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A COMPARATIVE STUDY OF PHYTOPLANKTON COMMUNITIES AND EUTROPHICATION STATUS IN TWO URBAN PONDS WITHIN DHAKA METROPOLIS

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Abstract

Changes in physicochemical water quality and plankton biomass over time can clearly indicate the eutrophication status of a water body. Urban ponds are particularly susceptible to cultural and natural eutrophication, making it essential to study their water quality and phytoplankton biomass. This study examined two urban ponds within the University of Dhaka campus: Shahidullah Hall Pond (SH-pond) and Museum Pond (Mu-pond). Common phytoplankton in both ponds included species like *Pediastrum simplex, Melosira granulata* var. *angustata*, *Synedra nana, Ceratium* sp., and *Ceratium furcoides*, along with zooplankton such as *Brachionus* sp., *Keratella cochlearis*, and copepod nauplii. The higher diversity of zooplankton compared to phytoplankton suggests that zooplankton overgrazing has reduced phytoplankton species composition. The study's results indicate a clear trend of eutrophication in both ponds. Over three decades, SH-pond showed increases in water temperature (4.5°C), alkalinity (0.32 meq/L), dissolved oxygen (6.84 mg/L), soluble reactive phosphorus (21.35 µg/L), nitrate (137.77 µg/L), and chlorophyll-a (23.76 µg/L), with water transparency decreasing by 67 cm. Eutrophication indicators like dissolved oxygen, nitrogen, phosphorus, and phytoplankton biomass (chlorophyll-a) increased by 1.9, 1.82, 2.23, and 2.21 times, respectively, suggesting significant eutrophication in Sh-pond. In contrast, over 26 years, Mu-pond data showed decreases in water temperature (2.66°C), pH (0.18), conductivity (31 µS/cm), silica (12.17 mg/L), and chlorophyll-a (12.4 µg/L), but increases in dissolved oxygen (7.61 mg/L), soluble reactive phosphorus (1.16 µg/L), and nitrate nitrogen (170.75 µg/L). This suggests a slower rate of eutrophication in Mu-pond. Human intervention is a critical factor influencing eutrophication in urban ponds, highlighting the need for effective management systems.

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Introduction

Drifting microscopic or semi-microscopic organisms from the plant and animal communities in water bodies form plankton[1]. These tiny organisms (typically ranging from less than 5 μm to over 1 mm) inhabit the pelagic zone, playing crucial roles in carbon synthesis, oxygen production, and the transfer of energy to higher trophic levels. Their functions are essential for the biological productivity and nutrient cycles of aquatic ecosystems[2,1,3]. Among plankton, drifting microalgae,i.e., the photoautotrophic components of almost all surface waters are called phytoplankton, while the heterotrophic part from the animal community are called zooplankton[4].

Ponds are relatively shallower closed water bodies, may be artificial or natural having large littoral but mostly without thermal stratification[5]. Pond ecosystems, whether naturally formed or artificially constructed, act as crucial intermediaries in nutrient and hydrological cycles and support rich biodiversity. In addition to the aesthetic and practical benefits of rural ponds, urban ponds play an important socioeconomic role, serving as emergency water sources for firefighting and domestic use. They also support biodiversity similar to that of larger water bodies. Over its 400-year history, the Dhaka metropolis has been enriched with numerous well-known ponds and wetlands in both its downtown and suburban[6,7,8,9,10,11,12,13]. But with due course, many of those got extinct creating severe loss to the biodiversity components and also creating a threat towards emergency water supply.

Urban ponds, if not properly protected and managed, are highly susceptible to eutrophication, which leads to a decline in water quality and biodiversity. Eutrophication of surface waters is a process that occurs over time[14,5]. so managing them properly, the water quality and biodiversity of the targeted ecosystems should be studied routinely. Based on this concept, previously studied two important ponds[15,11]of the University of Dhaka campus have been brought under routine check through the present investigation. Therefore, this research was conducted to investigate the limnological factors responsible for changes in the physicochemical conditions of the water, as well as the quality and quantity of the planktonic communities in Shahidullah Hall Pond and Museum Pond in Dhaka Metropolis over time.

Materials and Methods

The present study was carried out on Shahidullah Hall Pond (SH-pond) and Museum Pond (Mu-pond) which are located within the University of Dhaka Campus (GPS: 23.731543 lat. and 90.39485 long.). The ponds were limnologically investigated nearly two decades ago[15,11]. A detailed account on the morphometry, plankton, and physicochemical limnology of the two ponds could be had elsewhere[10,15,16,17,11,18,19,20].

A single grab sampling technique was adopted for each pond. On 2 Feb 2023 both the study sites were sampled at two stations in each from 12:00 noon to 01:00 PM. The sampled stations were for Shahidullah Hall pond east (SH-east) and west (SH-west) and for Museum Pond north part (Mu-north) and south part (Mu-south). The time difference of sampling for both the ponds was 1 h and their distance is nearly 1 km. At first the sampling stations

Mus-north and Mus-south were covered. After reaching the station the water and Secchi depths were measured using a graduated rope carrying a weight at the end and a standard Secchi disc, respectively. Thereafter, a field meter was used to measure the pH, TDS, and conductivity of water (Hanna Multi Instruments Code-HI9813-6, S/N-DO108196, Romania).

The air temperature was measured with the help of a mercury thermometer (Gallenkamp, UK). A Schindler-Patalas water sampler (plexiglass made transparent, 5 L cap.) was dipped up to half a meter depth and the water sample was collected. Water temperature was recorded from the thermometer housed in the sampler. Two Pyrex glass stoppered BOD bottles were filled with the sample water and immediately fixed by adding the Winkler's 1st and 2nd reagents and the bottles were carried to the laboratory for DO analysis. Another set of 2 L pond water was drained from the sampler and stored for carrying to the laboratory. Half of the collected sample from the selected stations was immediately preserved in Lugol's solution and formalin respectively for further microscopic analysis to study the phytoplankton composition of these water habitat. To complete all the manipulation at each pond 1 h duration was needed. After collection, all the samples were taken to the National Professor AKM Nurul Islam Laboratory, Department of Botany, University of Dhaka for further analysis. Laboratory procedures applied to determine all the physicochemical and biological parameters are those mentioned in Bhuiyan et al.[21]. Both the preserved samples collected from these two habitats were used for the identification of microalgae by using light microscopes at 40× and 100× magnification. Microscopic photography was done for identification and morphological study (Zeiss, Axio, Lab. A1, Zeiss Axiocam ERc 5s, Germany).

Results and Discussion

Figures 1-5 illustrate the presence of plankton taxa documented in the two ponds under study. In Shahidullah Hall Pond, the plankton community consisted of 5 phytoplankton taxa and 7 zooplankton taxa. Those are: *Pediastrum simplex*, *Melosira granulata* var. *angustata*, *Synedra nana*, *Ceratium furcoides*, and *Ceratium* sp. and *Brachionus angularis*, *B. plicatilis*, *Filinia opliensis*, *Keratella cochlearis*, *K.quadrata*, copepod nauplii and *Heliodiaptomus* sp. for phyto- and zooplankton, respectively.

On the other hand, Museum Pond was represented by 7 species of phytoplankton and 10 species of zooplankton. Those are: *Oscillatoria* sp., *Pediastrum simplex*, *P. simplex* var. *sturmii*, *Melosira granulata* var. *angustata*, *Synedra nana*, *Ceratium* sp. and *Ceratium furcoides*. The principal taxa of the zooplankton community were composed of by *Diflugia* sp., *Chromogaster* sp., *Polyartha* sp., *Brachionus pallas*, *B. forficula*, *Brachionus* sp., *Keratella cochlearis*, copepod nauplii, copepodite stage, and *Diaptomus* sp. The plankton composition in both ponds was typical, with a notable higher diversity of zooplankton compared to phytoplankton in each habitat. This imbalance suggests that phytoplankton were likely overgrazed by zooplankton, leading to a decrease in their species composition. Additionally, a shift in the phytoplankton community from coccoid green algae to dinoflagellates was observed in both ponds[11,17].

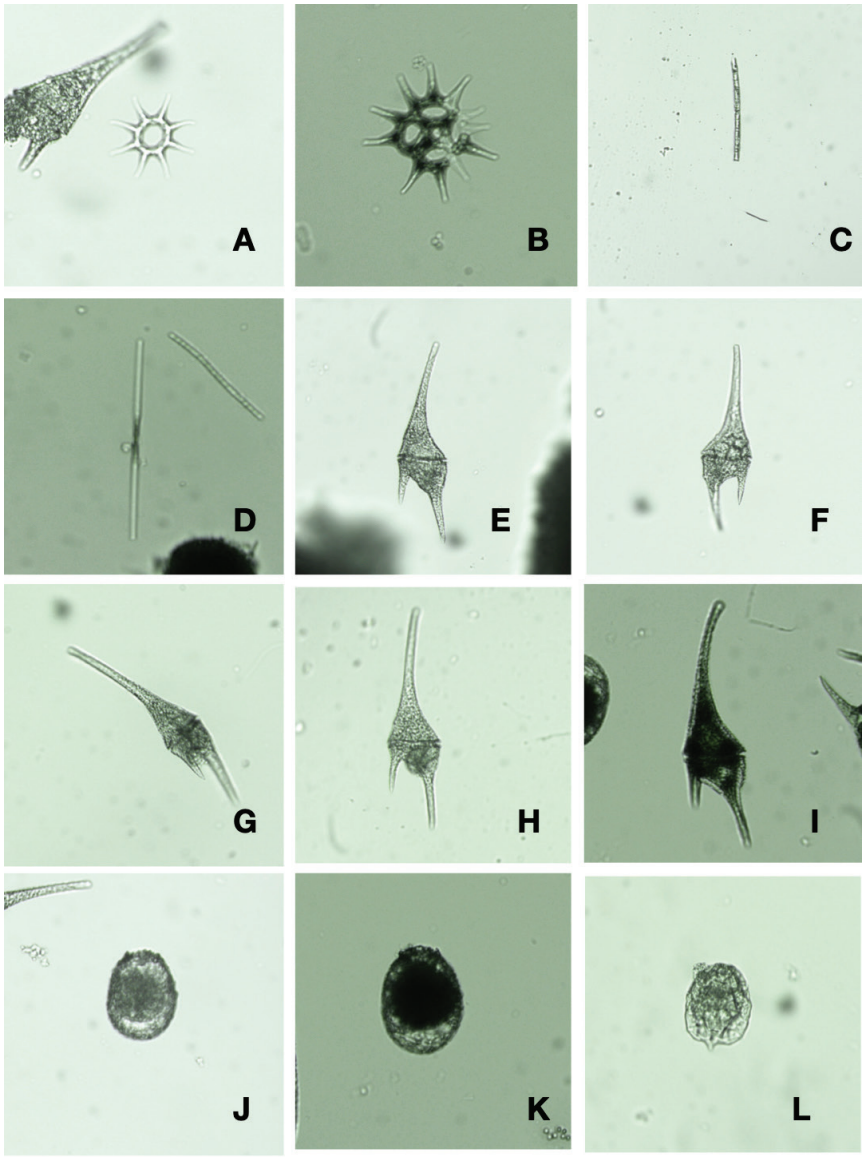

Fig. 1. A-L. Phyto- and zooplankton taxa recorded in the present investigation from Shahidullah Hall Pond. A-B, Pediastrum simplex; C, *Melosira granulata* var. *angustata*; D, *Synedra nana* (girdle view); E-H, *Ceratium furcoides*; I, *Ceratium* sp.; J-K, *Difflugia* sp.; *Brachionus* sp.

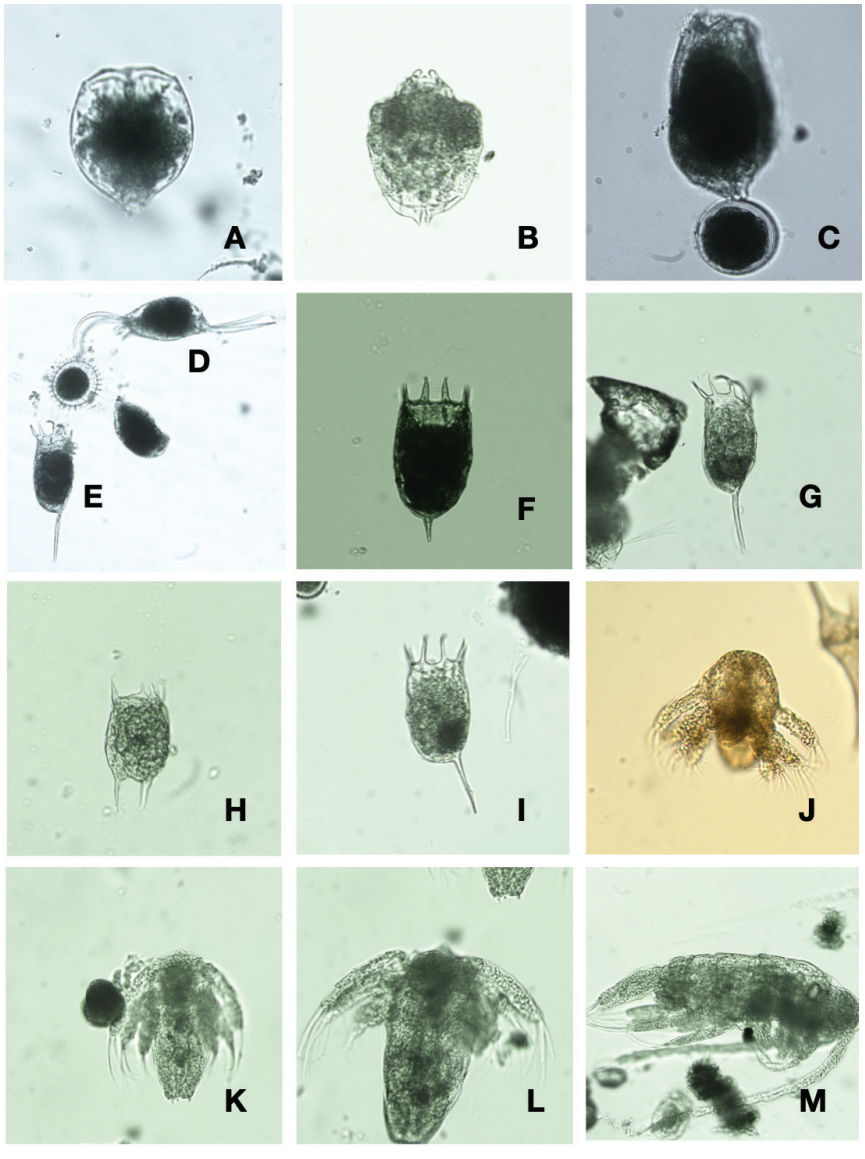

Fig. 2. A-M. Zooplankton taxa recorded in the present investigation from Shahidullah Hall Pond. A-B, *Brachionus angularis*; C, *B. plicatilis*; D, *Filinia opliensis*; E-G, & I, *Keratella cochlearis*; H, *K. quadrata*; J-L, copepod nauplii; M, *Heliodiaptomus* sp.

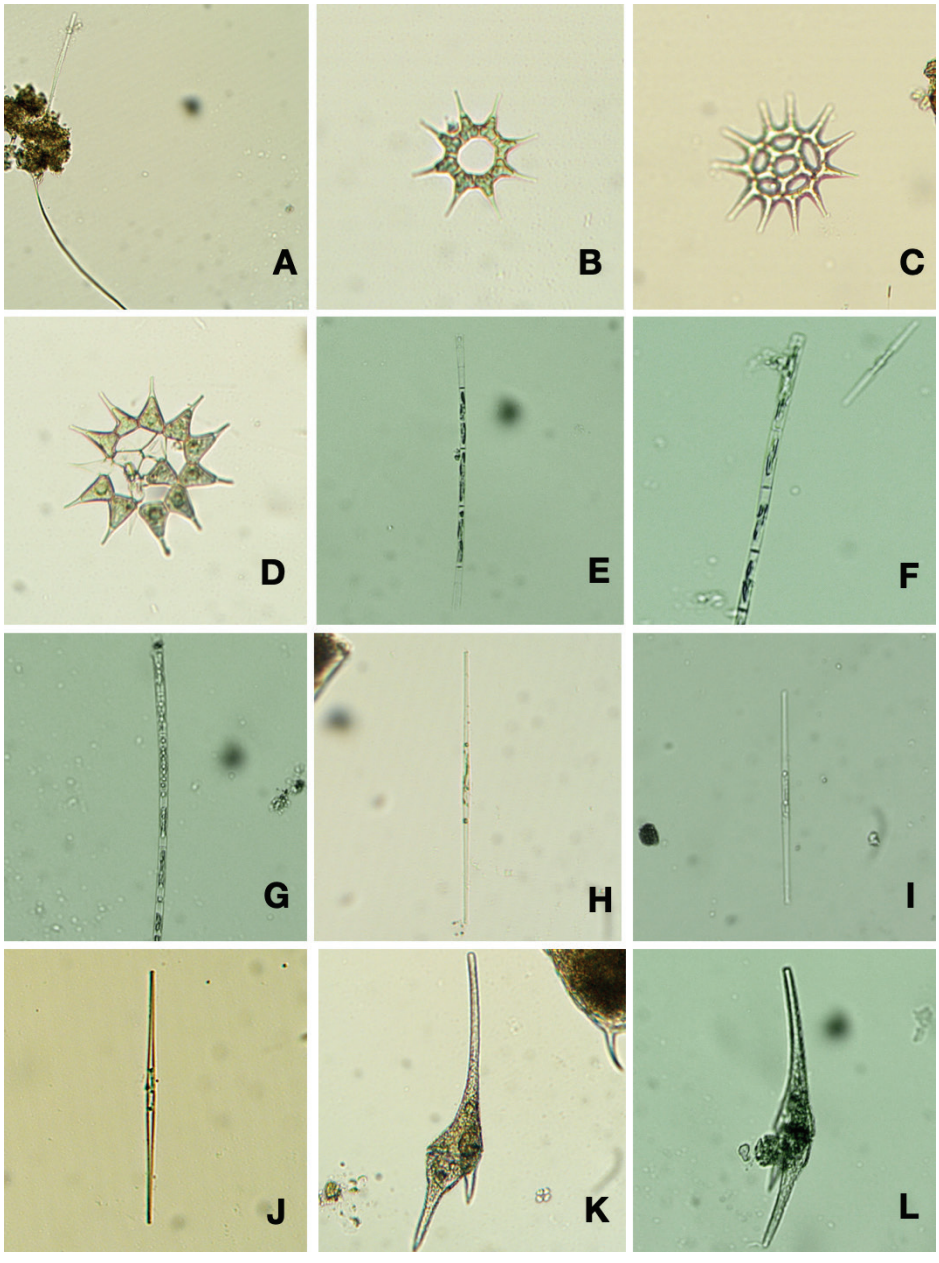

Fig. 3. A-L. Museum pond phytoplankton recorded from the present investigation. A, *Oscillatoria* sp.; B-C, *Pediastrum simplex*; D, *Pediastrum simplex* var. *sturmii*; E-G, *Melosira granulata* var. *angustata*; H-J, *Synedra nana* (valve view); K-L, *Ceratium* sp.;

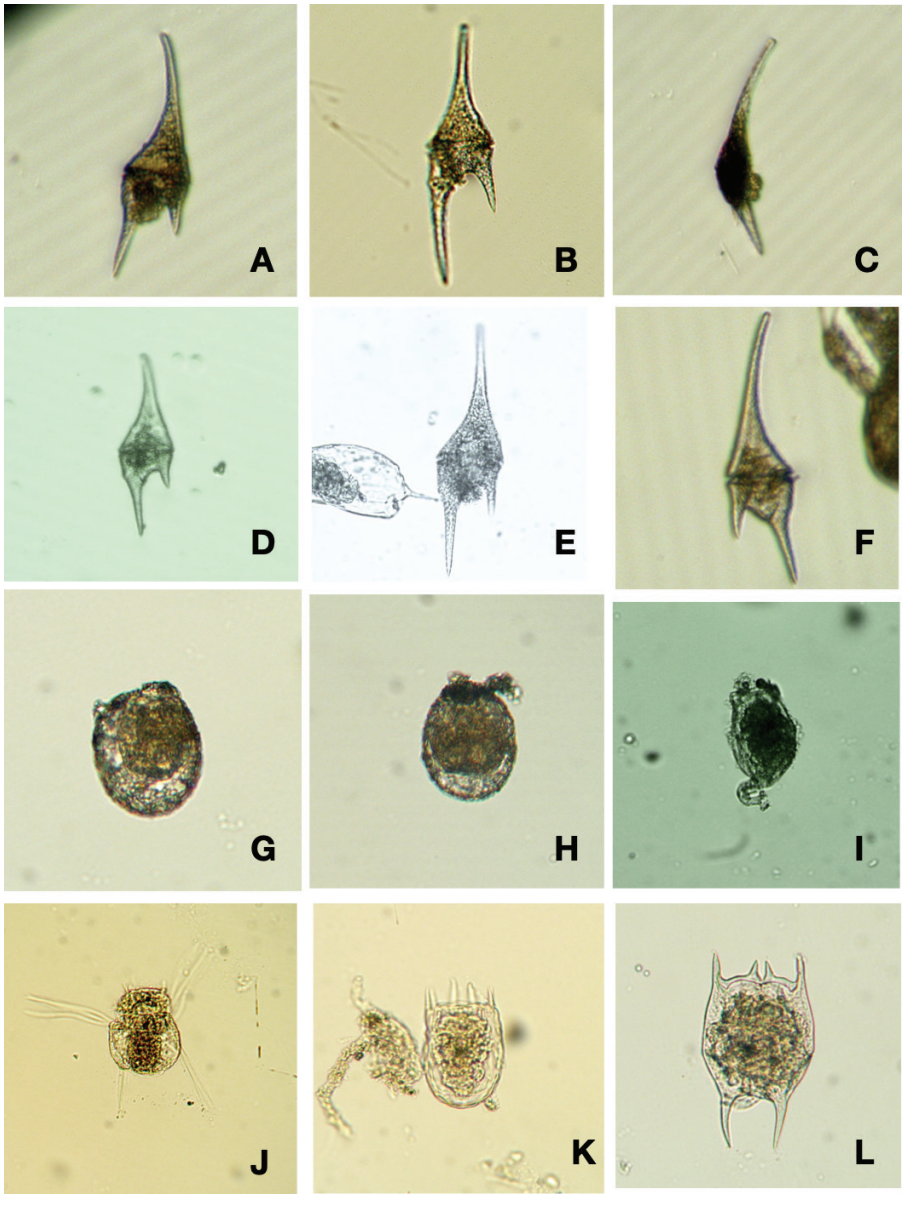

Fig. 4. A-L. Phyto- and zooplankton taxa recorded in the present investigation from Museum pond. A-F, *Ceratium furcoides*; G-H, *Diflugia* sp.; I, *Chromogaster* sp.; J, *Polyartha* sp.; K, *Brachionus pallas*; L, *B. forficula*.

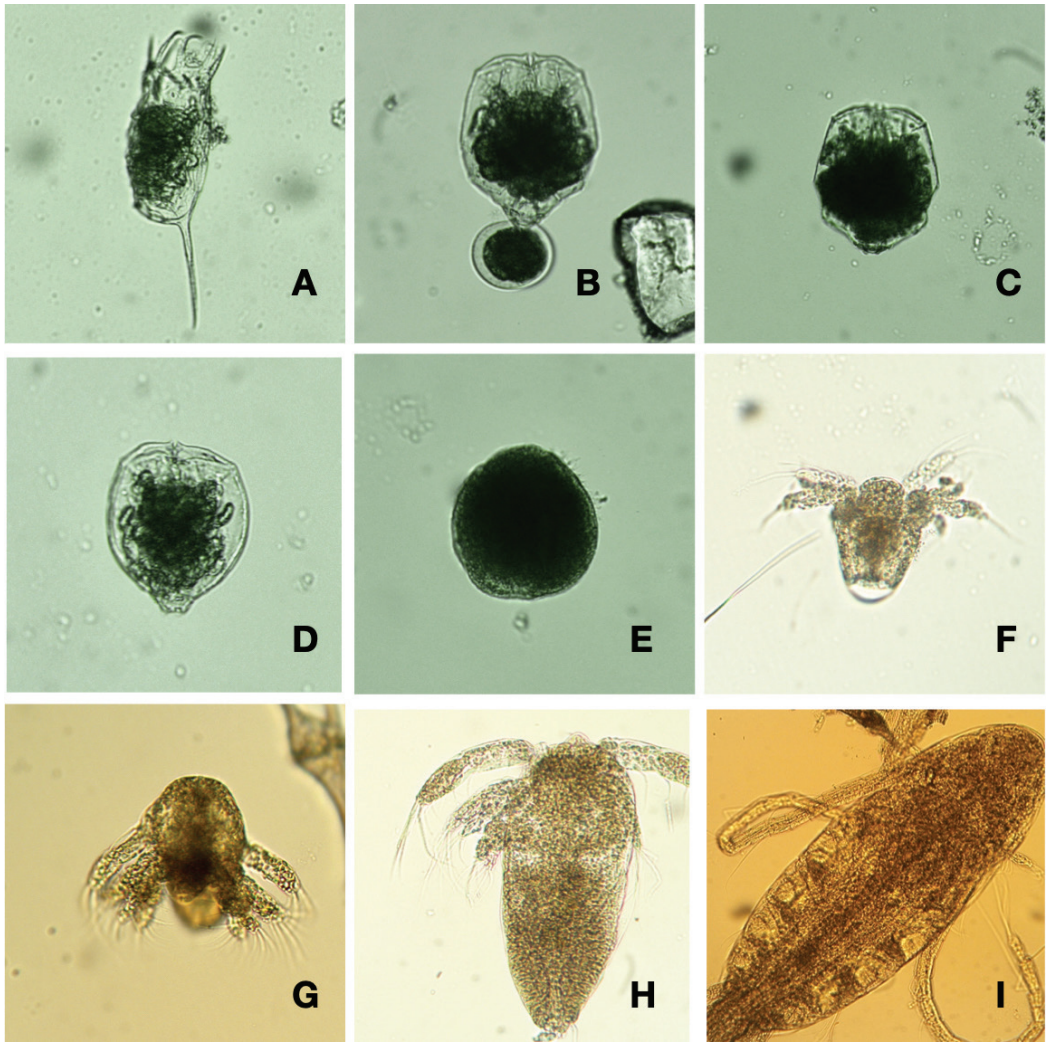

Fig. 5. A-I. Zooplankton taxa recorded in the present investigation from the Museum pond. A, *Keratella cochlearis*; C-D, *Brachionus* sp.; E, *Brachionus* sp. (top view); F-G, copepod nauplii; H, copepodite stage; I, *Diaptomus* sp.

Data on 14 water quality parameters from the east and west stations of Shahidullah Hall Pond and north and south stations of Museum Pond have been presented in Table 1. On a spatial scale, the studied stations of SH-pond did not show much variation. Air and water temperature, water depth, Secchi depth, TDS, electrical conductivity, and pH varied by 1 and 2°C, 1 cm, 2 cm, 10 mg/L, 0.02 μS/cm, and 0.1, respectively. Other parameters for the same pond varied 5.28 mg/L, 0.06 meq/L, 0.1 mg/L, 45 μg/L, 8.28 μg/L for DO, alkalinity, NO_3, SRP, and chl-a, respectively. No difference was found for CO_2 and SRS concentration in the studied stations of SH-pond (Table 1). While in the Mus-pond no variation was found

in the air temperature for the north and south stations. However, for water temperature and depth, Secchi depth, TDS, electrical conductivity and pH varied by 1˚C, 3 cm, 9 cm, 15 mg/L, 0.02 μS/cm, and 0.01 unit, respectively. In the same pond, DO, alkalinity, CO_2, NO_3, SRP, SRS, and chl-a varied by 5.85 mg/L, 0.05 meq/L, 0.96 mg/L,0.04 mg/L, 5 μg/L, 0.80 mg/L and 1.18 μg/L, respectively (Table 1).

Table 1. Spatial distribution of physicochemical parameters in the two studied ponds

Sites	Air t ºC	Wat t ºC	Z (cm)	Z (cm)	s TDS (mg/L)	Cond (μS/cm)	pH	DO (mg/L)	Alkal (meq/L)	CO_2 (mg/L)	NO_3 (mg/L)	SRP (μg/L)	SRS (mg/L)	Chl-a (μg/L)	PD (×10³ ind/L
SH-east	29	25	46	39	222	0.31	7.6	11.79	2.05	8.71	0.30	25	0.36	47.36	1620
SH-west	28	23	45	37	212	0.29	7.5	17.07	2.11	8.71	0.20	70	0.36	39.08	2310
M-north	27	20	35	20	330	0.46	6.9	11.79	2.71	10.64	0.29	30	2.80	16.58	600
M-south	27	21	32	29	345	0.48	6.8	17.64	2.76	9.68	0.25	35	2.00	17.76	213

Ten water quality parameters found common in the historic database (for February, 1991, 1997, and 2023) for both the Shahidullah Hall Pond and Museum Pond (February 1997 and 2023) have been presented in Table 2. In SH-pond, on a temporal scale i.e., over a time span of three decades water temperature, alkalinity, DO, SRP, NO_3, and chl-a have shown an increase by 4.5 °C, 0.32 meq/L, 6.84 mg/L, 21.35 μg/L, 137.77 μg/L, and 23.76 μg/L, respectively. The concomitant decrease in water transparency caused by all the above-mentioned parameters, and as it has been revealed by a decrease in Secchi depth by 67 cm. The three main eutrophication indicating parameters namely, DO, N, P, and phytoplankton biomass (chl-a) were increased by 1.9, 1.82, 2.23, and 2.21-fold, respectively (Table 2). This data suggests that a clear eutrophication phenomenon has occurred in the pond water.

For Mu-pond 10 water quality parameters in common with the Sh-pond and for two years only (1997 and 2023) were available (Table 2). The time span covered was 26 years. Over this period comparison of data of Mu-pond reveals that there had been a drop in the water temperature (2.66°C), pH (0.18), conductivity (31 μS/cm), Si (12.17 mg/L), and chl-a (12.4 μg/L) but an increase in DO (7.61 mg/L), SRP (1.16 μg/L), NO_3-N (170.75 μg/L).

In Bangladesh, studies related to the long-term changes in the water quality parameters in a single water body is almost nil. Afroze and Khondker[22] compared the water quality of a eutrophicated waterbody with that of a protected one and found that in the eutrophicated water body chl-a, SRP, Si, and NO_3-N were higher by19-, 39-, 4.6-, and 1.75-fold compared to the protected pond. But DO and Zs decreased by1.5- and 5.5-fold[22]. In another study carried out by Zerin et al[23] on a section of the river Buriganga, Dhaka Metropolis passed through heavily populated area found a reduction of Secchi depth, and the concentration of NO_3-N, DO, phytoplankton species number, and density by factors of 3.5, 36.33. 3.5, 1.67, and 675.89 respectively over a period of 40 years[23]. In the same study chl-a value increased 1.13 times over a period of 10 years span[23]. In the present study the Sh-pond showed also

an increase in the concentration of DO, N, P, and phytoplankton biomass. Similarly, in the Mu-pond of the present investigation DO, SRP, and NO_3-N were found higher in to some extent.

Table 2. A comparative analysis (data of February), showing the water quality changes occurred in the two ponds over a period of nearly three decades.

Parameters	Shahidullah Hall Pond (February)			Museum Pond (February)	
	1991	**1997**	**2023**	**1997**	**2023**
Water temperature (ºC)	24.0	23.12	28.5	23.16	20.5
Secchi depth (cm)	105	-	38	-	24.5
pH	7.5	7.06	7.5	7.03	6.85
Alkalinity (meq/L)	1.76	1.58	2.08	1.58	2.74
Conductivity (µS/cm)	360	547	300	501	470
DO (mg/L)	7.59	7.06	14.43	7.11	14.72
Si (mg/L)	10.71	6.69	0.36	14.57	2.4
SRP (µg/L)	26.15	19.02	47.50	31.34	32.5
NO_3-N (µg/L)	112.23	239.12	250.00	99.25	270
Chl-a (µg/L)	19.61	8.71	43.37	29.57	17.17

Conclusion

The comparative study of two ponds regarding eutrophication status indicates that SH-pond is more impacted by cultural eutrophication. This is attributed to its location between two residential halls of the University of Dhaka, where it is influenced by a significant number of non-resident students and staff. In contrast, Mu-pond benefits from stricter access control by the National Museum authority, limiting public entry without proper authorization. Many urban ponds in Dhaka Metropolis have disappeared over time, leaving only a few remaining. Sh-pond, nearly 200 years old, is approaching eutrophication due to these influences. Effective management strategies are therefore essential and should be implemented by the administrative authority to safeguard against cultural eutrophication.

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Disclosure of conflict of interest

There is no conflict of interest in this manuscript.

Statement of ethical approval

There is no animal/human subject involvement in this manuscript.

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