# Study of Varied Habitats and its Effect on Algal Diversity from Fergusson College, Pune

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Fergusson college campus is located in Pune City, Maharashtra, India. Founded in 1885 and run by Deccan Education Society spread across 109 acres of land which can be divided into two parts as FC campus and FC hill. FC campus consists of departmental gothic style old buildings as well as newly constructed buildings while FC hill lies towards the west of the main campus. Total (129) and (125) algal forms were observed from FC campus and FC hill respectively out of which (100) and (88) were identified up to generic level and (76) and (57) were identified up to species level respectively indicating high algal diversity presence due to its varied habitats available for its survival. At FC campus only three divisions of algae were reported as cyanophyta (90%) with the scarce presence of chlorophyta (8%) and bacillariophyta (2%) while at FC hill four divisions of algae were reported as cyanophyta (78%) followed by chlorophyta (16%) with the scarce presence of bacillariophyta (5%) and euglenophyta (1%) respectively. Even though cyanophyta was dominant, variation can be seen in cyanophyta coccoid and cyanophyta filamentous forms. At FC campus cyanophyta filamentous forms (62) dominated over cyanophyta coccoid forms (54) were as at FC hill, cyanophyta coccoid forms (52) dominates over cyanophyta filamentous forms (46). Chroococcus, Microcystis, Gloeocapsa, Phormidium, Oscillatoria was present abundantly while Merismopedia, Lyngbya and Scytonema were present optimally at both the sites. All these Cyanophytic members possess well-developed sheath around there cell/trichome which might help them withstand adverse environmental conditions.

**Keywords:** Algal Distribution; Cyanobacterial Allergenicity; Cyanophyta; Subaerial Algae; Terrestrial Algae.

Algal flora has been studied by several workers throughout the world. Rindi and Guiry (2003)<sup>1</sup> studied algae from the walls of Galway city, western Ireland. Alghanmi and Jawad (2017)<sup>2</sup> studied the biodiversity of cyanobacteria from agricultural fields from Al-Diwaniyah city and a total of (26) species were recorded by them, out of which *Oscillatoria* was dominant. Bernstein *et al*  (2011)<sup>3</sup> performed a study to show cyanobacterial allergenicity.

The algal flora of India was studied by several workers. Sethi *et al.*  $(2012)^4$  collected different samples from the biological crust and subaerial habitat from the eastern region of India and reported (24) species of cyanobacteria and (6) species of microalgae. Satpati *et al.*  $(2013)^5$ 

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studied mangrove forest at Sundarban and recorded (32) species of algae. Datta and Keshri (2014)<sup>6</sup> investigated soil and subaerial algae from village Burdwan, West Bengal, India and recorded (22) taxa of blue-green algae. Kharkongor and Ramanujam (2014)<sup>7</sup> reported (85) taxa of algae collected from tree barks from forested areas of Meghalaya. Satpati and Pal (2016)<sup>8</sup> recorded *Trentepohlia rigidula* from two very distinct

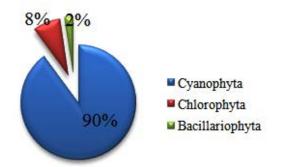


Fig. 1. Divisional Diversity at FC Campus

habitats like tree bark and cemented wall from West Bengal, India. Adhikary and Keshri (2015)9 studied cyanobacterial biofilms on the stone temple from Bhubaneshwar and reported (17) species of cyanobacteria while in monsoon additional 25 species of cyanobacteria were observed in the biofilms of these temples. Palanivel and Uma Rani (2016)<sup>10</sup> studied two temple tanks from the suburb of Chennai were they found chlorophyceae was the dominant group at both the temple tanks. Dirborne and Ramanujam (2017)<sup>11</sup> studied algal flora from the pine forest and subtropical broadleaf forest from East Khasi Hills Dist. of Meghalaya with a comparative study on cyanobacteria and diatoms. Das and keshri (2017)<sup>12,13</sup> studied algal diversity from Koch-Bihar a district from West Bengal situated at foothills of Eastern Himalayas from where they reported (11) taxa of coccoid cyanoprokaryotes belonging to (5) genera and (24) taxa of Oscillatoriales under cyanoprokaryotes.

Similar work was carried out in different parts of Maharashtra by several workers. Pandkar

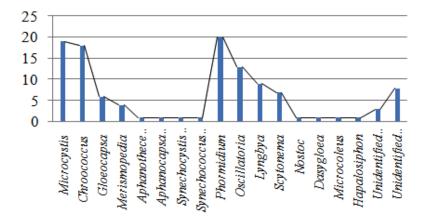


Fig. 2. Generic Diversity at FC Campus

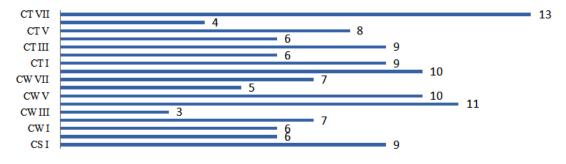


Fig. 3. Total Forms per Spot at FC Campus

S.	Algal Forms						Dif	ferent Si	Different Sampling Sites	Sites									
lo.		CS I	пCS	CW I	СW	Ш	CW	v CW	CW VI	CW VII	CW VIII	CT I	пCT	⊟C	IN CT	v CT	CT VI	CT VII	Total
	Cvanophyta	8	5	5	9	ŝ	6	7	5	7	9	6	9	6	9	8	4	13	116
	Coccoid	ŝ	0	-	0	-	5	5	-	б	б	5	ŝ	5	4	б	б	5	54
	Filamentous	5	б	4	4	0	4	6	4	4	б	4	ŝ	4	0	S	-	~	62
	Microcystis	+	+	+	+	+	-	-	+	-	+	7	+	+	+	-	+	+	19
-:	Microcystis marginata	•	•	•	'	•	+	•			+	+							б
1.2	Microcystis aeruginosa	•		•	'	'	•	+		+									0
13	Microcystis flos-aguae				'	•										+			-
717	Microcystis robusta											+							
	Chrococoust	-	-		-		+	ç		-		-	-	ç	ç	-	ç	+	- 2
-	CHIOOCOCCAS			•	-	•	-	1						1 -	1 -		1	-	<u>o</u> o
7.1	Chroococcus minutus	+	+	•	•	•	•	•	•	+	•	+	+	+	+	+			×
q	Chroococcus turgidus	•	•	•	+	•	•	+		•	•	•			+				ŝ
e.	Chroococcus minor	•	•	•	•	•	•	+		•		•		+			+		ę
4	Chroococcus minimus	•	,	,	1	•	+	,	,	,	,	,	,	,	,	,	,	,	-
S	Chroococcus cohaerens	,	'	'	'	'		'		'		'					+	,	1
"	Gloeocansa				'	•		+					-	-		-		-	9
, r	Gloancanea niavascane	1			1								+	+	+	+		+	v
	Moniculation mgr escens							· -				· -	-		-	-			<del>ء</del> ر
	Merismopeata	•	•	•		•	•	-		•	•	-		-	•				t (
4.1	Merismopedia punctata	•	•	•	•	•	•	•		•		+						+	7
4.2	Merismopedia convoluta	,	'	'	'	'	•	+		•		•							-
4.3	Merismopedia tenuissima	'	•	•	'	•	•	•	•	•	•	•		+	•				
5	Aphanothece stagnina		'	'	'	'	'	,		'	,	+		,	,			,	-
9	Aphanocapsa biformis	,	•	•	'	•	+	•		•	•	•			•				-
	Synechocystis aquatilis	•	•	•	'	'	•	•		•	+				•				-
8	Synechococcus aeruginosus		'	'	'		+	,		,		,	,	,	,	,	,	,	-
6	Phormidium	-	-	+	-	,	-	-	,	+	2+	7	ŝ	-	,	+	,	-	20
9.1	Phormidium truncicola	•		•	'	•						,						+	-
9.2	Phormidium foveolarum	•	•	•	'	•										+			-
9.3	Phormidium fragile	+	,	'	+	'	+	+		,	+	+	+	+	,	,	,	,	8
4	Phormidium ambiguum		'	+	'	'	'	'		,	,	,	+	,	,	,	,	,	6
9.5	Phormidium jadinianum	•		•	'	•		•	•		+	+	+						ę
9	Phormidium uncinatum	,	+	,	'			,					,	,		,	,	,	-
10	Oscillatoria	-	-	7	,	7	-	,	-	2	,	,	,	,	,	,	,	+ 2	13
10.1	Oscillatoria limosa	,	,	+	,	+	+	,	,	+	,	,	,	,	,	,	,	+	\$
10.2	Oscillatoria vizaganatensis		,	,	'			,		+				,				+	2
10.3	Oscillatoria peronata	,	,	+	,	,	,	,	,	,	,	,	,	,	,	,	,	,	-
10.4	Oscillatoria caneta	,	1		1	+													-
10.5	Oscillatoria willei		+																
10.6	Occillatoria cubbunic	+							+										· (
0.01	Osciliatoria subbrevis	F	•	•	•	•	•	•	F	•	•	•	•	•	•	•	•	•	1
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7	9	6 6

CT I to CT VII-Tree scraping from FC Campus.

et al. (2010, 2012)<sup>14,15</sup> reported algal diversity from Fergusson College with a very rare algal species named Oedocladium for the first time from Pune. Pandkar (2011)<sup>16</sup> performed daily air sampling for 11 months at Nagpur city and identified (16) algal genera out of which Phormidium, Microcoleus, Scytonema, Anabaena, Lyngbya were known to be allergenic. Nikam et al. (2013)17 studied cvanobacterial diversity from Ahmednagar, Pune and Satara district of Maharashtra and reported (94) cyanobacterial species belonging to (38) genera, (14) families and (5) orders from 627 soil samples collected. Mahadik and Jadhav (2013)<sup>18</sup> studied the Ujani reservoir from Indapur tehsil under the Pune area and reported (75) species under (42) genera of algae. Nimbhore and Jadhav (2014)<sup>19</sup> studied algal flora of the Brinjal field of Aurangabad tehsil and reported (21) species under (14) genera belonging to cyanophyceae, chlorophyceae and bacillariophyceae. Wadhave (2014)<sup>20</sup> studied rice fields from Bhadrawati tehsil from Chandrapur dist. Maharashtra and reported (74) algal taxa.

Only two reports were there on studies carried out at Fergusson College as Pandkar (2010, 2012)<sup>14,15</sup>. Apart from these reports on the Fergusson campus, there is not a single report from Fergusson hill. Hence these particular sites were chosen for present taxonomic study which will give an insight on changes taking place in algal composition over the past few years.

In the current paper, results are acquired by collecting algal samples from various terrestrial and subaerial sources and cultures obtained from them are reported. The study represents a comparative account of algal flora from the Fergusson campus and Fergusson hill as well as reports allergic algae from these two places.

## MATERIAL AND METHOD

Fergusson college campus is located in Pune City, Maharashtra, India (18031'17.75''N & 73050'20.17''E). It is divided into two sites as FC Campus and FC Hill. Both the sites are always flooded with students. These sites were also utilized by the elderly for recreational activities.

Samples from FC hill and FC campus were collected in July (2019). A total of 34 samples were collected out of which 17 were from FC campus and the remaining 17 were from FC hill

No.	Algal Forms	HS	н Н	HST I	HST II	Diff HST III	erent Sai HST IV	Different Sampling Sites HST HST HST HS III IV V V	ites HST VI	111 VII	HST VIII	МН	Ш	HT I	П	ΗΠ	HT IV	HTA I	HTA II	Total
1	Cvanophyta	5	2	=	5		9	=	5	<i>س</i>		2	5	s	9	4	m	m	~	98
	Cocoid	7	7	9	7	7	4	4	С	2	2	ę	4	С	7	7	7	7	5	52
	Filamentous	б	ę	5	ę	-	7	7	0	-	-	4	-	7	4	0	-	-	ę	46
	Chroococcus	-	'	С	-	1	7	7	0	-	-	1	5 +	-	1	+	-		ŝ	26
_	Chroococcus minutus		,	+		+	+	+		+	+	+	+	+	+		+		+	12
~	Chroococcus various		,					+												-
ω.	Chroococcus turgidus	+	,	+	+	•	+		+										+	9
1.4	Chroococcus minor		,	+		,	,	,	+	,	,	,	,	,	,	,	,	,	+	ę
5.1	Chroococcus macrococcus		,										+							-
	Microcystis	+	+	+	+	+	+	+	+	+	+	,	+	+	+	+	+	+	+	18
2.1	Microcystis aeruginosa		,				,	+	,					,		,	,	,		-
	Aphanocapsa	,	-	7	,	,	-	,	,	,	,	,	,	,	,	,	,	,	,	4
3.1	Aphanocapsa grevillei		,	,		,	+	,	,	,	,	,	,	,	,	,	,	,	,	-
3.2	Aphanocapsa elachista		+				,		,					,		,	,	,		-
3.3	Aphanocapsa biformis		,	+		,	,	,	,	,	,	,	,	,	,	,	,	,	,	-
3.4	Aphanocapsa roeseana		,	+			,		,					,		,	,	,		-
	Gloeocapsa		,	'	•	•	•		•			+		+	,				,	7
	Gloeothece rupestris		•	•															+	-
	Phormidium	1	-	2+	7		7	e	7		-	-	-	-	1		-		+	23
	Phormidium microtomum	+	•	•	•	•	•		•									•	•	-
6.2	Phormidium ambiguum		'		+	,	+	+	+			,		+		,	,	,		5
6.3	Phormidium cebennense		,	'	•	,	+	,	,			,	,	,	,	,	,	,	,	-
6.4	Phormidium fragile		+	+	•	•	•	+	•	•	+	+					+	•	+	7
6.5	Phormidium subfuscum		'	•			,					,			+	,	,	,	,	-
6.6	Phormidium jadinianum		•	•	•	•	•		•				+					•	•	-
6.7	Phormidium foveolarum		•	+	•			+	+									+		4
6.8	Phormidium angustissimum		,	'	+	•	•		•			,			,				,	
	Scytonema		•	•				5 +				+				+				S
7.1	Scytonema julianum		'	•	•		•	+							,					-
7.2	Scytonema hofmanni		•	•	•	•		+	•											-
	Oscillatoria	7	,		1			+												4
	Oscillatoria princeps	+	,	•	•	•			•											-
8.2	Oscillatoria vizagapatensis	+	,	,	,	,	,	,	,	,	,	,	,	,	,	,	,	,	,	-
8.3	Oscillatoria acuta		,		+															-
	Lynghya		+	•	•	•									+					ę
10	Arthospira		,	+			,		,					,		,	,	,	+	0
	Plectonema wollei		+	•	•	•	•		•											-
12	Microcoleus		,	+		,														-
;					I	1		•	•	•	•	•	•	•				•	•	

respectively. Samples were collected from different sites like tree barks, stones, cemented walls and water tanks. The dry samples were collected using a scalpel and was stored in a clean zip lock bag while water samples were collected using centrifuge tubes. Collected samples were inoculated in the B.G.11 medium under natural conditions. Growth was observed after three weeks of inoculation. Upon optimum growth, semi-permanent slides were prepared using glycerin as a mounting medium. The identification of algae was done by using standard available literature (Desikacharya, 1959; Prescott, 1954)<sup>23,24</sup>.

B.G. 11 broth with minerals, M1958-500G (HIMEDIA, Lot # 0000314677) was used to make media while LM5209 binocular microscope with LM1918 5MP CMOS camera was used for identification and microphotography. All other reagents used were of lab grade.

### **RESULT AND DISCUSSION**

Total of 116 cyanophyta members were observed from 17 different spots from the FC campus. Fig. 1 clearly showed a dominance of cyanophyta (90%) with a scarce presence of chlorophyta (8%) and bacillariophyta (2%) respectively. Cyanophyta was further divided into coccoid and filamentous forms. Filamentous (62) forms were little more than coccoid forms (54). In filamentous forms genus, Phormidium (20) was dominant with P. fragile reported from (8) samples. The second dominant group among filamentous cyanophyte was Oscillatoria (13) were O. limosa was reported from (5) samples. Lyngbya was reported from (9) samples out of which L. lutea was reported from (4) samples. Scytonema was reported from (7) samples with species like S. hofmanni and S. burmanicum from (2) samples each. Apart from these filamentous forms, Plectonema tomasinianum was reported from (2) samples followed by Nostoc, Dasygloea, Microcoleus, and Hapalosiphon were reported from (1) sample only. (Table 1)

In coccoid forms, Microcystis (19) was dominant followed by Chroococcus (18). From Chroococcus, C. minutus (8) was reported most of the time. Gloeocapsa were reported from (6) samples out of which G. nigrescens was identified up to species level from (5) samples.

<u>0</u>	15 Unidentified Filamentous Form	,	,	,	,	+	,	,	,	+	,	+	+	,	+	+	,		,	9
Π	Chlorophyta	-	-	-	З			0			1	0		1	1		1	9		20
1	Desmid	+	+	+	+ + +			‡			+	‡		+			+	++++++		18
7	Unidentified Chlorophyta Form			,		,	,			,			,		+			+	,	2
Ξ	Bacillariophyta			-	-	-					1							-	-	9
-	Diatom	,		+	+	+	,		,	,	+	,	,	,	,	,	,	+	+	9
N	Euglenophyta										1									1
-	Euglena										+						,			1
	Algal Forms Per Spot	9	9	13	6	4	9	13	5	æ	9	6	5	9	7	4	4	6	6	
,		:																		
Sam	Sampling spots from FC Hill- HS I and HS II- Soil from	Soil fron	n FC hill; i	HST I to I	HST VIII-	Stone scra	apping fro	m FC hill;												
MH	HW 1 and HW II –Wall scrapping from FC hill; HT I to	II; HT I th	o HT IV- 1	free scrap	ping from	FC hill; h	[TA I and	HTA II- Ta	nk water f	rom FC h	ll.									
				•	,															

4

*Merismopedia* was reported from (4) samples with *M. punctata* reported from (2) samples. Other coccoid forms recorded were *Aphanothece stagina*, *Aphanocapsa biformis*, *Synechocystis aquatilis* and *Synechococcus aeruginosus* from one sample each. Desmid (8) and diatoms (3) were scarce belonging to chlorophyta and bacillariophyta respectively. (Table 1)

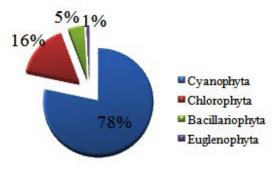
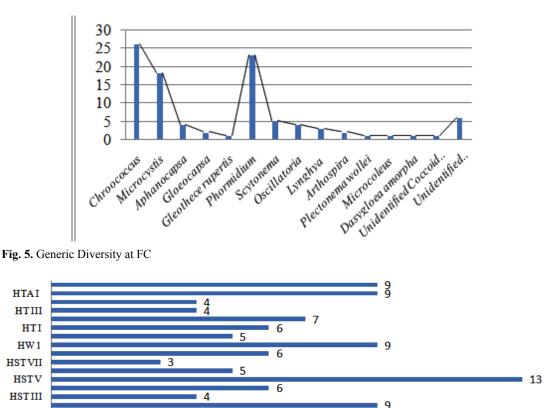


Fig. 4. Divisional Diversity at FC Hill

Total of 98 cyanophyta members were observed from 17 different spots from FC hill. Fig. 4 clearly showed the dominance of cyanophyta (78%) followed by chlorophyta (16%) while bacillariophyta (5%) and euglenophyta (1%) were scarcely recorded. Coccoid (52) forms were little more than filamentous (46) forms. Coccoid forms recorded showed the dominance of Chroococcus (26) with C. minutus (12) recorded from most of the samples. A second largest genus recorded from coccoid forms was Microcystis (18) were M. aeruginosa was identified up to species level from (1) sample only. Genus Aphanocapsa was recorded from (4) samples which were further identified up to species level as A. grevillei, A. elachista, A. biformis and A. roeseana. Other coccoid forms reported were Gloeocapsa (2) and *Gloeothece rupesrtris* (1). (Table 2)

In filamentous forms, *Phormidium* (23) was dominant with *P. fragile* (7) recorded most of the time. *Scytonema* was reported from (5)



6

Fig. 6. Total Algal Forms per Spot at FC Hill

HSTI

HSI

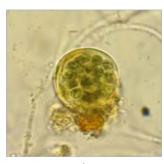
13

samples with *S. julianum* and *S. hofmanni* recorded from (1) sample each. *Oscillatoria* was reported from (4) samples with species like *O. princeps*, *O. vizagapatensis* and *O. acuta* reported from (1) sample each. *Lyngbya* (3), *Arthospira* (2) and *Microcoleus* were identified up to generic level while *Plectonema wollei* and *Dasygloea amorpha* were identified up to species level from (1) sample only. Desmid (18) and diatoms were reported from chlorophyta and bacillariophyta respectively. (Table 2)

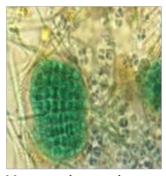
Total (116) and (98) cyanophytic members from FC campus and FC hill respectively showed species richness which also points towards various substratum are adding to its algal diversity. Upon comparison of Fig.3 and Fig.6, it has been observed that tree scraping, stone scraping, and wall scraping shows a majority of cyanophytic algal forms compare to soil and water samples. It can be due to undisturbed crevices of trees, stones, and walls while soil samples and tank water sample shows less algal forms which may due to destructive human activity.

From Fig.2 and Fig.5, it's quite clear that genera like Chroococcus, Microcystis, Gloeocapsa, Phormidium, Oscillatoria were present abundantly while Merismopedia, Lyngbya and Scytonema were present optimally at both the sites. All these cyanophytic members possess well-developed sheath around there cell/trichome which might help them withstand adverse environmental conditions. This finding correlates with Pandkar (2010, 2012)<sup>14,15</sup>. Similar results were obtained by Sethi (2012)<sup>4</sup>, Karande (2012)<sup>23</sup>. According to Sethi cyanobacteria were prominent in soil, building facades as well as on tree bark while green alga flourished only if sufficient moisture was available in the substratum while Karande stated that higher numbers of microalgae were reported from biofilms collected from the higher altitude. According to results obtained by Roy (2015)<sup>24</sup> on studies carried on East Kolkata Wetlands of West Bengal showed the presence of chlorophyte being dominant over cyanophyte but species like Chroococcus, Merismopedia and Synechococcus flourish throughout the year.

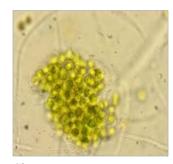
Microphotograph from FC Campus Cyanophytic Coccoid Forms



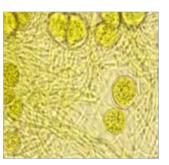
Microcystis robusta



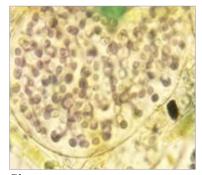
Merismopedia convolute



Chroococcus minor



Chroococcus turgidus

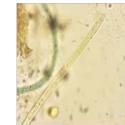


Gloeocapsa nigrescens

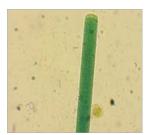
## Cyanophytic Filamentous Forms



Scytonema



Phormidium uncinatum Oscillatoria limosa

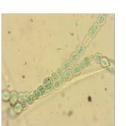


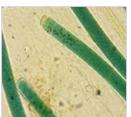
Oscillatoria subbrevis



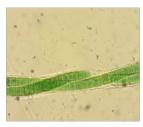
Phormidium ambiguum Haplosiphon

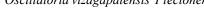
Microphotograph from FC Hill Cyanophytic Coccoid Forms

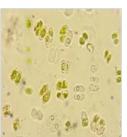




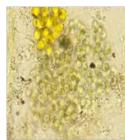
Oscillatoria vizagapatensis Plectonema



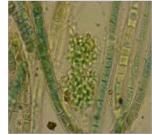




*Gloeothece rupestris* 



Aphanocapsa biformis



Chroococcus various

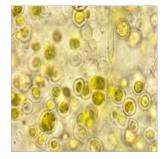




Chroococcus micrococcus



Chroococcus turgidus



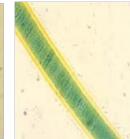
Chroococcus minutus



Chroococcus minimus

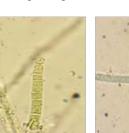
## Cyanophytic Filamentous Forms



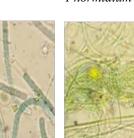


Plectonema

Oscillatoria princeps



Phormidium subfuscum Scytonema



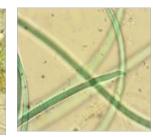
Microcoleus



Phormidium ambiguum



Phormidium microtomum



Oscillatoria acuta

## CONCLUSION

Total 129 algal forms were observed from FC Campus and 125 algal forms were observed from FC Hill out of which 116 and 98 were cyanophyta members from FC Campus and FC hill respectively. Cyanophyta members were found to be dominant at both the places with the presence of chlorophyta, bacillariophyta and euglenophyta respectively. The dominance of cyanophyta members was due to the presence of well-developed sheath around them which helps them to withstand adverse environmental conditions.

The present algal taxonomic study will provide insight into how algal diversity changed over the past few years. Forms such as *Phormidium, Lyngbya, Scytonema, Microcystis* reported to be allergenic has been encountered. Presences of allergenic algae manifest medical threat to humans were this study will act as baseline data.

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