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Investigating The Function of Algae as A Bioindicator for Water Quality Assessment

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ABSTRACT
Objectives: To explore the algal floral diversity and its role in determining water quality.
Methods: In 2024, algae and water samples were collected every month. Formalin at 2 to 3% was used to keep unicellular algae, whereas formalin at 4% was used to keep macroalgae. The Canon advanced digital camera was used to capture microphotographs of algae. We utilised the Palmer pollution index to find out how clean the water was.
Results: The research found 201 algae species spread throughout 57 genera, 42 families, 25 orders, 10 classes, and 7 divisions. The overall score for the Lake's Algal Genus Pollution Index. It was determined that Lake has a possible absence of organic pollutants.
Conclusion: We firmly promote for the protection and management of algae species to ensure a sustainable stock of algal-derived products in the future. It was shown that the water quality of Lake was influenced by human activity and must be regulated.

Key words: Pollution Index of Lake, water quality, anthropogenic activities, algal floral diversity

Introduction

Algae are a wide category of basic, photosynthetic creatures that may be unicellular or multicellular. They have a very basic body termed a thallus, which cannot be distinguished from genuine roots, stems, and leaves and lacks circulatory tissues. They are quite different in terms of size, shape, structure, colour, behaviour, and environment. Because of their immense biological diversity, algae may be found in a wide range of ecosystems, including oceans, rivers, lakes, ponds, and streams.(Lowe, Ri., Pan, Y., 2006). They may be found anywhere from the depths of the ocean to the world's highest summits. Linnaeus originally used the name "Algae" in 1753. Algae are an essential food source for aquatic organisms and contribute significantly to the aquatic food chain or food web.

They are an excellent source of natural human nutrition.(Reynolds 2020) Microalgae are an excellent source of biofuel, with better productivity than conventional crops (Khatoon and Pal, 2015). Many important antibiotics and medications are derived from these species. Pharmaceutical firms employ them to make medications that are used to treat illnesses such as cancer, acquired immune deficiency syndrome (AIDS), arthritis, respiratory ailments, and infections caused by viruses, bacteria, and fungus (V, Vadlapudi, 2012). Algae help to purify water by removing nutrients and contaminants. (Rojo, 2004). Because of their quick reactivity to pollution, algae are thought to be excellent bioindicators of water quality.

Algae are significant biological organisms for water filtration because they absorb organic and inorganic contaminants, heavy metals, and radioactive materials. (Rawson, D.S., 2020, Stockner 2000). Microalgae are bioindicators of eutrophication and may be used to monitor water quality. The presence of green algae and diatoms indicates oligotrophic conditions, but the prevalence of blue green algae indicates eutrophic conditions in water bodies. Due to the enormous relevance and contribution of algae, an endeavour was undertaken to record the existence of important algal species. The goals of this study were to undertake thorough research on the collection, identification, and categorisation of algal flora in order to assess phycological variety and its function in determining water quality in the study region for the first time. This study is noteworthy since it is a current and new work. The study should be of interest to readers in the fields of botany, ecology, conservation biology, agriculture, and environmental sciences, etc.

Materials and methods

Study site- Himayathsagar Lake

Himayathsagar Lake Coordinates 17°18′N 78°21′E. The construction of reservoirs on the Esi, a tributary of the Musi River, was completed in 1927, with the intention of providing a drinking water source for Hyderabad and protecting the city from floods, which Hyderabad suffered in 1908. It was built during the reign of the last Nizam of Hyderabad, The Himayat Sagar dam and Osman Sagar reservoirs provided continuous water supply to the twin cities of Hyderabad and Secunderabad until recently. Due to population growth, they are not sufficient to meet the cities' water supply-demand. Himayat Sagar is an artificial lake about 20 kilometres (12 mi) from Hyderabad in the Ranga Reddy district of Telangana, India. It lies parallel to a larger artificial lake called Osman Sagar. The storage capacity of the reservoir is 2.9 tmc ft.

Sampling sites

For present study, algal and water samples were collected from five randomly selected sampling Sites

Sampling of algae

Algae was collected on a regular monthly basis from January to December 2024. Epiphytic algae and desmid flora were gathered using a pipette. Filamentous algae species were obtained using forceps. Diatoms were collected using a tooth brush, whereas macroalgae were picked up by hand. The gathered algae samples were placed in bottles and tagged.

Preservation of algae

Unicellular algae were preserved in 2 to 3% formalin while macro algae were kept in 4% formalin (Mason, 1967).

Laboratory studies and identification of algae

The algal samples were sent to the Hydrobiology , Algal biotechnological laboratory at C.K.M. Government Arts and Science College for microphotography. Microphotographs of algae species were captured using a camera affixed to the microscope (MT5300H-Japan). The algal species specimens were identified using authoritative literature to the species or variety level (Smith 1950, Prescott 1962).

Analysis of algae

The collected material was assessed on the basis of morphological, cytological and reproductive characters during microscopic examination. After detail analysis, algae were documented and tabulated for evaluation of algal biodiversity from the study area.

Palmer pollution index

Palmer pollution index was used to evaluate water quality

Results

The current research identified 201 algae species among 57 genera, 42 families, 25 orders, 10 classes, and 7 divisions from the study region in 2018. The highest number of families (18) was supplied by the division Bacillariophyta, followed by Chlorophyta with 14 families and Cyanophyta with 5 families. Euglenophyta supplied two families, but Glucophyta and Dinophyta each gave one family. Table 1. The Bacillariophyta exhibited dominance with a frequency of 47%, followed by Chlorophyta at 38% and Cyanophyta at 19%. The minor divisions Euglenophyta, Charophyta, and Dinophyta had low representation, with frequencies of 2%, 1.5%, and 1%, respectively (Fig. 2).

The Naviculaceae and Fragillariaceae families had the greatest species diversity, whilst Glucocystaceae displayed the least (Table 1). The highest number of detected species was 95, mostly from Bacillariophyta, followed by 76 species from Chlorophyta. The minimum number of species was represented by Glaucophyta and Dinophyta, each including one species. Bacillariophyta produced the highest number of genera (25), followed by Chlorophyta with 21 genera and Cyanophyta with 6 genera. Euglenophyta was represented by three genera, but the other divisions were not specified.

Each was documented with one genus. The division with the highest number of orders was Chlorophyta, contributing 11 orders, followed by Bacillariophyta with 6 orders and Cyanophyta with 4 orders, while the other divisions each contributed 1 order (Fig. 3). The predominant genus was Navicula, including 14 species, followed by Spirogyra and Cymbella, each with 11 species. The least number of species was supplied by Troschia and Lyngbya (Fig. 4 and Table 1). The division Bacillariophyta exhibited dominance with a frequency of 47%, followed by Chlorophyta at 38% and Cyanophyta at 19%, respectively. The minor divisions Euglenophyta, Charophyta, and Dinophyta had low representation, with frequencies of 2%, 1.5%, and 1%, respectively. Figure 5.

Evaluation of organic pollution by Palmer's algal genus

The contamination of surface water has emerged as a significant environmental issue. Organic pollution in water bodies results in eutrophication, which subsequently accelerates the growth of specific algal species in these environments.(Thomann, R.V., 2009). Algae serve as a natural indicator of environmental conditions due to their ability to form blooms in water bodies and exhibit vigorous growth. Numerous studies conducted by different authors have demonstrated a significant relationship between algal species and both polluted and unpolluted water.(Schindler, D.W., 2014)

Various factors such as the mixing of water masses, light availability, temperature, salinity, and nutrient levels exert influence. Bioindicator organisms serve as valuable tools for detecting the impacts of pollutants within aquatic ecosystems. Various environmental factors influence the presence and spread of algae. The mass of cyanobacteria is affected by the concentration of hydrogen ions (pH), with subsequent influences from temperature, light, soil type, and the availability of nutrients. The mass can be quantified through the frequency and intensity of the biotic community as a result of eutrophication. Numerous investigations into algal species have validated their significance in evaluating pollution levels in aquatic environments.

Kolkwitz and Marsson (1950) divided bodies of water into five zones based on how polluted they were and suggested using aquatic species as bioindicators to check the water quality.

Werner (1977), Watanabe, T(2016) suggested nine separate areas based on how much organic contamination there was in water bodies. Coprozoic, Polysaprobic, Mesosaprobic, Oligosaprobic, and Katharobic were the zones that Werner suggested. It was observed that each zone was distinct based on its physical, chemical, and biological traits. He named the indicator species in these areas that changed how they grew when contaminants were present in water bodies. The polysaprobic zone has no algae at all, save for blue-green algae Spirulina and green algae Euglena viridis. In the alpha-Mesozoic zone, blue-green algae were the most common kind of algae, whereas in the Beta-Mesozoic zone, diatoms and green algae were the most common. We only discovered Dinophyta and Charophyta in oligosaprobic zones. Palmer (1969) came up with the idea of a pollution index based on the types and numbers of algae seen in water bodies. This pollution index is a good way to check the water quality for high or low levels of organic pollutants (Table 2). We found pollution-tolerant algae in all the research area's locations and gave each algal species a pollution index score. A pollution index value of 20 or above means that there is a lot of organic contamination in the water. A score between 15 and 19 indicates that there is likely organic contamination. A pollution index score of 10 to 14 means that there is considerable organic pollution, whereas a score of 0 to 10 means that there is no organic pollution in the water. We employed algae genera to find out how clean the water was in the freshwater bodies we studied. The overall score of the algal genus pollution index for the lake was 14, 9, 10, 18, and 25, respectively. Table 3 shows that Lake probably contains organic contamination.

Table-1

Algal flora explored from freshwater lake of the study area

Divisions, Class, Order, Family, Genus and Species name

Cyanophyta Cyanophyceae Order: Chroococcales

Family: Chroococcaceae

1.Chroococcus turgidus (Kutzing) Naegeli
2. Chrococcus limneticus Lemmermann
Family: Microcystacae
3. Gleocapsa punctate Nageli
4. Gleocapsa bituminosa Kutzing

Order: Nostocales

Family: Nostocaceae

5.Nostoc muscorum C.A. Agardh

Order: Oscillatoriales

Family: Oscillatoriaceae

6. Lyngbya birgei G.M. Smith
7. Lyngbya martensiana Meneghini ex Gomont
8.Lyngbya majuscule Harvey ex Gomont
9. Oscillatoria tenuis C.A. Agardh
10. Oscillatoria limosa C.A. Agardh
11.Oscillatoria princeps Vaucher
12.Oscillatoria sancta (Kutzing) Gomont
13.Oscillatoria fracta G.W.F.Carlson
14.Oscillatoria acuta Bruhl
15.Oscillatoria chilkensis Biswas
16.Oscillatoria obscura Bruhl &Biswas
17.Oscillatoria curviceps C.A. Agardh
18.Oscillatoria anguina Bory ex Gomont

Order: Synechococcales
Family: Merismopediaceae
19. Merismopedia glauca (Ehrenberg) Kutzin
Chlorophyta Chlorophyceae Order: Chlorococcales
Family: Oocystaceae
20.Ankistrodesmus falcatus var. radiates (Chod) Lemmermann
Order: Chlamydomonadales
Family:Volvocaceae
21.Volvox aureus Ehrenberg
22.Pandorina morum Bory
Family: Chlorococcaceae
23. Schroederia setigera (Schroeder)Lemmermann
Order: Sphaeropleales
Family: Scenedesmaceae
24.Scenedesmus quadricauda (Turpin) Brebisson
25.Scenedesmus opoliensis Richter
26.Scenedesmus protuberans Fritsch and Rich
27.Scenedesmus longus Meyen
28.Scenedesmus dimorphus (Turpin) Kutzing
29. Scenedesmus carinatus (Lemmermann) Chodat
30.Scenedesmus communis E.Hegewald
31.Scenedesmus abundans var.longicada G.M Smith
32.Scenedesmus quadricauda var.maxima West & GS West
33.Scenedesmus abundans (Kirchner) Chodat
34.Tetraedron regulare Kutzing
35.Tetraedron caudatum (Corda) Hansgirg
36.Tetradron trigonum var.minus Reinch
37.Troschia aspera Reinsch
38. Coelastrum microporum Nacgeli
39.Coelosphaerium kuetzinginum
Family: Hydrodictyaceae
40.Pediastrum duplex Meyen
41.Pediastrum duplex var. gracillimum West & GS West
42.Pediastrum simplex var echnulatum Wittrock
43.Pediastrum biwae var. ovatum (Ehrenberg) Tiffany
44.Pediastrum simplex var.duodenarium (Bailey) Rabenhorst
45.Pediastrum boryanum var.longicorne Raciborski
Order: Oedogoniales
Family: Oedogoniaceae
46.Oedogonium macrandrium Wittrock
47.Oedogonium cardiacum (Hassall) Wittrock
48.Oedogonium majus (Hansgirg) Tiffany
Order: Tetrasporales
Family: Sphaerocystidaceae
49.Sphaerocystis schroeteri R.Chodat
Order: Microsporales
Family: Microsporaceae
50.Microspora quadrata Hazen
51.Microspora willeana Lagerheim
52.Microspora tumidula Hazen
Order: Chetophorales
Family: Chaetophoraceae
53.Draparnaldia plumose (Vaucher) C.A. Agardh
54.Chaetophora lobata F.Schrank
55.Chaetophora elegans (Roth) Agardh Ulvophyceae
Order: Ulvotrichales
Family: Ulotrichaceae
56.Ulothrix gemilata Kutzing
57.Ulothrix zonata (Weber & Mohr) Kutzing
58. Ulothrix aqualis Kutzing
Order: Cladophorales
Family: Cladophoraceae

59.Cladophora glomerata (Linnaeus) Kutzing
60.Cladophora oligoclona Kutzing Zygnematophyceae
Order: Zygnematales
Family: Zygnemataceae
61.Spirogyra communis (Hassall) Kutzing
62.Spirogyra biformis C.C.Jao
63.Spirogyra maxima Link in C.G.Nees
64.Spirogyra neglecta (Hassall) Kutzing
65.Spirogyra subsalsa Link in C.G.Nees
66.Spirogyra tetrapla Transeau
67.Spirogyra elongata (Vaucher) Kutzing
68.Spirogyra fluviatilis Hilse
69.Spirogyra punctiformis Trascan
70.Spirogyra rectuangularis Transeau
71.Spirogyra catenaeformis (Hassall) Kutzing
72.Zygnema tenue Kutzing
73.Zygnema sterile Transeau
74.Zygnema insigni (Hassall)
75.Zygnema aplanosporum Stancheva,J.D.Hall & Sheath
76.Mougetia micropora Taft
77.Mougetia viridis (Kutzing) Wittrock
Order: Desmidiales
Family: Desmidiaceae
78.Cosmarium formosulum Hoffman
79.Cosmarium botrytis Meneghini
80.Cosmarium speciosum Lundell
81.Cosmarium granatum Brebisson
82.Cosmarium nitidulum Denotaris
83.Cosmarium subtumidum Nordstedt
84.Staurastrum rzoskae Meyen ex Ralfs
Family:Closteriaceae
85.Closterium acutum (Lyngbye) Brebisson
86.Closterium parvulum Naegeli
87.Closterium leibleinii Kutzing
88.Closterium lanceolatum Kutzing
89.Closterium intermedium Ralfs
90.Closterium littorale Gay
91.Closterium lunula (Mueller) Nitzch
92.Closterium pseudolunula Borge
93.Closterium acerosum var.elongatum Brebisson
94.Closterium striolatum Ehrenberg
Trebouxiophyceae
Order: Chlorellales
Family: Chlorallaceae
95.Chlorella conductrix Brandt
Charophyta
Charophyceae **Order: Charales**
Family: Characeae
96.Chara coralina Klein ex C.L.Willdenow
97.Chara globular Thuiller
98.Chara vulgaris Linnaeus
Bacillariophyta **Bacillariophyceae** **Order: Bacillariales**
Family:Anomoeneidaceae
99.Anomoeoneis vitrea Pfitzer
100.Anomocoenis exilis (Kutzing) Cleve
101.Anomoconies serianus (Brebisson) Cleve
Family:Catenulaceae
102.Amphora holsatica Hustedt
Family:Achnanthidiaceae
103.Achanthes microcephala (Kutzing) Cleve
Family:Cocconeidaceae
104.Cocconeis plancetula Ehrenberg

Family: Bacillariaceae
105.Denticula tennis Kutzing
106.Nitzchia palea (Kutzing) Wm. Smith
107.Nitzschia sublinearis Hustedt
108.Nitzchia acicularis (Kutzing) Wm. Smith
109.Nitzchia hungarica Grunow
110.Nitzchia denticula Grunow
111.Nitzchia palea var.tenuirostris Grunow
Order: Fragilariaales
Family:Fragilariaceae
112.Diatom vulgare Bory
113.Diatoma anceps (Ehrenberg) Kirchner
114.Fragillaria viresecens Ralfs
115.Fragillaria pinnota Ehrenberg
116.Fragillaria capucina Desmazieres
117.Fragilaria vaucheriae (Kutzing) J.P.Peterson
118.Fragillaria intermedia (Grunow) Grunow
119.Fragillaria crotonensis var.prolongata Grunow
120.Stauroneis phoenicentron (Nitzsch) Ehrenberg
121.Stauroneis acuta Wm.Smith
122.Stauroneis phoenicentrum var.amphilepta (Ehrenberg) Cleve
123.Stauroneis anceps var.birostris (Ehrenberg) Cleve
124.Synedra dorsiventralis Mueller
125.Synedra ulna (Nitzsch) Ehrenberg
126.Synedra acus Kutzing
127.Synedra parasitica (Wm.Smith) Hustedt
128.Synedra amphicephala Kutzing
129.Synedra affinis Kuetz
130.Synedra crystalina (C.A.Agardh) Kutzing
Order:Naviculales
Family:Naviculaceae
131.Caloneis bacillum (Grunow) Mereschkowsky
132.Gyrosigma acuminatum (Kutzing) Cleve
133.Gyrosigma wormleyi (Sullivant) Boyer
134.Gyrosigma Kuetzingii (Grunow) Cleve
135.Gyrosigma scalproides Rabenhorst
136.Navicula tuscula (Ehrenberg) Grunow
137.Navicula gracilis Ehrenberg
138.Navicula protracta (Grunow) Cleve
139.Navicula exigua (Gregory) Muller
140.Navicula veneta Kutzing
141.Navicula salinarum Grunow
142.Navicula rhyncocephala Kutzing
143.Navicula radiosa Kutzing
144.Navicula viridula Kutzing
145.Navicula cuspidata Kutzing
146.Navicula grimmei Krasske
147.Navicula dicephala (Ehrenberg) Wm.Smith
148.Navicula reinhardtii (Grunow) Van Heurek
149.Navicula gregaria Donkin
Family: Rhopalodiaceae
150.Rhopalodia gibba (Kutzing) Mueller
151.Rhopalodia gibba var.ventricosa (Kutzing) H.Peragallo & M. Peragallo
152.Epithemia adnata (Kutzing) Brebisson
153.Epithemia argus (Ehrenberg) Kutzing
Family: Pinnulariaceae
154.Pinnularia nobilis Ehrenberg
155.Pinnularia braunii (Grunow) Cleve
156.Pleurosigma angulatum (Quekett) Wm.Smith
157.Pleurosigma salinarum (Grunow) Grunow
Family: Neidiaceae
158.Nedium iridis (Ehrenberg) Pfitzer

159.Nedium dubium (Ehrenberg) Pfitzer
Family:Sellaphoraceae
160.Sellaphora capitata D.G.Mann& S.M. McDonald
161.Sellaphora pupilla (Kutzing) Meresckowsky
Family: Amphipleuraceae
162.Frustulia rhomboids (Ehrenberg) DeToni
163.Frustulia viridula (Brebisson) DeToni
Family: Stauroneidaceae
164.Craticula cuspidata (Kutzing) D.G.Mann
Order: Surirellales
Family:Surirellaceae
166.Cymatopleura solea (Brebisson) Wm.Smith
167.Cymatopleura elliptica f.spiralis (Chase) Boyer
168.Surirella linearis Wm.Smith
169.Surirella saronica Auerswald
170.Surirella didyma Kutzing
171.Surirella splendida (Ehrenberg) Kutzing
172.Surirella linearis var.constricta (Ehrenberg) Grunow
173.Surirella ovata Kutzing
174.Surirella minuta Kutzing
175.Surirella patella Kutzing
Order: Mastogloiales
Family:Mastogloiaceae
176.Mastogloia smithii Tshwait
177.Mastogloia smithii var.amphicephala Grunow
Order:Cymbellales
Family:Cymbellaceae
178.Cymbella tumida (Brebisson) Van Heurck
179.Cymbella leptoceros (Ehrenberg) Grunow
180.Cymbella laevis Naegeli
181.Cymbella lanceolata (Brebisson) Van Heurck
182.Cymbella prostrata (Berkeley) Cleve
183.Cymbella turgida Gregory
184.Cymbella acqualis Wm.Smith
185.Cymbella affinis Kutzing
186.Cymbella parva (Wm.Smith) Cleve
187.Cymbella aspera (Ehrenberg) Cleve
188.Cymbella brehmii C.A.Agardh
Family:Gomphonemataceae
189.Gomphonema ventricosum Gregory
190.Gomphonema constrictum Ehrenberg
191.Gomphonema micropus Kutzing
192.Gomhonema sphaerophorum Ehrenberg
193.Gomhonema angustatum (Kutzing) Grunow
194.Gomhonema parvulum (Kutzing) Grunow
Euglenophyta Euglenophycaea Order: Euglenales
Family: Euglenaceae
195.Euglena limnophila Ehrenberg
196.Euglena sociabilis P.A. Dangeard
197.Euglenaformis proxima (Dangeard) M.S.Bennett
Family: Phacaceae
198.Phacus longicauda (Ehrenberg) Dujardin
199.Astasia cylindrical Fromental
Glaucophyta Glaucophyceae
Order:Glaucocystales
Family: Glaucocystaceae
200.Gloescystis ampla Kutzing Dinophyta
Dinophyceae
Order: Phytodiniales
Family: Phytodinaceae
201.Cystodinium steinii Transeau

Discussion

The algae represent a fascinating group of plants, characterised by their primitive nature and global distribution, owing to their ability to thrive in a wide range of environmental conditions. Algae serve as the main producers in various aquatic ecosystems because of their capacity for photosynthesis. They are highly significant organisms from ecological, commercial, and medical perspectives. Our study in freshwater bodies revealed a rich diversity of algal species, including three new records: Phacus longicauda, Closterium leibeleinii, and Pediastrum duplex var. gracillimum. Variations in algal composition and diversity were observed in the lake, showing differences at the bottom, middle, and surface layers of water due to the formation of a thermocline in the water body. Diatoms were the predominant group among microalgae, followed by green algae and blue-green algae. Bioindicator organisms reveal the impacts of various pollutants in aquatic ecosystems. Phytoplanktons serve as a dependable means to assess the water quality of wetlands (Crosseti et al., 2008). Freshwater bodies and lakes are defined by the predominant algal group present. We analysed the water bodies in our study area based on algal genus and determined that the lake likely exhibits signs of organic pollution. While the lake indicated a confirmation of low organic pollution. Species of Chlorophyta such as Chlamydomonas and Euglena, along with members of Bacillariophyta like Navicula, Synedra, and Gomphonema, as well as blue-green algae like Oscillatoria and Phormidium, thrive in waters that are organically polluted (Palmer, 1969). Anand (2000) examined the ecology of a diatom species and observed their significance as indicators of water quality parameters. The prevalence of green algae and diatoms signifies oligotrophic conditions, whereas the abundance of blue-green algae suggests eutrophic conditions in water bodies. Our findings align with those of Palmer (1969) and Musharaf et al. (2011).

Table 2 Palmer algal genus pollution index.

S. No.	Genus	Index	Genus	Index
1	Ankistrodesmus	4	Nitzchia	3
2	Closterium	1	Scenedesmus	4
3	Euglena	1	Syndra	2
4	Gomphonema	1	Pandorina	1
5	Chlorella	1	Oscillatoria	5
6	Navicula	3	Phacus	2
7	Cyclotella	5	Phormidium	1
8	Chlaymydomonas	3	Stigeoclonium	2

Table 3 Pollution indicating algal genera from water bodies of the study area.

Algal Genus	**Freshwater Lake**
Ankistrodesmus	4
Closterium	1
Euglena	1
Gomphonema	1
Chlorella	–
Navicula	3
Cyclotella	–
Chlamydomonas	–

Nitzschia	3
Scenedesmus	–
Syndra	2
Pandorina	–
Oscillatoria Phacus	*2*
Phormidium	–
Total	**17**

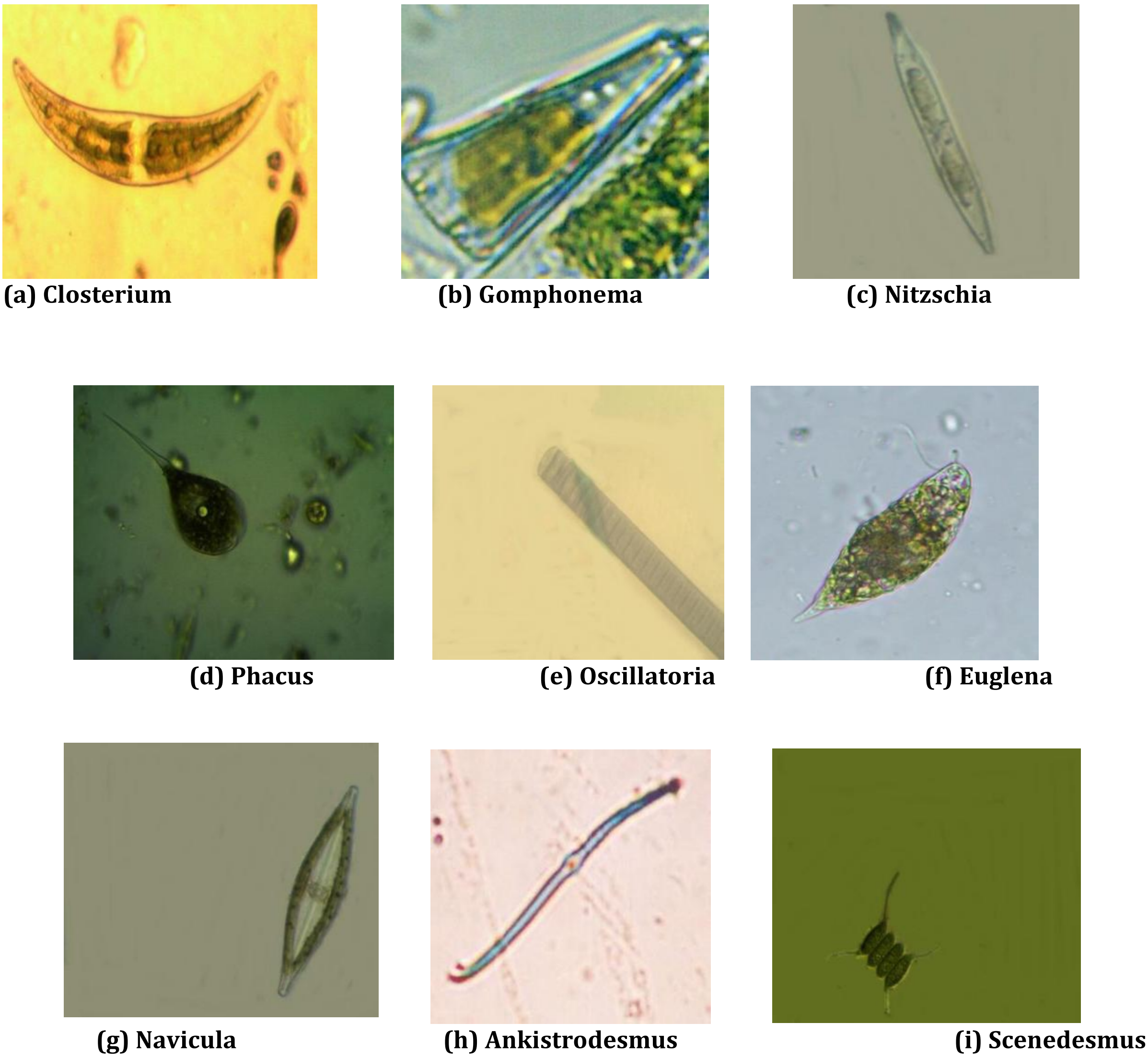

Fig. 1. (a-i) Pollution tolerating genera identified from the freshwater lake of the study area

Conclusion

The water from the freshwater lake is utilised for household, industrial, and agricultural uses. The present investigation found that the decline is attributable to pollution. Conservation and management of these water bodies are necessary to ensure their long-term availability. Sustainable water usage and management are advocated for the survival of water bodies in the research region. It is proposed that future research include molecular studies of algae as well as phylogeny of representative taxa. The utilisation of algae for biofuel, bioremediation, therapeutic purposes, human algal diet, and fish flora should be investigated for commercial and industrial uses, as well as the benefits to humanity.

Declaration of Competing Interest

The authors declare that they have no known competing financial interests or personal relationships that could have appeared to influence the work reported in this paper.

DISCLAIMER (ARTIFICIAL INTELLIGENCE)

Author(s) hereby declare that NO generative AI technologies such as Large Language Models (ChatGPT, COPILOT, etc) and text-to-image generators have been used during writing or editing of this manuscript.

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