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Reporting aero-algal forms by fan dust sampling method from Mumbai, India

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Abstract

Mumbai is one of the metropolitan cities of India and is also known as the 'Financial Capital of India'. Mumbai has located (19°04'34" N 72°52'39" E) as an island in the Arabian Sea on the west coast of India. Air pollution is a major issue in any metropolis city and Mumbai city is also facing the same issue. It has an annual average PM 2.5 concentrations higher than required due to heavy transport and building construction activities. Normally the strong wind blows in from the Arabian Sea over peninsular Mumbai. The air acts as a transit mediator for both abiotic and biotic airborne particles. The airborne dust with biotic components like bacteria, fungi, protozoans, pollen grains and other microorganisms disperse and deposit on various household objects such as chairs, tables, fans, beds, doors, floors, etc. Dust is a mixture of various biotic components that can cause several kinds of allergies. For the study, the ceiling fan was considered as an aero sampler to collect the fan dust samples. A total of 10 fan dust samples were collected from ceiling fans of different places in Mumbai and its suburbs from January to February 2022. Some dust samples have been transferred to the sterile culture tubes containing BG-11 broth medium and kept for incubation under natural conditions. The remaining part of the fan dust samples was used in the direct slide preparation. Total 85 aero-algal forms were recorded from both direct slide & culture slide scanning respectively. Out of 85 aero-algal forms identified, (75) belong to the division Cyanophyta, (6) algal forms to Chlorophyta and (4) algal forms to Bacillariophyta respectively. The genus Chroococcus, Merismopedia, Anabaena, Nostoc, Lyngbya and Phormidiumwere among the forms recorded on both first-day and tenth-days samples. This finding correlates with the earlier reports indicating cyanophyte members as a dominant aero-algal group. It can be stipulated that a fan can be used as an effective and easily reachable aero-sampler for such studies. The genus Gloeocapsa, Nostoc, Anabaena, Lyngbya and Phormidium were among the aero-algae having allergenic properties recorded during the study. However, such indoor allergenic aero-algal forms indicate important health hazards, requiring more research.

Keywords: Mumbai environment; Ceiling fan; Allergenic aero-algal forms; Cyanophyta; Biotic components

INTRODUCTION

Mumbai is one of the metropolitan cities of India and is also known as the 'Financial Capital of India'. As per the UN reports, as of 2018, it is the 8th most populous city in the World and the 2nd most populous city in India. Mumbai is located (at 19°04'34" N 72°52'39" E) as an island in the Arabian Sea on the west coast of India. It has a warm and humid climate. Air pollution is a major issue in any metropolis city and Mumbai city is also facing the same issue. The Air Quality of Mumbai is not fulfilling the guidelines recommended by the WHO. It has an annual average PM2.5 concentration higher than required due to heavy transport and building construction activities. Normally the strong wind blows in from the Arabian Sea over peninsular Mumbai which acts as a transit mediator for both abiotic and biotic airborne particles. According to NEERI reports, the dust comes from unpaved roads (45%) followed by paved surfaces (26%), construction activities (8%), vehicles (3%), and the rest from other sources (like industries, domestic sector, aircraft, marine vessels, etc.) which contribute to the Mumbai's dust load. The airborne dust with biotic components like bacteria, fungi, protozoans, pollen grains and other microorganisms disperse and deposit on various household objects such as chairs, tables, fans, beds, doors, floors, etc. Dust is a mixture of various biotic components that can cause several kinds of allergies. One of the biotic components of dust is algae reported first time from sea dust by (Ehrenberg, 1852). In addition, other pioneer researchers, who studied airborne algae include (Salisbury., 1866, Meier *et al.*, 1935, van Overeem., 1935, Schlichting.,

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1961, Brown., 1971, Lee *et al.*, 1989, Broady., 1996 and Marshall *et al.*, 1997).

Several studies show that the distribution and survival of airborne algae are affected by meteorological conditions such as temperature, wind velocity, humidity % etc. It bears an important role either directly or indirectly in the distribution of airborne algae as reported by (Schlichting., 1969, Smith., 1973, Balakrishnan *et al.*, 1980 and Roy-Ocotla *et al.*, 1993). According to (Tormo *et al.,* 2001), airborne algae have been found in almost all environments like other biotic particles but the algae are less frequent in the air compared to other microorganisms like bacteria. They are dispersed passively through the wind. The dispersal, distribution, stability and abundance of aero-algal forms have been studied by (Devi *et al.*, 2005, Sharma *et al.*, 2006 and Pandkar, 2021). On the other hand, (Ramesh Chandra., 2014) report the impact of climate change on the role of microbial activity altering the soil status. Using different methods and places, several workers investigate the airborne algae. (Luty *et al.*, 1967) reported aerospora of Santa Catalina Mountains and the Tucson area at various latitudes. (Rosas *et al.*, 1989) from Mexico, (Tiberg *et al.*, 1983) from Sweden, (Fulton *et al.*, 1966) use aircraft to collect samples. (Bernstein *et al.*, 1970) reported viable algae from house dust, (Schlichting., 1971) uses seafoam as a sample, (Burge *et al.*, 1982) uses rotarod air sampler to investigate indoor allergens. (El-Gamal., 2008) from Cairo reported aero-algal forms using petri plate exposure method. (Nuhu *et al.*, 2008) from Saudi Arabia use biofilm from a green house evaporative cooling system to assess cyanobacteria. (Ambu *et al.*, 2008) in his review article reported the indoor air quality and illness in Malaysian buildings. The first-ever outdoor study was carried out by (Hui-Ping *et al.*, 2011) to investigate the distribution of airborne algae at Bukit Jalil in Kuala Lumpur, while a survey was carried out by (Chu *et al.*, 2013) to study the intramural premises of an office building of Kuala Lumpur for the presence of cyanobacteria and airborne algae. In a short review, a systematic dispersal of airborne algae was explored by (Tesson *et al.*, 2016).

Sharma *et al.*, 2006 using the Tilak air sampler and Petri plate exposure methods, have reported the airborne algae at the height of 2.5m, in which Cyanophyta members were found to be dominant. (Dubey *et al.*, 2010) used a gravity slide sampler and petri plate exposure method and reported the allergenic aero-algal forms from the Kanpur wetland. (Verma *et al.*, 2012), by using the Petri plate exposure method recorded cyanophyte as a major airborne alga in Kanpur rural. (Sathish C. *et al.*, 2020) reported airborne algae from Bengaluru using petri plate methods and indicated soil algae as a source of aero-algae. (Sharma *et al.*, 2010), suggested that atmospheric dryness helps the airborne algae to be abundant in the atmosphere. (Seetharam *et al.*, 2016) considered spider webs as a sample to study the aerospora at Pakhal Wildlife Sanctuary, Warangal. (Pandkar., 2011)an investigated Nagpur air for allergenic aero-algal forms at the human breathing level using a mini Lakhanpal-Nair Air Sampler mounted on the Vespa Scooter. (Patil *et al.*, 2014) recorded 24 allergenic algal forms from Pune using the Petri plate exposure method. (Jadhav *et al.*, 2010) investigated aero-algae of Aurangabad using the Petri plate exposure method were as (Jadhav *et al.*, 2021) reported aero-algal forms by house dust sample methods. (Chougule *et al.*, 2016), collected house dust from patients suffering from nasal-bronchial allergy and found Cyanophyta as commonly occurring algal members from those houses from Sangli. Pandkar, 2011[b] introduced ceiling fan as a cost-effective air sampler and reported aero-algal forms from Nagpur. (Kamble *et al.*, 2021) reported allergenic aero-algal forms using fan dust samples from Pune. But there is not a single report on aero-algae from Mumbai; hence the work was carried out to report indoor aero-algal forms using the ceiling fan as an aero-biological sampler.

For the study, the ceiling fan was used as an aero sampler and fan dust samples were collected from five different sites (shops and houses) in Mumbai and its suburbs. This preliminary research focuses on the effective use of a fan as an alternative aero-sampler and primarily reports aero-algal forms from the fan dust samples.

MATERIALS AND METHODS

The ceiling fans, commonly utilized in the house, shop or workplace is considered as an easily available and affordable aero sampler for this study. Total 10 fan dust samples were

Table 1: Sampling sites and its abbreviation

Sampling Sites	Sample Collection (First Day)	Sample Collection (Tenth Day)
New Tirupati Medical, Dahisar (East)	FD 1a	FD 1b
Hare Krishna CHS, Andheri (East)	FD 2a	FD 2b
Balram Niwas Naigaon, Dadar (East)	FD 3a	FD 3b
Ashirwad Building, Mulund (West)	FD 4a	FD 4b
Ramabai Colony, Ghatkopar (East)	FD 5a	FD 5b

collected from the ceiling fans of five different places in Mumbai and its suburbs from 26th January 2022 to 08th February 2022. At first, with the help of a brush and a spatula dust was obtained from the blades of the ceiling fan on butter paper and collected in a plastic bag. The fan blades were wiped with 70% v/v ethanol using tissue paper after the collection of the fan dust. The fans were utilized in the normal way for the next ten days. On the tenth day, the dust samples were collected from the fan blades using the brush and kept in plastic bags. These dust samples were utilized for direct slide preparation and part of it was cultured and slides were prepared from the cultures obtained.

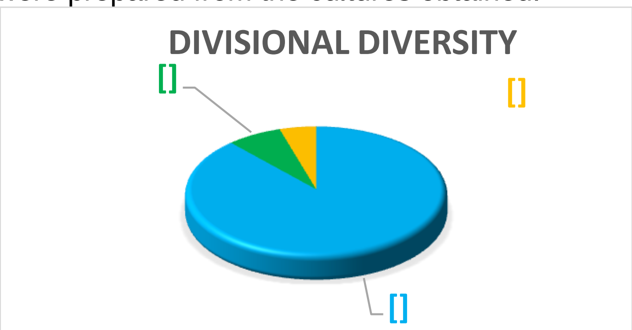

Figure-1: Algal diversity at the divisional level

Slide Culture Preparation

The collected dust samples from the ceiling fans have been brought to the laboratory. Some part of the dust samples has been transferred to the sterile culture tubes containing BG-11 broth medium and kept for incubation under natural conditions. The cultural growth was visible after one month. The semi-permanent slide was prepared from the cultures obtained.

Direct Slide Preparation

The fan dust was first macerated with dilute Hydrochloric acid to remove calcium and magnesium carbonates from the dust. The traces of acid were removed by centrifuging it with sterilized distilled water (Pandkar, 2011). The supernatant was used for preparing a semi-permanent slide for algal identification. The slides were scanned under the compound microscope and identification was done by referring to the standard literature (Prescott., 1954 and Desikachary., 1959).

RESULTS AND DISCUSSION

Total 85 aero-algal forms were recorded from both direct slide and culture slide scanning. Out of 85 aero-algal forms reported, (75) algal forms belong to the division Cyanophyta, (6) algal forms to Chlorophyta and (4) algal forms to Bacillariophyta respectively. The Cyanophytes were found dominant in the indoor environment of Mumbai. Out of (85) aero-algal forms recorded, (38) were recognized up to the division level, (18) up to the genera level and (29) up to the species level, respectively (Table 2 & Table 3). The Cyanophytes were found to be dominant (88.2%), followed by Chlorophytes (7.1%) and Bacillariophytes (4.7%) respectively (Figure 1). Cyanophytes were further classified into coccoid and filamentous forms. It has been observed that in direct slide scanning, cyanophyta coccoid forms (29) were found to be dominant over filamentous forms (5) were as in culture slide scanning both coccoid cyanophytes (23) and filamentous cyanophytes (18) were found to be at par (Table 2, Table 3).

Table 2: Aero-algal Diversity from Direct Slide Scanning

S. No.	Particular	Sampling Spots										
		FD 1a	FD 2a	FD 3a	FD 4a	FD 5a	FD 1b	FD 2b	FD 3b	FD 4b	FD 5b	Total
1	Cyanophyta	7	5	4	3	3	3	1	3	3	2	34
1A	Coccoid	6	5	3	3	3	3	1	1	2	2	29
1B	Filamentous	1	-	1	-	-	-	-	2	1	-	5
II	Bacillariophyta	-	2	-	2	-	-	-	-	-	-	4

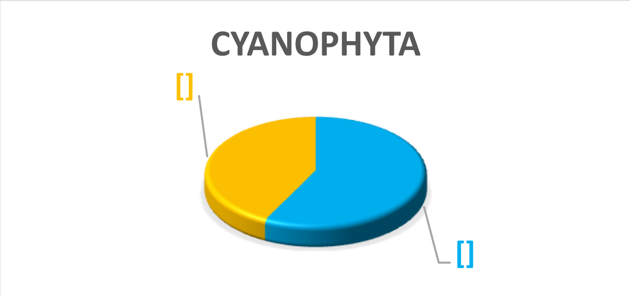

Figure 2: Morphological Diversity of Cyanophyta from Culture Samples

From direct slide scanning, aero-algal forms were identified up to the division level only except *Navicula* belonging to division Bacillariophyta was identified up to the generic level. It may be due to dehydration and deformation of algal forms exposed to adverse environmental conditions. From culture slide scanning, total (47) aero-algal forms were reported, which were further identified up to the generic level out of which 29 were identified up to the species level respectively. The genus *Chroococcus* (14) was dominant with *Chroococcus minor* recorded from (7) samples followed by *Chroococcus minimus* and *Chroococcus minutus* recorded from (5) and (2) samples each. It was followed by genus *Merismopedia* (6) with *Merismopedia glauca, Merismopedia punctata* and *Merismopedia tenuissima* recorded from (2), (2) and (1) samples each.

Table 3: Aero-Algal Diversity from Fan Dust culture

S. No.	Particular	Sampling Spots										
		FD 1a	FD 2a	FD 3a	FD 4a	FD 5a	FD 1b	FD 2b	FD 3b	FD 4b	FD 5b	Total
I	Cyanophyta	3	4	3	4	4	4	5	5	3	6	41
Ia	Coccoid	2	2	1	2	3	3	3	2	2	3	23
Ib	Filamentous	1	2	2	2	1	1	2	3	1	3	18
1	*Chroococcus*	1	1	-	1	1	2	3	1	2	2	14
1.1	*Chr. minor*	+	+	-	+	+	+	+	-	+	-	7
1.2	*Chr. minimus*	-	-	-	-	-	+	+	+	+	+	5
1.3	*Chr. minutus*	-	-	-	-	-	-	+	-	-	+	2
2	*Gloeocapsa*	1	-	-	-	1	-	-	-	-	-	2
2.1	*Gl. punctata*	-	-	-	-	+	-	-	-	-	-	1
2.2	*Gl. aeruginosa*	+	-	-	-	-	-	-	-	-	-	1
3	*Merismopedia*	-	-	1	1	1	1	-	1	-	1	6
3.1	*M. glauca*	-	-	-	-	-	+	-	-	-	-	1
3.2	*M. punctata*	-	-	+	+	-	-	-	-	-	-	2
3.3	*M. tenuissima*	-	-	-	-	+	-	-	+	-	-	2
4	*Mixosarcina*	-	1	-	-	-	-	-	-	-	-	1
4.1	*M. burmensis*	-	+	-	-	-	-	-	-	-	-	1
5	*Anabaena*	-	1	-	-	-	-	-	2	-	2	5
5.1	*A. naviculoides*	-	+	-	-	-	-	-	+	-	+	3
5.2	*A. oryzae*	-	-	-	-	-	-	-	-	-	+	1
6	*Nostoc*	1	1	-	1	-	-	-	1	-	1	5
6.1	*N. cacicola*	-	-	-	-	-	-	-	-	-	+	1
7	*Lyngbya*	-	-	-	-	1	1	1	-	-	-	3
7.1	*L. nordgardhii*	-	-	-	-	-	+	-	-	-	-	1
8	*Phormidium*	-	-	1	1	-	-	-	-	1	-	3
8.1	*P. foveolarum*	-	-	-	-	-	-	-	-	+	-	1
9	*Stigonema*	-	-	-	-	-	-	1	-	-	-	1
II	Chlorophyta	2	1	2	1	-	-	-	-	-	-	6
1	*Chlorella*	+	-	+	-	-	-	-	-	-	-	2
2	*Chlorococcum*	+	+	-	+	-	-	-	-	-	-	3
3	*Gloeocystis*	-	-	+	-	-	-	-	-	-	-	1
Total Forms per Spot		5	5	5	5	4	4	5	5	3	6	47

The genus *Anabaena* was reported from (3) samples, out of which two were identified up to species level as *Anabaena naviculoides* and *Anabaena oryzae*. *Nostoc* was also recorded from (5) samples, out of which one was identified up to species level as *Nostoc cacicola. Lyngbya*

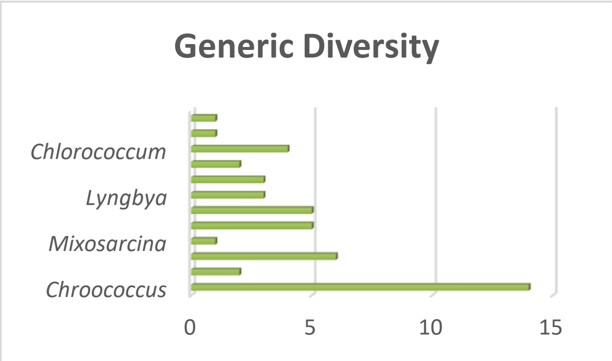

Figure 3: Generic Diversity of Culture Samples

and *Phormidium* were recorded from (3) samples each respectively, where only one *Lyngbya nordgardhii*and *Phormidium foveolarum*were identified up to species level respectively. *Gloeocapsa* was recorded from (2) samples, out of which two were identified up to species level as *Gloeocapsa punctata*and *Gloeocapsa aeruginosa*. The *Mixosarcina burmensis* and *Stigonema*were recognized from (1) sample each. Algal members belonging to Chlorophyta were recorded from (4) samples only, out of which three were identified up to the generic level as *Chlorella, Chlorococcum* and *Gloeocystis*. (Table 3 & Figure 3).The Chlorophyta members were recorded in First Day fan dust samples only as Cyanophyta members such as *Chroococcus, Merismopedia, Anabaena, Nostoc, Lyngbya* and *Phormidium* were recorded on the both first-day and tenth-days samples of fan dust (Table 3). The ceiling fan was capable of capturing such kinds of algal forms as an aero-sampler and indicating its potency (Figure 4).

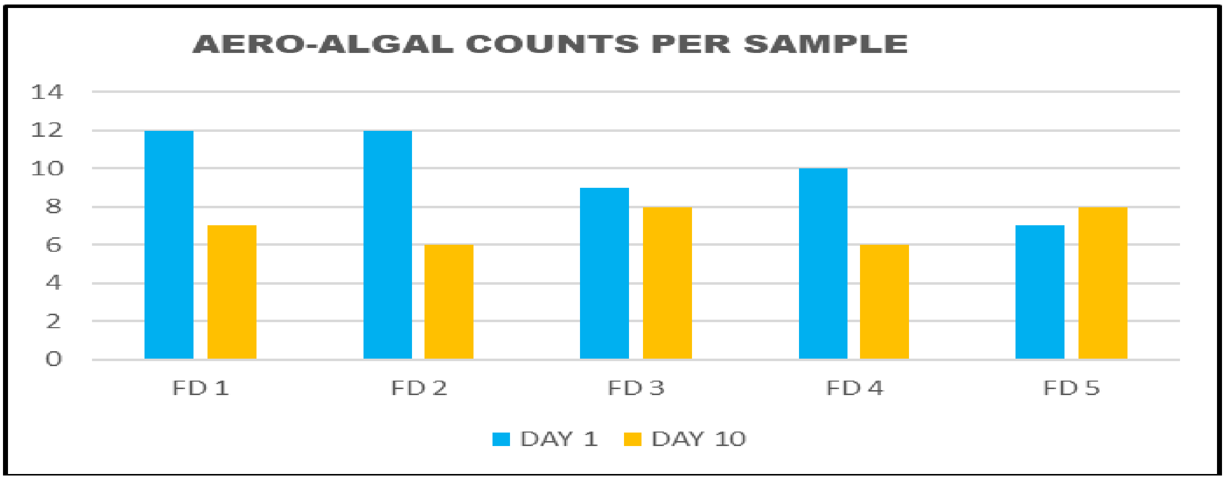

Figure 4: Comparative Account of Aero-Algal counts obtained from Day 1 & Day 10 Fan Dust sample

Collectively, 85 aero-algal forms were recorded from 10 fan dust samples collected from 3 houses and 2 shops in Mumbai and its suburbs. Total (75) Cyanophytes, (6) Chlorophytes and (4) Bacillariophytes aero-algal forms were reported respectively. Cyanophyta members were found as dominant indicating their adaptiveness toward adverse environmental conditions. They are also been considered as natural nitogen biofertilizers. (Aarti Yadav., 2019) has also recommended use of cyanophyta members as renewable nitogen source. The genera *Gloeocapsa, Nostoc, Anabaena, Lyngbya* and *Phormidium* were among the aero-algae having allergenic properties recorded during the study. The presence of such indoor allergenic aero-algal forms indicate important health hazards and require frequent monitoring and remedial preventive measures to minimized its counts.

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