



Study on Freshwater Macroinvertebrate Diversity Indicators in Himayath Sagar Lake, Hyderabad, Nalgonda District, Telangana

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Abstract : This Research represents the initial comprehensive work in the characteristics and diversity that of Aquatic Macroinvertebrates in Himayath Sagar Lake. Macroinvertebrate samples were collected and preserved from a depth of 1 meter across three different sites to identify and analyze the diversity of these organisms. The research aims to assess environmental and spatial factors influencing macroinvertebrate communities using Shannon Diversity, Simpson's diversity, and the Biological Monitoring working Party index. All in all 362 Species of macro invertebrates record were kept, with the most abundant groups being Mollusca, Annelids, and Arthropods. The current Research focus in variability of macro invertebrate communities on the lake, primarily to determine whether they serve as indicators of pollution or an unpolluted environment. As an essential part of the urban freshwater network, effective management of the lake requires consideration of both the local landscape and the broader environmental context.

Keyword ;Macroinvertebratediversity

Introduction:

Aquatic ecosystems, especially lentic ecosystems, are crucial for maintaining genetic diversity and species richness, which are essential for ecological stability (Sharma et al., 2004). Within these ecosystems, benthic habitats are vital for supporting macroinvertebrate communities (Sivakumar et al., 2000). Aquatic insects play significant roles at secondary trophic levels, contributing to various ecological functions. They act as bioindicators of water quality and are involved in processes such as organic matter decomposition and nutrient cycling (Voshell, 2002). The diversity and composition of macroinvertebrate communities can vary greatly in response to environmental conditions, making them effective indicators of pollution levels (De Pauw et al., 1983). Among aquatic insects, groups such as mayflies, dragonflies, damselflies, and stoneflies are particularly important in their respective habitats across different life stages (Shayeghi et al., 2017). Additionally, some aquatic insects have medical significance, either directly or as vectors for diseases like malaria, dengue, Zika virus, and chikungunya (Mansoreh et al., 2014). This Research investigates the composition and dynamics of aquatic macroinvertebrate communities of Himayath Sagar Lake, Hyderabad, Telangana. The objective is to assess species diversity, community structure, and biomass, while also analyzing diversity and similarity indices across different sites within the lake.

Materials Methods:

Study Site:

Himayath Sagar Lake is a prominent freshwater reservoir located near Hyderabad in the Indian state of Telangana. Constructed in 1927, the lake serves as a crucial source of drinking water for Hyderabad and its surrounding areas, and plays a significant role in local water management and flood control. The lake, along with its catchment area, also supports a diverse range of flora and fauna, making it an important site for ecological studies and biodiversity conservation.

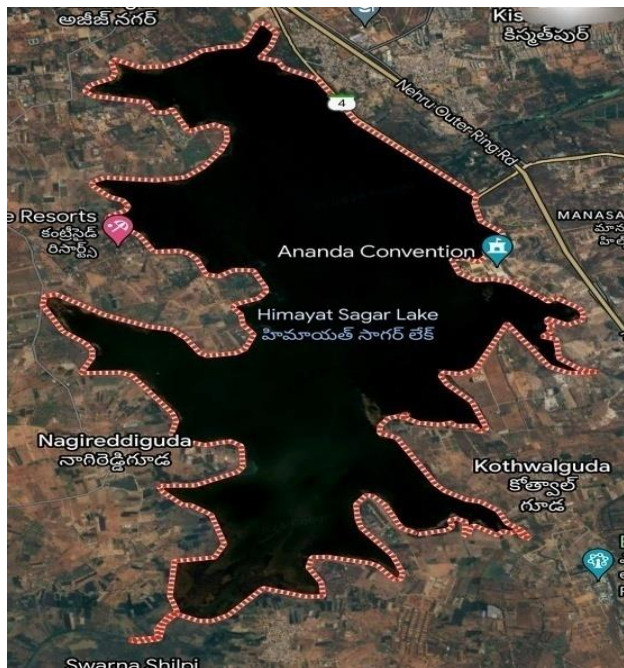
The study was conducted at three distinct sites within Himayath Sagar Lake, each selected to represent different microhabitats and environmental conditions, providing a comprehensive understanding of the macroinvertebrate communities across the lake. The three study sites are described as follows:

Site 1 (17°19'47.6"N, 78°21'55.8"E): Located at the northeastern part of the lake, this site is characterized by relatively shallow waters with a depth of approximately 1–2 meters. The area is influenced by inflows from nearby agricultural lands and urban runoff, which may introduce various nutrients and pollutants into the lake. The shoreline is fringed with dense aquatic vegetation, including species such as *Typha angustifolia* (cattail) and *Hydrilla verticillata*, providing habitat and shelter for numerous macroinvertebrates.

Site 2 (17°17'20.8"N, 78°21'32.1"E): Situated in the southern part of the lake, this site is deeper, with water depths ranging from 3 to 5 meters. The site is more exposed, with relatively sparse vegetation along the shoreline, primarily consisting of submerged and emergent plants like *Nymphaea nouchali* (water lilies) and *Vallisneria spiralis*. The water clarity here is typically moderate, influenced by both natural sedimentation and anthropogenic activities, such as fishing and boating.

Site 3 (17°19'12.7"N, 78°19'59.6"E): Located in the lake's water most point, this site features a mix of shallow and deep zones with a variety of substrates, including silt, sand, and gravel. The site is near the lake's outflow point, where water exchange is relatively higher, resulting in dynamic hydrological conditions. The area supports a mixture of aquatic macrophytes and algae, which provides a diverse habitat for macro invertebrates. Human activities such as livestock grazing along the banks and recreational activities contribute to varying degrees of nutrient input and disturbance.

These sites were chosen to capture a broad spectrum of environmental conditions and habitat types within Himayath Sagar Lake, allowing for a detailed analysis of macroinvertebrate diversity, distribution, and community structure. The diversity of these sites provides a representative cross-section of the lake's ecological conditions, which is critical for understanding the environmental factors influencing macroinvertebrate communities and assessing the overall health of the aquatic ecosystem.



Sampling Methods:

Macroinvertebrate samples were collected from three randomly selected locations within Himayath Sagar Lake during the summer of 2024. To ensure a representative sampling, each site was chosen to capture different habitat characteristics, particularly focusing on areas with aquatic vegetation and surrounding plant life. Sampling at each point was conducted for a duration of five minutes, during which the team carefully collected specimens from the water column and the submerged vegetation.

A variety of sampling tools and equipment were employed to collect macroinvertebrates effectively. The primary tool was a D-frame net, which is designed to capture small organisms from various aquatic environments, especially among dense vegetation and complex substrates. Forceps and needles were used to carefully handle and isolate the collected specimens to avoid damage. Additionally, a ladle was used for scooping organisms from the water surface and shallow zones, and sample containers (250 ml glass containers) were used to securely store the samples. Each sample was promptly preserved in either 70% formalin or ethanol to prevent decomposition and maintain the integrity of the organisms for further analysis. Labels containing essential details, such as the date, time, location of collection, and other relevant information, were affixed to each container to ensure accurate record-keeping and identification.

Macroinvertebrate Taxonomic Identification:

After collection, the samples were transferred to the laboratory for detailed taxonomic identification. The identification process was conducted using a microscope to examine the fine morphological features of each specimen. Systematic identification keys, such as the guide provided by (Voshell 2002) and the manual by (Needham & Needham 2021), were employed to accurately identify the various species of freshwater macroinvertebrates.

Each specimen was carefully examined for distinct characteristics, such as body shape, size, coloration, and other morphological traits critical for accurate identification. The identification process followed standard taxonomic protocols to ensure that all species were correctly classified, which is vital for subsequent analysis of community structure, diversity, and ecological assessments. The data obtained from this identification process were then recorded systematically for further ecological and statistical analysis.

Diversity Indices

The diversity of Macro invertebrates in Himayath Sagar Lake was assessed using several indices, including the Shannon Diversity Index (H'), Simpson's Diversity Index (D), and the Biological Monitoring Working Party (BMWP) Score.

Shannon Diversity Index (H')

The diversity index of Shannon (H') is a widely used measure for assessing kinds diversity in both aquatic and terrestrial ecosystems. Utilizing the formula index was determine provided by Shannon and Weaver (Weaver, 1963):

Shannon diversity Index

$$H' = - \sum P_i \ln P_i (I)$$

Σ is the total; P_i is the proportion of individual species; \ln is nature log

The Shannon wiener diversity index (H') is the commonly calculated of aquatic and terrestrial biodiversity .

Simpson's Diversity Index (D):

The diversity index of Simpson's was used to quantify the dominance of species within the community. It is calculated as:

$$D=1- \sum_{i=1}^s (p_i)$$

D=Dominated index , n= number of individuals in the species, N = the entire number of species.

Biological Monitoring Working Party (BMWP) Score:

The BMWP value was determined by evaluating the taxonomic values assigned to different families of macroinvertebrates. Higher scores indicate a greater sensitivity to pollution, thereby reflecting better water quality (Prat et al., 2009). The classification scale ranges from 1, representing very poor water quality, to 6, indicating excellent water quality. The BMWP score is commonly used for ecological assessments and water quality monitoring.

Table 1 is Biological Monitoring Working criteria (BMWP)

Class	Range	Quality	Characteristics	Colour
I	≥121	Very Good	Very clean water	Dark blue
II	101 -120	Good	Clean water	Light blue
III	61 - 100	Acceptable	Moderately polluted water	Green
IV	36 -60	Doubt	Polluted water	Yellow
V	16- 35	Critic	Very polluted water	Orange
VI	≤15	Very Critic	Heavily polluted water	Red

Results:

The analysis of macroinvertebrate diversity across the three study sites within Himayath Sagar Lake revealed notable variations in species richness, abundance, and diversity index. The findings, summarized within the table below, provide insights into the community structure and ecological status of the lake. (Table 3).

Species Richness and Abundances

In order calculated the species richness the total number of taxa (S), was relatively similar across the three sites, with Site 1 having 15 taxa and Sites 2 and 3 both having 16 taxa. However, the total number of individuals sampled varied, with Site 1 recording the highest number (140 individuals), followed by Site 2 (124 individuals), and Site 3 (98 individuals). This variation in individual counts suggests differences in habitat conditions or resource availability across the sites, which may influence the overall community structure.

Dominance and Diversity Indices

The Dominance Index (D), which indicates the degree to which a few species dominate the community, was lowest at Site 3 (0.1202), indicating a more even distribution of individuals among species at this site. In contrast, Site 2 showed the highest dominance value (0.1903), suggesting a greater abundance of a few dominant species. Site 1 had a moderate dominance value of 0.139.

The diversity indices of Simpson's, the range from 0 to 1 and reflects the possibility that two randomly chosen samples will be from different fauna, was highest at Site3 (0.8798), indicating a high level of diversity and evenness. Site 1 also showed a high diversity value (0.861), while Site 2 exhibited the lowest Simpson's Diversity Index (0.8097), suggesting a relatively lower diversity compared to the other sites.

Shannon Diversity Index (H') and Evenness

The Shannon Diversity Index (H') values were highest at Site 3 (2.345), followed by Site 1 (2.235) and Site 2 (2.072). This pattern indicates that Site 3 had the most diverse macroinvertebrate community, while Site 2 had the least. The evenness index (e^{H/S}), which measures the relative abundance of species, was also highest at Site 3 (0.6522), suggesting a more balanced distribution of individuals among the species present. Site 1 had a moderate evenness value (0.6233), while Site 2 showed the lowest evenness (0.4963), indicating that certain species were more dominant at this site

Table 2: is Diversity Index of Macroinvertebrates

Diversity indices	Site 1	Site 2	Site 3
Taxa S	15	16	16
Individuals	140	124	98
Dominance_D	0.139	0.1903	0.1202
Simpson_1-D	0.861	0.8097	0.8798
Shannon_H	2.235	2.072	2.345
Evenness_e ^{H/S}	0.6233	0.4963	0.6522

Univariate Analysis:

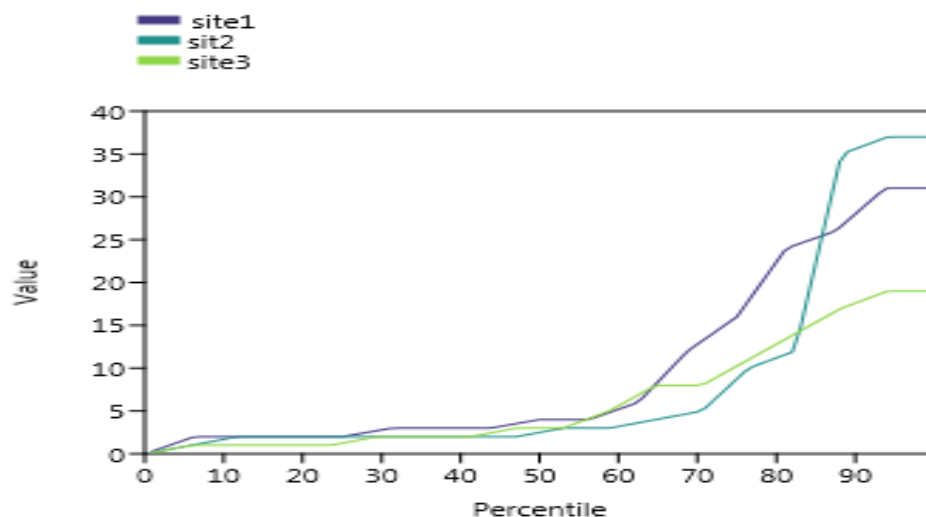
The univariate analysis of macroinvertebrate counts across the three sites in Himayath Sagar Lake reveals varying levels of variability in species abundance. Site 1 showed a moderate variability with the mean count is 9.33 with a standard deviation of ± 2.60 , suggesting relatively stable environmental conditions with some fluctuations in macroinvertebrate populations. In contrast, Site 2 exhibited the high variability; the mean value is 7.75 and the standard deviation of ± 2.86 , indicating considerable fluctuations likely due to heterogeneous conditions, such as varying pollution levels, substrate differences, or aquatic vegetation cover. Site 3 had the lowest variability, with a mean of 6.13 and a standard deviation of ± 1.52 , suggesting more uniform habitat conditions that support a stable macro invertebrate community. Overall, these results highlight the ecological dynamics at play within different sections of the lake, where Sites 1 and 3 appear more stable, and Site 2 is characterized by greater environmental variability.

Table 3: Macroinvertebrate family founded the BMWP values from

Phylum	Class	Order	Family	IBMWP values	Abundance Site 1	Abundance site 2	Abundance site 3	
Mollusca	Gastropoda	Hygrophila	Planorbidae	5	0	5	0	
		Mesogasteropoda	Viviparidae	6	2	10	14	
			Physidae	3	6	35	17	
Annelida	Clitellata	Tubificida	Naididae	1	24	12	3	
Arthropoda	Malacostraca	Decapoda	Palaemonidae	ND	26	4	0	
	Arachnida	Trombidiformes	Hydrobaetidae	6	0	2	1	
	Insecta	Odonata	Gomphidae	8	0	0	1	
			Macromiidae	ND	0	2	11	
			Coenagrionidae	6	12	2	8	
			Lestidae	7	31	3	0	
			Trichoptera	Polycentropodidae	7	0	2	0
	Ephemeroptera	Baetidae	4	16	2	19		
Isonychiidae		5	0	3	0			
Caenidae		7	0	2	0			
Metretopodidae		ND	3	0	2			
Hemiptera	Belostomatidae	5	2	1	5			
	Notonectidae	5	0	2	1			
			Nepidae	5	2	0	8	

		Coleoptera	Dytiscidae	5	2	0	0
			Noteridae	ND	3	0	2
			Hydrophilidae	5	4	0	0
		Diptera	Chironomidae	2	4	37	2
			Chaoboridae	2	3	0	1
			Stratiomyidae	ND	0	0	3
			Total	94	140	124	98

Fig2. The percentile plot for the Macroinvertebrates pollution



The plot is described in the highest value for site 2 is mention for the Fig 2 is taken the high value the 35 values are increasing the percentile plot.

Discussion:

Macroinvertebrates serve as crucial biological indicators of aquatic ecosystem health. The observed diversity in Himayath Sagar Lake suggests a moderately polluted environment, as indicated by the BMWP score of 94 (Class 3: Acceptable, Moderately Polluted). The absence of Plecoptera and Trichoptera, coupled with the presence of Ephemeroptera, aligns with findings from similar studies, such as those conducted on the River Actopan in Veracruz (Castillo et al., 2017). The total count of 362 macroinvertebrates across all sites reflects the lake's diverse and abundant macroinvertebrate community.

Aquatic macroinvertebrates are increasingly recognized for their sensitivity to environmental stressors, making them valuable bioindicators of freshwater ecosystems. Recent research highlights their efficacy in detecting subtle changes in water quality, particularly in areas affected by human activities (Arimoro & Keke, 2017). The use of Shannon-Wiener diversity index, Simpson's dominance index, and Pielou's evenness index, as applied in this study, provides a robust assessment of ecological health. Higher diversity indices, such as those observed at Site 3, generally indicate a more stable and less disturbed environment, consistent with findings by Park et al. (2020) who demonstrated a correlation between diversity indices and environmental conditions. The moderate pollution level suggested by the BMWP score is in line with studies indicating that increased pollution leads to reduced macroinvertebrate diversity.

The functional feeding groups (FFGs) among macroinvertebrates offer valuable insights into the trophic dynamics and energy flow within aquatic ecosystems. Research by Wu et al. (2022) emphasizes the importance of FFGs in bioassessment, where shifts in the relative abundance of different groups can indicate changes in organic matter inputs and overall ecosystem function. Analyzing FFG distribution in Himayath Sagar Lake could further elucidate the lake's ecological health and identify specific pollution sources.

Land use changes and anthropogenic activities significantly impact macroinvertebrate communities. Studies such as Li et al. (2021) have shown that urban runoff and agricultural practices degrade water quality and alter macroinvertebrate assemblages. The lower diversity and higher dominance at Site 1 may reflect such impacts, a trend observed in similar ecosystems where pollution-tolerant species often dominate disturbed habitats. Comparing macroinvertebrate diversity in Himayath Sagar Lake with other regional lakes, like Hussain Sagar in Hyderabad, supports the reliability of macroinvertebrates as bioindicators across various aquatic environments (Sivaramakrishna et al., 2019).

Advances in molecular techniques, such as DNA metabarcoding, are revolutionizing bioassessment by enabling more precise identification of macroinvertebrate taxa and detecting subtle shifts in community composition that traditional methods might overlook (Elbrecht et al., 2017). Incorporating these techniques in future studies could enhance the sensitivity and accuracy of bioindicator-based assessments in Himayath Sagar Lake. Additionally, climate change poses emerging challenges to freshwater

ecosystems, affecting macroinvertebrate communities through alterations in temperature, precipitation, and hydrological regimes. Hering et al. (2019) discuss how climate change may impact the bioindicator potential of macroinvertebrates, underscoring the need for long-term monitoring to fully understand these effects. Monitoring climate change impacts on bioindicators in Himayath Sagar Lake could provide valuable insights for adaptive management strategies.

Conclusion:

The study of macroinvertebrate diversity in Himayath Sagar Lake underscores the importance of these organisms as bioindicators of water quality and ecosystem health. The observed diversity highlights their role in monitoring urbanization, pollution, and habitat alterations. Advances in molecular techniques, like DNA metabarcoding, have improved our ability to assess biodiversity, offering insights into species composition and functional traits.

The findings are consistent with broader research indicating that macroinvertebrate communities are sensitive to alternative in water quality and biodiversity condition. Variations in macroinvertebrate diversity, community structure reflect the current state of water quality in the lake, providing a baseline for future monitoring. The address in the ongoing difficulties with urbanization and environmental degradation, it is vital to integrate macroinvertebrate monitoring into regular water quality assessments and conservation strategies. Enhanced understanding of these bioindicators will support the development of more effective management practices to preserve freshwater ecosystems. Future research should continue to explore the relationships between macroinvertebrate communities and environmental stressors, focusing on adaptive management strategies that address the dynamic nature of aquatic ecosystems.

Recommendations:

1. **Regular Monitoring:** Implement a routine monitoring program for macroinvertebrate communities in Himayath Sagar Lake to track changes in biodiversity and water quality over time. This will provide crucial data for assessing conservation measures and identifying emerging issues.
2. **Enhanced Pollution Control:** Strengthen pollution control measures to mitigate the effects of urban runoff and agricultural practices on the lake. Focus on reducing nutrient and sediment loads that impact water quality and macroinvertebrate health.
3. **Habitat Restoration:** Prioritize habitat restoration projects to improve the ecological integrity of Himayath Sagar Lake. Restoring riparian zones and enhancing aquatic vegetation will benefit macroinvertebrates and other aquatic organisms.
4. **Public Awareness and Education:** Develop educational programs for local communities and stakeholders about the role of macroinvertebrates as bioindicators and the importance of water quality for ecosystem health. Increased awareness can support conservation initiatives.
5. **Integration of Advanced Techniques:** Utilize advanced monitoring techniques, such as DNA metabarcoding and functional trait analysis, to enhance biodiversity assessments and understand the functional roles of macroinvertebrates in the ecosystem.

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