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ASSESSMENT OF AQUATIC MACROPHYTES, PHYTOPLANKTONS AND WATER QUALITY OF KAVADI LAKE IN UTTAR KANNADA DISTRICT, KARNATAKA, INDIA

Kartik A G, Rashmi S*

Post Graduate Department of Botany, JSS College of Arts, Commerce and Science (Autonomous), Ooty road, Mysuru, Karnataka, India.

ABSTRACT: The present study was carried out to document the aquatic and wetland plants of Kavadi lake in Yellapur, Uttar Kannada district of Karnataka State, India. Floristic survey was carried out during 2018-2019. The study on aquatic macrophytes in Kavadi lake was documented with 24 species of flowering plants belonging to 20 genera and 18 families, in which 18 species were aquatic plants and 6 species were Marsh/wetland plants. All the plants were categorized under submerged (SM), emergent anchored (EA), rooted floating leaves (RFL), free floating (FF) and wetland plants (WT). Out of 18 families reported, dominant families were Lythraceae with 3 species followed by Araceae, Cyperaceae, Menyanthaceae and Scrophulariaceae with 2 species each. Diversity of phytoplankton was recorded with a total of 33 species, under 26 genera belonging to 18 different families. Family Desmidiaceae was dominated with 8 genera and 9 species. The collected water samples were analyzed for different physico-chemical parameters viz. pH, electric conductivity, temperature, odour, CO_2, chloride, Total hardness, calcium, magnesium, DO, BOD and COD. The study reveals that the Kavadi lake possesses appreciable quantum of aquatic plants and phytoplankton's, after physicochemical analysis the results were found that the sample of habited water is free from pollution and ecologically balanced. Potable water is safe enough to be consumed by humans and can be used for irrigation and pisciculture.

KEYWORDS: Lythraceae, Desmidiaceae, Kavadi lake, Physico-chemical.

Corresponding Author: Dr. Rashmi S* Ph.D.

Post Graduate Department of Botany, JSS College of Arts, Commerce and Science (Autonomous), Ooty road, Mysuru, Karnataka, India. Email Address: rashms@gmail.com

1. INTRODUCTION

Lakes serve as an important life support system by helping in recharging of aquifers and regulating hydrological regimes. Restoration and recharge water table is possible due to the lakes, so the lakes play an important role in our lives [1]. The lakes also act as natural traps for sediments and nutrients, there by helps to regulate water quality and sedimentation of the river systems from the catchment area. The degradation of the lake is due to encroachment and eutrophication loads and silt [2]. Wetlands are one of the crucial natural resources. Wetlands are ranked third among the most productive ecosystem on earth. They are valuable sources, sinks and transformers of a multitude of chemical, biological and genetic material and are considered the 'Kidneys of the Earth' for the cleaning function they perform through biogeochemical cycles. The total area of wetlands in India is 15.26 Mha, which is around 4.63% of the geographical area of the country [3]. Aquatic plants interact with and influence the hydrological, geomorphological and physico-chemical environments, and interact with a wide range of other organisms, from microbes to vertebrates [4]. Wetland plants retain the requisites like carbon and methane balance of our environment and thus maintaining greenhouse equilibrium. Submerged plants are the generators of oxygen in the aquatic system. In controlled growth situations, either naturally or by human interference, aquatic plants can purify water, but if uncontrolled growth takes place, they can reach the levels of pests and are frequently regarded as aquatic weeds. Aquatic plants can reduce biological oxygen demand, and these plants are now exploited for bio filtration of organic waste in the waste water treatment systems [5]. Many terrestrial weeds are also found in the Ecotone region of wetlands that possess several medicinal properties [6]. Several works relating to aquatic and wetland flora have been carried out by many workers throughout the world, including various parts of India [7-10]. Studies of the ecology of lake phytoplankton have provided a wealth of insight into the interactions between abiotic factors and biotic ones such as competition and predation. Growth of phytoplankton is influenced by the presence of limiting nutrient caused by the inflow of fresh water [11]. Some notable studies on phytoplankton diversity have been made [12, 13]. The quality of water generally refers to the composition of water present at the optimum level for stable growth of plants and animals. Aquatic organisms need a healthy environment to live and adequate nutrients for their growth; the productivity depends on the physicochemical characteristics of the water body [14, 15]. The reports on water quality assessment have been recorded [16-28]. In the present study Kavadi lake was surveyed for the diversity of aquatic macrophytes and also phytoplankton for the assessment of biotic potential, which contributes to overall estimation of the basic nature and general economic potential of the water body. A long side analysis of water quality in relation to physicochemical parameters was performed.

2. MATERIALS AND METHODS

Study Area

The present study was carried out to examine the status of the lake "KAVADI" which is spread over 62 acres in Yellapur Taluk, Uttar Kannada district (Fig 1). It is located in the Western Ghats of Karnataka. Yellapur is located at 14.97 N 74.72 E. It has an average elevation of 541 meters (1774 feet). The district average annual rainfall was 3654 mm. Yellapur has a tropical climate. The temperature ranges from 25^0 to 33^0 C [19].

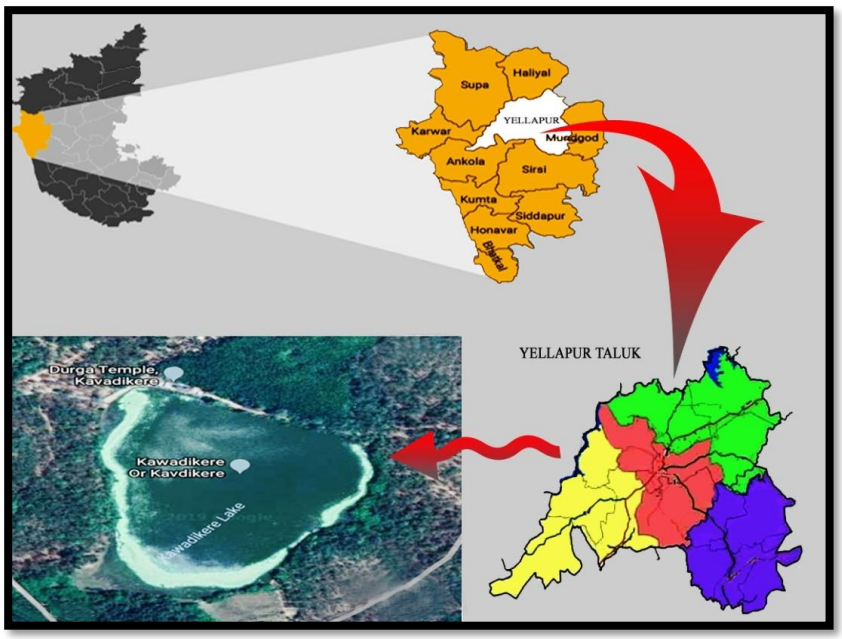

Fig 1: Map showing geographical localities of the study area

Collection of Aquatic and Wetland Plants

Sampling of the aquatic plants from Kavadi lake was done during the winters of 2018-19. The determination of project location was done by method of purposive sampling on 6 sites, for collection of aquatic and wetland plants. The type of aquatic plants contained in the plot was identified, on each plot by three repetitions. Samples of aquatic plants were collected in a plastic bag and labelled, with local names, place and date of sampling. Collected samples were packed in bags neatly and brought to the laboratory for further identification. The identification of aquatic plants was done with the help of standard books, monographs and also with the help of available literatures particularly the local floras [20].

Collection of Water Sample for Phytoplankton Analysis

Plankton samples were collected between 10 am to 12 pm. Collection of phytoplankton samples was made by sieving 25 liters of habitat water from approximately 10-12 cm below the surface level.

Six sampling stations were selected to collecting of water sample. Plankton samples were examined under a high-power microscope and identification up to genus and species level was done with the help of standard books and monographs [21].

Collection of Water Sample for Physico-Chemical Analysis

During water quality investigation, 6 sampling sites were outlined and samples were collected in the morning hours between 9 am to 11am. For lake water sample collection, the closed bottle was dipped in the lake at the depth of 0.7 to 0.9 m, and then a bottle was opened inside and was closed again to bring it out at the surface. The samples collected from 6 different points were mixed together to prepare an integrated sample [8]. Chemical parameters were determined by using standard methods immediately after taking them into laboratory [16]. The collected water samples were analyzed for different physico-chemical parameters (Table 1) viz. pH, electric conductivity, temperature, odour CO_2, chloride, Total hardness, calcium, magnesium, DO, BOD, COD, by following the standard protocols [22]. All the above analyses were performed in triplicate.

Statistical Analysis

The results of the physicochemical evaluation (n=3) were expressed as mean ± standard error mean (SEM).

Table 1: Parameters and methods employed in the chemical examination of water samples

Sl. No.	Parameter of water analysis	Methods
1.	BOD	Bottle incubation for 3-days at 30^0C
2.	Calcium	EDTA Titrimetric
3.	Chloride	Argentometric Titration
4.	CO_2	Titrimetric
5.	COD	Open Reflux
6.	DO	Winkler azide modification titrimetric
7.	Electric conductivity	Conductivity cell potentiometric
8.	Magnesium	Calculation from total hardness and calcium
9.	Odor	Qualitative human receptor
10.	pH	Potentiometric
11.	Temperature	Centigrade thermometer
12.	Total hardness	EDTA Titrimetric

3. RESULTS AND DISCUSSION

Aquatic and Wetland Plants in Kavadi Lake

The study on aquatic macrophytes in Kavadi lake was documented with 24 species of flowering plants belonging to 20 genera and 18 families, in which 18 species were aquatic plants and 6 species were Marsh/wetland plants (Table 2). Out of 24 macrophytes, 13 species belong to 10 genera and 9 families of Dicotyledons and 9 species belongs to 8 genera and 7 families of Monocotyledons, 1 species each belongs to algae and bryophytes. Nearly 4 species were annuals and 17 perennial species. 3 plants fall in between annuals and perennial categories and can be either of the two according to the wetland

systems. Some of the annuals also show tendencies towards perenniality if the wetland is permanent.

Table 2: List of aquatic and wetland species in the Kavadi lake of Yellapur, Uttar Kannada district of Karnataka, India

Sl. No	Scientific name	Common name	Family	Habit	Habitat	Life form
1	*Centella asiatica* L.	Asiatic pennywort	Apiaceae	H	P	WT
2	*Chara* sp.	Stonewort	Characeae	H	P	SM
3	*Coldenia procumbens* L.	Creeping coldenia	Boraginaceae	H	A	WT
4	*Cryptocoryne spiralis* Fisch. ex Wydler	Balansae red	Araceae	H	P	SM
5	*Cryptocoryne undulata* Wendt	Crypt undulata	Araceae	H	P	SM
6	*Cyperus iria* L.	Rice flat sedge	Cyperaceae	H	A/P	EA
7	*Dracaena marginata* Lam.	Dragon tree	Asparagaceae	S	P	WT
8	*Echinochloa crus-galli* (L.) Beauv.	Barnyard grass	Poaceae	H	P	EA
9	*Eleocharis dulcis* Trin. Ex Hensch.	Chinese Water chestnut	Cyperaceae	H	P	EA
10	*Eriocaulon cinereum* R. Br.	Pipe worts	Eriocaulaceae	H	A / P	SM
11	*Hydrocotyle sibthorpioides* Lam.	Lawn marsh pennywort	Araliaceae	H	P	WT
12	*Isoetes melanopoda* Gay & Durieu	Quillworts	Isoetaceae	G	P	SM
13	*Limnophila repens* Benth.	Creeping marsh weed	Plantaginaceae	H	A / P	SM
14	*Lindernia crustacea* L.	Malaysian False Pimpernel	Scrophulariaceae	H	P	WT
15	*Myriophyllum spicatum* L.	Eurasian water milfoil	Haloragaceae	H	P	SM
16	*Nymphaea odorata* Aiton	White water lily	Nymphaeaceae	H	P	RFL
17	*Nymphoides indica* L.	Water snowflake	Menyanthaceae	H	P	RFL
18	*Nymphoides peltata* Kuntze	Floating heart	Menyanthaceae	H	P	RFL
19	*Persicaria lapathifolia* L.	Pale persicaria	Polygonaceae	H	A	WT
20	*Rotala densiflora* Koehne	Dense flowered rotala	Lythraceae	H	A	EA
21	*Rotala macrandra* Koehne	Giant red rotala	Lythraceae	H	A	EA
22	*Rotala rotundifolia* Koehne	Dwarf rotala	Lythraceae	H	P	EA
23	*Utricularia macrorhiza* LeConte	Bladderwort	Lentibulariaceae	H	P	FF
24	*Vallisneria americana* Michx	Tape grass	Hydrocharitaceae	H	P	SM

[H = Herb, S= Shrub, G = Grass, A = Annual, P = Perennial, EA= Emergent Anchored, FF = Free Floating, RFL = Rooted with Floating Leaved, SM = Submerged, WT = Wetland]

All the plants were categorized under rooted submerged-26% (RSM), rooted emergent anchored-31% (REA), rooted floating leaves- 13% (RFL), free floating-4% (FF) and wetland plants-26% (WT) (Fig 2). Submerged plants represented by 8 species viz. *Chara* sp., *Cryptocoryne spiralis* Fisch. ex Wydler,

Cryptocoryne undulata Wendt, *Eriocaulon cinereum* R. Br., *Isoetes melanopoda* Gay & Durieu, *Limnophila repens* Benth., *Myriophyllum spicatum* L., *Vallisneria americana* Michx. Followed by emergent anchored with 8 species viz. *Cyperus iria* L., *Echinochloa crus-galli* (L.) Beauv., *Eleocharis dulcis* Trin. Ex Hensch., *Rotala densiflora* Koehne, *R. macrandra* Koehne, *R. routundifolia* Koehne. Free floating plants were only one *Utricularia macrorhiza* LeConte. Out of 18 families reported, dominant families were Lythraceae with 3 species followed by Araceae, Cyperaceae, Menyanthaceae and Scrophulariaceae with 2 species each (Fig 3). And the rest 13 families Characeae, Eriocaulaceae, Isoetaceae, Haloragaceae, Nymphaeaceae, Lentibulariaceae, Apiaceae, Boraginaceae, Asparagaceae, Polygonaceae, Hydrocharitaceae and Poaceae were represented by single species. Species diversity in different stations showed, station 6 had luxuriant growth of 16 plants compared to other stations (Table 3). *Myriophyllum spicatum* L. and *Rotala macrandra* Koehne was found to be grown in all the stations. *Rotala macrandra* Koehne and *Eriocaulon cinereum* R. Br. are endemic species.

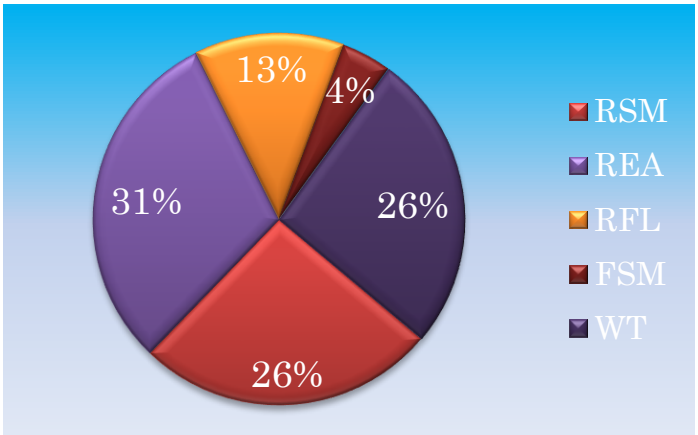

Fig. 2: Percentage of different life forms of aquatic plants

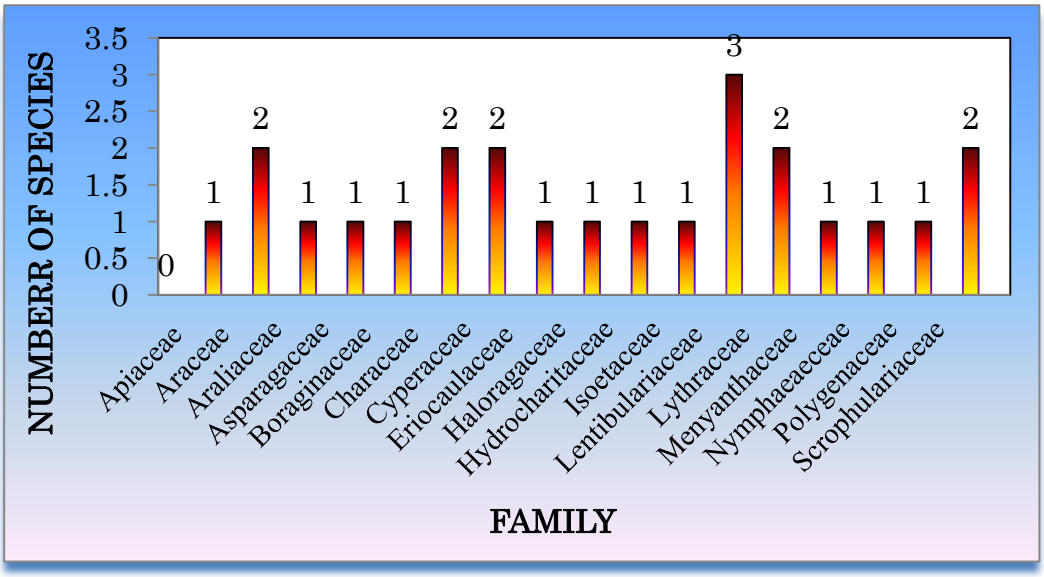

Fig 3: Dominant aquatic plant families with respect to species richness

Table 3: Species diversity in Kavadi lake by different stations

Sl. No.	Name of the plant species	Sampling stations					
		S1	S2	S3	S4	S5	S6
1.	*Centella asiatica* L.			✓			
2.	*Chara* sp.			✓			
3.	*Coldenia procumbens* L.			✓	✓		
4.	*Cryptocoryne spiralis* Fisch. exWydler			✓			
5.	*Cryptocoryne undulata* Wendt			✓			
6.	*Cyperus iria* L.				✓		
7.	*Dracaena marginata* Lam.					✓	
8.	*Echinochloa crus-galli* (L.) Beauv.	✓					
9.	*Eleocharis dulcis* Trin. ex Hensch.	✓					
10.	*Eriocaulon cinereum* R. Br.			✓			
11.	*Hydrocotyle sibthorpioides* Lam.			✓			
12.	*Isoetes melanopoda* Gay & Durieu	✓					
13.	*Limnophila repens* Benth.			✓			
14.	*Lindernia crustacea* L.			✓			
15.	*Myriophyllum spicatum* L.	✓	✓	✓	✓	✓	✓
16.	*Nymphaea odorata* Aiton	✓	✓		✓		
17.	*Nymphoides peltata* Kuntze	✓		✓			
18.	*Nymphoides indica* L.	✓	✓	✓		✓	
19.	*Persicaria lapathifolia* L.	✓					
20.	*Rotala densiflora* Koehne			✓			
21.	*Rotala macrandra* Koehne	✓	✓	✓	✓	✓	✓
22.	*Rotala rotundifolia* Koehne	✓	✓		✓	✓	✓
23.	*Utricularia macrorhiza* LeConte	✓	✓	✓			
24.	*Vallisneria americana* Michx			✓	✓		

Phytoplankton Diversity in Kavadi Lake

The Phytoplankton community in which, whole populations depends were largely influenced by the seasons. In the present study, water sample was collected during the winter season. Diversity of phytoplankton was a total of 33 species, under 26 genera belonging to 18 different families (Table 4). The phytoplankton members belongs to family Desmidiaceae was dominated with 8 genera and 9 species, followed by Bacillariaceae, Chlorellaceae, Gonatozygaceae (under 2 genera with 2 species each), Characeae, Closteriaceae, Hydrodictyaceae, Microcystaceae, Neidiaceae, Mesotaeniaceae, Oedogoniaceae, Scenedesmaceae, Zygnemataceae, Fragilariaceae,

Microcoleaceae (under 1 genera with 1 species each), Naviculaceae (under 1 genera with 4 species), Oscillatoriaceae, Saturoneidaceae (under 1 genera with 2 species) (Fig 4). Most common phytoplanktons were *Bacillaria paradoxa* Gmelin, *Closteriopsis longissima* Lemmermann, *Desmidium aptogonium* Lagerh., *Euastropsis richteri* Lagerheim, *Gonatozygon* sp., *Microcystis* sp., *Navicula trivialis* Lange-Bertalot, *Nitzschia intermedia* Hantzsch, *Oedogonium* sp., *Oscillatoria* sp., *Trichodesmium lacustre* Klebahn and *Stauroneis anceps* Ehrenberg.

Table 4: List of Phytoplankton species in the Kavadi lake of Yellapur, Uttar Kannada district of Karnataka, India

Sl. No	Scientific name	Family
1.	*Bacillaria paradoxa* Gmelin	Bacillariaceae
2.	*Chlorella* sp.	Chlorellaceae
3.	*Closteriopsis longissima* Lemmermann	Chlorellaceae
4.	*Closterium* sp.	Closteriaceae
5.	*Cosmarium intermedium* Delponte	Desmidiaceae
6.	*Cosmarium margispinatum* M. Hirano	Desmidiaceae
7.	*Desmidium aptogonium* Lagerh.	Desmidiaceae
8.	*Desmidium grevillii* De Bary.	Desmidiaceae
9.	*Euastropsis richteri* Lagerheim	Hydrodictyaceae
10.	*Genicularia elegans* West & G.S. West	Gonatozygaceae
11.	*Gonatozygon* sp.	Gonatozygaceae
12.	*Hyalotheca mucosa* Ralfs	Desmidiaceae
13.	*Micrasterias foliacea* Bailey ex Ralfs	Desmidiaceae
14.	*Microcystis* sp.	Microcystaceae
15.	*Navicula cincta* Ralfs	Naviculaceae
16.	*Navicula gregaria* Donkin	Naviculaceae
17.	*Navicula recens* Lange-Bertalot	Naviculaceae
18.	*Navicula trivialis* Lange-Bertalot	Naviculaceae
19.	*Neidium* sp.	Neidiaceae
20.	*Netrium digitus* Itzigsohn & Rothe	Mesotaeniaceae
21.	*Nitzschia intermedia* Hantzsch	Bacillariaceae
22.	*Oedogonium* sp.	Oedogoniaceae
23.	*Oscillatoria* sp.	Oscillatoriaceae
24.	*Oscillatoria tenuis* C.Agardh ex Gomont	Oscillatoriaceae
25.	*Pleurotaenium ehrenbergii* DeBary	Desmidiaceae
26.	*Scenedesmus incrassatulus* Bohlin	Scenedesmaceae
27.	*Spirogyra* sp.	Zygnemataceae

28.	*Stauroneis anceps* Ehrenberg	Stauroneidaceae
29.	*Stauroneis gracilior* E. Reichardt	Stauroneidaceae
30.	*Synedra ulna* Ehrenberg	Fragilariaceae
31.	*Tetmemorus granulatus* Brebisson ex Ralfs	Desmidiaceae
32.	*Trichodesmium lacustre* Klebahn	Microcoleaceae
33.	*Triploceras gracile* Bailey	Desmidiaceae

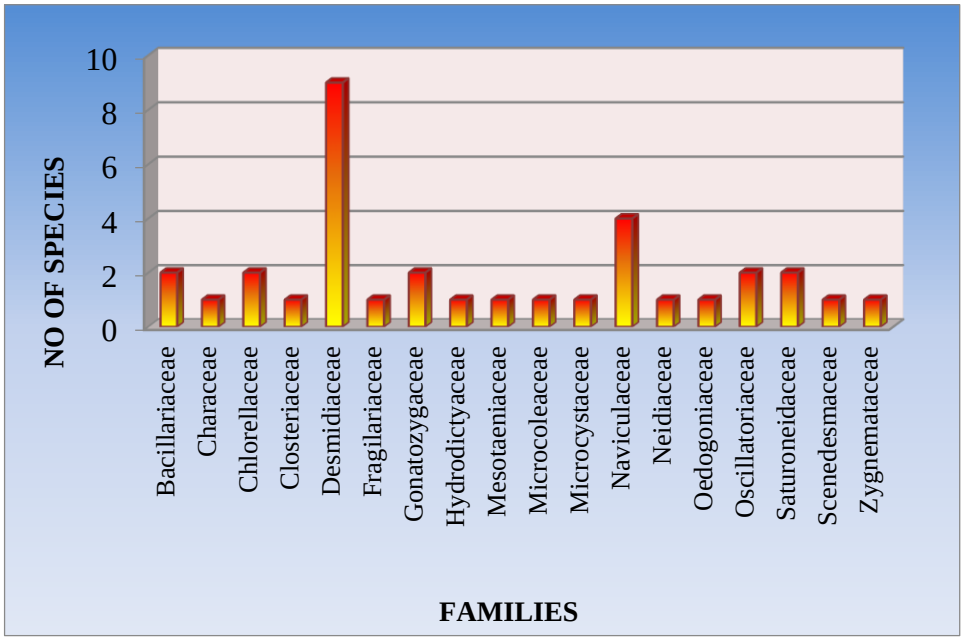

Fig 4: Dominant phytoplankton families with respect to species richness

Physico-Chemical Analysis Of Water Samples

The temperature of the water samples was taken on the spot in January, 2019. Among the samples taken from the different place's temperature ranged from 20 ± 2ºC. The pH value of the water samples was tested in the laboratory using electric pH meter (EQ 610), in which pH was recorded to be 6.19 ± 0.005, slightly acidic. Physical parameters like odour test, were agreeable in Kavadi lake. The electric conductivity of the water samples was tested in the laboratory using electric conductivity meter (EQ 664A). The results reflect that the mean conductivity was 39.866 ± 0.115 µS. Inorganic Chemical parameters like Calcium, Magnesium, total hardness, chlorides showed 8.015 ± 1.388 mg/L, 2.592 ± 0.742 mg/L, 30.666 ± 1.154 mg/L, 19.973 ± 0.034 mg/L respectively. Organic nutrients like Carbon dioxide (CO_2), Dissolved oxygen (DO), Biological oxygen demand (BOD), Chemical oxygen demand (COD) showed 8.8 ± 2.540 mg/L, 6 ± 0.4 mg/L, 4.04 ± 1.421mg/L and 122.666 ± 1.847 mg/L respectively (Table 5).

Table 5: Physico-chemical parameters of water samples in the Kavadi lake of Yellapur, Uttar Kannada district of Karnataka, India

Sl. No.	Parameter of water analysis	Result
1.	BOD	4.04 ± 1.421 mg/L
2.	Calcium	8.015 ± 1.388 mg/L
3.	Chloride	19.973 ± 0.034 mg/L
4.	CO_2	8.8 ± 2.540
5.	COD	122.666 ± 1.847mg/L
6.	DO	6 ± 0.4 mg/L
7.	Electric conductivity	39.866 ± 0.115µS
8.	Magnesium	2.592 ± 0.742 mg/L
9.	Odour	Agreeable
10.	pH	6.19 ± 0.005
11.	Taste	Agreeable
12.	Temperature	20 ± 2°C
13.	Total hardness	80.66 ± 1.154 mg/L

Aquatic plants are important as they supply food and shelter for many aquatic organisms. They serve as a substratum to different micro and macro organisms [23]. In the present study 24 species of aquatic plants were reported in Kavadi lake which is located in Uttar Kannada district, which is almost similar to the reported wetland flora in 29 different localities in 9 taluk of Uttar Kannada district [19]. 45 indigenous wetland plants in Pakri-Pewa Tal, Narya Tal, Ratoi Tal of Mau district of Uttar Pradesh, India was reported [26]. Which are medicinally important species belonging to 36 genera and 23 families of angiosperms. Some important medicinal plants like *Centella asiatica* and *Echinochloa crus-galli* was similarly recorded in our location. The aquatic medicinal plants of Hazaribag district of Jharkhand, India, reported 24 hydrophytes from water bodies belonging to 20 families [25]. The presence of phytoplankton in freshwater bodies is a widely accepted indicator of water quality. Identification of the algal species, the knowledge of the algal cell number, or the physiological state of cells may also be important in providing a true picture of the water quality or trophic state [26]. Aquatic plants constitute an important component of an aquatic ecosystem. Macrophytes though providing a food and shelter for aquatic animals may also increase diurnal variability of ecologically important physico-chemical variables and inhibit mixing process that might improve habitat quality [27]. Physico-chemical parameter study is very important to get exact idea about the quality of water and we have compared results of different physico-chemical parameter values with standard values [17]. Some physical test was performed for testing of its physical appearance such as temperature, color, odour, pH, turbidity, TDS etc., while chemical tests were performed for its BOD, COD,

dissolved oxygen, hardness and other characters. The nutrients and heavy metal profile of Madivala lake, Bangalore South, Karnataka was analyzed, which showed more of heavy metals compared to our study [28].

4. CONCLUSION

Data provided in the study may be helpful for the preparation of comprehensive flora of the Yellapur Taluk and can also contribute to the floristic documentation of the district. Efforts to conserve biodiversity and preserve traditional food systems need to be combined and enhanced. As the results obtained during the study of water analysis was compared with ISI standards. Potable water is safe enough to be consumed by humans or used with low risk of immediate or long-term harm. Habited water is generally used by animals, birds and aquatic life. The disturbance in this biological system and ecological system may affect health of living organisms.

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CONFLICT OF INTEREST

Authors have no conflict of interest.

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