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Planktonic Cyanoprokaryota and Bacillariophyta of East Kolkata Wetlands Ecosystem, a Ramsar Site of India with reference to diversity and taxonomic study.

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Abstract:

The present paper deals with 53 phytoplankton taxa comprising of 34 species belonging to 15 different genera of Cyanoprokaryota and 19 species grouped under 12 genera of Bacillariophyta, recorded from East Kolkata Wetlands, a Ramsar site. Investigation was carried out for a period of 2 years (January 2012 to January 2014). Emphasis was given on taxonomic identification of the recorded taxa including the scanning electron microscopic (SEM) investigation. Dominant taxa recorded were *Chroococcus dispersus, Synechocystis aquatilis, Merismopedia punctata, M. glauca, Pseudoanabaena galeata, P. catenata, Anabaenopsis raciborskii, Navicula halophila, Nitzschia palea, Cyclotella striata* whose further detailed morphology was studied with the help of SEM.

Key words: Bacillariophyta, Cyanoprokaryota,, East Kolkata Wetlands, Phytoplankton, SEM, Taxonomy

Introduction:

Wetlands are one of the most productive ecosystems on Earth (Ghermandi et. al. 2008). As per Ramsar Convention, 26 of the total wetlands are designated as Ramsar sites, among the total of 94 wetlands (natural and manmade) recorded from India (Ramsar Convention, 2012), one of which is East Kolkata Wetlands (EKW) of West Bengal. Wetlands in India may vary from high altitude Himalayan lakes, followed by wetlands in flood plains of river system, coastal wetlands, area under paddy cultivation and so on. On the basis of hydrological, ecological and geological characteristic, wetlands can be classified as marine (coastal wetlands), estuarine (including deltas, mangrove swamps), lacustrine (lakes), riverine (rivers and streams) and palustrine types (marshes, swamps and bogs) (Cowardin et al. 1979). Following this classification, EKW our study site can be grouped under lacustrine wetlands.

Wetlands are known to sustain a varied diversity of both flora and fauna. Flora includes various forms that range from microscopic planktonic algae to macrophytes. In aquatic ecosystem, phytoplanktons play a major role in maintaining the floral diversity as they are the basis of aquatic food chain. Wetlands harbor diverse groups of phytoplanktons, the simplest prokaryotic form being Cyanoprokaryotes (formerly known as Blue Green Algae) and many eukaryotic forms. One such eukaryotic form is Bacillariophyta. Other groups are like Chlorophytes, Chrysophytes, Euglenophytes, Desmids, etc. In our previous study we have described the taxonomy and diversity of planktonic chlorophytes (under communication). This paper deals with diversity study of Cyanoprokaryotes and members of Bacillariophyta.

The first Indian phycologist who took an initiative in studying Cyanonoprokaryotes in India was Kirtikar (1886). From then onwards began the extensive study of Cyanoprokaryotes from different fresh, brakish and marine water bodies, moist soil, and different paddy fields. (Ramakrishnan and Kannan, 1992; Rao, 1998; Venkataraman, 1975).Extensive study of Cyanoprokaryotes and planktonic diatoms has been conducted in different wetlands of India. Deep et al. (2013) enlisted 55 species of Cyanoprokayotes, determining the diversity in wetlands of Sambalpur, Orissa. Sasamal et al. (2005) recorded planktonic diatom bloom formation in the coastal wetlands of Orissa. Wetlands of Assam, which is also designated as Ramsar Site of Bhramaputra river basin had been thoroughly surveyed by Sharma (2015). He recorded 55 taxa of phytoplanktons, with Bacillariophyceae as dominant and Cyanoprokaryotes as subdominant groups. Reports from coastal wetlands in southern and western part of India, also accounts for taxonomic identification (Venkataraman, 1939; Subrahmanyan, 1946). Venkataraman (1939) reported 98 forms of diatoms from Madras coast. Subrahmanyan (1946) also gave a systematic account of 171 forms of planktonic diatom from South Indian coast. 17 different Cyanoprokaryotes were reported by Sivakumar et al. (2012) from the Coastal wetlands of Tamil Nadu.

Many reports of EKW include management programmes to conserve this wetland which spans over the entire eastern outskirts of a metropolitan city, Kolkata for the human benefit; however, very few works dealt with the taxonomy or diversity study of phytoplanktons (Pradhan et al. 2008; Ray Chaudhuri et al. 2007, 2008; Kundu et al. 2008). For diversity and taxonomic study on phytoplankton population no report is available from the study area. The present communication thus deals with the diversity and taxonomic enumeration of planktonic members of Cyanoprokaryota and Bacillariophycean members of East Kolkata Wetlands.

Material and methods:

Study area

The East Kolkata Wetland (EKW) is a complex of natural and human made wetland, situated at the eastern outskirts of the metropolitan city Kolkata, India. 45.93 % of EKW includes manmade water area (Kundu et al. 2008).This pond (Captain Bhery) serves the dual purpose of recycling sewage water of Kolkata metropolitan city and for fish cultivation extensively. This wetland is declared as a "Wetland of International Importance" by Government of India and the Ramsar Convention had declared this wetland as "Ramsar Site no. 1203" in 19th August 2002 (Ramsar Secretariate, 2013). The geographic coordinates of EKW was found to be 88°24.641′ east latitude and 22°33.115' north latitude as determined by GARMIN GPS map 76 CSx device. The study area covers an area of almost 450 m^2 having a depth of 3–4 ft. The sewage water includes municipal waste, agricultural runoff and industrial effluents of urban and semi urban areas. The sampling spots were selected along the transects of the pond and samples were collected from depth of 1.5-2 cm below surface water of the wetlands. No epipelic or benthic flora was recorded.

Sampling and taxonomic identification

Phytoplankton sampling was carried out at a regular interval of 15 days for 2 years from January 2012 to January 2014. Different transects along the sampling spot were chosen for the purpose of sampling. Phytoplankton net of mesh size 20 µ was used for phytoplankton sampling. Approximately 50L of water was passed through the plankton net and ultimately concentrated to 300ml containing huge plankton population. It was then preserved in 4% formalin and brought back to the laboratory for taxonomic identification with the help of standard keys using monograph and relevant available literature viz. Prescott (1982), Desikachary (1959), Komarek and Anagnostidis (1999, 2005, 2013), Husted (1930). Samples were viewed under low, high and oil immersion objective of Carl- Zeiss Axiostar microscope and microphotographs of these samples were taken using a digital camera (Canon T2-T2 1,6x SLR 426115).

Scanning Electron Microscopic study

Phytoplankton samples were washed with saline phosphate buffer (PBS) for 2-3 times and then centrifuged at 8000 rpm. A drop of washed material was taken on a glass cover slip (Blue Star) and dried at 20°C. The samples were repeatedly washed with different ethanol grade and dried at room temperature. After complete dehydration the cover slips were placed on carbon tape and put in Quorum (Q 150 TES) gold coater to coat the samples with gold. Images have been taken at different magnification with the use of Carl Zeiss EVO 18 (EDS 8100) microscope with Zeiss Inca Penta FETX 3 (Oxford instruments) attachment.

Results:

A total of 53 taxa of Cyanoprokaryota and Bacillariophyta along with their seasonal abundance have been recorded (Table 1). Systematic enumeration of Cyanoprokaryotes and Bacillariophycean members had been based on Komarek and Anagnostidis classification (1999, 2005 and 2013) and Husted (1930) respectively. Out of 53 planktonic taxa, 10 species were found to be dominant and can be reffered to as major taxa. These are: *Chroococcus dispersus, Synechocystis aquatilis, Merismopedia punctata, M. glauca, Pseudoanabaena galeata, P. catenata, Anabaenopsis raciborskii, Nitzschia palea, Navicula halophila, Cyclotella striata.* SEM observation was carried out for these 10 species for detailed study as distinct cell wall morphology and constrictions on the wall are not properly distinct in light microscopy. Taxonomic enumerations of the identified taxa are as follows:

PHYLUM- CYANOPROKARYOTA-I

ORDER- CHROOCOCCALES

FAMILY- MERISMOPEDIACEAE

1. *Merismopedia minima* Beck (Fig. 1a)

(Geitler, 1932, p.129 c; Desikachary, 1959, pl. 29, fig. 6; Komarek and Anagnostidis 1999, p. 175, fig. 222)

Cells pale blue-green, 4 to many in small colonies, 0.5-0.6µm broad, free swimming, groups of four cells 2-3 × 3µm.

2. *Merismopedia punctata* Meyen (Fig. 1b)

(Geitler, 1932, p. 129 c; Desikachary, 1959, pl. 23, fig. 5 and pl. 29, fig. 6; Komarek and Anagnostidis, 1999, p. 172, fig. 222)

Colonies small, 4-64 cells, about 60 µm broad; cells not closely packed, spherical or ovoid, 2.5-3.5µm broad, pale blue-green.

SEM observation: Distinct cell wall morphology visible (fig. 4e).

3. *Merismopedia glauca* (Ehrenberg) Naegeli (Fig. 1c)

(Desikachary, 1959, pl. 29, fig. 5; Komarek and Anagnostidis, 1999, p. 172, fig. 222)

Colonies mostly small with 16-64 cells, 45-50 µm diameter; cells spherical or oval, closely arranged, 3-6 µm broad, pale blue-green.

SEM observation: Cell wall clearly visible. Smooth wall, with distinct constriction between the adjacent cells (fig. 4d)

4. *Merismopedia Trolleri* Bachmann (Fig. 1d)

(Precott, 1982, pl. no. 101, fig. 5)

Colonies containing 8-16 cells, each with a distinct sheath, cell contents with pseudovacuoles, appearing brownish or purplish because of light refraction; cells 2-3.5 µm diameter.

5. *Synechocystis aquatilis* Sauvageau (Fig. 1o)
(Desikachary, 1959, pl. 25, fig. 9; Komarek and Anagnostidis, 1999, p. 172, fig. 222)
Cells spherical, single or in twos, 4-6 µm broad, pale blue-green.
SEM observation: Cell wall smooth. Constriction between the cells distinctly visible (fig. 4a)

6. *Coelosphaerium pallidum* Lemmermann (Fig. 2e)
(Prescott, 1982, pl. 106, fig. 3; Komarek and Anagnostidis, 1999, p. 172, fig. 222)
An ovate colony of small, ovate cells crowded; cell contents pale blue-green, without pseudovacuoles; cells 1-2.5 µm in diameter, 2-3.5µm long.

FAMILY- SYNECHOCOCCACEAE
7. *Synechococcus elongatus* Naegeli (Fig. 1n)
(Geitler, 1932, p.273, fig. 133 a-c; Desikachary, 1959, pl. 25, figs. 7, 8; Komarek and Anagnostidis, 1999, p. 123, fig. 137)
Cells cylindrical, 1.4-2 µm broad, 1½-3 times as long as broad, single or 2-4 cells together, contents homogeneous and light blue-green.

8. *Rhabdoderma irregulare* (Naumann) Geitler (Fig. 1t)
(Prescott, 1982, pl. 103, figs. 9, 10)
Colony consisting of sigmoid, cylindrical cells irregularly arranged within a copious, gelatinous envelope; cells 1-2 µm in diameter, 4.5-6 µm long.

9. *Rhabdoderma lineare* Schmidle and Lauterborn in Schmidle (Fig. 2a)
(Prescott, 1982, pl. 103, figs. 11, 12)
Colony consisting of cylindrical, nearly straight cells, colonial envelope transparent and wide; cells 1-2 µm in diameter, 8-10 µm long; cell contents blue-green, homogeneous.

10. *Rhabdogloea rhaphidioides* (R. Et. E Chodat) Komarek (Fig. 2c)
Basionym- *Dactylococcopsis rhaphidioides*
(Geitler, 1932, p.281, fig.137; Desikachary, 1959, p. 158, pl. 29, fig. 3; Prescott, 1982, pl. no. 105, figs. 13-15 all as *Dactylococcopsis rhaphidioides;* Komarek and Anagnostidis 1999, p. 105, fig. 108)
Cells elongate- fusiform, seldom straight, usually arcuate or sigmoid, narrowed but not sharply pointed at the poles, arranged in colonies of 2-8 within a hyaline, gelatinous envelope; cells 1-3 µm in diameter, 5-20 µm long.

11. *Rhabdogloea Smithii* (Chodat and Chodat) Komarek (Fig. 2d)
Basionym - *Dactylococcopsis Smithii*
(Prescott, 1982, pl. 105, figs. 3, 4 as *Dactylococcopsis Smithii*; Komarek and Anagnostidis 1999, p. 105, fig.109)
Colony ovate or nearly broadly fusiform, containing 2-8 fusiform cells which are nearly straight or slightly arcuate; on end of the cell pointed and the other bluntly rounded; cells 3-4 µm in diameter, 10-15 µm long.

12. *Rhabdogloea fascicularis* (Lemmermann) Keshri and Shikdar comb. nov. (Fig. 2g)
Basionym - *Dactylococcopsis fascicularis*
(Geitler, 1932, p. 283, fig. 138b; Desikachary 1959, p.158, pl. 29, fig. 3; Prescott, 1982, pl. 105, figs. 10-12 all as *Dactylococcopsis fascicularis*)
Colonies composed of 2-8 elongate, arcuate or spirally sigmoid cells tapering to fine points at the poles, compactly twisted, cells 1-1.5 µm in diameter, 10-15 µm long.

FAMILY- MICROCYSTACEAE
13. *Microcystis aeruginosa* Kuetzing (Fig. 2j)
(Prescott, 1982, pl. 101, fig. 5)
A free-floating or sedentary colony of numerous spherical cells closely and irregularly arranged within copious mucilage, forming ovate, globose, or irregularly shaped masses; cell contents pale or bright blue-green.

FAMILY- CHROOCOCCACEAE
14. *Chroococcus limneticus* Lemmermann (Fig. 1j)
(Geitler, 1932, p. 234, fig. 113a; Desikachary, 1959, pl. 26, fig. 2; Komarek and Anagnostidis 1999, p.209, fig. 382)
Colonies blue green, cells spherical or subspherical after division, 2-20, free floating in a gelatinous layer, without sheath cells 6-6.5 µm diameter, with sheath 8-14µ diameter, sheath colourless; cells are blue-green.

15. *Chroococcus dispersus* (V. Keissler) Lemmermann (Fig. 1k)
(Geitler, 1932, p. 233, fig. 113d; Desikachary, 1959, p.106; Prescott, 1982, pl. 100, fig. 7, Komarek and Anagnostidis, 1999, p. 286, fig. 373)
Free-floating mucilaginous colony with 4-8 cells, either solitary and then widely separated from each other or in groups isolated from each other, blue-green, without sheath 3-4 µm broad, with sheath 5-6 µm broad.
SEM observation: Cell wall smooth with distinct constrition between the two cells (fig. 4b)

16. *Chroococcus dispersus* var. *minor* G.M.Smith (Fig. 1l)
(Prescott, 1982, pl. 100, figs. 1-3)
A variety of *Chroococcus dispersus* having smaller cells, 1.5-2 µm in diameter, cells without sheath.

17. *Chroococcus turgidus* (Kuetzing) Naegeli (Fig. 1m)
(Desikachary, 1959, pl. 26, fig. 6)

Cells spherical to ellipsoidal, single or in groups, blue-green, without sheath 15-25 µm diameter, with sheath 20-30 µm diameter, sheath colourless, cell contents coarsely granular.

FAMILY- GOMPHOSPHAERIACEAE

18. *Gomphoshpaeria aponina* Kuetzing (Fig. 2f)

(Komarek and Anagnostidis, 1999)

Cells pyriform or cordate in stages of division, usually within wide gelatinous sheath; cells 4-5 µm in diameter, 8-12 µm long.

PHYLUM- CYANOPROKARYOTA-II

ORDER- OSCILLATORIALES

FAMILY- PSEUDOANABAENACEAE

SUBFAMILY- SPIRULINOIDEAE

19. *Spirulina subsalsa* Oersted ex Gomont (Fig. 1p)

(Geitler, 1932, p. 150, fig. 176; Desikachary, 1959, pl. 36, figs. 3, 9; Komarek and Anagnostidis, 2005, p. 150, fig. 176)

Trichomes 1-2 µm broad, blue-green, mostly somewhat irregularly densely spirally coiled, rarely regularly coiled forming bright blue-green or yellowish green thallus; spirals very close to each other, 3-5 µm broad.

20. *Spirulina Nordstedtii* Gomont (Fig. 1s)

(Prescott, 1982, pl. 108, fig. 12; Komarek and Anagnostidis, 2005, p. 148, fig. 175)

Trichomes closely and regularly spiraled, 2 µm diameter, spiral 4-7 µm, distance between spirals 2-5 µm in diameter, cell contents pale or bright blue-green.

21. *Spirulina subtilissima* Kuetzing ex Gomont (Fig. 1q)

(Desikachary, 1959, pl. 36, fig. 10; Komarek and Anagnostidis, 2005, p. 144, fig. 168)

Trichome 0.3-0.9 µm broad, regularly spirally coiled, blue-green or yellowish, spirals 1.5-2.5 µm broad, distance between spirals 1.25-2 µm.

22. *Spirulina laxissima* West,G.S. (Fig. 1r)

(Desikachary, 1959, pl. 36, fig. 5; Komarek and Anagnostidis, 2005, p. 141, fig. 160)

Trichome 0.7-0.8 µm broad, blue-green, spirals very loose, but regular, 4.5-5.3 µm broad; 12-18 µm distant from each other, end cells rounded, obtuse.

SUBFAMILY- PSUEDOANABAENOIDEAE

23. Pseudoanabaena catenata Lauterborn (Fig. 2h)

(Komarek and Anagnostidis, 2005, p. 82, fig. 59)

Filamentous; filaments solitary straight or slightly waved, simple, without branching, 0.8-3 µm wide, composed of cylindrical cells, usually with slight constrictions at the distinct cross-walls.

SEM observation: Cell wall smooth with distinct constriction between the two cells (fig. 4c)

24. *Pseudoanbaena galeata* Bocher (Fig. 2i)

(Komarek and Anagnostidis, 1992, p.87, fig. 67)

Filamentous; filaments solitary straight or slightly waved, simple, without branching, cells longer than wide, 0.8-2 µm wide, 1.5-3.5 µm long.

SEM observation: Cell wall morphology clearly visible. Two cells Cell wall smooth with distinct constriction between the two cells (fig. 4f).

SUBFAMILY- LEPTOLYNGBYOIDEAE

25. *Planktolyngbya contorta* (West, G.S.) Anagnostidiset Komarek (Fig. 1e)

(Komarek and Anagnostidis, 2005, pl. 163, fig. 196)

Filaments solitary, free floating , spirally coiled, 2-2.5 µm wide, coils 33-35 µm broad, making 1-2 turns, sheaths thin, colourless, trichomes pale blue-green.

FAMILY- OSCILLATORIACEAE

SUBFAMILY- OSCILLATORIOIDEAE

26. *Oscillatoria subbrevis* Schmidle (Fig. 1u)

(Desikachary, 1959, pl. 37, fig. 2, pl. 40, fig. 1; Komarek and Anagnostidis, 2005, p. 588, fig. 877)

Trichomes single, 5-6 µm broad, nearly straight, not attenuated at the apices; cells 1-2 µm long, not granulated at cross-walls; end cell rounded, calyptra absent.

27. *Oscillatoria limnetica* Lemmermann (Fig. 1v)

(Desikachary, 1959, pl. 37, fig. 3)

Trichome straight or slightly bent, distinctly constricted at the cross-walls, pale blue-green; 1.5 µm broad, not attenuated, not capitate; cells 2-4 times as long as broad, 4-8µ long; end cells rounded, calyptra absent.

28. *Oscillatoria rubescens* DC ex Gomont (Fig. 1x)

(Desikachary, 1959, pl. 42, fig. 12)

Trichomes straight,at the ends gradually attenuated, 2-4 µm broad, not constristed at the cross-walls, sometimes forming purple red, or violet, free-swimming; cells ½ - ⅓ as long as broad, end cells capitate.

29. *Oscillatoria acutissima* Kufferath (Fig. 1w)

(Prescott, 1982, pl. 109, fig. 1)

Trichomes solitary or scattered, gradually tapering at the apex, which is slightly curved or bent, apical cell acute-conical; with a calyptra; cells 1-2 µm diameter, not constricted at cross-walls.

FAMILY- GOMONTIELLACEAE

30. *Cyanarcus hamiformis* Pascher (Fig. 2b)

(Prescott, 1982, pl. 103, figs. 7, 8)

Unicellular, cells 0.5-0.75 µm in diameter, 3-4µ long, cells strongly curved, describing ½ to ⅔ of a circle.

PHYLUM- CYANOPROKARYOTA- III

ORDER- NOSTOCALES

FAMILY- NOSTOCACEAE

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31. *Anabaenopsis tanganyikae* (West, G.S.) Wolosz.et Miller (Fig. 1f)
(Desikachary, 1959, pl. 63, figs. 4, 8)
Trichomes free-swimming, very short, spirally coiled, 1-2 µm , mostly 1-½ spirals; without sheath; trichomes not constricted at the cross-walls; cells cylindrical, 2-3 times longer than broad, 3-5 µm long, without gas vacuoles; heterocyst ellipsoidal, 3×5 µm.

32. *Anabaenopsis circularis* (West, G.S.) Wolosz.et Miller (Fig. 1g)
(Desikachary, 1959, pl. 63, fig. 5)
Trichomes free-swimming, very short, mostly spirally coiled, with 1-1½spirals, 4-5 µm broad; cells spherical, granular; heterocyst spherical, 3-5 µm broad.

33. *Anabaenopsis arnoldii* Aptekarj (Fig. 1h)
(Desikachary, 1959, pl. 5, figs. 2, 7)
Trichome with a thick gelatinous sheath, spirally coiled, ½-9 spirals, cells spherical, seldom nearly ellipsoidal, 5-6 µm broad, with gas vacuoles, heterocyst intercalary or terminal.

34. *Anabaenopsis raciborskii* Wolosz. (Fig. 1i)
(Desikachary, 1959, pl. 63, figs. 6, 7)
Filaments short, either straight or seldom spirally coiled, with 1-2 ½ spirals, not constricted at the cross-walls, with a heterocyst at either end; cells cylindrical, without gas vacuoles, 2-3 times longer than broad; heterocyst 1-2.5 µm broad.
SEM observation- distinct cell wall morphology visible (fig. 4g)

PHYLUM- BACILLARIOPHYTA
CLASS- BACILLARIOPHYCEAE
SUBCLASS - BACILLARIOPHYCIDAE
ORDER - NAVICULALES
SUBORDER - NAVICULINEAE
FAMILY - NAVICULACEAE

35. *Navicula cryptocephala* Kuetzing (Fig. 2q)
(Husted, 1930, p. 296, fig. 496; http://westerndiatoms.colorado.edu/taxa/species)
Valves are lanceolate with protracted apices. The axial area is narrow and straight. The central area is large and circular. The raphe is straight, with 'drop-like' expanded external proximal ends. Striae are radiate around the center, becoming convergent at the apices.

36. *Navicula peregrine* (Ehrenberg) Kuetzing (Fig. 3e)
(Husted, 1930, p. 300, fig. 516; http://westerndiatoms.colorado.edu/taxa/species)
Valves are lanceolate with obtusely rounded ends. The axial area is narrow and widens gradually into a more or less circular central area. The central area is about one-half as wide as the valve. The raphe is weakly lateral, with expanded proximal ends that are slightly deflected to the primary side. Striae are radiate, becoming convergent near the ends.

37. *Navicula tripunctata* (O.F. Muller) Bory de Saint-Vincent (Fig. 3c)
(Lange-Bertalot, 2001; Aboal et al. 2003; http://westerndiatoms.colorado.edu/taxa/species.)
Valves are linear-lanceolate with wedge-shaped ends, 6-10 µm wide and 32-60 µm long. The raphe is straight. The axial area is narrow, linear, with the central area transversely rectangular or elliptical. The striae are almost parallel throughout the valve, weakly radiate in the middle.

38. *Navicula phyllepta* Kuetzing (Fig. 2l)
(Aboal et al. 2003)
Valves elliptical-lanceolate, narrowed towards end somewhat rostrate apices, axial area narrow, valves length 12-45 µm, striae 14-20 in 10µm.

39. *Craticula cuspidata* (Kuetzing) D. G. Mann (Fig. 3a)
Basionym- *Navicula cuspidata* (Kuetzing) Kuetzing
(Husted, 1930, p. 269, fig. 433; as *Navicula cuspidata*; Aboal et al. 2003; http://westerndiatoms. colorado.edu /taxa/species)
Valves rhombic to elliptic lanceolate with rounded and slightly constricted ends. Axial area narrow, central area slightly broadened. Length 20-50 µm, breadth 2-20 µm.

40. *Craticula halophila* (Grunow) D. G. Mann (Fig. 2p)
Basionym- *Navicula halophila* (Grunow) Cleve
(Husted, 1930, p. 269, fig. 436; as *Navicula* halophila, Aboal et al. 2003; http://www.algaebase .org/search/species/detail/?species)
Valves boat–shaped and more or less rectangular in girdle view. Cells longer than broad.
SEM observation: Striae uniseriate, slightly punctuated, each composed of 7-14 irregularly shaped, coarse foramina. Valve surface almost flat. Central raphae raised above the valve surface. Raphae end simply terminating in simple helictoglossa (fig. 4i)

41. *Cymbella lanceolata* (C. Agardh) C. Agardh (Fig. 3d)
Basionym- *Navicula lanceolata* (C. Agardh) Kuetzing
(Husted, 1930, p. 305, fig. 540, as *Navicula lanceolata*; Aboal et al. 2003)
Valves linear- rectangular, with obtuse end walls. Striae in longitudinal rows, fine in nature. Length- 8-10 µm, breadth- 3-4 µm.

FAMILY- PLEUROSIGMATACEAE

42. *Pleurosigma angulatum* (Quekett) W. Smith (fig. 3b)
(Husted, 1930, p. 227, fig. 342)
Valves lanceolate, slightly sigmoid, ends sub-acute, 50-60 µm long, 5-7 µm broad. Raphae more sigmoid than valve,

excentric near the ends. Transverse and oblique striae, equidistant.

ORDER - THALASSIOPHYSALES
FAMILY - CATENULACEAE

43. *Amphora coffeaiformis* (C. Agardh) Kuetzing (Fig. 3f)
(Husted, 1930, p. 344, fig. 634)
Frustules in girdle view elliptic lanceolate, truncate. Valves arcuate on the dorsal margin and straight or slightly concave on the ventral margin. Ends of the valves slightly protracted and capitates. Striae delicate. Length 8-10 µm, breadth- 3-4 µm.

ORDER- MASTOGLOIALES
FAMILY- ACHNANTHACEAE

44. *Achnanthes* sp. Bory de Saint-Vincent (Fig. 3g)
(Husted, 1930, p. 200, fig. 273-286; Scott and Thomas, 2005)
The frustules are heterovalvar. The raphae valve usually posses a central area of thickened silica, called fascia or staurus. The striae are uni-, bi- or triseriate and composed of areolae covered by complex sieve plates.

ORDER- BACILLARIALES
FAMILY- BACILLARIACEAE

45. *Nitzschia acicularis* (Kuetzing) W. Smith (Fig. 3l)
(Husted, 1930, p.423, fig. 821; Aboal et al. 2003; http://westerndiatoms.colorado.edu/taxa/species)
The central part of the valve has nearly parallel sides and a sharp tapering. The extended distal portions of the valve are tapered towards fine apices. The striae are not visible with light microscopy.

46. *Nitzschia frustulum* (Kuetzing) Grunow (Fig. 2q)
(Husted, 1930, p. 414, fig. 795; Aboal et al. 2003)
Frustules isopolar, bilaterally symmetrical. Cells lie in valve or girdle view and isolated valves always in valve view. Valves bilaterally symmetrical, linear to lanceolate, with sub-rostrate poles. Striae clearly visible under light microscope. Length 5-50µm, width 3-5µm.

47. *Nitzschia palea* (Kuetzing) W. Smith (Fig. 3i)
(Opute, 1974; Husted, 1930, p. 414, fig. 801)
Valves linear to lanceolate with short wedge-shaped tapering ends. Length 40-50µm, breadth 3-5µm.
SEM observation: Valve margins symmetric, convex on both sides. Central part of the cell showing large central interspace, eccentric raphae divided by central nodule-fibulae regularly spaced (fig. 4h)

48. *Nitzschia fruticosa* (Fig. 3h)
(Husted, 1930 ; Aboal et al, 2003)
More than one valves giving a rosette shaped appearance. Valves linear to lanceolate with short wedge-shaped tapering ends. Length 20-30 µm, breadth 2-5 µm.

49. *Pseudonitzschia* sp. Peragallo (Fig. 2o)
(Husted, 1930)
Cells are narrow and fusiform or boat-shaped, united in stepped chains with overlapping valve ends. Chains are motile. Cells are yellow brown in colour. The valve face is covered with slits and pores. The raphe is off-centric and not raised above the valve.

CLASS - MEDIOPHYCEAE
SUBCLASS - THALASSIOSIROPHYCIDAE
ORDER - LEPTOCYLINDRALES
FAMILY- LEPTOCYLINDRACEAE

50. *Leptocylindrus danicus* Cleve (Fig. 3m)
(Scott and Thomas, 2005; http://westerndiatoms.colorado.edu/taxa/species)
The weakly silicified cells are cylindrical and occur in chains. Cell length (pervalvar axis) is normally 3-5 times the cell width (diameter). Adjacent cells are closely abutted. The valve of one cell is slightly convex, while the adjacent valve is slightly concave.

51. *Aulacoseira granulata* (Ehrenberg) Simonsen (Fig. 2k)
(Hauk, 2003, p. 20, pl. 25, figs. 1-10, pl. 26, figs. 1-4)
Basionym- *Gaillonella granulata* Ehrenberg 1843
Frustules are cylindrical, join face-to-face and form filamentous colonies. Valves are 4-17 µm in diameter, with a mantle height of 4-20 µm. The ratio of the mantle height to valve diameter is usually greater than 0.8 but less than 5. The mantle has straight sides and the valve face is flat. The mantle areolae are square. Linking spines are located at the end of each pervalvar costa. Linking spines are short, triangular or bifurcated.

ORDER- THALASSIOSIRALES
FAMILY- THALASSIOSIRACEAE

52. *Thalassiosira weissflogii* (Grunow) Fryxell and Hasle (Fig. 3j,k)
(http://westerndiatoms.colorado.edu/taxa/species)
Basionym- *Micropodiscus weissflogii* Grunow in Van Heurck 1880
Valves are round, flat, with short mantles. The frustules are relatively lightly silicified. Areolae are fine and details of their structure are not visible with the light microscope A single, prominent rimoportula is present on the margin of the valve.

FAMILY- STEPHANODISCACEAE

53. *Cyclotella striata* (Kuetzing) Grunow (Fig. 2m)
(Husted 1930, p. 99, fig. 71; Heft 10, p. 100, fig. 67)

Cells disc- shaped, 6-18 µm in diameter. Valves with more or less broad, evenly striated border, striae 10-12 in 10 µm. central portion with pflexesand coarsely punctuate.

SEM observation- The marginal zone consists of ridges separated by furrows. The shape of ridges is rectangular. Areolae perforate the cell wall in the marginal zone. Grabuels cover the entire outer valve surface and sometimes form dendritic silica structure. Spines present at the end of furrows on the valve face. They are conical (fig. 4j, k)

Discussion:

East Kolkata Wetlands of West Bengal, India, contributes dual roles in sewage treatment which largely depends on phytoplankton population, the main contributor in primary production in one hand and also helps in cleaning the pollutants (Pradhan et. al., 2008). One of the important aspect of this particular wetland is that, unlike others viz. Delta Marsh, bogs, fens etc. it showed no benthic algal growth but only phytoplanktons, “the free wanderers”. Therefore floristic study of phytoplankton population is important in ecological point of view also. This wetlands is also economically important for fish production, where phytoplanktons are directly consumed by fishes. Similar type of studies on phytoplankton diversity of coastal West Bengal revealed that the seasonal variation and salinity level control the phytoplankton abundance (Choudhury and Pal, 2010, 2011, 2012).

Total 53 taxa comprising of both Cyanoprokaryota and Bacillariophyta have been reported in this communication and other 61 taxa from Chlorophyta have already been communicated (data unpublished). Therefore total 114 phytoplankton taxa have been reported from 2 years’ regular samplings. From the investigation it became clear that the phytoplankton community of this wetland is dominated by Chlorophyte population throughout the year and the Cyanoprokaryota was found to be the second dominant group showing maximum abundance in winter and least abundance during summer. However, members of *Chroococcus* sp., *Merismopedia* sp., *Synechococcus* sp. and *Spirulina* sp. flourished throughout the year with maximum abundance in winter mainly. Whereas Bacillariophycean members were recorded throughout the year but their population size is much smaller than that of Cyanoprokaryota and Chlorophyta.

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Table 1: List of seasonal abundance of recorded planktonic Cyanoprokaryota and Bacillariophyta:

Sl.no.	Name of the taxa	Seasonal abundance of the recorded taxa				
		summer	monsoon	autumn	winter	spring
	CYANOPROKARYOTA					
1.	*Merismopedia minima*	++	++	++	++++	+++
2.	*M. punctata*	++	++	++	++++	+++
3.	*M. glauca*	++	++	++	++++	+++
4.	*M. Trolleri*	++	++	++	++++	+++
5.	*Synechocystis aquatilis*	+	+	++	++++	+++
6.	*Coelosphaerium pallidum*	+	+	++	++++	+++
7.	*Synechococcus elongates*	++	++	++	++++	+++
8.	*Rhabdoderma irregulare*	+	+	++	++++	+++
9.	*R. lineare*	+	+	++	++++	+++
10.	*Rhabdogloea raphidoides*	+	+	++	++++	+++
11.	*R. Smithii*	+	+	++	++++	+++
12.	*R. fascicularis*	+	+	++	++++	+++
13.	*Microcystis aeruginosa*	+	+	++	++++	+++
14.	*Chroococcus limneticus*	++	+	++	++++	+++
15.	*C. disperses*	++	+	++	++++	+++
16.	*C. disperses var. minor*	++	+	++	++++	+++
17.	*C. turgidus*	++	+	++	++++	+++
18.	*Gomphosphaeria aponina*	+	+	+	++++	++
19.	*Spirulina subsalsa*	++	++	++	++++	+++
20.	*S. Nordstedtii*	++	++	++	++++	+++
21.	*S. subtilissima*	++	++	++	++++	+++
22.	*S. laxissima*	++	++	++	++++	+++
23.	*Pseudoanabaena catenata*	++	++	++	++++	+++
24.	*P. galeata*	++	++	++	++++	+++
25.	*Planktolyngbya contorta*	+	+	+	++++	+++
26	*Oscillatoria rubescens*	+	+	+	++++	+++
27.	*O. subbrevis*	+	+	+	++++	+++
28.	*O. limnetica*	+	+	+	++++	+++
29.	*O. acutissima*	+	+	+	++++	+++
30.	*Cyanarcus hamiformis*	++	++	++	++++	+++
31.	*Anabaenopsis tanganyikae*	++	++	++	++++	+++
32.	*A. circularis*	++	++	++	++++	+++
33.	*A. arnoldii*	++	++	++	++++	+++
34.	*A. raciborskii*	++	++	++	++++	+++
	BACILLARIOPHYTA					
35.	*Navicula crytocephala*	++	++	++	++	++
36.	*N. tripunctata*	++	++	++	++	++
37.	*N. peregrine*	++	++	++	++	++
38.	*N. phyllepta*	++	++	++	++	++
39.	*Craticula cuspidata*	++	++	++	++	++
40.	*C. halophila*	++	++	++	++	++
41.	*Cymbella lanceolata*	++	++	++	++	++
42.	*Pleurosigma angulatum*	++	++	++	++	++
43.	*Acnanthes sp.*	+	+	+	+	+
44.	*Amphora coffeaiformis*	+	+	+	+	+
45.	*Nitzschia acicularis*	++	++	++	++	++
46.	*N. frustulum*	++	++	++	++	++

47.	*N. palea*	++	++	++	++	++
48.	*N. fruticosa*	++	++	++	++	++
49.	*Leptocylindrus danicus*	+	+	+	+	+
50.	*Aulacoseira granulata*	+	+	+	+	+
51.	*Thalassiosira weissflogii*	+	+	+	+	+
52.	*Cyclotella striata*	+	+	+	+	+
53.	*Pseudonitzschia sp.*	+	+	+	+	+

(+ - least abundant, ++ - less abundant, +++ - abundant, ++++ - Highly abundant)

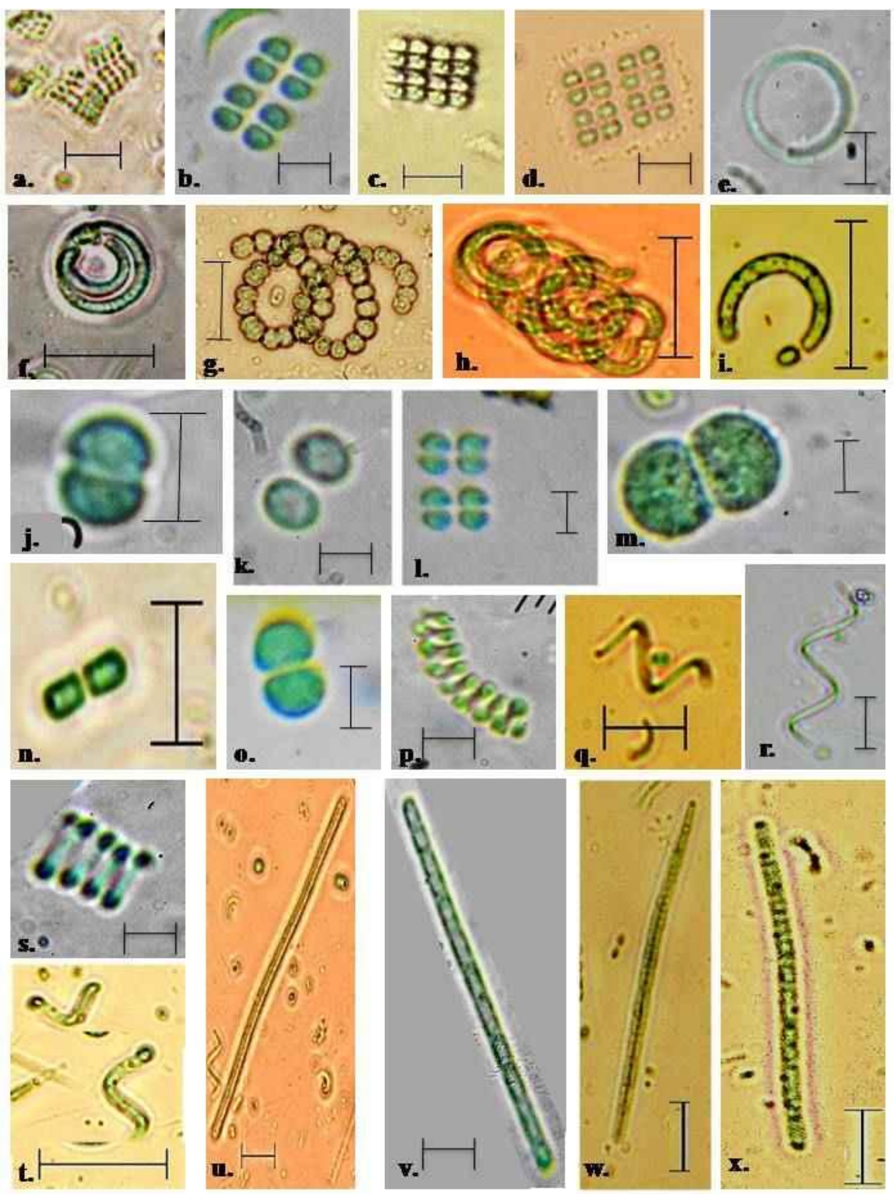

Figure 1 (10µm scale) Microphotographs of:
a. *Merismopedia minima*, b. *M. punctata*, c. *M. glauca*, d. *M. trollei*, e. *Planktolyngbya contorta*, f. *Anabaenopsis tanganyikae*, g. *A. circularis*, h. *A. arnoldii*, i. *A. raciborskii*, j. *Chroococcus limneticus*, k. *C. dispersus*, l. *C.dispersus* var. *minor*, m. *C. turgidus*, n. *Synechococcus elongatus*, o. *Synechocystis aquatilis*, p. *Spirulina subsalsa*, q. *S. subtilissima*, r. *S. laxissima*, s. *S. Nordstedtii*, t. *Rhabdoderma irregulare*, u. *Oscillatoria subbrevis*, v. *O. limnetica*, w. *O acutissima*, x. *O. rubescens*.

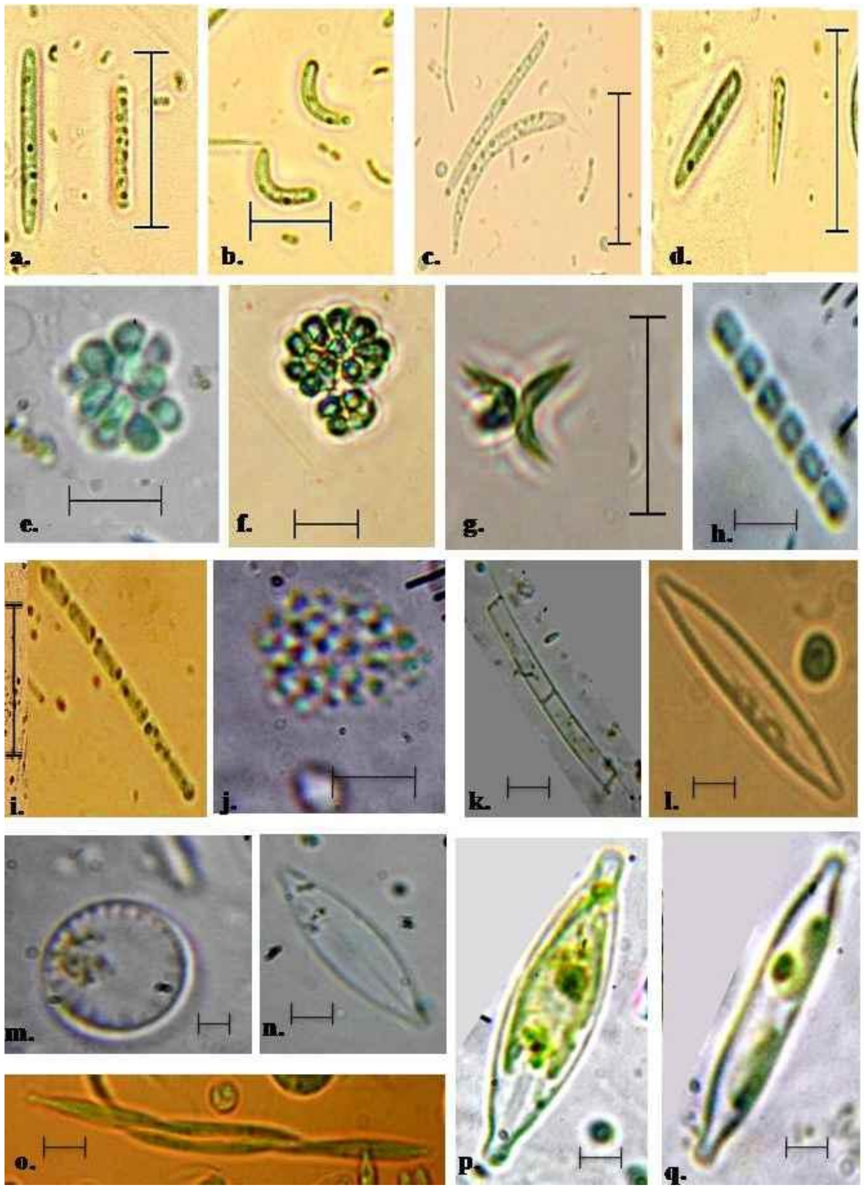

Figure 2 (10µm scale) Microphotographs of:
a. *Rhabdoderma lineare*, b. *Cyanarcus hamiformis*, c. *Rhabdogloea rhaphidioides*, d. R. Smithii, e. *Coelosphaerium pallidum*, f. *Gomphosphaeria aponina*, g. *Rhabdogloea fascicularis*, h. *Pseudoanabaena catenata*, i. *P. galeata*, j. *Microcystis aeruginosa*, k. *Aulacoseira granulata* , l. *Navicula phyllepta*, m. *Cyclotella stiata*, n. *Navicula cryptocephala*, o. *Pseudonitzschia* sp., p. *Craticula halophila*, q. *Nitzschia frustulum*.

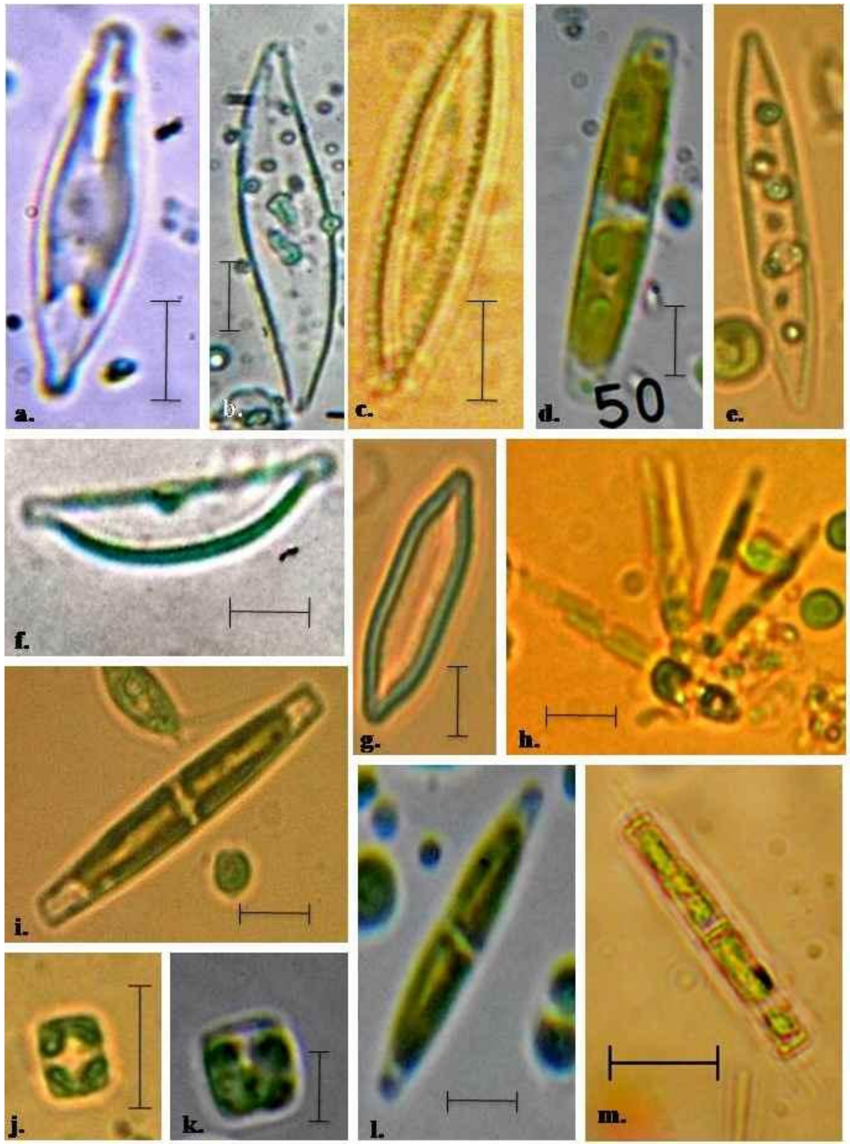

Figure 3 (10 µm scale) Microphotographs of:
a. *Craticula cuspidata*, b. *Pleurosigma angulatum*, c. *Navicula tripunctata*, d. *Cymbella lanceolata*, e. *Navicula peregrine*, f. *Amphora coffeaeformis*, g. *Acnanthes* sp., h,i. *Nitzschia fruticosa*, j,k. *Thalasiosira weissflogii*, l. *Nitzschia acicularis*, m. *Leptocylindrus danicus*.

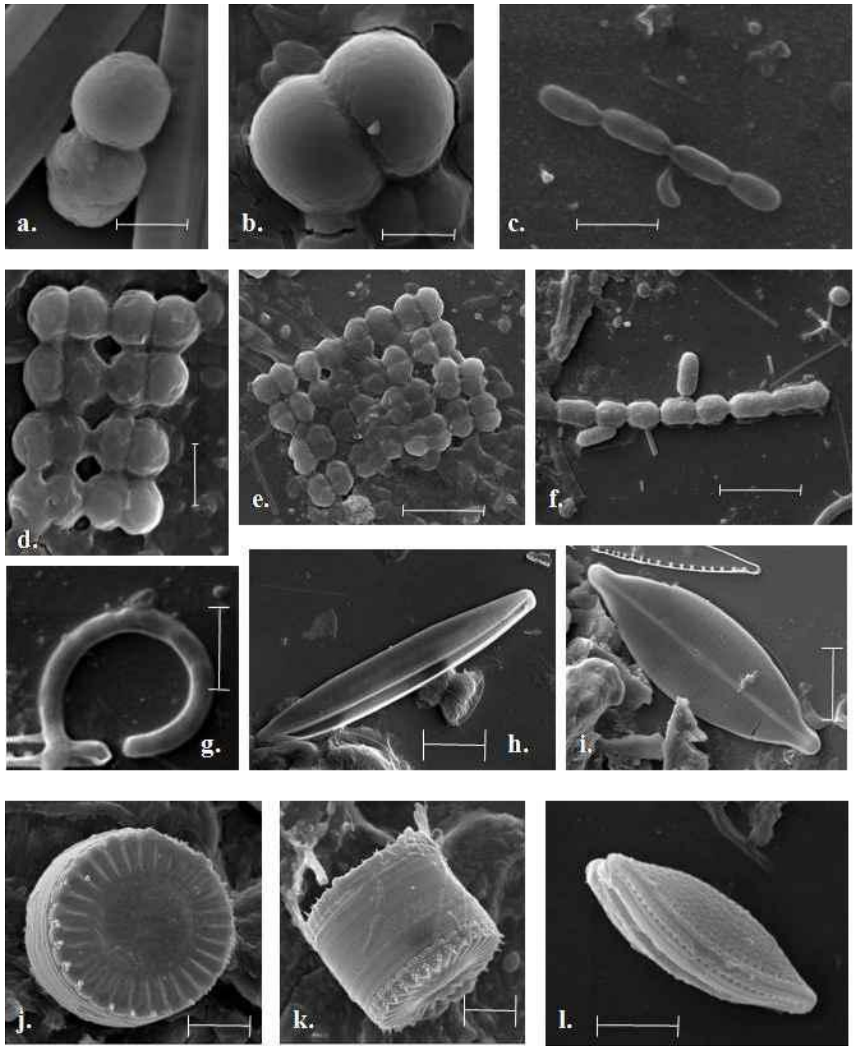

Figure 4 (2 µm scale) SEM Microphotographs of:
a. *Synechocystis aquatilis*, b. *Chroococcus dispersus*, c. *Pseudoanabaena galeata*, d. *Merismopedia glauca*, e. *M. punctata*, f. *Pseudoanabaena catanata*, g. *Anabaenopsis raciborskii*, h. *Nitzschia palea*, i.`2 *Navicula halophila*, j. *Cyclotella stiata*, k. Side view of *Cyclotella striata*, l. *Nitzschia* sp.