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Seasonal and spatial distribution of freshwater diatoms from Thrissur Kole lands (part of Vembanad - Kol, Ramsar site), Kerala

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Abstract

The present paper is a report of the freshwater diatoms documented from the Kole lands of Thrissur, Kerala. The water samples were collected from ten stations for a period of one year from February 2005 to January 2006. The Kole lands of Thrissur are part of the Vembanad - Kol, a declared Ramsar site of Kerala. 74 taxa of diatoms are identified and of which 35 taxa are new reports to the diatom flora of Kerala. The diatom taxa are represented by 20 genera viz. *Achnanthes* (2), *Amphora* (2), *Anomoeneis* (1), *Caloneis* (2), *Cocconies* (1), *Cymbella* (3), *Eunotia* (6), *Fragilaria* (3), *Gomphonema* (4), *Gyrosigma* (1), *Melosira* (3), *Navicula* (15), N*itzschia* (7), *Pinnularia* (9), *Pleurosigma* (1), *Rhopalodia* (1), *Stauronies* (4), *Surirella* (5), *Synedra* (3) and *Tabellaria* (1).

Key words: Bacillariophyceae, Freshwater Diatoms, Kole lands, Pollution tolerant algae, Ramsar site, Vembanad – Kol

Introduction

The knowledge about the species diversity was essential in order to understand life in all its totality and to preserve and manage it for future generations (Pandey, 1995). Gopal (2005) illustrated the strong need for research on biodiversity in developing countries. Systematics and taxonomy are vital for the future development of biodiversity research (Martens and Segers, 2005).

The taxonomic composition of algae can provide a highly precise and accurate characterization of biotic integrity and environmental conditions. The taxonomic composition varies spatially and temporally in a water body, autecological characterizations of environmental conditions based on taxonomic composition consistently reflect the physical and chemical changes. The diatoms have been widely used for the water quality assessment in wetland studies (Alvarez-Blanco *et al*., 2011; Sudhakar *et al*., 1994).

The present paper deals with the diatoms found in the Kole lands of Thrissur district, Kerala. The Kole lands form a unique freshwater ecosystem and are the rice granary of Thrissur and Malappuram districts of Kerala (Johnkutty and Venugopal, 1993). The Thrissur Kole lands are part of the Vembanad - Kol, a declared Ramsar site of Kerala (http://www.ramsar.org). The Kole lands geographically distributed in Mukundapuram, Chavakkad and Thrissur taluks of Thrissur district, Kerala are designated as 'Thrissur Kole' (10,187 ha.).

The information regarding the freshwater diatom flora of Kerala is inadequate (Easa, 2004). The freshwater diatom flora of Southern Kerala was studied and reported 29 taxa belonging to nine genera namely *Eunotia, Cocconeis, Stauroneis, Neidium, Navicula, Cymbella, Gomphonema, Pinnularia* and *Surirella* by Jose and Patel (1989). John and Francis (2013) reported 53 taxa of diatoms coming under 22 genera from Idukki district, Kerala.

Materials and Methods

The present investigation was carried out in the Kole lands of Thrissur district, Kerala. The study area lies between 10^0 20′ to 10^0 40′ North latitudes and 75^0 58′ to 76^0 11′ East longitudes. The surface water samples were collected monthly from the Kole lands of Thrissur district, Kerala from ten stations for a period of one year from February 2005 to January 2006. The stations are (1) Pullur, (2) Muriyad, (3) Nambiankavu, (4) Mapranam, (5) Chemmanda, (6) Cherpu, (7) Palakkal, (8) Chettupuzha,

(9) Anthikkad and (10) Enamavu.

The samples collected were preserved in 4% formalin solution as per standard procedures (APHA, 1998). The identification of the algal taxa up to the species level was carried out with the help of keys and descriptions given by standard publications (Venkataraman, 1939; Krishnamurthy, 1954; Sarode and Kamat, 1984). For the purpose of the identification of the members of Bacillariophyceae, a portion of the concentrated sample was cleaned using concentrated hydrochloric acid, sulphuric acid and potassium permanganate crystals (Sarode and Kamat, 1984) and the Camera lucida drawings were prepared. The data were analyzed for the three seasons i.e., pre-monsoon (February - May), monsoon (June - September) and post-monsoon (October - January).

Results and discussion

During the present study 74 taxa of diatoms belonging to 20 genera have been collected and are described systematically with Camera lucida diagrams (Plate 1 and 2). Of these 35 taxa are new reports to the diatom flora of Kerala (Table 1). The list of diatom taxa recorded during the study is given in Table 1 with the seasonal and spatial variation.

Table: 1 Seasonal and spatial variation of diatoms in Thrissur Kole lands

Sl. No:	Name of algae	Seasonal variation	STATIONS									
			1	2	3	4	5	6	7	8	9	10
1	*Melosira granulata* (Ehr.) Ralfs	● ■ ▲	+	+	+	+	+	–	+	+	+	+
2	*M. granulata* (Ehr.) Ralfs var. *angustissima* Muell.	● ■ ▲	–	+	+	+	+	+	+	+	+	+
3	* *M. granulata* (Ehr.) Ralfs var. *mazzanensis* Meister	●	–	–	–	+	–	–	–	–	–	–
4	*Tabellaria fenestrata* (Lyngbye) Kuetz.	● ■ ▲	+	–	+	+	+	+	+	–	+	+
5	* *Fragilaria brevistriata* Grun. var. *vidarbhensis* Sarode *et* Kamat	● ■ ▲	+	+	–	+	+	–	–	–	+	–
6	* *F. intermedia* Grun. fa. *chandrapurensis* Sarode *et* Kamat	● ■ ▲	+	+	+	+	–	+	–	–	+	+
7	*F. leptostauron* (Ehr.) Hustedt var. *woerthensis* Mayer	● ■ ▲	+	–	–	+	+	–	–	–	+	+
8	*Synedra ulna* (Nitz.) Ehr.	● ■ ▲	–	–	–	–	–	+	+	+	+	+
9	*S. ulna* (Nitz.) Ehr. var. *amphirhynchus* (Ehr.) Grun.	● ■ ▲	+	+	+	+	+	+	–	–	+	+
10	* *S. ulna* (Nitz.) Ehr. var. *biceps* Kuetz.	● ■ ▲	–	–	–	–	–	–	+	–	+	+
11	* *Eunotia camelus* (Ehr.) A. Berg. var. *gibbosa* Gandhi	● ■	–	+	–	–	–	–	–	–	+	–
12	*E. camelus* (Ehr.) A. Berg. var. *karveerensis* Gandhi	● ▲	–	–	–	+	–	–	–	–	–	–
13	* *E. monodon* Ehr.	● ■	–	–	+	–	–	–	–	+	–	–
14	* *E. robusta* Ralfs var. *tetraodon* (Ehr.) Ralfs	● ■ ▲	+	+	+	+	+	+	+	+	+	+
15	*E.E. rostellata* Hustedt	● ■ ▲	+	+	+	+	+	–	+	–	–	+
16	* *E. valida* Hustedt var. *ambigua* Gonzalves *et* Gandhi	■ ▲	+	–	–	+	–	–	–	–	–	–
17	*Cocconeis placentula* Ehr.	● ■ ▲	–	–	–	–	+	–	–	–	+	+
18	*Achnanthes brevipes* Agardh var. *intermedia* (Kuetz.) Cleve	●	–	–	–	–	+	–	–	–	–	–
19	* *A. inflata* (Kuetz.) Grun. fa. *vidarbhensis* Sarode *et* Kamat	● ■ ▲	–	+	–	+	+	–	–	–	+	–
20	* *Gyrosigma acuminatum* (Kuetz.) Rabh.	● ■ ▲	–	–	–	–	–	+	–	+	+	+
21	* *Pleurosigma elongatum* W. Smith var. *karianum* (Grun.) Cleve	● ■ ▲	–	–	–	–	–	+	–	–	+	+
22	* *Caloneis permagna* (Bail.) Cleve	● ■ ▲	–	+	–	+	+	–	–	+	–	+
23	* *C. silicula* (Ehr.) Cleve var. *intermedia* Mayer	● ■ ▲	–	–	–	–	+	+	–	+	+	+
24	* *Stauroneis anceps* Ehr.	● ■	+	–	–	+	+	–	–	+	+	–
25	*S. phoenicenteron* Ehr.	● ■ ▲	+	+	–	–	+	+	+	+	–	+
26	* *S. phoenicenteron* Ehr. fa. *capitata* Gonzalves *et* Gandhi	● ■ ▲	–	+	–	+	–	+	–	+	+	+
27	*S. phoenicenteron* Ehr. fa. *producta* Gandhi	● ■ ▲	–	–	–	–	+	+	–	–	–	+
28	* *Anomoeneis sphaerophora* (Kuetz.) Pfitzer	● ■ ▲	+	+	–	–	+	+	–	–	–	–
29	*Navicula bacillum* Ehr.	●	–	–	–	–	–	–	–	–	–	+
30	*N. cari* Ehr. *fa. indica* Sarode *et* Kamat	■ ▲	–	–	–	+	+	+	–	+	+	–
31	*N. cincta* (Ehr.) Kuetz.	●	–	–	–	+	–	–	–	–	–	–
32	* *N. constans* Hustedt var. *symmetrica*	●	–	–	–	+	–	–	–	–	–	–

	Hustedt											
33	*N. cuspidata* Kuetz.	■ ▲	+	–	+	+	+	–	+	+	–	+
34	*N. cuspidata* Kuetz. var. *ambigua* (Ehr.) Cleve	● ■	–	–	–	–	–	–	–	+	–	–
35	* *N. cuspidata* Kuetz. var. *major* Meister	● ▲	–	–	–	+	–	+	–	+	–	–
36	* *N. gracilis* Ehr.	● ■ ▲	+	+	+	+	–	+	+	+	–	–
37	*N. halophila* (Grun.) Cleve fa. *subcapitata* Ostrup	● ■	+	+	–	–	–	–	–	–	–	–
38	* *N. protracta* Grun.	▲	–	–	–	–	+	–	–	–	–	–
39	*N. pupula* Kuetz. var. *capitata* Hustedt	●	–	–	–	+	–	–	–	–	–	–
40	* *N. pusilla* W. Smith	● ▲	–	–	–	+	–	+	–	–	+	–
41	* *N. rhynchocephala* Kuetz.	● ■ ▲	+	–	–	–	–	–	–	+	–	–
42	*N. rostellata* Kuetz.	● ■ ▲	–	–	–	+	+	+	–	+	+	–
43	*N. subrhynchocephala* Hustedt	● ■ ▲	+	–	–	–	–	–	–	+	–	–
44	* *Pinnularia aestuarii* Cleve var. *interrupta* (Hustedt) A. Cl.	● ■ ▲	+	+	+	+	+	–	+	+	+	+
45	* *P. braunii* (Grun.) Cleve	● ■ ▲	–	+	+	+	–	–	–	–	–	+
46	* *P. brebissonii* (Kuetz.) Cleve	● ▲	–	–	–	–	–	–	+	–	+	+
47	*P. brevicostata* Cleve var. *indica* Gandhi	● ▲	–	–	–	+	+	–	–	–	–	–
48	* *P. dolosa* Gandhi var. *chariessa* Gandhi	● ■ ▲	–	+	–	–	+	+	+	+	+	+
49	*P. gibba* Ehr.	● ■ ▲	+	+	+	+	+	+	–	+	+	+
50	*P. interrupta* W. Smith	● ■ ▲	+	–	+	+	+	+	+	+	+	+
51	*P. major* (Kuetz.) Cleve var. *linearis* Cleve	● ■ ▲	–	+	+	+	+	+	+	+	+	+
52	*P. viridis* (Nitz.) Ehr.	● ■ ▲	+	+	+	+	–	+	+	+	+	–
53	*Amphora coffeaformis* Agardh	■ ▲	+	–	–	–	–	–	–	–	–	–
54	* *A. ovalis* Kuetz. var. *gracilis* (Ehr.) Cleve	■	–	–	–	–	–	+	–	–	–	–
55	*Cymbella hustedtii* Krasske	● ■ ▲	–	+	–	–	–	–	–	+	+	–
56	*C. tumida* (Breb.) Van Heurek.	▲	–	+	–	–	–	–	–	–	–	–
57	*C. turgida* (Greg.) Cleve	● ■ ▲	+	+	+	+	+	+	+	+	+	+
58	* *Gomphonema gracile* Ehr. var. *lanceolata* (Kuetz.) Cleve	● ■ ▲	–	+	–	–	–	+	–	+	+	+
59	*G. lanceolatum* Ehr.	● ■ ▲	+	+	+	+	+	+	+	–	+	+
60	*G. parvulum* (Kuetz.) Grun.	● ■ ▲	+	+	+	+	–	–	+	+	–	+
61	* *G. sphaerophorum* Ehr.	●	–	–	+	–	–	–	–	–	–	–
62	* *Rhopalodia gibba* (Ehr.) Muell.	● ▲	–	–	–	+	–	–	–	+	+	–
63	* *Nitzschia clausii* Hantzsch	●	–	–	+	–	–	–	–	–	–	–
64	*N. closterium* W. Smith	● ■	–	–	–	–	–	+	–	+	+	+
65	* *N. ignorata* Krasske.	● ■ ▲	+	+	–	+	+	+	+	+	+	+
66	* *N. intermedia* Hantzsch	● ■ ▲	+	–	+	–	+	–	+	–	–	+
67	*N. obtusa* W. Smith	● ■ ▲	–	–	–	–	+	+	–	–	+	+
68	*N. palea* (Kuetz.) W. Smith	■ ▲	–	–	–	–	–	+	–	–	+	–
69	* *N. sigma* (Kuetz.) W. Smith	● ■	–	–	–	–	–	–	–	–	+	+
70	*Surirella biseriata* Breb.	●	–	–	–	+	–	–	–	–	–	–
71	*S. robusta* Ehr.	● ■ ▲	+	–	–	–	–	+	–	+	+	–
72	* *S. robusta* Ehr. var. *splendida* (Ehr.) V.H.	● ■ ▲	–	+	–	+	–	–	–	–	+	+
73	*S. tenera* Gregory	● ■ ▲	–	–	–	–	+	+	–	+	–	–
74	*S. tenera* Greg. var. *nervosa* A.S.	● ■ ▲	–	–	–	–	–	–	–	–	+	–

● Pre–monsoon, ■ Monsoon, ▲ Post–monsoon, + Present, - Absent, * New report to algal flora of Kerala
Stations: (1) Pullur, (2) Muriyad, (3) Nambiankavu, (4) Mapranam, (5) Chemmanda, (6) Cherpu, (7) Palakkal, (8) Chettupuzha, (9) Anthikkad and (10) Enamavu

The taxonomic enumeration of diatoms in the Thrissur Kole lands revealed that *Navicula* was the most diverse genera represented by 15 species (sp.) followed by *Pinnularia* (9 sp.), *Nitzschia* (7 sp.), *Eunatia* (6 sp.) and *Surirella* (5 sp.). The station 9 (Anthikkad) showed more diversity of diatoms with 41 taxa (Table 2). The seasonal analysis of diatoms at different stations revealed that 44 taxa were observed throughout the year irrespective of the seasonal changes and the maximum diversity of diatoms observed during pre-monsoon season with 66 species (Table 1). Naviculaceae was the diverse family of class Bacillariophyceae in the study area during the period of study.

The analysis of diatoms in the study area showed six pollution tolerant algal species (Paul, 2012) namely *Melosira granulata* (Ehr.) Ralfs, *Cocconeis placentula* Ehr., *Synedra ulna* (Nitz.) Ehr., *Navicula cuspidata* Kuetz., *Gomphonema parvulum* (Kuetz.) Grun. and *Nitzschia palea* (Kuetz.) W. Smith and are the indicators of organic pollution (Palmer, 1969). *Achnanthes*, *Cocconies*, *Cymbella*, *Fragilaria*, *Gomphonema*, *Melosira*, *Navicula*, *Nitzschia*, *Pinnularia*, *Stauronies*, *Surirella* and *Synedra* are the pollution tolerant diatom genera found in the study area (Table 2). The waste disposal is observed in the study area during the period of study. The diatoms are used as the bio-indicators of pollution (Alvarez-Blanco *et al*., 2011; Sudhakar *et al*., 1994).

Table 2: Distribution of diatom taxa in Thrissur Kole lands, Kerala

Sl. No:	Name of genera	Total no: of taxa reported	No: of taxa in stations									
			1	2	3	4	5	6	7	8	9	10
1	* *Melosira*	**3**	1	2	2	3	2	1	2	2	2	2
2	*Tabellaria*	**1**	1	-	1	1	1	1	1	-	1	1
3	* *Fragilaria*	**3**	3	2	1	3	2	1	-	-	3	2
4	* *Synedra*	**3**	1	1	1	1	1	2	2	1	3	3
5	*Eunotia*	**6**	3	3	3	4	2	1	2	2	2	2
6	* *Cocconies*	**1**	-	-	-	-	1	-	-	-	1	1
7	* *Achnanthes*	**2**	-	1	-	1	2	-	-	-	1	-
8	*Gyrosigma*	**1**	-	-	-	-	-	1	-	1	1	1
9	*Pleurosigma*	**1**	-	-	-	-	-	1	-	-	1	1
10	*Caloneis*	**2**	-	1	-	1	2	1	-	2	1	2
11	* *Stauroneis*	**4**	2	2	-	2	3	3	1	3	2	3
12	*Anomoeneis*	**1**	1	1	-	-	1	1	-	-	-	-
13	* *Navicula*	**15**	5	2	2	9	4	5	2	8	3	2
14	* *Pinnularia*	**9**	4	6	6	7	6	5	6	6	7	7
15	*Amphora*	**2**	1	-	-	-	-	1	-	-	-	-
16	* *Cymbella*	**3**	1	3	1	1	1	1	1	2	2	1
17	* *Gomphonema*	**4**	2	3	3	2	1	2	2	2	2	3
18	*Rhopalodia*	**1**	-	-	-	1	-	-	-	1	1	-
19	* *Nitzschia*	**7**	2	1	2	1	3	4	2	2	5	5
20	* *Surirella*	**5**	1	1	-	2	1	2	-	2	3	1
Total no: of taxa		**74**	**28**	**29**	**22**	**39**	**33**	**33**	**21**	**34**	**41**	**37**

*** Pollution tolerant genera (Palmer, 1969)**

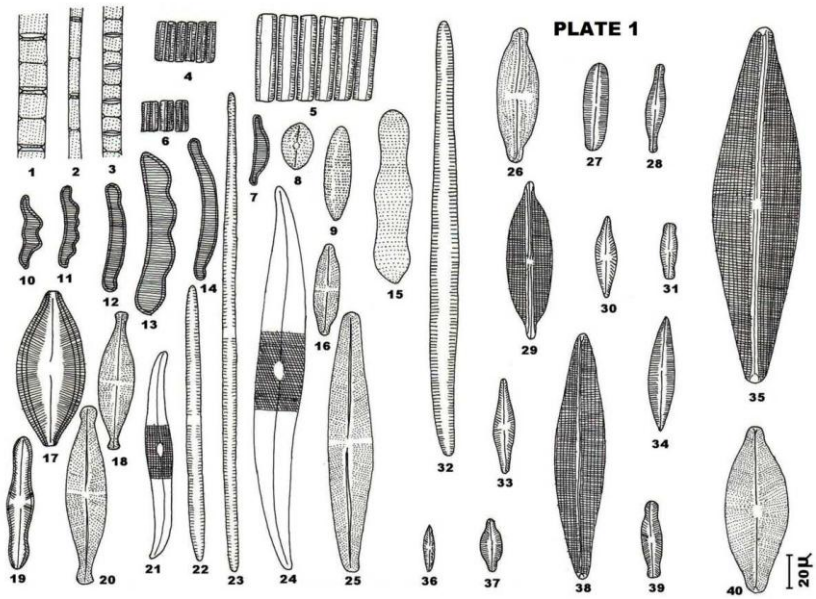

PLATE 1 (Figs. 1–40): 1. *Melosira granulata* (Ehr.) Ralfs **2.** *M. granulata* (Ehr.) Ralfs var. *angustissima* Muell. **3.** *M. granulata* (Ehr.) Ralfs var. *mazzanensis* Meister **4.** *Fragilaria brevistriata* Grun. var. *vidarbhensis* Sarode *et* Kamat **5.** *F. intermedia* Grun. fa. *chandrapurensis* Sarode *et* Kamat **6.** *F. leptostauron* (Ehr.) Hustedt var. *woerthensis* Mayer **7.** *Eunotia rostellata* Hustedt **8.** *Cocconeis placentula* Ehr. **9.** *Achnanthes brevipes* Agardh var. *intermedia* (Kuetz.) Cleve **10.** *Eunotia camelus* (Ehr.) A. Berg. var. *gibbosa* Gandhi **11.** *E. camelus* (Ehr.) A. Berg. var. *karveerensis* Gandhi **12.** *E. monodon* Ehr. **13.** *E. robusta* Ralfs var. *tetraodon* (Ehr.) Ralfs **14.** *E. valida* Hustedt var. *ambigua* Gonzalves et Gandhi **15.** *Achnanthes inflata* (Kuetz.) Grun. fa. *vidarbhensis* Sarode *et* Kamat **16.** *Stauroneis phoenicenteron* Ehr. fa. *producta* Gandhi **17.** *Caloneis permagna* (Bail.) Cleve **18.** *C. anceps* Ehr. **19.** *C. silicula* (Ehr.) Cleve var. *intermedia* Mayer **20.** *Stauroneis phoenicenteron* Ehr. fa. *capitata* Gonzalves *et* Gandhi **21.** *Gyrosigma acuminatum* (Kuetz.) Rabh. **22.** *Synedra ulna* (Nitz.) Ehr. **23.** *S. ulna* (Nitz.) Ehr. var. *biceps* Kuetz. **24.** *Pleurosigma elongatum* W. Smith var. *karianum* (Grun.) Cleve **25.** *Stauroneis phoenicenteron* Ehr. **26.** *Anomoeneis sphaerophora* (Kuetz.) Pfitzer **27.** *Navicula bacillum* Ehr. **28.** *N. halophila* (Grun.) Cleve fa. *subcapitata* Ostrup **29.** *N. cuspidata* Kuetz. var. *ambigua* (Ehr.) Cleve **30.** *N. rhynchocephala* Kuetz. **31.** *N. protracta* Grun. **32.** *Synedra ulna* (Nitz.) Ehr. var. *amphirhynchus* (Ehr.) Grun. **33.** *Navicula cari* Ehr. *fa. indica* Sarode *et* Kamat **34.** *N. gracilis* Ehr. **35.** *N. cuspidata* Kuetz. var. *major* Meister **36.** *N. cincta* (Ehr.) Kuetz. **37.** *N. constans* Hustedt var. *symmetrica* Hustedt **38.** *N. cuspidata* Kuetz. **39.** *N. pupula* Kuetz. var. *capitata* Hustedt **40.** *N. pusilla* W. Smith

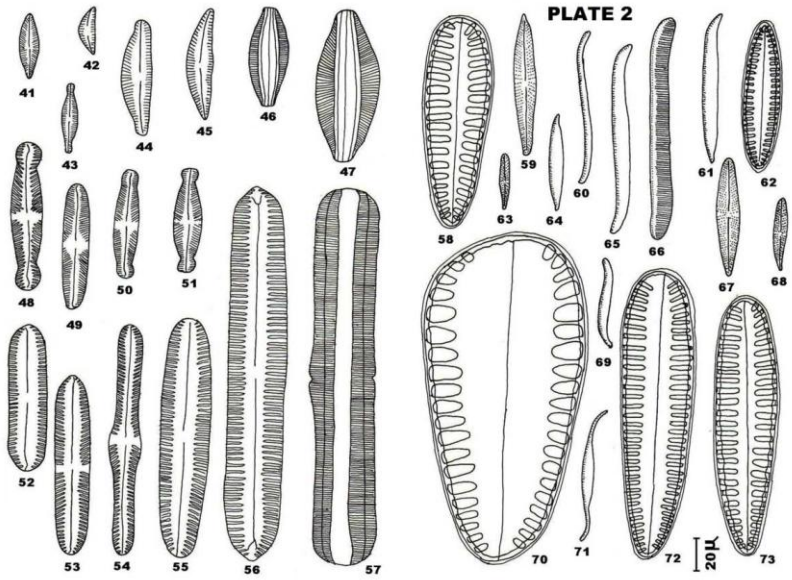

PLATE 2 (Figs. 41–73): 41. *Navicula rostellata* Kuetz. **42.** *Cymbella hustedtii* Krasske **43.** *Navicula subrhynchocephala* Hustedt **44.** *Cymbella tumida* (Breb.) Van Heurek. **45.** *C. turgida* (Greg.) Cleve **46.** *Amphora coffeaeformis* Agardh **47.** *A. ovalis* Kuetz. var. *gracilis* (Ehr.) Cleve **48.** *Pinnularia gibba* Ehr. **49.** *P. brebissonii* (Kuetz.) Cleve **50.** *P. interrupta* W. Smith **51.** *P. braunii* (Grun.) Cleve **52.** *P. brevicostata* Cleve var. *indica* Gandhi **53.** *P. aestuarii* Cleve var. *interrupta* (Hustedt) A. Cl. **54.** *P. dolosa* Gandhi var. *chariessa* Gandhi **55.** *P. viridis* (Nitz.) Ehr. **56.** *P. major* (Kuetz.) Cleve var. *linearis* Cleve **57.** *Rhopalodia gibba* (Ehr.) Muell. **58.** *Surirella robusta* Ehr. var. *splendida* (Ehr.) V. H. **59.** *Gomphonema gracile* Ehr. var. *lanceolata* (Kuetz.) Cleve **60.** *Nitzschia ignorata* Krasske. **61.** *N. sigma* (Kuetz.) W. Smith **62.** *Surirella biseriata* Breb. **63.** *Gomphonema sphaerophorum* Ehr. **64.** *Nitzschia palea* (Kuetz.) W. Smith **65.** *N. intermedia* Hantzsch **66.** *N. obtusa* W. Smith **67.** *Gomphonema lanceolatum* Ehr. **68.** *G. parvulum* (Kuetz.) Grun. **69.** *Nitzschia clausii* Hantzsch **70.** *Surirella robusta* Ehr. **71.** *Nitzschia closterium* W. Smith **72.** *Surirella tenera* Gregory **73.** *S. tenera* Greg. var. *nervosa* A. S.

The physico-chemical parameters of the study area were reported by Paul and Sreekumar (2013) and the diversity of the phytoplankton in the Thrissur Kole lands was affected by rainfall, salinity, hardness, magnitude of the flood dictated by the Karuvannur River and the conversion of the wetland area into paddy fields during summer. The present work is a contribution to the diatom flora of Kerala and it added 35 taxa new to the algal flora of Kerala.

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References

Alvarez-Blanco, I., Cejudo-Figueiras, C., Becares, E., and Blanco, S. 2011. Spatiotemporal changes in diatom ecological profiles: Implications for biomonitoring. *Limnology* 12(2): 157-168.

APHA. 1998. *Standard methods for the examination of water and waste water*. 20th edn. American Public Health Association, Washington DC.

Easa, P.S. 2004. *Biodiversity documentation for Kerala. Part 1: Algae*. KFRI handbook no. 17. Kerala Forest Research Institute, Peechi, Kerala, India. 106 pp.

Gopal, B. 2005. Relevance and policy dimensions of research on biodiversity in freshwater ecosystems: a developing country perspective. *Hydrobiologia* 542: 19-21.

John, J. and Francis M.S. 2013. *An illustrated algal flora of Kerala*. vol. I. Idukki district. Green Carmel Scientific Books, Kochi. 281 pp.

Johnkutty, I. and Venugopal, V.K. 1993. *Kole lands of Kerala*. Kerala Agricultural University, Thrissur. 68 pp.

Jose, L. and Patel, R.J. 1989. Contribution to the freshwater diatom flora of Kerala. *J. Phytol. Res.* 2(1): 45-51.

Krishnamurthy, V. 1954. A contribution to the diatom flora of south India. *J. Indian Bot. Soc.* 33(4): 354-381.

Martens, K. and Segers, H. 2005. Taxonomy and systematics in biodiversity research. *Hydrobiologia* 542: 27-31.

Palmer, C.M. 1969. A composite rating of algae tolerating organic pollution. *J. Phycol.* 5: 78-82.

Pandey, A.K. 1995. *Conservation of biodiversity: Present status and future strategy*. In: Pandey, A.K. (ed.). *Taxonomy and Biodiversity*. CBS Publishers and distributors, New Delhi. pp. 44-51.

Paul, P.T. and Sreekumar, R. 2013. Assessment on hydrographic parameters and phytoplankton abundance of Thrissur Kole lands (Part of Vembanad - Kol, Ramsar Site), Kerala. *International Journal of Advanced Life Sciences* 6(5): 583-593.

Paul, P.T. 2012. *Studies on the algal flora of Kole lands of Thrissur district, Kerala*. Ph.D. Thesis, Mahathma Gandhi University, Kottayam, Kerala. 501 pp. http://shodhganga.inflibnet.ac.in:8080/jspui/handle/10603/25928

Sarode, P.T. and Kamat, N.D. 1984. *Freshwater diatoms of Maharashtra*. Saikripa prakashan, Aurangabad. 338 pp.

Sudhakar, G., Jyothi, B. and Venkateswarlu, V. 1994. Role of diatoms as indicators of pollution gradients. *Environmental monitoring and assessment* 33: 85-99.

Venkataraman, G. 1939. A systematic account of some south Indian diatoms. *Proc. Indian Academy of Sci.* 10(6): 293-368.