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The occurrence of genus *Spirogyra* (Zygnemataceae, Chlorophyceae) from the ponds of Shivamogga district and it's distributional additions to the algal flora of Karnataka, India

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Abstract
Spirogyra is a filamentous green alga, present at the ubiquitous habitats and encompassing of 529 taxa in worldwide. Among them 302 taxa were reported from the various habitats of India. A total of 36 taxa were recognized from Karnataka and 4 taxa from the water bodies of Shivamogga on the basis of reliable literatures. Henceforth, an attempt was framed to fetch out the data on distribution, and occurrence of genus *Spirogyra* from the ponds of Shivamogga district Karnataka, India. The periodical survey was conducted from September 2018 – January 2021 for the investigation of different taxa occur in the ponds of Shivamogga District. The present study reveals the description, collection location with coordinates and occurrence of Sixteen species of *Spirogyra* from the seven perennial ponds of Shivamogga District. Among them, six species *viz S. affinis*, *S. corrugata*, *S. dubia*, *S. longata*, *S. punctulata* and *S. submaxima* are reported for the first time from the freshwater bodies of the state and treated as new distributional additions to the algal flora of Karnataka.

Keywords: *Spirogyra*, occurrence, ponds of Shivamogga, distributional additions and algal flora of Karnataka

Introduction
Spirogyra Link is a filamentous, free-floating, uniseriate, and intertwined chloroplast holding green alga. It belongs to the family Zygnemataceae under the order Zygnematales of class Chlorophyceae. The occurrence and distribution of *Spirogyra* are widespread and reported from an extensive range of habitats, including rivers, ponds, backwaters, roadside ditches, swift-flowing rivers, slow-moving streams, and stagnant water bodies. The etymology of *Spirogyra* indicates the presence of helical or spiral arrangement of the chloroplasts towards the analytic character for genus identification. Based on external appearance, it is commonly named Water silk, Mermaid's tresses, and Blanketweed. Examination of spores under the microscope, numbers of the chloroplast, cell size (length x width) type of cell wall, and the process of conjugation are the ideal features to diagnose a specific taxon of *Spirogyra* (Wongsawad and Peerapornpisal, 2014) [39]. A sum of 529 taxa of *Spirogyra* has been taxonomically flagged with proper scientific evidence (Guiry and Guiry, 2021) [8].

India has been endowed with 302 taxa of *Spirogyra*, reported from various parts of India by several researchers in different decades (Guiry and Guiry, 2021) [8]. The crucial studies on morphology, anatomy, and taxonomy of *Spirogyra* were carried out for many years (Smith, 1950) [31] and in India, it has been lineout by Randhawa in 1938 [22]. A total of 1761 algal taxa were recorded from Karnataka and *Spirogyra jogensis* was the species literately reported under the genus *Spirogyra* in Algal flora of Karnataka (Gupta & Das, 2018) [9]

A perusal of the literature survey on *Spirogyra* from Karnataka supports the occurrence of 36 taxa (Table – I) from Karnataka.

Table 1: *Distribution of Genus Spirogyra recorded from the freshwater bodies of Karnataka.*

S.No.	Name of the Taxa	Collection Location	Source
1.	*Spirogyra accidentalis* (Transeau) Czurda	Vijayanagara	Manjappa *et al*., 2017
2.	*Spirogyra adornata* Ling	Udupi	Saroja Naik and Gopal, 2017
3.	*Spirogyra aequinoctialis* G.S.West	Chitradurga	Ramesh Ratageri, 2016
4.	*Spirogyra alternata* Kuetz.	Udupi	Saroja Naik and Gopal, 2017
5.	*Spirogyra borgeana* Transeau	Shivamogga & Cauvery river basin	Rajeshwari and Krishnamurthy, 2015; Scientific report of Department of Forest, Ecology & Environment, Government of Karnataka (2017)
6.	*Spirogyra communis* (Hassall) Kuetz.	Vijayanagara	Manjappa *et al*., 2017
7.	*Spirogyra condensata* (Vaucher) Dumortier	Yadgir & Belgaum	Baskar Katari *et al*, 2015; Varsha Sanjay Khude, 2019
8.	*Spirogyra crassa* (Kuetz.) Kuetz.	Coorg, Dakshina Kannada & Chitradurga	Divya *et al*, 2013; Miranda and Krishnakumar, 2015; Ramesh *et al*., 2016
9.	*Spirogyra distenta* Transeau	Bengaluru	Raghavendra *et al*, 2015
10.	*Spirogyra ellipsospora* Transeau	Chitradurga	Ramesh *et al*., 2016

11.	*Spirogyra farlowii* Transeau	Dakshina Kannada	Miranda and Krishnakumar, 2015
12.	*Spirogyra fluviatilis* Hilse	Tumkur	Ravishankar *et al*., 2009
13.	*Spirogyra gracilis* Kuetz.	Bengaluru	Raghavendra *et al*, 2015
14.	*Spirogyra gratiana* Transeau	Tumkur, Sharavathi river basin (Shivamogga & Karwar Dist,) & Dakshina Kannada	Ravishankar *et al*., 2009; Ramachandra *et al*, 2012; Miranda and Krishnakumar, 2015
15.	*Spirogyra hyalina* Cleve	Yadgir	Bhaskar Katari *et al*., 2015
16.	*Spirogyra indica* Krieger	Ballary	Samad Kottur, 2018
17.	*Spirogyra inflata* (Vaucher) Dumortier	Chikkamagalure	Thippeswamy and Malathi, 2008
18.	*Spirogyra jogensis* Iyengar	Mysore	M. O. P. Iyengar, 1958
19.	*Spirogyra majuscula Kuetz.*	Dakshina Kannada	Miranda and Krishnakumar, 2015
20.	*Spirogyra maxima* (Hassall) Wittrock	Uttara Kannada	Kotresha *et al*., 2008
21.	*Spirogyra micropunctata* Transeau	Mysore (Dalvoi lake) & Cauvery river basin	Mahadev and Ahamad, 2008; Scientific report of Department of Forest, Ecology and Environment, Government of Karnataka (2017)
22.	*Spirogyra nitida* (O.F.Müller) Leiblein	Chikkamagalure & Dakshina Kannada	Thippeswamy and Malathi, 2008; Miranda and Krishnakumar, 2015
23.	*Spirogyra notabilis* Taft	Shivamogga	Rajeshwari and Krishnamurthy, 2015
24.	*Spirogyra paludosa* Czurda	Cauvery river basin	Scientific report of Department of Forest, Ecology and Environment, Government of Karnataka (2017).
25.	*Spirogyra pratensis* Transeau	Dakshina Kannada	Miranda and Krishnakumar, 2015
26.	*Spirogyra punctata* Cleve	Belgaum	Yashwanthrao and Rajanna, 2014
27.	*Spirogyra punctiformis*	Cauvery river basin	Scientific report of Department of Forest, Ecology and Environment, Government of Karnataka (2017).
28.	*Spirogyra quadricauda* C.-C.Jao		
29.	*Spirogyra quinine* (O.F.Mull.) Dumortier		
30.	*Spirogyra rhizobrachialis* C-C Jao	Sharavathi river basin (Shivamogga & Karwar Dist.)	Ramachandra *et al*, 2012
31.	*Spirogyra rivularis* (Hassall) Rabenhorst	Bengaluru	Raghavendra *et al*, 2015
32.	*Spirogyra singularis* Nordstedt	Chikkamagaluru, Vijayanagara	Raghavendra Gowda and Vijaya Kumara, 2009; Manjappa *et al*., 2017
33.	*Spirogyra subsalsa* Kuetz.	Chikkamagaluru, Tumkur, Belagavi & Uttar Kannada	Raghavendra Gowda and Vijaya Kumara, 2009; Ravishankar *et al*., 2009; Sedamkar and Vasanthkumar, 2016
34.	*Spirogyra tenuissima* (Hassall) Kuetz.	Dakshina Kannada	Miranda and Krishnakumar, 2015
35.	*Spirogyra triplicata* (Collins) Transeau	Dakshina Kannada	Miranda and Krishnakumar, 2015
36.	*Spirogyra varians* (Hassall) Kuetz.	Dakshina Kannada	Miranda and Krishnakumar, 2015

Though the state of Karnataka is endowed artistically with the enormous diversity of genus *Spirogyra*, the occurrence of this particular genus in central parts, especially at Shivamogga is sporadic, inadequate, and inordinate. Henceforth, the present study was subjected to fetch the details on the occurrence of *Spirogyra* from the ponds of Shivamogga district, Karnataka.

Materials and Method

Shivamogga district is a part of the naturally rich biodiversity malnad region of Karnataka and it is situated between 13º 27' to14º 39' N lat. and 74º 38' to 76º 34' E long. With a mean elevation of 640 MSL in the western part of Karnataka. The average temperature during summer ranges from 20^0C to 36^0C. Monsoon is experienced between July to September and heavy rainfall is the characteristic feature of the Shivamogga region and receives an average rainfall of 1811mm. The winter season in Shivamogga starts in December and lasts till February. The winter temperature ranges from 25^0C to 37^0C. Shivamogga is the origin of major rivers namely Gangavati, Kali, Tadadi, and Sharavathi. Other important rivers flowing through the Shivamogga district are Bhadra, Varada and Thunga, Kumadvathi, Vedavathi, and Kushavathi. These rivers serve as a major source of water for Shivamogga.

There are plenty of ponds in Shivamogga District, many ponds are perennial, some are seasonal and are rich in phytoplankton diversity. Perennial ponds water is using for drinking purpose as well as irrigation, fishing, washing and bathing. Seven perennial ponds *i.e*., Mattur pond (Shivamogga), Siddapura pond (Bhadravathi), Tammadikoppa pond (Theerthahalli), Goutur pond (Hosanagar), Kutralli pond (Shikaripura), Ulavi doddakere pond (Soraba), Keladi hirekere pond (Sagara) (Fig.1, Plate – I & II) were selected for exploration of the genus *Spirogyra*. The periodical survey was conducted from September 2018 – January 2021 in different seasons. The GPS coordinates, habits and habitats were recorded & photographed. The samples were collected in the clean container using a plankton net whereas the attached and filamentous forms are collected with help of a scalpel, by hand, or by scraping with the help of the knife. The collection was carried out early morning and late evening. The samples were preserved in 4% formalin and deposited in Department of Applied Botany, Kuvempu University. The live form as well as preserved format of the algal samples were examined under a compound light microscope to witness the colour, shape, length, width, filamentous form, surface nature, size, cell wall arrangements in layers, chloroplast shape and numbers and reproductive characters of the *Spirogyra*.

Further, the available standard literature, monographs, pictorial guides, and identification manual such as Randhawa 1937; Tiffany 1937; Transeau 1938; Prescott

1962 [17]; Kim 2004 [10]; Naz and Azam, 2008 [25]; Ravishankar 2009 [23]; Rosalina Stancheva *et al* 2013; Satpathi & Pal, 2013 [28]; Sudiptha Kumar Das and Onkar Nath Maurya 2015 [32]; Tomoyuki Takano *et al* 2019 [35];and online resource (algaebase - https://www.algaebase.org/) were referred to diagnose the confusion on identification, accepted name of the taxa, proper author citation, and other nomenclature issues.

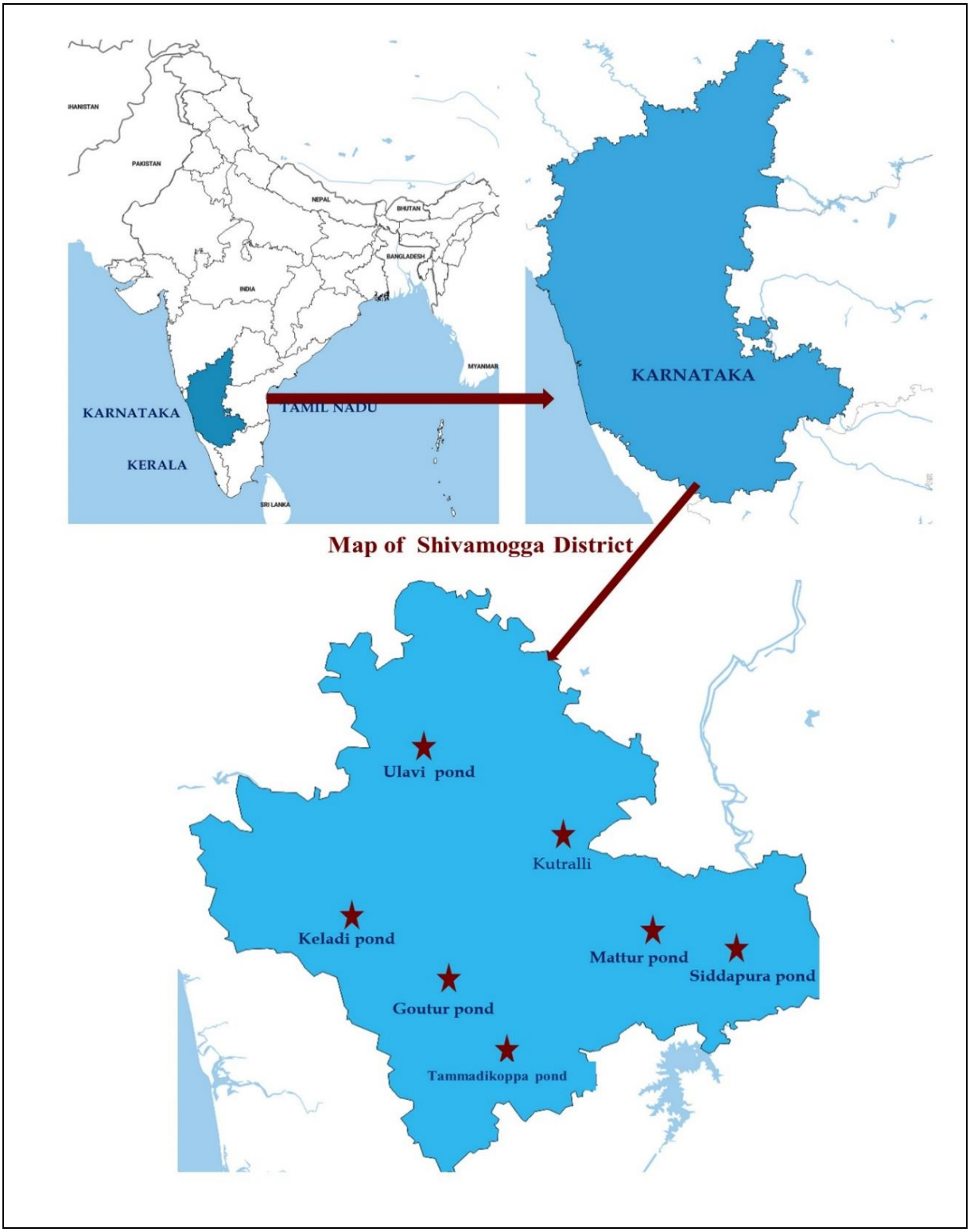


Fig 1: Map of Study Area

Results

The present study divulges the occurrence of Sixteen species of *Spirogyra* from the seven perennial ponds of Shivamogga District. Among them, six species i.e., *S. affinis, S. corrugata, S. dubia, S. elongata, S. punctulata* and *S. submaxima* are reported for the first time from the freshwater bodies of Karnataka and new additions to the algal flora of Karnataka (Table – II).

Table 2: *Distribution of spirogyra in different ponds of Shivamogga district.*

S.No.	Taxa name	GTR	KTI	KLI	MTR	SDA	TMA	ULI
1.	*Spirogyra affinis* (Hassall) Petit *	-	-	+	-	-	-	-
2.	*Spirogyra corrugata* Transeau* (= *Temnogyra corrugata* (Transeau) Yamagishi)	-	-	-	-	-	-	+
3.	*Spirogyra crassa* (Kutz.) Kutz.	-	-	-	+	+	-	-
4.	*Spirogyra distenta* Transeau	-	-	-	+	-	-	-
5.	*Spirogyra dubia* Kutz. *	+	-	-	-	-	-	-
6.	*Spirogyra ellipsospora* Transeau	-	+	-	-	-	-	-
7.	*Spirogyra elongata* (Vaucher) Dumortier* (=*Spirogyra decimina* var. *elongata* (Vaucher) Petlovany)	-	+	-	-	-	-	-
8.	*Spirogyra fluviatilis* Hilse	+	-	-	-	-	-	-
9.	*Spirogyra gratiana* Transeau	+	-	-	-	-	+	-
10.	*Spirogyra hyalina* Cleve	-	-	-	-	-	+	+
11.	*Spirogyra maxima* (Hassall) Wittrock	-	-	-	+	-	-	-
12.	*Spirogyra notabilis* Taft	-	-	-	+	-	-	-
13.	*Spirogyra punctulata* C.C. Jao*	-	-	-	-	-	+	-
14.	*Spirogyra submaxima* Transeau *	-	-	-	-	-	-	+
15.	*Spirogyra subsalsa* Kutz.	+	-	-	-	+	-	-
16.	*Spirogyra varians* (Hassall) Kutz.	-	-	+	+	-	-	-

Note: *Following acronyms are used in the tables to abbreviate the name of the ponds present in Shivammoga* GTR: Goutur; KTI: Kutralli; KLI: Keladi; MTR: Mattur; SDA: Siddapura; TMA: Tammadikoppa & ULI: Ulavi.
* = *New distributional records/additions to the algal flora of Karnataka*

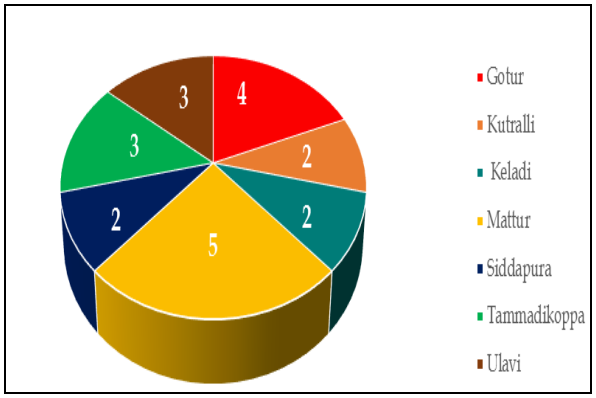


Fig 2: Distributional data of *Spirogyra* in different ponds of Shivammoga

The number of taxa was maximum in Mattur pond (5 No.) followed by Goutur pond (4 No.), Tammadikoppa (3 No.), Ulavi (3 No.). Likewise, Kutralli, Keladi, and Siddapura were represented with 2 taxa of *Spirogyra*. The taxa express less distribution and merely recorded from one pond are *S. affinis* (Keladi), *S. corrugata* (Ulavi), *S. distenta* (Mattur), *S. dubia* (Goutur), *S. ellipsospora* (Kutralli), *S. fluviatilis* (Goutur), *S. elongata* (Kutralli), *S. maxima* (Mattur), *S. notabilis* (Mattur), *S. punctulata* (Tammadikoppa) and *S. submaxima* (Ulavi). (Table – II & Fig. 2).

Further, the systematic account, description, geographical coordinates with collection sites were enumerated.

Systematic treatment of Spirogyra
Phylum: Chlorophyta
Class: Zygnematophyceae
Order: Zygnematales
Family: Zygnemataceae
Genus: *Spirogyra*

Spirogyra affinis (Hassal) Petit
Source for the identity of the species: Randhawa 1938 [22], pp. 344, Fig. 37 (L. 25 - 32 µm, W. 36 - 46 µm, 2.4 to 4 turns, Zygospores ellipsoid, both lateral as well as scalariform conjugation).
Filaments, unbranched free-floating, vegetative cells 28 µm in width, 40 µm in length, chloroplast bearing many disc-shaped pyrenoids makes 4 turns per cell. Zygospores ellipsoid; yellowish in color. Conjugation occurs in both lateral as well as in scalariform (Plate – III: a).

Collection site: Keladi pond, Shivamogga District, Karnataka.

Coordinates of the collection Location: 14° 14' 0.2754" N & 75° 1' 14.16" E
*Distribution in India***:** Freshwater, Jammu & Kashmir, Punjab, Maharashtra.

Note: The occurrence and distribution of this taxon is reported for the first time from Karnataka; hence it is treated as the new distributional addition to the algal flora of Karnataka.

Spirogyra corrugata Transeau
Source for the identity of the species: Takano *et al*, 2019 [35], pp. 7, Fig.4 a (L. 200-600 µm, W. 28-34 µm, 3 to 5 turns, Zygospores ovoid, Ladder like conjugation).
Unbranched filaments, free-floating; vegetative cells 28 µm broad and 220 µm long. Plane end wall, Chloroplast 3 in numbers with numerous disc-shaped pyrenoids making 3 to 4 turns per cell. Ladder-like structure formed by conjugation. Zygospores Ovoid in shape (Plate – III: b).

Collection site: Ulavi pond, Shivamogga District, Karnataka.

Coordinates of the collection Location: 14° 16' 32.448" N & 75° 6' 48.816" E.
*Distribution in India***:** Freshwater, Bihar, Kerala, Maharashtra, Punjab, Uttar Pradesh, West Bengal.

Note: The occurrence and distribution of this taxon is reported for the first time from Karnataka; hence it is treated as the new distributional addition to the algal flora of Karnataka.

Spirogyra crassa (Kutz.) Kutz.
Source for the identity of the species: Prescott 1962 [17], pp. 804, Pl. 72, Fig. 8, Tiffany 1937, Pl. 5, Fig. 63 (L. 140-165 µm, W. 126-330 µm, 0.5-1 turn, Zygospores ovoid, Scalariform conjugation).
Filaments unbranched, free-floating with cylindric, rarely enlarged squarish-shaped cells. Vegetative cells are 137 µm wide and 150 µm long. Chloroplast varies from 6 to 12, bearing numerous larger pyrenoids, makes 0.5 to 1 turn per cell. Median wall smooth and brown. Scalariform Conjugation and Zygospores ovoid in shape (Plate – III: c).

Collection site: Mattur pond & Siddapura Pond, Shivamogga District, Karnataka.

Coordinates of the collection Location: 13° 52' 37.2" N & 75° 34' 37.2" E and 13° 50' 13.2" N & 75° 40' 48" E.
*Distribution in India***:** Freshwater, Kerala, Punjab, Andaman & Nicobar, Karnataka.

Spirogyra distenta Transeau
Source for the identity of the species: Kim *et al*, 2004 [10], pp. 96, Fig.3 (L. 54- 116 µm, W. 44- 46 µm, 1.5 to 3 turns, Zygospores ellipsoid or globular, Scalariform conjugation).
Filaments unbranched, olive green in color with cylindric cells and plane septum. Vegetative cells 44 µm in width 98.5 µm in length. Chloroplast 2 in numbers with numerous pyrenoids makes 2 to 3 turns per cell. Scalariform type of conjugation and Zygospores ellipsoid or globular in shape (Plate – III: d).

Collection site: Mattur pond, Shivamogga District, Karnataka.

Coordinates of the collection Location: 13° 52' 37.2" N & 75° 34' 37.2" E.
Distribution in India: Freshwater, Andaman & Nicobar, Kerala, Punjab, Karnataka.

Spirogyra dubia Kutz.
Source for the identity of the species: Kim *et al*, 2004 [10], pp. 97, Fig.4 (L. 123-311 µm, W. 40-50 µm, 1 to 3.5 turns, Zygospores ellipsoid, Scalariform conjugation).
Filamentous, light green in color, unbranched with cylindric cells consist of blunt end and plane septum. Cells 49 µm in width and 297.5 µm in length and having 3 chloroplasts with many disc-shaped pyrenoids makes 2.5 to 3 turns per cell. Scalariform oof conjugation and Zygospores are oblong to ellipsoid in shape (Plate – III: e).

Collection site: Goutur pond, Shivamogga District, Karnataka.

Coordinates of the collection Location: 13° 59' 0.42" N & 75° 14' 57.84" E.
Distribution in India: Freshwater, Andaman & Nicobar, Bihar, Gujarat, Madhya Pradesh, Maharashtra, Manipur, Punjab, Uttar Pradesh.

Note: The occurrence and distribution of this taxon is reported for the first time from Karnataka; hence it is treated as the new distributional addition to the algal flora of Karnataka.

Spirogyra ellipsospora Transeau
Source for the identity of the species: Tiffany 1937, Pl. 5, Fig. 72, Kim *et al*, 2004 [10], pp. 98, Fig.5 (L. 208-604 µm, W. 137-150 µm, 1 to 2.5 turns, Zygospores ellipsoid with pointed ends, Scalariform conjugation).
Filaments dark green in color, unbranched with cylindric cells. Vegetative cells 139 µm in width and 215 µm in length. Containing 6 chloroplasts with numerous pyrenoids makes 2 to 2.5 turns per cell. Conjugation in the form of Scalariform and zygospores ellipsoid with pointed ends (Plate – III: f).

Collection site: Kutralli pond, Shivamogga District, Karnataka.

Coordinates of the collection Location: 14° 16' 59.736" N & 75° 19' 8.22" E.
Distribution in India: Freshwater, Assam, Arunachal Pradesh, Karnataka, Maharashtra, Manipur, New Delhi, Punjab, Uttar Pradesh, Uttarkhand, West Bengal.

Spirogyra elongata (Vaucher) Dumortier
Source for the identity of the species: Tiffany 1937, Pl. 9, Fig. 128 & 129, Rosalina Stancheva *et al*, 2013 [24], pp. 594 Fig. 3 E & F (L. 50-320 µm, W. 30- 40 µm, 2 to 5 turns, Zygospores ellipsoid to ovoid, Predominantly lateral rarely scalariform conjugation).
Filaments dark green in color, unbranched and transverse walls plane. Vegetative cells frame in the size of 35 µm in width and 54 µm in length. Encompassing of 1 or 2 chloroplasts makes 3 turns per cell. Conjugation predominately lateral rarely and scalariform. Zygospores ellipsoid to oval in shape (Plate – III: g).

Collection site: Kutralli pond, Shivamogga District, Karnataka.

Coordinates of the collection Location: 14° 16' 59.736" N & 75° 19' 8.22" E.
*Distribution in India***:** Freshwater, Punjab, Uttarkhand, West Bengal.

Note: This taxon has been recorded as *"Spirogyra longata"* but the basionym, *Conjugata elongata* Vaucher was given as "longata" in text, it was corrected to "elongata" in an Erratum. - (10 Feb 2013) - M.D. Guiry. The occurrence and distribution of this taxon is reported for the first time from Karnataka; hence it is treated as the new distributional addition to the algal flora of Karnataka.

Spirogyra fluviatilis Hilse
Source for the identity of the species: Prescott 1962 [17], pp. 806, Pl. 73, Fig. 5, Tiffany 1937, Pl. 5, Fig 67 (L. 70-240 µm, W.35- 45 µm, 2.4 to 4 turns, Zygospores oval to ellipsoid, Scalariform conjugation).
Unbranched filaments, vegetative cells 42 µm wide, 168 µm long, transverse walls plane, 4 chloroplasts making 3 to 3.5 turns per cell, fertile cells inflated, scrobiculated median

wall, Conjugation Scalariform, Zygospores oval to ellipsoid (Plate – III: h).

Collection site: Goutur pond, Shivamogga District, Karnataka.

Coordinates of the collection Location: 13° 59' 0.42" N & 75° 14' 57.84" E.
Distribution in India: Freshwater, Meghalaya, Uttar Pradesh, Punjab, Karnataka.

Spirogyra gratiana Transeau
Source for the identity of the species: Prescott 1962 [17], pp. 808, Pl. 74, Fig. 9, Transeau 1938 [36], pp. 527, Fig. 12 (L. 144-400 µm, W. 28 - 33 µm, 4 turns, Zygospores ellipsoid to cylindric ellipsoid, Both lateral and scalariform conjugation).
Filaments pale to olive-green color and unbranched. Vegetative cells 30 µm wide, and 152 µm long. Consisting of 3 chloroplasts with disc-shaped pyrenoids makes 4 turns per cell. Lateral and Scalariform form of conjugation occurs; Zygospores ellipsoid to cylindric ellipsoid in shape (Plate – IV: a).

Collection site: Goutur pond, Shivamogga District, Karnataka.

Coordinates of the collection Location: 13° 59' 0.42" N & 75° 14' 57.84" E.
Distribution in India: Freshwater, Karnataka.

Spirogyra hyalina Cleve
Source for the identity of the species: Naz and Azam, 2008 [25], Pl. 3, Fig. 12, Sudiptha Kumar Das and Onkar Nath Maurya 2015 [32], pp. 131, Fig. 4, F (L. 124.8- 186 µm, W. 30-40 µm, 2 turns, Zygospores ellipsoid, Scalariform conjugation).
Free-floating light green to olive-green; unbranched filaments. Vegetative cells vary from 35 µm in width and 130 µm in length. End wall plane with 3 chloroplasts containing pyrenoids making 1.5 turns per cell. Conjugation scalariform type and Zygospores ellipsoid in shape with brown color (Plate – IV: b).
Collection site: Ulavi pond and Tammadikoppa pond Shivamogga District, Karnataka.
Coordinates of the collection Location:14° 16' 32.448" N & 75° 6' 48.816" E; 13° 41' 36.744" N & 75° 14' 11.12" E.
*Distribution in India***:** Freshwater, Almost throughout the country.

Spirogyra maxima (Hassall) Wittrock
Source for the identity of the species*:* Rosalina Stancheva *et al*, 2013 [24], pp. 598, Fig. 5 I **(**L. 90-280 µm, W. 120-150 µm, 2.4 to 4 turns, Zygospores lenticular, Scalariform conjugation).
Olive green to dark green in color, filamentous and unbranched filaments. Vegetative cells in the size of 125 µm broad, 95 µm long on transverse walls plane. Cells hold 8 numbers of chloroplast bearing several pyrenoids. Mesospore brown, multi-layered; conjugation by scalariform and lenticular Zygospores (Plate – IV: c).

Collection site: Mattur pond, Shivamogga District, Karnataka.

Coordinates of the collection Location: 13° 52' 37.2" N & 75° 34' 37.2" E.
Distribution in India: Freshwater, Almost throughout the country.

Spirogyra notabilis Taft
Source for the identity of the species: Rosalina Stancheva *et al*, 2013 [24], pp. 599, Fig. 6 A (L. 100-309 µm, W. 33-35 µm, 2.4 to 4 turns, Zygospores Ovoid to Cylindric ovoid, Scalariform conjugation).
Filaments, light green in color and unbranched. Vegetative cells size varies from 34 µm wide and 125 µm long with transverse walls plane. Pyrenoids are arranged on 4 chloroplasts making 2 turns per cell. Conjugation formation by scalariform and zygospores Ovoid to Cylindrical-ovoid in shape (Plate – IV: d).

Collection site: Mattur pond, Shivamogga District, Karnataka.

Coordinates of the collection Location: 13° 52' 37.2" N & 75° 34' 37.2" E.
Distribution in India: Freshwater, Karnataka, Punjab.

Spirogyra punctulata C. C. Jao
Source for the identity of the species: Satpathi *et al*, 2013 [28], pp.36, Pl. 4, Fig. 11, pp. 39, Pl. 7, Fig. 6 (L. 105-305 µm, W. 40-80 µm, 1 to 2 turns, Zygospores elliptical with pointed ends, Scalariform conjugation).
Free-floating, unbranched filaments; vegetative cells 45 µm in width, 120 µm in length on plane end walls. Chloroplasts bearing numerous pyrenoids make 2 turns per cell, Conjugation in the form of scalariform and Zygospores elliptical with pointed ends (Plate – IV: e).

Collection site: Tammadikoppa pond Shivamogga District, Karnataka.

Coordinates of the collection Location: 13° 41' 36.744" N & 75° 14' 11.112" E.
Distribution in India: Freshwater, Bihar, Gujarat, Jammu & Kashmir, Kerala, Maharashtra, Punjab, Uttar Pradesh, West Bengal.

Note: The occurrence and distribution of this taxon is reported for the first time from Karnataka; hence it is treated as the new distributional addition to the algal flora of Karnataka.

Spirogyra submaxima Transeau
Source for the identity of the species: Randhawa 1938 [22], pp. 361, Fig. 36, Rosalina Stancheva *et al*, 2013 [24], pp. 598, Fig. 5 C & D (L. 100-400 µm, W. 95-105 µm, 2.4 to 4 turns, Zygospores globose, Scalariform conjugation).
Filamentous, olive-green to brownish-gold in color, unbranched and free-floating, Vegetative cells in the size of 100 µm broad, 105 µm long, with thick walls, containing 8 chloroplasts making 0.5 turns per cell, covered by pectic layer. Conjugation is scalariform and zygospores brown in color with globose shape (Plate – IV: f).

Collection site: Ulavi pond, Shivamogga District, Karnataka.

Coordinates of the collection Location: 14° 16' 32.448" N & 75° 6' 48.816" E.
Distribution in India: Freshwater, Almost throughout the country.

Note: The occurrence and distribution of this taxon is reported for the first time from Karnataka; hence it is treated as the new distributional addition to the algal flora of Karnataka.

Spirogyra subsalsa Kutz.
Source for the identity of the species: Prescott 1962 [17], pp. 806, Pl. 73, Fig. 2 (L. 269- 272 µm, W. 38-40 µm, 5 turns, Zygospores ovoid, Scalariform conjugation).
Filaments unbranched, free-floating, and vegetative cells frame the size of 38.5 µm in width and 269.5 µm in length, 2 chloroplasts bearing disc-shaped pyrenoids makes 5 turns per cell. Conjugation Scalariform and ovoid shape of Zygospores (Plate – IV: g).

Collection site: Goutur pond & Siddapura pond, Shivamogga District, Karnataka.

Coordinates of the collection Location: 13° 59' 0.42" N & 75° 14' 57.84" E and 13° 50' 13.2" N & 75° 40' 48" E.
Distribution in India: Freshwater, Jammu & Kashmir, Madhya Pradesh, Sikkim, Karnataka.

Spirogyra varians (Hassal) Kutz.
Source for the identity of the species: Prescott 1962 [17], pp. 812, Pl. 76, Fig. 11, Tiffany 1937 [34], Pl. 5, Fig. 64, Rosalina Stancheva *et al*, 2013 [24], pp. 600, Fig. 7, C & D (L. 40-203 µm, W. 35-40 µm, 2 turns, Zygospores ellipsoid, Scalariform conjugation).
Unbranched filaments, vegetative cells are 35 µm wide, 55 µm long, with plane end walls. Single chloroplast with numerous pyrenoids makes 1.5 to 2 turns per cell. Fertile cells are inflated, with yellowish-green colored filaments. Mostly, scalariform type of conjugation and rarely lateral. Zygospores ellipsoid, rarely ovoid (Plate – IV: h).

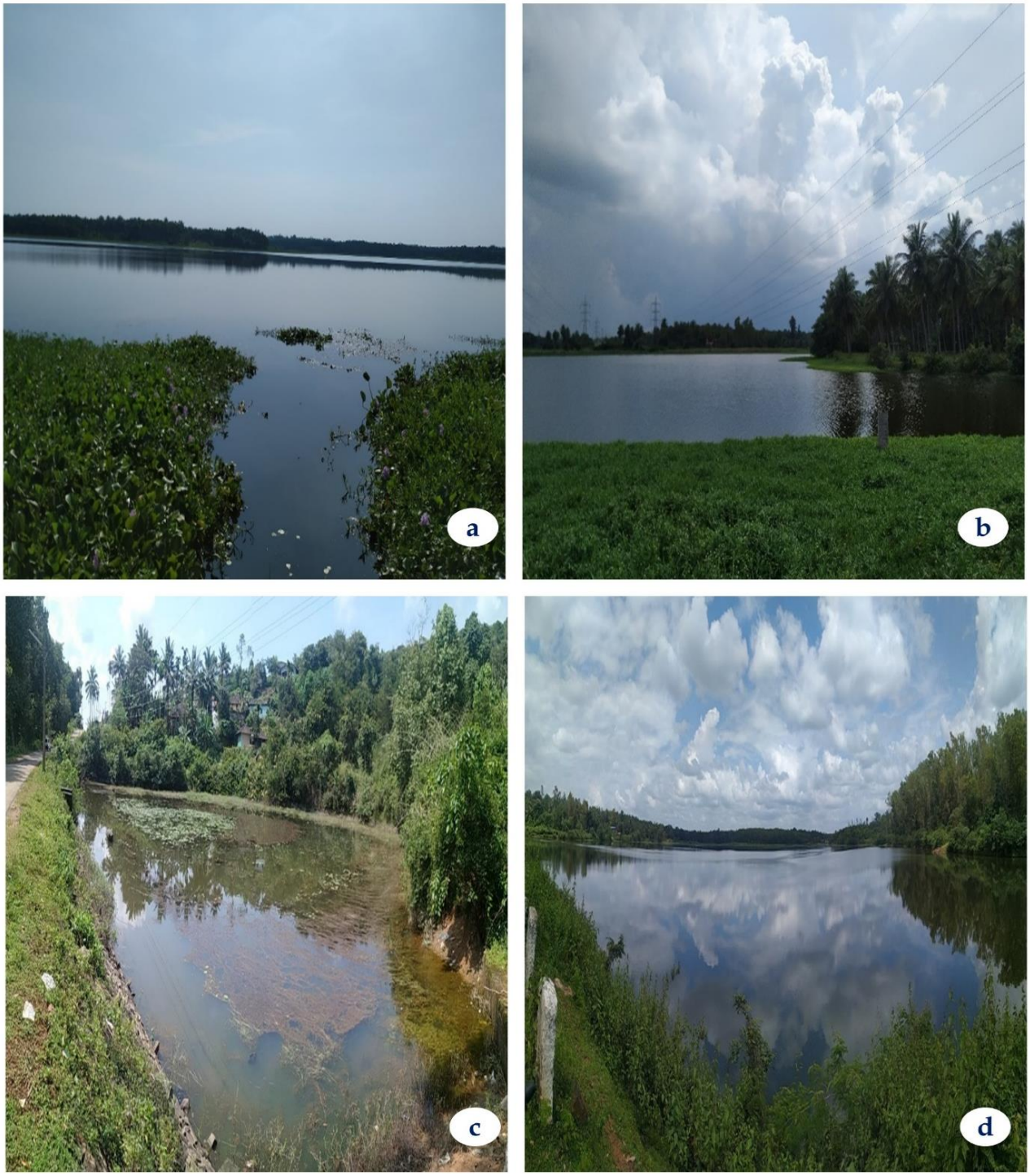
Collection site: Mattur pond & Kutralli Pond Shivamogga District, Karnataka.

Coordinates of the collection Location: 13° 52' 37.2" N & 75° 34' 37.2" E and 14° 16' 59.736" N & 75° 19' 8.22" E.
*Distribution in India***:** Freshwater, Jammu & Kashmir, Madhya Pradesh, Manipur, Punjab, Uttar Pradesh, Karnataka.

Discussion
The attention on the genus *Spirogyra* was paid in Karnataka in the mid of 20th century. *Spirogyra jogensis* was discovered by Iyengar (1958) from the freshwater bodies of the Mysore district. Later on, Mahadev and Ahamad (2008) [12] were studied the density of the phytoplankton relates to the environmental variables of water and identified *S. micropunctata.* From the Dalvoi lake of Mysore district. Limnological Role of Aquatic Plants in Godhuli Pond in Uttara Kannada was studied and *S. singularis* and *S. subsalsa* were examined from the wetlands of Lakkavali range, Bhadra Wildlife sanctuary from Chikkamagaluru district (Vijaya Kumara and Raghavendra Gowda, 2009) [18]. Diversity of freshwater algae in two Lakes of Tumkur framed by Ravishankar *et al*., (2009) [23] and revealed the occurrence of *S. fluviatilis, S. subsalsa*, and *S. gratiana.*
The existence of *S. inflata* and *S. nitida* were encountered from the Bakri stream, a tributary of river Bhadra, Chikkamagalure district (Thippeswamy and Malathi, 2008) [33]. Ramachandra *et al*., (2012) [20] detailed the ecological profile of the Sharavathi river basin (Shivamogga, and Karwar Districts) and inspected the frequency of *S. gratiana* and *S. rhizobrachialis.* The algal blooms of *S. crassa* were examined from the surface water samples of the Iritty River from Coorg district by Divya (2013) [5]. The diversity of *S. punctata* correlation with physico-chemical parameters was opined from the Fort lake of Belgaum district (Yashwanthrao and Rajanna, 2014) [40]. Seasonal variation of *S. rivularis, S. distenta*, and *S. gracilis* was analyzed from the Anchepalya Lake of Bengaluru by Raghavendra Gowda, (2015). A detailed account of preliminary study and seasonal occurrence of *S. hyalina*, and *S. condensata* were investigated *from* the freshwater lake of Gogi, Yadgir District by Bhaskar Katari *et al*., (2015) [4]. Rajeshwari and Krishnamurthy (2015) recorded the occurrence of *S. notabilis* and *S. borgeana* from the river Bhadra at the outlet of Bhadra Dam, Shivamogga District. Observation on Microalgal diversity about the physicochemical parameters was assayed by Miranda and Krishna kumar (2015) [15] and reported the presence of *S. crassa, S. farlowii, S. gratiana, S. majuscula, S. nitida, S. pratensis, S. tenuissima, S. triplicata*, and *S. varians* from the industrial sites of Dakshina Kannada district.
Physico-chemical Parameters and Primary Productivity of *S. aequinoctialis, S. ellipsospora*, and *S. crassa* were assayed by Ramesh *et al*., (2016) [21] from the few freshwater bodies of Chitradurga district. Saroja *et al*., (2017) [27] were deliberated the seasonal variation and population of *S. adornata* and *S. alternata* from two freshwater lakes of Udupi district. Seasonal dissimilarities in species composition, diversity, and population dynamics of phytoplankton were carried out and the availability of *S. singularis, S. accidentalis*, and *S. communis* were confirmed from the water tank of Vijayanagara district (Manjappa *et al*., 2017). The presence of *S. borgeana, S. paludosa, S. punctiformis, S. quadricauda, S. quinine*, and *S. micropunctata* was accessed by Department of Forest, Ecology and Environment, Government of Karnataka (2017) [27]. *S. indica* was reported from the freshwater bodies of Bellary district (Samad Kottur, 2018) [26]. Varsha Sanjay Khude (2019) [37] studied the seasonal algal diversity from the Jawahar tank of the Belgaum district and recorded the presence of *S. condensata.* The present study also confirms that, 42 taxa of the *Spirogyra* is recorded from the various freshwater bodies of Karnataka, which is greater than the previous reports investigated by others. Also, present study reveals that, occurrence and distribution of genus *Spirogyra* is maximum (16 species) in Shivamogga district than the other districts of Karnataka. Among them 6 taxa were recognized as the new distributional additions to the algal flora of Karnataka.

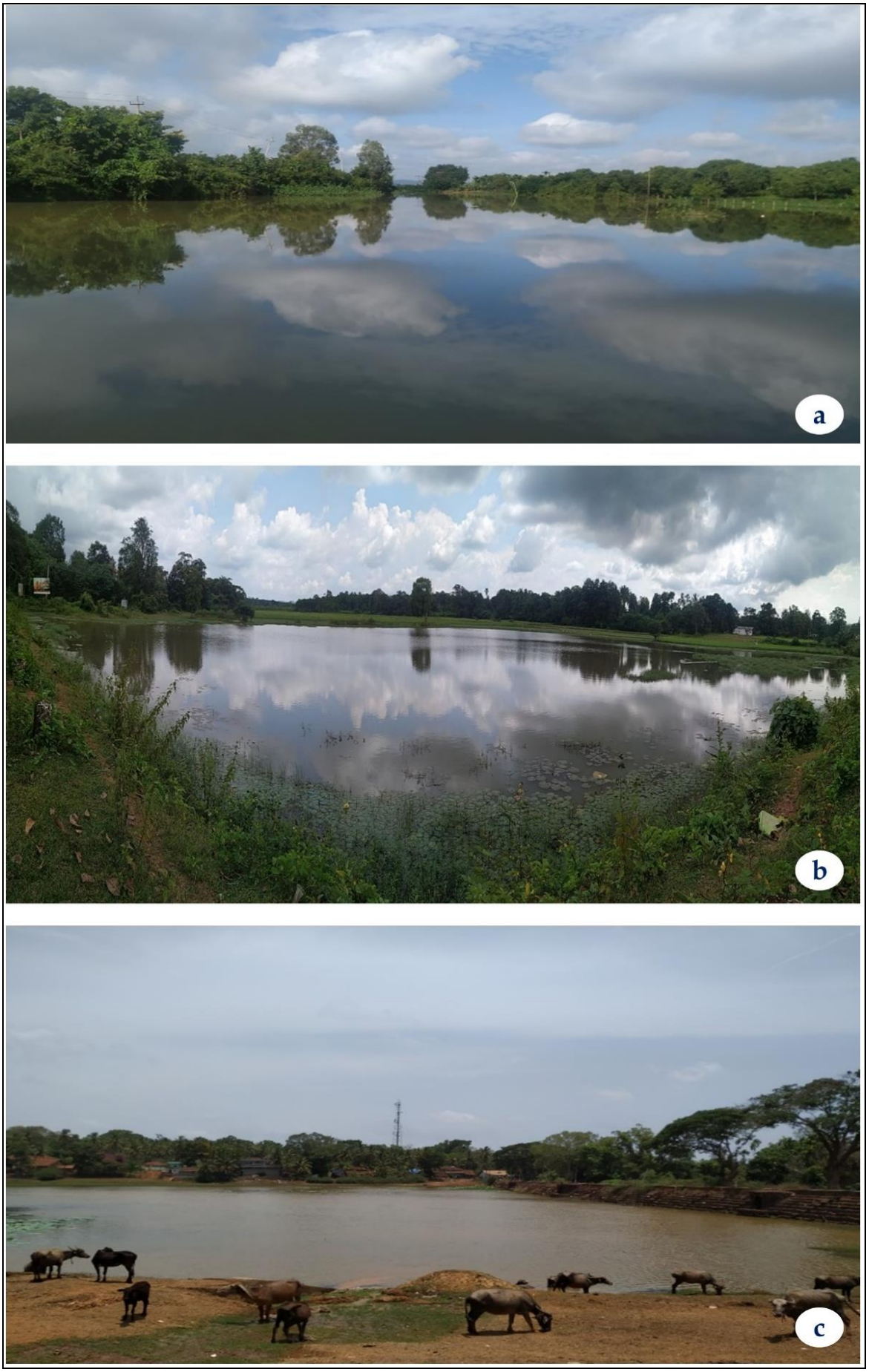
Conclusion
Aquatic ecosystem provides the appropriate habitats for enormous diversity of aquatic flora, fauna and other associated organisms. They are the important environmental factors and forms the bases for the ecological pyramid of an aquatic Ecosystem. The algae are the one of the biotic

compounds of an ecosystem which act as the biological indicators of organic pollution hence it is essential to study the Algal diversity of the water bodies to determine the eminence of water. In recent days, *Spirogyra* sp. has been considered as the traditional food and consumed in the north and northeast of Thailand. It encompasses large quantities of nutritional compositions such as carbohydrates, fats, proteins, multivitamins, minerals, and antioxidants. The components such as alkaloids, steroids, flavonoids, tannins, Terpenoids exhibit antimicrobial activity against many test organisms. Though genus *Spirogyra* has been recognized for its bioprospecting activities, most of the taxa of *Spirogyra* have not been focused, due to the lacuna on the survey, identification, and inadequate attention of their availability in a particular geographical area. Hence, this present attempt was made to fetch out the preliminary data on the distribution of genus *Spirogyra* from the seven different ponds of Shivamogga District, Karnataka. Also, the information furnished at the enumeration part (taxa name with author details, collection site, the coordinate of location, and distribution) would be the first-hand information to the researchers for extending their research in advanced level.



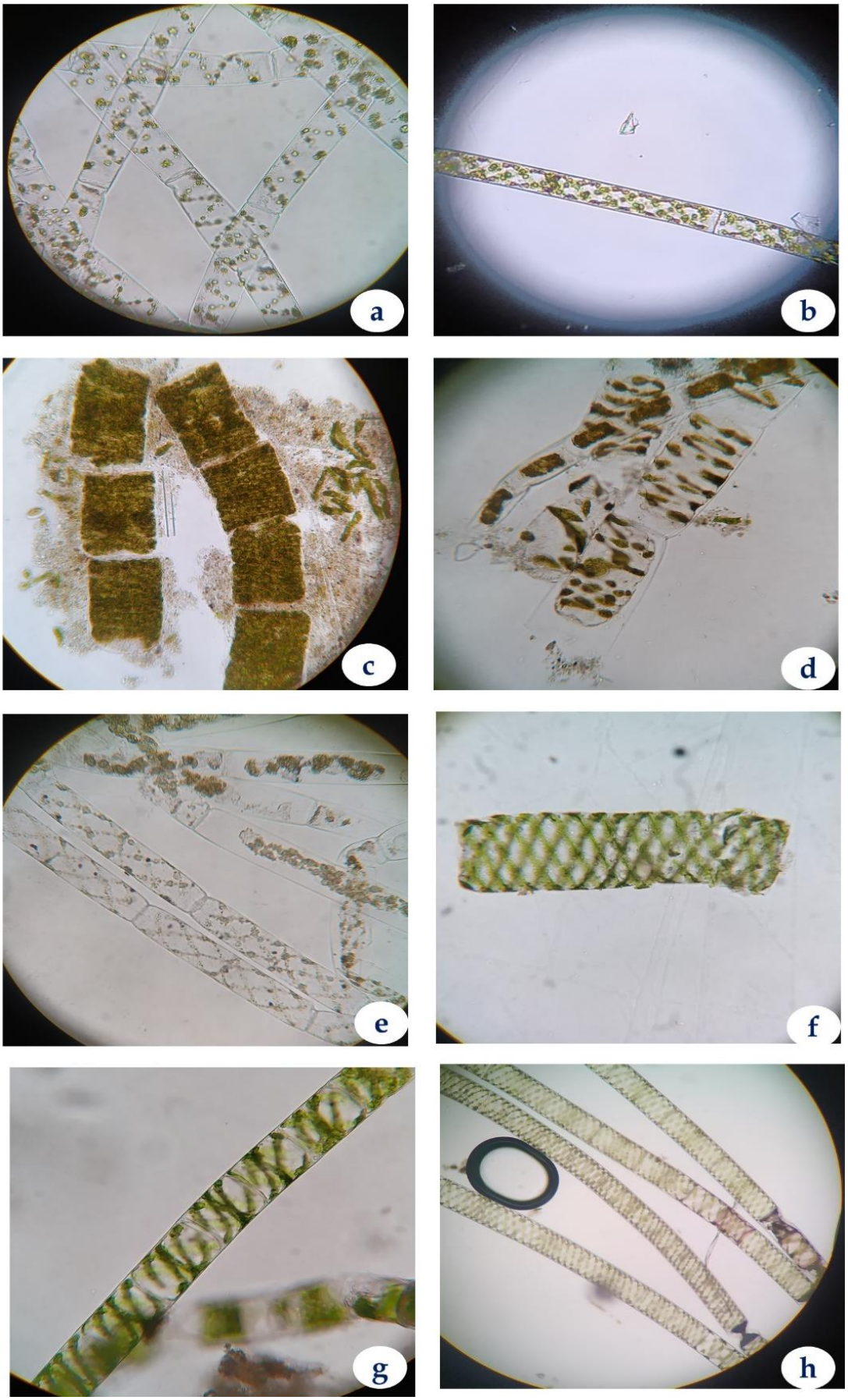
a: Mattur pond; b: Siddapura pond; c: Tammadikoppa pond; d: Keladi pond

Plate 1: Habitats of different ponds in Shivammoga district, Karnataka



a: Kutralli Pond; b: Goutur Pond; c: Ulavi Pond

Plate 2: Habitats of different ponds in Shivamogga District, Karnataka



a: *Spirogyra affinis*; b: *Spirogyra corrugata*; c: *Spirogyra crassa* d: *Spirogyra distenta*; e: *Spirogyra dubia*; f: *Spirogyra ellipsospora*; g: *Spirogyra elongata*; h: *Spirogyra fluviatilis*;

Plate 3: Examination of *Spirogyra* under microscopic observation

a: *Spirogyra gratiana*; b: *Spirogyra hyalina*; c: *Spirogyra maxima*; d: *Spirogyra notabilis*; e: *Spirogyra punctulata*; f: *Spirogyra submaxima*; g: *Spirogyra subsalsa*; h: *Spirogyra varians*;

Plate 4: Examination of *Spirogyra* under microscopic observation

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