Journal of Algal Biomass Utilization
J. Algal Biomass Utln. - Copyright © PHYCOSPECTRUM
ISSN: 2229 – 6905

Diatom flora of Kanekal reservoir, Ananthapuramu district, Andhra Pradesh, India.

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Abstract

Diatoms are the most species-rich group of the eukaryotic algae, consisting of more than 10,000 described species and potentially cryptic species, found in all kinds of aquatic habitats. In the present study, fresh water bodies of Kanekal region of Anantapuramu district were explored for their diatom wealth and evaluated taxonomic diversity among diatom taxa. Forty three taxa belonging to 21 genera were recorded which reveals Gomphonema recorded as predominant genus represented by 6 species followed by Mastogloia and Nitzschia 4 each, Amphora and Eunotia 3 each, Cyclotella, Gomphoneis, Navicula and Tryblionella 2 each and one species each represented by Aulacoseira, Bacillaria, Caloneis, Cymbella, Epithemia, Gyrosigma, Halamphora, Hantzschia, Pinnularia, Pleurosira, Rhopalodia, Stenopterobia and Surirella.

Key words: Kanekal, Diatoms, lake, Andhra Pradesh

Introduction

Diatoms are interesting micro algae occur as unicellular and in colonial forms. Cells are enclosed in a shell made up of hydrates of silica (SiO_2+H_2O) called frustule. Diatoms obtain siliceous material from dissolved silica compounds. This frustule surface is characterised with variety of perforation, identification of the diatoms routinely based on the morphology of silica frustule, apart from the perforations valves in many taxa may be provided with a variety of small teeth, shorter or longer spines or siliceous projections of different shapes and sizes. These structures also help the diatom cells in floating. These organisms play crucial role as primary producers in an aquatic ecosystem with their ubiquity and abundance. They are found in all kinds of habitats. Besides planktonic habit, they constitute one of the most important components of the benthic flora. When they die frustules sink to the bottom, accumulate in the sediment and form thick layers referred to as *diatomaceous earth*. Diatomaceous earth can be mined and used in industrial applications (e.g. for filtration and insulation), as silica resists degradation.

Anantapuramu district, falling under Rayalaseema region and largest in Andhra Pradesh (19130 km^2) lies between 13^0-40'&15^0-15' N and 76^0-50' & 78^0-30' E. The district of Anantapuramu has a fairly good elevation which provides the area with tolerable climate throughout the year. Even though Anantapuramu region faces regular drought conditions, the district possesses water bodies which are strikingly different from rest of the state with reference to species richness and distribution pattern of diatom diversity.

From Andhra Pradesh Jayaram (1995), Madhav and Kondalarao (2004) and Narasimha Rao et al. (2010-2015) reported diatoms as a part of algal studies. Meeravali et. al (2015-2017) reported diatoms from selected water bodies of Anantapuramu district. Most of the publications on diatoms from the state are in the form of check lists and carry no precise taxonomic distribution and description.

The study area, Kanekal, is situated in South-western portion of Ananthapuramu district, situated in Rayalaseema region of Andhra Pradesh state. The study area is famous for Kanekal lake and reservoir which are the sole source of water for the irrigation needs of surrounding villages. The lake is fed by Tungabhadra high level canal. The lake water is distributed to surrounding areas with minor canals. Geographically the study area is stretched between 14^0.787'-14^0.808' N and 77^0.036"-77.089" E, 20 and water samples were collected from ponds and puddles apart from lake and reservoir during 2015-2016.

Materials and Methods

Diatom samples were randomly collected from the water bodies and preserved in 4% formalin. Samples were digested with hot H_2O_2 and used in present study. The permanent slides were prepared with DPX as mount. Photo micrographs were prepared by using Olympus CH20i Biological microscope, and Olympus E-420 digital SLR camera.

Results and Discussion

Exploration of water bodies yield in Kanekal region, a total of 43 taxa belonging to 21 genera of 14 families were reported. The identification of taxa was done by using standard methods adopted by Gandhi (1955, 56, 57, 57b, 58, 67), Venkataraman (1939), Prasad and Srivatsava (1992) with additional help of Hustedt (1930) and Cleve-Euler (1951-55). The taxonomic validation revealed *Gomphonem*a (6) recorded as most dominant genus followed by *Mastogloia* (4) and *Nitzschia* (4). *Pleurosira indica* reported by Karthick et al., (2011) from Kodaikanal lake (2,133 m) is interestingly seen in Kanekal lake.

Classification:
Empire Eukaryota
Kingdom Chromista
Phylum Ochrophyta
Class Coscinodiscophyceae
Order Aulacoseirales
Family Aulacoseiraceae

***Genus Aulacoseira* Thwaites 1848.**
***A. ambigua* (Grunow) Simonsen (Pl. I, fig. 1).**

Basionym: *Melosira crenulata* var. *ambigua* Grunow

Foged 1981, p. 104, pl. I, fig. 12; Taylor et. al. 2007, pl. 2; Karthick et. al. 2013, pl. 3.

Frustules cylindrical, join face-to-face form filamentous colonies, diameter 4-6 µm, mantle height 6-10 µm. Rows of mantle areolae in linking valves curved slightly to right. Separation valves often with spines 2-3 very small.

Note:
An opaque extension is present in individual cells and terminal cells of the colony.

Class Mediophyceae
Subclass Thalassiosirophycidae
Order Stephanodiscales
Family Stephanodiscaceae

Genus *Cyclotella* (Kützing) Brébisson 1838.
1. Central portion coarsely punctate, valve radius >30-40 µm……*C. striata*

1. Central portion not coarsely punctate, valve radius < 15 µm……..*C. automus*

***C. atomus* Hustedt 1837. (Pl. I, fig. 2).**

Hustedt, F. 1937. Systematische und ökologische Untersuchungen über die Diatomeen-Flora von Java, p.143, pl. IX [9]: figs 1-4.

Frustule small, symmetry valve radial, girdle rectangular, central area smooth, marginal indistinct, Diameter 4-12 µm, costae 4-6 in 10 µm.

***C. striata* (Kutzing) Grunow 1880. (Pl. I, fig. 3).**
Basionym:
Coscinodiscus striatus Kützing

Van Heurck, 1899, p. 444, pi. 22, fig. 651; Boyer, 1927, p. 37; Hustedt, 1930, p. 744, fig. 176; Subrahmanyan, 1946, p. 92, fig. 31.

Cells discoid, rectangular, valves with, two distinct surface areas, the central portion coarsely punctate, valve surface striate, striae 10 in 10 µm. radius of valve 30-40 µm.

Order Eupodiscales
Family Eupodiscaceae
***Genus Pleurosira* (Meneghini) San Leon 1848.**

***P. indica* B. Karthick & J.P. Kociolek 2011. (Pl. I, fig. 17).**

Basionym: *Biddulphia laevis* Ehrenberg 1843
Synonym(s): Cerataulus laevis (Ehr.) Ralfs in Pritchard1861

B.Karthick and J.P. Kociolek 2011, Four new centric diatoms, p.27,fig. 1&2.

Valve circular-elliptical. Ocelli marginal, two, opposite, size equal. Striae very fine, unresolvable. Diameter 75-90 µm.
Note:
This species is first time reported from waters of Andhra Pradesh and Telangana. after by Kartick et. al (2011) from Tamilnadu.

Class Bacillariophyceae
Subclass Eunotiophycidae
Order Eunotiales
Family Eunotiaceae
***Genus Eunotia* Ehrenberg 1837.**

1. Valve dorsal flat, poles rostrate-out, raphe terminal nodule indistinct, striae fine…….*E. **.grunowi* var *uplandica***
1. Valve dorsal convex, poles not rostrate-out, terminal nodule distinct, striae coare…….2

2. Valve dorsal deep constriction present, ventral concave, length 20-30 µm.....***E. pectinalis***
2. Valve dorsal constriction absent, ventral linear, length 30-40 µm…… *E. tschirchiana*

***E. grunowi* var *uplandica* A.Cleve (Pl. I, fig. 4).**

Cleve-Euler, A., 1951-55, p. 97, fig. 421, Gandhi H.P, 1962b. p. 117, figs. 4-7, . Prasad, B. N. and Srivastava, M. N. 1992. Vol 1, p. 178, pl. 25. fig. 8.

Valves dorsi ventral, symmetrical to the transapical axis. Margin dorsal flat, ventral parallel-concave. Poles rostrate out. Raphe small terminal nodule indistinct. Length 20-30 µm, breadth 2-4 µm, striae fine 10-12 in 10 µm.

***E. pectinalis* (Kützing) Rabenhorst 1864. (Pl. I, fig. 5).**

Van Heurck, H. 1896.p. 300, p. 9, figs. 370&371. Prasad, B. N. and Srivastava, M. N. 1992. Vol 1, p. 183, pl. 25. figs. 1.

Valves dorsi ventral, symmetrical to the transapical axis. Margin dorsal flat, ventral parallel-concave. Poles broadly rounded, dorsal deep constriction present. Raphe small terminal nodule distinct. Length 20-30µm, breadth 2-4 µm, striae fine 10-12 in 10 µm.

***E. tschirchiana* O. Müll 1890. (Pl. I, fig. 6).**

Müller, O. (1890). Bacillariaceen aus Java. I. *Berichte der Deutschen* p. 328, pl. XIX [19]: figs 14-17, Hustedt, F., 1938. P.173, pl.12.figs23-29; Prasad, B. N. and Srivastava, M. N. 1992. Vol 1, p. 188, pl. 25. figs. 9-10.

Valves dorsi ventral, valve view linear, arcuate. Margin dorsal strongly convex, ventral linear. Poles dorsal deep constriction present, ventral sharp bend. Raphe small terminal nodule distinct. Length 30-40 µm, breadth 3-5 µm. Striae coarse 8-12 in 10 µm.

Order Cymbellales
Family Cymbellaceae
***Genus Cymbella* Agardh 1830.**
***C. cistula* (Ehrenberg) Kirchner 1878. (Pl. I, fig. 7).**

Basionym: *Bacillaria cistula* Ehrenberg

Kirchner. O. Algen. In: *Kryptogamen-Flora von Schlesien. Part 1*1878, p. 189, Txt. 482, Venkataraman, G., 1939. A Systematic account of S.Indian Diatoms. p.344, fig. 136.

Valves strongly dorsiventral. Margin dorsal arched, ventral convex, inflated centre. Apices rounded. Raphe central, proximal straight, distal deflected dorsally. Axial area narrow. Central area small elliptical, stigma present, 2-3. Length 35-80 µm, breadth 10-15µm. Striae coarse 8-12 in 10 µm.

Family Gomphonemataceae
***Genus Gomphoneis* Cleve 1894.**

Note: This genus is recorded for the first time from Andhra Pradesh and Telangana states.

1. Valves oval-elliptical, apices round……..***G. olivaceum***

1. Valves not oval-elliptical, apices not round.....***G. eriensis***

***G. eriensis* (Grunow) Skvortzov & Meyer 1928.**

Valves lanceolate, apices cuneate, valve centre inflated one side…..***G. eriensis* var eriensis**

Valves not lanceolate, apices capitate, valve margin

entire……...……...……...***G. eriensis* var**. ***variabilis.***

***G. eriensis* var. *eriense* Skvortzov & Meyer 1928. (Pl. I, fig. 8).**

Basionym: *Gomphonema eriense* Grunow
Homotypic Synonym(s): *Gomphonema eriense* Grunow 1878
Heterotypic Synonym(s): *Gomphonema eriense var. rostrata* M.Schmidt 1899 *Gomphoneis eriense var. rostrata* (M.Schmidt) Skvortzow and Meyer 1928.

Skvortzov & Meyer, A contribution to the diatoms of Baikal Lake 1928: 28; pl. 2, fig. 110

Valves lanceolate-clavate. Apices head protracted-capitate, foot round. Raphe straight. Axial area linear, narrow. Central area present, stigma 1. Length 75-95 µm, breadth 10-12 µm. Striae coarse, proximal 1-2 short, 10-12 in 10 µm

***G. eriense var. variabilis* Kociolek and Stoermer 1988. (Pl. I, fig. 9).**

Kociolek, J.P. & Stoermer, E.F. Taxonomy, ultrastructure and distribution of *Gomphoneis* (1988), 79, fig. 193-223.

Valves clavate, central area gibbose. Apices head protracted-capitate. Raphe straight. Axial area linear, narrow. Central area present, stigma 1-3. Length 40-60 µm, breadth 10-25 µm. Striae coarse, proximal 1-2 short, 10-12 in 10 µm.

***G. olivaceum* (Hornemann) Dawson ex Ross and Sims 1978. (Pl. I, fig. 10).**

Basionym: *Ulva olivacea* Hornemann 1806
Synonym (s): *Gomphonema olivaceum* (Hornemann) Brébisson 1838.

Valves ovate-elliptical. Apices obtuse. Raphe straight. Axial area linear, narrow. Central area present, central area broadened by short striae. Length 20-30 µm, breadth 8-10 µm. Striae coarse, proximal 1-2 short, 6-8 in 10 µm.

***Gomphonema* Ehrenberg 1832.**

1. Head pole apices mucronate…….. *G. augur*
1. Head pole apices not mucronate……2

2. Valve lanceolat……..…3
3. Apices broad round, central area braod……. *G. vibrio*
3. Apices not round, central area small…… .*G. lanceolatum* var. *insignis*

2. Valve club shaped, linear…….4

4. Apices rostrate, central area round…….. *G. parvulum*
4. Apices not rostrate, central area not round……5

5. Valves linear-lanceolate, axial area narrow, indistinct at apices, striae middle radiate…….. *G. subclavatum*

5. Valves not linear, axial area narrow distinct at apices, striae middle not radiate……..…… *G. affine*

***G. affine* Kützing 1844. (Pl. I, fig. 11).**

Kützing, *Die Kieselschaligen Bacillarien oder Diatomeen* F.T. 1844. P. 86, pl. 30: fig. 54,

Frustule club shaped. Apex rostrate. Raphe centre, straight. Axial area linearly narrow. Central area distinct. Length 30-80 µm, breadth 8-15 µm. Striae radial, coarse 10-15 in 10 µm.

G. augur Ehrenberg 1841.

Valves linear-lanceolate, central striae 3-4 absent on both sides

……....***G. augur* var. *turris***

Valves wedge shaped, central striae absent on one side…

……...***G. augur* var. *augur***

G. augur var. augur Ehrenberg. (Pl. I, fig. 12).

Ehrenberg C.G. *Bericht über die zur Bekanntmachung geeigneten Verhandlungen der Königlich-Preussischen Akademie der* 1841, pp. 197-219, Mubashir jeelani, Lake Ecology in Kashmir India, 2016, pp.103, table 25.

Frustules wedge shaped. Apex head pole apiculate, foot pole rounded, apices capitate. Raphe straight, simple. Axial area straight. Central area absents on one side. Length 40-60 µm, breadth 8-12 µm. Striae coarse, 8-12 in 10 µm.

***G. augur* var. *turris* (Ehrenb.) Lange-Bert. 1985. (Pl. I, fig. 13).**

Basionym: *Gomphonema turris* Ehrenb.

Krammer, K. and Lange-Bertalot, H. Naviculaceae Neue und wenig bekannte Taxa 1985. P. 44; pl. 37, fig. 1-7; pl. 38, fig. 1-4, 8-12, Gandhi H.P. Diatom flora. Bombay. Salsette, 1960, p. 108, figs. 72-73.

Frustules wedge shaped. Apex head pole apiculate, foot pole rounded. Raphe straight, simple. Axial area straight. Central area distinct. Length 30-60 µm, breadth 8-15 µm. Striae coarse, central 1-2 short one side, puncta isolated opposite side, 8-12 in 10 µm.

***G. lanceolatum* var. *insignis* (Greg.) Cleve (Pl. I, fig. 14).**

Basionym: *Gomphonema insigne* W.Gregory

Hustedt, F., A. Pascher's *Die Susswasser*1930, p.376, fig. 701, Prasad B. N. and Srivastava M. N. 1992. Vol 1, p. 253. pl. 33.fig. 2.

Valves linear-lanceolate, centre slightly inflated, apices rounded, base broadly rounded. Raphe thick, median, terminal fissures curved forming hook like structure. Central area unilateral, puncta present. Length 50-65 µm, breadth 8-12 µm. Striae 10-12 µm in 10 µm.

***G. parvulum* (Kützing) Kützing 1849. (Pl. I, fig. 15).**

Basionym: *Sphenella parvula* Kützing

Kützing, F.T. *Species algarum* 1849. P.65, txt.14, Van Heurck, H., 1896. P. 272. Pl. 7, fig. 306. Hustedt, F., A. Pascher's *Die Susswasser*1930, p.372, fig.713a; Gandhi H.P. Diatoms from Partabgarh, 1955, p. 327, figs. 30; Prasad B. N. and Srivastava M. N. 1992. Vol 1, p. 255, pl. 33, fig. 19.

Frustule club shaped. Apices rostrate, capitate. Raphe central, straight. Axial area straight, broad. Central area present. Length 15-30 µm, breadth 8-10 µm. Striae fine, 10-15 in 10 µm.

***G. subclavatum* (Grunow) Grunow 1884 (Pl. I, fig. 16).**

Basionym: *Gomphonema montanum var. subclavatum* Grunow

Grunow, A. Die Diatomeen von Franz Josefs-Land 1884, pp.98. pl. 1(A): fig. 13, Prakash Narayan and G. K. Barupal., A Systematic Account of the Fresh Water Diatom from Kaylana lake. 2015, pp. 3437, [Plate – 1(10), Fig. – 1E]

Valve linear-clavate. Apices round. Axial area narrow, indistinct at apex. Central area clear, linear, lanceolate, valve surface striate, striae radiate at middle and parallel at poles. Length 25-35 µm, breadth 8-10 µm. Striae 8-10 in 10 µm.

***G. vibrio* Ehrenberg 1843. (Pl. II, fig. 26).**

Ehrenberg 1843, S. Bhakta et. al Phyco diversity. Bahuda river. Odisha, 2011, p. 85. Pl. 2, fig. 12.

Frustule elongate, club shaped, middle region swollen. Apex round. Raphe straight. Axial area narrow, straight. Central area distinct, small, round. Length 60-100 µm, breadth 8-14 µm. Striae coarse, 8-12 in 10 µm.

Order Mastogloiales
Family Mastogloiaceae
***Genus Mastogloia* Thwaites in W. Smith 1856.**

1. Valve walls strongly protracted, apices capitate, raphe straight**:**

2. Valves stumpy, length 20-30…….. ***M. baltica***

2. Valves elliptical, length 35-45 µm……..……. ***M. smithi* var*. amphicephala***

1. Valve walls not strongly protracted, apices not capitate, raphe not straight**:**

3.Valves elliptical, central area round, centra striae radiating, short…….. ***M. elliptica***

3. Valve oblong elliptical, central area elliptic-rectangular, striae not radiating…….. …….. ***M. grevellie***

***M. baltica* Grunow in Van Heurck 1880. (Pl. II, fig. 1).**

Van Heurck *Synopsis des Diatomées de Belgique* Atlas, 1880, PL. IV, fig. 24; Sarode and Kamat, 1984, p 60, pl 6, f 128.

Valves elliptic. Margin protracted. Apices capitate. Raphe straight. Axial area narrow, centre not broad. Length 20-30 µm, breadth 5-8 µm. Striae unresolvable.

***M. elliptica* (C.Agardh) Cleve in Schmidt 1893. (Pl. II, fig. 2).**

Basionym: *Frustulia elliptica* C.Agardh
Schmidt, A.W.F. *Atlas der Diatomaceen-kunde***, 1893,** pl. 185: figs 24-27**.**

Valve narrow, elliptic. Apices cuneate. Raphe filiform. Axial area narrow, centre round, expanded. Central area prominent, elliptic-rectangular. Length 25-30 µm, breadth 5-7 µm. striae short radiating, 12-16 in 10 µm.

***M. grevillei* W. Smith in W.Gregory 1856. (Pl. II, fig. 3).**

Gregory, W. Notice of some new species of British fresh-water *Diatomaceae* 1856, 4, pl. 1: fig. 16.

Valves oblong elliptical. Margin convex, protracted. Apices rostrate. Raphe straight, proximal inflated. Axial area narrow, straight. Central area rectangular. Valvo copulae prominent 2-4 in 10 µm. Length 40-60 µm, breadth -10 µm. Striae fine, 10-12 in 10 µm.

M. *smithii var. amphicephala* Thwaites ex W. Smith 1856. (Pl. II, fig. 4).

Smith, W. *A synopsis of the British Diatomaceae*, 1856, p. 65, pl. 54, fig. 341; Rao, VNR et. al Epiphytic diatoms from south India 1982.

Valves elliptic. Margin convex, protracted. Apices rostrate, capitate. Raphe straight, proximal inflated. Axial area narrow, straight. Central area circular. Valvo copulae prominent 2-4 in 10 µm. Length 30-40 µm, breadth 6-10 µm. Striae fine, 10-12 in 10 µm.

Order Naviculales
Suborder Naviculineae
Family Naviculaceae
Genus *Caloneis* Cleve 1894.

***C. silicula var. minuta* (Grunow) Cleve 1894. (Pl. II, fig. 5).**

Basionym: Navicula ventricosa f. minuta Grunow.

Cleve, P.T. Synopsis of the naviculoid diatoms. Part I. 1894. P. 52, Cleve-Euler, A., 1951-55. p. 100, figs. 1144m&n; Gandhi. H.P. Diatoms. Lonavala. 1962, p. 134, pl. 1, fig. 7; B. N. and Srivastava, M. N. 1992. Vol 1, p. 223, pl. 29. fig. 9.

Valves linear-lanceolate, three marginal inflations. Apices cuneate, rounded. Raphe thin, straight. Axial area broad, straight. Central area prominent, reaches margin. Length 30-55 µm, breadth 6-8 µm. Striae fine 15-25 in 10 µm.

***Genus: Gyrosigma* Hassall 1845.**

***G. distortum* var. *parkeri* (M.B.Harrison) Cleve. (Pl. II, fig. 9).**

Basionym: Pleurosigma parkeri Harrison

Cleve P.T. 1894 Synopsis of the Naviculoid diatoms. Part I. p. 116, KS Mohan 1987, Bacillariophyceae of two south Indian lakes, p.16, table.4.

Valves sigmoid-gibbose central margin. Apices attenuate. Raphe central. Axial area linear, narrow. Central area circular. Length 60-80 µm, breadth 15-25 µm. Striae fine unresolvable.

***Genus Navicula* Bory 1822.**

1. Valve margin convex, apices acute, central area semi-circular…
…….. ***N. digitoradiata***
1. Valve margin straight, apices roastrate, central area unilateral….
…….. ***N. viridula* var. *linearis***

***N. digitoradiata* (W.Gregory) Ralfs 1861. (Pl. II, fig. 10).**

Basionym: *Pinnularia digitoradiata* W. Gregory.

Pritchard, A. (1861) *A history of infusoria, pl.*40, Sanilkumar, M G et. al., (2009) Planktonic Microalgae.

Valves lanceolate. Apices acute. Raphe straight, distal curved. Axial area narrow, straight. Central area semi-circular. Length 40-60 µm, breadth 6-8 µm. Striae coarse, radiate, proximal small one side, 8-10 in 10 µm.

***N. viridula* var. *linearis* Hustedt 1937. (Pl. II, fig. 11).**

Homotypic Synonym(s): *Navicula viridula f. linearis* (Hustedt) H.Kobayasi 2002

Hustedt 1937: 264; pl. 19, fig. 1-2.

Valves linear-lanceolate. Margin parallel. Apices sub-rostrate. Raphe straight, distal hooked opposite directions. Axial area narrow. Central area prominent, unilateral, elliptical. Length 55-65 µm, breadth 6-8 µm. Striae proximal small, radiate, distal convergent, 10-12 in 10 µm.

Suborder Neidiineae
Family Amphipleuraceae
Genus *Halamphora* (Cleve) Levkov 2009.

***H. coffeaeformis* Levkov 2009. (Pl. II, fig. 12).**

Basionym: *Frustulia coffeiformis* C.Agardh

Levkov *Amphora sensu lato*. In: *Diatoms of Europe* 2009. P.179; pl. 91; figs 1-14; pl. 94: fig. 17-27; pl. 99: figs 15-23 (as *'coffeaeformis')*, B. N. and Srivastava, M. N. 1992. Vol 1, p. 261, pl. 32. fig. 4.

Valves semi-lanceolate. Margin dorsal arched, ventral linear, slightly concave. Apex rostrate, capitate. Raphe eccentric, straight. Axial area narrow. Length 30-50 µm, breadth 4-12 µm. Striae dorsal coarse, radiate, 8-12, ventral fine, short 14-18 in 10 µm.

Suborder Sellaphorineae
Family: Pinnulariaceae
***Genus Pinnularia* Ehrenberg 1843.**

***P. nodosa Smith. 1856.* (Pl. II, fig. 13).**

Basionym: *Navicula nodosa* Ehr.

Smith, W. 1856, *A synopsis of the British Diatomaceae*; Das. S.K.& S.P. Adhikary 2012, Fresh water Algae. Nagaland. p.118, pl. 3, fig. 75

Valve linear. Margin triundulate. Apices sub-capitate. Raphe eccentric, proximal pointed, distal hooked. Axial area broad. Central area large, reaches margin. Length 30-50 µm, breadth 4-6 µm. Striae 10-15 in 10 µm.

Order Bacillariales
Family Bacillariaceae
***Genus Bacillaria* Gmelin 1791.**

B. paxillifera (O.F.Müller) T.Marsson 1880. (Pl. II, fig. 18).
Heterotypic Synonym(s): *Bacillaria paradoxa* J.F.Gmelin 1791, *Nitzschia paradoxa* (J.F.Gmelin) Grunow 1880.

T.Marsson Diatomaceen von Neu-Vorpommern 1901: p. 254 (as *'paxillifer'*), Cleve Eu`ler, A, plat. Schwed, Finn, V: 1952, figs.1457 (=*N paradoxa v,. genuine*Nach Grunow,), Gopinathan C. P. 1984, Littoral diatoms of Southwest coast Ind.,p. 26, fig. 3(s-u).

Valves linearly-lanceolate. Apices rostrate-cuneate. Raphe system fibulate, sub-central. Length 30-80 µm, breadth 2-5 µm. Striae 30-40 in 10 µm. Fibulae small bars, linked at their bases by faint longitudinal lines giving a ladder-like appearance.

***Genus Hantzschia* Grunow 1877.**

***H. virgata var. gracilis Hust.* 1930. (Pl. II, fig. 19).**

Hustedt, F., A. Pascher's *Die Susswasser* 1930, p.395, fig. 753, Cleve-Euler, A, plat. Schwed, Finn, V, 1952: figs. 1423 b-c (=*H (Roper) Grun. Virgate var gracilis Hust*.), S.K Rai, Taxonomic studies on some freshwater diatoms, E. Terai Nepal 2006, p.17. fig.12.

Valves linear-lanceolate, margin dorsal convex-straight, ventral concave. Apices slender capitate. Raphe ventral. Length 85-100, breadth 4-6. Striae 15 in 10.

***Genus Nitzschia* Hassall 1845.**

1. Apices tapering ends bent opposite directions……*N. longissima* var. *reversa.*
1. apices ends not bent opposite directions…….2

2. Apices extremely long, sub-capitate, valves margin one side straight…
……...*N. sublinearis.*
2. Apices not long, not subcapitate, valve margin both sides convex……
……...3

3. Valves small, dorsal undulation absent, apices acute, length 25-30 µm..
……. *N. sociabilis*
3. Valves big, dorsal undulation present, apices drawn out capitate,

length 30-60 µm……... *N. umbonata*

***N. longissima* var. *reversa* Grunow. (Pl. II, fig. 20).**

Heterotypic Synonym(s): Nitzschia reversa W.Smith

Jeetendra et. al 2015, Seasonal variation. Microalgal abundance. Chloraophyl a. Mumbai coast. P.4, Table.2, sp. 56, Guiry, M.D. & Guiry, G.M. 2016. *AlgaeBase*. World-wide electronic publication, National University of Ireland, Galway.

Valves fusiform. Margin convex-parallel. Apices long drawn tapering ends bent opposite directions. Raphe thin. Length 40-50 µm, breadth 4-6 µm. Striae unresolvable. Fibulae fine.

***N. sociabilis* Hust. 1957. (Pl. II, fig. 21).**

Heterotypic Synonym(s): *Nitzschia subtubicola* H.Germain 1981.

Hustedt Die Diatomeenflora des Flus-systems der Weser. Ver. Bremen 1957 p. 354, figs 91-94, Prasad, B. N. and Srivastava, M. N. 1992. Vol 1, p. 307, pl. 35. figs. 15.

Valves small, linear-lanceolate. Apices acute. Length 25-30 µm, breadth 2-5 µm. Striae fine unresolvable, fibulae 6-8 in 10 µm.

***N. sublinearis* Hantzsch 1860. (Pl. II, fig. 22).**

Hustedt, F.., A. Pascher's Die Susswasser 1930, p.411, Fig786, Gandhi H.P. Diatoms from Partabgarh, 1955, p. 330, figs. 37.

Valves linear-lanceolate. Apices extremely long, rostrate, sub-capitate. Length 50-85 µm, breadth 3-6 µm. Striae unresolvable. Fibulae 10-14 in 10 µm.

***N. umbonata* (Ehrenberg) Lange-Bertalot 1978. (Pl. II, fig. 23).**

Lange-Bertalot, H. Zur Systematik, Taxonomie und Ökologie des ,1978 p. 648, pls 1, 2, 4.

Valves lanceolate. Margin dorsal undulated. Apices drawn out,capitate. Length 30-60 µm, breadth 2-3 µm. Striae fine unresolvable. Fibulae 6-8 in 10 µm.

***Genus Tryblionella* W. Smith 1853.**

1. Valve margin both sides straight, apices rostrate, sternum central narrow, striae coarse……. *T. apiculata*
1. Valve margin both sides concave, apices capitate, sternum central broad, striae fine……..... *T. hungarica*

***T. apiculata* Gregory 1857. (Pl. II, fig. 24).**

Gregory.W. On the post-Tertiary diatomaceous sand. 1857. P. 79; pl.1, fig.43, Alakananda B et. al., 2011 Biomonitoring to assess the efficacy of restoration. Urban water bodies. Wetlands of Bangalore.

Valves linear, panduriform. Margin both sides almost straight. Apices rostrate, sub-capitate. Raphe eccentric. Axial area possess longitudinal sternum. Length 60-80 µm, breadth 4-8 µm. Striae prominent, 12-16 in 10 µm.

***T. hungarica* Frenguelli 1942. (Pl. II, fig. 25).**

Basionym: *Nitzschia hungarica* Grunow

Frenguelli,J. Diatomeas del Neuguén (Patagonia). XVII 1942. p.178, pl. 8: fig.12,

Valves linear, panduriform. Margin both sides concave. Apices cuneate, capitate. Raphe eccentric. Axial area possesses longitudinal sternum, broad. Length 40-80 µm, breadth 4-6 µm. Striae fine, 15-25 in 10 µm.

Order Rhopalodiales
Family Rhopalodiaceae
Genus Epithemia Kützing, 1844.

***E. adnata* (Kützing) Brébisson (Pl. II, fig. 6).**

Basionym: *Frustulia adnata* Kützing

Hustedt 1930, p.385, fig. 729; Krammer & Lange-Bertalot 1997, p. 152, pl. 107, figs. 1-11, pl. 108, figs. 1-3., Surajit Roy and Jai Prakash Keshri 2015, Pl. I, Figs. 1-14.

Valves dorsiventral, margin dorsal convex, ventral slightly concave. Apices capitate broadly rounded. Raphe is bi-arcuate, never reach dorsal margin. Length 20-30 µm, breadth 6-10 µm. Striae 10-12in 10 µm, costae 3-4 in 10 µm, 4-6 striae between adjacent costae.

***Genus Rhopalodia* O. Müller 1895.**

***R. gibberula* (Ehrenberg) Otto Muller 1895. (Pl. II, fig. 7).**
Basionym: *Eunotia gibberula* Ehrenberg

Müller, [G.F.] O. (1895). *Rhopalodia* ein neues Genus der Bacillariaceen, pl.2, Rao, VNR et. al., (1982)) Epiphytic diatoms from south India.

Frustule lunate. Margin dorsal convex, ventral concave. Apices cuneate, capitate, bent ventrally. Raphe fibulate. Length 35-45µm, breadth 6-8 µm. striae fine, indistinct, costae 3-4 in 10 µm, fibulae 4-5 in 10 µm.

Order Surirellales
Family Surirellaceae

***Genus Stenopterobia* Brébisson in Van Heurck 1896.**

***S. curvula* (W. Smith) Krammer 1987. (Pl. II, fig. 14).**

Basionym: *Nitzschia curvula* W.Smith

Lange-Bertalot & Krammer Bacillariaceae, Epithemiaceae, Surirellaceae. Neue und wenig bekannte Taxa 1987, p. 108, pl. 58, figs 1-4.

Valves narrow, girdle view sigmoid. Raphe prominent, position entire. Length 40-120 µm, breadth 2-4 µm. Costae prominent 4-6 µm, striae fine, unresolvable.

***Genus Surirella* Turpin 1828.**

***S. ovalis* Brébisson 1838. (Pl. II, fig. 17).**

Heterotypic Synonym(s): *Surirella lanceolata* H.P.Gandhi 1955

Brébisson, [L.] A. 1838. de *Considerations sur les diatomées et essai d'une classification Flore de Normandie, p.1, txt. 3; Kuetzing, F.T., 1849. p.38; Van Heurck, H., 1896. P. 373, pl. 13, fig. 585;* B. N. and Srivastava, M. N. 1992. Vol 1, p. 317, pl. 38. fig. 4.

Valves linear-ovate. Pole, apices truncate, base cuneate. Raphe marginal. Axial area narrow. Central area appears free, large. Marginal folds distinct. Length 30-40 µm, breadth 10-15 µm. Costae thick, marginal, 4-8 in 10 µm

Order Thalassiophysales
Family Catenulaceae
***Genus Amphora* Ehrenberg in Kützing 1844.**

1. Valves elliptic oval, valve ventral almost straight…… ***A. ovalis***

1. Valve not elliptic oval, valve ventral convex**:**

   2. Apices acute, raphe eccentric, central area small……***A. leneolata***

   2. Apices cuneate, raphe not eccentric, central area large……***A. pediculus***

***A. lineolata* Ehr. 1844. (Pl. II, fig. 8).**

Heterotypic Synonym(s): *Navicula lineolata* Ehrenberg 1838, *Amphora tenera* W.Smith 1853
Ehrenberg, *Die Infusionsthierchen als vollkommene Organismen* 1838, p.189, Subramanyan a systematic account of the marine diatoms. Madras coast. 1946, p. 184, fig. 407.

Valves linear, semi-elliptical. Apices acute. Margin dorsal protracted, ventral straight. Raphe eccentric, straight. Axial area narrow. Length 20-30 µm, breadth 6-8 µm. Striae fine, unresolvable.

***A. ovalis (*Kützing*)* Kützing. 1844. (Pl. II, fig. 16).**

Basionym: *Frustulia ovalis* Kützing

Kützing, F.T. *Die Kieselschaligen Bacillarien oder Diatomeen* 1844, p. 107, pl. 5, fig. 35, 39, Hustedt, Bacil p. 342, (= f gracilis (Ehr) Cl), Gandhi H.P.1960 Diatom Flora of Bombay&Sal. p. 101, fig. 60.

Valves elliptical-oval. Margin dorsal protracted, ventral almost straight. Apex rostrate, capitate. Raphe eccentric, proximal deflected dorsal. Axial area linear. Central area not prominent. Length 35-50 µm, breadth 4-8 µm. Striae proximal dorsal coarse, ventral fine, short, 12-18 in 10 µm.

***A. pediculus* (Kützing) Grunow ex A. Schmidt 1875. (Pl. II, fig. 15).**

Grunow ex A. Schmidt *Atlas der Diatomaceen-kunde. Series I,* 1875. pl. 26: fig. 99.

Valves dorsiventral. Margin dorsal arched, ventral slightly concave. Apex cuneate. Raphe straight. Axial area narrow. Central area indistinct. Length 50-60 µm, breadth 6-8 µm. Striae dorsal proximal short, forms free space, 14-18 in 10 µm.

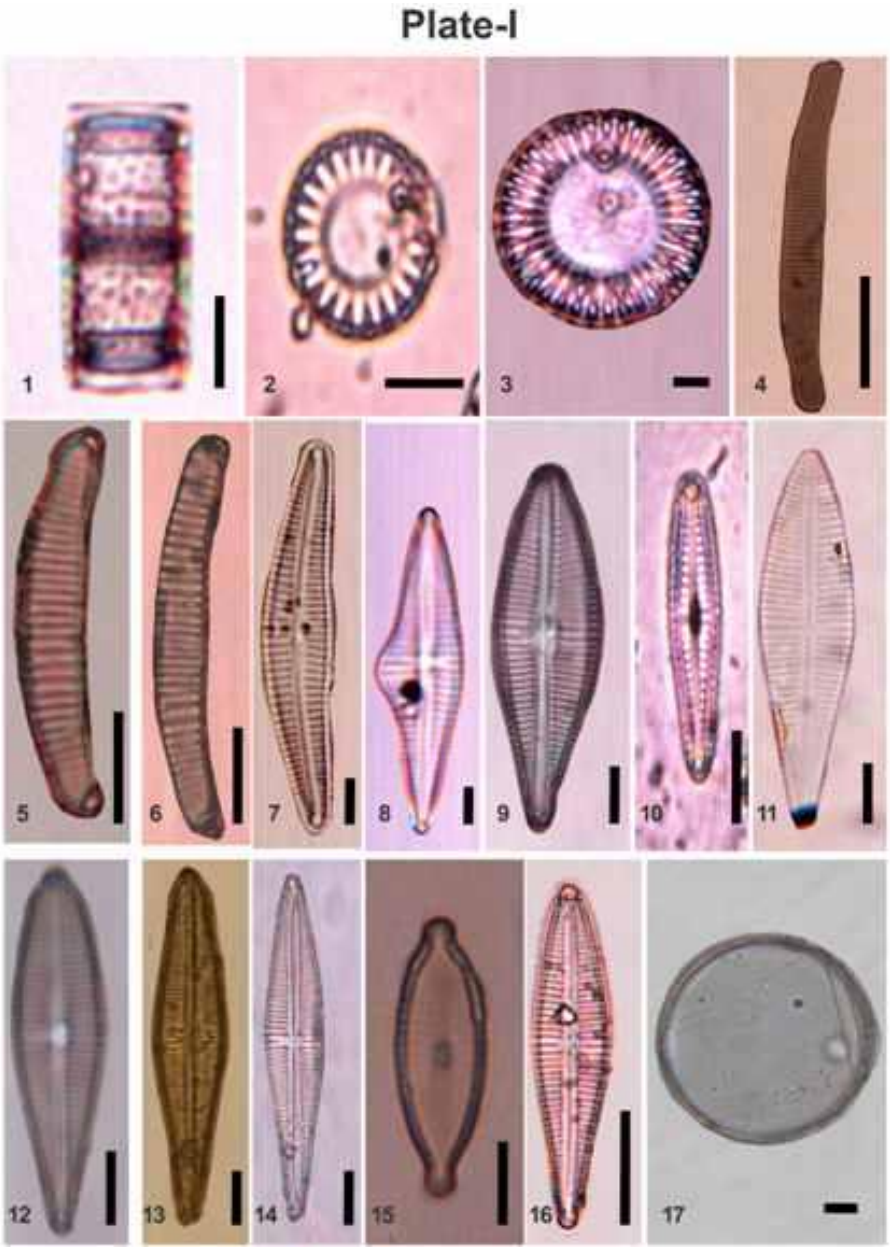

Plate-1: 1. *Aulacoseira ambigua* (Grunow) Simonsen, 2. *Cyclotella atomus* Hustedt, 3. *C. striata* (Kutzing) Grunow, 4. *Eunotia grunowi* var *uplandica* A.Cleve, 5. *E. pectinalis* (Kützing) Rabenhorst, 6. *E. tschirchiana* O. Müll, 7. *Cymbella cistula* (Ehrenberg) Kirchner, 8. *Gomphoneis eriensis* var. *eriense* Skvortzov & Meyer, 9. *G. eriense var. variabilis* Kociolek and Stoermer, 10. *G. olivaceum* (**Hornemann) Dawson ex Ross and Sims, 11.** *Gomphonema affine* Kützing, 12. G. augur var. augur Ehrenberg, 13. *G. augur* var. *turris* (Ehrenb.) Lange-Bert, 14. *G. lanceolatum* var. *insignis* (Greg.) Cleve, 15. *G. parvulum*

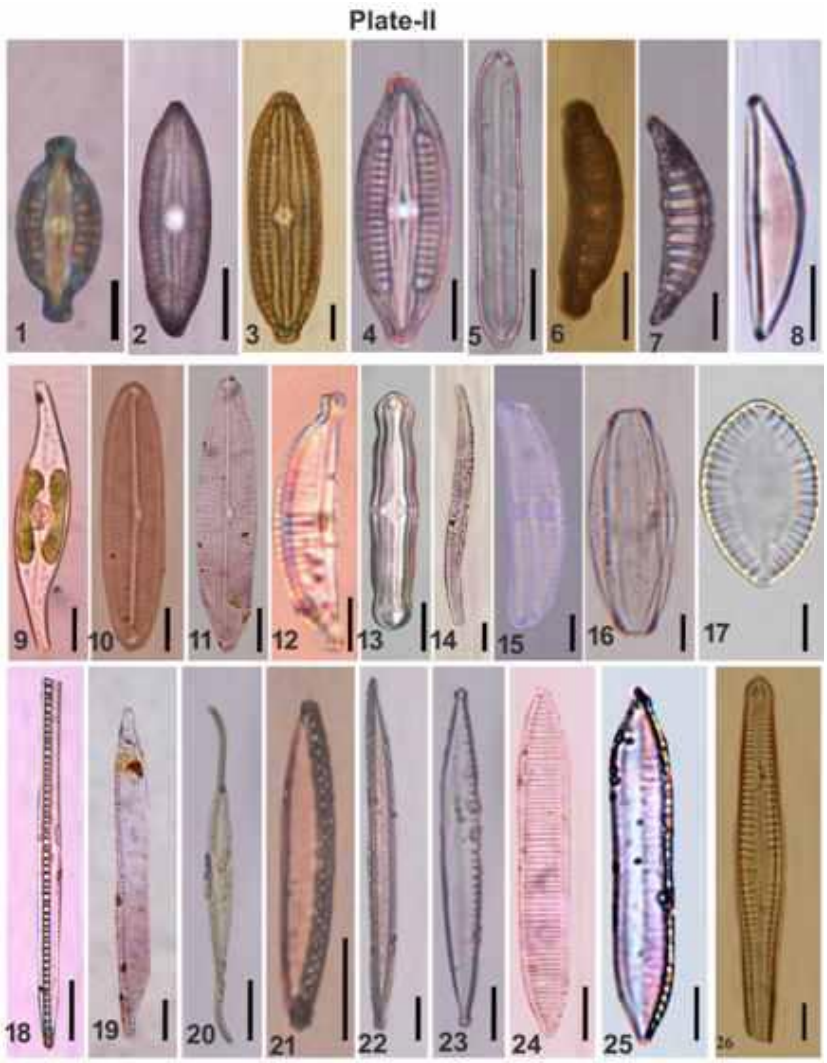

Plate-2: 1. *Mastogloia baltica* Grunow in Van Heurck, 2. *M. elliptica* (C.Agardh) Cleve in Schmidt, 3. *M. grevillei* W. Smith in W.Gregory, 4. M. *smithii var. amphicephala* Thwaites ex W. Smith, 5. *C. silicula var. minuta* (Grunow) Cleve, 6. *Epithemia adnata* (Kützing) Brébisson, 7. *Rhopalodia gibberula* (Ehrenberg) Otto Muller, 8. *Amphora lineolata* Ehr. 9. *Gyrosigma distortum* var. *parkeri* (M.B.Harrison) Cleve. 10. *Navicula digitoradiata* (W.Gregory) Ralfs 1861. 11. *N. viridula* var. *linearis* Hustedt, 12. *Halamphora coffeaeformis* Levkov, 13. *Pinnularia nodosa Smith.* 14. *Stenopterobia curvula* (W. Smith) Krammer, 15. *Amphora pediculus* (Kützing) Grunow ex A. Schmidt, 16. *A. ovalis (*Kützing*)* Kützing. 17. *Surirella ovalis* Brébisson, 18. *Bacillaria paxillifera* (O.F.Müller) T.Marsson, 19. *Hantzschia virgata var. gracilis Hust. 20. N. longissima* var. *reversa* Grunow. 21. *N. sociabilis* Hust. 22. *N. sublinearis* Hantzsch, 23. *N. umbonata* (Ehrenberg) Lange-Bertalot, 24. *Tryblionella apiculata* Gregory, 25. *T. hungarica* Frenguelli and 26. *Gomphonema vibrio* Ehrenberg

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