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ORIGINAL RESEARCH ARTICLE

Freshwater Algal Assemblages in Seasonal Ponds: An Opportunity in Coastal Agriculture and Aquaculture

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Algae are considered the foundation of aquatic bodies. Seasonal ponds might be a blessing to society through temporal aquaculture during monsoon and agriculture during desiccation in winter season. The biochemical constitution of the aquatic food web is determined by the algal composition. Moreover, the algal diversity mostly drives the nutritional index of fisheries by the nutritional transection of interconnecting agent zooplankton. The current study has found major algal groups, such as Chlorophyta (10 genera), Bacilariophyta (05 genera), Cyanophyta (04 genera), and Euglenophyta (07 genera) in three chosen short-timed rain-fed ponds. The aquatic algae are very renowned for their photosynthesis & nutritional contribution to the food web, chemical compounds in the industries, soil conditioning capability as fertilizers, and allelochemical activities in ecosystems. According to these multivariate roles, algal biomass can create potential opportunities for the future world.

Keywords: Freshwater algae, Algal toxins, Algal fertilizer.

Aquatic algae contribute to the nutritional requirement of greater fisheries. The algal composition determines the zooplankton diversity and survival success (1,2). Subsequently, zooplankton accumulates and transfers essential glycogen, protein, lipid, vitamins, and minerals to the higher trophic level (3). Algal nutritional composition is based on aquatic nutrients such as carbon (C), nitrogen (N), phosphorus (P), silica (Si), minerals, and metals. According to morphological differences, algae can be divided into various groups like Chlorophyte (green algae), Bacillariophyta (diatom), Cyanophyta (blue-green algae), and Euglenophyta (*Euglena*). The dominance or bloom of a specific algal group depends on the ratio of C/N/P/Si and the geomorphological status of aquatic bodies (4). The seasonal ponds genuinely hold water in monsoon and early post-monsoon seasons for a maximum of six to seven months. After summer desiccation, algae regenerate and sustain in these seasonal ponds. During desiccation, these seasonal ponds could be used as agriculture fields for vegetables. The bottom soil structure of seasonal ponds is enriched with nitrogen, phosphorus, and essential minerals are derived from deceased algal biomass. Green waters are required for zooplankton restoration, larval development of finfishes, shellfishes, reptiles, amphipods, and other endemic aquatic organisms (5–14). Furthermore, brood invertebrates and vertebrates are getting ready for spawning in these seasonal rain-fed ponds. Among all algal groups, Chlorophyta and Bacillariophya are more ecofriendly to zooplankton and fisheries but Cyanophyta and Euglenophyta have controversial roles in the aquatic ecosystem. Many studies showed that normally Chlorophya dominates aquatic bodies followed by Bacillariophyta, Cyanophyta, and Euglenophyta due to their superior photosynthetic activities through sufficient chlorophyll-a than others (15–17). However, the

dominance of cyanobacteria is due to their opportunistic survival strategies in the harsh and polluted environment because of excessive nutrients (nitrogen and phosphorus) from agriculture, residential and industrial surface runoff (18–23). In this study, we aimed to determine the abundance and diversity of freshwater algae in seasonal ponds. We also focused to identify the dominant algal group as well as measuring related water quality parameters for a better understanding of algal ecology.

MATERIALS AND METHODS

Our study was focused to identify and measure four groups of algae: Chlorophyta, Bacillariophyta, Cyanophyta, and Euglenophyta in three selected short-timed ponds during monsoon (July-2021 to September-2021) in Sonapur, situated at coastal district Noakhali, Bangladesh (Table 1 & Figure 1). The algal samples were collected weekly during sampling periods for further analysis in the laboratory. The samples were sieved by a micro-mesh-sized net (mesh size: 15 µm) and preserved in 5% buffered formalin.

Table 1. Sampling short-timed coastal ponds, Noakhali, Bangladesh.

Rain Fed Ponds	Geographical Status	Water Color (Physical appearance)
Pond A	22°79′76′′ N & 91°10′29′′ E	Light green
Pond B	22°79′68′′ N & 91°10′29′′ E	Light Brown
Pond C	22°79′29′′ N & 91°10′37′′ E	Dark green

Furthermore, the freshwater algae were recognized and estimated in Sedgwick rafter cell through a compound light microscope by following the method as described in the literature (24,25). The essential statistical analysis was accompanied in SPSS (Version 17) and Microsoft Excel (2010) for graphical presentation and elaborate data analysis.

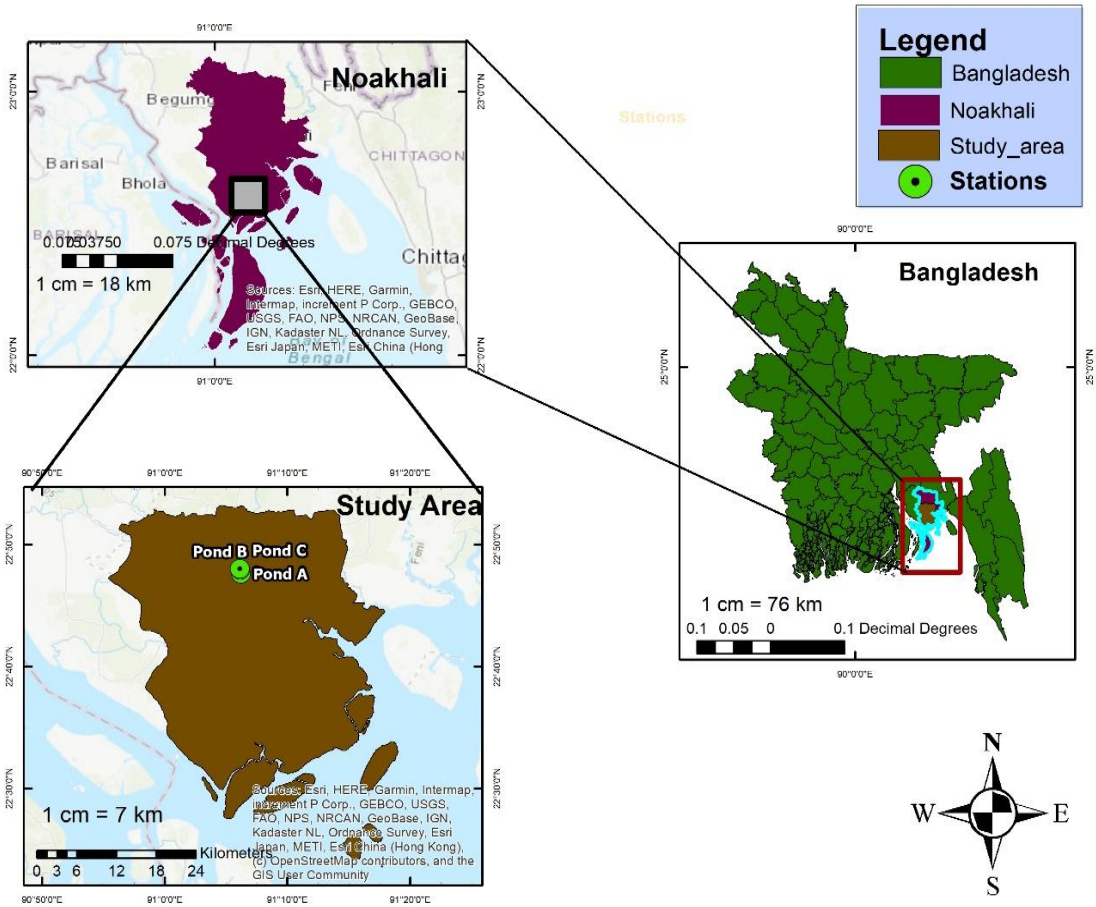

Figure 1. Sampling coastal ponds (Pond A, B &C) in Noakhali, Bangladesh.

RESULTS AND DISCUSSION

The total phytoplankton abundance was recorded in pond A (39735.03 ± 5977.60), and pond B (31416.66 ± 3491.78) were oriented with dominant Chlorophyta (A: 27702.08 ± 1774.92, B: 17716.66 ± 1540.28) and other groups such as Bacillariophyta (A: 2753.78 ± 1224.74, B: 5166.66 ± 920.21), Cyanophyta (A: 2987.5 ± 1393.76, B: 1431.25 ± 181.25) and Euglenophyta (A: 6291.66 ± 1738.17, B: 7102.08 ± 2822.10) as presented in figure 1 and 2.

Additionally, in pond C, the highest phytoplankton abundance (61047 ± 8576.09) was recorded, where Cyanophyta (8937.5 ± 1250) was found dominant and followed by Chlorophyta (40187.5 ± 3094.27), Bacillariophyta (10875 ± 661.43), and Euglenophyta (1047 ± 235.79) (Figure 1 and 2). In this study, we identified ten genera of chlorophyte (*Ankistrodesmus, Chlorogonium, Characium, Closterium, Cosmarium, Oocystis, Pediastrum, Scenedesmus, Ulothrix,* and *Zygnema*), five genera of Bacillariophyta (*Cyclotella, Cymbella, Fragilaria, Navicula,* and *Synedra*), four genera of Cyanophyta (*Aphanothce, Gomphosphaeria, Merismoedia,* and *Oscillatoria*) and seven genera of Euglenophyta (*Euglena, Phacus, Holophyra, Arcella, Trachelomonus, volvox,* and *Micrasterias*) were identified from all the three sampling ponds (Table 2).

Chlorophyta is recognized as largely distributed green algae in freshwater bodies. This green algal group produces their own energy through photosynthesis by their chlorophyll a and b. They are completely depending on sunlight and aquatic nutrients such as nitrogen and phosphorus (2,22,26,27). Cyanophtya (blue-green algae) have more opportunities for surviving in the harsh environment through their buoyancy by their gas vacuole, having additional photosynthetic pigments like phycoerythrins, as well as phycocyanin, storing nitrogen and phosphorus during food scarcity, erecting allelochemicals for self-defense or to suppress their competitors (4,17,27). Bacilariophyta requires one exceptional nutrient as silica than other groups for their frustule construction. So, the silica plays a limiting factor to the distribution and abundance of Bacillariophyta (4,27). In the Euglenophyta group, most algae are heterotrophic, but some have chloroplast for photosynthesis (27,28). Cyanophyta and Euglenophyta both are well known for their blooming excellency and toxin production in highly polluted water bodies (2,17). The most responsible pollutants, such as phosphorus and nitrogenous nutrients, promote their blooms and toxin production (4,18). Several cyanotoxins (e.g. anatoxin-a, homoanatoxin-a, anabaenopeptins, aplysiatoxins, β-methylamino-L-alanine, cylindrospermopsin, dermatotoxins, hepatotoxins, lipopolysaccharide endotoxins, lyngbyatoxins, microcystins, nodularin, palytoxins, saxitoxins) and euglea-toxin (e.g. euglenophycin- ichtyotoxin) have severe effects on fisheries and subsequently in human health (29,30).

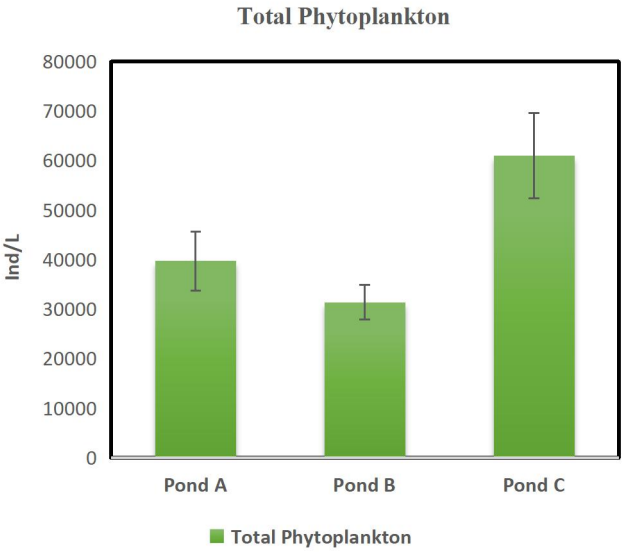

Figure 1. The total phytoplankton abundance in coastal seasonal ponds A, B, and C.

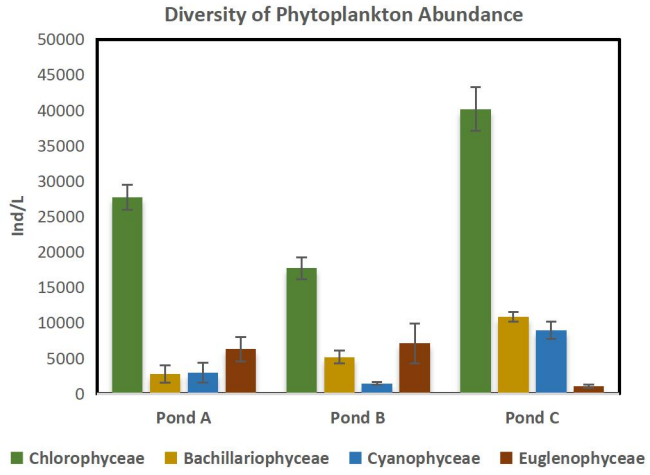

Figure 2. The total abundance of Chlorophyta, Bacillariophyta, Cyanophyta, and Euglenophyta in coastal seasonal ponds A, B, and C.

Table 2. The phytoplankton genera (Chlorophyta, Bacillariophyta, Cyanophyta, and Euglenophyta) in all sampling coastal ponds, Noakhali, Bangaldesh.

Name of phytoplankton genera			
Chlorophtya	**Bacillariophyta**	**Cyanophyta**	**Euglenophyta**
Ankistrodesmus	*Cyclotella*	*Aphanothce*	*Euglena*
Chlorogonium	*Cymbella*	*Gomphosphaeria*	*Phacus*
Characium	*Fragilaria*	*Merismoedia*	*Holophyra*
Closterium	*Navicula*	*Oscillatoria*	*Arcella*
Cosmarium	*Synedra*	-	*Trachelomonus*
Oocystis	-	-	*Volvox*
Pediastrum	-	-	*Micrasterias*
Scenedesmus	-	-	-
Ulothrix	-	-	-
Zygnema	-	-	-

In the coastal district, Noakhali is oriented with larger number of freshwater ponds for many years. These seasonal or permanent ponds are found supportive to the local people by drinkable water, fisheries, and daily obligatory usages (18,31). Seasonal harmful algal blooms are recognized as a serious threat to drinking water of local people. These toxic and bad odorous algal bloom suppress the fisheries through off-flavor in fish mussels and massive mortalities (32). Thus the noxious algal bloom is harmful to the coastal fisheries. The inland freshwater ponds are very sensitive to several anthropogenic pollutions by surface runoff with chemical pollutants such as phosphorus, heavy metals, micro or macro plastics, and nitrogenous substances (6,18). These chemical pollutions influence the harmful algal blooms in freshwater ponds. The numerous wild, household, and intuitional ponds could be very potential sources of fisheries in coastal districts in Bangladesh. Additionally, it is necessary to control the supply of chemical pollutants to these potential freshwater reservoirs, which promote the harmful cyanobacterial and *Euglena* blooms (32).

The green algal group chlorophyte has appeared in the water body in several forms such as colonial, filamentous, and even solitary and even co-dominated with cyanobacteria in the eutrophic ecosystem without any notable toxicity like cyanobacteria but could occasionally behave nuisance with the concentrated filamentous algal community (32). In nutrient-enriched aquatic bodies, some genera of green algae form bloom and introduce hypoxia, bad odor, and tastes in water. One of the most bloom-forming green alga *Botryococcus* is found in introducing extremely buoyant surface-oriented blooms, which appear as scum (32). Many studies have already reported that the aquatic algal bloom is firstly introduced by a green algal bloom, then cyanobacteria cloud take over the opportunity to photosynthesis in low light, oxygen-depleted, nitrogen and phosphorus enriched middle column in aquatic bodies (4,17). Euglenophyta is another confirmed organic pollution tolerant algal group after Cyanophyta, which is found in the polluted and harsh aquatic environment (2,28).

Different types of aquaculture such as finfish (freshwater and estuarine), prawn, crab, oyster cultures are observed in the adaptive earthen pond, pen, cage, and tank culture formats. Unfortunately, local people are losing their interest in this coastal aquaculture because of the deterioration of freshwater ponds due to anthropogenic pollutions and insufficient social concerns and knowledge on fisheries potentiality (18,33). The algal assemblages of these freshwater ponds are the foundation of aquaculture, but the dominance of Cyanophyta and Euglenophyta need to be monitored and controlled for better fisheries production. The conducting study was focused on identifying algal species and measure their abundance for better consideration of the presence and supremacy of harmful algal groups such as Cyanophyta and Euglenophyta. The *Euglena* and cyanobacterial distribution in all sampling ponds (conducting study) indicate the presence of chemical pollutants and high organic pollution in water bodies. However, the governance of Chlorophyta in all sampling seasonal ponds specifies the fertile environment for zooplankton and subsequent fisheries (15,16). The silica enriched algal group Bacillariophyta (diatoms) is preferable to zoo-

plankton for easy edibility, tastes, nutritional values, and comparatively lower toxicity than cyanobacteria and *Euglena* (34–36). Normally, Chlorophyta and Cyanophyta are found dominated in freshwater bodies than Bacillariophyta, but diatoms are available in maximum shallow, deep, seasonal, or permanent inland ponds. In line with the finding of the current study, previous study also found a comparable abundance of Bacillariophyta in seasonal ponds (6,16). Another vital application of these seasonal pond water to the associated agriculture fields is through irrigation. The dried freshwater algal biomass like blue-green algae (Cyanophyta) is already applied as an enriched organic biofertilizer in rice cultivation fields (37,38). The algae-rich water irrigation from inland seasonal ponds to the crop or vegetable fields might be very supportive for sustainable production.

Moreover, the desiccated freshwater ponds during summer and winter could be used for the cultivation of seasonal vegetables. Our study determined the algal diversity and abundance to evaluate the aquaculture capacities and potential contributions to agriculture fields.

CONFLICT OF INTEREST

All authors declared no conflict of interests.

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CONCLUSION

The inland fisheries and agriculture are recognized as a crucial concern for the next generations. The inland freshwater and coastal fisheries are widely dependent on seasonal rain-fed ponds in parallel with rivers and estuaries. Moreover, inland ponds are easier to access and manage than rivers because of the lentic (confined) environment. Additionally, these seasonal ponds are very vulnerable to anthropogenic pollution through growing urbanization. The algal community is the first responder to any type of environmental fluctuations such as global warming, abnormal raining schedules, and nutritional (nitrogen, phosphorus, and silica) supplies. The inland seasonal ponds might be a promising opportunity for fresh or coastal water aquaculture and agriculture if the algal communities are chemically and nutritionally supportive to both aquatic and terrestrial higher flora and fauna.

REFERENCES

1. Khan NS. Ecological potentiality of plankton. A perspective on nutrition, toxicity, and bio-indication. Environ. Sci. Ecol. Curr. Res. 2021;2(1):1040.
2. Bellinger EG, Sigee DC. Freshwater Algae: Identification, Enumeration and Use as Bioindicators. Wiley Blackwell. Edition: 2nd. 2015.
3. Bertt MT, Muller-Navarra DC. The role of highly unsaturated fatty acids in aquatic foodweb processes. Freshw. Bilogy. 1997;38:483–99.
4. Suthers IM, Rissik D. Plankton: A guide to their ecology and monitoring for water quality. CSIRO Publishing. 2009.
5. Bari JBA, Islam MS, Nisa SA, Tisha NA, Mashkova I, Khan NS. Response of freshwater zooplankton as biological indicators to the aquatic chemical properties. Curr. Environ. 2021;1(1):9-14.
6. Sarker MM, Hossain MB, Islam MM, Mustafa KAH, Idris MH. Unravelling the diversity and assemblage of phytoplankton in homestead ponds of central coastal belt, Bangladesh. Aquac Res. 2021;52:167–184.
7. Mashkova IV, Kostriykova AM, Trofimenko VV, Slavnaya AI. Study of the zooplankton community as an indicator of the trophic status of reservoirs of the Chelyabinsk Region, Russia. IOP Conf. Ser. Earth Environ. Sci. 2019;344(1).
8. Rahman KMM, Nahar M, Adhikary RK, Khan NS, Rahman MM, Asadujjaman M, et al. Socio-economic condition and occupation migration of fisherman of the Jamuna River under Shirajgonj District in Bangladesh. Middle-East J. Sci. Res. 2014;22:633–638.
9. Rahman MM, Ali MR, Sarder MRI, Mollah MFA, Khan NS. Development of sperm cryopreservation protocol of endangered spiny eel, *Mastacembelus armatus* (Lacepede 1800) for ex-situ conservation. Cryobiology. 2016;73:316–323.
10. Sultana T, Rahman M, Hossain A. Present status and sustainability of prawn (*Macrobrachium rosenbergii*) farming in Noakhali district. 2017;1(1):51–57.
11. Quaiyum MA, Rahman MM, Sarker SB, Alam MM, Khan NS, Rahman MS, et al. Microbiological quality assessment of Chapila (*Gudusia chapra*) and Tengra (*Mystus vittatus*) in Bangladesh. Stamford J. Microbiol. 2013;2:6–9.
12. Khan NS. Microbial water quality of freshwater prawn, Lambert academic publishing. 2012.
13. Khan NS, Islam MR, Hossain MB, Quaiyum MA, Shamsuddin M, Karmaker JK. Comparative analysis of microbial status of raw and frozen freshwater prawn (*Macrobrachium rosenbergii*). Middle East J. Sci. Res. 2012;12:1026–1030.
14. Khan NS, Sarder MRI, Al-Faroque MA, Mollah MFA. Standardization of sperm cryopreservation techniques of Indian Major Carp Rohu (*Labeo rohita*, Hamilton 1822). Int. J. Fish. Aquat. Stud. 2015;175–181.
15. Khan NS, Bari JBA. The effects of Physico-chemical parameters on plankton distribution in poultry manure and artificial formulated feed treated fish ponds

Noakhali, Bangladesh. International J. Fish. Aquat. Stud. 2019;7(5):1–7.
16. Khan NS, Islam S. State the organic pollution level in rain fed ponds, Noakhali , Bangladesh. Int. J. Fish. Aquat. Stud. 2019;7:438–441.
17. Khan NS, Tisha NA. Freshwater algal tolerance to organic pollution: A Review. Pollut. Res. 2020;39(4):1297–301.
18. Khan NS, Islam S, Bari JBA, Kamal MM. Monsoonal plankton distribution and physico-chemical water qualities in a rain-fed lake in Noakhali, Bangladesh. Bangladesh J. Fish. 2020;32(1):179–84.
19. Siddique MAM, Rahman M, Khan NS, Islam MM. Size frequency, length-weight, and length-length relationship of bearded worm Goby *Taenioides cirratus* (Blyth, 1860) from the Noakhali Coast, Bay of Bengal. Thalassas. 2021;37:347–351.
20. Khan NS, Islam MS, Bari JBA, Tisha NA. Water quality evaluation by monitoring zooplankton distribution in wild ponds, Noakhali, Bangladesh. Nature Environment Pollution Technology. 2020;19(4):1767-1770.
21. Waseeh MA, Rahman AAFM, Khan NS. Effects of artificial food additives in Vietnam Koi, *Anabas Testudineus* (Bloch, 1792) Pond Culture System. Int. J. Fish. Aquat.s Res. 2020;5(3):50–4.
22. Mustafa MG, Parvez MS, Hossain MA, Ahmed S. Fisheries diversity around Nijhum Dwip island of Bangladesh in relation to some environmental parameters. J. NOAMI. 2018;35:77–91.
23. Amira FS, Rahman MM, Kamaruzzaman BY, Jalal KCA, Hossain MY, Khan NS. Relative abundance and growth of male and female *Nemipterus furcosus* population. Sains Malaysiana. 2016;45:79–86.
24. Stirling HP. Chemical and biological methods of water analysis for aqauculturists. Institute of Aquaculture, University of Stirling, Scotland. 1985. 119pp.
25. Van Vuuren SJ, Taylor J, Gerber A, Van Ginkel CE. Easy identification of the most common freshwater algae: a guide for the identification of microscopic algae in South Africa. University of North-West and Department of Water Affairs and Forestry. 2006.
26. Khalil MI, Sultana T, Hasan MR. Study of fish biodiversity of Nijhum Dwip, Noakhali, Bangladesh. J. Agric. Ecol. Res. Int. 2021;17–25.
27. Wetzel RG. Limnology: Lakes and Reservoir Ecosystem. Burlington. Academic. Edition: 3rd. 2001.
28. Zimba P V, Moeller PD, Beauchesne K, Lane HE, Triemer RE. Identification of euglenophysin-A toxin found in certain euglenoids. Toxicon. 2010;55:100–1.
29. Du X, Liu H, Yuan L, Wang Y, Ma Y, Wang R, et al. The diversity of cyanobacterial toxins on structural characterization, distribution and identification: A systematic review. Toxins (Basel). 2019;11(530).
30. Kaushik R, Balasubramanian R. Methods and approaches used for detection of cyanotoxins in environmental samples: A review. Crit. Rev. Environ. Sci. Technol. 2013;43:1349–83.
31. Khan NS, Uddin A, Bari JBA, Tisha NA. Evaluation the potentiality of ancient ponds by Palmer's algal pollution. Int. J. Fish. Aquat. Res. 2019;4(4):28–31.
32. Paerl HW, Fulton RS, Moisander PH, Dyble J. Harmful freshwater algal blooms, with an emphasis on cyanobacteria. Sci. World. 2001;1:76–113.
33. Khan NS, Islam MS, Bari JBA, Tisha NA. Water quality evaluation by monitoring zooplankton distribution in wild ponds, Noakhali, Bangladesh. Nat. Environ. Pollut. Technol. 19(4):1767–70.
34. Gorokhova E, El-Shehawy R, Lehtiniemi M, Garbaras A. How copepods can eat toxins without getting sick: Gut bacteria help zooplankton to feed in cyanobacteria blooms. 2021;11:589816.
35. Hanim IA, Scott M, Friedrich R. Selective feeding of three *Cladocera* species in mixtures of freshwater algae. Res. J. Chem. Environ. 2019;23(5):89-97.
36. Liu H, Chen M, Zhu F, Harrison PJ. Effects of diatom silica content on copepod grazing, growing and reproduction. Front. Mar. Sci. 2016;3(89).
37. Metting B. Biodiversity and application of microalgae. J. Ind. Microbiol. 1996;17:477–89.
38. Kim JK, Kottuparambil S, Moh SH, Lee TK, Kim Y-J, Rhee J-S, et al. Potential application of nuisance microalgae blooms. J. Appl. 2015;27(3):1223-34.

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