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Use of Aquatic Insects as Biomonitoring Tools to Assess the Water Quality Status of Two Freshwater Lakes of Mysore, Karnataka, India

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Abstract The present study encompasses the use of aquatic insects as bio-indicators for monitoring the health of two freshwater lakes- Varuna Lake and Dalvoy Lake in Mysore district, Karnataka, India. Monthly sampling from six sampling sites in both lakes was conducted for a period of six months (April 2019–September 2019) between 7:00 a.m. - 10:00 a.m. local time. A total of 34 species of aquatic insects were recorded, 28 species from Varuna Lake and 22 species from Dalvoy Lake. The insect orders Coleoptera and Hemiptera accounted for the highest number of species from both lakes. The diversity indices such as the Shannon index (2.86), Evenness (0.62), and Margalef's index (4.64) were higher in Varuna Lake as compared to Dalvoy Lake. Family-level biotic indices and scores further revealed that Varuna Lake was the least polluted and had higher species richness than Dalvoy Lake. Physicochemical factors like electrical conductivity, total dissolved solids, calcium, and hardness were elevated in Dalvoy Lake, suggesting perturbation of the water. The results of our study suggest that biotic indices, in conjunction with physicochemical studies, are useful for determining the overall health status of a particular water body.

Keywords Aquatic Insects, Biotic Indices, Biomonitoring, Dalvoy Lake, Varuna Lake

1. Introduction

Freshwater ecosystem occupies a relatively small portion (0.8%) of the earth's surface. This minute fraction of the world's water is home to at least 100,000 species, or nearly 6 percent of all known species [1]. These ecosystems offer a range of economically significant commodities and services to human societies, including but not limited to drinking water, irrigation, transportation, and recreational opportunities. Additionally, they serve as habitats for diverse flora and fauna [2]. Despite their importance, freshwater resources across the world have been subjected to an increasing pollution load resulting from both anthropogenic factors, such as urbanization, industrialization, and agricultural practices, which intensify the use of water resources, and natural phenomena, such as surface runoff during rainstorms, erosion, and weathering of sedimentary rocks, which deteriorate surface waters and hinder their suitability for domestic and economic use [3–5]. It is therefore essential to routinely monitor these fragile habitats. There are numerous tools, techniques, and methodologies available to assess changes in an aquatic environment. The conventional physico-chemical evaluation of water quality offers precise and accurate data regarding the quality of water within a specific geographical area during the sampling period [6–8]. However, only small subsets of the thousands of harmful compounds that may be released into surface waters are regularly chosen for investigation in routine monitoring. Pollutant concentrations also change dramatically over time. Pollutants that are released into water body can be chemically detected within a relatively short time, but their impacts might continue for many months. In this regard, living organisms are best suited to demonstrate the synergistic impact of multiple contaminants acting together within that environment [9,10]. Numerous studies have explored the species-environment interaction and the physical attributes of freshwater river, stream, pond, and lake ecosystems in an effort to develop trustworthy, predictable biotic species to assess the quality of the habitat [11–15]. The method of assessing the overall health of an aquatic ecosystem through the analysis of biotic communities is commonly referred to as biomonitoring.

Aquatic insects are found in diverse freshwater ecosystems, including streams, rivers, ponds, and lakes. According to the reports of the Freshwater Animal Diversity Assessment 2008, more than sixty percent of the reported freshwater species that live in or are closely linked with fresh water are insects. This is due to the fact that many insect species have aquatic larval stages in their life cycle [16]. More than 3% of all insect species begin as aquatic larvae before they emerge as winged terrestrial adults [17]. These insect nymphs can account for more than 95% of all macroinvertebrates in diverse freshwater habitats. Due to their preference for freshwater habitats and remarkable diversity, aquatic insects serve as valuable indicators of overall water quality. Their widespread distribution, sedentary nature, long life cycles, and susceptibility to environmental stressors further enhance their utility as bioindicators in assessing integrated water quality [18]. The composition of aquatic macroinvertebrates can be used to compute many types of indices, such as diversity, dissimilarity, and biotic indices [19]. Various insect taxa have been suggested or employed as effective bioindicators, including but not limited to Ephemeroptera, Odonata, Plecoptera, Hemiptera, Coleoptera, Diptera, and Trichoptera, either collectively or individually. The indicator species are used in the biotic indices, such as the Biological Monitoring Working Party (BMWP) score, the Average Score Per Taxon (ASPT), the Family Biotic Index (FBI), and the SIGNAL 2 scores, which examine the community structure without paying too much attention to species that do not show up in large numbers [20–22].

Mysore (12°30'N and 76°65'E) is regarded as the cultural capital of the state of Karnataka and is the second fastest growing city after the state capital Bengaluru. The city has been expanding at an alarming rate as more people migrate to it from various parts of the state. This has resulted in a discernible increase in the number of residential areas and satellite towns being built in rural areas near cities, creating peri-urban regions. The process of transforming natural landscapes into urban areas is a common land-use transition that has significant implications for the loss and degradation of freshwater habitats. This process places considerable strain on indigenous flora and fauna [23]. To effectively protect existing water resources and develop practical conservation and management plans, it is necessary to acquire baseline data on biodiversity [24]. Several investigations are made in various ponds and lakes in Mysore, focusing primarily on the physicochemical water quality and diversity of planktons [25–27]. However, there is a dearth of studies pertaining to the composition and distribution of aquatic macroinvertebrates in these waterbodies. Thus, the present investigation was conducted with the following aims: i) to assess aquatic insect diversity in two freshwater lakes in Mysore, and ii) to evaluate the biological water quality of the selected lakes based on the aquatic insect composition by applying biotic indices such as the BMWP index, ASPT, and SIGNAL 2 score.

2. Materials and Methods

2.1. Study Area

The study was conducted for six months, from April 2019 to September 2019, in two freshwater lakes of Mysore district, Varuna Lake (12°27'50.31" N and 76°74'58.72" E) and Dalvoy Lake (12°25'17.81" N and 76°65'72.29" E), which are perennial water bodies experiencing varying degrees of human disturbance (Figure 1). Dalvoy Lake is located very close to the city surrounded by community settlements and small-scale industries, thus constantly flooded by surface runoff, sewage and industrial waste. Varuna Lake is situated on the periphery of the city, surrounded by agricultural plots and prospective residential projects. Varuna Lake water is frequently used for domestic, recreational and farming activities but is rarely utilized for drinking purposes. Varuna Lake supports diverse aquatic macrophytes such as *Nymphaea, Nelumbo, Ceratophyllum, Hydrilla verticellata, Ottelia alismoides, Vallisneria, Typha angustifolia* etc. Aquatic vegetation in Dalvoy Lake is dominated by *Eichornia crassipes, Lemna minor* and *Wolffia globosa.*

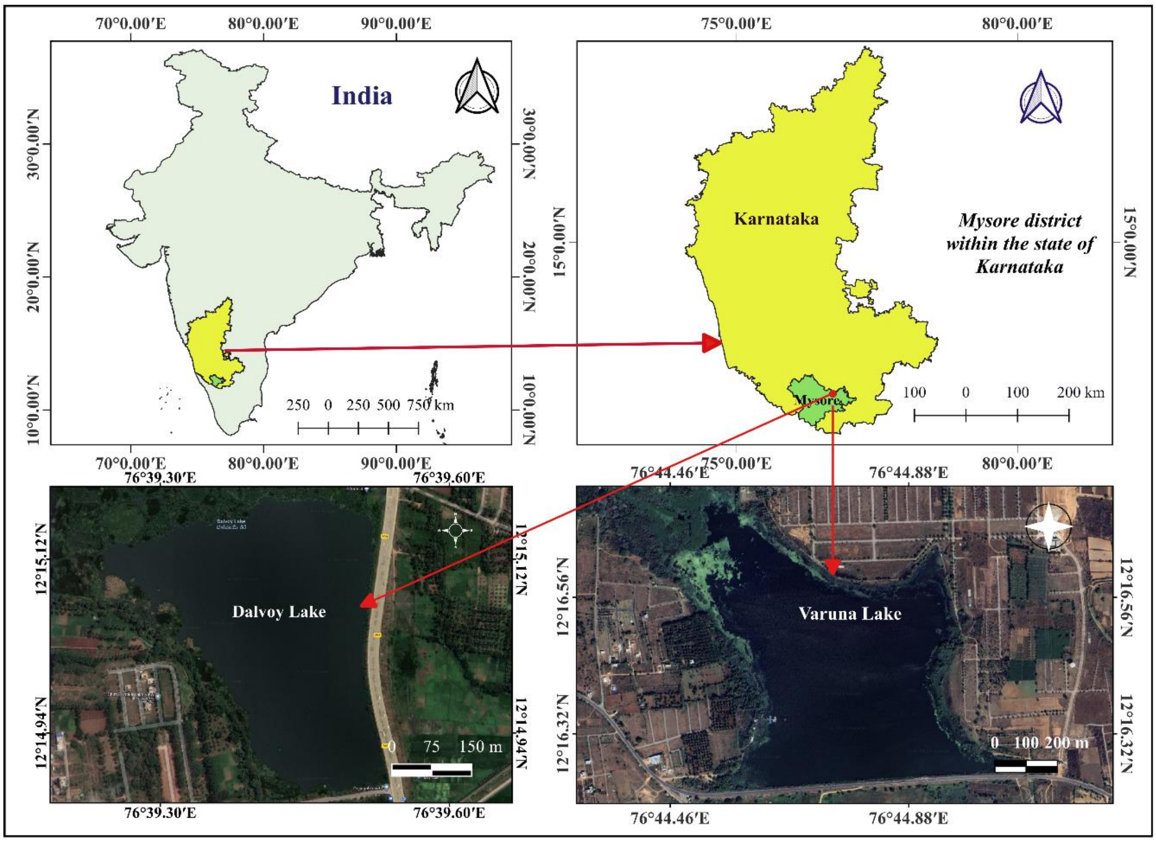

Figure 1. Location map of the study area

2.2. Sample Collection

Aquatic insects were systematically collected from three corners of the lake within an area of $10m^2$ at an interval of 30 days between 7 am and 10 am local time. The collection was done using a circular pond net (opening 30×30 cm^2, mesh size 500 µm) by disturbing the substrate of littoral zone and dragging the net under water for one minute around the vegetation. A sample is made up of three such drags [28–30]. Collected insects were immediately sorted and preserved in 70% Ethanol. The specimens were identified to the lowest possible taxon at the laboratory using a stereo zoom microscope (Labomed CZM4) following standard identification keys [31–39]. Additionally, water samples have been taken from each of the designated sampling sites. Standard methods were employed to analyze physicochemical parameters such as air temperature, water temperature, pH, electrical conductivity, dissolved oxygen, free carbon dioxide, calcium, and hardness [40,41].

2.3. Data Analysis

The diversity indices like the Shannon-Weiner Index (H′), Evenness Index (J’), Margalef Index (M), and Berger-Parker Index of Dominance (d) for the insect community were computed using the PAST (Version 4.03) statistical software. The bioassessment of the lakes was performed by computing the Biological Monitoring Working Party (BMWP) index, Average Score Per Taxon (ASPT) and Stream Invertebrate Grade Number – Average Level (SIGNAL 2) score following standard literature [42–44]. The BMWP score, a family-level water pollution index, is calculated by adding the individual scores of all families present in a given ecosystem, with these scores indicating their respective pollution tolerance levels. Sensitivity scores more than 100 points indicate an undisturbed habitat, while low values indicate serious contamination of an aquatic ecosystem. The Average Score Per Taxon (ASPT) is calculated by dividing the BMWP score by the total number of observed families. It gives the mean tolerance score of all taxa in the community. The SIGNAL 2 score is calculated by taking the mean of the pollution sensitivity grades assigned to the families present in the habitat, which can range from 10 (indicating high sensitivity) to 1 (indicating high tolerance). Species recorded in this study were ranked on the basis of the relative abundance of individual species using a geometric series model using PAST statistical software. This model plots rank as an independent variable against logarithms of species abundance as the dependent variable.

3. Results and Discussion

3.1. Distribution and Abundance of Aquatic Insects

A total of 34 species of aquatic insects from 16 families and 6 orders (Coleoptera, Hemiptera, Diptera, Odonata, Ephemeroptera, and Trichoptera) were recorded during the study (Table 1). In Varuna Lake, 28 species from all six insect orders were recorded, while 22 species representing five insect orders (Coleoptera, Hemiptera, Diptera, Ephemeroptera, and Odonata) were collected from Dalvoy Lake (Figures 2 & 3). Among the 16 families that were documented, it was observed that 12 families (Dytiscidae, Noteridae, Hydrophilidae, Belostomatidae, Micronectidae, Notonectidae, Pleidae, Nephidae, Culicidae, Chironomidae, Coenagrionidae, and Baetidae) exhibited a shared presence in both lakes. According to the results, the insect diversity was highest in Varuna Lake, whereas the insect abundance was highest in Dalvoy Lake. In both lakes, taxa richness showed very high significance with diversity index.

Table 1. The number of aquatic insects collected in Varuna Lake and Dalvoy Lake

Sl. No.	Order	Family	Insect taxa	VL	DL	Total
1	**Coleoptera**	Dytiscidae	*Laccophilus anticatus*	2	0	2
2			*Laccophilus flexuosus*	25	8	33
3			*Hydroglyphus flammulatus*	9	12	21
4		Noteridae	*Canthydrus laetabilis*	64	12	76
5			*Canthydrus luctuosus*	12	52	64
6			*Neohydrocoptus bivittis*	4	0	4
7		Hydrophilidae	*Berosus indicus*	2	0	2
8			*Amphiops* sp.	6	22	28
9			*Hydrophilus* sp.	4	12	16
10			*Regimbartia* sp.	4	4	8
11			*Helochares* sp.	20	12	32
12	**Hemiptera**	Belostomatidae	*Diplonychus rusticus*	31	181	212
13		Naucoridae	*Heleocoris* sp.	12	0	12
14		Micronectidae	*Micronecta haliploides*	4	0	4
15			*Micronecta siva*	4	0	4
16			*M. scutellaris*	6	8	14
17		Gerridae	*Limnogonus nitidus*	0	8	8
18		Notonectidae	*Anisops* sp.	2	143	145
19		Pleidae	*Paraplea liturata*	0	36	36
20			*Paraplea frontalis*	4	0	4
21		Nephidae	*Ranatra filiformis*	3	5	8
22			*Laccotrephes ruber*	0	2	2
23	**Diptera**	Culicidae	*Culex sp.*	14	105	119
24			*Anopheles sp.*	4	0	4
25		Stratiomyidae	*Stratiomys* sp.	0	53	53
26		Chironomidae	*Chironomous* sp.	7	57	64
27		Ephydridae	Ephydra larva	0	3	3
28		Syrphidae	*Eristalis* sp.	0	4	4
29	**Odonata**	Libellulidae	*Diplocodes* sp.	8	0	8
30		Coenagrionidae	*Ischnura* sp.	18	7	25
31		Lestidae	*Lestes* sp.	6	0	6
32	**Ephemeroptera**	Baetidae	*Cloeon* sp.	4	36	40
33			*Baetis* sp.	42	0	42
34	**Trichoptera**	Leptoceridae	*Triplectides* sp.	15	0	15

***VL** = Varuna Lake; **DL** = Dalvoy Lake

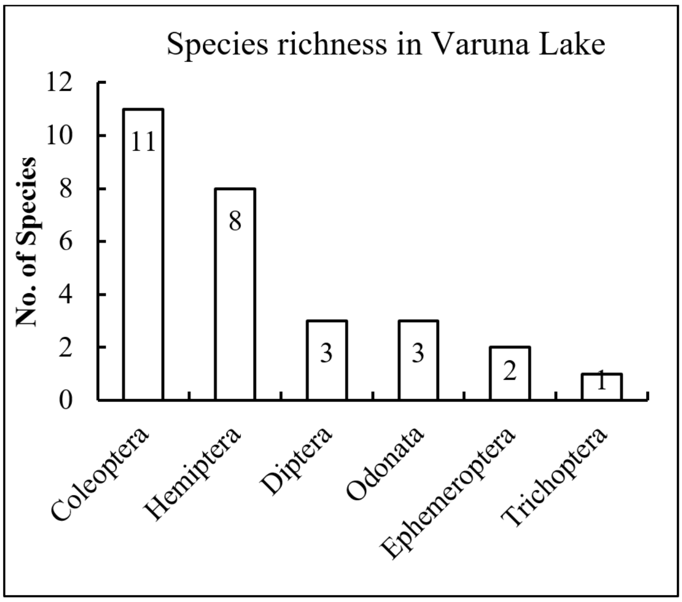

Figure 2. Species richness of aquatic insect orders in Varuna Lake

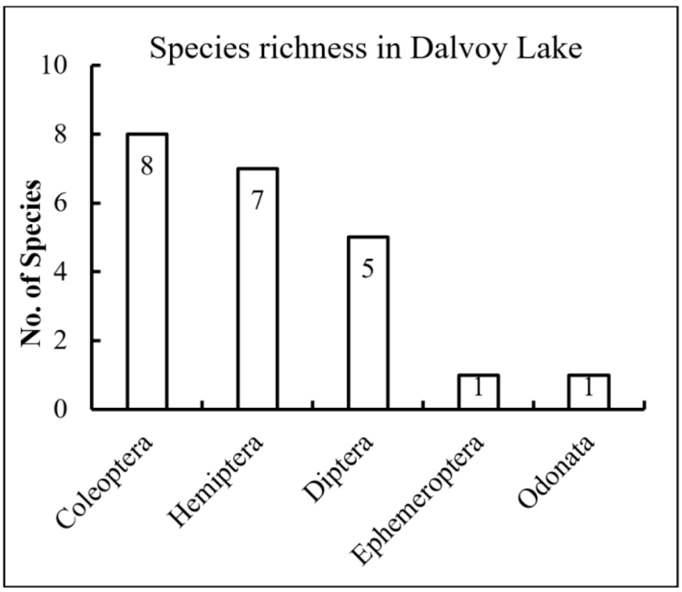

Figure 3. Species richness of aquatic insect orders in Dalvoy Lake

The slope of the rank abundance curve indicates uniformity in the distribution of species abundance of aquatic insects in both lakes. The slope of rank abundance at Dalvoy Lake was marginally steeper than that at Varuna Lake (Figures 4 & 5). The chi-square statistic for Dalvoy Lake (56.71) was also higher than that of Varuna Lake (39.14) suggesting that the geometric series model better fitted the data on the Dalvoy Lake. In Varuna Lake *Canthydrus laetabilis*, *Diplonychus rusticus*, *Laccophilus flexuosus* and *Helochares* sp. occupied ranks 1, 2, 3 and 4, respectively, having a relative abundance of 19.05%, 12.50%, 9.23% and 7.44% respectively. The remaining 25 species at Varuna Lake are ranked between 5 and 28. At Dalvoy Lake *Diplonychus rusticus*, *Anisops* sp., *Culex* sp. and *Chironomous* sp. occupied 1, 2, 3 and 4 ranks, respectively, having a relative abundance of 23.15%, 18.29%, 13.43% and 7.29% respectively. The remaining 18 species at Dalvoy Lake are ranked between 5 and 18.

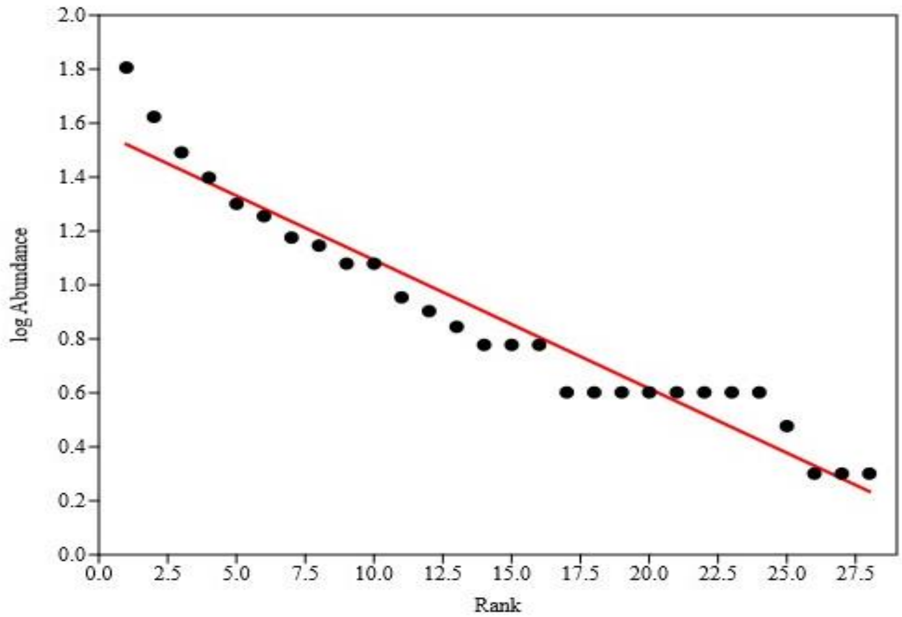

Figure 4. Rank abundance (geometric series) curve of aquatic insect species recorded from Varuna Lake (**VL**)

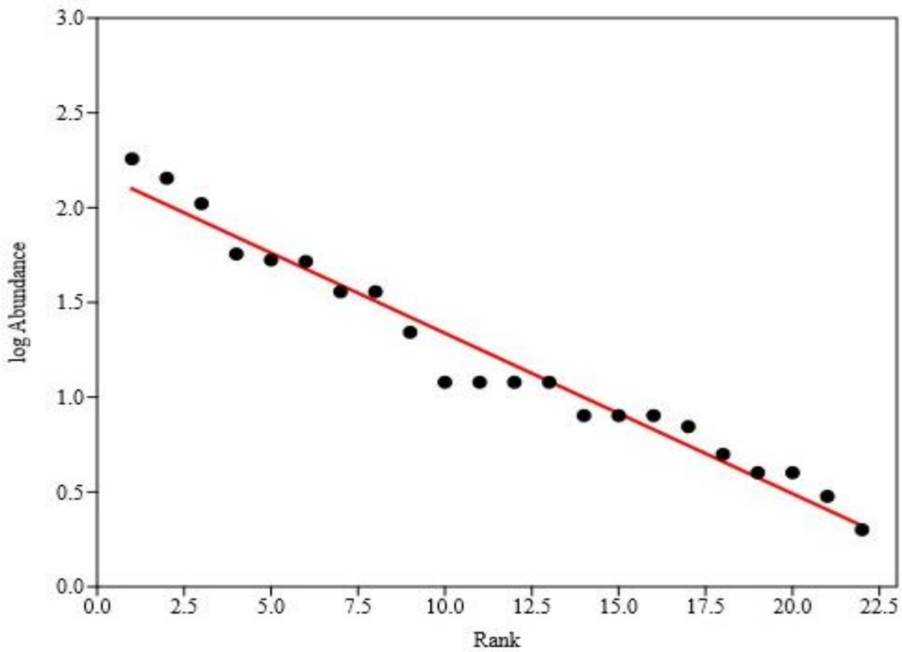

Figure 5. Rank abundance (geometric series) curve of aquatic insect species recorded from Dalvoy Lake (**DL**)

3.2. Diversity Indices

Diversity indices give vital information on the relative abundance and distribution of species within a given ecological community, making it easier to understand the structure of the community [45,46]. In this study, it was found that the Shannon diversity index and the evenness index of Varuna Lake were slightly higher than those of Dalvoy Lake (Table 2). Varuna Lake had a Shannon Index of 2.86, while Dalvoy Lake had a value of 2.41. The Shannon diversity index (H') serves as a measure of community dynamics within an ecosystem, with its value varying from 0 in communities consisting of a single taxon to higher values in communities harboring numerous taxa, each represented by a limited number of individuals [47]. The Evenness Index serves to evaluate the even distribution of species within a community by normalizing the heterogeneous variables to their maximum values and assuming that each species in the sample has an equal number of individuals [48]. The evenness index exhibits a range of values, with '0' representing a lower level of equitability and '1' signifying a higher level of equitability. The evenness index of Varuna Lake was 0.624, while that of Dalvoy Lake was 0.510, indicating that species were more evenly distributed in Varuna Lake. This is further exemplified by the fact that Varuna Lake exhibits a relatively lower Berger Parker index of dominance (0.1905) in comparison to Dalvoy Lake (0.2315). The Margalef diversity index exhibited values of 4.641 and 3.152 at Varuna Lake and Dalvoy Lake, respectively. A Margalef water quality index value greater than 3 implies clean water; a value below 1 reflects highly polluted water; and a value in the middle of the scale indicates moderately polluted water [49]. In the current study, the Margalef Diversity Index value of Varuna Lake was found to be more than 3, suggesting a healthy environment, whereas the value at Dalvoy Lake was marginally higher than the baseline score.

Table 2. Diversity indices of aquatic insects of Varuna Lake and Dalvoy Lake

	Varuna Lake	Dalvoy Lake	Perm p (eq)
Taxa_S	28	22	0.097
Individuals	336	782	0
Shannon_H'	2.861	2.419	0.0001
Evenness_e^H/S	0.6241	0.5104	0.0148
Margalef	4.641	3.152	0.0001
Berger-Parker	0.1905	0.2315	0.1107

3.3. Biomonitoring Scores

Aquatic insects exhibit remarkable sensitivity to a diverse array of biotic and abiotic environmental factors. The community structure of these organisms is commonly employed as a reliable indicator for evaluating the overall health of an aquatic ecosystem [19]. Biotic indices consider the sensitivity or tolerance of various species or groups to pollution and assign them a numerical value, the sum of which provides a pollution index for a specific location [46]. The standard BMWP score and SIGNAL 2 score assigned for each taxon collected in the present study are shown in Tables 3 & 4. The range of BMWP score and SIGNAL 2 score indicate the quality of water [21]. In this study, Varuna Lake had a higher BMWP score (88) than Dalvoy Lake (68). Thus, according to BMWP score, the water quality of Varuna Lake was categorized as “good” while Dalvoy Lake’s water quality was categorized as “moderate”. According to the ASPT scores, Dalvoy Lake (4.25) indicated poor water quality with moderate levels of pollution, whereas Varuna Lake (5.5) showed doubtful water quality. ASPT is the average tolerance score of all taxa in the community. An ASPT score greater than 6 is typically indicative of pristine habitats with a relatively high number of taxa that have high score values, suggesting water of good quality [50]. The computation of the SIGNAL 2 score index involved assigning a numerical value, referred to as a 'grade number', ranging from 1 to 10 to the aquatic insect families present. Families with a low-grade number are considered to be more tolerant of pollution, while those with a high-grade number are regarded as more sensitive to pollution. In this study, Varuna Lake had the highest SIGNAL 2 score of 2.66, while Dalvoy Lake had the lowest score of 2.37 (Tables 3 & 4). According to the results of the Biological Monitoring Working Party (BMWP) score, Average Score per Taxon (ASPT), and SIGNAL 2 scores, it can be seen that there were more families in Varuna Lake that were moderately sensitive to pollution than families that are tolerant to pollution. This suggests that the aquatic habitat in Varuna Lake has not undergone significant alterations. This is supported by the presence of pollution-intolerant taxa like *Triplectides* sp. (Family: Leptoceridae) in Varuna Lake, whereas the presence of tolerant species like *Stratiomys* sp., *Culex* sp., *Eristalis* sp., *Chironomous* sp., and Ephydra larva in Dalvoy Lake suggests organic enrichment. Numerous Dipteran taxa are known to inhabit heavily polluted bodies of water with a broad range of tolerance [51,52]. There are several elements that have an effect on the organisms living in an aquatic ecosystem, including variations in the physicochemical parameters, the level of water pollution (whether it be severe or mild), the depth of the water body, and the types of aquatic vegetation present [53,54]. Due to its proximity to human settlements, Dalvoy Lake experiences a substantial influx of untreated domestic and industrial waste, resulting in a greater prevalence of pollution-tolerant species.

Table 3. SIGNAL 2 and BMWP scores of aquatic insect families recorded in Varuna Lake

Sl. No	Family	SIGNAL 2 Sensitivity grade	Weight factor	Grade x Weight factor	BMWP
1	Dytiscidae	2	5	10	5
2	Noteridae	4	5	20	7
3	Hydrophilidae	2	5	10	5
4	Belostomatidae	1	5	5	5
5	Naucoridae	2	4	8	5
6	Micronectidae	2	4	8	5
7	Notonectidae	1	1	1	5
8	Pleidae	2	2	4	5
9	Nephidae	3	2	6	5
10	Culicidae	1	4	4	2
11	Chironomidae	3	3	9	2
12	Libellulidae	4	3	12	8
13	Coenagrionidae	2	4	8	6
14	Lestidae	1	3	3	9
15	Baetidae	5	5	25	4
16	Leptoceridae	6	4	24	10
		Total	59	157	**(BMWP) 88**
		Signal Score		2.66	**(ASPT) 5.5**

Note: Signal score = (Total of grade x weight factor)/ Total of weight factor; BMWP = Sum of tolerant scores of families present.

ASPT = Total of BMWP score/ Total number of families present.

Note: Water quality status: BMWP score, 0-10=Very Poor; 11-40=Poor; 41-70=Moderate; 71-100=Good; >100=Very good [30, 42, 43, 44].

ASPT score: > 6= Clean water, 5-6= Doubtful quality, 4-5 = Moderate pollution, < 4 = Severe pollution [30, 43].

Signal 2 score: 0-7= Suggest pollution > 7=Suggest good habitat and water quality [42].

Weight factor = abundance weighting, 1 – 2 = 1; 3 – 5 = 2; 6 – 10 = 3; 11 – 20 = 4; >20 = 5 [42].

Table 4. SIGNAL 2 and BMWP scores of aquatic insect families recorded in Dalvoy Lake

Sl. No	Family	SIGNAL 2 Sensitivity grade	Weight factor	Grade x Weight factor	BMWP
1	Dytiscidae	2	4	8	5
2	Noteridae	4	5	20	7
3	Hydrophilidae	2	5	10	5
4	Belostomatidae	1	5	5	5
5	Micronectidae	2	3	6	5
6	Notonectidae	1	5	5	5
7	Gerridae	4	3	12	5
8	Pleidae	2	5	10	5
9	Nephidae	3	3	9	5
10	Culicidae	1	5	5	2
11	Chironomidae	3	5	15	2
12	Stratiomyidae	2	5	10	4
13	Ephydridae	2	2	4	2
14	Syrphidae	2	2	4	1
15	Coenagrionidae	2	3	6	6
16	Baetidae	5	5	25	4
		Total	65	154	**(BMWP) 68**
		Signal Score		2.37	**(ASPT) 4.25**

Note: Signal score = (Total of grade x weight factor)/ Total of weight factor; BMWP = Sum of tolerant scores of families present.

ASPT = Total of BMWP score/ Total number of families present.

Note: Water quality status: BMWP score, 0-10=Very Poor; 11-40=Poor; 41-70=Moderate; 71-100=Good; >100=Very good [30, 42, 43, 44].

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Signal 2 score: 0-7= Suggest pollution > 7=Suggest good habitat and water quality [42].
Weight factor = abundance weighting, 1 – 2 = 1; 3 – 5 = 2; 6 – 10 = 3; 11 – 20 = 4; >20 = 5 [42].

3.4. Physico-Chemical Variables

The mean values of measured physicochemical parameters at Varuna Lake and Dalvoy Lake from this study are shown in Table 5. There was little to no difference in air temperature, water temperature, or pH levels between the study sites during the study period. The most striking feature of the water at Dalvoy Lake (1055.61 μS cm^{-1}) was its high conductivity as compared to Varuna Lake (275.67 μS cm^{-1}). The conductivity of water serves as an indicator of the presence of freely available ions, including nitrates, chlorides, and bicarbonates, within the water [55]. A high level of conductivity at Dalvoy Lake is attributed to the significant input of organic and inorganic waste. Low DO concentrations and correspondingly high Free CO_2 at Dalvoy Lake may be attributed to increased respiratory activity among the aquatic biota, enhanced decomposition of organic matter, and decreased rates of photosynthesis. In both lakes, air temperature showed a significant positive relationship with water temperature (Table 6). A rise in water temperature accelerates chemical reactions, decreases the solubility of gases, and intensifies odours [41]. The amount of dissolved oxygen was higher in Varuna Lake, which may be attributed to the presence of a high amount of macrophytes in the littoral zone of the lake. The study found a statistically significant relationship between the Shannon diversity index (H') and taxa richness with water temperature, indicating that water temperature exerted a considerable impact on the composition of aquatic insect assemblages in Varuna Lake [56]. In any aquatic system, the diversity of species and their distribution, as well as the physicochemical properties of the water, are related to one another and also influence one another [55]. According to the results of the biotic indices and physicochemical analysis, it can be concluded that Dalvoy Lake experienced a more significant decline in water quality than Varuna Lake.

Table 5. Mean Values (±SD) of environmental variables in Varuna and Dalvoy Lakes

Parameters	Varuna Lake	Dalvoy Lake
AT (℃)	27.92 ±1.63	27.63 ±1.74
WT (℃)	28.29 ±2.05	28.13 ±1.85
Rain fall (mm)	5.32 ±3.26	3.85 ±1.79
pH	7.71 ±0.73	7.65 ±0.21
EC (μS cm^{-1})	275.67 ±46.32	1055.61 ±69.90
DO (mg/L)	4.97 ±0.36	3.08 ±1.06
Free CO_2 (mg/L)	7.02 ±2.02	38.33 ±14.27
Calcium (mg/L)	16.70 ±3.16	50.33 ±3.63
Hardness (mg/L)	96.06 ±14.41	267.22 ±17.37

Note: AT – Air temperature, WT – Water temperature, EC – Electrical Conductivity, DO – Dissolved oxygen, Free CO_2 – Free Carbon dioxide.

Table 6. Pearson correlation (r) coefficient between selected physicochemical parameters and aquatic insect diversity and richness during the study period in Varuna Lake and Dalvoy Lake

Varuna Lake		Dalvoy Lake	
Variables	**r**	**Variables**	**r**
Air temp. vs Water temp.	0.929**	Air temp. vs Water temp.	0.901*
Air temp. vs Rainfall	-0.821*	pH vs Cond. (μS)	-0.888*
Rainfall vs Cond. (μS)	-0.933**	Free CO_2 vs H'	0.813*
Water temp. vs DO	-0.876*	Taxa S vs H'	0.899*
Water temp. vs Taxa S	0.846*		
Water temp. vs H'	0.827*		
Taxa S vs H'	0.986***		

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

***Correlation is significant at the 0.001 level (2-tailed).

4. Conclusions

The findings of the present study indicate substantial variation in the water quality and composition of aquatic insects observed in Varuna and Dalvoy Lakes. Although, the differences in diversity indices were small, this only indicates the replacement of sensitive species by tolerant varieties in Dalvoy Lake. This is evidenced by the existence of pollution-tolerant taxa such as *Eristalis* sp., *Stratiomys* sp., Ephydra larva of order Diptera in Dalvoy Lake. The presence of pollution-sensitive taxa *Triplectides* sp. (Trichoptera) in the Varuna indicates good water quality. This is also corroborated by high biomonitoring scores recorded in Varuna Lake as compared to Dalvoy Lake. Our study highlights the ecological potential of lakes in urban vicinities in supporting diverse flora and fauna and may have substantial conservation value. Consequently, it is suggested that the lakes in urban areas need to be protected from any further deterioration of their water quality by creating awareness among general public and implementing conservation measures.

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