The study of algal diversity from fresh water bodies of Chimmony Wildlife Sanctuary, Kerala, India

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Abstract: The algal diversity of the freshwater ecosystem is very significant because they are the primary energy producers in the food web. The study for the algal diversity was conducted at Chimmony Wildlife Sanctuary, Thrissur, Kerala, India, from selected sampling sites (Pookoyil thodu, Kidakkapara thodu, Viraku thodu, Nellipara thodu, Anaporu thodu, Kodakallu thodu, Odan thodu, Mullapara thodu, Chimmony dam). The identified algal species belong to four different classes: Chlorophyceae, Euglenineae, Rhodophyceae, and Cyanophyceae. Sixty-one algal species were identified, represented by 37 genera, 22 families, and 14 orders. Among the four, Chlorophyceae was the dominant class.

Keywords: Biodiversity, Chlorophyceae, conservation, Cyanophyceae, Euglenineae, freshwater, Rhodophyceae, taxonomy, Thrissur.
INTRODUCTION

Algae are the most abundant aquatic organisms present in the freshwater ecosystem. Algae were responsible for the beginning of multicellular life on our planet and could be the key to our future survival. They are an essential source for producing fine chemicals, natural pigments, vitamins, polysaccharides, bioflocculants, and growth promoters. Algae are also a significant producers of oxygen than plants (Rai et al. 2000).

The freshwater ecosystems are mainly categorized into two types: lotic and lentic. The rivers, streams, waterfalls, canals fall into the lotic type, and the stagnant waters like pools, lakes, reservoirs and paddy fields fall into the lentic type. The freshwater algal diversity varies from unicellular phytoplankton to colonial and much larger multicellular algae. The algal biodiversity depends upon the physicochemical parameters of the water bodies. In the food chain of aquatic ecosystems, algae are the primary producers, making them very important. So the conservation and knowledge about algal biodiversity are necessary for maintaining a healthy aquatic ecosystem.

The information regarding species diversity is an essential component to realize life in its fullness and conserve it for future generations (Pandey 1995). Therefore, there is a strong demand for research on biodiversity in developing countries (Briji 2005; Tessy & Sreekumar 2017). Generally, the taxonomy is considered an outdated science that cannot keep up with the present biodiversity crisis (De Clerck et al. 2013). But for the future development in biodiversity research, systematics and taxonomy are important (Koen & Segers 2005).

The study of biodiversity as the present one opens new opportunities to understand the different algal forms in their respective natural habitat. In the current scenario, hardly a few genera are used in the industry, giving a broad scope for other potential obtainable algae. Even though plenty of literature is available on fresh water algal diversity of Kerala, there is no published record available on the algal diversity of Chimmony Wildlife Sanctuary. Hence the study.

MATERIALS AND METHODS

Study area

The study was conducted in Chimmony Wildlife Sanctuary (CWS; Figure 1), which is situated in the Thrissur District of Kerala state. It belongs to Mukundapuram taluk and within geographical limits of 10.40° & 10.48° E and 76.41° & 76.56° N. CWS has an area extent of 85.067 km$^2$ and water spread area of 10.1 km$^2$. The sanctuary consists of more than 250 streams, which drains into the Chimmony Reservoir (George 2012; Velayudhan et al.)

![Figure 1. Location of sampling sites in Chimmony Wildlife Sanctuary.](image-url)
In this study, 10 different streams were selected to study the algal flora (Table 1).

**Sampling**

The algal samples were collected from 10 different stations using forceps, scalpel, and blade. The collections were made from the surface level, the underside of rocks, mucilage masses attached to dripping rocks, and tree trunks. 4% formalin solution was used for preservation. The collected specimens were observed under a microscope by preparing wet mounts within 48 hours. The algal specimens were identified using standard literature, monographs and research papers (Ralfs 1848; Turner 1892; Desikachary 1959; Randhawa 1959; Prescott 1961; Pal & Kundu 1962; Ramanathan 1964; Phillipose 1967; Hindak 1977; Hirose et al. 1977; Hindak 1984; West & West 1904; Kouwets & Coesel 1984; Prasad & Misra 1992; Wolowski 1998; Wotowski & Hindak 2005).

**RESULTS**

In the study conducted in CWS, 61 algal species were recorded, which belongs to four different classes (Chlorophyceae, Euglenineae, Rhodophyceae, and Cyanophyceae). These species are represented by 37 genera, 22 families, and 14 orders (Table 2). The class Chlorophyceae represents 33 taxa under 22 genera, the class Euglenineae represents seven taxa under four genera, the class Rhodophyceae represents one taxa under one genera, and the class Cyanophyceae represents 20 taxa under 10 genera.

**Class: Chlorophyceae**

**Order: Volvocales**

**Family: Chlamydomonadaceae**

**Genus: Chlamydomonas Ehrenberg**

1. *Chlamydomonas globosa* Snow (Image 1)
   Prescott, 1961, p.71, pl.1, figs. 8,9
   The cells are globose, enclosed in a hyaline, gelatinous sheath. The cell is 3–5 μm in diameter and 5–10 μm long. The cell consists of a parietal cup-shaped chloroplast with basal pyrenoid and a contractile vacuole at the anterior end. The cell is covered with a smooth membrane and two flagella at the anterior end. The pigment spot is small and inconspicuous.

**Family: Volvocaceae**

**Genus: Gonium Mueller**

2. *Gonium pectorale* Mueller (Image 2)
   Prescott, 1961, p. 75, pl.1, fig. 22
   The colony consists of 16 ellipsoid to subspherical cells arranged in a flat quadrangular plate. This quadrangular plate consists of four inner cells covered by 12 marginal cells. The anterior ends of marginal cells were projecting outwards. Each cell is enclosed in an individual sheath and the cells are 5–20 μm in diameter.

**Order: Tetrasporales**

**Family: Tetrassporaceae**

**Genus: Tetrasspora Link**

3. *Tetrasspora gelatinosa* (Vauch.) Desvaux (Image 3)
   Prescott, 1961, p. 88, pl.5, figs. 3,4
   The thallus is a macroscopic attached floating cylindrical sac where each cell are irregularly arranged. The thallus is globular and bullate, in which spherical cells are arranged in a tetrad manner. The thallus is covered in a thick mucilaginous sheath, and the cells are 6–10 μm in diameter.

**Order: Chlorococcales**

**Family: Chlorococccaceae**

**Genus: Chlorococcum Fries**

4. *Chlorococcum humicola* (Naeg.) Rabenhorst (Image 4,5)
   Prescott, 1961, p. 212, pl.45, fig. 1
   The colony is unicellular, non-motile, with spherical cells in various small clumps. Each cells consist of a completely filled spherical chloroplast with a single pyrenoid. The cell is 7–10 μm in diameter.

**Family: Selenastraceae**

**Genus: Monoraphidium Komarkova - Legnerova**

5. *Monoraphidium griffithii* (Berkeley) Komarekova - Legnerova (Image 6)

**Table 1. Latitude and Longitude of sampling sites**

| Sampling sites | Latitude (E) and Longitude (N) |
|----------------|-------------------------------|
| 1. Pookoyil thodu | 10.4600, 76.4744 |
| 2. Kidakkapara thodu | 10.4641, 76.4658 |
| 3. Viraku thodu | 10.4497, 76.4444 |
| 4. Nellipara thodu | 10.4458, 76.4638 |
| 5. Anaporu thodu | 10.4300, 76.5069 |
| 6. Mullapara thodu | 10.4388, 76.5141 |
| 7. Payampara thodu | 10.4522, 76.5047 |
| 8. Chimmony dam | 10.4605, 76.4722 |

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Table 2. Algal species identified from Chimmony Wildlife Sanctuary.

| No. | Class             | Order          | Family                  | Genus          | Species                                      |
|-----|-------------------|----------------|-------------------------|----------------|----------------------------------------------|
| 1   | Chlorophyceae     | Volvocales     | Chlamydomonadaceae      | Chlamydomonas  | globosa Snow                                 |
| 2   |                   | Volvocaceae    | Gonium                  | pectorale      | Mueller                                      |
| 3   | Tetrasporales     | Tetrasporaceae | Tetraspora              | gelatinosa     | (Vauch.) Desvaux                             |
| 4   |                   | Chlorococcales | Chlorococaceae          | Chlorococcum   | humicalia (Naeg.) Rabenhorst                 |
| 5   |                   | Selenastaceae  | Monoraphidium          | griffithii     | (Berkeley) Komarekova - Legnerova            |
| 6   |                   | Scenedesmaceae | Scenedesmus             | quadriricusa   | var. maximus West & West                     |
| 7   | Ulotrichales      | Ulothrichaceae | Ulothrix                | aequalis       | Kuetzing                                     |
| 8   |                   | Cladophorales  | Cladophoraceae          | Pithophora     | oedogonia (Mont.) Wittrock                   |
| 9   |                   | Trentepohilaeae| Trentepohila            | aurea          | (L.) Martius                                 |
| 10  |                   | Oedogoniales   | Oedogoniaceae           | areschoegi     | Wittrock                                     |
| 11  |                   |                |                         | arcosdalseae   | Jao                                          |
| 12  |                   |                |                         |                |                                              |
| 13  |                   |                |                         | Mougeostia     |-scalaris Hassall                            |
| 14  |                   |                |                         | Zacynuma       | carenatum Taft                              |
| 15  |                   |                |                         | acanthophora   | (Skuja) Czurda                               |
| 16  |                   |                |                         | condensata     | (Vauch.) Kuetzing                            |
| 17  |                   |                |                         | decimina       | (Mueller) Kuetzing                           |
| 18  |                   |                |                         | fuellebornei   | Schmidle                                     |
| 19  |                   |                |                         | micrumpunctata | Transeau                                     |
| 20  |                   |                |                         | naevanglai     | Transeau                                     |
| 21  |                   |                |                         | rhizobrachiales| Jao                                          |
| 22  |                   |                |                         | Cylindracystis | brebissoni (Rafs) De Bary                   |
| 23  |                   |                |                         | Nitrium        | digitus (Ehrbg.) Itzigs. & Rothe             |
| 24  |                   |                |                         | Actinotaenium  | silvae-nigrae (Rabanus) Kouwets & Coesel     |
| 25  |                   |                |                         | Closterium     | ehrenbergii meneghini var. ehrenbergii       |
| 26  |                   |                |                         | moniliferum    | Ehrenberg ex Raufs                           |
| 27  |                   |                |                         | Tumidulum      | Gay                                          |
| 28  |                   |                |                         | Cosmarium      | botrytis Meneg                              |
| 29  |                   |                |                         | subtumidum     | Nordst                                        |
| 30  |                   |                |                         | Micrasterias   | radions Turn var. bogoriensis (Brebl)        |
| 31  |                   |                |                         | Pleurotaenium  | trabecula (Ehrbg) Nag                        |
| 32  |                   |                |                         | Staurastrum    | zonatum Borges var. majus Presc.             |
| 33  | Charales          | Characeae      | Nitella                 | furcata (Raxdargh apud Bruzelius) Agardh     |
| 34  |                   |                |                         |                |                                              |
| 35  |                   |                |                         | Euglena        | elastica Prescott                            |
| 36  |                   |                |                         | Phacus         | minuta Prescott                              |
| 37  |                   |                |                         | Phacus         | curvicauda Swirenko                          |
| 38  |                   |                |                         | abolus Pochmann|                                              |
| 39  |                   |                |                         | Lepacncus      | orbicularis var. caudotus Skzortzow          |
| 40  |                   |                |                         | Trachelomonas  | acus (Muller) marin and Mellionian           |
| 41  | Rhodophyceae      | Batrachospermales| Batrachospermaceae      | Sheathia       | boryana (Sirodot) Salomaki & M.L.Vis         |
Hindak, 1984, p. 219, pl. 79, figs. 5, 8
The cell is straight and fusiform, having a tapering from the centre towards the pointed ends. The cell is 45–50 μm long and 2–3 μm broad.

6. *Monoraphidium indicum* Hindak (Image 7)
Hindak, 1977, p. 105, pl. 44
The cells are very thin and are accurately curved. The cell has a tapering towards the end and it is pointed. The cell is 40–45 μm long and 1.5–2 μm broad.

**Family: Scenedesmaceae**
**Genus: Scenedesmus**

7. *Scenedesmus quadricauda* var. *maximus* West & West (Image 8)
M. T Philipose, 1967, p. 283, fig. 187 g
The colonies are usually four-celled with much larger cells. The cell is 25–30 μm long and 10–11 μm in diameter. The spines are 25–35 μm long.

**Order: Ulotrichales**
**Family: Ulotrichaceae**

8. *Ulotrix aequalis* Kuetzing (Image 9)
K.R Ramanathan, 1964, p. 36, pl. 9 I-L
The thallus is non-branching, filamentous with cylindrical cells. The cells are 12–14 μm broad and 24–28 μm long. The cells consist of a striated cell wall, girdle shaped broad chloroplast covering half of the wall surface with one or more pyrenoids.

**Order: Cladophorales**
**Family: Cladophoraceae**

9. *Pithophora oedogonia* (Mont.) Wittrock (Image 10, 11; Image 12, 13)
Prescott, 1961, p. 140, pl. 22, figs. 7–10
The filaments are slender 50–60 μm in diameter with solitary branching. Each cell are cylindrical and long. The akinetes are cylindrical and slightly swollen and acuminate at the terminal. Akinetes are 55–140 μm in diameter and 90–350 μm long.

**Order: Chaetophorales**
**Family: Trentepohliaceae**

10. *Trentepohlia aurea* (L.) Martius (Image 14, 15, 16)
Prescott, 1961, p. 133, pl. 67, figs. 6–9
The cells are rusty-brown in colour sometimes the thallus shows yellow colour in shaded regions. The cells are slightly swollen but slightly reduced in diameter towards apices. The cell has a smooth wall, and it is 4–10
μm in diameter. The sporangia are generally terminal on curved cells with 15–20 μm in diameter. The gametangia are not frequently observed, and they will be the same size as the sporangia.

Order: Oedogoniales
Family: Oedogoniaceae
Genus: Oedogonium Link

11. Oedogonium areschougii Wittrock (Image 17)
   Prescott, 1961, p. 204
   The filament is nannandrous & gynandrosporous. The filaments are cylindrical in shape with a 10–12 μm diameter and 35–28 μm long. The oogonia is pyriform globose shaped and operculate with 30–35μm diameter and 36–40 μm long. The smooth-walled oospore is not completely filled inside the oogonia. The diameter of the oospore is 23–25 μm. The dwarf males are unicellular attached near or on the oogonia with 6–7 μm diameter and 13–15 μm long.

12. Oedogonium croasdaleae Jao (Image 18, 19)
   Prescott, 1961, p.204, pl.41, fig. 11
   The filament is nannandrous and gynandrosporous. The vegetative cells are cylindrical 25–30 μm in diameter
and 150–200 μm long. The oogonia are two in a series, 60–70 μm in diameter and 80–113 μm long. The dwarf males are 9–17 μm in diameter and 48–55 μm long.

Order: Zygnematales
Family: Zygnemataceae
Genus: Mougeotia C.A. Agardh
13. Mougeotia scalaris Hassall (Image 20)
   Prescott, 1961, p. 304, pl. 71, figs. 6, 7
   The filaments are 14–20 μm in diameter and 34–182 μm long. The chloroplast consists of 4–6 pyrenoids. The zygospores are globose to ovate with smooth walls and formed in the tube due to scalariform conjugation. The zygospore measures up to 30–35 μm in length and 26–30 μm in diameter.

Genus: Zygnema Agardh
14. Zygnema carinatum Taft (Image 21)
   Randhawa, 1959, p. 225, fig. 160
   The filaments are greenish and unbranched. The cells are rectangular to square in shape. Presence of two star-shaped chloroplasts. The cell is 11–15 μm long and 10 μm broad. The scalariform conjugation results in the formation of globose shaped zygospore in the tube. The globose zygospore is formed at the right angle of the tube, and it measures 13–16 μm in length and 15–20 μm in breadth.

Genus: Spirogyra Link
15. Spirogyra acanthophora (Skuja) Czurda (Image 22)
   Randhawa, 1959, p. 376, fig. 413
   The filaments are 300–328 μm long and 60–65 μm wide. The zygospores are 37–42 μm in diameter and 50–62 μm in length.

16. Spirogyra condensata (Vauch.) Kuetzing (Image 3: 23)
   Prescott, 1961, p. 312, pl. 72, figs. 5, 6
   The filaments are 111–153 μm long and 40–53 μm wide. Smooth walled zygospores were formed due to conjugation, and it measures up to 35–37 μm in diameter and 52–60 μm in length.

17. Spirogyra decimina (Mueller) Kuetzing (Image 24, 25)
   Prescott, 1961, p. 313
   The filaments are 130–133 μm long and 20–24 μm wide. Presence of two chloroplasts. The zygospores are cylindrical to ovate with a smooth wall that measures up to 32–38 μm in diameter to 30–35 μm in length.

18. Spirogyra fuellebornei Schmidle (Image 26)
   Randhawa, 1959. P. 316, fig. 291
   The filaments are long and cylindrical having 238–376 μm long and 26–31 μm broad. Presence of two chloroplast, having 3–4 turns in a cell. The zygospores are 30–39 μm in diameter and 58–65 μm in length.

19. Spirogyra micropunctata Transeau (Image 27)
   Prescott, 1961, p. 317, pl. 73, fig. 9
   The filaments are 243–300 μm long and 29–35 μm wide. The scalariform conjugation produces an ellipsoidal zygospore, which measures up to 35–40 μm in diameter and 60–72 μm long.

20. Spirogyra novaeanngliae Transeau (Image 28)
   Prescott, 1961, p. 318, pl. 75, figs. 1–3
   The filaments are 200–230 μm long and 58μm wide. The zygospore is ovate to ellipsoidal. The zygospore exhibits a brown colour which measures up to 50–60 μm in diameter and 85–90 μm in length.

21. Spirogyra rhizobrachialis Jao (Image 3: 29)
   Prescott, 1961, p. 320, pl. 76, figs. 1, 2
   The filaments are 43–50 μm in diameter and 120–211 μm long. Presence of two crenate and deeply toothed chloroplast. The fertile cylindrical cells form zygospores through conjugation. The zygospore is ellipsoidal brown, which measures up to 40–50 μm in diameter and 111 μm in length.

Family: Mesotaeniaceae
Genus: Cylindrocystis De Bary
22. Cylindrocystis brebissonii (Ralfs) De Bary (Image 30, 31)
   W. West & G.S. West, 1904, pl. 4, figs. 23–32, pl.5, fig. 10
   The cells are cylindrical with round apices. The chloroplast consists of a few large radiating prolongations. The cell body is 35–40 μm long and 22–28 μm in broad.

Genus: Netrium (Nageli) Itzigsohn & Rothe in Rabenhorst
23. Netrium digitus (Ehrbg.) Itzigs. & Rothe (Image 32)
   W. West & G. S. West, 1904, pl. 6, fig. 14–16
   The cell is generally large and elliptic to oblong in shape. The cell is gradually attenuated from the centre towards the apices, which is rounded and truncated. The chloroplast is axile with deeply notched free margins. The cell body is 150–160 μm long and 40–45 μm in diameter.
Image 12–21. 12, 13—Pithophora oedogonia | 14, 15, 16—Trentepohlia aurea | 17—Oedogonium areschougii | 18, 19—Oedogonium croasdaleae | 20—Mougeotia scalaris | 21—Zygnema carinatum. (© Joel Jose)
Family: Desmidiaceae
Genus: Actinotaenium (Nageli) Teiling
24. *Actinotaenium silvae-nigrae* (Rabanus) Kouwets & Coesel (Image 33)

Kouwets & Coesel, 1984, p. 555–562, fig. 23

The cell is cylindrical with broadly rounded ends with a smooth cell wall. The cell is 60–65 μm long and 20–25 μm wide.

Genus: Closterium Nitzsch ex Ralfs
25. *Closterium ehrenbergii Meneghinii* var. *Ehrenbergii* (Image 34)

Hirose, H, et al., 1977

The cell body is large and bulged at the centre with a smooth cell wall. The chloroplasts consist of 4–7 laminae with many scattered pyrenoids. The cell body is 250–890 μm long and 50–165 μm wide.
26. **Closterium moniliferum** Ehrenberg ex Ralfs (Image 35)

Prasad & Misra, 1992, p. 113, pl. 12, fig. 4.

The cell is curved with rounded apices. The chloroplast consists of 7–10 pyrenoids arranged in a median series. The cell is 140–155 μm long and 7–20 μm broad.

27. **Closterium tumidulum** Gay (Image 36)

Turner, 1892, p.19, pl.1, fig. 20

The cell is small and curved with an acute tip. The cell is 90–100 μm long and 10–15 μm broad.

**Genus: Cosmarium** Ralfs

28. **Cosmarium botrytis** Meneg (Image 37)

Ralfs, 1848, p.99, pl. 16, fig. 1

The cell has denticulate margins with a deeply constricted linear notch at the centre. The cell is 54.1–77.6 μm long and 40.6–60.6 μm broad.

29. **Cosmarium subtumidum** Nordst (Image 38)

Prescott, 1961, p. 70, pl. 29, figs. 12, 13
Image 39–45. 39—Micrasterias radians var. bogoriensis | 40—Pleurotaenium trabecula | 41—Staurastrum zonatum var. majus | 42–45—Nitella furcata. (© Joel Jose)
The cell body is 30–43 μm long, 14–19 μm wide and isthmus is 12–14 μm.

Genus: *Micrasterias* C. Agardh

30. *Micrasterias radians* Turn var. *bogoriensis* (Breb) G.S. West (Image 39)

The cell body is 121–206 μm long, 126–170 μm wide and the isthmus is 14–17 μm wide.

Genus: *Pleurotaenium* Nageli

31. *Pleurotaenium trabecula* (Ehrbg) Nag (Image 40)

The cylindrical cell body is 400–434 μm long and 30–40 μm in diameter. The cell is constricted at the centre, with a slight bulge at the base semi cell. The chloroplast is elongated with 3–4 laminae.

Genus: *Staurastrum* (Meyen) Ralphs

32. *Staurastrum zonatum* Borges var. *majus* Presc. (Image 41)

The semi cells consist of five long dentate ends with rings of granules and the apex biundulate with some tiny teeth. The cell body is 40–70 μm long, 81–90 μm wide and the isthmus is 13–16 μm.

Order: Charales
Family: Characeae
Genus: *Nitella* C. Agardh

33. *Nitella furcata* (Roxburgh apud Bruzelius) Agardh (Image 42–45)

The plant is monoecious. The stem is 600–1,000 μm thick and antheridia is terminal, which is 200–250 μm in diameter. The oogonia are 1–2, together, which are 230–240 μm long and 210–310 μm in diameter. Spiral cells showing 7–8 convolutions and the coronula are 70–100 μm high and 70 μm at the base.

Class: Euglenineae
Order: Euglenales
Family: Astasiaceae
Genus: *Euglena* Ehrenberg

34. *Euglena elastica* Prescott (Image 46)

The cells have the potential to change shape regularly, when in motion. Usually the cells are spindle-shaped but often swollen in the mid-region and slightly tapered to the apices. The cell consists of many irregularly ovoid-shaped chloroplasts. The cell is 10–11 μm in diameter and 80–90 μm long.

35. *Euglena minuta* Prescott (Image 47)

The cells are highly active, which are fusiform to pyriform in shape. The smooth membranated cell consists of one plate-like chloroplast with a pyrenoid. The cell is 14–16 μm long and 2–6 μm broad.

Genus: *Phacus* Dujardin

36. *Phacus curvicauda* Swirenko (Image 48)

The cells are ovoid and slightly spiral, which causes the caudus to curve slightly to the left. The cell consists of numerous ovoid-globular chloroplasts. The cell is 40–48 μm in diameter and 48–60 μm long.

37. *Phacus obolus* Pochmann (Image 49)

The cells are broadly oval and slightly narrower at the anterior end with straight, conical cauda at the posterior end. The cell consists of numerous ovoid-globular chloroplasts. Cells are 34–42 μm long and 22–35 μm broad.

38. *Phacus orbicularis* var. *caudatus* Skzortzow (Image 50)

Cells are ovoid with a long, straight, sharply pointed caudus. 1–2 paramylon bodies are present. Cells are 38–41 μm in diameter and 50–70 μm long.

Genus: *Lepocinclis* Perty

39. *Lepocinclis acus* (Muller) Marin & Melkonian (Image 51)

The cells are long, elongate, thin and spindle-shaped, gradually tapering to apices which forms a sharp tail. Numerous disc-shaped chloroplasts are present, and two paramylon bodies are present. The cells are 10–12 μm diameter and 150 μm long.

Genus: *Trachelomonas* Ehrenberg

40. *Trachelomonas hispida* var. *papillata* Skvortzow (Image 52)

The cell is 25–30 μm in diameter and 35–40 μm long. The wall is brown smooth except for a few minute spines near the flagellum aperture.
Image 46–53. 46—Euglena elastica | 47—Euglena minuta | 48—Phacus curvicauda | 49—Phacus obolus | 50—Phacus orbicularis var. caudatus | 51—Lepocinclis acus | 52—Trachelomonas hispida var. papillata | 53—Sheathia boryana. (© Joel Jose).
Class: Rhodophyceae  
Order: Batrachospermales  
Family: Batrachospermaceae  
Genus: *Batrachospermum* Roth  
41. *Sheathia boryana* (Sirodot) Salomaki & M.L.Vis (Image 53; Image 54)  
Prescott, 1962, p.567, pl. 136, fig. 4; Sheath & Hymes, 1980, p.1306, figs. 31–36; John & Francis, 2013, p. 237.  
The plant is 5–9 cm high and has a highly mucilaginous thallus, which is brown to green. The central axes are 4–5 μm wide, and glomeruli are ellipsoidal to globular. The lateral branches have short internodes. The carpogonia are 4–5 μm wide at the basal portion and 25–30 μm long. The trichogyne are elongate, club-shaped and embrace the carpogonia. The carposporophyte is globular and scattered close to the periphery. The carposporophyte measures 14–150 μm in diameter.

Class: Cyanophyceae  
Order: Chroococcales  
Family: Chroococcaceae  
Genus: *Aphanocapsa* Nag  
42. *Aphanocapsa pulchra* (Kutz) Rabenh (Image 55)  
T.V. Desikachary, 1959, p.132, pl. 21, fig. 2  
The thallus is gelatinous and blue-green. The cells are spherical, loosely arranged in single or sometimes doubles with individual sheaths. The cells are 6–7 μm in diameter.

Genus: *Microcystis* Kutz  
43. *Microcystis aeruginosa* Kutz. (Image 56)  
T.V. Desikachary, 1959, p. 93, pl. 17, fig. 1, 2, 6  
The colonies are free-floating and attaining a macroscopic size with a mucilaginous envelope. The cells in the colony are spherical with distinct hyaline colonial mucilage. The colonies are light brown and round with 5–7 μm in diameter. Gas vacuoles are present.

Order: Nostocales  
Family: Microchaetaceae  
Genus: *Microchaete* Thuret  
44. *Microchaete uberrima* Carter, N (Image 57, 58)  
T.V. Desikachary, 1959, p.511, pl. 104, figs. 5–7, 10, 13, 16, 18  
The trichomes were long up to 4 mm, with cylindrical cells having a firm sheath. The filaments were 10–15 μm broad with intercalary heterocyst.

Family: Oscillatoriaceae  
Genus: *Oscillatoria* Vaucher  
45. *Oscillatoria limosa* Agardh ex Gomont (Image  59)  
T.V. Desikachary, 1959, p.206, pl. 42, fig.11  
The thallus is blue-green with a straight trichome that is slightly constricted. The trichomes are 12–13 μm broad and 2–4 μm long.

46. *Oscillatoria subbrevis* Schmidle (Image 60, 61)  
T. V. Desikachary, 1959, p.207, pl. 37, fig. 2, pl. 40, fig. 1  
The trichomes are single, straight and not attenuated with round cell, calyptra absent. The trichome is 5–6 μm broad, and the cells are 3–4 μm long. The trichomes are blue-green, and they exhibit an oscillating movement at the apex.

47. *Oscillatoria vizagapattensis* Rao, C.B. (Image 62)  
T.V. Desikachary, 1959, p.205, pl. 39, figs. 16, 18.  
The cells are much shorter than the broad and form a broadly rounded cap with a slightly thickened outer wall. The trichome is blue-green in colour and 8–10 μm broad.

Genus: *Phormidium* Kutz.  
48. *Phormidium abronema* Skuja (Image 64)  
T.V. Desikachary, 1959, p.257.  
The thallus is blackish-green to light bluish. The trichomes consist of the hyaline mucilaginous sheath. The cells are cylindrical or barrel-shaped. The trichome is 3–4 μm broad and 16–17 μm long.

49. *Phormidium hansgirgi* Schmidle (Image 63; Image 65)  
T.V. Desikachary, 1959, p.272, pl. 43, fig. 20  
The filaments are straight with a very thin mucilaginous sheath. The trichomes are cylindrical and not capitate. The hormogones are short. The trichomes are 12–14 μm broad and 2–3 μm long.

50. *Phormidium microtomum* Skuja (Image 66)  
T.V. Desikachary, 1959, p.257, pl. 43, fig. 16, 17  
The trichomes are greyish-brown, straight with a thin colourless sheath. The ends of trichomes are attenuated, and cells are well constricted at the cross wall. The trichome is 6–8 μm broad with apical rounded hyaline calyptra.

51. *Phormidium molle* (Kutz.) Gomont (Image 67)  
T.V. Desikachary, 1959, p.255, pl. 59, fig. 8  
The trichomes are thin, straight, constricted at
cross walls and not attenuated at the ends. The cells are quadrate or barrel-shaped with rounded ends and calyptra absent. The trichome is 2–3 μm broad and 8–7 μm long.

52. *Phormidium retzii* (Ag.) Gomont (Image 68)
   T.V. Desikachary, 1959, p.268, pl. 44, figs. 13-15
   The filaments are straight with a thin mucilaginous sheath. The trichomes are blue-green with a thin sheath. The ends are not attenuated and not capitate. The trichomes are 11–13 μm broad and 8–10 μm long.

53. *Phormidium truncicola* Ghose (Image 70)
   T.V. Desikachary, 1959, p.258, pl. 59, fig. 9
   The trichomes consist of thin membrane and are constricted at cross walls. The calyptra is absent. The trichomes are 6–8 μm broad and 2–3 μm long.

54. *Phormidium usterrii* Schmidle (Image 69)
   T.V. Desikachary, 1959, p.257.
   Trichomes with thin mucilaginous sheath. The cells are shorter than broad with short rectangular cells with broadly round ends. The trichome is blue-green, consisting of densely or irregularly aggregated rounded cells. The cell is 2–5 μm in diameter.

Family: Nostocaceae

Genus: *Anabaena* Bory de Bornet & Flahault

55. *Anabaena anomala* Fritsch (Image 71)
   T.V. Desikachary, 1959, p.398, pl. 73, fig. 2
   The thallus is thin and gelatinous. The cells are spherical, and apical cells are rounded. The trichome is blue-green, consisting of densely or irregularly aggregated rounded cells. The cell is 2–5 μm in diameter.

56. *Anabaena sphaerica* Bornet et Flahaut (Image 72)
   T.V. Desikachary, 1959, p.393, pl. 71, fig. 8
   Gelatinous thin sheath present, Trichomes are pale blue-green in colour. Cells are barrel-shaped and 2–7 μm long. End cells are rounded. Heterocysts are 9–11 μm broad and 13–17 μm long with a smooth yellow outer wall.

Genus: *Cylindrospermum* Kutz

57. *Cylindrospermum stagnale* (Kutz.) Born.et Flah (Image 73, 74)
   T.V. Desikachary, 1959, p.363, pl. 65, fig. 9
   The thallus is blue-green with a mucilaginous sheath. The cells are constricted at the cross wall and nearly quadrant to cylindrical with spherical or oblong heterocyst. The trichomes are cylindrical and 2–5 μm broad.

Family: Rivulariaceae

Genus: *Gloeotrichia* Ag.

58. *Gloeotrichia echinulata* (J. E. Smith) P. Richter (Image 75, 76)
   Prescott, 1962, p.557, pl. 134, figs. 1,2
   The colonies are tiny macroscopic and opaque at the centre and translucent at the periphery. The colonies are free-floating, spherical and covered in a gelatinous sheath. The trichomes radiate from a common centre and are tapered from basal heterocyst to a fine hair-like end. The cells are cylindrical to barrel-shaped 6–9 μm wide, and the cells are joined end to end to form long chains.

Genus: *Scytonema* Ag.

59. *Scytonema ocellatum* Lyngbye ex Born. et Flah (Image 77)
   T.V Desikachary, 1959, p.467, pl.100, fig.2
   The thallus is broad, with a thick mucilaginous sheath. The thallus is brownish to reddish with false branching. The thallus is covered in a firm mucilaginous sheath. The filaments are 11–15 μm broad.

60. *Scytonema rivulare* Borzi ex Born. et Flah (Image 78)
   T.V Desikachary, 1959, p.452, pl.100, fig.2
   The thallus is broad, with a thick mucilaginous sheath. The thallus is brownish to reddish with false branching. The cells are shorter than broad and 30 μm broad.

Order: Stigonematales

Family: Nostochopsisidae

Genus: *Nostochopsis* Wood em. Geitler

61. *Nostochopsis lobatus* Wood em. Geitler (Image 79; Image 80, 81)
   T.V. Desikachary, 1959, p.570, pl. 120, figs. 1-8
   The thallus is irregularly lobed, blue-green with a thick mucilaginous matrix. The cells are barrel-shaped. The heterocyst are mostly lateral, spherical to ellipsoidal. The trichomes are 5–9 μm wide and 6–10 μm long.

DISCUSSION

The freshwater ecosystem holds the most biodiversity among all other ecosystem. The study of freshwater habitat is significant as it occupies only 0.5% of the earth surface, but is equally crucial because they are the cheapest natural source for domestic and industrial purposes (Norton et al. 1996).

The present study portraits the algal diversity of CWS. In our study, Chlorophyceae and Cyanophyceae...
Image 54–63. 54—Sheathia boryana  |  55—Aphanocapsa pulchra  |  56—Microcystis aeruginosa  |  57, 58—Microchaete uberrima  |  59—Oscillatoria limosa  |  60, 61—Oscillatoria subbrevis  |  62—Oscillatoria vizagapattensis  |  63—Phormidium hansgirgi. (© Joel Jose)
algae were dominant. The preliminary study conducted in Kannam River, Kannur, Kerala for the diversity of algae has reported 40 algal species of which Chlorophyceae was dominant, followed by Cyanophyceae (Girish et al. 2018). The algal population of Pennar River, Kottayam, has reported 61 algal species were Chlorophyceae was dominant (Joseph & Claramma 2010). In our study also, more algae were reported from the order Zygnematales, and Spirogyra was the most common genus. The algal species from order Nostocales of Cyanophyceae was dominant. A similar type of diversity was observed in the Gundur lake of Tamil Nadu. Out of 87 algal species reported from Gundur Lake, 37 species were Cyanophyta (Vijayan et al. 2014). The algae from Chlorophyceae and
Image 73–79. 73, 74—Cylindrospermum stagnale | 75, 76—Gloeotrichia echinulata | 77—Scytonema ocellatum | 78—Scytonema rivulare | 79—Nostochopsis lobatus. (© Joel Jose)
Cyanophyceae were dominant in species composition compared to other classes.

CONCLUSION

Overall, the biodiversity study conducted in Chimmony Wildlife Sanctuary shows a good presence of algae. The study also revealed that Spirogyra was dominant from Chlorophyceae, Phacus was dominant from Euglenineae, and Phormidium was dominant from Cyanophyceae. The algal diversity directly depends on season and the physicochemical parameters of the freshwater ecosystem. Therefore, extensive seasonal studies are required for acquiring more knowledge about algal diversity.

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The study of algal diversity from fresh water bodies of Chimmony Wildlife Sanctuary, Kerala, India
— Joel Jose & Jobi Xavier, Pp. 21246–21265

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