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Research Article

Eukaryotic Microalgae and Cyanobacterial Diversity Analysis from Bharathidasan University Campus, Tamil Nadu, India

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Abstract: Eukaryotic microalgae and Cyanobacteria have immense biodiversity, and are an almost unexploited resource. They have been identified as a hopeful and commercially valuable resource of high-value products such as proteins, fatty acids, pigments, vitamins, alkaloids, flavonoids and steroids etc., in the food and aquaculture industries. Microalgae are a promising candidate for the production of useful products due to their low cost biomass production, ease of cultivation, and glycosylation patterns similar to that of higher plants. Though quite a few species of microalgae have been identified as a potential candidate to fulfill our needs, remain unexplored. The aim of the present study is to enumerate the microalgal diversity in the vicinity of Bharathidasan university (Tiruchirapalli, TamilNadu, India). Physicochemical parameters of the water samples were also determined.the pH of the sites varied from 6.5 to 7.4, lkalinity was between 24 mg L^{-1} and 42 mg L^{-1}, total alkalinity was between 312 mg L^{-1} and 681 mg L^{-1}, calcium, magnesium, chloride and nitrate levels varied between 329 mg $L^{-1}$and 1318 mg L^{-1}, 220 mg L^{-1} and 826 mg L^{-1}, 12.99 mg L^{-1} and 193.33 mg L^{-1}, 4.0 mg L^{-1} and 9.8 mg L^{-1}, respectively. Nitrite, total phosphorus and inorganic phosphorus levels were found to be between 2.1 mg L^{-1} and 4.3 mg L^{-1}, 2.4 mg L^{-1} and 6.7 mg L^{-1}, and 1.2 mg L^{-1} and 4.3 mg L^{-1}. Biodiversity of both eukaryotic microalgae and cyanobacteria recorded the members of the belonging to *Oscillatoria* sp. are predominant in diversity and distribution followed by other taxa such as *Spirulina laxissima, Staurastrum manfeldtii, Merismopedia elegans, Cosmarium blyttii* and *Cosmarium subcucumis*.

Keywords: Microalgae, Cyanobacteria, Diversity Analysis, Bharathidasan University, Physicochemical Properties

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1. INTRODUCTION

Eukaryotic microalgae and Cyanobacteria are microscopic, oxygenic, photosynthetic organisms. Microalgae are economically significant, because they hold a wide range of biotechnological and industrial benefits. They are the dominant group of organisms in aquatic environments with sufficient nutrients and light, and they appear to form a bloom with a single or a few species where eutrophication and favourable conditions exist[1]. In freshwater aquatic ecosystems such as rivers, lakes, wetlands, and canals, they are one of the most important primary producers. Microalgae can be found in all sources and storage of water and depending on their abundance, can be very beneficial to the environment[2]. Microalgae and Cyanobacteria have immense biodiversity and are an almost unexploited resource. There are an estimated 200,000-800,000 species on the planet, with around 35,000 species described. So far, just a few hundred have been cultured in laboratories. Just a few microalgae species have been cultured and evaluated for their possible economic value. Microalgae and Cyanobacteria have been identified as a hopeful and commercially valuable source of high-value products such as proteins, vitamins, fatty acids, carotenoids and steroids in the food and aquaculture industries. Oil prices, declining global oil supplies, and environmental degradation caused by non-renewable fuel (fossil) use have reignited interest in microalgae as fuel substitute[3].Microalgal discipline (Phycology) is increasingly spreading around the world, attracting several large corporations to investigate it. When exposed to nutrient stress, a variety of green algae strains have the ability to expand in mass culture and produce significant amounts of lipids. *Chlorella* sp. is a type of algae that grows quickly and can be grown in large quantities. Microalgae are a promising candidate for the production of useful products due to their low cost, easy way of cultivation, glycosylation patterns similar to that of higher plants, and biological protection[4]. Wetlands provide habitat for a diverse range of microorganism's despite being subjected to extremes of environmental stress, such as freezing and desiccation. Phototrophic microorganisms, such as cyanobacteria and eukaryotic microalgae, play an important role in these environments, particularly in arid and semiarid areas around the world. The Tiruchirappalli district which represents Tamil Nadu's central region in Tropical India, is rich in freshwater aquatic ecosystems. This area is enriched by the Cauvery river delta and warm weather. The Cauvery River divides Tiruchirappalli district, and a network of canals spans the river's delta area, allowing water to be stored in reservoirs near the city. The biodiversity of algal flora in water bodies shows a connection of occurrence and physicochemical factors and it acts as a good indicator of climate change[5]. The Phytoplanktons can double their rate of reproduction in the same period of time under optimal conditions (i.e., sunlight, temperature, salinity, etc.,). The environment determines the richness and uniqueness of indigenous freshwater biota. The productivity of algae which are the prominent producers in the food chains mainly depends on the quality of water. Water is considered as an inevitable renewable resource for the functioning of all life forms on earth. The increased human activities have added more biological stress on these habitats in the last 25 years, resulting in changes in their characteristics. The scientific approach of natural resource extraction and conservation is regarded as much needed. Algal diversity in freshwater wetlands has been extensively studied in India to know its physicochemical characteristics of the affected water bodies[6]. The present study focuses on determining the microalgal biodiversity at Bharathidasan university which is located in Tiruchirapalli, India. The physicochemical properties of the water samples were also evaluated.

2. MATERIALS AND METHODS

2.1 Sample location

Samples were collected in and around Bharathidasan University in Thiruchirappalli, Tamilnadu in the year 2020, between December and January, and sampling locations were chosen randomly based on the position and density of the microalgal population[7].

2.2 Sample collection

Algal mats and plankton epiphytic microalgae samples were collected. Plankton nets with mesh sizes of 200 and 42 µm were used to rinse and tilt the samples with water. The residues of the 42 µm mesh filtration were used to extract phytoplankton and epiphytic microalgal samples[8].

2.3 Sample preservation

Water and microalgae samples were collected in plastic vials and polyethylene bags with code numbers indicating the location and area of collection from ponds, lakes, and rivers. Figures 1 - 8 show the sample collected areas along with their geographic location[9].

Fig 1: Sample collection site1(Physics department)

Fig 2: Sample collection site 2 (Commerce department)

Fig 3: Sample collection site 3 (English department)

Fig 4: Sample collection site 4 (Helipad)

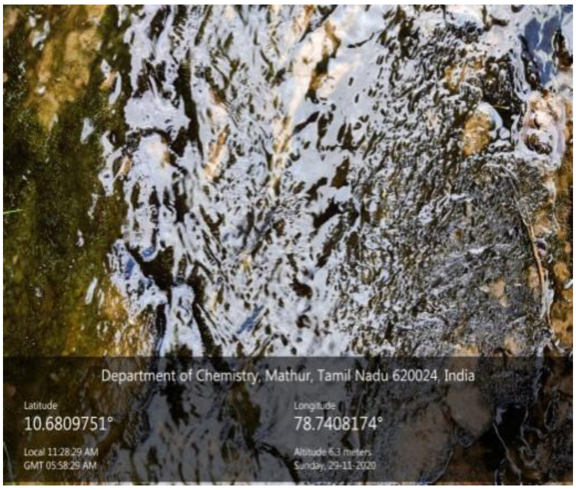


Fig 5: Sample collection site 5 (Chemistry department)

Fig 6: Sample collection site 6 (Periyar road)

Fig 7: Sample collection site 7 (Administrative building)

Fig 8: Sample collection site 8 (Hostel road)

2.4 Determination of physico-chemical parameters

To examine the physicochemical parameters, water samples were taken from each sampling site. At the sampling sites, physicochemical parameters, such as pH using pH meter (Spectrum Technologies, USA), were measured . Alkalinity, total alkalinity, total phosphorus, inorganic phosphorus, calcium, magnesium, chloride, nitrate, nitrite in water samples from the sites were measured using standard methods (APHA, 1989). The experiments were replicated three times for each sampling site, and the average values of the chemical parameters were recorded[10].

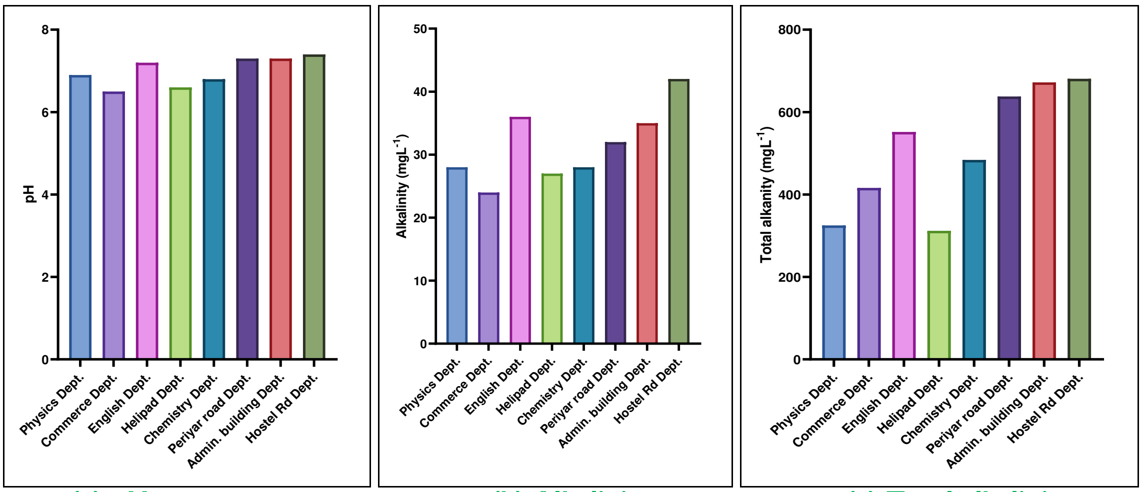
2.5 Microalgal diversity analysis

The samples were morphologically identified using published reports and standard monographs. Microphotographs of the samples were taken with a photo microscopic system (Mikroskope, Micros, Austria), and the biodiversity of each sample was recorded[11].

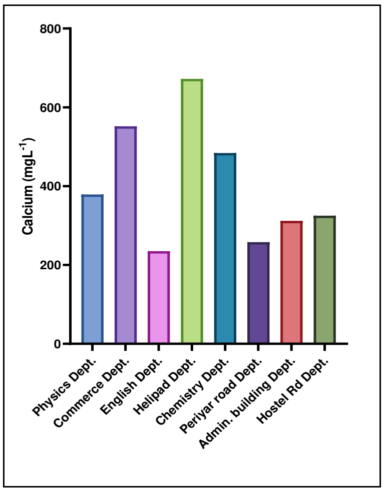
2.6 Physicochemical analysis

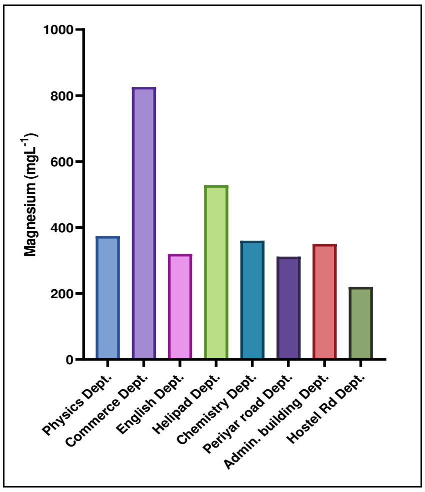
Physicochemical parameters evaluated for the study on 8 different sites were pH, alkalinity, total alkalinity, calcium, magnesium, chloride, nitrate, nitrite, total phosphorus and inorganic phosphorus. Physicochemical parameters of 8 sites were presented on Figure 9. pH of the sites varied from slightly acidic (6.5) to slightly alkaline (7.4) at commerce dept (site-2) and hostel road (site-8). Alkalinity varied between 24 mg L^{-1} (Commerce dept.) to 42 mg L^{-1} (Hostel road). Total alkalinity was found to be low at helipad (312 mg L^{-1}) and high at Hotel road (681 mg L^{-1}). Calcium, magnesium, chloride and nitrate levels varied between 329 mg L^{-1}(Commerce dept.) to 1318 mg L^{-1}(Chemistry dept.), 220 mg L^{-1}(Hostel road) to 826 mg L^{-1}(Commerce dept.), 12.99 mg L^{-1}(Periyar road) to 193.33 mg L^{-1}(Helipad) and 4.0 mg L^{-1}(Physics dept.) to 9.8 mg L^{-1}(Helipad). Nitrite, total phosphorous and inorganic phosphorus levels were found to be between 2.1 mg L^{-1} (English dept.) to 4.3 mg L^{-1}(Admin. building dept.), 2.4 mg L^{-1}(commerce dept.) to 6.7 mg L^{-1}(Periyar road), and 1.2mgL-1 (helipad) to 4.3mgL-1 (Periyar road), respectively.

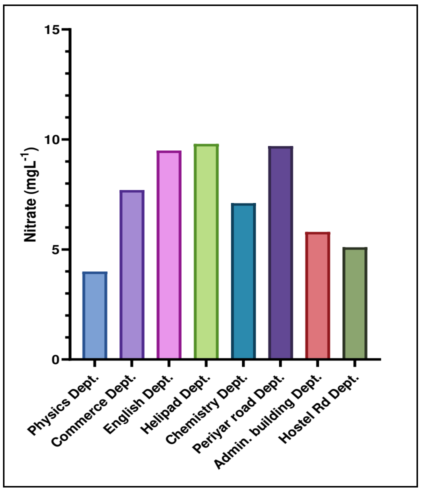
3. RESULTS



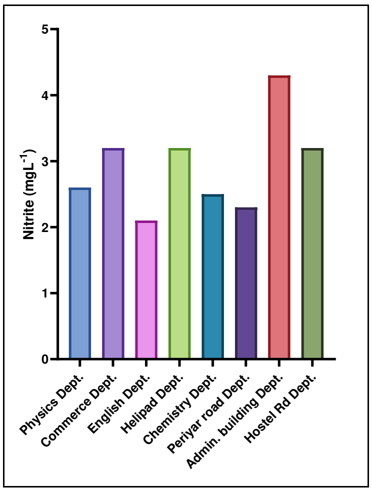
(a) pH (b) Alkalinity (c) Total alkalinity

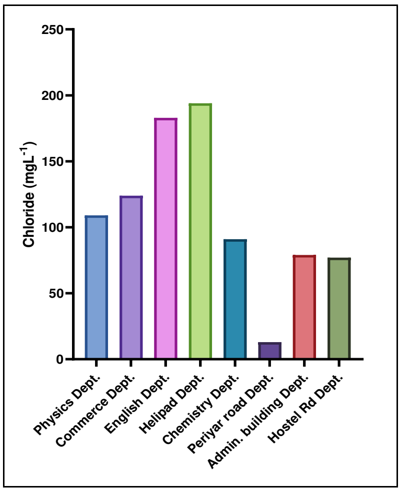


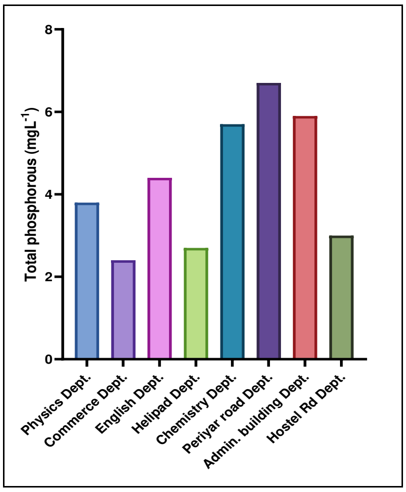




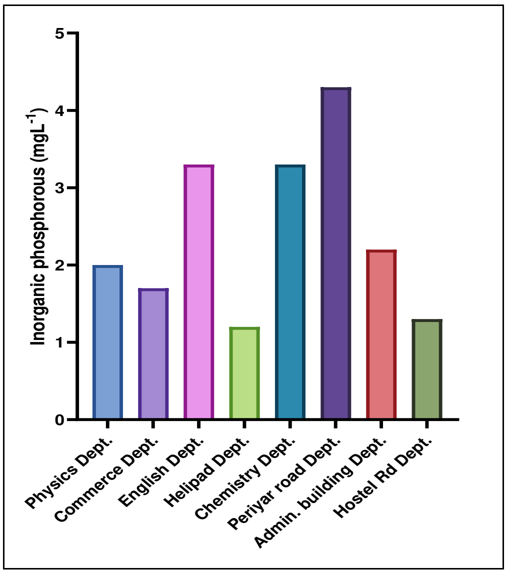
(d) Calcium **(e) Magnesium** **(f) Nitrate**







(g) Nitrite **(h) Chloride** **(i) Total phosphorous**



(j) Inorganic phosphorous

Fig 9: Physicochemical properties of the water samples collected at different sites within Bharathidasan University.

2.7 Microalgal diversity analysis

Microalgal diversity analysis was carried out on 8 different sites in and around Bharathidasan university. The samples were observed under microscope and the algal species were identified based on its morphology. Several cultivable and non-cultivable algal species were identified from the analysis. Figure 10 to 14 shows the microalgal and cyanobacterial species identified from various sites in and around Bharathidasan University. The collective microalgal diversity identified was presented in Table 1 to 3. *Oscillatoria* sp. was found to be predominant and was observed on all the sites. Similarly, Diatoms (*Navicula cryptocephala*) were identified on 3 different sites; Phormidium *digueti*) and *Cosmarium* spp. (*Cosmarium blyttii* and *Cosmarium subcucumis*) were observed on 2 different sites. Some of the rare microalgal and cyanobacterial species were observed on helipad (*Chloromonas typhlos and Chroococcus turgidus*), Chemistry dept (*Staurastrum manfeldtii*), administration, Building (*Merismopedia elegans and Cosmarium blyttii*) and Hostel road (*Cosmarium subcucumis*).

Table 1: Description of Species of Filamentous Cyanobacteria found in the samples

S.No	Species Identified	Species Details
1	*Scytonema chiastum*	It grows in filaments that form dark mats. They are aquatic and are either free-floating or grow attached to a submerged substrate, while others species grow on terrestrial rocks, wood, soil, or plants. *It is* nitrogen fixer, and can provide fixed nitrogen to the leaves of plants on which it is growing. It forms a symbiotic relationship with fungi to produce a lichen.
2	*Oscillatoria princeps*	The cyanobacterium is dark blue green, due to the presence of phycocyanin and phycoerythrin. Individual filaments are blue green to olive green. Growth takes place only by transverse division hence the trichome comprises a single row of cells stacked one above the other. A cytoplasmic sheath is present which is very thin, hyaline and indistinct. Mature trichomes are straight, the cells much broader than long and has hemispherical apical cell with keritomized (irregular to radial thylakoid arrangement) content. Trichome unconstricted in growth phase and constrictions are observed during reproduction. Distinct cross walls are presented. The size of the cells varies from 57.6 μm to 69.1 μm in width and 5.2 μm to 9.6 μm in length thus the ratio of the length and breadth is 1:8.
3	Phormidium *diguetii*	It forms long, unbranching filaments inside a rigid mucilaginous sheath. Sheaths may form tangles or mats, intermixed with other phytoplankton species. They reproduce asexually. Their filaments break apart and each cell forms a new filament. The mats grow around atolls, salt marshes, or in freshwater.
4	Oscillatoria variabilis C.B.Rao.	It reproduces by fragmentation, facilitated by dead cells which separate a filament into separate sections, or hormogonia, which then grow. Each filament of oscillatoria consists of trichome which is made up of rows of cells. The tip of the trichome oscillates like a pendulum. In reproduction, it takes place by vegetative means only. Usually the filament breaks into a number of fragments called hormogonia. Each hormogonium consists of one or more cells and grows into a filament by cell division in one direction.
5	Phormidium tanganyikae (G.S.West) Anagnostidis	Single trichome, free swimming, olive green, straight or nearly straight, at the ends gradually tapering, and bent, sometimes not bent, rounded or obtuse rounded, constricted at the cross walls; cells quadrate, 10-12 μm at the end 6 μm long, at the ends up to twice as long as broad.
6	*Oscillatoria rubescens*	A fresh water, blue green alga. Commonly found in fresh and polluted water of ponds, pools, drains, streams, and also in damp soils and rocks. These form bluish scums on water surface or at pond-bottom.
7	*Phormidium corium*	Size-1.4-2 μm; colour-green; shape-filament; characteristics: filaments are straight or slightly curved. Trichomes, 4.0-4.7 μm wide, are intensely motile and oscillating, not constricted at the granulated cross-walls, briefly attenuated at the ends, bent, hooked. Apical cells are obtuse-conical or rounded-conical, rarely slightly depressed, without calyptra or thickened outer cell wall.
8	*Spirulina laxissima*	Size-3–12 μm; colour: green; shape: cylindrical helix; characteristics- patterned arrangement of its multicellular cylindrical trichome in an open helix. Trichomes are composed of cylindrical cells that undergo binary fission in a single plane, perpendicular to the main axis
9	*Trichormus fertilissimus (Rao) Komárek*	Size-10.6-18.8μm; colour-Blue green; shape- beadlike or barrel-like cells; characteristics- interspersed enlarged spores (heterocysts), found as plankton in shallow water and on moist soil.
10	*Phormidium uncinatum*	Stratum broadly expanded, dark green to brownish black, adherent, thin, firm, or floating attached at the base, thick, torn; filaments straight or slightly bent, sheath mucilaginous, distinct or diffluent in an amorphous mucilage, not coloured blue by chlor-zinc-iodide; trichome blue-green, not constricted at the cross-walls, 6-9 μm broad, ends briefly attenuated.
11	*Geitlerinema splendidum (Greville ex Gomont) Anagnostidis*	Size-15-22μm broad and 3-5μm long; colour- Pale-brown; shape-filamentous ; characteristics- apical cell rounded with convex calyptra containing numerous large granules. Thallus: Expanded, initially light brown which turns dark brown to blackish in later phase. Trichome: Straight or wavy, gradually arcuate towards ends, 15-22μm broad, constricted at the ± granulated cross-walls, usually parallelly arranged.
12	*Oscillatoria tenuis*	Size-6-11μm long, 2-3μm width; colour- blue green; shape- filamentous; characteristics- it has apical cells with broadly rounded apex without thickened outer membrane. Thallus: Thin, blue-green. Trichome: Free, straight, 6-11μm broad, indistinctly constricted at the cross walls.
13	*Oscillatoria vizagapatensis*	Size-13-15μm long and 3-5μm width; colour-Blue green; shape- discoidal in shape; characteristics- it has apical cell hemispherical or flattened with thickened calyptroidal outer

		cell wall. Thallus: Light brown to dark brown to blackish in later phases of growth. Trichome: Pale-brown in colour, 13-15μm broad, cylindrical, usually straight or rarely curved, slightly constricted at the granulated cross-walls
14	*Oscillatoria princeps Vaucher ex Gomont.*	Size-, 2-4μm; colour-blue green; shape- filamentous ; characteristics- it content granular, apical cell conical to widely rounded with slightly thickened outer cell wall, calyptra present. Thallus: Expanded, blackish-green or olive green in colour. Trichome:Blue-green or olive-green in colour, usually straight, rarely coiled, irregularly flexuous, cylindrical, 7-11μm broad, slightly narrow towards ends, slightly constricted at the granulated cross-walls.
15	*Microcoleus vaginatus*	Size-4–10 μm; colour-blue green; shape-filamentous ; characteristics- The main diacritical characters are related to the cytomorphology of trichomes, including: narrowed trichome ends, calyptra, cells shorter than wide up to more or less isodiametric, and facultative presence of sheaths.
16	*Calothrix gloeocola*	Unusually for bacteria, the filaments of this species have an elongated base and a pointed tip with transparent hair at the end. The filaments have coatings that are either firm or jelly-like, and they all are made up of concentric layers that are colored yellow or brown. The filament also grows like the root of a plant. Sometimes the filament sheds and can reproduce asexually by dropping fragments (hormogonia) off the stem.
17	*Microcoleus paludosus*	Filamentous single or forming a dark blue-green stratum, unbranched or sometimes divided at the end; shealth slightly gelatinous, not coloured violet by chlor-zinc-iodide, with many straight or rope like trichomes not granulated at the cross walls, constricted at the crosswalls.5-7 μm broad; cells nearly as long asa or twice as long as broad, 4-13 μm long, bright blue-green ; end cell not capitates, conical.
18	*Oscillatoria subbrevis*	Size- 3-4.5 μm; colour-blue green; shape-filament; characteristics- Thallus: Thin, olive-green. Trichome: Free, 5-8μm broad, nearly straight, not attenuated at the apex. Growth in liquid medium shows solitary trichomes attached to the bottom and side wall of the flask. On agar plates trichomes creep and form a thin layer.

The above table gives the description of Species of Filamentous Cyanobacteria found in the samples collected in and around Bharathidasan University in Thiruchirappalli, Tamilnadu in the year 2020.

Table 2: Description of the Species of Eukaryotic Microalgae and non-filamentous Cyanobacteria Species Description in the samples

S.No	Species Identified	Species Details
1	*Tetradesmus dimorphus (Turpin) M.J.Wynne.*	Size- 11-18 μm long, 3.5-7 μm wide; colour-green; shape- coenobial; characteristics-.
2	*Chroococcus mipitanensis (Wolszynska) Geitler*	They are typically characterized as living in small colonies of 2 cells that are surrounded by a clear, mucus sheath.
3	*Chroococcus minor*	They are typically characterized as living in small colonies of 4 cells that are surrounded by a clear, mucus sheath.
4	*Chlorella sorokiniana*	Size- 2 to 10 μm; colour-green; shape-spherical; characteristics- It has a characteristic green color and pleasant grass odor. Its cells divide rapidly to produce four new cells every 17 to 24 hours.
5	*Staurastrum manfeldtii*	Size- 42-50 μm length , 42-50 μm breadth; colour-green; shape- subcylindric; characteristics- unicellular desmid with two semicells divided by a deep midline constriction or isthmus, each with short or long arm-like processes, which may be patterned with an array of ridges or spines, and are radially arranged around the cell (cf. Micrasterias, in which "arms" always lie in one plane).
6	*Aphanocapsa elachista*	Size-2–3.8 μm; colour- green; shape- spherical; characteristics- grows on stones in the wells with neutral water (pH 7.0) and high conductivity (approximately 651 μS cm-1).
7	*Merismopedia elegans*	Size- 2.5 x 3.6 μm; colour-green; shape- rectangular colonies; characteristics- it comprises flattened, free-living, platelike (rectangular), more or less rectangular colonies that have one layer of cells, arranged loosely or densely in perpendicular rows and enveloped by fine, colorless, usually indistinct, and marginally diffuse mucilage.
8	*Monoraphidium contortum*	Cells solitary, irregularly curved, from sigmoid to spiral (1.0-1.5 turns), gradually tapered apices, pointed ends; single parietal chloroplast without pyrenoids. Cell dimensions: 7.5-12 μm in length, 1.5-2 μm in width.
9	*Euglena gracilis*	*E.*It has a highly flexible cell surface, allowing it to change shape from a thin cell up to 100 μm long, to a sphere of approximately 20 μm. Each cell has two flagella, only one of which emerges from the flagellar pocket (reservoir) in the anterior of the cell, and can move by swimming, or by so-called "euglenoid" movement across surfaces.
10	*Microcystis protocystis*	Size- 2-3um; colour-green; shape-spherical;. I
11	*Cosmarium subcucumis*	Size-65-71 μm long, 25-39 μm wide; colour-green; shape-hemispherica; characteristics- unicellular; variable in shape; a constriction at the center of the cell body; mostly longer than wide; flattened; each semicell hemispherical, spherical, ellipsoidal, rectangular,

		pyramidal or kidney-shaped; no apical indentation.
12	*Monomorphina pyrum*	Cells are napiform, nearly spherical but with a long, straight, sharply pointed caudus; broadly rounded anteriorly periplast forming an envelope widely separated from an elliptical protoplast, the periplast. spirally striated; paramylon bodies not observed; chloroplasts numerous, ovoid indistinct discs. Size of cells is approx. 19 µm in diameter and 36 µm in length.
13	*Chloromonas typhlos*	Size-11-20 µm long and 5-15 µm wide; colour-green; shape- round or oval; characteristics- The cells had a slightly dorsoventral structure he cells contained one nucleus, a prominent papilla at the flagella base, a cup-shaped chloroplast with perforations and branched incisions on the surface, the pyrenoids were not observed. The nucleus usually was located in the middle of the protoplast.
14	*Cosmarium blyttii*	Size- 20–30 µm; colour-dark green; shape- bi-lobed; characteristics- In this complex genus the cells are very variable. All are constricted in the middle leading to its bi-lobed appearance.

The above table is the Description of the Species of Eukaryotic Microalgae and non-filamentous Cyanobacteria Species Description in the samples collected in and around Bharathidasan University in Thiruchirappalli, Tamilnadu in the year 2020.

Table 3: Diatom and Macroalgae Species Description

S.No	Species identified	Species details
1	*Navicula rostellata*	Size- 32-41 µm; colour-brown; shape-boat shaped; characteristics- valves are lanceolate with protracted apices The axial area is narrow and straight. The central area is large and circular. The raphe is straight, with 'drop-like' expanded external proximal ends. Striae are radiate around the center, becoming convergent at the apices.
2	*Navicula cryptocephala*	Size- 25.0-34.1 µm long, 5.8-6.7 µm wide; colour- brown; shape- boat-shaped; characteristics- valves are lanceolate with protracted apices The axial area is narrow and straight. The central area is large and circular. The raphe is straight, with 'drop-like' expanded external proximal ends.
3	*Navicula gregaria*	Size-25.0-34.1 µm long, 5.8-6.7 µm wide; colour- brown; shape- boat shaped; characteristics- The axial area is narrow and straight. The central area is asymmetric and elliptical. The raphe is straight, with external proximal raphe ends sharply bent toward the primary side of the valve.

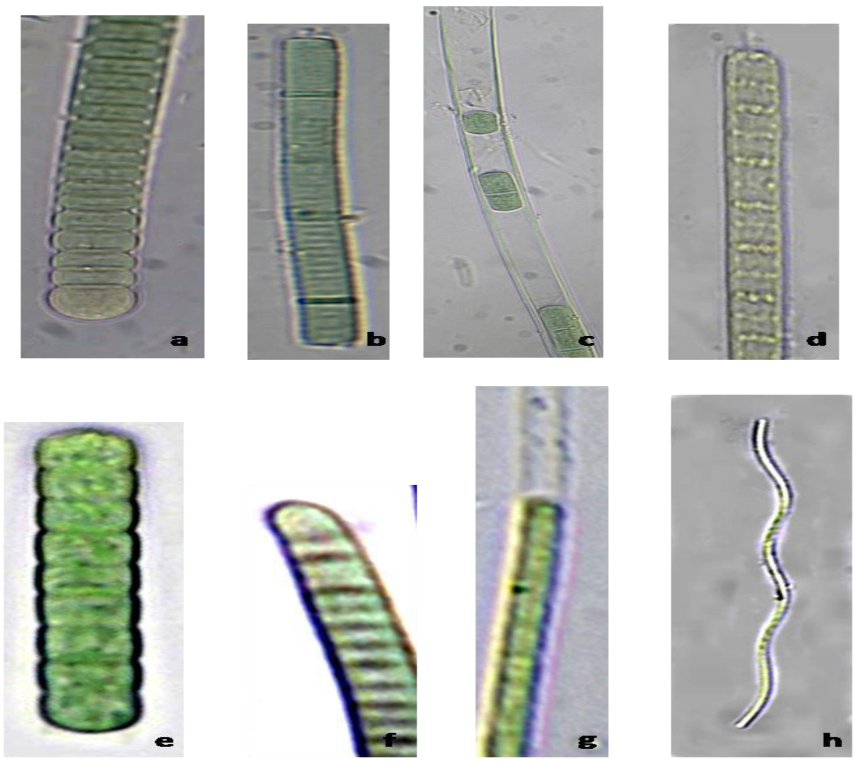


Fig 10: a) *Scytonema chiastum*; b) *Oscillatoria princeps*; c) *Lyngbya digueti* ; d) *Oscillatoria variabilis;* e) *Oscillatoria tanganyikae;* f) *Oscillatoria rubescens;* g) *Phormidium corium;* h) *spirulina laxissima*

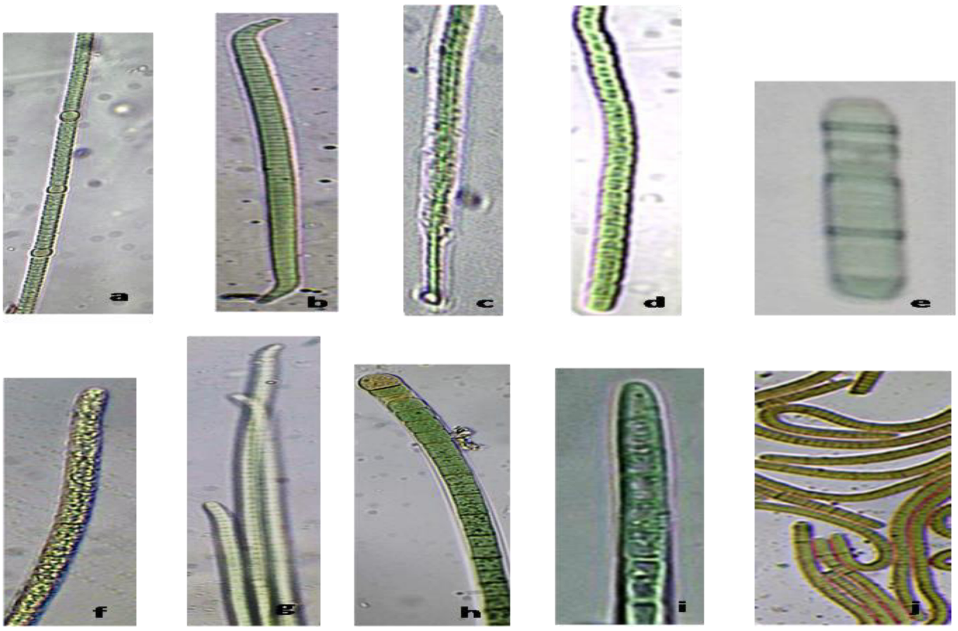


Fig 11: a) *Anabaena fertilissima*; b) *Phormidium uncinatum*; c) *Oscillatoria splendida;* d) *Oscillatoria tenius;* e) *Oscillatoria vizagapatensis;* f) *Oscillatoria amphibia;* g) *Microcoleus vaginatus;* h) *Calothrix gloeocolaom;* i) *Microcoleus paludosus;* j) *Oscillatoria subbrevis*

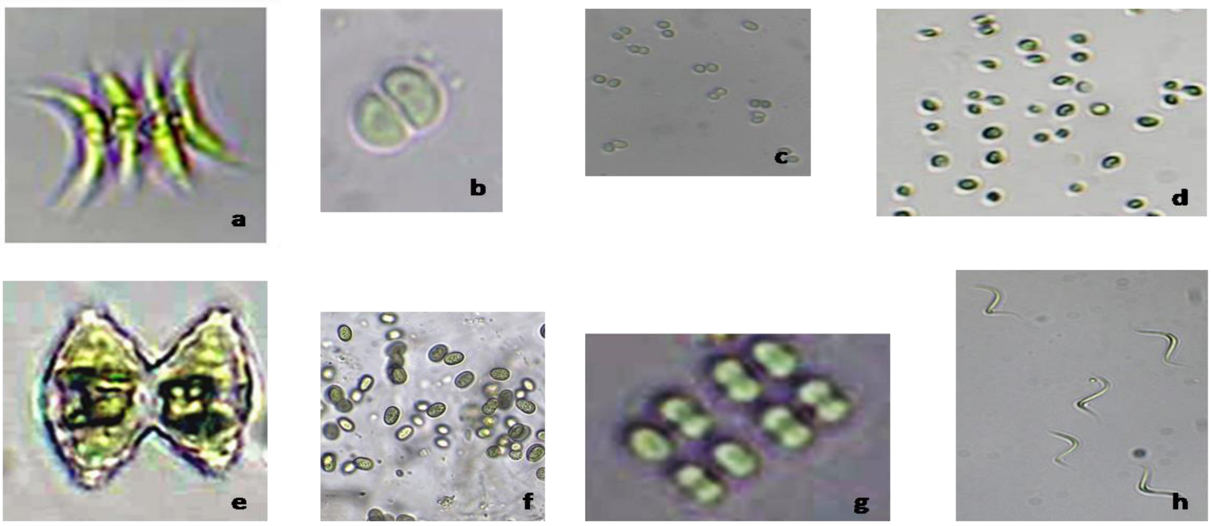


Fig 12: a) *Scenedesmus dimorphus*; b) *Chroococcus turgidus*; c) *Chroococcus minor;* d) *Chlorella sorokiniana* ; e) *Staurastrum manfeldtii;* f) *Aphanocapsa elachista* ; g) *Merismopedia elegans;* h) *Monoraphidium contortum*

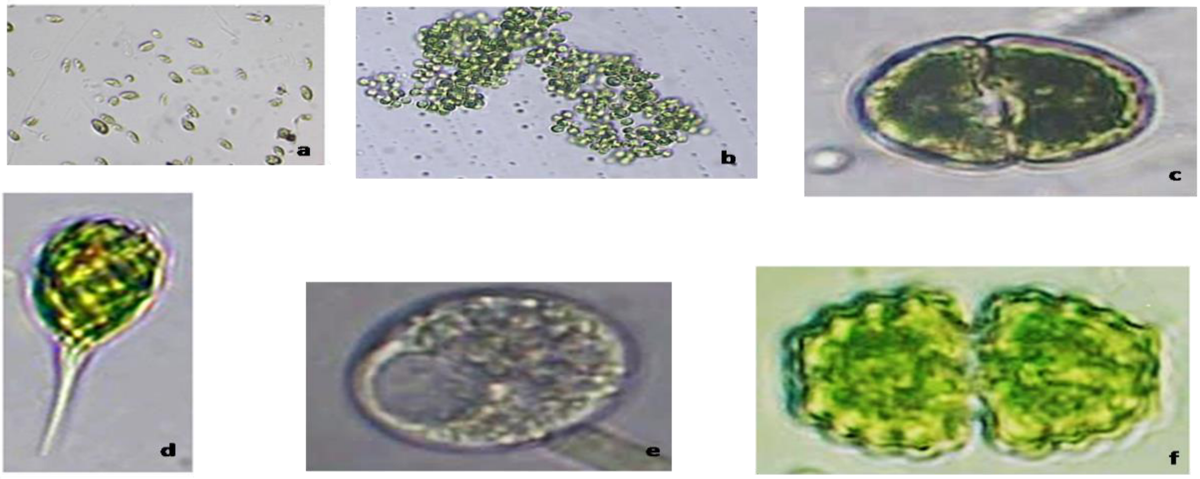


Fig 13: a) *Euglena gracilis; b)Microcystis protocystis; c) Cosmarium subcucumis; d) Monomorphina pyrum; e) Chloromonas typhlos; f) Cosmarium blyttii*

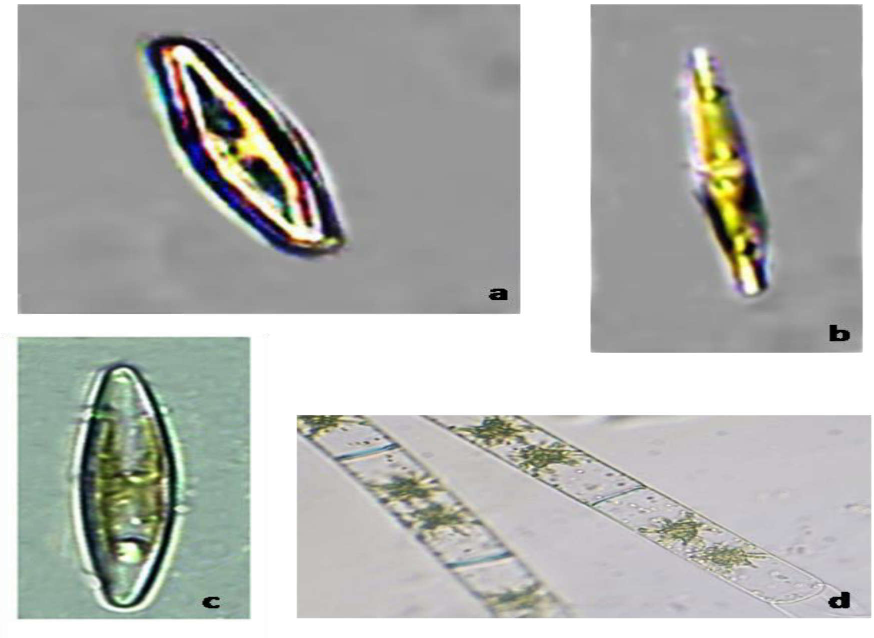


Fig 14: a) *Navicula rostellata*; b) *Navicula cryptocephala* ; c) *Navicula gregaria*; d) *Zygnema excompressum*

4. DISCUSSION

Eukaryotic microalgae and Cyanobacteria account for 4–27% of the whole microbial biomass in both terrestrial and aquatic ecosystems. These play an important role in primary processing, decomposition, nutrient cycling, and energy flow in an ecosystem. Microalgae includes eukaryotic protists, filamentous forms, and prokaryotic Cyanophyceae, and are a diverse group of organisms[12]. These are found all over the world, possess potential cellular mechanism to thrive in harsh environments, and approximately half of the world's photosynthetic activity is attributed to them. Furthermore, they produce 70% of the world's biomass[13]. These are among the most widely used indicators of the biological and physicochemical health of the marine ecosystem. These algae are extremely labile to the ecosystem in which they live, and any change in the atmosphere causes a shift that makes several transformations of algal species in terms of habitat tolerance, productivity, diversity, and dominance. As a result, they are often employed in the measurement of pollution levels based on its biodiversity. Since their advantages such as large population size, rapid growth rate, low cost, ease of maintenance, and response to low levels of pollutants, they are an excellent option for pollution monitoring[14]. These provide a fast, accurate, and quantifiable indication of environmental changes[15]. The current study focused on determining the algal biodiversity and physiochemical analysis of several sites on Bharathidasan University because there had been no previous studies on the microalgal diversity in this region. Physicochemical approaches can be used to determine the quality and composition of water samples with high precision and sensitivity. However, an integrative method for measuring both biotic and abiotic parameters is needed to assess the quality of water[16]. The pH level is a significant environmental factor to consider. The spatial variance was found to be negligible during this study. At this study period, the pH value range (6.5 to 7.4) was favorable for the algal population and since the pH is lower, primary producers can access nutrients (such as phosphate and nitrate). According to Mishra[17] *et al.,* (2008), algae and macrophytes in the water body reduce carbon dioxide and calcium carbonate levels, increasing the pH of the water, which is essential for aquatic plant and planktonic organism survival. The majority of chemical and biochemical reactions are influenced by the pH of water. The algae also act as a pollution indicator in waters which are contaminated with acidic and alkaline wastes. The study also discovered a connection between pH and total alkalinity, implying that the higher the pH (alkaline), the higher the total alkalinity. Chloride in natural waters is mostly derived from sediment and its levels above a certain threshold suggest pollution, which may be caused by organic wastes or industrial effluents. The permissible limit of chloride in industrial effluents, according to the Bureau of Indian Standards (BIS), is 250 mg L^{-1}. At certain locations in the current analysis, the values were found to be below the appropriate range[17]. In water bodies, nitrate is necessary for the growth of certain cyanophycean and chlorophycean algae[18]. Inorganic contamination and eutrophication was indicated by higher nitrate concentrations in some of the study's at several locations. Nitrate or nitrogen, which is commonly present in natural waters, is the end product of aerobic decomposition of organic matter[19]. Nitrification usually occurs at higher temperatures and higher dissolved oxygen levels, when microbial activity is at its peak[20]. In this analysis, the higher nitrate content (9.8 mg L^{-1}) in Site-4 was because of one of the reasons mentioned above. Nitrate is an essential nutrient for marine organisms, and when combined with other nutrients like phosphate, it promotes algal bloom, which leads to eutrophication[17,21]. According to the Pollution Control Board (1998), the permissible upper limit of nitrate nitrogen for discharge into inland surface water is 10 mg L^{-1}. Total phosphorus is an essential nutrient that can also be a constraint. It is responsible for the growth of phytoplankton in marine environments[22]. According to the Pollution Control Board (1998), the maximum amount of phosphate phosphorus that can be discharged into inland surface water is 5 mg L^{-1}. Inorganic contamination was indicated by a higher total phosphorus concentration (6.7 mg L^{-1} in site-6) in the current sample. Hedge[23] (2007) found a higher concentration of chloride, nitrate, and sulphate in Mangalore's surface waters. Most elemental concentrations were low due to dilution caused by heavy rains during the monsoons. The concentration of Cl^- in the rainwater of India's west coast is particularly high when compared to other tropical areas. Strong winds prevailing over the north western Indian Ocean, especially during the southwest monsoons, may be to blame for the increased output of sea salt aerosol[24]. *Oscillatoria* spp. was identified to be the most general cyanobacterial species. Under higher light attenuations, members of the Oscillatoriaceae family have been reported to be the dominant flora which is attributable to their ability to maintain growth even at lower underwater irradiance.[24] This confirms the findings of this analysis with Oscillatoriaceae members forming the dominant flora and the diverse existence of the genus *Oscillatoria*, as well as the abundance of *Oscillatoria princeps* in nearly all of the sites. *Oscillatoria* is very tolerant to water pollution[24]. *Oscillatoria* and *Phormidium* are the most prevalent genera in sewage, according to Singh and Saxena[25] (1969). *Oscillatoria* species have a light-capturing mechanism that operates around the visible spectrum. These results correlate with the present study. The Bray-Curtis Dissimilarity is a way to measure the dissimilarity of the microalgae population between two different sites[26]. This metric is often used in ecology and biology to quantify how two sites are different in terms of the species found in those sites[27]. The Bray-Curtis Dissimilarity always ranges between 0 and 1. It is calculated by the formula: $BC_{ij} = 1 - (2*C_{ij}) / (S_i + S_j)$ where, C_{ij}-The sum of the lesser values for the species found in each site; Si-The total number of specimens counted at site *I;* S_j-The total number of specimens counted at site *j.* The index 0 and 1 denotes the high similarity and no similarity[28,29]. In the present study, the microalgae species found in each site were observed to be different and no similar species were observed between sites. Therefore, bray-curtis dissimilarity between the different sites was 1.

5. CONCLUSION

The Microalgal and Cyanobacterial diversity within the sites of Bharathidasan university was analysed in the present study. Physicochemical parameters of the water samples were also determined. From the physicochemical analysis, the pH of the sites varied from 6.5 to 7.4; Alkalinity varied between 24mgL^{-1} to 42mgL^{-1}; Total alkalinity between 312mgL^{-1} to 681mgL^{-1}.Calcium, magnesium, chloride and nitrate levels varied between 329mg$L^{-1}$to 1318 mgL^{-1}, 220mgL^{-1} to 826mgL^{-1}, 12.99mgL^{-1} to 193.33mgL^{-1} and 4.0mgL^{-1} to 9.8mgL^{-1}. Nitrite, total phosphorous and inorganic phosphorous levels were found to be between 2.1mgL^{-1} to 4.3mgL^{-1}, 2.4mg$L^{-1}$to 6.7mgL^{-1}, and 1.2mgL-1 to 4.3mgL-1. Diversity analysis showed that the predominant algae was *Oscillatoria* sp. Other varieties, such as *Anabaena fertilissima*, *Lyngbya digueti, Phormidium uncinatum Staurastrum manfeldtii*, *Merismopedia elegans, Microcoleus vaginatus, Scenedesmus dimorphus, Chroococcus turgidus, Chroococcus minor, Chlorella sorokiniana, Monomorphina pyrum, Euglena gracilis, Monoraphidium contortum, Cosmarium blyttii, Navicula rostellata, Navicula cryptocephala* and *Cosmarium subcucumis* were also identified.

6. AUTHORS CONTRIBUTION STATEMENT

Soundararajan S and KarkuvelRaja R made substantial contributions to conception and design, and/or acquisition of data, and/or analysis and interpretation of data. Sanjay Prasad S and Vishnu chitthan S participated in drafting the article and revising it critically for important intellectual content; and Thajuddin N gives final approval of the version to be submitted and any revised version.

7. CONFLICT OF INTEREST

Conflict of interest declared none.

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