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Assessment of water quality and plankton composition of Nikli Haor, Kishoreganj, Bangladesh

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Abstract

Haor ecosystems of Bangladesh play significant roles in fisheries, aquatic biodiversity and on ecotourism along with other socio-economic activities of the area. So, knowledge on water quality and the structure of the grazing food chain to support fisheries production are highly important research issues. In this respect, Tanguar Haor of Sunamganj District and Hakaluki Haor of Moulvi Bazar District have already been studied. In the present research, the physicochemical and biological water quality parameters, including phytoplankton biomass and population density were studied in the Nikli Haor, Kishoreganj. Water and plankton samples from five stations (D1 - D5) were collected on June 27, 2022. The sampling was done on a 10 km stretch of haor water and 16 different variables were analyzed. Air temperatures ranged from 31.0 – 33.7°C, while water temperatures ranged from 30.40 – 31.40°C. Secchi depths ranged from 0.87 – 1.21 m and water depths of the studied stations ranged from 1.75 – 7.22 m. Of the chemical parameters pH and alkalinity varied from 7.9 – 8.3 and 0.65 – 0.92 meq/L, respectively. The concentration of dissolved oxygen (DO) and free-CO_2 in the haor water ranged from 7.35 - 11.55 and 0.49 – 1.05 mg/L, respectively. The electrical conductivity (EC) and total dissolved solids (TDS) varied from 30.00 – 50.00 µS/cm and 34.00 – 42.00 mg/L, respectively. Among dissolved nutrients, the range of soluble reactive phosphorus (SRP) concentration was recorded as 6.7 - 45.6 µg/L, whilst soluble reactive silicate (SRS) varied from 6.10 – 11.20 mg/L. Values of NO_3-N measured for the haor water ranged from 0.33 – 0.81 mg/L. Phytoplankton biomass as chl-*a* varied from 5.92 - 31.97 µg/L, its degraded product, phaeophytin concentration ranged from 1.60 - 3.31 µg/L. Among biological parameters, the phytoplankton density ranged from 10.40×10^6 – 17.50×10^6 ind./L across the 5 sampling sites. A total of 42 taxa of plankton were identified and presented with their images and systematic positions. Chlorophyta and Chrysophyta were the most dominant divisions of phytoplankton and yielded on total 10 and 11 taxa, respectively. Cyanophyta was represented by 6 taxa. Pyrrophyta was represented by 4 taxa. From zooplankton one rhizopod, two copepods and three rotifers populations were identified from the community. Considering the biological quality of plankton and the concentration of key nutrients the Nikli Haor water may be classified as meso- to eutrophic.

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Introduction

Among the wetlands of Bangladesh, *Haors* are most prominently classified aquatic ecosystems distributed in seven districts[1]. They are shallow scattered tectonic depressions present in the levees of rivers. Their hydrological regime is highly seasonal e.g., during rainy seasons, the basins store water coalesces together and take a huge shallow lake shape. But in the dry season individual basins are exposed due to drying of water from the shallower parts and thus, reducing the whole water area.

Haor ecosystems fulfill tremendous hydrological, socio-economic, and ecological roles in some districts of Bangladesh. They are rich in biodiversity components and contribute significantly towards fish production, and environmental balance maintenance[2,3]. For the pelagic grazing food chain, the role of phytoplankton is inevitable, and this group also contributes to balance the aquatic ecosystem via processes like photosynthesis, exudation, energy transformation, etc.[4,5]. So far, floristic composition of phytoplankton has been worked out for major haors of greater Sylhet districts[6-8]. But there is almost no information on the phytoplankton community on the Haors of Kishoreganj District. The present attempt has therefore been made to study the community composition and interactions of phytoplankton from Nikli Haor of Kishoreganj District.

Materials and Methods

Nikli Haor is situated in the Kishoregonj District of Dhaka Division, Bangladesh with GPS between 24°19′0.12″ N and 90°55′59.88″ E (Fig. 1). The haor has an area of 14.40 km^2 and 5 study stations were selected in the central area of it for collecting samples. The study stations are hereinafter named as D-1, D-2, D-3, D-4, and D-5 (Fig. 1). The approximate distance among the individual stations was 2 km. Each study station was reached using engine-driven boat. After the boat was anchored, water depth (Z) was measured with a graduated rope carrying a weight at its end. The Secchi depth (Zs) was measured by a Secchi Disc[9]. An integrated water sample over 0.5 m water depth from the pelagic of each selected station was collected with the help of a Schindler-Patalas (modified, 5 L cap.) depth sampler. With this water, one Pyrex clear glass bottle (1 L cap.) containing 1 ml of Lugol's iodine (fixative) was immediately filled up for the quantification of phytoplankton via sedimentation technique[10]. A field multimeter (Hanna Multi Instruments Code – HI9813-6, S/N-D0108196, Romania) was used to measure pH, electrical conductivity (cond.) and total dissolved solids (TDS) *in situ* using a suitable portion of sub-sample from this water. While collecting the water sample, the water temperature was read from the mercury thermometer housed in the sampler. Air temperature was recorded with another piece of identical centigrade thermometer. Clear glass stoppered Pyrex BOD bottles (125 ml cap.) in duplicate was filled with the collected water sample and was immediately fixed by adding 1 ml of each of manganous sulphate and Winkler's reagent to the sample. The bottles were stoppered, sealed and carried to the laboratory keeping those submerged under water in a plastic bucket for the analysis of dissolved oxygen (DO).

A second haul of 5 L sample from the same study station was done and drained into a black light proof canister (5 L cap.) filling up to the brim; screw-capped, sealed and was transported to the laboratory for the chemical analysis of some selected water quality parameters.

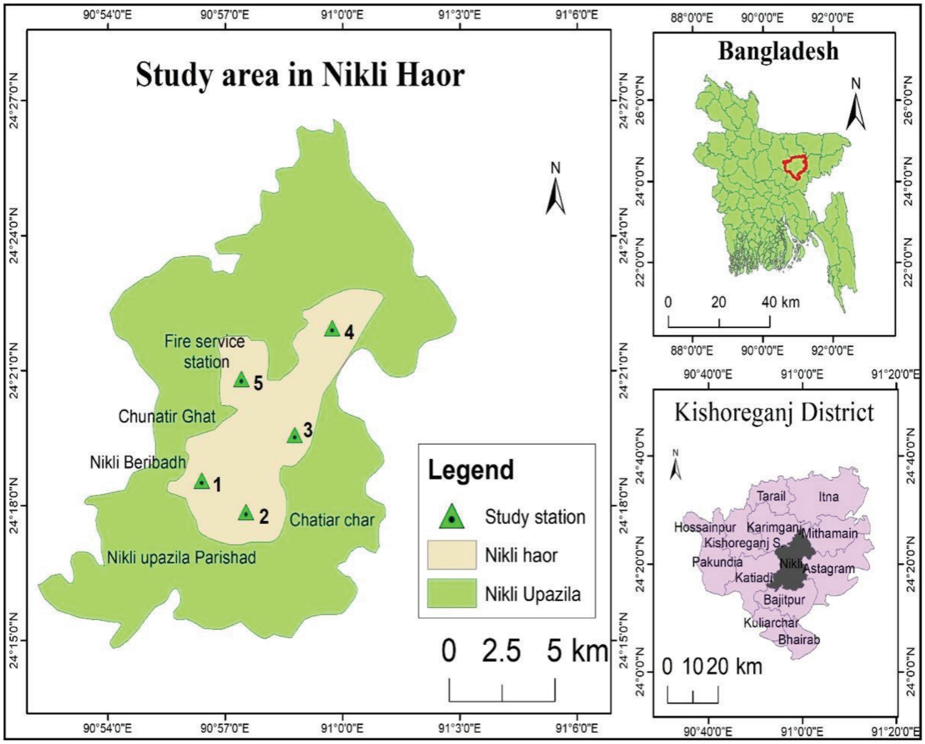

Fig. 1. Geographical location of Nikli Haor study stations with respect to the district of Kishoreganj, Bangladesh.

Net-plankton sample was collected by passing 100 L of pelagic water through a plankton net (37 μm) and the concentrate was preserved with 4% buffered formaldehyde in a sample vial. Both the sedimented and plankton- net-concentrates were used for the qualitative study of plankton. Procedures for collecting samples from all the studied stations were same. After collection, the samples were given ice packs wherever necessary and transported to the National Professor A. K. M. Nurul Islam Laboratory, Department of Botany, University of Dhaka for further analyses. Time period required to transport the samples to the laboratory was nearly 12 h after the last collection of samples in the Haor was completed. After reaching the laboratory, measurements of the water quality parameters were completed within the next 48 hours except the qualitative and quantitative aspects of plankton.

A Sartorius Filtration Device (Göttingen, Germany) fitted with Whatman GF/F (48 mm circles) filter paper was used to filter the sample. The residue collected on the filter paper was used to determine the concentration of chlorophyll-*a* (chl-*a*) and phaeopigment (phaeo.) while the filtrate was used for the analyses of different water quality parameters. Soluble reactive silicate (SRS), chl-*a* and phaeo., soluble reactive phosphorus (SRP), and nitrate nitrogen (NO_3-N) were determined by using standard methods(10-13), respectively. Microscopic observation for the qualitative analysis of phyto- and zooplankton were done with the help of a Zeiss Axio Lab. A1 Research Microscope (Germany) attached with a Zeiss Axiocam ERc 5s photographic attachment. Imaging of plankton species together with the data collection on cell length and breadth were recorded with the help of the same microscope. The taxa were identified using related scientific articles(14-21).

Results and Discussion

The physicochemical and biological parameters determined for Nikli Haor have been presented in Table 1. Mean air temperature recorded from the study stations showed a difference of 2.82°C, while the mean value was 32.0 and 30.82°C for air and water temperature, respectively. Highest water depth (7.22 m) was recorded from D-3 but D-5 showed lowest water depth (1.75 m). The mean water depth was 3.84 m for all the stations (Table 1).

Table 1. Physicochemical and biological water quality parameters of Nikli Haor

Stations Parameters	D – 1	D – 2	D –3	D –4	D – 5	Mean ± SD (n = 5)
Air temperature (°C)	31.1	33.7	32.2	31.0	32.0	32 ± 1.09
Water temperature (°C)	30.4	31.4	30.8	30.5	31.0	30.82 ± 0.41
Water depth (m)	3.51	4.12	7.22	2.62	1.75	3.84 ± 0.93
Secchi depth (m)	0.98	0.87	1.21	0.91	1.01	1 ± 0.18
TDS (mg/L)	41.0	34.0	37.0	40.0	42.0	38.8 ± 3.27
Electrical conductivity (μS/cm)	50.0	30.0	40.0	30.0	35.0	37 ± 8.37
pH	8.2	8.0	8.3	7.9	8.1	8.1 ± 0.16
DO (mg/L)	7.35	8.56	11.55	8.29	9.43	9.04 ± 1.59
Free carbon-dioxide (mg/L)	1.002	1.051	0.791	0.661	0.490	0.799 ± 0.23
Alkalinity (meq/L)	0.80	0.76	0.92	0.65	0.79	0.78 ± 0.10
SRP (μg/L)	20.6	11.4	27.1	45.6	6.7	38.8 ± 23.95
SRS (mg/L)	8.24	6.10	10.52	11.20	6.93	8.60 ± 2.36
NO_3-N (mg/L)	0.47	0.81	0.78	0.33	0.44	0.56 ± 0.21
Chl-*a* (μg/L)	9.43	31.97	26.05	8.29	5.92	16.33 ± 11.83
Phaeopigment (μg/L)	3.20	3.31	1.93	1.73	1.60	2.35 ± 0.83
Total PP (ind.×10^4 ind/L)	1040	1120	1750	1190	1270	12.74 ± 2.79

On an average the water transparency (as Secchi depth) of the Haor was 1 m. D-3 and D-5 showed the highest transparency. The loading of TDS varied from 34 - 42 mg/L with a mean of 38.8 ± 3.27 mg/L. The range of electrical conductivity was almost similar as that with the TDS (30 - 50 mg/L; mean 37.00 ± 8.37 mg/L). The difference between the highest and lowest recorded pH is small (0.4). The range of pH was 7.9 - 8.3 but the average yielded an alkaline value of 8.1 (Table 1). The DO concentration ranged from 7.35 - 11.35 mg/L, while the free carbon-dioxide ranged from 0.49 - 1.00 mg/L. The mean values of the former and later parameters were 9.04 and 0.79 mg/L, respectively. Among the dissolved nutrients, the SRP concentration of the Haor water ranged from 6.7 - 45.6 μg/L, with a mean value of 38.8 μg/L for all the studied five study stations. The concentration of SRS, and NO_3-N ranged from 6.10 - 11.20 and 0.33 - 0.81 mg/L, respectively (Table 3). Biological variables relevant to water quality however, ranged from 5.92 - 31.97, and 1.60 - 3.31μg/L, for chl-*a* and phaeopigment, respectively. The density of phytoplankton (PP) ranged from 1040 - 1750 × 10^4 ind./L having a mean of 12.7 × 10^4 ind./L.

The qualitative enumeration of phytoplankton species was done following standard method[22]. The division Cyanophyta was represented by 6 species while Chlorophyta, Euglenophyta, Chrysophyta, and Pyrrhophyta were represented by 10, 2, 11, and 4 species, respectively (Table 2, Figs. A, B, C, D & E). However, the zooplankton community was represented by 1 rhizopod, 1 ciliate, 3 rotifers, 2 copepods and copepod nauplii (Table 2, Fig. F). Total taxa of plankton recorded were 42 for Nikli Haor.

Table 2. List of the recorded plankton taxa from Nikli Haor

Serial	Species	Fig.	Serial	Species	Fig.
1	*Microcystis aeruginosa* **CYANOPHYTA**	D 3	22	*M. granulata* var. *angustissima*fa. *spiralis*	E 5
2	*Oscillatoria* sp.	D 7	23	*Fragilaria lapponica*	A35
3	*Anabaena* sp.	A 5	24	*Fragilaria intermedia*	C 7
4	*Pseudanabaena limnetica*	D 2	25	*Fragilaria virescens*	A44
5	*Pseudanabaena mucicola*	A 6	26	*Synedra ulna*	D 4
6	*Synechocystis aquatilis*	D 8	27	*Navicula helvetica*	A42
7	*Pandorina morum* **CHLOROPHYTA**	A10	28	*Gomphonema apicatum*	A40
8	*Gonium pectorale*	A22	29	*Rhopalodia gibba*	E 8
9	*Pleodorina* sp.	A12	30	*Cymbella tumidula*	A41
10	*Volvox carteri*	A14	31	*Peridinium* sp. **PYRRHOPHYTA**	B 1
11	*Crucigenia crucifera*	A15	32	*Peridinium beliense*	B 9
12	*Monoraphidium subclavatum*	A20	33	*Ceratium hirundinella*	B 3
13	*Centritractas belenophoras*	A31	34	*C. furcoideds*	B 5
14	*Pediastrum duplex*	A18	35	*Cucurbitella mespiliformis* **ZOOPLANKTON**	A28
15	*Mougeotia* sp.	A25	36	Ciliata	A 2
16	*Zygnema* sp.	A23	37	*Monostyla closteriocera* **ROTIFERA**	F 5
17	*Staurastrum* sp.	A27	38	*M. bulla*	F 7
18	*Trachelomonas hispida*	F10	39	*Keratella cochlearis*	F 9
19	*T. armata* var. *longispina*	A30	40	*Heliodiaptomus viduus* **CRUSTACEA**	F 6
20	*Melosira granulata* **CHRYSOPHYTA**	A33	41	*Cyclops* sp.	F12
21	*M. moniliformis*	A45	42	Copepod nauplii	F 2

The phytoplankton population was found to contain intact potential bright chromatophores indicating their active contribution to the grazing food chain of the Haor. The population of zooplankton was collected intermixed with the phytoplankton which indicates a functional grazing activity by the former.

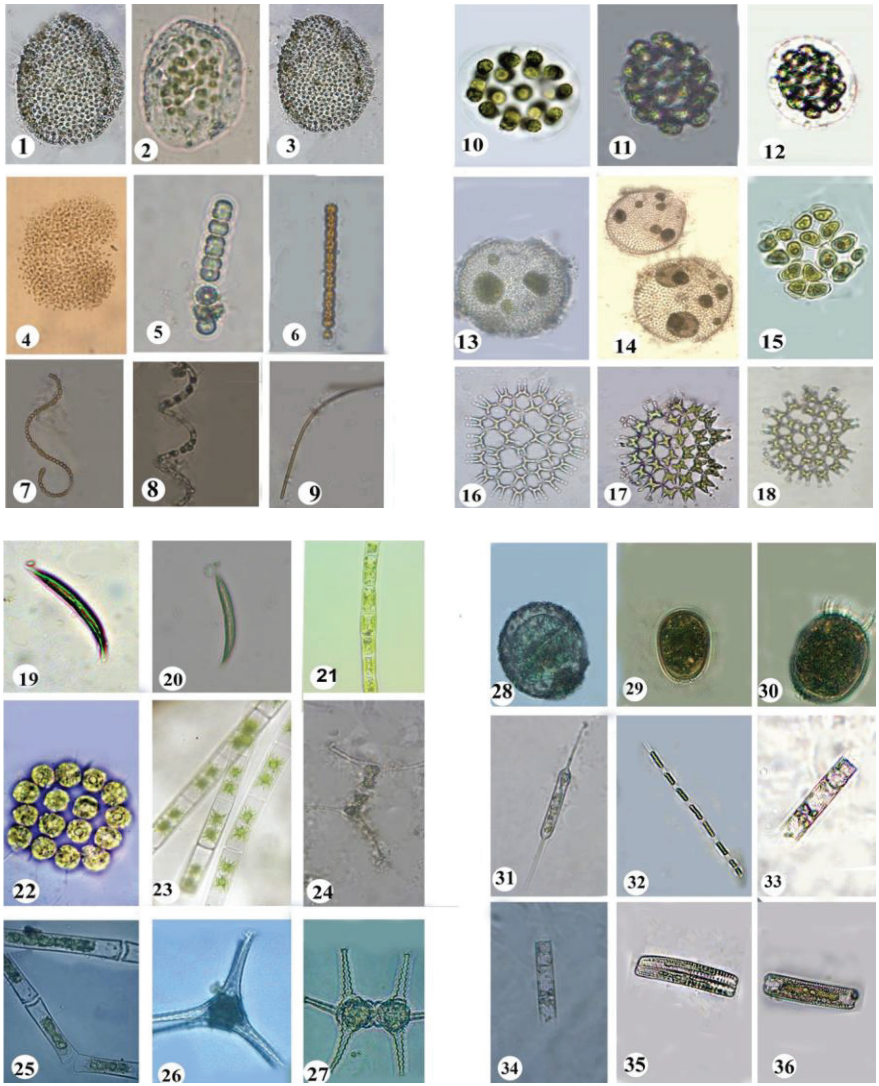

Fig. A. Photographs of phytoplankton.1-36: 1, 3, *Volvox carteri.*; 2. a ciliate; 4. *Microcystis aeruginosa*; 5. *Pseudanabaena mucicola.*; 6. *Anabaena* sp.; *Volvox carteri*; 7, 8. *Melosira granulata* var. *angustissima* fa. *spiralis.*; 9. *Oscillatoria* sp.; 10, 11, 12. *Pandorina morum*; 13, 14. *Volvox carteri*; 15. *Crucigenia crucifera*; 16, 17, 18. *Pediastrum duplex*; 19, 20. *Monoraphidium subclavatum*; 21, 25. *Mougeotia* sp.; 22. *Gonium pectorale*; 23. *Zygnema* sp.; 24, 26, 27. *Staurastrum* sp.; 28. *Cucurbitella mespiliformis*; 29. *Trachelomonas hispida*; 30. *T. armata* var. *longispina*; 31. *Centritractas belenophoras*; 32. *Pseudanabaena limnetica*; 33, 34. *Melosira granulata*; 35, 36. *Fragilaria lapponica*.

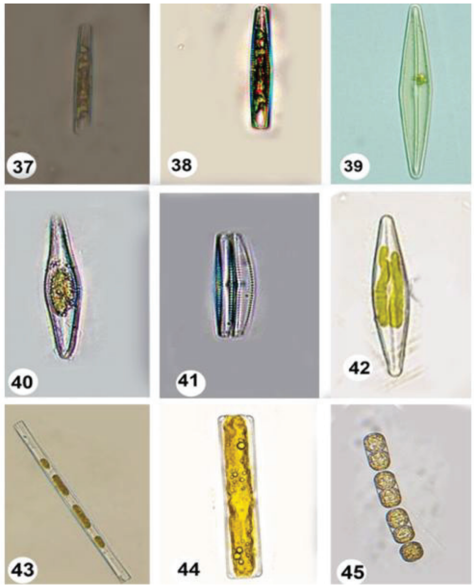

Fig. A. (Contd.) 37 – 45: 37. *Melosira granulata;* 38, 40. *Gomphonema apicatum;* 39, 42. *Navicula helvetica;* 41. *Cymbella tumidula;* 43. *Synedra ulna;* 44. *Fragilaria virescens;* 45. *Melosira moniliformis.*

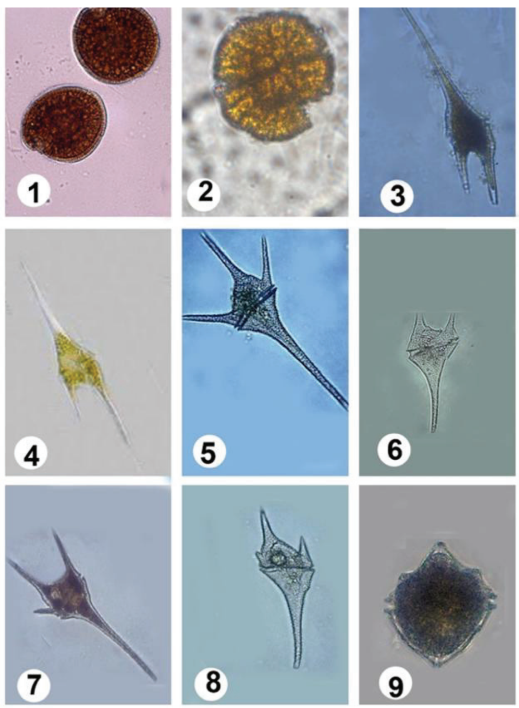

Fig. B. Photographs of phytoplankton from Nikli Haor. 1- 9. 1, 9. *Peridinium* sp.; 2. *Trachelomonas* sp. (broken lorica); 3, 6, 8. *Ceratium hirundinella*; 4, 5, 7. *Ceratium furcoides*; 9. *Peridinium baliense*.

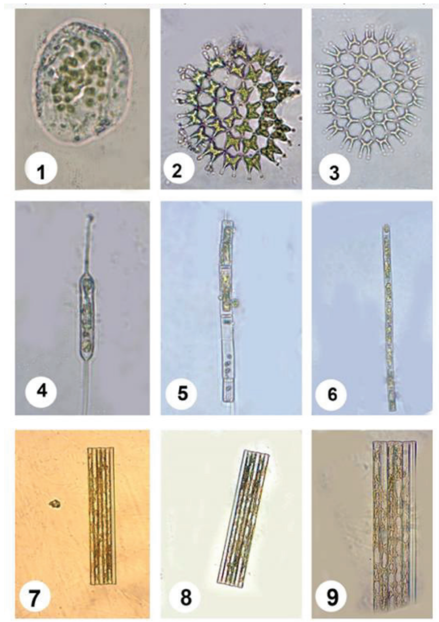

Fig. C. Images of plankton from Nikli Haor. 1- 9. 1. A ciliate; 2, 3. *Pediastrum duplex*; 4. *Centritractas belenophorus*; 5, 6. *Melosira granulata* var. *angustissima*; 7, 8, 9. *Fragilaria intermedia*.

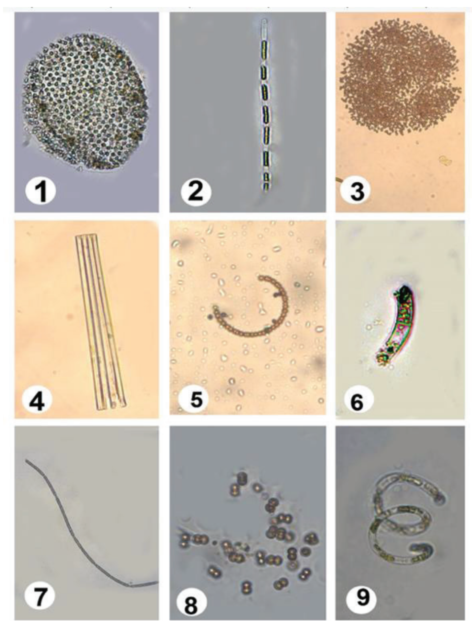

Fig. D. Photomicrographs of phytoplankton from Nikli Haor. 1- 9. 1. *Volvox caeteri*; 2. *Pseudanabaena limnetica*; 3. *Microcystis aeruginosa*; 4. *Synedra ulna*; 5. *Anabaena* sp. 6. *Melosira* sp.; 7. *Oscillatoria* sp.; 8. *Synechocystis aquatilis*; 9. *Melosira granulata* var. *angustissima* fa. *spiralis*.

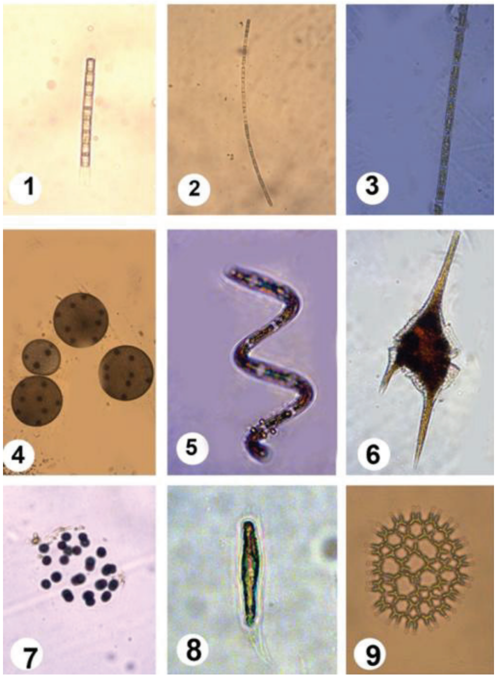

Fig. E. Photographs of phytoplankton.1-9: 1, 2, 3. *Melosira granulata*; 4. *Volvox carteri*; 5. *Melosira granulata* var. *angustissima* fa. *spiralis*; 6. *Ceratium hirundinella*; 7. *Pleodorina* sp.; 8. *Rhopalodia gibba*; 9. *Pediastrum duplex*.

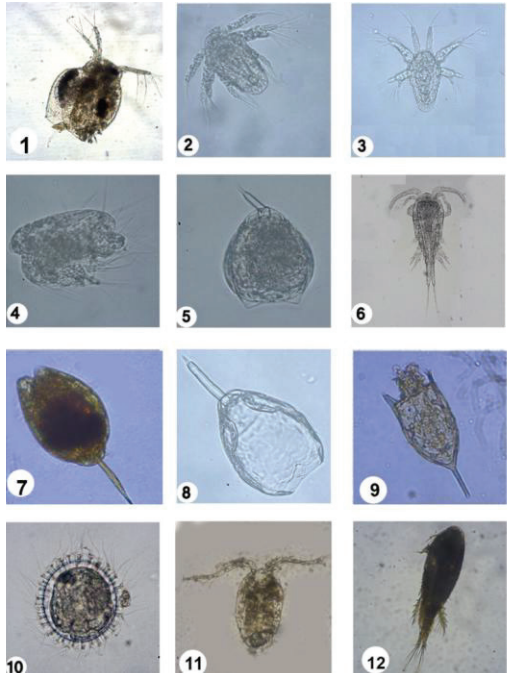

Fig. F. Images of plankton. 1-12: 1, 2, 3, 4. Copepod nauplii; 5. *Monostyla closteriocera*; 7, 8. *M. bulla*; 9. *Keratella cochlearis*; 10. *Trachelomonas hispida*; 6. *Heliodiaptomus viduus*; 11-12. *Cyclops* sp.

The physicochemical and biological data of Nikli Haor has been compared with two other major haor ecosystems of Bangladesh namely Hakaluki- and Tanguar Haor (Table 3). From Table 3, it is evident that the water quality and phytoplankton biomass of Nikli Haor are quite comparable with Hakaluki Haor. The data ranges for water temperature, water depth, transparency, TDS, conductivity, and chl-*a* are closer for both the Haors, but the SRP concentration of Nikli Haor looks higher. The maximum transparency (Zs 1.21 m) of Nikli Haor is the lowest compared to Hakaluki - and Tanguar Haor (1.91 and 2.08 m, respectively). Chl-*a* concentration which indicates the activity of the grazing food chain is moderate (5.92 - 31.97 μg/L) in Nikli Haor and is more or less comparable with the range quoted for Hakaluki Haor (34.67- 40.60 μg/L). Much lower range is however quoted for Tanguar Haor (5.50 - 8.45 μg/L). From this comparison it could be said that these three Haors do not differ much with respect to their physicochemical characteristics.

Table 3. A comparative study of physicochemical and biological parameters of three spectacular Haor Ecosystems of Bangladesh

Haor	Air (t°C)	Wat. (t °C)	Z (m)	Zs (m)	TDS (mg/L)	Cond. (µS/cm)	pH	DO (mg/L)	CO_2 (mg/L)	SRP (µg/L)	SRS (mg/L)	NO_3-N (mg/L)	Chl-*a* (µg/L)	Phae. (µg/L)
Nikli Haor	31-33.7	30.4-31.4	1.75-7.22	.91-1.21	34-42	30-50	7.9-8.3	7.35-11.55	.49-1.05	6.7-45.6	6.10-11.20	.33-.81	5.92-31.97	1.60-3.31
Hakaluki Haor	28.2-30.4	28.1-28.4	2.74-5.14	.74-1.91	35-42	40-50	7.2-7.8	2.8-5.4	.096	10.68-14.5	16.09-35.42	.116-.122	34.67-40.60	1.51-8.72
Tanguar Haor	23-31	24.4-29.9	5.49-9.50	2.08	58-61	70-80	7.2-7.6	3-3.04	.097-.1	22.75-25.72	10.94-11.59	.190-.330	5.50-8.45	3.12-3.81

The highest pH of Nikli Haor was recorded 8.3, indicating that the water is alkaline. Since it immediately affects the water's chemical, physical, and biological properties, it provides an indication of the quality of the water. pH also affects the amount of photosynthesis and the biological composition of the water body. An organism that can endure at a certain pH level cannot adjust to a little pH fluctuation[23,24]. It was discovered that when compared to Hakaluki and Tanguar Haor, their pH values fell between 6.22 and 6.66 and 7.5 and 9.7, respectively[8,26]. In comparison to Nikli and Tanguar Haor, Hakaluki Haor had a somewhat acidic composition of water. Water's alkalinity is a calming quality that serves as a buffer. The alkalinity of Nikli Haor was 0.784 meq/L (39.2 mg/L), which was the alkalinity of the water in the prewinter season. On the other side, the range of alkalinity for Tanguar Haor was 16.5 – 67.5 mg/L and for Hakaluki Haor it was 12 - 42 mg/L.[25-27]. The present comparison thus revealed that Nikli Haor's alkalinity was within the limits of Tanguar and Hakaluki Haor.

Dissolved oxygen (DO) and free carbon dioxide (free CO_2) are inversely correlated because in the same body of water, from dawn to dusk, DO stays high during the day owing to photosynthesis, while free CO_2 remains high during the night due to the consequence of respiration. On the day of sampling, the highest concentration of DO in Nikli Haor was determined to be 11.55 mg/L, whereas the highest concentration of free carbon dioxide was 1.05 mg/L.

It is well-recognized that DO can be used as a water quality assessment indicator because its concentration interacts with the number of other factors of a water body by providing direct and indirect information on bacterial activity, photosynthesis, nutrient availability, stratification, etc.[28]. The DO of Nikli Haor was often higher than other haors because of the absence of biodegradable trash around. Water temperature has an impact on DO as well. Like DO, carbon dioxide is also a biogenic gas for water because both gases are vital for carrying out the biological productivity of water. Aquatic plants use the free carbon dioxide in the water to fuel photosynthesis, and they produce oxygen as a byproduct that benefits the dissolved heterotrophic community. So, the rise in oxygen and the fall in carbon dioxide are consequential processes in an aquatic ecosystem. The average concentration of free carbon dioxide in Nikli Haor during the sampling month of June was 0.799 mg/L, which is significantly higher than Tanguar Haor's concentration e.g., 0.082 – 0.085 mg/L[26]. This resulted in the prediction of the presence of a large number of organisms in the Haor water, which ultimately suggested rich biodiversity of pelagic plankton.

In the present investigation, the EC value of Nikli Haor ranged from 30 - 50 μS/cm. While EC values from other Haors of Bangladesh like Hail Haor were 37 μS/cm on average and Tanguar Haor showed an average EC of 80 μS/cm[26]. In Hakaluki Haor, the EC value ranged from 38 - 589 μS/cm[25]. According to FAO, water with high EC cannot be appropriate for residential and agricultural uses, including fisheries. Additionally, regular use of fertilizers and pesticides tends to raise EC, which is a common factor in almost all haor-based rice cultivation systems of Bangladesh. This comparison demonstrates that relatively a lower EC of Nikli Haor water is better for fisheries and agricultural uses. This is also consistent with the aquatic wildlife flora and fauna and could thus act as a sanctuary that protects a variety of fish species, particularly those that are endangered. Temperature is another factor that affects controlling the EC, the rate for every 1-degree Celsius rise in water temperature, the electric conductivity increases by 3%.

Results of the present study carried out on Nikli Haor, Kishoreganj show that the water quality is comparable with other similar studies done on Hakaluki Haor, Moulvi Bazar, and Tanguar Haor, Sunamganj[26,27]. The concentration of key nutrients i.e., N, P and Si along with pH, TDS values and transparency all support a moderately luxuriant phytoplankton flora and zooplankton fauna. The chl-*a* range and SRP condition reveal the quality of water to be meso- to eutrophic. From the qualitative standpoint of phytoplankton systematics, the taxa recorded do also show the functionality of haor ecosystem. The unique population of the order of green algae Volvocales (*Volvox, Eudorina, Pandorina*) in the plankton samples of Nikli Haor shows its good water quality condition (Figs. A, D, E). Some other forms like *Centritractus*, *Mallomonas*, *Ceratium*, *Peridinium* (Figs. A, B, C) all represent the typical floristic composition of haor phytoplankton as those recorded from Hakaluki and Tanguar Haors. Some detailed studies covering the annual flux of nutrients and flora and fauna and aquatic macrophytes should be targeted in future in Nikli Haor, Kishoreganj.

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