Study of Zooplankton diversity in two selected lakes in Dhaka city, Bangladesh

Course Title: Thesis

A thesis submitted in partial fulfillment of the requirements for Master of Philosophy (M.Phil)

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CERTIFICATE

This is to certify that the thesis titled **"Study of Zooplankton diversity in two selected lakes in Dhaka city, Bangladesh"** is an original research work conducted by Shilpi Rani Sikder, (registration no: 114/2018-2019, M.Phil-thesis), Department of Zoology, University of Dhaka, Bangladesh. She has successfully completed her M.Phil first part. This thesis has been carried out under close supervision for the partial fulfillment of the requirements of the M.Phil degree in Zoology, Faculty of Biological Sciences, University of Dhaka, Bangladesh.

22 January, 2026

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DECLARATION

I hereby declare that this report titled **Study of Zooplankton diversity in two selected lakes in Dhaka city, Bangladesh** is a presentation of my original research work. Wherever contributions of others are involved, every effort is made to indicate this clearly, with due reference to the literature review and acknowledgement of the collaborative research and discussion. The work was done under the supervision of Supervisor, Professor, Dr. Gawsia Wahidunnessa Chowdhury, Department of Zoology, University of Dhaka, Bangladesh.

I further declare that this dissertation or any part of it has not been submitted elsewhere for any degree or diploma award.

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Reg. No.: 114/2018-2019

M. Phil (Thesis)

Session: 2018-19

Department of Zoology

University of Dhaka, Bangladesh

Dedicated

To

My Parents

& My

Family members

ACKNOWLEDGEMENTS

All praises are laid upon the almighty God, who given me kind blessing to complete this research work. I accomplishing this study report, I have received my cooperation and assistance from many in various ways which cannot be mentionable.

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Abstract

Urban aquatic ecosystems are essential components of the urban environment, playing crucial ecological roles such as water purification, habitat provision, and biodiversity support. Despite their immense significance, these ecosystems face numerous challenges due to climate change and anthropogenic pressures. Therefore, this study aimed to investigate the zooplankton diversity in Dhanmondi and Ramna Lakes, two major urban water bodies in Dhaka, Bangladesh, to understand the influence of different environmental parameters and seasonal changes on the abundance and composition of zooplankton between April 2022 and August 2023. Zooplankton were sampled from eight stations per lake during the dry and wet seasons using a 64-μm plankton net, and water quality parameters (temperature, pH, DO, conductivity, salinity, TDS) were measured in situ. Quantitative estimation and identification were conducted using Sedgewick–Rafter counting and standard taxonomic keys. Statistical analyses included ANOVA, correlation, and multivariate regression. A total of 53 taxa were recorded, with 34 taxa in Dhanmondi and 19 in Ramna. Branchiopoda were the dominant group in both lakes (53–55%), while Bdelloidea and Insecta were least abundant. Seasonal variation showed consistently higher dominance of Branchiopoda in both seasons, whereas Bdelloidea and Flagellata remained low. Water quality comparison revealed a significant difference only in TDS ($p < 0.001$). Correlation analysis showed strong negative relationships between temperature and DO, while regression indicated DO and pH as the main predictors of zooplankton abundance, explaining 36–37% of the variation.This findings are not only vital for preserving biodiversity but also for ensuring the proper management of these two vital urban ecosystems as it revealed the zooplankton community dynamics as well as their seasonal variability. Furthermore, the findings of this study will inform improved conservation and management practices so that the urban lakes continue to thrive and provide essential ecological services.

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Introduction

1 Introduction

1.2 Background of the study

Urban freshwater ecosystems within Dhaka city are increasingly under ecological stress due to rapid urbanization, unplanned development, wastewater discharge, and changes in land-use patterns. Lakes and ponds in Dhaka such as Dhanmondi, Ramna, Hatirjheel, and Crescent, play critical roles in sustaining aquatic biodiversity, regulating microclimates, and receiving stormwater. Several studies have shown that anthropogenic pressures continue to degrade these waterbodies, affecting both water quality and the structure of aquatic communities(Islam et al., 2014; Pasha et al., 2023). As a result, scientific assessments of urban freshwater ecosystems have become increasingly important for understanding ecological dynamics and guiding sustainable management interventions.

Recent ecological studies in Dhaka and other regions of Bangladesh have examined phytoplankton, zooplankton, zooperiphyton, macrophytes, and microbial communities in lentic systems, highlighting their responses to physicochemical variables and pollution gradients (Begum & Alam, 1987; Islam et al., 2015) (Sultana et al., 2023). In particular, zooplankton comprising protozoans, rotifers, cladocerans, copepods, and ostracods—are widely recognized as sensitive bioindicators of freshwater ecosystem health. Their rapid turnover rates, trophic position, and dependence on environmental conditions make them key components for evaluating the ecological integrity of lakes and ponds (Allan, 1976; Brandl, 2005; Wetzel, 2001).

Although research on planktonic communities in Bangladesh is not entirely lacking, many earlier surveys in Dhaka's lakes were limited in scope, often reporting only broad taxonomic categories or focusing on selected physicochemical parameters without detailed community-level analyses (Islam et al., 2014; Khondker & Rahim, 1991). Consequently, there remains a need for updated, lake-specific assessments of zooplankton assemblages that integrate quantitative diversity measures with contemporary water quality dynamics. This gap is particularly relevant today, as urban lakes experience continued environmental change due to increased sedimentation, nutrient loading, and pollution associated with expanding urban activities (Nabila et al., 2022; Uddin et al., 2023).

Zooplankton composition and abundance are strongly shaped by environmental factors such as temperature, dissolved oxygen, pH, conductivity, nutrient availability, and food resources, all of which are known to vary across Dhaka's urban lakes (Begum & Alam, 1987; Islam et al., 2015). For example, rotifers typically dominate in nutrient-enriched and moderately polluted systems (Jakhar, 2013; Sultana et al., 2023), while cladocerans and copepods often reflect variations in predation pressure, habitat complexity, and water quality (Brandl, 2005; Jeppesen et al., 2000). Since urban lakes differ in morphology, catchment characteristics, and pollution exposure, comparative studies can provide valuable insights into how local environmental conditions influence zooplankton communities.

Given this context, the present study focuses on Dhanmondi and Ramna Lakes, two major freshwater reservoirs located in the central administrative and recreational zones of Dhaka. Both lakes are subject to varying degrees of anthropogenic pressure, yet they remain ecologically important for supporting aquatic life and providing ecosystem services to the city's residents. By examining the physicochemical characteristics alongside the diversity and distribution of zooplankton taxa, this study aims to generate an integrated understanding of ecological status and potential environmental drivers affecting these waterbodies.

1.2 Problem Statement

The aquatic ecosystem of Bangladesh faces several threats including pollution caused by industrial effluents, domestic waste and agricultural runoff. This degradation poses serious threat to the biodiversity, particularly zooplankton, which are essential components in the aquatic food web. However, limited studies exist on zooplankton diversity, especially in urban lake waters of Bangladesh despite their ecological importance. Key gaps include the lack of understanding of how environmental factors like dissolved oxygen, pH, and total dissolved solids influence zooplankton abundance, and how seasonal variations impact their community structure. The absence of such knowledge acts as a barrier to the development of evidence-based conservation strategies. Therefore, this study seeks to fill these gaps by investigating the zooplankton communities of Dhanmondi and Ramna Lakes, examining their seasonal changes and the environmental variables influencing their dynamics, with the ultimate goal of informing sustainable management practices of the urban aquatic ecosystems.

1.3 Rationales

Zooplanktons are the essential component of food cycle as well as a vital indicator of ecosystem health. Therefore, understanding the interactions between zooplankton and their environment is essential for assessing the overall health of the urban lake ecosystems. Urban lakes like Dhanmondi and Ramna, where increasing anthropogenic pressures threaten ecological balance are essential to study. The findings of this study highlighted the significant factors such as dissolved oxygen, pH, and total dissolved solids influencing zooplankton abundance. By focusing on these dynamics, this research provides insights into how zooplankton responds to environmental stressors, offering a baseline for structured conservation strategies.

1.4 Objectives

The present study is planned to prepare a list of zooplankton recorded from the two selected lakes at Dhaka city. The specific objectives are:

- To estimate the quantitative value of zooplankton from two selected lakes at Dhaka city.
- To assess the seasonal variation of Zooplankton in selected lakes.
- To understand the role of different environmental variables on Zooplankton Abundance in the Dhanmondi and Ramna Lake

Chapter-2

Materials and Methods

2. Materials and Methodology

2.1 Sampling Period

The study was conducted in two lakes of Dhaka city from April 2022 to August 2023. The aim of this study was to understand the seasonal variability and diversity in zooplankton abundance in both Dhanmondi and Ramna Lakes. This period was chosen to represent two distinct seasons including the wet season (June–September) and the dry season (October–February). The wet season is characterized by heavy precipitation, increased freshwater runoff which can eventually lead to higher primary productivity and variability in water quality. On the other hand, the dry season is comprised of reduced precipitation, lower water levels, and a concentration of pollutants and salinity. Therefore, through this approach, a comprehensive understanding of the community dynamics and seasonal variability in zooplankton abundance in the two urban lakes of Dhaka city was understood well.

2.2 Study Area

Over the past ten years, a significant amount of scientific research has been conducted on Dhaka's lakes due to the socioeconomic and environmental consequences of declining water quality. Numerous studies examined the lakes' rising pollution levels(Ahmed, 2017). Numerous zooplankton are in danger of going extinct(Yokoyama & Park, 2003), putting aquatic biodiversity at risk as well. For instance, research that addressed the quality of the river water in and around Dhaka found that industrial wastes had lowered the water's quality. Urban lakes are heavily contaminated by household discharge and municipal waste, which includes a variety of organic and inorganic contaminants, especially in urban regions like Dhaka, Bangladesh (Islam & Shamsuddoha, 2018). As recreational spaces for the city's highly crowded inhabitants, the lakes in the big cities are regarded as vital ecological areas (Alam & Rabbani, 2012; Nabila et al., 2022). Industrial effluents, municipal wastes, runoff, sewage, and hazardous materials are causing the lakes of Dhaka City, such as Gulshan Lake, Banani Lake, and Dhanmondi Lake, which together account for only 10% to 15% of the city's total water bodies, to deteriorate more and more (Hashan & Moniruzzaman, 2022).

2.2.1 Dhanmondi Lake

Dhanmondi Lake is situated in the heart of Dhaka City, nestled within the Dhanmondi residential area. Geographically, it lies between 23°43'N latitude and 90°26'E longitude. (Ahmad, 2009). The lake is significant historically since it was once a dead channel of the Karwan Bazar River before being joined to the Turag River(Ahmad, 2009). However, these days, Dhanmondi Lake remains partially connected with the Begunbari Canal, enhancing its hydrological and ecological linkages within the urban environment (Ahmed et al., 2015).

2.2.2 Ramna Lake

Ramna Lake, located in the Ramna Thana area, is another vital aquatic ecosystem. Covering an area of 8.76 acres, the lake varies in width from 9 to 9.4 meters at different points and extends 812 meters in length. The geographic coordinate of this lake lies between 23.7365° N latitude and 90.4006° E to 90.4013° or 90° 24' 5" E longitude (MS Islam et al., 2015). Similar to Dhanmondi Lake, Ramna Lake originated from a channel of the Karwan Bazar River. It was historically connected to both the Turag River and the Buriganga River, which underscores its importance in the hydrological network of the region.

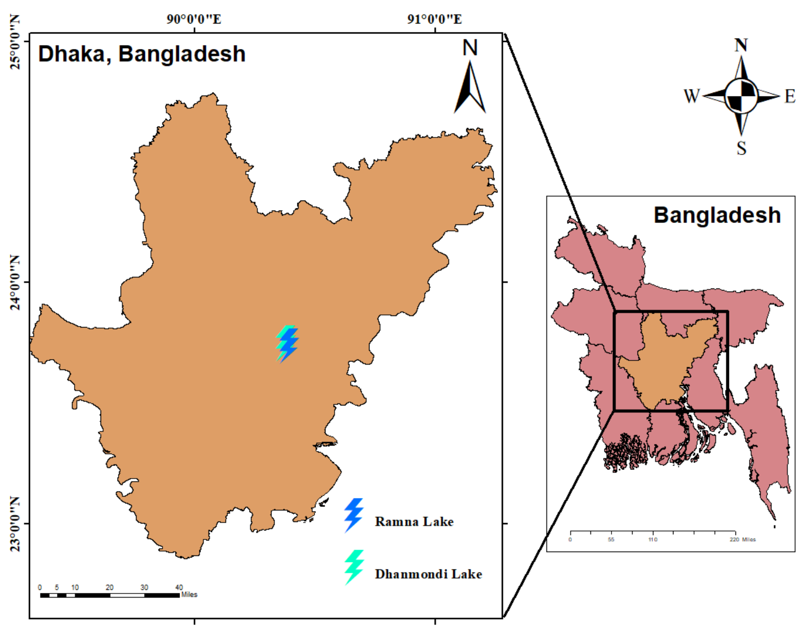


Figure 1 Geographic Location of the study Area (left side of the map indicates the two lakes in the Dhaka city

2.2 Sample collection & Preservation

To ensure representative sampling, plankton samples were collected from the two selected lakes from different spots to study zooplankton abundance. Samples were collected from 8 sampling spots from Dhanmondi lake and 8 sampling spots from the Ramna Lake. A plankton net with

64µm mesh size was used to collect the Plankton samples. The planktons were concentrated in the cylinder-shaped iron bottle of the plankton net. About 30 ml water was retained in the bottom collector was then transferred to the sample container.

Moreover, from the both Lake, water samples were obtained using a bucket for obtaining various physio-chemical factors, including temperature, turbidity, pH, DO, hardness, etc. A mercury thermometer was used to gauge the temperature of the water at each station from the both lake the Dhanmondi Lake and the Ramna Lake. With a tabletop electrometric pH meter, water's pH was tested. A Secchi disc was used to gauge the clarity of the water. Four separate locations in the both Lake were used to collect the sample, which were then quantified and examined in a lab setting with the use of the appropriate tools and substances. The sample container was marked with number and spot name carefully and not mixing together because each spot was considered as a separate spot. Filtered water sample was immediately preserved in 5% formalin to avoid any damage of the plankton for long term preservation.

Table 1 Comprehensive summary of Environmental Variable Observations at Different Stations using Instrumental Methods

Location	Variables	Instrument	Station
Dhanmondi Lake	Temperature (˚C)	Mercury thermometer	
	Salinity (PSU)	Salinity Meter	
	DO (mg/l)	DO Meter	8 stations
	TDS (mg/l)	Secchi disc	
Ramna Lake	Conductivity		
	pH	Electronic pH meter	
	Zooplankton	Plankton net	

Figure 2 Sample collection of Plankton using plankton net (a &b) and water quality parameters (c)

2.3 Analysis in the Laboratory

Observation of zooplankton was conducted under a higher resolution Olympus compound microscope, model CH30RF200, Japan and zooplankton was done on Sedgewick-Rafter counting chamber (S-R cell) in laboratory at the Department of Zoology, University of Dhaka.

The S-R cell is the device most commonly used (LeGresley & McDermott, 2010; Littleford et al., 1940; Steinberg et al., 2012; Varghese et al., 2015). The S-R cell is approximately 50 mm long by 1mm deep. The sample was transfered with a dropper. Placing the cover in this manner helped to prevent formation of air bubbles in the corners of the cell. The cover slip was rotated slowly to cover the inner portion of the S-R cell during filling. Before proceeding of the count, the S-R cell was allowed to stand at least for 5 minutes to permit the setting of the planktons. In a counting cell about 1ml sample was taken and spread over evenly. The cell contains 1000 squares and it was placed under a microscope for counting. 10x and 40x magnifications were used in the microscope to count planktons carefully in each square. It took longer or shorter time to count depending on the density of the plankton number.

Figure 3 Identification of the zooplankton samples collected from the Dhanmondi Lake and Ramna Lakein the laboratory

2.4 Identification of Zooplankton

Zooplankton was identified up to genera or species level. Zooplankton were identified by following keys given by Fager and McGowan (1963); (Goswami, 2004); Jenkins and Buikema Jr (1998); Slotwinski et al. (2014).

2.5 Estimating the Number

The cells counted were used for quantitative estimation of cell density using the following formula of Andersen and Throndsen (2003); Booth (2018) and Hewes et al. (1984)

$$N = (A\times1000\times C)/(V\times F\times L)$$

Here,

N= Number of plankton cells or units per liter of original water

A= Total number of zooplankton counted

C= Volume of a final concentration of the samples in ml

V= Volume of a field in cubic mm

F= Number of fields counted

L= Volume of original water in liters

2.4 Statistical Analysis

Percentage of the classes and families of zooplankton in both Dhanmondi and Ramna Lake were analyzed from the abundance in R programming software. The percentages of the classes of zooplankton were demonstrated in two donut charts for both Dhanmondi and Ramna Lake while the percentages of the families of zooplankton in the Dhanmondi and Ramna Lake were illustrated through two pie charts. All these plots are generated using R software. For the donut charts, ggplot2 and dplyr packages were installed. Again, for showing the abundance of the total number of taxa in both Dhanmondi and Ramna Lake for dry season and wet season, two bar plots were being generated using the R programming software.

A correlation plot is generated to understand the relationship among the environmental variables of the Dhanmondi and Ramna Lake which was also generated in the R programming software. Analysis of variance between the two selected lakes was performed to understand the difference between the environmental variables of the two lakes. Apart from that, to understand the role of various environmental variables on the zooplankton abundance, a multivariate regression was performed.

Chapter-3

Results

3. Results

3.1 Quantitative value of zooplankton from two selected lakes at Dhaka city

During the study period, 24 zooplankton species were recorded in total from the Dhanmondi and Ramna Lake (Fig 4). The zooplankton community was categorized into a number of important taxonomic groups, up to the class and family levels. In Dhanmondi Lake, Monogononta was the most abundant class, accounting for approximately 52.94% of the total zooplankton population. Rhizophoda and Branchiopoda, on the other hand, contributed the least, at just 2.94%. Ostracoda accounted for around 54.05% of the population in Ramna Lake, resulting in the most prominent class. Bdelloidea and Ciliophora, on the other hand, made up only 2.7%. The Cyclopidae family predominated in Ramna Lake, whereas the Calanoidae family was the most prevalent in Dhanmondi Lake. Seasonal variability showed that, there are notable differences in zooplankton abundance, with lower counts in the dry season (October–February) and greater counts during the wet season (June–September). Branchiopoda showed year-round dominance in both lakes.

Around 52.94% of the zooplankton found in Dhanmondi Lake during the investigation were members of the Branchiopoda class (Fig 5a). Given that this class accounts for about half of the zooplankton population, thus, only 2.94% of the zooplankton population was in the least common classes, Bdelloidea and Insecta. This significant difference revealed a very low abundance of these classes in Dhanmondi Lake. The low abundance of Bdelloidea and Insecta showed a distinct variability in the distribution of zooplankton groups, suggesting that Branchiopoda is more prevalent in the lake ecology.

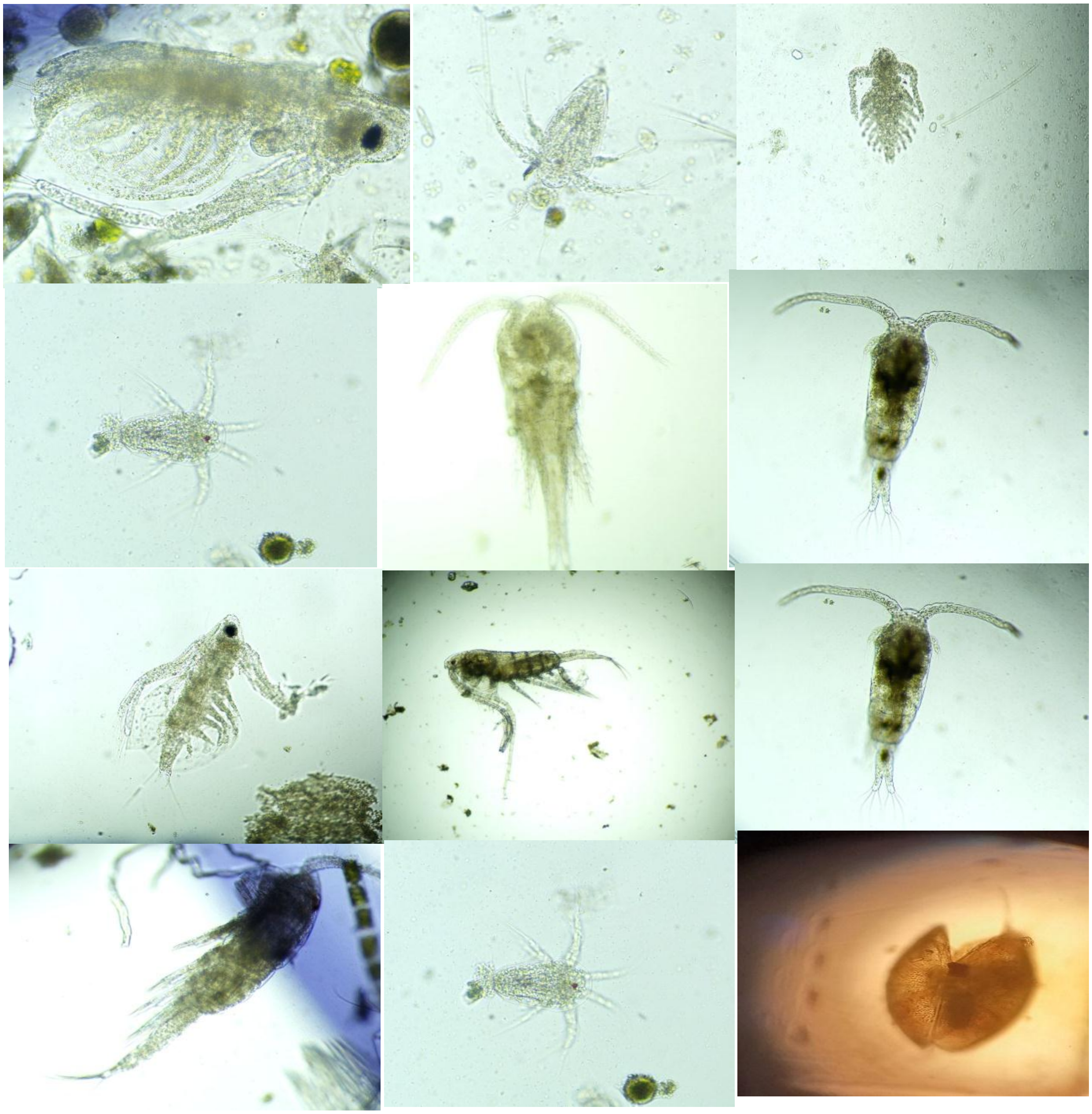


Figure 4 Observed Zooplankton species in the laboratory using microscope

In Ramna Lake as well, Branchiopoda (55%) were the most abundant zooplankton class(Fig 5b). The dominance of the branchiopods in the aquatic environment of the lake can be clearly understood from their relative percentage. Conversely, the groups Bdelloidea and Insecta were the least abundant class found in the study, each comprising of around 5% of the total zooplankton population.

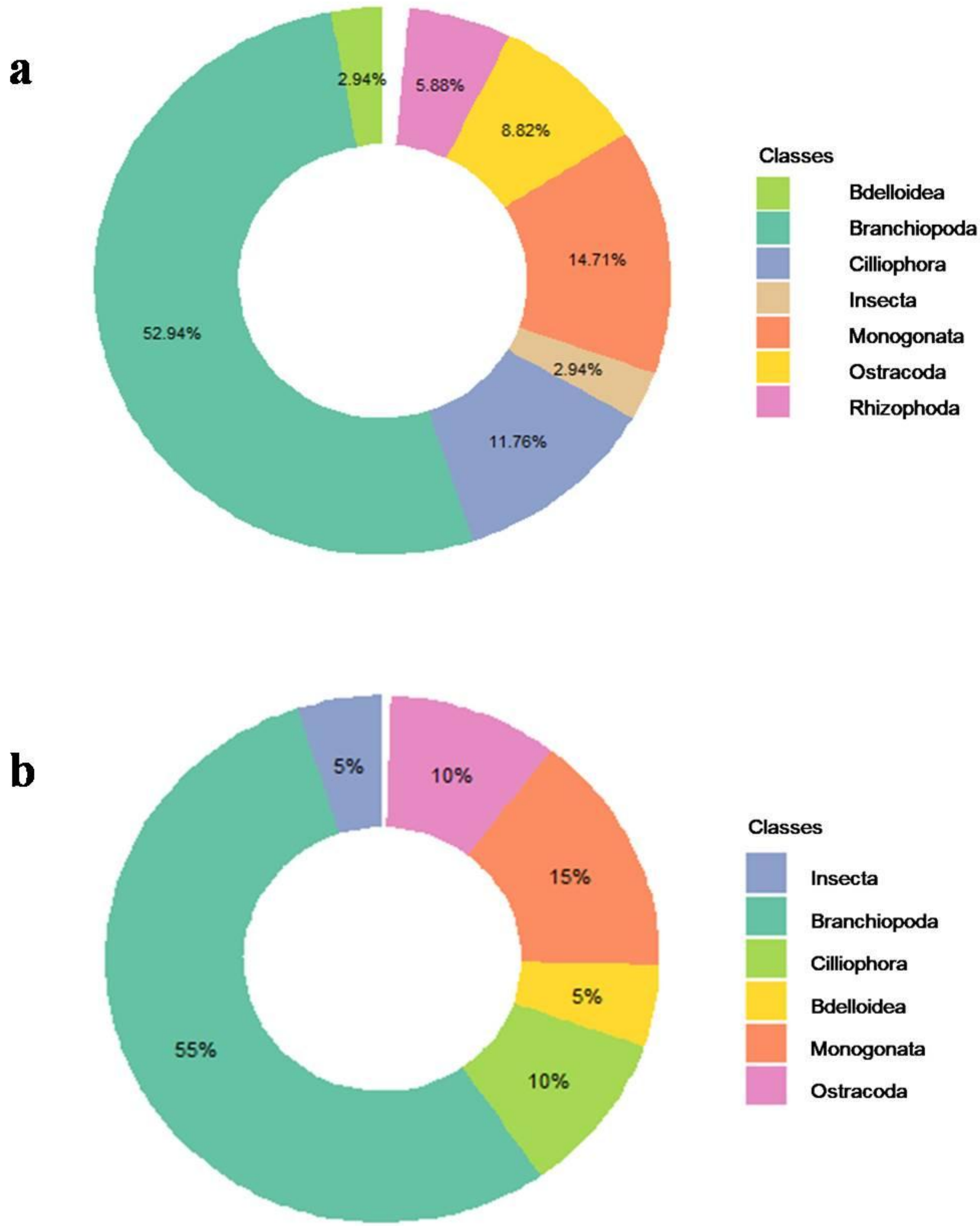


Figure 5 Percentage of the classes of Zooplankton in Dhanmondi(a) and Ramna Lake(b)

These results point to a significant difference in Ramna Lake's zooplankton classes' abundance and distribution. In comparison to the Ostracode class, Bdelloidea and Ciliophora exhibit comparatively low percentages, indicating their restricted presence within the zooplankton community and a lesser ecological prominence. The distribution pattern of the several zooplankton groups in Ramna Lake suggests a variety of ecological interactions and population dynamics.

In addition, the distribution of zooplankton families was examined in both the Ramna and Dhanmondi Lake (Fig. 6). The family Calanoidae was found to be the most abundant zooplankton family in Dhanmondi Lake (Fig. 6a), with the highest frequency of observation among all the zooplankton families. The zooplankton community structure of Dhanmondi Lake observed to be dominated by the Calanoidae family, based on their high amount of presence. Moreover, it was also observed that, the other zooplankton groups in Dhanmondi Lake were found in nearly equal proportions, with each group comprising around 3% of the total zooplankton population. Aside from the prominent Calanoidae family, this rather even distribution among other families suggests a varied yet balanced presence of several zooplankton families. Similarly, in Ramna Lake, the Cyclopidae family was found to be the most abundant group of zooplankton, accounting for about 15% of the total (Fig 6b). The Cyclopidae family's abundance indicates that it played a major role in the Ramna Lake zooplankton population. The majority of zooplankton families in Ramna Lake were identified at comparable percentages to those in Dhanmondi Lake, with each family making up approximately 5% of the overall zooplankton population. Apart from Cyclopidae dominance, the constant distribution across different families revealed a balanced zooplankton community structure in Ramna Lake.

Overall, the findings from the current study showed that, zooplankton families are more common in each of the two lakes. The Calanoidae and Cyclopidae families were the most commonly observed in Dhanmondi and Ramna Lakes, respectively. In both lakes, the distribution of other families was more uniform, with each family making a roughly equal contribution to the total zooplankton population.

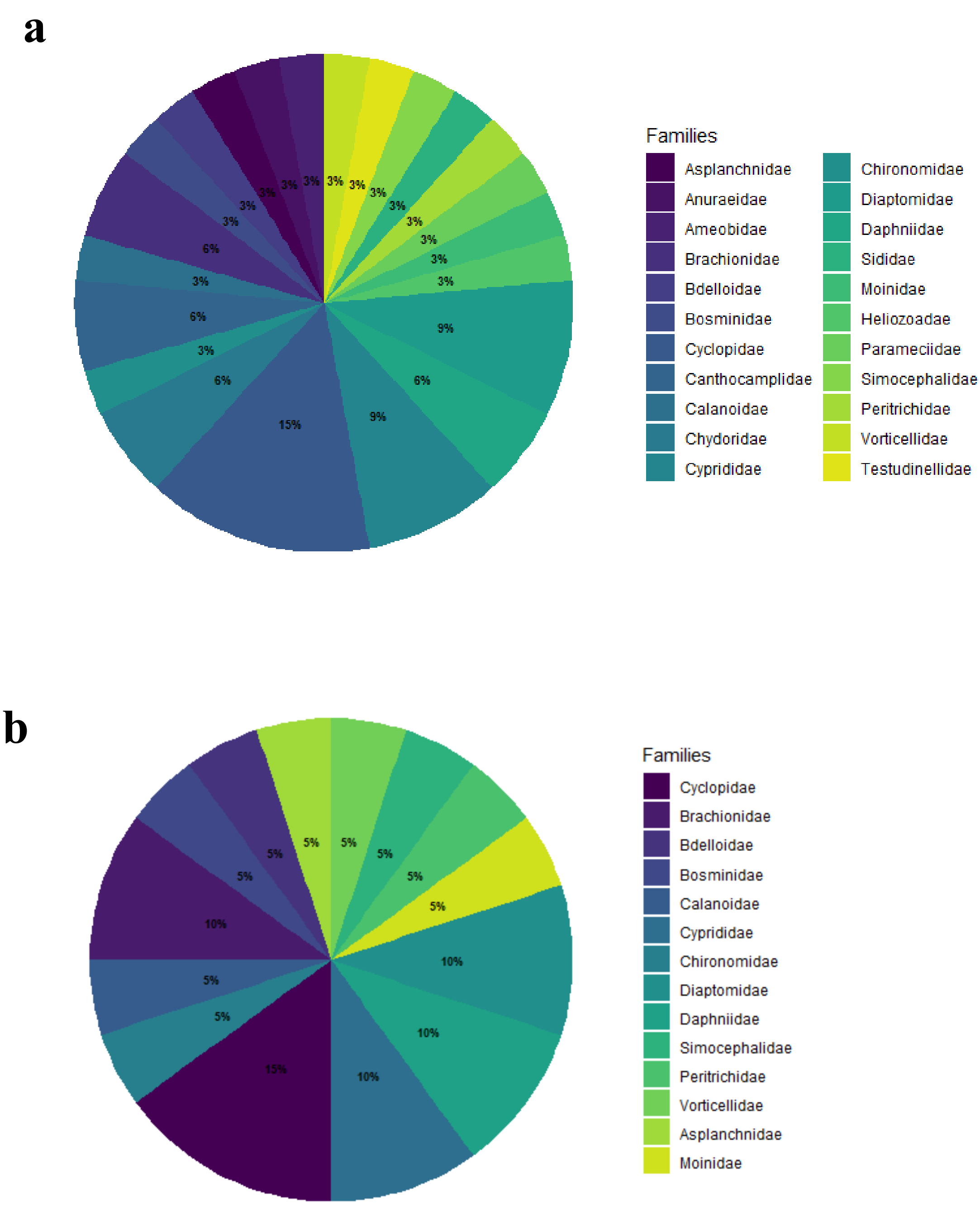


Figure 6 Percentage of the Families of Zooplankton in Dhanmondi(a) and Ramna Lake(b)

Table 2 Zooplankton Class-Level Richness and Relative Composition in Dhanmondi and Ramna Lakes

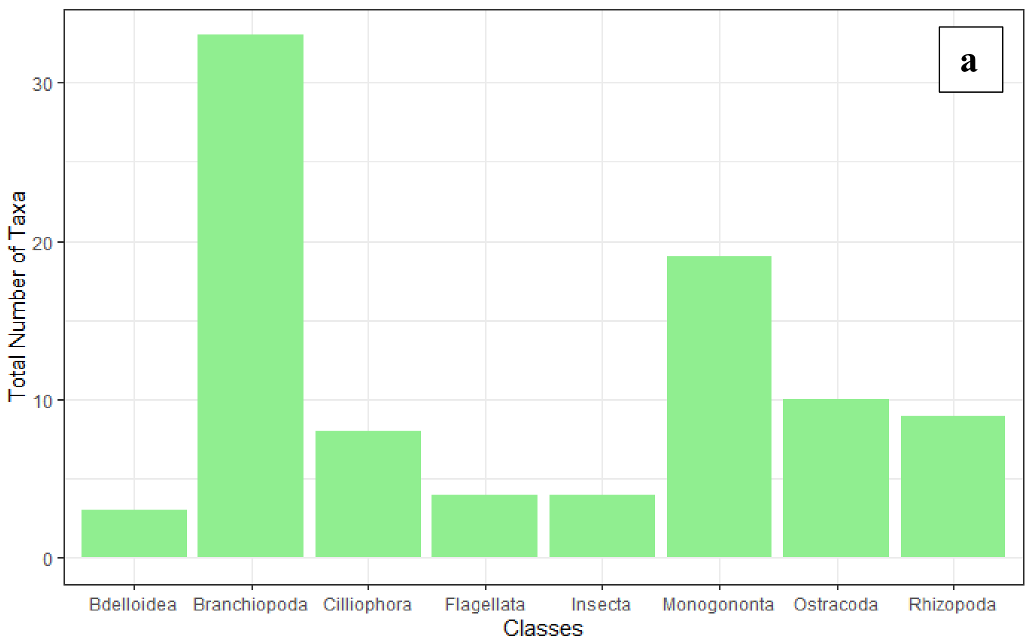
Class	Dhanmondi (No. of taxa)	Ramna (No. of taxa)	Mean richness (%) ± SEM*	Range	Interpretation
Branchiopoda	18	11	53.97 ± 1.50	18–55	Dominant in both lakes
Monogononta	5	3	14.86 ± 0.15	14–15	Similar between lakes
Ciliophora	4	2	10.88 ± 0.18	10–12	Slightly richer in Dhanmondi
Bdelloidea	1	1	3.97 ± 0.03	3–5	Similar low occurrence
Ostracoda	3	2	9.41 ± 0.17	8–10	Comparable
Rhizopoda	2	0	2.94 ± 0.05	2–3	Found only in Dhanmondi
Insecta	1	1	3.97 ± 0.04	3–5	Equal, minor component

**SEM shown for relative richness values only; no statistical test performed due to single observation per lake.*

Table 2 demonstrates the relative taxonomic richness and composition of zooplankton populations in Dhanmondi and Ramna Lakes. Seven zooplankton classes were found in both lakes. With roughly 53–55% of all known taxa in both systems, Branchiopoda comprised the most taxon-rich group. The next most prevalent classes, making up 10–15% of all taxa, were Monogononta and Ciliophora. While all other groups have been recorded from both study locations, Rhizopoda was only found in Dhanmondi Lake. Overall, Dhanmondi Lake had a higher overall taxonomic richness (34 taxa) than Ramna Lake (20 taxa), indicating a marginally higher level of biological variety and habitat variability. The percentage representation of zooplankton classes shows a generally comparable community composition in both water bodies, with minor differences in group dominance and diversity, even if statistical comparison of richness was not possible due to single-lake-level data.

3.2 Assessment of the seasonal variation of Zooplankton in the Dhanmondi and Ramna Lake

The seasonal variability of zooplankton abundance was also observed in both Dhanmondi and Ramna Lakes. In each lake, the total number of taxa observed under each class was investigated in both dry and wet seasons to understand the variability and dominance of zooplankton in the two urban lake ecosystems.



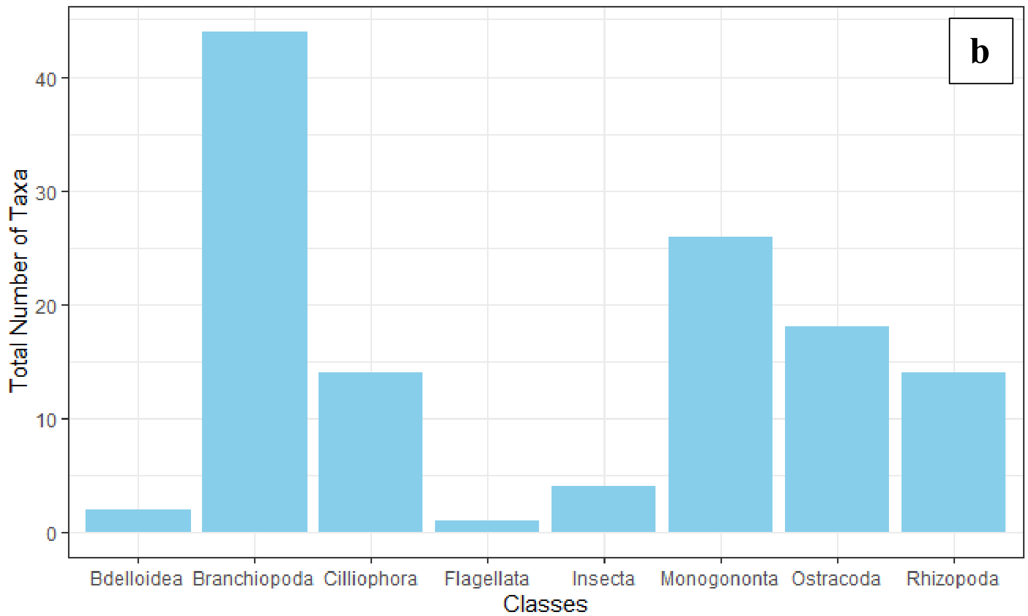


Figure 7 Total NO of Taxa in Dhanmondi Lake during dry(a) and wet season(b)

Some unexpected trends were found when the distribution of various zooplankton classes in Dhanmondi Lake was analyzed over the rainy and dry seasons (**Fig. 7**). During the dry season, the class Branchiopoda showed the highest abundance (**Fig. 7a**), with a significant rise in the total number of taxa observed. This class was significantly larger than the others, indicating the importance of Branchiopoda in the zooplankton population of the lake during the dry season. On the other hand, Flagellata, the taxonomic category with the fewest known species, showed the lowest abundance during this time, making it the class least common during the dry season. During the wet season, Branchiopoda remained the class with the highest number of taxa and continued to be the most abundant (**Fig 7b**). Branchiopoda continues to be the most numerous class in both seasons, indicating its year-round dominance in the lake's zooplankton ecology. The class with the lowest abundance, Flagellata, changed to Bdelloidea during the wet season, when the least number of taxa were seen. This seasonal variation in the least abundant class shows that the distribution of the least abundant zooplankton classes varies between the dry and wet seasons, even if Branchiopoda continuously maintains its dominance.

The analysis of various zooplankton classes in Ramna Lake during the dry and rainy seasons revealed notable patterns in their abundance (**Fig 8**). The class Branchiopoda showed the highest abundance during the dry season, with a much higher number of taxa than other classes (**Fig 8a**).

Branchiopoda showed a significant numerical benefit, demonstrating their unambiguous dominance of the zooplankton population throughout the dry season. The population of this dominance is noticeably higher than those of other zooplankton classes. On the other hand, out of all the classes, the Bdelloidea class had the fewest taxa observed during the dry season, indicating the lowest abundance. There is a glaring difference in the distribution of zooplankton classes in the lake between the relatively small amount of Bdelloidea and the massive amount of Branchiopoda.

The analysis of the wet season (**Fig. 8b**) showed a similar pattern. Continuing to hold the record for the most reported taxa, the Branchiopoda class proved to be the most plentiful once more. The zooplankton ecosystem of Ramna Lake is dominated by Branchiopoda, as evidenced by its steady dominance and high abundance seen in both seasons. This continuous frequency indicates that Branchiopoda may survive and proliferate in both dry and wet seasons under favorable environmental conditions. Throughout the rainy season, Bdelloidea remained the class with the lowest abundance and the fewest observed taxa. The ongoing low abundance of Bdelloidea in both seasons suggests that this class is the least common in the lake, which may indicate that Bdelloidea's environmental conditions are not as favorable as those of other zooplankton classes. These findings point towards a regular pattern in Ramna Lake, where Bdelloidea consistently has the lowest abundance and Branchiopoda consistently maintains its dominance in both seasons. This implies that these classes have a consistent seasonal distribution pattern inside the lake. The steady low quantity of Bdelloidea and the steady dominance of Branchiopoda indicate a stable ecological structure in the lake, where some classes retain their abundance regardless of seasonal fluctuations.

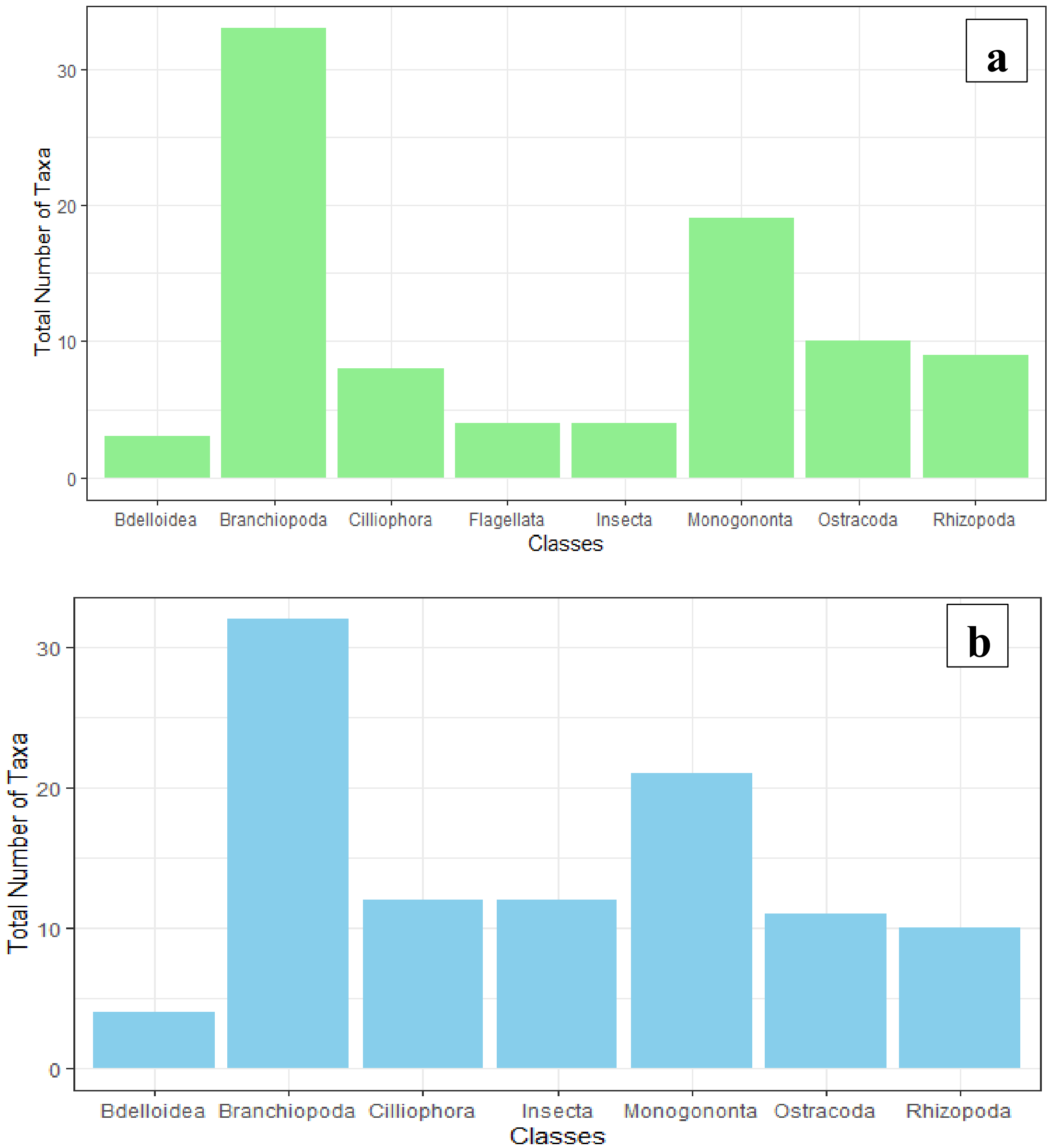


Figure 8 Total no of Taxa in Ramna Lake during dry(a) and wet season(b)

The data of environmental conditions (temperature, salinity, DO, turbidity, TDS and pH) were collected from around 8 sites of both Dhanmondi and Ramna Lake (Table 3).

Table 3 *Range of measured environmental variables at eight sampling sites of Dhanmondi and Ramna Lakes*

Parameters	Dhanmondi Lake (min-max)	Ramna Lake (min-max)
Temperature (°C)	19.2-27.8	18.25-28
DO (mg/l)	7.25-9.36	7.25-9.4
pH	6.25-7.13	6.25-7
Conductivity (µS/cm)	191-281	192-293
TDS (mg/l)	109.5-137.5	135-141

The relationship among the environmental variables in Dhanmondi and Ramna Lakes were further assessed using correlation analysis (Fig. 8). A strong positive correlation ($r = 0.82$, $p < 0.01$) was observed between salinity and dissolved oxygen (DO), suggesting that higher salinity was associated with elevated DO levels. Conversely, temperature exhibited a strong negative correlation with DO ($r = –0.74$, $p < 0.05$), indicating reduced oxygen solubility at higher temperatures.

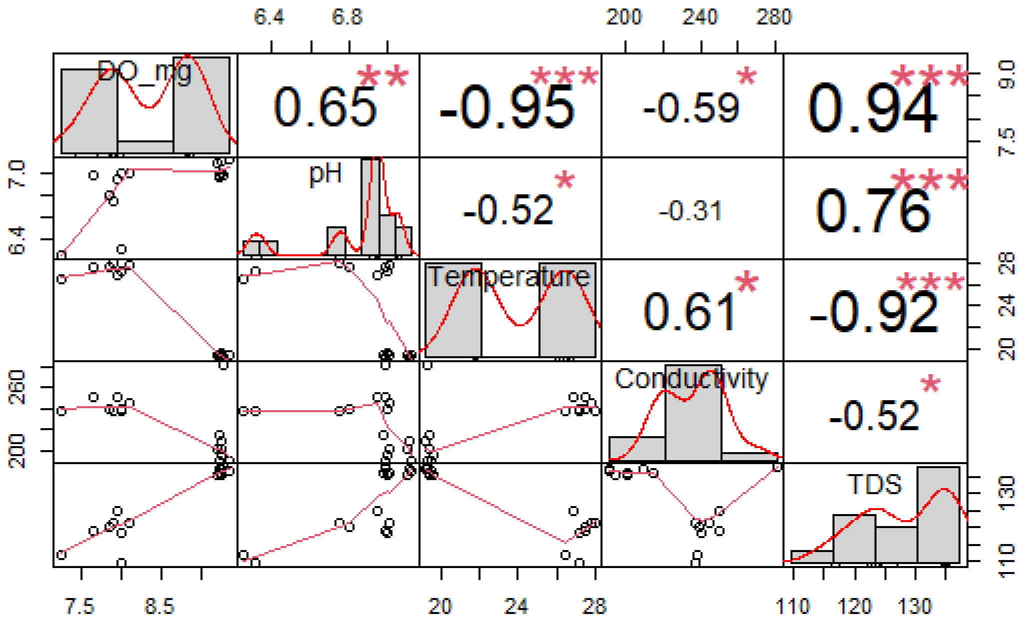


Figure 9 Relationship among environmental variables in the Dhanmondi Lake

However, there is a strong inverse relationship between temperature and dissolved oxygen (DO), meaning that higher temperatures are associated with lower DO concentrations. In aquatic ecosystems, this inverse relationship is well-established because rising temperatures typically cause oxygen to become less soluble in water, which lowers DO concentrations.

Additionally, there is a strong negative correlation between salinity and temperature, meaning that lower temperatures are associated with higher salinity levels. This could be because of the unique hydrodynamic and climatic characteristics of the lake, where saline water intakes may be colder than the lake's average ambient temperature. These inputs could come from groundwater sources or surface runoff during specified times of the year. Alternatively, this pattern could represent seasonal changes in which times of increased salinity due to salt concentration and evaporation occur with lower temperatures.

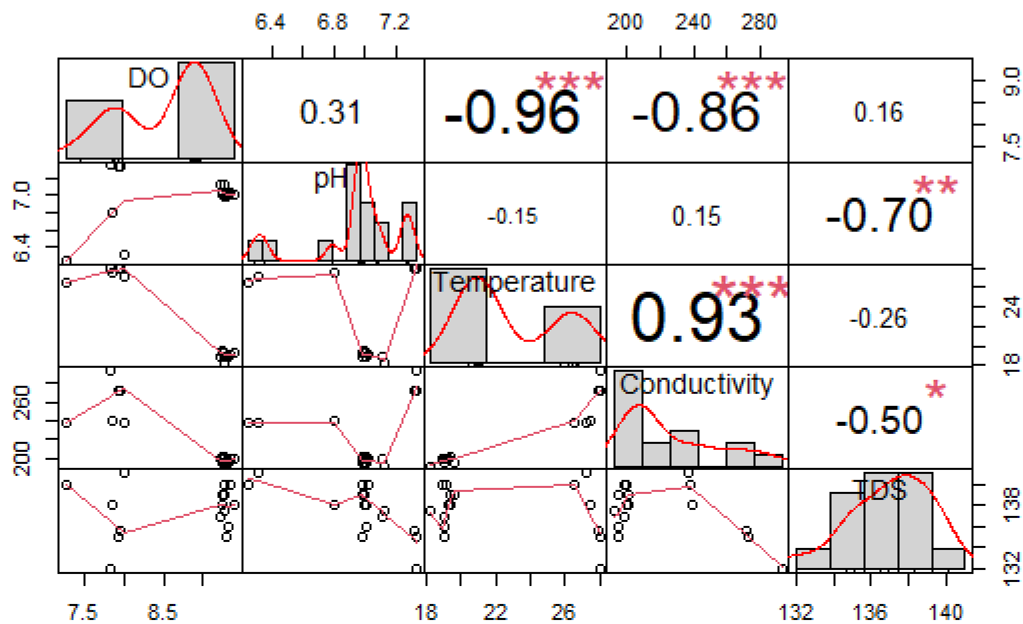


Figure 10 Relationship among environmental variables in the Ramna Lake

A study of Ramna Lake's environmental components revealed important interactions that shed light on the ecosystem's dynamics. Specifically, there is a substantial negative association (r = -0.96) between Temperature and Dissolved Oxygen (DO). This implies that when the temperature rises, there is a discernible decrease in the amount of dissolved oxygen in the water. A almost perfect negative relationship is demonstrated by a correlation coefficient of -0.96, which indicates that the concentration of dissolved oxygen continuously falls across the recorded data points as temperature rises. In addition, a high positive relationship between conductivity and temperature is indicated by the 0.93 correlation coefficient. This demonstrates that when the temperature rises, Ramna Lake's water shows higher conductivity values. A near-perfect direct link is indicated by the correlation coefficient of 0.93, which means that when the temperature rises, the water's conductivity rises practically proportionately. These correlations demonstrate how changes in temperature can affect Ramna Lake's overall chemical composition as well as the amount of oxygen available to aquatic life. While there is a strong positive correlation between temperature and conductivity, which suggests that higher temperatures are linked to higher ion concentrations in the water, the strong negative correlation between temperature and DO suggests that rising temperatures result in a significant reduction in oxygen levels. The fact that temperature has a dual effect on conductivity and DO highlights how important thermal conditions are in determining the ecosystem's chemical and physical characteristics.

To understand the statistical comparison of the environmental parameters at Dhanmondi and Ramna Lakes, initially a one-way ANOVA, was applied to compare water quality parameters between the two lakes The study of the temperature data shows that the p-value of 0.4613 is more than the standard significance level of 0.05. This result suggests that there is no statistically significant difference in mean temperature between Dhanmondi and Ramna Lakes. As a result, the two lakes' temperature profiles are rather similar. Therefore, Dhanmondi and Ramna Lakes have statistically similar temperatures, conductivities, and dissolved oxygen levels, but they differ significantly in total dissolved solids. Similar to that, the analysis of the dissolved oxygen (DO) levels between the lakes shows a p-value of 0.50, which is also greater than the significance level of 0.05.

Analysis of total dissolved solids (TDS) provides a diverse scenario. In this instance, the p-value is 0.0004, significantly less than the 0.05 threshold. This finding suggests there are notable differences between the mean TDS levels in Dhanmondi and Ramna Lakes. The significant difference in TDS levels suggests that there are noticeable differences in the two lakes' concentrations of dissolved solids.. Ultimately, an analysis of the conductivity data provides a p-value of 0.58, exceeding the significance threshold of 0.05 once more. This result suggests there are no significant variations between the mean conductivities of Dhanmondi and Ramna Lakes.

However, as only two groups were compared, data were reanalyzed using independent samples t-tests. Both tests yielded consistent results, confirming that TDS levels differed significantly between lakes ($p < 0.01$), while other parameters did not differ significantly ($p > 0.05$).

Table 4 Descriptive statistics and independent samples t-test comparing water quality parameters between Dhanmondi and Ramna Lakes

Parameters	Lakes	Mean ± SEM	t-value	df	p-value	Interpretation
DO (mg/L)	Dhanmondi	8.51 ± 0.19	0.68	30	0.50	ns (no difference)
	Ramna	8.69 ± 0.19				
pH	Dhanmondi	6.92 ± 0.08	1.13	30	0.27	ns (no difference)
	Ramna	7.04 ± 0.07				
Salinity	Dhanmondi	0.13 ± 0.00	-0.44	30	0.66	ns (no difference)
	Ramna	0.13 ± 0.00				
Temperature (°C)	Dhanmondi	23.41 ± 0.96	0.75	30	0.46	ns (no difference)
	Ramna	22.66 ± 0.99				
Conductivity (µS/cm)	Dhanmondi	224.13 ± 6.earlier	0.55	30	0.58	ns (no difference)
	Ramna	218.75 ± 8.19				
TDS (mg/L)	Dhanmondi	126.97 ± 2.42	4.01	30	**0.0004**	**Significant**
	Ramna	136.81 ± 0.79				

The findings of the independent samples t-test (**Table 4**) demonstrate a significant difference in mean TDS values between Dhanmondi and Ramna Lakes ($t = 4.01$, $p < 0.001$), suggesting that Ramna Lake has greater dissolved solids. Temperature, DO, pH, conductivity, and salinity were among the other factors that did not exhibit significant variations ($p > 0.05$). With the exception of TDS, which represents different ionic concentrations and potential variations in nutrient imports or anthropogenic effect, these data indicate generally similar physicochemical conditions between the lakes.

3.3 Role of different environmental variables on Zooplankton Abundance in the Dhanmondi and Ramna Lake

Several significant findings have been identified from the Multivariate regression analysis conducted to understand the influence of environmental factors on zooplankton abundance in Dhanmondi Lake (Fig 11a). The analysis revealed that Dissolved Oxygen (DO) was the primary driver of zooplankton abundance, explaining 24% of the variation. This indicates that DO levels have a substantial impact on the population dynamics of zooplankton in the lake. Following DO, pH was found to account for 22% of the variance in zooplankton abundance, suggesting that the acidity or alkalinity of the water is another crucial factor affecting zooplankton populations. Total Dissolved Solids (TDS) explained a smaller portion of the variance, only 2%, indicating a relatively minor influence on zooplankton abundance compared to DO and pH.

Overall, the environmental variables included in the regression model can account for about 36.93% of the variance in zooplankton abundance, as indicated by the multiple R-squared value of 0.3693. This value suggests that while the model captures a significant portion of the variability in zooplankton abundance, a considerable fraction remains unexplained, implying the influence of other factors not examined in this study. The adjusted R-squared value, which takes into account the number of predictors in the model, is 0.14. This lower value indicates that only 14% of the variability in zooplankton abundance is explained by the environmental variables when the complexity of the model is considered. The discrepancy between the adjusted R-squared and the multiple R-squared values suggests the potential for overfitting, indicating that some predictors might not be significantly contributing to the model.

The model's F-statistic is 1.61, with a p-value of 0.2402. Since the p-value exceeds the traditional significance threshold of 0.05, it suggests that the model as a whole is not statistically significant. This lack of statistical significance implies that, although the model includes variables that are individually important, collectively they do not provide a robust explanation for the variance in zooplankton abundance. The high p-value further indicates that there is a substantial likelihood that the observed relationships could be due to random chance rather than a true underlying pattern.

Table 5 Multivariate Regression Analysis to understand the role of Environmental variables on Zooplankton Abundance in the Dhanmondi Lake

Multiple R-squared	Adjusted R-squared	F-statistic	p-value
0.3693	0.14	1.61	0.2402

Table 6 Multivariate Regression Analysis to understand the role of Environmental variables on Zooplankton Abundance in the Ramna Lake

Multiple R-squared	Adjusted R-squared	F-statistic	p-value
0.3641	0.08141	1.288	0.3441

These findings highlight the complexity of ecological systems and the challenges in identifying and quantifying the influence of various environmental factors. The primary importance of DO and pH suggests that water quality parameters are critical for zooplankton populations. However, the overall insignificance of the model underscores the need for further research to identify other influential factors and improve the model's explanatory power. Additionally, the potential issue of overfitting signals the necessity for a more refined model that can better capture the true relationships without being influenced by noise or irrelevant variables.

In conclusion, while DO and pH are identified as significant drivers of zooplankton abundance, the study also reveals the limitations of the current model in fully explaining the observed variability. This calls for more comprehensive studies that include a broader range of environmental variables and perhaps consider temporal and spatial variations to develop a more accurate and reliable model of zooplankton dynamics in Dhanmondi Lake.

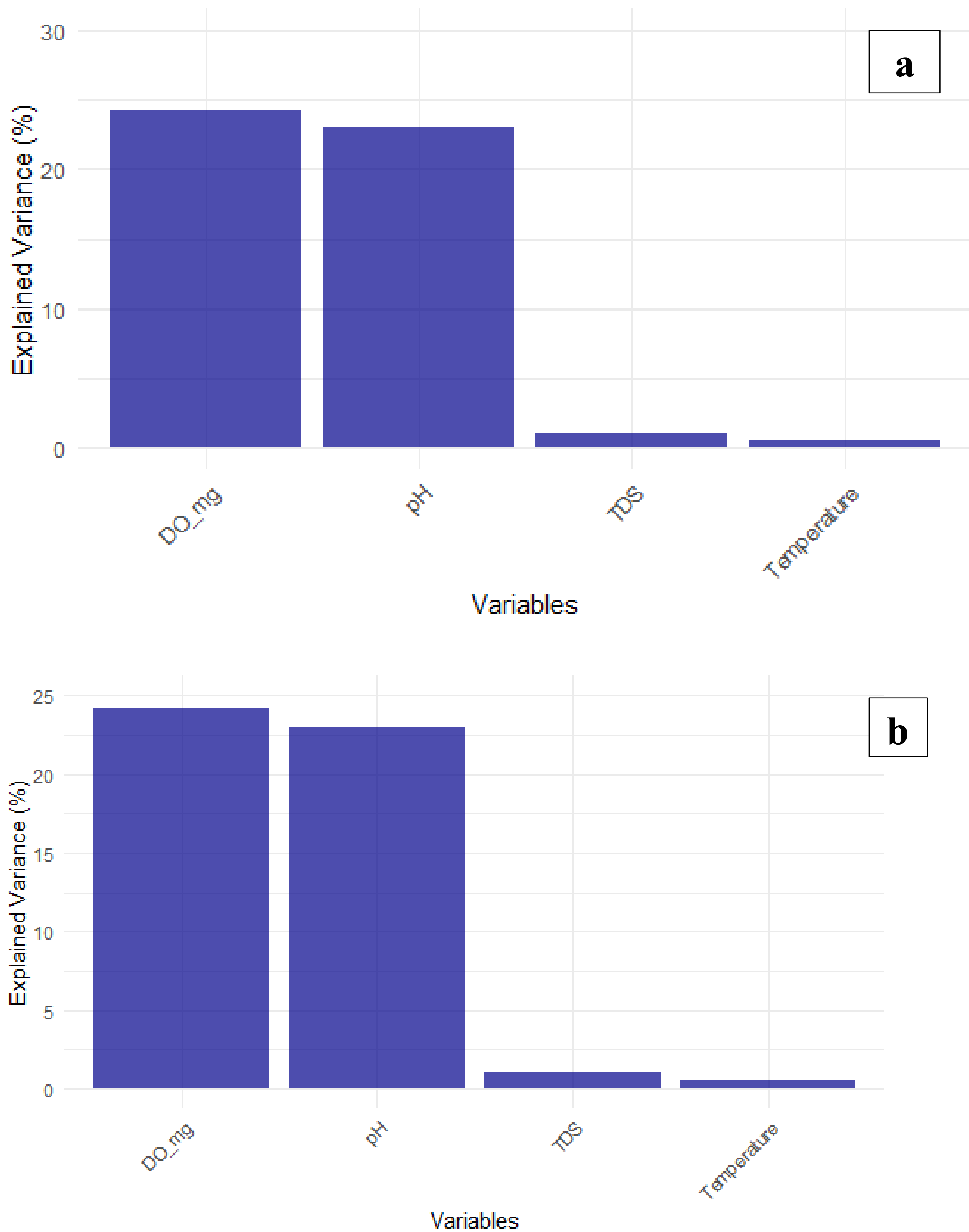


Figure 11 Role of different environmental variables on zooplankton abundance in the the Dhanmondi (a) and Ramna Lake (b)

In other words, the environmental factors in the model do not account for the fluctuations in zooplankton abundance any more than a model lacking any predictors would. These results suggest that, although there might be a link between zooplankton abundance and the environmental variables taken into account, it is not strong enough to be regarded as statistically significant within this model. This shows that the zooplankton populations in Dhanmondi Lake may be more significantly impacted by other variables. These could include biological processes like competition and predation, the accessibility of food, or other unquantifiable environmental factors. The findings suggest that in order to obtain a more profound comprehension of the dynamics impacting zooplankton populations in this specific ecosystem, a more thorough inquiry that takes into account a wider range of plausible factors is required.

Considering a multiple R-squared value of 0.3693, the model's included environmental factors can account for about 36.93% of the variance in zooplankton abundance. When the number of predictors considered, the adjusted R-squared value of 0.14 showed a considerable decrease, indicating overfitting and the inclusion of factors that might not have much predictive ability. With a p-value of 0.2402, the F-statistic of 1.61 further suggests that the model is not statistically significant overall. This high p-value suggests that there is a significant chance that the explanatory capacity of the model is the result of random chance rather than true forecasting ability. Consequently, even while DO and pH alone seem important, their combined effect is insufficient to explain the observed variations in zooplankton abundance.

In Ramna Lake, the multivariate regression analysis results provide information about the correlations between various predictors and the attributes or measurements of the lake (Fig 11b). The multiple R-squared value of the model is 0.3641, indicating that the independent variables that were part of the research can explain roughly 36.41% of the variance in the dependent variable, which most likely represents some feature of the circumstances or attributes of Ramna Lake. This number indicates a moderate amount of explanatory power, meaning that the model can account for a significant portion of the variance in the dependent variable.

However, the adjusted R-squared value decreases to 0.08141 when the number of predictors is taken into account. This significant decrease indicates that the complexity of the model—which includes several predictors—does not significantly increase its explanatory ability. With the number of predictors taken into consideration, the corrected R-squared value indicates that only approximately 8.14% of the variance is truly explained, which raises the potential of overfitting and the inclusion of non-contributory factors. Moreover, the model's p-value is 0.3441 and its F-statistic is 1.288. When compared to a model without predictors, this p-value shows that the model does not significantly increase the comprehension of the dependent variable. This is in line with the customary threshold for statistical significance, which is 0.05. The absence of statistical significance implies that the model's predictors are ineffective in explaining Ramna Lake's dependent variable's variability.

These results suggest that although part of the variability in the lake's circumstances is captured by the environmental factors included in the analysis, they are insufficient to offer a statistically meaningful explanation. This model did not take into account other aspects that might have a greater impact, such as biological interactions, nutrition dynamics, or extra environmental conditions.

Chapter-4
Discussion

4. Discussion

The study of zooplankton populations in Dhanmondi and Ramna Lakes in Dhaka revealed notable variations in the abundance and distribution of different zooplankton classes and families. Bdelloidea and Insecta were the least prevalent classes in Dhanmondi Lake, however, Branchiopoda was the most prevalent. According to the distribution pattern, certain environmental conditions may be the reason why Branchiopoda was observed higher than other zooplankton classes in Dhanmondi Lake. In contrast, Ostracode was the most common class and Bdelloidea and Ciliophora were the least common in the zooplankton community structure of Ramna Lake. Unlike Dhanmondi Lake, Ramna Lake's unique environmental conditions support distinct dominating zooplankton species, as seen by this unique community composition. Seasonal variations further demonstrated the zooplankton populations' dynamic nature in both lakes. It is evident that Branchiopoda were more common in Dhanmondi and Ramna Lakes throughout both the rainy and dry seasons. The seasonal dominance of Branchiopoda highlighted their resilience and flexibility to changing environmental conditions, including changes in water temperature, availability of nutrients, and other ecological factors. Additionally, the study discovered significant relationships between zooplankton abundance and other key environmental parameters. Temperature, salinity, and dissolved oxygen levels have been identified as significant factors influencing zooplankton population dynamics and distribution. Specifically, both lakes' levels of dissolved oxygen were negatively impacted by temperature. Higher temperatures make oxygen less soluble in water, which may affect aerobic organisms. This is compatible with a common biological occurrence. Using analysis of variance (ANOVA), the two lakes' total dissolved solids (TDS) were found to differ considerably. This implies that the water quality requirements and potential sources of pollution have varying effects on each lake. The conductivity, temperature, and dissolved oxygen levels between Dhanmondi and Ramna Lakes, however, did not differ much. Regression analysis results indicated that while temperature, salinity, and dissolved oxygen are important environmental factors, other factors may have a greater impact on zooplankton abundance.

4.1 Water quality

Significant relationships between zooplankton abundance and key environmental parameters were discovered. Temperature, salinity, and dissolved oxygen levels have been identified as significant factors influencing zooplankton population dynamics and distribution. Specifically, both lakes' levels of dissolved oxygen were negatively impacted by temperature. Higher temperatures make oxygen less soluble in water, which may affect aerobic organisms. This is compatible with a common biological occurrence. Using analysis of variance (ANOVA), the two lakes' total dissolved solids (TDS) were found to differ considerably. This implies that the water quality requirements and potential sources of pollution have varying effects on each lake. The conductivity, temperature, and dissolved oxygen levels between Dhanmondi and Ramna Lakes, however, did not differ much. Regression analysis results indicated that while temperature, salinity, and dissolved oxygen are important environmental factors, other factors may have a greater impact on zooplankton abundance.

Significant correlations between environmental factors in Dhanmondi Lake and Ramna Lake are revealed by the results of multivariate regression analysis, which offers important insights into the underlying ecological processes forming these aquatic ecosystems. The delicate interplay between chemical and physical variables controlling water quality is highlighted in Dhanmondi Lake by the substantial correlations found between salinity and dissolved oxygen (Jan - E - Alam et al., 2017). Salinity can have an impact on how soluble oxygen is in water; higher salinities may result in lower amounts of dissolved oxygen. This link emphasizes how crucial it is to comprehend how changes in salt levels can affect aquatic creatures' access to oxygen, which in turn shapes the ecological dynamics of the lake.

Moreover, Elci (2008) highlights the possible impacts of thermal stratification and biological oxygen demand on aquatic ecosystems due to the negative correlations between temperature and dissolved oxygen found in Dhanmondi Lake. The solubility of oxygen diminishes with increasing water temperature, which may cause oxygen depletion in the lake's deeper levels (Blumberg & Di Toro, 1990). The distribution and abundance of aquatic species can be affected by thermal stratification, which can worsen this process by forming different thermal layers that limit oxygen exchange between surface and deeper waters (Zhang et al., 2015).

Similar to this, the strong negative relationship found in Ramna Lake between temperature and dissolved oxygen emphasizes how important temperature is in regulating the solubility of oxygen and the metabolic rates of aquatic organisms (Brune et al., 2000). The ability of water to hold dissolved oxygen diminishes with increasing temperature, which may have an impact on aquatic species' ability to survive and behave (Kramer, 1987). It is crucial to comprehend this link in order to forecast the potential effects of seasonal or man-made temperature variations on Ramna Lake's ecological processes.

Furthermore, the Ramna Lake conductivity and temperature positive correlations point to possible temperature effects on water chemistry and ion concentrations, which may then have an impact on nutrient cycling (Curtinrich et al., 2022). Temperature variations can affect the rates of microbial activity and biochemical reactions, which can have an effect on the cycle processes and nutrient availability in the lake environment.

According to ANOVA results comparing environmental parameters, there is a significant difference in the concentrations of Total Dissolved Solids (TDS) between Dhanmondi and Ramna Lakes. This difference highlights the different water chemistry and possible sources of contamination in these two urban lakes (Islam et al., 2014). Variations in TDS concentrations indicate distinct environmental circumstances and water quality statuses between the lakes, despite similar temperatures, conductivities, and dissolved oxygen concentrations (Uddin et al., 2023). These variations highlight how crucial it is to modify management strategies to meet particular problems and preserve each lake's natural integrity (Richter et al., 2003).

4.2. Zooplankton community

4.2.1 Protozoa

Bdelloidea and Ciliophora were the least common in the zooplankton community structure of Ramna Lake. Amoebas are members of the rhizophoda family, which typically favors environments with stable conditions and a lot of organic matter. An urban lake that receives a range of inputs would have less of these features (Shiel, 1995). The steady decline in Bdelloidea abundance highlights the stability of the zooplankton community structure in Ramna Lake (Jaroměřská, 2019). Rotifer subfamily Bdelloidea is generally found in more stable environments with a consistent food source, such as unpolluted water bodies with consistent nutrient levels. Their low abundance in Ramna Lake might indicate that the lake's conditions are more variable or less suitable for sustaining their populations (Ricci & Melone, 2000).

Dynamic responses to environmental perturbations are suggested by the observed seasonal variations in zooplankton abundance, especially the changing trends in the least abundant class between the dry and wet seasons (Mackas et al., 2012). The composition and distribution patterns of protozoa communities can be influenced by seasonal variations in temperature, precipitation, and nutrient availability (Jeppesen et al., 2014).

4.2.2 Rotifers

In Dhanmondi Lake, Bdelloidea and Insecta were the least prevalent classes; however, Branchiopoda was the most prevalent. Around 52.94% of the zooplankton in Dhanmondi Lake are members of the Branchiopoda class. Similar findings were observed in earlier research findings (Yan et al., 2019). Rotifers, especially Branchiopoda, frequently predominate in these kinds of ecosystems because of their quick reproduction cycles and capacity to adapt to shifting environmental conditions (Serra et al., 2019). Their dominance showed their adaptability and durability which made them crucial markers of the ecological health of urban freshwater ecosystems (Thorp & Covich, 1991). Their ability to adapt allows them to quickly establish themselves and take over a wide range of aquatic ecosystems, particularly those affected by urban runoff and nutrient enrichment. Studies show that because rotifers can endure in environments with fluctuating water quality, they are reliable markers of an ecosystem's health (Pourriot, 1977).

Given that Bdelloidea and Insecta together make up only 2.94% of the total, their low abundance may be related to specific ecological factors including water quality, predation pressures, and food availability. The dominance of Monogononta in Dhanmondi Lake might be attributed to factors such as different nutrient inputs, possibly from urban runoff or other anthropogenic sources, leading to eutrophic conditions that favor the growth of these rotifers (Peng et al., 2023). The water chemistry of Dhanmondi Lake, perhaps characterized by higher levels of organic matter and microalgae, provides an ideal feeding environment for Monogononta (Khondker & Rahim, 1991). The prevalence of Monogononta in Dhanmondi Lake, which is explained by urban runoff adding nutrients to the water, is consistent with research by Allan (1976) showing that elevated nitrogen levels in urban lakes can produce favorable conditions for rotifers to live.

The seasonal decline or increase of rotifer abundance in both lakes is influenced by environmental changes, including temperature, dissolved oxygen levels, and nutrient availability. Rotifers like Monogononta can rapidly exploit favorable conditions in both wet and dry seasons, demonstrating their resilience to seasonal variations (Si, 1991).

4.2.3 Cladocera (Branchiopoda)

Branchiopoda was the most prevalent class in both Dhanmondi and Ramna Lakes. Their dominance highlighted their resilience and flexibility to changing environmental conditions, including changes in water temperature, availability of nutrients, and other ecological factors. Branchiopods are noted for their ability to adapt quickly to changes in habitat conditions, such as variations in temperature, dissolved oxygen levels, and nutrition availability (Tladi, 2020). Examples of these animals include fairy shrimp, clam shrimp, and water fleas. Branchiopoda's ability to use available resources efficiently and their resilience to environmental unpredictability are implied by their dominance, which is stable across seasons (Chakraborty & Mallick, 2020).

The predominance of Branchiopoda in Ramna Lake suggests that specific sediment and water quality conditions are conducive to their survival and reproduction (Meisch, 2000). Branchiopods are frequently found in regions with a lot of sedimentary deposits, which Ramna Lake can provide, because they can adapt effectively to a wide range of environmental circumstances (McCormack et al., 2019). Their robust exoskeletons allow them to live in environments that are subject to frequent change, such as areas that are rich in silt and organic materials.

The Branchiopoda class has consistently dominated Dhanmondi Lake during both the rainy and dry seasons. This indicates how adaptable and resilient this taxonomic group is in a variety of aquatic settings. This result is consistent with earlier studies conducted by (Si, 1991), which demonstrated how adaptable branchiopods are to different environmental circumstances. Branchiopoda was found to be the most prevalent class in Ramna Lake throughout both the wet and dry seasons, highlighting their ecological significance and longevity in these lakes (Si, 1991).

4.2.4 Copepods

The high concentration of the family Calanoidae in Dhanmondi Lake at the family level is indicative of their versatility and effective feeding methods (Jenkins & Buikema Jr, 1998), which enable them to dominate a variety of freshwater habitats. Calanoidae copepods are particularly well-suited to nutrient-rich environments due to their ability to consume a wide range of phytoplankton and detritus. Their efficient feeding mechanisms allow them to thrive in diverse and fluctuating conditions, making them resilient inhabitants of urban lakes. This adaptability and feeding flexibility contribute to their high abundance in Dhanmondi Lake, where nutrient inputs from urban runoff and other sources create an ideal habitat for their proliferation (Reid & Williamson, 2010).

Similarly, the prevalence of Cyclopidae in Ramna Lake, which accounts for about 15% of the overall zooplankton population, emphasizes how resilient and climate-adaptable these organisms are. Copepods belonging to the family Cyclopidae are adaptable predators and omnivores that may live in a variety of habitats by utilizing a variety of food sources (Dussart & Defaye, 2001).

Copepod populations in both lakes respond to seasonal shifts in temperature, dissolved oxygen, and nutrient availability, which influence their reproduction and feeding activity throughout wet and dry periods (Tladi, 2020).

4.2.5 Ostracoda

Ostracode was the most common class in Ramna Lake. In Ramna Lake, the high prevalence of Ostracodes, which are small crustaceans encased in a bivalve-like shell, suggests that the habitat conditions, such as sediment composition and availability of microhabitats, are conducive to their proliferation (Mesquita-Joanes et al., 2012). These conditions might include factors like the presence of specific types of vegetation that provide shelter and food sources, as well as a water chemistry profile that favors their reproductive and survival rates. Additionally, the nutrient levels, pH, and dissolved oxygen content in Ramna Lake could be more suitable for Ostracodes, allowing them to thrive and outcompete other zooplankton species (Pasha et al., 2023).

Tatur (2005) pointed out that the abundance of ostracods in Ramna Lake, which are connected to particular sedimentary environments, implies that sediment stability and quality are important factors in forming zooplankton populations. This discovery emphasizes how important habitat features are in dictating species abundance and dispersion in watery environments.

Ostracodes exhibit stable populations in Ramna Lake across seasons, demonstrating their adaptability to temperature and nutrient fluctuations (Si, 1991).

4.2.6 Other groups

Other zooplankton families make up around 3–5% of the overall population in both lakes, and their reasonably even distribution points to a complex community structure with a variety of ecological niches. According to Sommer et al. (1986), this balanced distribution denotes a stable ecosystem in which several zooplankton groups can coexist and support the biological activities of the lake. Such diversity provides resilience against environmental disturbances and is essential to preserving the lake's biological integrity (Carpenter et al., 1995).

Minor groups also show seasonal fluctuations influenced by temperature, dissolved oxygen, and nutrient availability, but their relative proportions remain stable, indicating ecosystem resilience (Chakraborty & Mallick, 2020).

Chapter-5

Concluding Remarks

5. Concluding Remarks

The findings of this study, especially the regression analyses that examined the connection between environmental factors and zooplankton abundance in Dhanmondi and Ramna Lakes, provide significant knowledge on the biological dynamics of urban aquatic ecosystems. Total dissolved solids (TDS), pH, and dissolved oxygen (DO) were all found to be significant predictors of zooplankton abundance in Dhanmondi Lake. However, the model's poor capacity to explain occurrences suggests that zooplankton populations may be impacted by additional, as-yet-unidentified causes. Additionally, it was found that environmental factors in Ramna Lake were related to zooplankton abundance, although with limited relevance, highlighting the complex nature of ecological interactions in urban aquatic environments. These results show how intricate and complex the ecological processes in urban lakes are. A comprehensive understanding of the various processes controlling zooplankton populations is necessary due to the observed complexity. Notwithstanding some of its limitations, such as its narrow focus on specific environmental features, this study emphasizes the need for more thorough and wide-ranging investigation. In order to gain a deeper understanding of the factors that influence zooplankton dynamics, future studies should consider a wider variety of biotic and abiotic elements including pollution, temperature fluctuations, and nutrition levels. It is impossible to fully comprehend urban lakes by focusing on a limited number of environmental factors due to the low explanatory power of regression models, which show that many interacting variables influence them. Thus, extensive methodologies are required to fully comprehend the breadth of influences on zooplankton populations. The goal of these activities should be to make urban lakes more resilient and sustainable so that they can continue to provide essential ecosystem services including habitat provision, water purification, and recreational opportunities. The findings from the research about the significance of monitoring and controlling a broader range of environmental issues can help environmental managers and policymakers. Thus, while the study has provided insight into the factors influencing the amount of zooplankton in urban lakes, it also emphasizes the need for further comprehensive and in-depth investigation. By using a more thorough and integrated approach, researchers and decision-makers may create and implement plans that address current problems while also anticipating and reducing future risks to urban aquatic habitats. This will ensure the long-term health, biodiversity, and functionality of urban lakes, benefitting both the environment and urban dwellers.

Figure 12 *Dhanmondi (right) and Ramna Lake (left) in the Dhaka city*

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Appendices

Appendix 1 Total No of taxa and relative percentage abundance of zooplankton under recorded classes.

Classes	No. of Taxa	Percentages (%)
Branchiopoda	18	52%
Monogononta	05	14%
Cilliophora	04	11%
Rhizopoda	02	6%
Bdelloidea	01	2%
Ostracoda	03	6%
Insecta	01	3%

Appendix 2 Total No. of taxa and relative percentages of Zooplankton under recorded Families

Families	No. of Taxa	Percentages (%)
Asplanchnidae	01	3
Anuraeidae	01	3
Ameobidae	01	3
Brachionidae	02	6
Bdelloidae	01	3
Bosminidae	01	3
Cyclopidae	05	15
Canthocamplidae	02	6
Calanoidae	01	3
Chydoridae	02	6
Cyprididae	03	9
Chironomidae	01	3
Diaptomidae	03	9
Daphniidae	02	6
Sididae	01	3
Moinidae	01	3
Heliozoadae	01	3
Parameciidae	01	3
Simocephalidae	01	3
Peritrichidae	01	3
Vorticellidae	01	3
Testudinellidae	01	3
Total	34	100%

Appendix 3 Spot wise no. of taxa and relative percentage of zooplankton from dry season under recorded classes in Dhanmondi Lake

Spot		Classes							
		Branchiopoda	Monogononta	Bdelloidea	Ostracoda	Rhizopoda	Flagellata	Cilliophora	Insecta
1	No. of Taxa	6	4	1	2	2		1	
	%	37.5%	25%	6.25%	12.5%	12.5%		6.25%	
2	No. of Taxa	7	2		2	1		1	
	%	53.84%	15.38%		15.38%	7.7%		7.7%	
3	No. of Taxa	7	4		2	2	1	1	1
	%	38.90%	22.22%		11.12%	11.12%	5.56%	5.56%	.56%
4	No. of Taxa	6	3		1	2		1	
	%	46.15%	23.07%		7.7%	15.38%		7.7%	
5	No. of Taxa	4	3		3	2		3	1
	%	33.33%	25%		25%	16.66%		25%	8.33 %
6	No. of Taxa	5	5		3	2		3	1
	%	26.31%	26.31%		15.78%	10.52%		15.78%	5.26 %
7	No. of Taxa	5	2		3	2		1	1
	%	50%	14.28%		21.42%	14.28%		7.14%	7.14 %
8	No. of Taxa	4	3	1	2	1		3	
	%	26.66%	20%	6.67%	13.33%	6.67%		20%	

Appendix 4 Spot wise no. of taxa and relative percentage of zooplankton from wet season under recorded classes in Dhanmondi Lake

Spot		Classes							
		Branchiopoda	Monogononta	Bdelloidea	Ostracoda	Rhizopoda	Flagellata	Cilliophora	Insecta
1	No. of Taxa	3	2	1	2	2		1	
	%	23.07%	15.38%	7.70%	15.38%	15.38%		7.70%	
2	No. of Taxa	5	2		1	1	1	1	1
	%	41.67%	16.67%		8.34%	8.34%	8.34%	8.34%	8.34%
3	No. of Taxa	6	2		2	1	1	1	1
	%	42.86%	14.28%		14.28%	7.15%	7.15%	7.15%	7.15%
4	No. of Taxa	6	2			1		1	
	%	60%	20%			10%		10%	
5	No. of Taxa	4	3		1	1		1	
	%	40%	30%		10%	10%		10%	
6	No. of Taxa	3	3		1	1		2	1
	%	27.27%	27.27%		9.09%	9.09%		18.18%	9.09%
7	No. of Taxa	4	3		1	1	1	1	1
	%	33.33%	25%		8.33%	8.33%	8.33%	8.33%	8.33%
8	No. of Taxa	2	2	2	2	1	1		
	%	20%	20%	20%	20%	10%	10%		

Appendix 5 Observed Zooplankton Species in the Dhanmondi Lake in Dry season

SL No.	Group	Taxa	Family	Class
1	Copepod	*Cyclops sp.*	Cyclopidae	Branchiopoda
2		*Diaptomus sp.*	Diaptomidae	
3		*Nauplius sp.*	Cyclopidae	
4		*Meta Nauplius Larvae*	Cyclopidae	
5	Cladocera	*Bosmina sp.*	Bosminidae	
6		*Daphnia sp.*	Daphniidae	
7		*Moina sp.*	Moinidae	
8		*Calanus sp.*	Calanoidae	
9		*Ceriodaphnia sp.*	Daphniidae	
10		*Simocephalus sp.*	Simocephalidae	
11		*Ceriodaphnia sp.*	Daphniidae	
12		*Alona sp.*	Chydoridae	
13	Rotifera	*Keratella sp.*	Branchionidae	Monogononta
14		*Brachionus sp.*	Branchionidae	
15		*Testudinella sp.*	Testudinellidae	
16		*Asplanchna sp.*	Asplanchnidae	
17	Ostracoda	*Cypris sp.*	Cyprinidae	Ostracoda
18		*Cyprodopsis sp.*	Cyprinidae	
19		*Heterodopsis sp.*	Cyprinidae	
20	Ciliophora	*Vorticella sp.*	Vorticelladae	Ciliophora
21		*Paramecium sp.*	Paramecidae	
22		*Peritricha sp.*	Pertitrichidae	
23	Rhizopoda	*Amoeba sp.*	Ameobidae	Rhizopoda
24	Arthropoda	*Chironomus larva*	Chironomidae	Insecta

Appendix 6 Observed Zooplankton Species in the Dhanmondi Lake in wet season

Sl no.	Group	Taxa	Family	Class
1	Copepod	*Cyclops sp.*	Cyclopidae	Branchiopoda
2		*Diaptomus sp.*	Diaptomidae	
3		*Nauplius sp.*	Cyclopidae	
4	Cladocera	*Bosmina sp.*	Bosminidae	
5		*Sida sp.*	Sididae	
6		*Calanus sp.*	Calanoidae	
7		*Moina sp.*	Moynidae	
8		*Alona sp.*	Chydoridae	
9		*Simocephalus sp.*	Simocephalidae	
10		*Water Flea*	Simocephalidae	
11		*Diaphanossoma sp.*	Sididea	
12		*Cypridopsis sp.*	Crprididae	
13	Rotifera	*Keratella sp.*	Branchionidae	Monogononta
14		*Asplanchna sp.*	Asplanchnidae	
15		*Brachionus sp.*	Brachionidae	
16	Ostracoda	*Cypris sp.*	Cyprididae	Ostracoda
17		*Heterocypris sp.*	Cyprididae	
18	Rhizopoda	*Amoeba sp.*	Amoebidae	Rhizopoda
19	Ciliophora	*Vorticella sp.*	Vorticelladea	Ciliophora
20		*Paramecium sp.*	Paramecidae	
21	Arthropoda	*Chironomus sp.*	Chironomidae	Insecta

Appendix 7 No of taxa and relative percentage of zooplankton under recorded classes in Ramna Lake

Classes	No. of Taxa	Percentage (%)
Branchiopoda	11	55%
Monogononta	03	15%
Bdelloidea	01	5 %
Ostracoda	02	10%
Cilliophora	02	10%
Insecta	01	5%
	20	100

Appendix 8 No. of taxa and relative percentages of Zooplankton under recorded Families in Ramna Lake

Families	**No. of Taxa**	**Percentages (%)**
Cyclopidae	**03**	15
Brachionidae	02	10
Bdelloidae	01	5
Bosminidae	01	5
Calanoidae	01	5
Cyprididae	02	10
Chironomidae	01	5
Diaptomidae	02	10
Daphniidae	02	10
Simocephalidae	01	5
Peritrichidae	01	5
Vorticellidae	01	5
Asplanchnidae	01	5
Moinidae	01	5
Total	20	100%

Appendix 9 Spot wise no. of taxa and relative percentage of zooplankton in winter season under recorded classes in Ramna Lake

Spot		Classes						
		Branchiopoda	Monogononta	Bdelloidea	Ostracoda	Rhizopoda	Cilliophora	Insecta
1	No. of Taxa	5	4	1	1	1	1	
	%	38.46%	30.77%	7.69%	7.69%	7.69%	7.69%	
2	No. of Taxa	4	3		2	1	1	
	%	36.36%	27.28%		18.18%	9.09%	9.09%	
3	No. of Taxa	4	2		1	1	1	1
	%	40%	20%		10%	10%	10%	10%
4	No. of Taxa	7	3		1	2	1	1
	%	46.67%	20%		6.67%	13.34%	6.67%	6.67%
5	No. of Taxa	4	3		1	2	2	
	%	33.34%	25%		8.34%	16.67%	16.67%	
6	No. of Taxa	5	5		3	2	3	1
	%	26.32%	26.32%		15.78%	10.52%	15.78%	5.26%
7	No. of Taxa	5	2		3	2	1	1
	%	35.71%	14.28%		21.43%	14.28%	7.14%	7.14%
8	No. of Taxa	4	3	1	2	1	3	1
	%	26.67%	20%	6.67%	13.33%	6.67%	20%	6.67%

Appendix 10 Spot wise no. of taxa and relative percentage of zooplankton from dry season under recorded classes in Ramna Lake

Spot		Classes						
		Branchiopoda	Monogononta	Bdelloidea	Ostracoda	Rhizopoda	Cilliophora	Insecta
1	No. of Taxa	4	2	1	1	1	1	
	%	40%	20%	10%	10%	10%	10%	
2	No. of Taxa	4	3		2	1	1	
	%	36.36%	27.28%		18.18%	9.09%	9.09%	
3	No. of Taxa	6	2		2	1	1	
	%	50%	16.17%		16.17%	8.33%	8.33%	
4	No. of Taxa	4	3		2	2	1	1
	%	30.77%	23.07%		15.38%	15.38%	7.69%	7.69%
5	No. of Taxa	5	3		1	2	2	1
	%	35.71%	21.42%		7.14%	14.28%	14.28%	7.14%
6	No. of Taxa	4	3		1	1	1	
	%	40%	30%		10%	10%	10%	
7	No. of Taxa	5	3		1	1	1	1
	%	33.33%	25%		8.33%	8.33%	8.33%	8.33%
8	No. of Taxa	4	2	1	2	1	1	
	%	36.36%	18.18%	9.09%	18.18%	9.09%	9.09%	

Appendix 11 Observed Zooplankton Species in the Ramna Lake in Dry season

Sl no.	Group	Taxa	Family	Class
1	Copepod	*Cyclops sp.*	Cyclopidae	Branchiopoda
2		*Diaptomus sp.*	Diaptomidae	
3		*Meta Naupleas sp.*	Cyclopidae	
4		*Nauplius sp.*	Cyclopidae	
5	Cladocera	*Bosmina sp.*	Bosminidae	
6		*Calanus sp.*	Calanoidae	
7		*Moina sp.*	Moynidae	
8		*Ceriodaphnia sp.*	Chydoridae	
9		*Simocephalus sp.*	Simocephalidae	
10	Rotifera	*Keratella sp.*	Branchionidae	Monogononta
11		*Asplanchna sp.*	Asplanchnidae	
12		*Brachionus sp.*	Brachionidae	
13	Ostracoda	*Cypris sp.*	Cyprididae	Ostracoda
14	Rhizopoda	*Amoeba sp.*	Ameboidae	Rhizopoda
15	Ciliophora	*Vorticella sp.*	Corticellidae	Ciliophora
16	Arthropoda	*Chironomus sp.*	Chironomidae	Insecta

Appendix 12 Observed Zooplankton Species in the Ramna Lake in wet season

Sl no.	Group	Taxa	Family	Class
1	Copepod	*Cyclops sp.*	Cyclopidae	Branchiopoda
2		*Diaptomus sp.*	Diaptomidae	
3		*Meta Naupleas sp.*	Cyclopidae	
4		*Nauplius sp.*	Cyclopidae	
5	Cladocera	*Bosmina sp.*	Bosminidae	
6		*Calanus sp.*	Calanoidae	
7		*Moina sp.*	Moynidae	
8		*Simocephalus sp.*	Simocephalidae	
9		*Daphnia sp.*	Daphniidae	
10	Rotifera	*Keratella sp.*	Branchionidae	Monogononta
11		*Asplanchna sp.*	Asplanchnidae	
12		*Brachionus sp.*	Brachionidae	
13	Ostracoda	*Cypris sp.*	Cyprididae	Ostracoda
14	Arthropoda	*Chironomus larva*	Chironomidae	Insecta
15	Ciliophora	*Vorticella sp.*	Corticellidae	Ciliophora