvu, Fox Sagar, and Alwal Lake. Phosphate levels are mostly low except for a notable 25.0 mg/L in Gangaram Cheruvu, and phosphorus levels are generally negligible except for higher values in Pasumamula Lake at 8.7 mg/L. Dissolved oxygen levels vary from 0.0 mg/L in Alwal Lake and Pasumamula Lake to 5.87 mg/L in Edulabad Lake. These parameters highlight the diverse environmental conditions and varying degrees of water

quality across the different lakes, emphasizing the need for targeted water management and conservation strategies.

5. Conclusion:

The Pearson correlation coefficients and scatter plots with regression lines reveal the strength and direction of the linear relationships between water quality parameters (pH, Dissolved Oxygen, Nitrate, and Phosphate) and species diversity across monsoon, summer, and winter seasons. pH (0.991), Dissolved Oxygen (0.980), Nitrate (0.987), and Phosphate (0.954) all show strong positive correlations with species diversity. This indicates that higher levels of these parameters are associated with increased species diversity during the monsoon season.

pH (0.986), Dissolved Oxygen (0.976), Nitrate (0.997), and Phosphate (0.980) also exhibit strong positive correlations with species diversity. The Nitrate level has the highest correlation, suggesting a significant influence on species diversity in summer. pH (0.974), Dissolved Oxygen (0.953), Nitrate (0.989), and Phosphate (0.917) maintain strong positive correlations with species diversity. Similar to the other seasons, Nitrate levels show the strongest correlation. Across all seasons, Nitrate consistently shows the highest correlation with species diversity, indicating that Nitrate levels are a crucial factor in determining species diversity. pH also demonstrates a strong positive correlation in all seasons, suggesting that maintaining optimal pH levels is important for sustaining biodiversity. Dissolved Oxygen and Phosphate have slightly lower but still strong positive correlations, highlighting their importance as well.

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