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# Seasonal variation of aquatic macrophytes, phytoplankton association and soil and water qualities at some selected sites of Savar–Dhaka regions of Bangladesh

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**Abstract**
Seasonal variation of aquatic macrophyte and phytoplankton and analysis of soil and water at some selected sites of Savar – Dhaka regions of Bangladesh namely Hazaribagh Site-A), Hemayetpur Site-B), Banktown Site-C) and Jahangirnagar University Site-D, control site) of Dhaka district were investigated from April-2011 to January-2012. Data on the number of species and their individuals per $2m^2$ randomly selected quadrats were recorded properly. Site- A, B and C water bodies were located in the industrial areas of Hazaribagh tanneries areas under Hajaribagh thana and teenage modern fashion and maxcom garments area, Hemayetpur and, Doel complex, Bank Town area under Savar Thana. The site-D water body was located in Jahangirnagar University besides the new arts building. Seasonal variation was recorded in all 03 three) different seasons namely summer, rainy and winter seasons. A total of 47 species of aquatic macrophytes under 30 different families were recorded from the research sites. The highest number of species was 24 in the summer season with a total of 314 individuals in site –B followed by 20 with 333 individuals in site –D, 17 with 518 individuals in site-C and 8 with 142 individuals in site – A. The highest number of species was 18 in the rainy season with a total of 458 individuals in site –D and 18 with a total of 378 individuals in site – B followed by 14 with 420 individuals in site –C, 5 with 153individuals in site-A. In the winter season, the highest number of species 13 were recorded in site – C with 370 individuals, 13 with 325 individuals in site – B followed by 12 with 97 individuals in site – D and 6 with 68 individuals in site – A. Seasonal variation is continuously occurring among them and also species vary for site variation. The most commonly occurring species in all four sites was Eichhornia crassipes. The total species number of macrophytes and their individual numbers were enriched with site-D water body in Jahangirnagar University than that of other water bodies. The average highest density resulted in 2.47 in site – C, the highest relative density 12.22 in site - A, The highest frequency 19 in site – D, the highest relative frequency 12.44 and the highest abundance value 7.35 were found in site – C. A total of 57 genera under 04 phytoplanktonic classes were recorded. From the total occurrence, it is clear that the highest dominant phytoplanktonic class was Bacillariophyceae total occurrence 5076 under 16 genera) followed by Chlorophyceae total occurrence 4053 under 28 genera), Cyanophyceae total occurrence 3022 under 10 genera) and Euglenophyceae Total occurrence 660 under 03 genera) respectively. The highest number of phytoplanktonic occurrences was observed in site – A in the rainy season 1202) and the lowest occurrence was observed in site - C in the same season 923). Soil moisture content was the highest 21.56 % at the rainy season in site D and lowest 1.46 at winter season in site – A. Maximum water holding capacity of the soil was the highest 46 % at the summer season in site D and lowest 31 % at the rainy season in site – C. Soil $P^H$ value was highest 6.8 at the summer season in site D and lowest 5 in site C in summer and site D in the rainy season. The highest water temperature was recorded in site – C in the summer season $38^0$C) and that of lowest was recorded in site – D in the winter season $22.3^0$C). The highest $P^H$ value recorded was 7.8 in site – A and that of the lowest value recorded in site – B in the rainy season 5.5). The highest TDS value was 3400 mg/L at winter season in site – A and lowest 400 mg/L at the rainy season in site A and winter in site – D. The highest TSS value 400 mg/L at winter season in site – A and lowest 100 mg/L at summer in site – A and at rainy in site –D. The highest amount of Dissolved Oxygen DO) was calculated in site – D in the rainy season 4.379 mg/L) and that of the lowest value calculated in site – A in the summer season 1.056 mg/L). Biochemical Oxygen Demand value calculated was the highest in site –D in summer season 2.226 mg/L) and the lowest in site – A in summer and rainy season and site – B in the winter season 0.453 mg/L). The highest COD value was 375 mg /L at summer in site – A and the lowest was 35 mg/L at winter season in site – D.

**Keywords:** seasonal variation, aquatic macrophytes, phytoplanktons, soil and water qualities, quadrat method, Savar- Dhaka regions of Bangladesh

## Introduction

Seasonal variation is a term to find out the changes in nature with the changes of seasons. Aquatic macrophytes are aquatic plants that can be seen in naked eyes in aquatic habitats. Macrophytes grow in or near water. Aquatic macrophytes play an important role in structuring in aquatic environments. These plants provide physical structure, increase habitat complexity and heterogeneity and affect various organisms like invertebrates, fishes and water birds Thomaz and Chuna, 2010) [2]. They may

be emergent, submerged or floating. They have a great role in the biological productivity aquatic ecosystem. Some aquatic macrophytes such as *Eichhornia crassipes* is a sheltered place for aquatic small fishes and aquatic snakes. Some macrophytes are eaten as foods by some aquatic fauna. They have a great role to maintain aquatic food chains. But, there are many problems related to the overgrowth of aquatic macrophytes in many lakes and rivers throughout the world Toda *et al*., 2019) [1]. Water bodies are the components of the landscape ecosystem. Macrophytes are the component of freshwater ecosystems, perform a key role in determining the structure and function of wetland ecosystems. Aquatic macrophytes reduce pollution by acting as nutrient pumps, indicate water quality, provide suitable breeding and shelter places for various aquatic fauna, support large quantities of a variety of epiphytic algae and periphytons as a source of food in the food chain of the aquatic environment Pandit, 1992) [3]. The normal role of aquatic vegetation lies especially in its ability to stabilize the sediments, to deliver the primary production to the water including its capacity for uptake and release of nutrients and their contribution to organic matter and to provide both habitat diversity and sources of food Triest, 1993) [4]. Aquatic plants are classified into three fairly natural groups with respect to their relation to water and air – submerged, floating and amphibious plants Weaver and Clements, 1929) [5]. Due to the diverse nature of life form categories of wetland plants of Bangladesh, they are classified into six groups as floating hydrophytes, suspended hydrophytes, anchored, submerged, amphibious and facultative hydrophytes Karim, 1993) [6]. Emergent macrophytes are more productive than submerged macrophytes and emergent and submerged vegetation differ in their seasonal patterns of organic carbons Weisner et. al., 1994) [7]. In 1987, late professor Dr. M. Salar Khan and Dr. Mahbuba Halim first recorded 123 aquatic angiosperms under 67 genera distributed in 35 families. Khan and Halim, 1987) [8].

Phytoplanktons are microscopic organisms that live in watery environments, both salty and fresh. Some phytoplanktons are bacteria, some are protists, and most are single-celled plants. Phytoplanktons are the autotrophic components of the plankton community and a key part of ocean and freshwater ecosystems. Phytoplanktons are the foundation of the aquatic food web**.** Phytoplankton is a group of free-floating microalgae that drifts with the water current and forms an important part of the ocean, sea, and freshwater ecosystems. The term phytoplankton comes from two Greek words, 'Phyto' meaning plants, and 'plankton' meaning drifter. The aquatic community depends upon the phytoplankton population for its primary productivity. The growth and abundance of various phytoplanktons are dependent on meteorological factors and physicochemical properties of water in the aquatic habitat Habib *et al*., 1984 and Ali *et al*., 1985) [16, 15]. A limnological study of four polluted ponds in and around Dhaka city was carried out with reference to indicator species Khondker *et al*., 1990) [14]. Phytoplanktons are valuable indicators of environmental conditions in aquatic ecosystems because they directly respond to many physical, chemical and biological changes in the aquatic ecosystems Stevenson *et al*., 1999) [12]. Phytoplanktons are microscopic minute), floating or suspended lower plants algae) that are distributed throughout the water mainly in the photic zone Verma and Agarwal, 2005) [11]. Phytoplanktons may be diatoms, green algae, dinoflagellate, blue-green algae, chrysophytes, cryptomonads, euglenoids, red algae Moniruzzaman, 2006) [10]. The presence of Oscillatoria, Spirogyra and Stigeoclonium can be taken as indicators of organic pollution Patrick, 1973). The aquatic community relies on the phytoplankton population for its primary productivity. The growth and abundance of various phytoplanktons are almost fully dependent on the meteorological factors and physico- chemical properties of water in the water bodies Habib *et al*., 1984 and Ali *et al*., 1985) [16, 15].

Water qualities are very important for the living flora and fauna of water. The other name of pure freshwater is life. However, Savar – Dhaka regions are very vital because there are more than a hundred industries in the Savar Dahaka regions. Site – A Hajaribag) is a tanneries polluted area, Especially readymade garments and knitting factories are present in sites B and C. On the other hand, site – D Jahangirnagar University, the control site) water body is free from industrial discharges in visual observation. Encroachment, disposal of untreated domestic and industrial wastewater and dumping of solid wastes have degraded the overall quality of the river Turag, which is located in Dhaka—the Capital City of Bangladesh Banu *et al*., 2013) [18].

Total Dissolved solids TDS) is one of the most important parameters for the aquatic environment. The value of TDS is generally less in the non-polluted freshwater body and more in the polluted water bodies. Total Suspended Solids TSS) value is also less in non-polluted freshwater bodies than polluted water bodies. Dissolved Oxygen DO) generally remain more in non-polluted water body than polluted water bodies. Biochemical Oxygen Demand $BOD_5$) value is more in non-polluted water bodies than polluted water bodies. Chemical Oxygen Demand COD) value is less in non-polluted water bodies than polluted water bodies.

**Materials and Methods**

This was a part of original research work from the dissertation entitled "Seasonal variation of aquatic flora and analysis of soil and water at some selected sites of Savar-Dhaka regions". This research work was submitted at the Department of Botany, Jahangirnagar University, Savar, Dhaka -1342 in August 2012 under the supervision of Plant Ecology Laboratory, Department of Botany, Jahangirnagar University-1342 in partial fulfillment for the requirement of the degree of Master of Science with a thesis in Botany. All the selected sites Water Bodies) were located almost in the same geographical position. The latitude and longitude of these four sites are $23^0 42^{'}$ N and $90^0 22'$E respectively. The Duration of the three seasons is divided as April-2011 to June-2011 as the summer season, July-2011 to October-2011 as the rainy season and November-2011 to January-2012 as the winter season. Data Collected from all four sites in all three seasons following the random quadrats method.

Quadrat is a square sample plot or unit for a detailed analysis of vegetation. Shukla and Chandel, 1982) [19]. The quadrat size was $2m^2$. Ten randomly $2m^2$ selected quadrats were fixed using nylon ropes and bamboo sticks for each site for data collection in all three seasons so that accurate variation was observed. The number of each species and their individuals were properly recorded for finding out the seasonal variation status of the macrophytes. Tables of recorded data and general calculations

were done manually using a normal calculator. Seasonal variation was depicted in the results and discussion section.

For phytoplanktons, 6-liter water samples from each separate site namely A, B, C and D were collected at two times 10 am and 5 pm and kept undisturbed in the dark place at room temperature for 48-72 hours for sedimentation. After sedimentation water from the bottles was sucked out carefully and the final volume adjusted to 20 ml. For qualitative analysis, the water samples were observed under a microscope Olympus CH -2) on a slide. The observed phytoplankton specimens were identified up to generic level by consulting national and international standards literature Needham and Needham, 1966; Ward and Whipple, 1959; Prescott and Vinyard, 1948; Kumar and Singh, 1971, Islam and Jaman, 1975; Islam, 1975; Khondker, 1997) [19, 20, 21, 22, 23, 24, 25]. 1 ml sedimented plankton sample was taken in a Sedgewick Rafter counting cell Model 50, Groticuless limited) method Boyd, 1979). The cover glass was placed carefully over the chamber to avoid air bubbles. By placing the counting chamber below the microscope and counting phytoplanktons was done. It was repeated at least 10 times. The colonial algae were treated as a single unit. Finally, the average number of phytoplanktons were expressed per liter of sample water by using the following equation,

$$\text{Phytoplankton (No./ml)} = \frac{C \times 1000}{A \times D \times F}$$

Where C for the total number of phytoplanktons counted, A for the area of field counted, D for depth of the field on mm and F For the number of fields counted.

The moisture content of the soil was determined by the gravimetric method. Moist sample soil was taken from the selected sites. Moist soil samples were taken in the previously weighted oven-dried) aluminum box. The weight of the sample soils was recorded. The aluminum boxes with moist soil were kept in the oven at $105^0$C for 48 hours. The oven-dried weight of the soil samples was recorded. The percentage of soil sample was calculated using the following formula;

Soil Moisture Content %) = $\underline{W_A}$ where the weight of fresh soil= weight of freshly collected soil + Aluminium $W_B$ Box) – Weight of the aluminum box = $W_A$ and $W_B$ for the weight of the oven-dried soil = Weight of the dry soil + aluminum box) – the weight of the aluminum box.

The maximum water holding capacity of the soil was determined after saturation. Distributed soil was taken in labeled dried pots. The pots were blocked by cloth net-like) with a rubber band so that the soil could not be passed through the cloth and along the side of the pots. After that, each soil sample was taken in the labeled pots accordingly.

The pots with soil samples were kept in a water bath. The water level reached the height of about 1/3 of the pots and was kept undisturbed for 24 hours. The pots were removed from the water bath and the pots were kept on blotting paper/cloth to remove the excess moisture outside the pots. The weight of the moist soils and pots was taken together and the pots with soil were placed in an oven at $105^0$C for 24 hours. The oven-dried weight of the samples was recorded after cooling.

$$\text{The maximum water holding capacity} = \frac{W_1 - W_2}{W_2 - W_3}$$; Where, the weight of moist soil+weight of the pot =W1, Weight of the oven-dried soil + weight of the pot = $W_2$ and weight of the empty pot =$W_3$.

Soil $P^H$ value was important because the alkalinity or acidity of soil can be determined by studying the $P^H$ value of soil. So, it had an impact on the flora and fauna of the soil. With 10 polybags, soil samples from each of the four sites namely A, B, C and D were collected. 10 polybags sample from each site were mixed homogeneously and debris was removed. 20g of sample soil was measured and 50 ml of pure distilled water was taken on a measuring beaker. The weighted soil was mixed with water perfectly and homogeneously with a glass rod. The hand $P^H$ meter was calibrated with a buffer solution whose $P^H$ was 7.00. Next, it was cleaned with tissue paper and placed in the sample solution. The reading was taken when this was stable. Thus repeating the process 3 times for each site each season, the average of them was tabulated. After using the PH meter, every time, it was cleaned with distilled water and then with tissue paper.

The water temperatures of surface water below 10 cm of selected four water bodies were recorded in celceous scale by using $10^0$C-$110^0$C centrigrade mercury thermometer.

For $P^H$ of the water, glass with sample water was taken. A beaker of buffer solution whose $P^H$ was 7 was taken. The hand $P^H$ was calibrated with the buffer solution. It was washed with tissue paper. It was sunk into the homogeneously mixed sample solution. The reading was recorded.

The Amount of Dissolved Oxygen DO) is measured by the Winkler titration method. A glass-stoppered 330 ml BOD bottle was filled with sample water without an air bubble. Immediately after filling the BOD bottle, 2 mL of manganese sulfate solution was added using a pipette, dipping the end of the pipette just below the surface of the water. 2 mL of Azide Alkali potassium iodide was added similarly. The stopper was inserted with care to exclude air bubbles and mix by repeatedly inverting and shaking the bottle vigorously. Red precipitation will form if D.O is present in water. the precipitation was allowed to settle. 2 mL of concentrated sulphuric acid was added to the bottle. The stopper was inserted at once and mixed thoroughly as before. The solution was allowed to stand for at least five minutes to ensure the formation of iodine, which is to be titrated against 0.025 N sodium thiosulphate. 200 mL of this solution was withdrawn and titrated with standard sodium thiosulphate solution to a pale yellow colour. 1-2 mL of starch solution was added. This will give a blue colour. The titration was continued to the first disappearance of blue colour to normal watery colour. The volume of thiosulphate added was recorded accurately. The formula for Dissolved Oxygen,

DO in mg/L)=$\frac{A \times N \times 8 \times 1000}{V}$ was used to calculate Dissolved Oxygen; Where A was the volume of thiosulphate used in ml, N was the normality of thiosulphate used, V was the Effective volume of the sample taken in ml) = $\frac{300\text{-}4) \times 200}{(300)}$ = 197.33 ml.

Amount of Biochemical Oxygen Demand $BOD_5$) was the degree of microbially mediated $O_2$ consumption of water by organic pollutants. This was an empirical semi-quantitative method based on the oxidation of organic matter by suitable microorganisms during 5 days. The Dissolved Oxygen of sample water was measured and then the other BOD bottles were kept in a dark place for 5 days. After 5 days, again Dissolved Oxygen DO) was measured. The first Dissolved Oxygen DO) was called $D_1$ and after 05 days, the second time reading of dark place kept BOD Bottle was called $D_2$. This was the formula used for $BOD_5$ mg/l) $=D_1-D_2$, where $D_1$ = Amount of Dissolved Oxygen, $D_2$ = Amount of Dissolved Oxygen after 05 days DoE, 1993). Normal calculations were done by using a calculator. Chemical Oxygen Demand COD) of water was very important for the determination of the organic load of a water body. 25 ml collected water sample was taken in a 250 ml conical flask with a ground glass joint. 10 ml of $K_2Cr_20_7$ 0.25N) in $H_2S0_4$ 18N) was added to the sample. 1 gm $Ag_2S0_4$ and 1 gm $HgS0_4$ were added subsequently. The mixture was refluxed for 6 hours. After cooling, 8 drops of ferroin were added as an indicator. Then, it was titrated with the excess $K_2Cr_20_7$ by adding Mohr's salt solution 0.1N) in $H_2SO_4$ 8N) from a burette. The process was repeated for getting the average value for each season in each site.


**Fig 1:** Circles showing A, B, C and D site Bottom to top in the map) of Dhaka District of Bangladesh

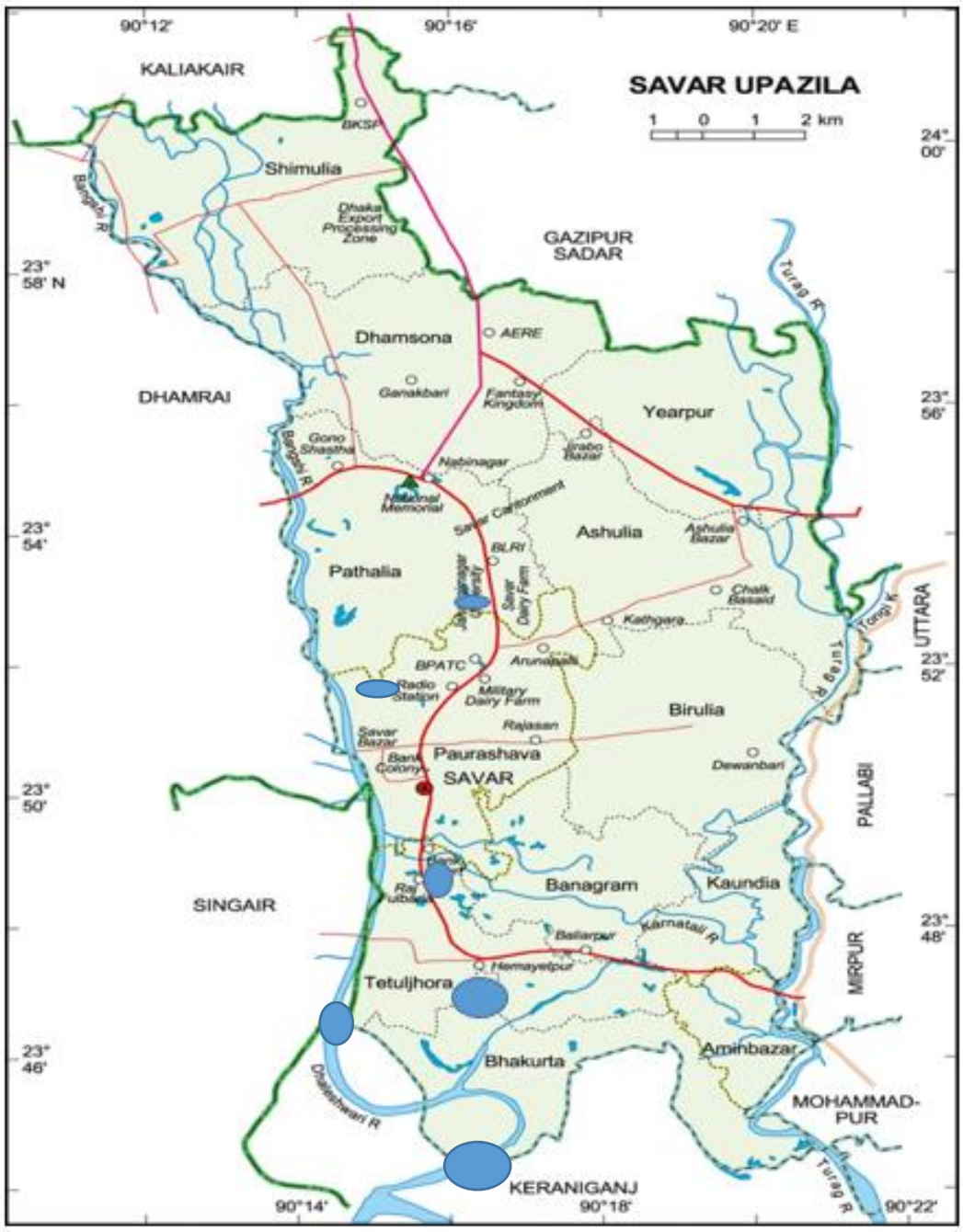


**Fig 2:** Circles showing B, C and D site Bottom to top in the map) of Savar in Dhaka of Bangladesh

**Results and Discussion**

All the recorded species of macrophytes were not occurring equally in all the sites. Again, seasonal variation was noticed among all sites and even within every single site from the tables of data. Table 01). The total number of the species and their individuals, the name of the seasons, the total number of quadrats studied were 10 for every single site. Density per $2m^2$ D), relative density RD), Frequency F), relative frequency RF) and abundance of species were properly recorded and tabulated to express the seasonal variation of the macrophytes of aquatic habitats and adjoining. Table 01 is the reflection of seasonal variation of aquatic macrophytes in all studied four sites in three different seasons with total recorded species number and individuals number. The highest number of species was 24 in the summer season with a total of 314 individuals in site –B followed by 20 with 333 individuals in site –D, 17 with 518 individuals in site-C and 8 with 142 individuals in site – A. The highest number of species was 18 in the rainy season with a total of 458 individuals in site –D and 18 with a total of 378 individuals in site – B followed by 14 with 420 individuals in site –C, 5 with 153 individuals in site-A. In the winter season, the highest number of species 13 were recorded in site – C with 370 individuals, 13 with 325 individuals in site – B followed by 12 with 97 individuals in site – D and 6 with 68 individuals in site – A. The highest average

density, frequency, and abundance value were recorded in site – A. total of 47 species under 30 families of aquatic macrophytes were recorded from the selected four sites of research Table - 02).

**Table 1:** Comparative seasonal variation of macrophytes in all four studied sites A, B, C & D) in three different seasons in the Dhaka district of Bangladesh

| Site | Summer season | | Rainy season | | Winter season | | Individuals total In all 03 seasons | Average D. /2m$^2$ | Average RD %) | Average F %) | Average RF %) | Aver-age A value) |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | Total species | Total individual | Total species | Total individuals | Total species | Total Indivi. | | | | | | |
| A | 8 | 142 | 5 | 153 | 6 | 68 | 363 | 1.51 | 12.22 | 17.08 | 12.44 | 5.21 |
| B | 24 | 314 | 18 | 378 | 13 | 325 | 1017 | 1.44 | 5.14 | 18.2 | 4.16 | 4.25 |
| C | 17 | 518 | 14 | 420 | 13 | 370 | 1308 | 2.47 | 5.85 | 20 | 6.75 | 7.35 |
| D | 20 | 333 | 18 | 458 | 12 | 97 | 888 | 1.62 | 4.96 | 19 | 5.16 | 6.51 |

*Axonopus compressus*, *Cyperus rotundus* and *Sacciolepis interrupta* were not found in the rainy season but in winter *Axonopus compressus* again appeared in the site A Hajaribagh*). Marsilea quadifolia*, *Ipomoea fistolusa*, *Leucas indica*, *Spilanthus acmella*, *Persicaria orientalis* and *Lipia nodiflora* were absent in rainy season and *Enhydra flactuans*, *Persicaria hydropiper*, *Marsilea quadifolia*, *Ricinus communis*, *Salvinia natans*, *Synedrella nodiflora*, *Ipomoea fistolusa*, *Lucas indica*, *Spillanthus acmella*, *Persicaria hydropiper* and *Lipia nordiflora* were not found in winter season in site – B. In site – C, *Colocasia esculenta*, *Scoparia dulcis* and *Chenopodium alba* were not found in rainy season and *Cyperus kyllinga*, *Psidium guajava*, *Nicotiana bonplandianum* and *Chenopodium alba* were absent in winter season in site – C. Cyperus rotundus and Echinocloa sp. were not found in rainy season and Salvinia natans, *Trapa bispinosa*, *Ipomoea aquatica*, *Blyxa echinosperma*, *Ludwigia hossipifolia*, *Mikania cordata*, *Dioscorea alata* and *Echinocloa sp.* were not found in winter season in site – D.

**Table 2:** List of total macrophytes recorded from all studied four sites A, B, C & D) of Dhaka district of Bangladesh

| Sl. No | Scientific Name | Local Name | Family Name | Habit Type | Occurring Site |
|---|---|---|---|---|---|
| 01. | *Alternanthera philoxeroides* | Henchi | Amaranthaceae | Herb | A, B & D |
| 02. | *Amaranthus spinosus* | Khatakhura | Amaranthaceae | Herb | B |
| 03. | *Axonopus compressus* | Carpetgrass | Poaceae | Herb | A, B & C |
| 04. | *Baccaurea ramiflora* | Burmese grape | Phyllanthaceae | Herb | C |
| 05. | *Blyxa echinosperma* | Blyxa | Hydrocharitaceae | Herb | D |
| 06. | *Chenopodium album* | Bathua Shak | Chenopodiaceae | Herb | C |
| 07. | *Chromolaena odorata* | Kanchira | Asteraceae | Shrub | B & D |
| 08. | *Costits speciosus* | Kushtha | Costaceae | Herb | D |
| 09. | *Cyperus kyllingia* | Kyllinga | Cyperaceae | Herb | C |
| 10. | *Cyperus rotundus* | Nutgrass | Cyperaceae | Herb | A & D |
| 11. | *Croton bonplandianum* | Ban tulsi | Euphorbiaceae | Herb | A |
| 12. | *Colocasia esculenta* | Kachu | Araceae | Herb | B, C & D |
| 13. | *Cucurbita maxima* | Lau | Cucurbitaceae | Climber | B |
| 14. | *Cynodon dactylon* | Dubbaghas | Poaceae | Herb | A, B & C |
| 15. | *Datura metel* | Dutra | Solanaceae | Shrub | B |
| 16. | *Discorea alata* | Chupriallu | Dioscoreaceae | Climber | D |
| 17. | *Echinocloa sp.* | Shamghas | Poaceae | Herb | D |
| 18. | *Enhydra flactuans* | Helencha | Asteraceae | Herb | A, B & C |
| 19. | *Euphorbia* hirta | Dudhiya | Euphorbiaceae | Herb | C |
| 20. | *Ficus heterophylla* | Fig plant | Moraceae | Tree | B |
| 21. | *Heliotropium indicum* | Hatisur | Boraginaceae | Herb | C |
| 22. | *Ipomoea aquatica* | Kalmi | Convolvulaceae | Free-floating herb | B & D |
| 23. | *Ipomoea fistulosa* | Dholkolmi | Convolvulaceae | Free-floating herb | B |
| 24. | *Leucas indica* | Dantoklos | Lamiaceae | Herb | B |
| 25. | *Lippa alba* | Motkhori | Verbenaceae | Shrub | B & D |
| 26. | *Lippa nodiflora* | Lippi | Verbenaceae | Herb | B & D |
| 27. | *Ludwigia hyssopifolia* | Kesardam | Onagraceae | Rooted-submerged | D |
| 28. | *Marsilea quardifolia* | Fourleaf clover | Marsileaceae | Rooted-floating herb | D |
| 29. | *Melastoma malbathricum* | Ban tejpata | Malastomaceae | Shrub | D |
| 30. | *Melochia corchorifolia* | Tikiokra | Sterculiaceae | Herb | C |
| 31. | *Mikania cordata* | Jasorolata | Asteraceae | Herb | D |
| 32. | *Nicotiana bonplandianum* | Ban tamak | Nicotiaceae | Herb | C |
| 33. | *Nymphaea rubra* | Red shapla | Nymphaceae | Rooted Floating herb | D |
| 34. | *Oryza sativa* | Dhan | Poaceae | Herb | D |
| 35. | *Panicum punctatum* | Karinghas | Poaceae | Herb | D |
| 36. | *Persicaria hydropiper* | biskatal | Polygonaceae | Herb | B |

| | | | | | |
|---|---|---|---|---|---|
| 37. | *Persicaria orientalis* | Barobiskatal | Polygonaceae | Herb | B & C |
| 38. | *Phyllanthus reticulatus* | Chitki | Euphorbiaceae | Shrub | D |
| 39. | *Pouzolgia zeylanica* | Kullaruki | Urtiaceae | Herb | B |
| 40. | *Pteris vittata* | Dhakishak | Polypodiaceae | Herb | B, C & D |
| 41. | *Ricinus communis* | Verenda | Euphorbiaceae | Herb | B |
| 42. | *Salvinia natans* | Indurkanipana | Salviniaceae | Free-floating herb | C |
| 43. | *Sacciolepis interrupta* | Nardulla | Poaceae | Herb | A |
| 44. | *Scoperia dulcis* | Bandhuni | Scrophulariaceae | Herb | C |
| 45. | *Spilanthus acmella* | Marhatitiga | Asteraceae | Herb | B |
| 46. | *Synedrella nidiflora* | Nakphul | Asteraceae | Herb | B |
| 47. | *Trapa bispinosa* | Singara | Trapaceae | Free-floating herb | D |

In table 02, a list of macrophytes recorded from the selected 04 Four) sites during research work was presented. A total of 47 species under 30 families of aquatic macrophytes were recorded from the selected four sites. *Eicchornia crassipes* was found in common in all four sites- A, B, C & D. The other most commonly found species were *Alternanthera philoxeroides, Axonopus compressus, Cynodon dactylon, Enhydra flactuans* in site A, B & C and *Colocasia esculenta* and *Pteris vittata* in site B, C & D respectively.

From table 03, it was clear that the highest number of phytoplanktonic occurrences was observed in site – A in the rainy season 1202) and the lowest occurrence was observed in site - C in the same season. Soil moisture content was the highest 21.56 % at the rainy season in site D and lowest 1.46 at winter season in site – A. Maximum water holding capacity of the soil was the highest 46 % at the summer season in site D and lowest 31 % at the rainy season in site – C. Soil $P^H$ value was highest 6.8 at the summer season in site D and lowest 5 in site C in summer and site D in the rainy season. The highest water temperature was recorded in site – C in the summer season $38^0$C) and that of lowest was recorded in site – D in the winter season $22.3^0$C). The highest $P^H$ value recorded was 7.8 in site – A and that of the lowest value recorded in site – B in the rainy season 5.5). The highest TDS value was 3400 mg/L at winter season in site – A and lowest 400 mg/L at the rainy season in site A and at winter in site – D. The highest TSS value 400 mg/L at winter season in site – A and lowest 100 mg/L at summer in site – A and at rainy in site –D. The highest amount of Dissolved Oxygen DO) was calculated in site – D in the rainy season 4.379 mg/L) and that of the lowest value calculated in site – A in the summer season 1.056 mg/L). Biochemical Oxygen Demand value calculated was the highest in site –D in summer season 2.226 mg/L) and the lowest in site – A in summer and rainy season and site – B in the winter season 0.453 mg/L). The highest COD value was 375 mg /L at summer in site – A and the lowest was 35 at winter season in site – D.

**Table 3:** Comparative variation of phytoplanktons, soil and water qualities of selected water bodies namely site –A Hazaribagh), Site – B Hemayetpur), site – C Banktown) and site – D Jahangirnagar University) water body of Dhaka District of Bangladesh

| SL. No. | Name of parameters | Site Name | Summer Season | Rainy Season | Winter Season |
|---|---|---|---|---|---|
| 1. | Phytoplanktonic Occurrence No.) | A | 1052 | 1202 | 989 |
| | | B | 1180 | 1007 | 1043 |
| | | C | 1061 | 923 | 1003 |
| | | D | 1160 | 1071 | 1120 |
| 2. | Soil Moisture Content %) | A | 2.41 | 10.91 | 1.46 |
| | | B | 2.49 | 10.21 | 4.48 |
| | | C | 3.09 | 19.19 | 3.22 |
| | | D | 2.38 | 21.56 | 2.65 |
| 3. | Maximum Water Holding Capacity %) of Soil | A | 40 | 35 | 38 |
| | | B | 42 | 32 | 36 |
| | | C | 44 | 31 | 35 |
| | | D | 46 | 33 | 39 |
| 4. | Soil $P^H$ Value | A | 5.4 | 6.5 | 5.9 |
| | | B | 5.1 | 5.7 | 5.2 |
| | | C | 5 | 5.5 | 5.4 |
| | | D | 6.8 | 5 | 6.7 |
| 5. | Water Temperature $^0$C) | A | 30 | 31 | 38 |
| | | B | 25.8 | 30 | 34 |
| | | C | 38 | 29.5 | 35 |
| | | D | 25 | 26 | 22.3 |
| 6. | Water $P^H$ Value | A | 7.8 | 7.5 | 7.6 |
| | | B | 7.1 | 6.2 | 6.9 |
| | | C | 7.6 | 5.6 | 6.6 |
| | | D | 6.8 | 5.5 | 6.2 |
| 7. | TDS Value mg/L) | A | 680 | 400 | 3400 |
| | | B | 520 | 700 | 800 |
| | | C | 1500 | 1100 | 700 |

| | | | | | |
|---|---|---|---|---|---|
| | | D | 500 | 600 | 400 |
| 8. | TSS Value mg/L) | A | 150 | 300 | 400 |
| | | B | 300 | 180 | 215 |
| | | C | 250 | 250 | 325 |
| | | D | 100 | 100 | 150 |
| 9. | Dissolved Oxygen mg/L) | A | 1.056 | 1.709 | 2.819 |
| | | B | 1.813 | 2.466 | 1.962 |
| | | C | 1.509 | 3.273 | 2.162 |
| | | D | 4.080 | 4.379 | 3.626 |
| 10. | Biochemical Oxygen Demand mg/L) | A | 0.453 | 0.453 | 1.509 |
| | | B | 0.906 | 0.906 | 0.453 |
| | | C | 0.453 | 1.360 | 0.680 |
| | | D | 2.226 | 1.813 | 1.813 |
| 11. | Chemical Oxygen Demand mg/L) | A | 375 | 273 | 324 |
| | | B | 153 | 161 | 154 |
| | | C | 182 | 190 | 131 |
| | | D | 50 | 52 | 35 |

A total of 57 Fifty-Seven) genera under 04 Four) phytoplanktonic classes were recorded. From the total occurrence, it is clear that the highest dominant phytoplanktonic class was Bacillariophyceae total occurrence 5076) followed by Chlorophyceae total occurrence 4053), Cyanophyceae total occurrence 3022) and Euglenophyceae Total occurrence 660) respectively Table 04). The all genera individuals were occurring but they differed in the total number of occurrence during all three seasons and four sites of our research.

**Table 4:** List of recorded phytoplanktons of different classes

| SL No. | Phytoplanktonic Class name | Name of The Occurring Genera of Phytoplanktons | Total Genera | Total Occurrence | Occurring Site |
|---|---|---|---|---|---|
| 1. | Bacillariophyceae | *Navicula, Pinnularia, Fragillaria, Cymbella, Eunptia, Syndra, Melosira, Gomphonema, Nitzschia, Amphora, Cyclotella, Gyrosigma, Opephora, Pleurosigma, Coconis and Hantzschia* | 16 | 5076 | A, B, C & D |
| 2. | Chlorophyceae | *Chlamydomonas, Chlorella, Chlorococcum, Chodatella, Clostarium, Cosmarium, Cylindrocystis, Diatoma, Eustropis, Hydrodictyon, Miarospora, Natrium, Oedogonium,* Pachycladon, *Pediastrum, Penium, Prasiola, Protococcus, Scenedesmus, Chlanydomonas, Saleenetrum, Spirogyra, Tetratesmus, Tetrahedron, Tetralantos, Ulothrix, Volvox and Zygnema* | 28 | 4053 | A, B, C & D |
| 3. | Cyanophyceae | *Anabaena, Anabaenopsis, Dermocarpa, Gteocapsa, Marismooedia, Miarocystis, Nostoc, Ocillatoria and Spirulina* | 10 | 3022 | A, B, C & D |
| 4. | Euglenophyceae | *Euglena, Paranema and Trachulomonus* | 03 | 660 | A, B, C & D |
| Total | | | 57 | 12811 | |

## Conclusion

Seasonal variation is occurring in the aquatic macrophytic vegetation. All the recorded species are not growing homogeneously in the same aquatic environment. A few species die or disappear with the change of the seasons. Variation is not only in seasons but also in sites. *Eicchornia crassipes* is the most commonly occurring aquatic macrophytes in Hazaribagh site-A) Hemayetpur site-B), Banktown site-C) and Jahangirnagar University site –D). Seasonal variation is also occurring in the aquatic phytoplanktonic classes. The occurrence number varies from season to season and also from site to site. Bacillariophyceae was the dominant phytoplanktonic class in the selected four sites of our research. From data of Soil moisture content, maximum water holding capacity of the soil, soil $P^H$ value, water temperature, water $P^H$ value, water TDS value, water TSS value, amount of Dissolved Oxygen DO) and amount of Biochemical Oxygen Demand BOD5) and Chemical Oxygen Demand value, We can conclude that the quality of soil and water of site – D Jahangirnagar University) was much better than site A Hazaribagh), site – B Hemayetpur) site – C Banktown). Such research can be carried out in all 64 districts of Bangladesh leading for higher degree purposes like Ph.D. to assess the scenario in whole Bangladesh perspective.

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