J. Indian bot. Soc. e-ISSN:2455-7218, ISSN:0019 - 4468 Vol. 101 (1&2) 2021:1-15

ALGAL FLORA OF TAMPARA LAKE, CHHATRAPUR, ODISHA, INDIA

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Date of online publication: 31st March 2021
DOI:10.5958/2455-7218.2021.00008.5

In the present investigation a total of 52 algal species were recorded from Tampara Lake, Chhatrapur, Odisha, India. These algal species are belonging to 36 genera of 27 families of 18 orders and 5 divisions (Cyanobacteria, Euglenophyta, Bacillariophyta, Chlorophyta and Charophyta). Out of 52 algal species, 7 are first time recorded from this lake while four species viz. *Eunotia bilunaris* (Ehrenberg) Schaarschmidt, *Chlamydomonas ehrenbergii* Gorozhankin [Goroschankin], *Crucigenia tetrapedia* (Kirchner) W. *et* G.S. West, *Monoraphidium irregulare* (G.M. Smith) Komárková-Legnerová have been recorded for the first time from India and three species viz.*Pinnularia amabilis* Krammer, *Mastogloia smithii* Thwaites ex W. Smith, *Euastrum spinulasum* Delponte var. *spinulosum* Delponte are new records from Odisha.

Key words: Algae, Diversity, Tampara Lake, Planktonic

About 97% of earth's water is in the ocean which is unfit for human consumption and remaining 2 to 3% is locked in the polar ice caps and only less than 1% is available as fresh water in rivers, lakes, streams, reservoirs and ground water. Freshwater is essential resource for human beings as well as other animals. A lake provides habitat for many aquatic microbes, animals and plants and supports bio-diversity in the surrounding environments as well. It also provides fishery's production and is important place for economy of local communities. Algae are ubiquitous in distribution about 90% of them are aquatic. Algae are ecologically important as they are known to produce more oxygen than other plants (Rai *et al.* 2000). In addition to this, algae flourishing in water bodies polluted with organic wastes play an important part in "Self-purification of water bodies", as they are able to accumulate nutrients, heavy metals, pesticides, organic and inorganic toxic substances in their cells/bodies (Alp *et al.* 2012; Sudha *et al.* 2020). Algal diversity in a Lake plays a significant role in determining tropic status and developing strategies for their conservation (Thakur *et al.* 2013; Maharana *et al.* 2019). The algal growth in a habitat influences the ecosystem and responds rapidly to changes in aquatic ecology particularly in relation to nutrients. About 15,000 species of algae have been recorded, but only a few of them are functionally useful in the waste stabilization of ponds (Shanthala *et al.* 2009). Algae, particularly phytoplanktons are the primary producers in aquatic food chain and play a key role in bio monitoring of trophic status of water bodies. According to Goswami (2012) the first step towards the conservation of an aquatic system should be identification and assessment of algal diversity composition of the aquatic body.

Tampara Lake is one of the largest freshwater Lake of Odisha. It is located near Chatrapur in Ganjam district beside the national highway and is 5.8 km long and 670 m wide. Integrated Coastal Zone Management project (A World Bank project) has identified this Lake to make it an Eco-tourism site so that more tourists can visit this Lake. The project also envisaged to employ local youths into various Eco-tourism activities through community participation. Apart from the large water body Tampara Lake, the adjoining area also has a virgin beach and lush green forest. Although a lot of literature on freshwater algal diversity of Odisha state is available (Jena *et al.* 2005, Jena *et al.* 2006 a,

Received on February 23, 2021 www.indianbotsoc.org Accepted on February 24, 2021

b, c, Ratha *et al.* 2006, 2007, Jena *et al.* 2008, Jena and Adhikary 2007, Adhikary *et al.* 2009, Jena and Adhikary 2011, Adhikary and Jena 2012, Dash *et al.* 2020, Behera *et al.* 2021), but no published record is available on algal diversity of Tampara Lake. Thus, for the first time algal diversity of this Lake has been studied owing to their great biological activities to understand the algal diversity patterns of this beautiful lake for pollution control and management.

MATERIALS AND METHODS

The study site and sample collection: The location (longitude and latitude) of different collection sites of Tampara Lake and the map Tampara Lake showing collection site is depicted in Map1. Total 60 algal samples were collected from 7 sites of this Lake during June and January of 2019, and January month of 2020. Samples were collected in sterilized Tarson tubes (15 ml). Plankton net of 25 µm mesh size (Hydro-bios Kiel, Cat. No. 438001) was used to collect planktonic samples. The occurrence of algae in other forms e.g. epilithic biofilms, benthic, epizoic algae were collected by using forceps, needle and brush.

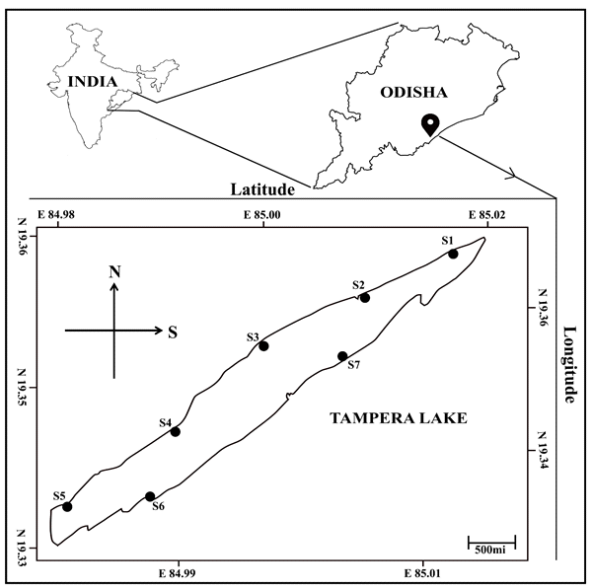

Figure 1: Map showing different collection sites of Tampara Lake, Chhatrapur, Odisha, India. **S1:** Near fishing jetty (N″19º 21.995′, E″085º 01.206′), **S2**: Near Humuribana (N″19º 21.931′, E″085º 01.113′); **S3**: Near to Coconut farm (N″19º 21.791′, E″085º 01.839′), **S4**: Near visitors site (N″19º 21.782′, E″085º 00.840′), **S5**: Near Picnic spot (N″19º 21.678′, E″085º 00.567′), **S6:** Near Tourism house (N″ 19º 21.592′, E″085º 00.509′), **S7**: Near village (N″19º 21.112′, E″085º 00.240′).

Sample preservation: Samples were preserved by adding in 4% (v/v) formaldehyde on the spot and replica of each samples were kept without any preservative for microscopic analysis. Voucher number was given to each sample and deposited at Department of Botany, Berhampur University.

Microscopy and microphotography: Collected samples were observed under phase contrast light microscope. The morphological characteristics of algal species were noted. The microphotograph of each species was taken by Olympus CCD colour camera (Olympus, Model no: SC-180) attached with the microscope (Olympus, Model: BX 53).

Morphological identification: Important morphological features like cell structure, cell/colony size, colour of the algal species were described and compared with the line diagram and microphotograph of algal taxa published in literature and identified (Deshikachary 1959, Scott and Prescott 1961, Philipose 1967, Gonzalves 1981, Komárek and Fott 1983, Deshikachary 1987, Hindák 1988, Hegewald *et al.* 1990, Komárek and Anagnostidis 2005, Adhikary *et al.* 2009, Das and Adhikary 2014, Das and Keshri 2016).

RESULTS AND DISCUSSION

In the present study a total of 52 algal species were recorded from Tampara Lake, Chatrapur, Odisha during 2019 and 2020 (Table 1, Figure1-52). These species are represented by 36 genera belonging to 27 families, 18 Orders and 5 divisions (Cyanobacteria, Euglenophyta, Bacillariophyta, Chlorophyta and Charophyta). Among these five divisions the Bacillariophyta were the dominant and Euglenophyta found least occurring in the

Table 1: List of algal species recorded from different sites of Tampara Lake, Chhatrapur, Odisha, India

Sl. No.	Algal Species	Locality of Tampara lake						
		S1	S2	S3	S4	S5	S6	S7
	Cyanobacteria							
1.	*Merismopedia ferrophila* Hindák	-	-	-	-	-	+	+
2.	*Merismopedia tenuissima* Lemmermann	-	-	-	-	+	+	+
3.	*Chroococcus schizodermaticus* West & G.S. West	-	-	-	+	+	+	-
4.	*Chroococcus turgidus* (Kützing) Nägeli	-	-	-	-	+	+	+
5.	*Spirulina major* Kützing ex Gomont	-	-	-	-	-	+	-
6.	*Oscillatoria leonardii* Compère	+	+	+	+	-	-	-
7.	*Anabaena subcylindrica* Borge	-	+	+	-	-	+	-
	Euglenophyta							
8.	*Euglena mutabilis* F. Schmitz	-	-	-	-	-	+	+
9.	*Euglena proxima* P.A. Dangeard	+	+	+	+	-	-	-
10.	*Colacium physeter* (Fott) Fott	-	+	-	-	+	-	+
11.	*Phacus longicauda* (Ehrenberg) Dujardin	-	-	-	+	-	-	-
12.	*Trachelomonas nigra* Svirenko	-	-	+	+	-	-	+
	Bacillariophyta							
13.	*Ulnaria ulna* (Nitzsch) Compère	-	-	-	-	+	+	-
14.	*Eunotia bilunaris* (Ehrenberg) Schaarschmidt	+	+	+	-	-	-	-
15.	*Mastogloia smithii* Thwaites ex W.Smith	-	-	+	+	-	+	-
16.	*Cymbella aspera* (Ehrenberg) Cleve	-	+	+	+	+	-	-
17.	*Gomphonema vibrio* Ehrenberg	-	-	+	-	+	+	+
18.	*Neidium affine* var. *amphirhynchus* (Ehrenberg) Cleve	-	-	-	+	-	-	+
19.	*Pinnularia amabilis* Krammer	-	-	-	-	+	-	+
20.	*Pinnularia borealis* Ehrenberg	+	+	+	+	+	-	-
21.	*Pinnularia viridis* (Nitzsch) Ehrenberg	+	-	-	-	-	+	-
22.	*Navicula radiosa* Kützing	-	+	-	-	-	-	+
23.	*Navicula viridula* var. *rostellata* (Kützing) Cleve	+	+	+	-	-	-	+
24.	*Gyrosigma scalproides* var. *eximium* (Thwaites) Cleve	+	+	-	+	-	-	+
25.	*Stauroneis anceps* Ehrenberg	+	+	-	-	-	+	-
26.	*Stauroneis pusila* Grunow	-	+	+	-	-	-	+
27.	*Amphora elliptica* (C.Agardh) Kützing	-	-	+	+	-	-	+
28.	*Amphora ovalis* (Kützing) Kützing	-	-	+	+	+	-	-
29.	*Nitzschia palea* (Kützing) W.Smith	-	-	-	-	+	+	-
30.	*Rhopalodia gibba* (Ehrenberg) O. Müller	-	+	-	-	+	+	-
	Chlorophyta							
31.	*Chlamydomonas ehrenbergii* Gorozhankin [Goroschankin]	-	-	-	-	-	-	+
32.	*Ankistrodesmus stipitatus* Komárková-Legnerová	-	-	-	-	-	+	+
33.	*Kirchneriella obesa* (West) West & G.S.West	+	-	-	-	-	+	-
34.	*Monoraphidium irregulare* (G.M.Smith) Komárková-Legnerová	-	-	-	+	-	+	-
35.	*Monoraphidium tortile* (West & G.S.West) Komárková-Legnerová	-	-	+	-	+	-	-
36.	*Coelastrum* scabrum Reinsch	-	+	+	-	-	-	-
37.	*Desmodesmus armatus* (Chodat) var. *spinus* (Fritsch et Rich) Hegewald	-	-	-	-	-	+	+
38.	Scenedesmus obliqus (Turpin) Kützing	-	-	+	-	+	-	+
39.	Scenedesmus planctonicus (Korshikov) Fott	-	-	-	+	-	+	-
40.	*Crucigenia tetrapedia* (Kirchner) Kuntze	-	-	+	+	-	-	+
41.	*Botryococcus braunii* Kützing	+	-	-	-	+	-	-
	Charophyta							
42.	*Closterium leibleinii* var. *angulatum f. minor* Türner	-	-	-	-	-	+	-
43.	*Closterium jenneri* Ralfs var. *Robustum* G.S. West	-	+	-	-	-	-	+
44.	*Cosmarium laeve* Rabenhorst	-	-	-	-	-	-	+
45.	*Cosmarium moniliforme* Ralfs	-	-	-	+	-	-	+
46.	*Cosmarium radiosum* Wolle	+	+	-	-	-	-	-
47.	*Cosmarium trilobulatum* var. *abscissum* (Schmidle) Willi Krieger & Gerloff	-	+	+	-	+	-	-
48.	*Cosmarium undulatum* var. *wollei* West	-	-	+	-	-	+	-
49.	*Euastrum spinulasum* var. *spinulosum* Delponte	-	-	-	-	+	-	-
50.	*Staurastrum bloklandiae* Coesel and Joosten	-	-	+	-	+	+	-
51.	*Staurastrum gracile* var. *nanum* Wille	-	-	-	+	-	-	+
52.	*Chara fragilis* Desvaux	+	-	+	-	+	-	-

+ = Present, - = absent

Tampara Lake. In the present study seven species were first time reported out of which four algal species are from first time from India namely *Eunotia bilunaris* (Ehrenberg) Schaarschmidt, *Chlamydomonas ehrenbergii* Gorozhankin [Goroschankin], *Crucigenia tetrapedia* (Kirchner) W. et G.S. West and *Monoraphidium irregulare* (G.M. Smith) Komárková-Legnerováa; three algal species are first time reported from Odisha namely *Pinnularia amabilis* Krammer, *Mastogloia smithii* Thwaites ex W. Smith and *Euastrum spinulasum* Delponte var. *spinulosum* Delponte. Further, the distribution of algal diversity of this lake were found approximately similar of our previous study of algal diversity of Kanjiahata Lake, Nandankanan, Odisha, India except some members of desmids and diatom (Dash *et al.* 2020). The details of systematic account and description of all the algal species are described below.

Systematic Account of Algal Species

Division: **Cyanobacteria**, Class: **Cyanophyceae**; Order: **Chroococcales,** Family: **Merismopediaceae,** Genus: ***Merismopedia*** Meyen, 1839

1. ***Merismopedia ferrophila*** Hindák, 1982 (Fig. 1)
Das and Adhikary 2014, p. 39, pl. 1, fig. 20
Colonies small, plate like, 16-celled, hyaline mucilage, colonies 11.11 µm long and 14.44 µm broad, cells widely oval, cell 2.77 µm long and 2.22 µm broad; planktonic.
Collection site: Near to Village (Humuribana), voucher no. TAMP13; TAMP53; date: 10.06.2019; 25.01.2020.

2. ***Merismopedia tenuissima*** Lemmermann, 1898 (Fig. 2)
Das and Adhikary 2014, p. 40, pl. 1, fig. 21
Colonies flat, rectangular, aggregation of 32 cells, mucilage colorless, diffluent, cells oval or spherical, after division hemispherical, with pale blue green content, cells 10-14 µm long and 5-7 µm broad, colony 25-30 µm long and 20-22 µm broad, planktonic.
Collection site: Near to village (Humuribana); voucher no. TAMP12; TAMP54; Date: 10.06.2019; 25.01.2020

Family: **Chroococcaceae**,
Genus: ***Chroococcus*** Nägeli, 1849

3. ***Chroococcus schizodermaticus*** West & G.S. West, 1892 (Fig. 3)
Perumal and Anand 2009, p. 32, pl. 2, Fig. 5.
Colonies microscopic, usually 2-4 celled, without or with diffluent mucilage, thick envelope, yellow brown, distinctly lamellated, often enlarged outer layer, cells spherical, planktonic.
Collection site: Near tourism house, voucher no. TAMP11, TAMP56; date: 20.01.2019; 25.01.2020

4. ***Chroococcus turgidus*** (Kützing) Nägeli, 1849 (Fig. 4)
Komárek and Anagnostidis, 2005, p.306, fig.407
Cells are spherical or ellipsoidal, solitary or in colonies, mostly 2-4 cells in a colony, colour usually green to olive, without sheath cell's diameter 8-32 µm and with sheath 13-35 µm; planktonic.
Collection site: Near village (Humuribana); voucher no: TAMP47; date: 25.01.2020

Order: **Oscillatoriales**: Family: **Spirulinaceae,** Genus: ***Spirulina*** Turpin ex Gomont, 1892

5. ***Spirulina major*** Kützing ex Gomont, 1892 (Fig. 5)
Komárek and Anagnostitidis 2005, p.148, fig.174.
Trichome solitary, bright blue green, microscopic, , 1-3 µm wide, screw like coiled, cross walls slightly constricted, 280-820 µm long and distance between spirals 2-5 µm; planktonic. Collection site: Near village (Humuribana); voucher no. TAMP18; TAMP57; date: 20.01.2019; 25.01.2020

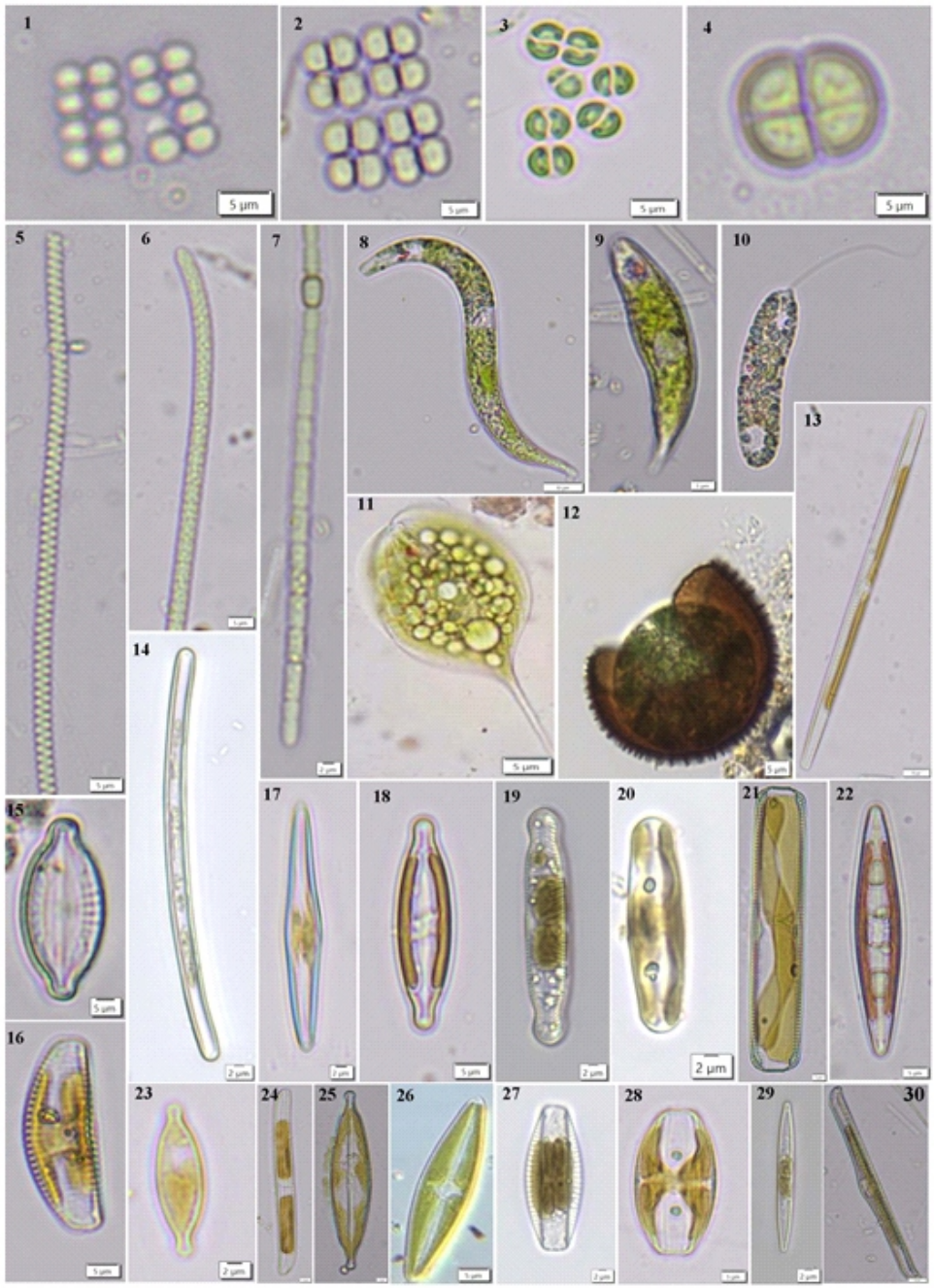

Figure 1-30: 1. *Merismopedia ferrophila* Hindák, **2.** *Merismopedia tenuissima* Lemmermann, **3**. *Chroococcus schizodermaticus* West & G.S. West, **4.** *Chroococcus turgidus* (Kützing) Nägeli, **5.** *Spirulina major* Kützing ex Gomont, **6.** *Oscillatoria leonardii* Compère, 7. *Anabaena subcylindrica* Borge, **8.** *Euglena mutabilis* F. Schmitz, **9.** *Euglena proxima* P.A. Dangeard, **10.** *Colacium physeter* (Fott) Fott, **11.** *Phacus longicauda* (Ehrenberg) Dujardin, **12.** *Trachelomonas nigra* Svirenko, **13.** *Ulnaria ulna* (Nitzsch) Compère, **14.** *Eunotia bilunaris* (Ehrenberg) Schaarschmidt, **15.** *Mastogloia smithii* Thwaites ex W.Smith, **16.** *Cymbella aspera* (Ehrenberg) Cleve, 17. *Gomphonema vibrio* Ehrenberg, **18.** *Neidium affine* var. amphirhynchus (Ehrenberg) Cleve, **19.** *Pinnularia amabilis* Krammer, **20.** *Pinnularia borealis* Ehrenberg, **21.** *Pinnularia viridis* (Nitzsch) Ehrenberg, **22**. *Navicula radiosa* Kützing, **23.** *Navicula viridula* var. rostellata (Kützing) Cleve, **24**. *Gyrosigma scalproides* var. eximium (Thwaites) Cleve, **25.** *Stauroneis anceps* Ehrenberg, **26.** *Stauroneis pusila* Grunow, **27.** *Amphora elliptica* (C.Agardh) Kützing, **28.** *Amphora ovalis* (Kützing) Kützing, **29.** *Nitzschia palea* (Kützing) W.Smith, **30.** *Rhopalodia gibba* (Ehrenberg) O. Müller

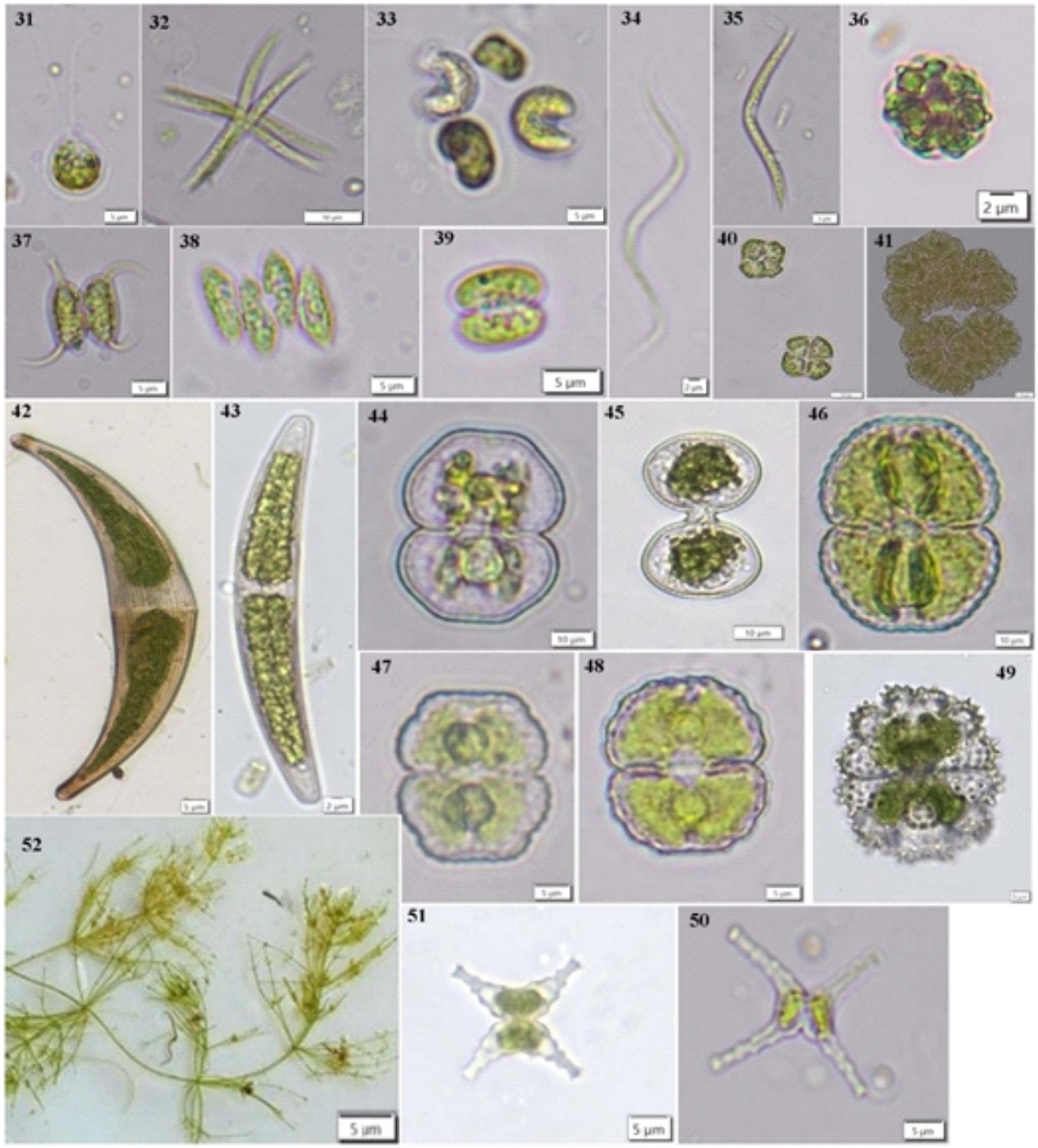

Figure 31-52: 31. *Chlamydomonas ehrenbergii* Gorozhankin [Goroschankin], **32.** *Ankistrodesmus stipitatus* Komárková-Legnerová, **33.** *Kirchneriella obesa* (West) West & G.S. West, **34.** *Monoraphidium irregulare* (G.M. Smith) Komárková-Legnerová, **35.** *Monoraphidium tortile* (West & G.S. West) Komárková-Legnerová, **36**. *Coelastrum scabrum* Reinsch, **37.** *Desmodesmus armatus* (Chodat) var. *spinus* (Fritsch et Rich) Hegewald, **38.** *Scenedesmus obliqus* (Turpin) Kützing, **39.** *Scenedesmus planctonicus* (Korshikov) Fott, **40.** *Crucigenia tetrapedia* (Kirchner) Kuntze, **41.** *Botryococcus braunii* Kützing, **42.** *Closterium leibleinii* var. *angulatum* f. *minor* Türner, **43.** *Closterium jenneri* Ralfs var. *robustum* G.S. West, **44.** *Cosmarium laeve* Rabenhorst, **45.** *Cosmarium moniliforme* Ralfs, 46. *Cosmarium radiosum* Wolle, **47.** *Cosmarium trilobulatum* var. abscissum (Schmidle) Willi Krieger & Gerloff, 48. *Cosmarium undulatum* var. *wollei* West, **49.** *Euastrum spinulasum* var. spinulosum Delponte, **50.** *Staurastrum bloklandiae* Coesel and Joosten, **51**. *Staurastrum gracile* var. *nanum* Wille, **52**. *Chara fragilis* Desvaux.

Family: **Oscillatoriaceae;** Genus: ***Oscillatoria*** Voucher ex Gomont, 1892

6. *Oscillatoria leonardii* Compère, 1967 (Fig. 6)

Das and Adhikary 2014, p. 67, pl. 3, fig.12

Trichome solitary, crosswall unconstricted,

pale blue green, apices rounded, cells are 6.4-7 µm long and 4-9 µm broad; planktonic.
Collection site: Near fishing jetty; voucher no. TAMP39; TAMP59; Date: 10.06.2019; 25.01.2020.

Order: **Nostocales**, Family: **Nostocaceae**, Genus: ***Anabaena*** Bory ex Bornet et Flahault, 1888

7. ***Anabaena subcylindrica*** Borge, 1921 (Fig. 7)
Komárek 2013, p. 805, figs. 1008 g-h
Trichomes solitary, straight, sometimes irregularly flexuous, slightly attenuated, cross-walls slightly constricted. Cells cylindrical, longer than broad, end cells bluntly conical. Intercalry heterocytes and cylindrical. Akinetes long-cylindrical with rounded or bluntly rounded ends, 100 µm long and 4 µm broad; planktonic.
Collection site: Near Coconut farm, Humuribana; voucher no. TAMP46, TAMP60; date: 20.01.2019; 25.01. 2020

Division: **Euglenophyta**, Class: **Euglenophyceae**, Order: **Euglenales**, Family: **Euglenidae,**
Genus: ***Euglena*** Eherenberg, 1830

8. ***Euglena mutabilis*** F. Schmitz,1884 (Fig. 8)
Wolowski and Hindák 2005, p. 32, figs. 172-173.
Cells elongaged spindle shaped, 66-73µm long and 7-8 µm broad, anterior end tapering, bluntly truncate; posterior end cylindrical and blunt tip; pellicle finely striated; chloroplasts 4 and each with a pyrenoid; paramylon bodies small, rectangular; planktonic.
Collection site: Near picnic spot; voucher no. TAMP41; TAMP62; 10.06.2019; 25.01.2020

9. ***Euglena proxima*** P.A. Dangeard,1902 (Fig. 9)
Wolowski and Hindák 2005, p. 30, figs. 60-63.
Cells spindle shaped, flagellate, anterior end bluntly truncate, broader at middle, posterior end gradually tapering to form a small tail piece; 13-20 µm broad at the middle and 58-80 µm long, chloroplast many, disc shaped; paramylon bodies small, cylindrical; pellicle sprirally striated; planktonic.
Collection site: Near fishing site; voucher No. TAMP44; Date: 25.01.2020.

Genus: **Colacium** Ehrenberg, 1838

10. ***Colacium physeter*** (Fott) Fott, 1973 (Fig. 10)
Wolowski and Hindák 2005, p. 33, figs. 190-193.
Cells obvoid, Euglena-like, flattened, longer then broad, a single long flagella at one end, chloroplast numerous, discoid. Cell 57-70 µm and 15-20 µm broad; planktonic.
Collection site: Near coconut farm, Humuribana; Voucher No. TAMP35; TAMP50; Date: 20.01.2019; 25.01.2020

Family: **Phacidae,** Genus: ***Phacus*** Dujardin, 1841

11. ***Phacus longicauda*** (Ehrenberg) Dujardin, 1841 (Fig. 11)
Wolowski and Hindák 2005, p. 36, fig. 227.
Cells broadly obovoid, pear shaped, marginally twisted, 40-70 µm broad and 90-170 µm long; anterior end rounded, shallowly blobbed, gradually tapering towards posterior end to form a long, straight, sharply pointed, cauda up to 70 µm long; pellicle longitudinally striated; chloroplast disc shaped; paramylon usually in form of a single large circular plate, often accompanied by smaller ones; cosmopolitan wide spread; planktonic.
Collection site: Near tourism house; voucher no. TAMP23; Date: 25.01.2020

Genus: ***Trachelomonas*** Ehrenberg, 1833

12. ***Trachelomonas nigra*** Svirenko, 1914 (Fig. 12)
Wolowski and Hindák 2005, p. 43, fig. 288.
Cells solitary, enclosed with a lorica, lorica 44×45µm, ellipsoidal, black, punctate, small single verrucae, especially at the posterior end

apical pore surrounded by several large verruca; planktonic.
Collection site: Near visitors office site; voucher no. TAMP45; TAMP51; date: 10.06.2019; 20.01.2020.

Division: **Bacillariophyta;** Order: **Licmophorales,** Family: **Ulnariaceae,** Genus: ***Ulnaria*** (Kützing) Compère, 2001

13. ***Ulnaria ulna*** (Nitzsch) Compère, 2001 (Fig. 13)
Karthick *et al.* 2013, pl. 18
Valves linear, with margins parallel, tapering to protracted to rostrate apices. Central sternum narrows, straight. Central area transversely expanded, square in shape; striae present at the margins of the central area, parallel; 50-76 µm long and 3-6 µm broad; Stria density 8-12 per 10 µm; planktonic.
Collection site: Near village (Humuribana); voucher no. TAMP26; TAMP45; date: 20.01.2019; 25.01.2020.

Order: **Eunotiales,** Family: **Eunotiaceae,** Genus: ***Eunotia*** Ehrenberg, 1837

14. ***Eunotia bilunaris*** (Ehrenberg) Schaarschmidt, 1880 (Fig. 14)
Cox 1996, p. 60, fig. 20 b, c
Valves lunate to strongly lunate, 67- 70 µm long and 3-6 µm broad, narrowing slightly before the bluntly rounded apices; cells often attached to each other or to the substratum at their apices; planktonic.
Collection site: Near fishing jetty; voucher no. TAMP40; TAMP48; date: 10.06.2019; 25.01.2020.

Order: **Mastogloiales;** Family: **Mastogloiaceae;** Genus: ***Mastogloia*** Thwaites ex W.Smith, 1856

15. ***Mastogloia smithii*** Thwaites ex W.Smith, 1856 (Fig. 15)
Karthick et al. 2013, pl. 57
Valve is elliptic-lanceolate with mostly convex sides and protracted, broadly rounded apices. The axial area is narrow, straight, and expanded into an asymmetric, elliptic to irregularly rectangular central area. The raphe is filiform, but becomes lateral at about ½ from the apices to the center. External proximal raphe ends are dilated slightly and rounded. Striae are less radiate and distinctly punctate. Locules numbers 6-9 in 10 µm. 46-47 µm Valve length, 21-22 µm Valve breadth and Stria density 17-18 µm; planktonic.
Collection site: Near village (Humuribana); voucher no. TAMP36; TAMP50; date: 20.01.2019; 25.01.2020.

Order: **Cymbellales,** Family: **Cymbellaceae,** Genus: ***Cymbella*** C. Agardh, 1830

16. ***Cymbella aspera*** (Ehrenberg) Cleve, 1894 (Fig. 16)
Das and Adhikary 2014, p. 254, pl. 19, fig. 20.
Frustules solitary, linear, broadly convex towards dorsal surface, striation transverse, parallel, 35 µm long and 10.71 µm broad; planktonic.
Collection site: Near coconut farm, Humuribana; voucher no. TAMP02; TAMP41; Date: 25.01.2020

Family: **Gomphonemataceae,** Genus: ***Gomphonema,*** 1832

17. ***Gomphonema vibrio*** Ehrenberg, 1843 (Fig. 17)
Jena *et al.* 2006c, p. 390, pl. 3, fig. 11.
Frustules linear-lanceolate, elongated, attenuated to long, sub acute, rostrate end, raphae thin, median, striation transverse, parallel, , 49-50 µm long and 7-8 µm broad; planktonic.
Collection site: Near visitors office site; voucher no. TAMP43; date: 25.01.2020

Order: **Naviculales,** Family**: Neidiaceae,** Genus**:** ***Neidium*** Pfitzer, 1871

18. ***Neidium affine*** **var.** ***amphirhynchus*** (Ehrenberg) Cleve, 1894 (Fig. 18)
Das and Adhikary 2014, p. 227, pl. 18, fig. 1

Frustules elliptical, lanceolate, with narrowly rostrate apices, raphe thin, central area slightly widened, 29-32 µm long and 6-9 µm broad, striation barely visible in fresh material; Planktonic.
Collection site: Near picnic spot; voucher no. TAMP14; TAMP43; date: 20.01.2019; 25.01.2020.

Family: **Pinnulariaceae;** Genus: ***Pinnularia*** Ehrenberg, 1843

19. *Pinnularia amabilis* Krammer, 2000 (Fig. 19)
Karthick *et al.* 2013, pl. 73
Valves linear, with slightly undulate valve outline. Ends broadly capitate. Raphe narrow and undulate. Proximal raphe ends unilaterally bent. Axial area linear, striae curves and radiate; valve 7-10 µm broad and 40-50 µm long, striae density 8-10 in 10 µm; planktonic.
Collection site: Near picnic spot; voucher no. TAMP42; TAMP55; date: 10.06.2019; 25.01. 2020

20. *Pinnularia borealis* Ehrenberg, 1843 (Fig. 20)
Cox 1996, p. 70, Ffig. 22 g.
Cells bluntly linear in valve view, with very conspicuous broad striae; valves 30-35 µm long, 8-10 µm broad; very broad, with the central 2 or 3 striae shorter; chloroplasts appear as quite thick bands in valve view; planktonic.
Collection site: Near fishing jetty; voucher no. TAMP28; date: 20.01.2019; 20.01.202

21. *Pinnularia viridis* (Nitzsch) Ehrenberg, 1843 (Fig. 21)
Das and Adhikary 2014, p. 233, Pl. 18, Fig. 12
Frustules linear oblong, rectangular in valve view, slightly attenuated towards the apex, apices rotundatus, striation transverse, striae 10-12 in 10 µm, 99.77 µm long and 24.13 µm broad; planktonic.
Collection site: Near village (Humuribana); voucher no. TAMP06; TAMP40; date: 10.06.2019; 25.01.2020.

Family: **Naviculaceae,** Genus: ***Navicula*** Bory, 1822

22. *Navicula radiosa* Kützing, 1844 (Fig. 22)
Cox 1996, p. 135, fig. 23 L
Frustules linear, lanceolate, elongated, attenuated from middle to both the ends, end rounded, slightly capitates, longer than broad, distinct striation, 54-60 µm long and 10-13 µm broad; planktonic.
Collection site: Near coconut farm, Humaribana; Voucher No. TAMP30; date: 15.01.2020

23. *Navicula viridula* var. *rostellata* (Kützing) Cleve, 1895 (Fig. 23)
Das and Adhikary 2014, p. 240, pl. 18, fig. 32.
Valves linear- lanceolate with abruptly constricted, produced capitate ends, 25-27 µm long and 8-10 µm broad, striae not clear in fresh materials; planktonic.
Collection site: Near fishing jetty; voucher no. TAMP15; TAMP32; Date: 20.01.2019; 20.01.2020
Family: **Pleurosigmataceae;** Genus: ***Gyrosigma*** Hassall, 1845

24. *Gyrosigma scalproides* var. *eximium* (Thwaites) Cleve, 1894 (Fig. 24)
Das and Adhikary 2014, p. 236, pl. 18, fig. 17
Valve solitary, sigmoid, gradually attenuated to the broadly rounded ends, raphe thin, sigmoid and centric with distinct central nodule, valve 87-90 µm long and 7-10 µm broad at middle; banthic.
Collection site: Near visitors office site; Voucher No. TAMP03; TAMP30; Date: 10.06.2019; 25.01. 2020

Family**: Stauroneidaceae,** Genus**: *Stauroneis*** Ehrenberg, 1843

25. *Stauroneis anceps* Ehrenberg, 1843 (Fig. 25)
Cox 1996, p. 67, pl. 137, fig. h
Chloroplast with approximately four pyrenoids each, nucleus often slightly off-centre with a conspicuous nucleolus; valves lanceolate with

rostrate apices 78.75µm long and 19.37µm wide; planktonic.
Collection site: Near fishing jetty; voucher no. TAMP01; date: 25.01.2020.

26. ***Stauroneis pusila*** Grunow, 1883 (Fig. 26)
Rath and Adhikary 2005, p. 82, pl. 12, fig. 75
Valves solitary, linear-lanceolate with short protracted prostrate ends, raphe thin, straight, median, axial area narrow, gradually widening towards the center to form stauros-shaped central area, margins of the central area slightly transverse by short 30-34 µm long, 10-13 µm broad; planktonic.
Collection site: Near village (Humuribana); voucher no. TAMP32; TAMP52; date: 10.06.2019; 25.01.2020.

Order: **Thalassiophysales**, Family: **Catenulaceae**, Genus: ***Amphora*** Ehrenberg ex Kützing, 1844

27. ***Amphora elliptica*** (C.Agardh) Kützing, 1884 (Fig. 27)
Jena *et al.* 2006c, p. 390, Pl. 3, Fig. 16
Frustules in girdle view elliptic lanceolate or slightly attenuated, obtuse truncate; central area wide, longer than broad, 30 µm long and 11 µm broad; striation distinct transverse at the both the sides; planktonic.
Collection site: Near visitors office site; Voucher No. TAMP37; TAMP48; date: 20.01.2019; 25.01.2020.

28. ***Amphora ovalis*** (Kützing) Kützing, 1844 (Fig. 28)
Jena *et al.* 2006c, p. 391, pl. 3, fig. 18.
Frustules in girdle view oval, strongly biconvex dorsal valves, ventral valve margin weakly concave, apex rotundus, truncated, striae transverse at the dorsal valves margin, 36 µm long and 17 µm broad; planktonic.
Collection site: Near tourism house; voucher no. TAMP48; date: 25.01.2020.

Division: **Bacillariophyta;** Order: **Bacillariales;** Family: **Bacillariaceae;** Genus: ***Nitzschia*** Hassall, 1845

29. ***Nitzschia palea*** (Kützing) W.Smith, 1856 (Fig. 29)
Jena *et al.* 2006, p. 391, pl. 3, fig. 25.
Frustules linear, sub lanceolate, attenuated to subacute apices, 42.4-27 µm long and 5.2 -7 µm broad, striae 10-12 in 10µm; planktonic.
Collection site: Near village (Humuribana); voucher no. TAMP33; TAMP44; date: 10.06.2019; 25.01.2020

Order: **Rhopalodiales,** Family: **Rhopalodiaceae,** Genus: ***Rhopalodia*** O. Müller,1895

30. ***Rhopalodia gibba*** (Ehrenberg) O. Müller (Fig. 30)
Jena *et al.* 2006c, p. 391, pl. 3, fig. 21-22.
Valves straight on the ventral side and with a inflated depression at the ends, dorsal side slightly convex, end rounded, costae transverse, parallel, 125 µm long and 13 µm broad; planktonic. Collction site: Near coconut farm, Humuribana; voucher no. TAMP38; TAMP41; date: 20.01.2019; 25.01.2020.

Division: **Chlorophyta;** Class: **Chlorophyceae;** Order: **Chlamydomonadales;** Family: **Chlamydomonadaceae,** Genus: ***Chlamydomonas*** Ehrenberg, 1833

31. ***Chlamydomonas ehrenbergii*** Gorozhankin [Goroschankin], 1891 (Fig. 31)
John *et al.* 2002, p. 308, pl. 77 D
Cells pear-shaped, basally rounded and apically attenuated, 8.5 µm wide, 11 µm long, without papilla; protoplast sometimes detached from cell wall; chloroplast cup-shaped, often irregularly thickened with a basal pyrenoid; eyespot median or anterior; planktonic.
Collection site: Near picnic spot; voucher no. TAMP24; date: 25.01.2020.

Order: **Sphaeropleales**; Family: ***Selenastraceae;*** Genus: ***Ankistrodesmus*** Corda, 1838

32. ***Ankistrodesmus stipitatus*** Komárková-Legnerová, 1969 (Fig. 32)
Jena and Adhikary 2007, p. 177, pl. 3, Fig. 3
Coenobia 2-8 celled; cells parallel joined at the middle, curved towards the ends, pointed ends; cells 3.0-4 µm broad and 30-35 µm long; planktonic.
Collection site: Near picnic spot; voucher no. TAMP27; TAMP58; date: 10.06.2019; 25.01.2020.

Genus: ***Kirchneriella*** Schmidle, 1893

33. ***Kirchneriella obesa*** (West) West & G.S. West, 1894 (Fig. 33)
Das and Adhikary. 2014, p. 176, pl. 13, fig. 25.
Coenobia 64 celled, irregularly arranged, cells strongly lunate with the ends almost near each other, outer side convex, ends of cells tapering with rounded bluntly pointed apices, cells 10-11 µm long and 6-7 µm broad; planktonic.
Collection site: Near village (Humuribana); voucher no. TAMP31; TAMP54; date: 20.01.2019; 25.01.2020.

Genus: ***Monoraphidium*** Komárková-Legnerová, 1969

34. ***Monoraphidium irregulare*** (G.M.Smith) Komárková-Legnerová, 1969 (Fig. 34)
Komarek and Fott. 1983, p. 636, pl. 179, fig. a.
Cells are longer than broader. Generally length is 47 µm and 3 µm breadth. Fusiform cells, sigmoidal bent, chloroplast parietal; planktonic.
Collection site: Near tourism house; voucher no. TAMP29; date: 25.01.2020.

35. ***Monoraphidium tortile*** (West & G.S.West) Komárková-Legnerová,1969 (Fig. 35)
Das and Adhikary 2014, p. 174, pl. 13, fig. 20.
Cells fusiform, slightly bent, with thinly attenuated ends, 43-44 µm long and 3-4 µm broad, chloroplast fills the entire parietal perimeter of the cell; planktonic.
Collection site: Near village (Humuribana); voucher no. TAMP22; date: 25.01.2020.

Family: **Scenedesmaceae;** Genus: ***Coelastrum*** Nägeli, 1849

36. ***Coelastrum scabrum*** Reinsch, 1877 (Fig. 36)
Philipose 1967, p. 231, fig. 140 a.
Spherical colonies, 16 celled, cells angular globose with three or more truncate processes from the outer surfaces, cells 7.5-8.5 µm in diameter; planktonic.
Collection site: Near coconut farm, Humuribana; voucher no. TAMP16; TAMP39; date: 10.06.2019; 25.01.2020.

Genus: Desmodesmus (Chodat) S.S.An, T. Friedl & E. Hegewald, 1999

37. ***Desmodesmus armatus*** (Chodat) var. spinus (Fritsch *et* Rich) Hegewald, 2020 (Fig. 37)
Jean and Adhikary, 2007, p. 179, pl. 3, fig.14.
Coenobia 2-4 celled, cells oblong to ellipsoid, arranged in a linear series, single spine arising from each pole of the terminal cells, sometimes spine curved towards tips, cells 5-13 µm long and 2-4 µm broad; planktonic.
Collection site: Near village (Humuribana); voucher no. TAMP51; TAMP40; date: 20.01.2019; 25.01.2020.

Genus: ***Scenedesmus*** Meyen, 1829

38. ***Scenedesmus obliqus*** (Turpin) Kützing, 1833 (Fig. 38)
Hegewald *et al.* 1990, p.7, pl. 4, fig. 2 a.
Coenobia 4-celled, cells arranged linearly on sub-linear series, fusiform with acute or slightly rounded ends, cells 10-20 µm long and 2-8 µm broad; planktonic.
Collection site: Near visitors office site; voucher no. TAMP50; date: 25.01.2020.

39. ***Scenedesmus planctonicus*** (Korshikov) Fott, 1973 (Fig. 39)
John *et al.* 2002, p. 397, pl.97, fig. E.
Coenobia 2 celled,cell broadly ovoid, inner wall straight, outer wall convex, apices broadly rounded, cells 6-12 µm long and 2.4-6.5 µm

broad; planktonic.
Collection site: Near tourism house; voucher no. TAMP52; date: 25.01.2020.
Class: **Trebouxiophyceae**; Order: **Trebouxiales**; Family: **Scenedesmaceae;**
Genus: ***Crucigenia*** Moren, 1830

40. ***Crucigenia tetrapedia*** (Kirchner) Kuntze, 1898 (Fig. 40)
Krienitz 1990, p.175, pl. 18, fig. A-C.
Colony four celled, quadrate with minute rectangular space at the centre, cells flat, triangular with rounded ends, outer side concave, colony 15-20 µm broad and cells 5-10 µm broad; Planktonic.
Collection site: Near visitors office site; voucher no. TAMP34; TAMP57; date: 20.01.2019; 25.01.2020.

Family: **Botryococcaceae**; Genus: ***Botryococcus*** Kützing, 1849

41. ***Botryococcus braunii*** Kützing, 1849 (Fig. 41)
Dash *et al.* 2020, p. 13, pl. 11, fig. 5.
Colonies free floating, cell shape spherical or irregular, green, without aconspicuous gelatinous envelope, enclosed tough hyaline membrane. Cells are 3-6µm broad and 6-12 µm long; planktonic.
Collection site: Near village (Humuribana); voucher no. TAMP17; date: 25.01.2020.

Division: **Charophyta**; Order: **Desmidiales**; Family: **Closteriaceae**, Genus: ***Closterium*** Nitzsch ex Ralfs, 1848

42. ***Closterium leibleinii*** var. ***angulatum*** f. ***minor*** Türner (Fig. 42)
Das and Adhikary 2014, p. 89, pl. 6, fig. 1
Cells of medium size, 3-4 times longer than broad, slightly curved, inner margin inflated at the middle, obtuse apices, cells 95-96 µm long and 22-23 µm broad; planktonic.
Collection site: Near village (Humuribana); voucher no. TAMP04; TAMP50; date: 10.06.2019; 25.01.2020.

43. ***Closterium jenneri*** Ralfs var. *robustum* G.S. West, 1899 (Fig. 43)
Adhikary and Jena 2012, p. 227, pl. 2, fig. 8.
Cells solitary, small, lunate the central part ventral side, without curvature slightly curved, dorsal side convex; slightly attenuated towards apex obtuse rounded; chloroplast axial with 2-3 ridges, granulated at the apex; cells longer than broad, 5-7 µm long and 14 µm broad; planktonic.
Collection site: Near Picnic spot; voucher no. TAMP20; TAMP47; date: 20.01.2019; 25.01.2020.

Family: **Desmidiaceae**; Genus: **Cosmarium** Corda ex Ralfs, 1848

44. ***Cosmarium laeve*** Rabenhorst, 1868 (Fig. 44)
Das and Adhikary 2014, p. 112, pl. 8, fig. 17
Cell solitary, longer than broad, sinus deeply constricted, closed, linear, semicells semicircular, slightly tapering, margin granular, apex less flattened with slightly depression at the middle, chloroplast axial, one pyrenoid at the centre in each semicell, cells 56.25 µm long, 35 µm broad; planktonic.
Collection site: Near picnic spot; voucher no. TAMP07; date: 25.01.2020.

45. ***Cosmarium moniliforme*** Ralfs, 1848 (Fig. 45)
Das and Adhikary 2014, p. 114, pl. 8, fig. 26.
Cells longer than broad, constriction deep, sinus widely open, semicells spherical with widely rounded apex, cell wall smooth, semi cells 41-43 µm long and 18-22 µm broad and isthmus7-8 µm broad; planktonic.
Collection site: Near Tourism house; voucher no. TAMP25; TAMP52; date: 10.06.2019; 25.01.2020

46. ***Cosmarium radiosum*** Wolle, 1884 (Fig. 46)
Das and Adhikary 2014, p. 117, pl. 8, fig. 36.
Cells longer than broad, deeply constricted, sinus narrowly linear with slightly dilated extremity, semi cells sub-semicirular, sides

strongly convex, apex rounded, semi cells 70 µm long, 52 µm broad; planktonic.
Collection site: Near fishing jetty; voucher no. TAMP08; TAMP10; date: 20.01.2019; 25.01.2020.

47. ***Cosmarium trilobulatum*** var. ***abscissum*** (Schmidle) Willi Krieger & Gerloff, 1962 (Fig. 47)
Das and Adhikary 2014, p. 118, pl. 9, fig. 2.
Cells small, semicells pyramidal, lateral angles rounded, truncated towards the pole, apices flatted, sinus narrow, linear, cell wall smooth, cells 20-26 µm long and 17- 20 µm broad; planktonic.
Collection site: Near coconut farm; voucher no. TAMP09; date: 25.01.2020.

48. ***Cosmarium undulatum*** var. ***wollei*** West, 1892 (Fig. 48)
Das and Adhikary 2014, p. 118, pl. 9, fig. 3.
Cells solitary, longer than broad, deeply constricted, sinus linear, semicells semicircular, margin crenate, semicells 22-25 µm long and 28-32 µm broad; planktonic.
Collection site: Near visitor office; voucher no. TAMP10; TAMP22; date: 20.01.2019; 25.01.2020.

49. ***Euastrum spinulasum*** var. ***spinulosum*** Delponte, 1876 (Fig. 49)
Das and Keshri 2016, p. 139, pl. XXVIII, fig. 467**.**
Cells small, nearly rectangular in outline, 1-2 times longer than broad; semicells sub quadrate in outline, basal lobes bi-lobed, rounded; lateral margins retuse deeply then formed little divergent upper lobes, lateral angles of upper lobes with single mucro; apical margins slightly convex with a shallow 'V' shaped medium notch; face of the semicells with a small medium protuberance; semicells 50 µm long and 46 µm broad; cell wall smooth; sinus narrow, closed, isthmus deep; planktonic.
Collection site: Near village (Humuribana); voucher no. TAMP19; TAMP55; date: 10.06.2019; 25.01.2020.

Genus: ***Staurastrum*** Meyen ex Ralfs, 1848

50. ***Staurastrum bloklandiae*** Coesel and Joosten, 1996 (Fig. 50)
Das and Adhikary 2014, p. 96, pl. 06, fig. 22**.**
Cell with 4 diverging, robustly dentated processes terminating in two stout divergent spines, semi cells subtriangular, two marginal dents at the apex, notch like sinus, openig widely, legth of the cell 27-31 µm long and 15-18 µm broad; planktonic.
Collection site: Near Village (Humuribana); voucher no. TAMP05; TAMP54; date: 20.01.2019; 25.01.2020.

51. ***Staurastrum gracile*** var. ***nanum*** Wille, 1880 (Fig. 51)
Lee 2015, p. 61, fig. 60
This variety is much smaller than the typical, the processes shorter. The apical margin of the semicells nearly straight or slightly convex. In vertical view cell is 4-rayed. Cells is 8-12 µm long and 3-5 µm broad; planktonic.
Collection site: Near picnic spot; voucher no. TAMP21; date: 25.01.2020.

Order: **Charales,** Family: **Characeae,** Genus: ***Chara*** Linnaeus, 1753

52. ***Chara fragilis*** Desvaux, 1810 (Fig. 52)
Prescott 1961, p. 137, pl. 82, fig. 6.8.
Plant monoecious, moderatly stout, 2.5-7.5cm height, stem with long internodes and triplastichouscorticutions primary and secondary cortical cell equal in diameter, stem with 6-9 leaves, plant monoecious, antheridia and oogonia at the same node and subtended by 2 bracts, oogonia 0.8-0.95 µm long, artheridia 0.5-1 mm diameter; benthic.
Collection site: Near visitors office site; voucher no. TAMP49; TAMP56; date: 10.06.2019; 25.01.2020.

The authors are thankful to MoEF & CC, Govt. of India for financial supports to carry out this of study. The authors are also thankful to Berhampur University for providing necessary facilities to carry out this work.

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