Assessment of Fluctuation in Aeromycological Diversity at Different Sites in Gorakhpur District, Uttar Pradesh, India

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Abstract

The purpose of the current study's aeromycological survey was to determine the effect of temperature and relative humidity within a day on prevalence of aeromycoflora diversity in different locations in Gorakhpur district, during first week of October in 2023. For sampling, the gravity-based Petri-plate approach using Potato Dextrose Agar (PDA) medium was employed to trap fungal spores and mycelial fragments. During study a total 21 identified species belonging to 13 fungal genera were isolated excluding Mucorales, mycelia sterilia and unidentified fungi. The findings reveal that a total 1506 and 2287 fungal isolates were recovered from air sampling of study sites during morning and late afternoon respectively. The highest mycoflora occurrence frequency (%) was found in Kushmi forest both in morning (19.46%) and late afternoon (22.60%) while, lowest in morning (6.30%) and late afternoon (7.08%) was determined in Baba Raghav Das (BRD) medical college and AIIMS (All India Institute of Medical Sciences), Gorakhpur respectively. Collectively, during morning sampling, *Cladosporium* sp. exhibited highest relative density (19.85%) followed by *Aspergillus flavus* (17.13%), *Aspergillus niger* (16.73%) and *Penicillium* sp. (10.89%), whereas, both *Acremonium* sp. (0.13%) and *Colletotrichum* sp. (0.13%) having lowest relative density followed by *Alternaria atra* (0.20%), and *Alternaria longipes* (0.33%). The late afternoon sampling reveals, *Cladosporium* sp. had highest relative density (22.39%) followed by *Aspergillus niger* (17.13%), *Aspergillus flavus* (16.73%) and *Penicillium* sp. (10.89%). Among all fungal spore types, genus *Aspergillus* showed dominancy in total spore count i.e. 700 (46.48%) and 1134 (49.58%) both in morning and late afternoon respectively. The spore count in air from morning to late afternoon enhanced with increase of temperature in major mycoflora viz. *Cladosporium* sp. (299 to 512), *Aspergillus niger* (252 to 491), *Aspergillus flavus* (258 to 349) and *Penicillium* sp. (164 to 185), strengthen the effect of meteorological factors (temperature, relative humidity etc) along with anthropogenic factors on aeromycoflora diversity.

Keywords: Aeromycobiota; Meteorological Factors; Library; Forest; Temple; Fungal isolates

1. Introduction

Air is crucial component of the environment that contains many abiotic and biotic entities, mandatory for existence of life. The biotic components of air, collectively known as 'bioaerosol' are minute biological particles suspended in atmosphere playing crucial role in various ecological, environmental and health related processes (Estillore et al., 2016; Kim et al., 2018). All the major groups of microbes including viruses, bacteria, fungi etc. are present in the atmosphere (Tastassa et al., 2024). Aeromycoflora includes fungal spores and microscopic mycelial fragments, which can be dispersed through the air over long distances (Adams et al., 2013). Fungal spores constitute a major component of aerobiota (Niu et al., 2021). The sources of mycoflora in air may be natural e.g. soil, decaying organic matter, water bodies and vegetation or anthropogenic e.g. agricultural activities, waste disposal etc. (Prussin & Marr, 2015). The air temperature, precipitation, relative humidity, geographic distribution, atmospheric turbulence, wind speed,

quantity of organic matter and UVB radiation are some of the meteorological factors that affect the sporulation and dispersal of fungi (Crandall & Gilbert, 2017; Grinn-Gofroń et al., 2018; van Rhijn et al., 2021; Ajikah et al., 2023).

Airborne fungi also play a vital role in ecological balance, agriculture, and various industries. They significantly contribute to nutrient cycling by decomposing organic matter to enrich soil fertility, and supporting plant growth through mycorrhizal associations (Park et al., 2024). Many airborne fungi are essential in industrial biotechnology to produce antibiotics, enzymes, organic acids and also used in pharmaceuticals and food processing. Additionally, few aeromycobiota play a key role in biocontrol, to suppress plant pathogens by potent antagonistic activity (Madsen et al., 2007). Certain aeromycoflora are valuable in bioremediation, breaking down pollutants and toxic substances, thereby helping to clean the air and soil (Vaksmaa et al., 2023). Their ability to spread through the air ensures their widespread benefits in maintaining biodiversity but on the other hand certain airborne fungal spores can also cause respiratory allergies, infections, and crop diseases, impacting agriculture and public health.

Airborne fungi are also key indicators of atmospheric bio-pollution level (Pusz et al., 2018; Castro e Silva et al., 2020), but, their absolute consequences are still unclear. Breathing in bioaerosol having airborne microbes and their by-products, can cause respiratory diseases along with other health issues such hypersensitivity, infections, pneumonia and toxic responses (Kim et al., 2018; Durugbo et al., 2023). Currently, over 80 fungal genera have been recognized as aeroallergens linked with respiratory tract (Rick et al., 2016; Letovsky et al., 2024). Species of many aerofungi, including *Aspergillus, Alternaria, Cladosporium, Fusarium, Penicillium* etc. may induce allergic responses, sore throat, severe asthma, fatigue, headache and irritation of eye and sinus in human (Oliveira et al., 2023).

Several aeromycological studies in India are crucial due to the country's diverse climate, vegetation, environmental conditions, and geographic area which influence airborne fungal spore distribution (Vijayalakshmi et al., 2020). Seasonal changes also have great impact on it (Kochar et al., 2014). Research across various regions has identified allergenic and pathogenic fungi affecting public health, agriculture, and air quality (Pavan & Manjunath, 2014; Baxi et al., 2016). Studies in urban and rural areas reveal seasonal variations in fungal spores, with higher concentrations during monsoon and post-harvest periods (Kakde et al., 2001).

Aeromycological studies offer novel understanding about the diversity, distribution, and dynamics of airborne fungal spores, contributing to public health, agriculture, and environment. It helps to identify emerging fungal allergens, track climate change impacts, and recognize conditions for disease outbreaks. The aim of this extramural and intramural study was to get knowledge about valuable information regarding identification, concentration and diversity of aeromycoflora in both indoor and outdoor environment to understand the cumulative aeromycoflora composition in different locations of Gorakhpur city.

2. Materials and methods

2.1. Selection of study area

Gorakhpur is a district in Uttar Pradesh, India, located at approximately 26.76°N latitude and 83.37°E longitude near Indo-Nepal border. It lies in subtropical region of country, characterized by hot summers (25°C–40°C), heavy monsoon rains (July–September), and cool winters (5°C–20°C) with frequent fog. The total eight study sites viz. Central library (CL), Deen Dayal Upadhyaya Gorakhpur University (DDUGU); Baba Raghav Das (BRD), medical college; All India Institute of Medical Sciences (AIIMS); Gorakhnath temple (GT); Botanical Garden (BG), DDUGU; Fertilizer factory (FF); Kushmi forest (KF) and Ramgarh tal/Nauka Vihar (RT/NV) in Gorakhpur district have been selected based on crowd mobility throughout day. CL, BRD, AIIMS and GT were selected to study indoor mycoflora from their central hall, outpatient department (OPD), OPD and outer hall respectively. The rest four sites i.e. BG, FF, KF and RT/NV were chosen to study outdoor mycoflora from their medicinal garden, urea loading area, forest and bank of RT/NV respectively.

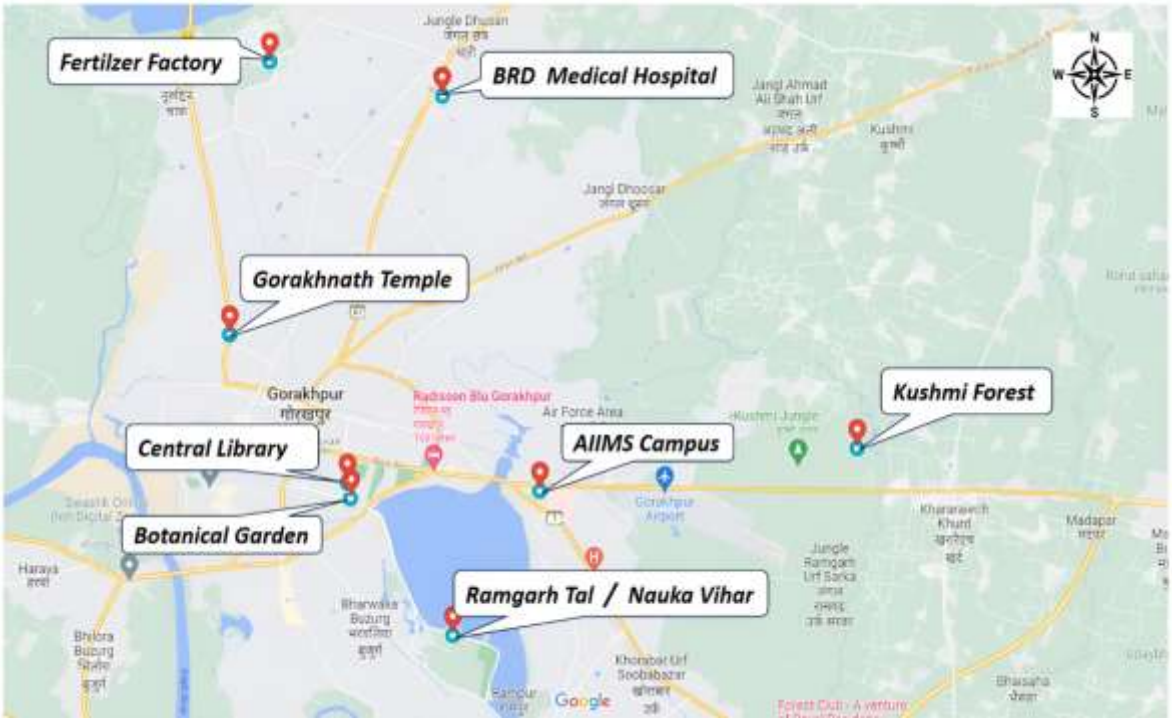

Fig. 1 Study sites in Gorakhpur district for aeromycobiota analysis

2.2. Determination of temperature and relative humidity of air

The temperature and relative humidity (RH) of study sites have been determined at the time of sampling by digital temperature and humidity meter (HTC HD-303) in morning (10-11 am) and late afternoon (4-5 pm).

2.3. Collection of air samples

Air samples were collected in the first week of October, 2023 on five different dates i.e. 02nd, 03rd, 05th, 06th and 7th October. During sampling, pre-poured Petri dishes with sterilized potato dextrose agar (PDA) medium prepared in 0.5% saline solution (to suppress Mucorales members) were exposed in air for 15 min. at study sites to trap the aeromycobiota. The samples were collected both in morning (10-11 am) and late afternoon (4-5 pm) by open plate technique (Menghare & Kayarkar, 2023). Ten poured Petri dishes were used to collect air samples in morning and late afternoon for each study sites separately. The inoculated Petri dishes with air samples were incubated (27±2°C) for seven days (Ghosh et al., 2011).

2.4. Identification of fungal species

The cultural and morphological characteristics of recovered fungal colonies were determined by their macroscopic and microscopic observations. The micro and macro morphology, as well as the surface and reverse colony colors on PDA media, were used to identify the fungal species (Ghosh et al., 2011). For microscopic study, fungi were stained and mounted in lactophenol cotton blue mixture. The fungi were identified up to genus and species level using manuals of fungi (Moubasher, 1993; Gilman, 2008; Mukerji & Manoharachary, 2010). The identified fungal colonies were purified and preserved on PDA slant at 4±2ºC.

2.5. Statistical analysis

Temperature and relative humidity measurements were recorded five times, and the results are shown as mean±SE. The percent relative density and percent occurrence frequency was calculated as follows –

$$\text{Relative density (\%)} = \frac{\text{Number of isolates of a species}}{\text{Total no.of isolates of all species}} \times 100$$

$$\text{Occurrence frequency (\%)} = \frac{\text{Total number of isolates at one study site}}{\text{Total no.of isolates of all study sites}} \times 100$$

A one-way ANOVA was performed on the collected data of temperature and relative humidity. Tukey's multiple range tests were used to separate the means when the ANOVA was significant ($p < 0.05$). Statistical software (SPSS 16.0; IBM, NY, USA) was used for data analysis.

3. Results

In the present study, average temperature and relative humidity of five different days i.e. 02nd, 03rd, 05th, 06th and 7th October, 2023 at eight different study sites (Fig. 1) were recorded both in morning (10-11 am) and late afternoon (4-5 pm). The lowest (21.68ºC) and highest (24.90ºC) average temperature in morning was recorded in KF and FF respectively. Whereas, in late afternoon, lowest (25.88ºC) and highest (29.52ºC) average temperature was found in KF and RT/NV respectively (Table 1). Similarly, lowest (54.76%) and highest (65.18%) mean relative humidity in morning was recorded in BRD and BG respectively. Whereas, in late afternoon, lowest (56.18%) and highest (70.08%) average relative humidity was found in BRD and KF respectively (Table 1).

Table 1: Temperature and relative humidity of selected study sites

S.No.	Study Sites		Coordinates	Temperature (ºC)		RH (%)	
				Morning (10-11 am)	Late afternoon (4-5 pm)	Morning (10-11 am)	Late afternoon (4-5 pm)
1.	Indoor	Central library, DDUGU	26°44'54.7"N 83°22'52.8"E	24.04±0.09^{bc}	27.72±0.12^{c}	64.00±0.12^{e}	66.14±0.12^{d}
2.		BRD Medical College	26°48'44.3"N 83°23'59.2"E	24.58±0.16^{cd}	28.98±0.06^{e}	54.76±0.17^{a}	56.18±0.09^{a}
3.		AIIMS, Gorakhpur	26°44'49.9"N 83°25'07.3"E	23.44±0.14^{b}	27.06±0.07^{b}	60.28±0.20^{c}	62.02±0.13^{b}
4.		Gorakhnath Temple	26°46'22.7"N 83°21'30.4"E	24.40±0.12^{cd}	28.88±0.09^{e}	62.62±0.12^{d}	64.48±0.13^{c}
5.	Outdoor	Botanical Garden, DDUGU	26°44'45.3"N 83°22'55.0"E	23.60±0.18^{b}	28.26±0.12^{d}	65.18±0.14^{f}	68.54±0.18^{e}
6.		Fertilizer Factory	26°49'04.8"N 83°21'58.3"E	24.90±0.16^{d}	28.32±0.11^{d}	58.82±0.09^{b}	62.14±0.14^{b}
7.		Kushmi Forest	26°45'15.2"N 83°28'48.8"E	21.68±0.12^{a}	25.88±0.09^{a}	64.96±0.19^{f}	70.08±0.27^{f}
8.		Ramgarh Tal	26°43'23.9"N 83°24'06.3"E	23.98±0.11^{bc}	29.52±0.04^{f}	62.90±0.15^{d}	64.40±0.07^{c}

Values are mean (n = 5) ± SE; $P < 0.05$. The means followed by same letter in the same column are not significantly different according to One-Way ANOVA and Tukey's multiple comparison tests

A total of 21 identified species belonging to 13 fungal genera were isolated excluding Mucorales, mycelia sterilia and unidentified fungi. The findings reveals that a total of 1506 and 2287 fungal colonies were recovered from air sampling of study sites during morning and late afternoon respectively (Table 2 & 3). The highest mycoflora occurrence frequency (%) was found in KF both in morning (19.46%) and late afternoon (22.60%) while, lowest in morning (6.30%) and late afternoon (7.08%) was determined in BRD and AIIMS (Table 2 & 3, Fig. 2). Collectively, during morning sampling, *Cladosporium* sp. exhibited highest relative density (19.85%) followed by *Aspergillus flavus* (17.13%), *Aspergillus niger* (16.73%) and *Penicillium* sp. (10.89%), whereas, both *Acremonium* sp. and *Colletotrichum* sp. (0.13%) having lowest relative density followed by *Alternaria atra* (0.20%), and *Alternaria longipes* (0.33%) (Table 2, Fig. 3). The late afternoon sampling reveals, *Cladosporium* sp. had highest relative density (22.39%)

followed by *Aspergillus. niger* (21.47%), *Aspergillus. flavus* (15.26%), *Aspergillus. fumigates* (9.49%) and *Penicillium* sp. (8.09%), whereas, *Colletotrichum* sp. (0.35%) having lowest relative density followed by *Alternaria longipes* (0.39%), *Acremonium* sp. (0.44%), *Rhizoctonia* sp. (0.48%) and *Alternaria atra* (0.52%) (Table 3, Fig. 3).

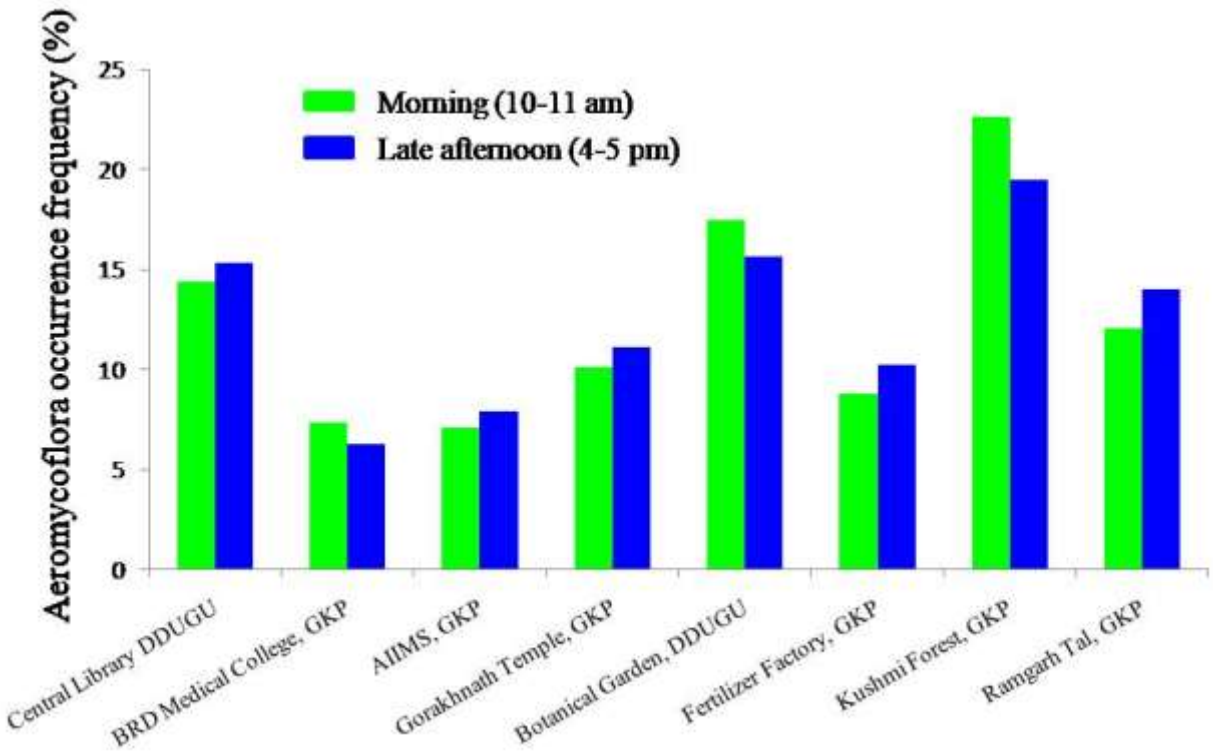

Fig. 2: Occurrence frequency (%) of aeromycobiota at different study sites

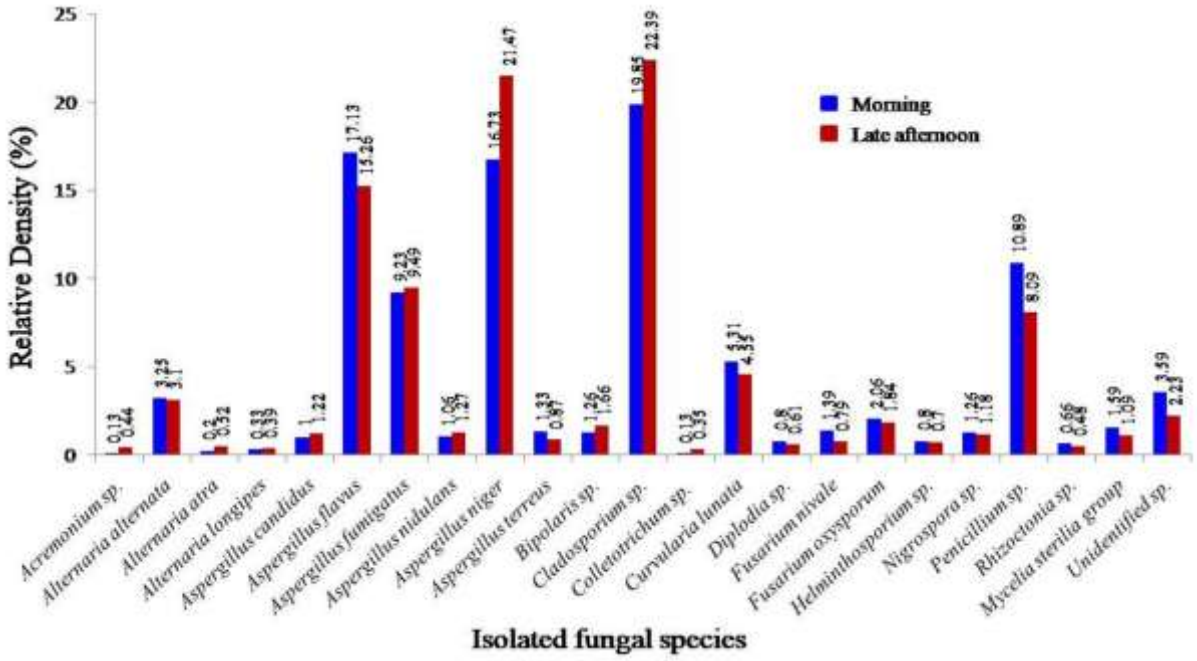

Fig. 3: Cumulative relative densities (%) of isolated aeromycobiota from different study sites

Table 2: Aeromycobiota diversity in morning (10-11 am) at different experimental sites in Gorakhpur (GKP)

Fungal Species	Total number of fungal isolates								Total Isolates	Relative Density (%)
	Indoor Sites				Outdoor Sites					
	Central Library DDUGU	BRD Medical College, GKP	AIIMS, GKP	Gorakhnath Temple, GKP	Botanical Garden, DDUGU	Fertilizer Factory, GKP	Kushmi Forest, GKP	Ramgarh Tal, GKP		
Acremonium sp.	-	-	-	-	-	-	02	-	**02**	**0.13**
Alternaria alternata	08	03	03	05	07	05	14	04	**49**	**3.25**
Alternaria atra	-	-	-	-	-	-	03	-	**03**	**0.20**
Alternaria longipes	-	-	-	-	-	-	05	-	**05**	**0.33**
Aspergillus candidus	05	-	-	-	03	-	03	04	**15**	**1.00**
Aspergillus flavus	31	17	22	33	37	41	43	34	**258**	**17.13**
Aspergillus fumigatus	22	08	11	13	29	12	19	25	**139**	**9.23**
Aspergillus nidulans	07	-	-	-	05	-	-	04	**16**	**1.06**
Aspergillus niger	43	21	26	29	32	31	37	33	**252**	**16.73**
Aspergillus terreus	07	-	-	-	05	-	06	02	**20**	**1.33**
Bipolaris sp.	04	-	-	-	03	-	12	-	**19**	**1.26**
Cladosporium sp.	48	23	29	40	39	32	51	37	**299**	**19.85**
Colletotrichum sp.	-	-	-	-	-	-	02	-	**02**	**0.13**
Curvularia lunata	09	05	06	07	14	12	14	13	**80**	**5.31**
Diplodia sp.	-	-	-	-	02	-	08	02	**12**	**0.80**
Fusarium nivale	-	02	-	04	04	-	06	05	**21**	**1.39**
Fusarium oxysporum	08	-	02	04	06	02	05	04	**31**	**2.06**
Helminthosporium sp.	-	-	-	-	02	-	07	03	**12**	**0.80**
Nigrospora sp.	04	-	-	-	05	-	07	03	**19**	**1.26**
Penicillium sp.	24	10	13	23	31	11	28	24	**164**	**10.89**
Rhizoctonia sp.	02	-	-	-	02	-	04	02	**10**	**0.66**
Mycelia sterilia group	03	02	-	03	03	03	06	04	**24**	**1.59**
Unidentified sp.	06	04	07	06	07	05	11	08	**54**	**3.59**
Mucorales* (No. of Genera)	04*	03*	03*	02*	04*	03*	04*	04*	-	-
Total Isolates	231	95	119	167	236	154	293	211	**1506**	
Frequency of Occurrence (%)	**15.34**	**6.30**	**7.90**	**11.09**	**15.67**	**10.23**	**19.46**	**14.01**		

Mucorales* including *Rhizopus* sp., *Mucor* sp., *Mortierella* sp., *Circinella* sp. and *Absidia corymbifera* were recovered but not included among the total isolates.

Table 3: Aeromycobiota diversity in late afternoon (4-5 pm) at different experimental sites in Gorakhpur (GKP)

Fungal Species	Total number of fungal isolates								Total Isolates	Relative Density (%)
	Indoor Sites				Outdoor Sites					
	Central Library DDUGU	BRD Medical College, GKP	AIIMS, GKP	Gorakhnath Temple, GKP	Botanical Garden, DDUGU	Fertilizer Factory, GKP	Kushmi Forest, GKP	Ramgarh Tal, GKP		
Acremonium sp.	02	-	-	-	01	-	07	-	**10**	**0.44**
Alternaria alternata	13	06	04	03	09	07	21	08	**71**	**3.10**
Alternaria atra	-	-	-	-	-	-	12	-	**12**	**0.52**
Alternaria longipes	-	-	-	-	02	-	05	02	**09**	**0.39**
Aspergillus candidus	08	-	-	02	05	03	04	06	**28**	**1.22**
Aspergillus flavus	49	23	28	42	57	39	65	46	**349**	**15.26**
Aspergillus fumigatus	32	13	14	28	45	19	39	27	**217**	**9.49**
Aspergillus nidulans	06	-	02	-	09	-	07	05	**29**	**1.27**
Aspergillus niger	69	51	39	58	82	42	96	54	**491**	**21.47**
Aspergillus terreus	04	-	-	-	03	02	08	03	**20**	**0.87**
Bipolaris sp.	04	-	-	02	04	-	25	03	**38**	**1.66**
Cladosporium sp.	72	51	47	56	78	64	86	58	**512**	**22.39**
Colletotrichum sp.	-	-	-	-	-	-	08	-	**08**	**0.35**
Curvularia lunata	14	07	05	13	17	09	27	12	**104**	**4.55**
Diplodia sp.	-	-	-	-	03	-	08	03	**14**	**0.61**
Fusarium nivale	02	-	-	02	04	-	07	03	**18**	**0.79**
Fusarium oxysporum	07	-	02	03	09	03	11	07	**42**	**1.84**
Helminthosporium sp.	-	-	-	-	05	-	09	02	**16**	**0.70**
Nigrospora sp.	06	02	-	-	11	-	05	03	**27**	**1.18**
Penicillium sp.	31	11	16	19	38	08	41	21	**185**	**8.09**
Rhizoctonia sp.	02	-	-	-	02	-	05	02	**11**	**0.48**
Mycelia sterilia group	03	02	02	02	04	03	07	02	**25**	**1.09**
Unidentified sp.	08	02	03	02	11	02	14	09	**51**	**2.23**
Mucorales* (No. of Genera)	04*	03*	03*	02*	05*	03*	05*	04*	-	-
Total Isolates	**332**	**168**	**162**	**232**	**399**	**201**	**517**	**276**	**2287**	
Frequency of Occurrence (%)	**14.52**	**7.35**	**7.08**	**10.14**	**17.45**	**8.79**	**22.60**	**12.07**		

Mucorales* including *Rhizopus* sp., *Mucor* sp., *Mortierella* sp., *Circinella* sp. and *Absidia corymbifera* were recovered but not included among the total isolates.

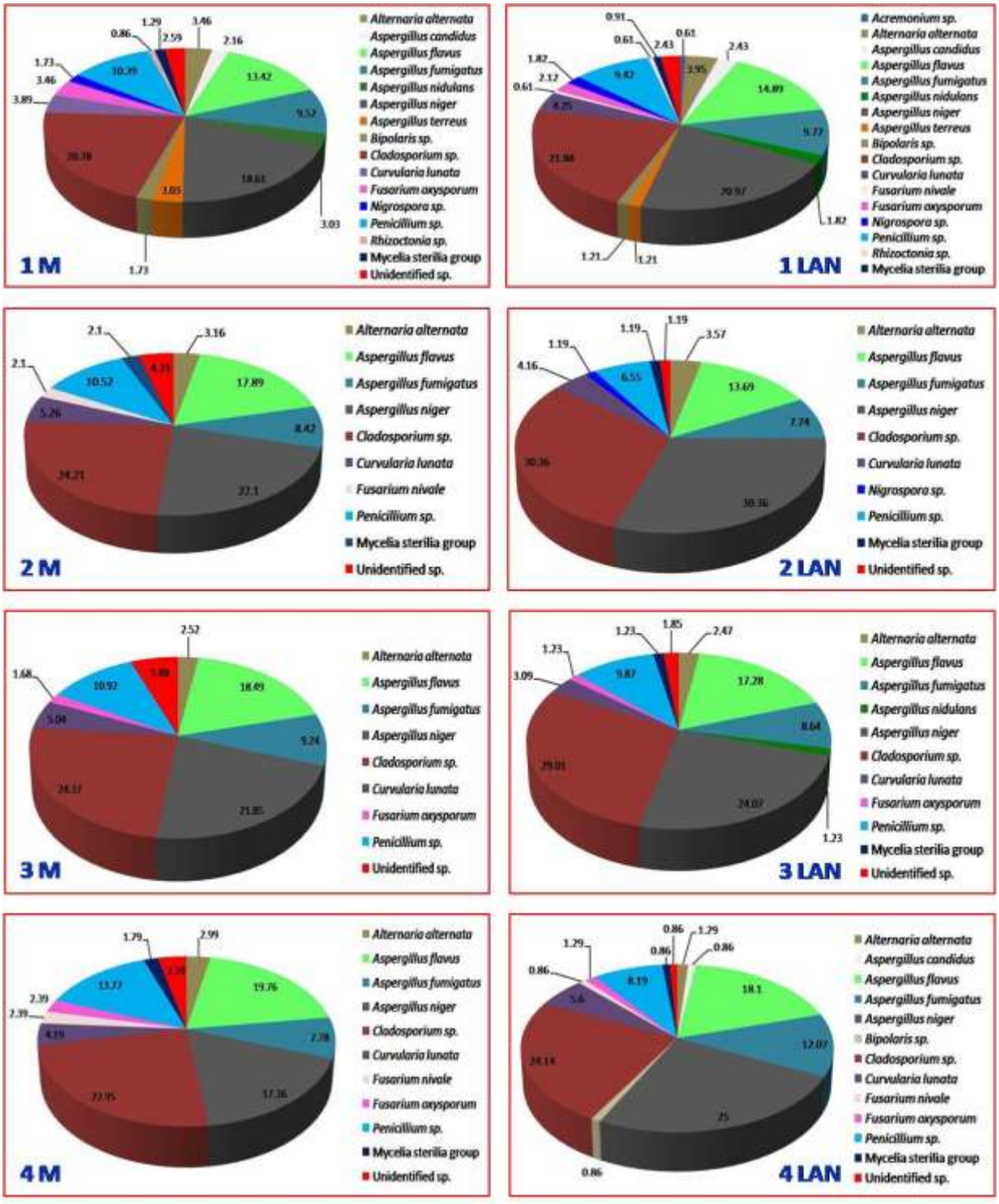

Fig. 4a: Relative densities (%) of isolated aeromycobiota from individual indoor study sites

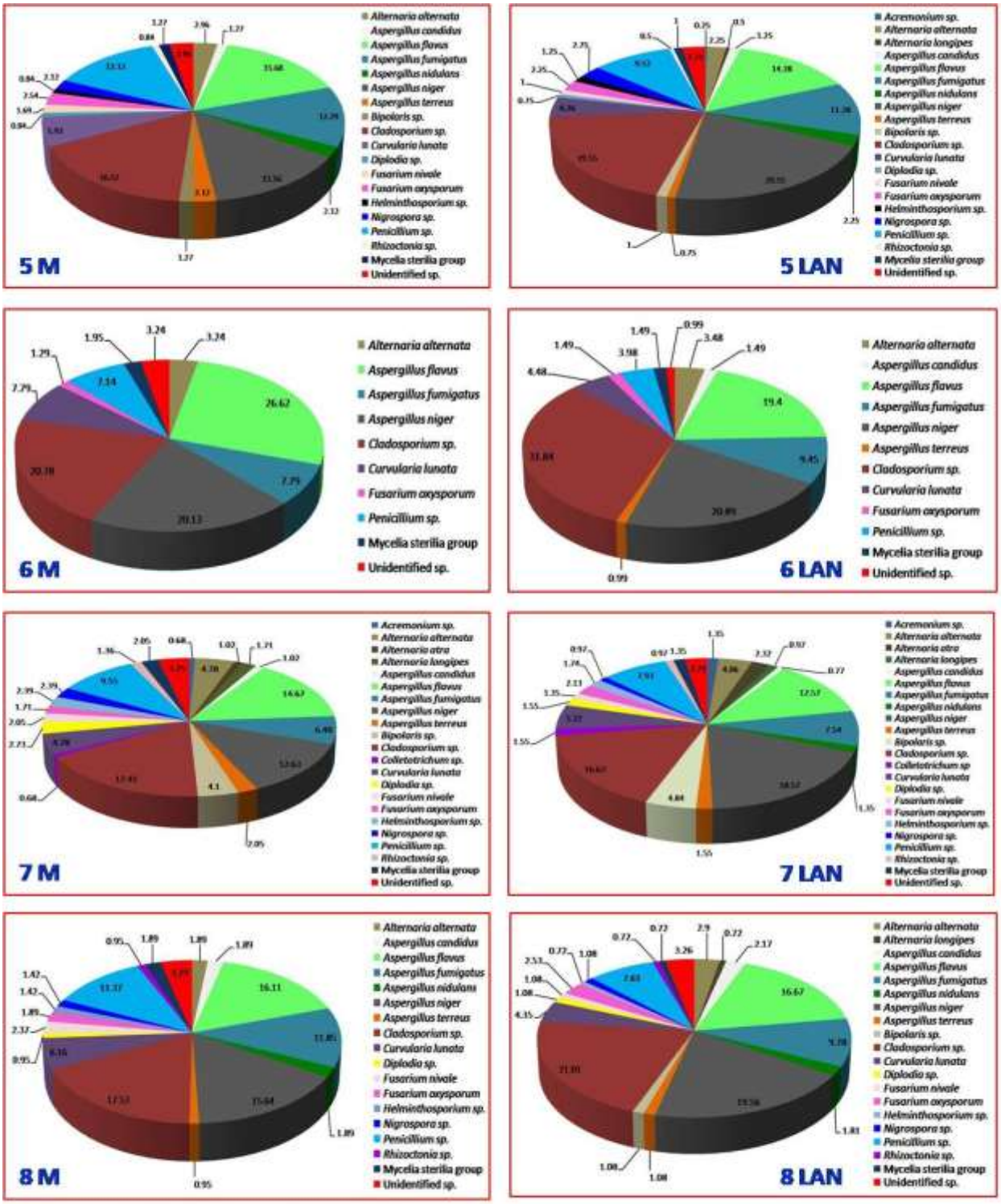

Fig. 4b: Relative densities (%) of isolated aeromycobiota from individual outdoor study sites

Individually, in morning least aeromycological diversity (08 identified species) was found in both BRD and AIIMS, whereas, highest species diversity was recorded in KF (20 species) followed by BG (17 species). Similarly, in late afternoon, BRD exhibited least species diversity (08 species) followed by AIIMS (09 species) while, highest species diversity was again recorded in KF (21 species) followed by BG (19 species) (Table 1, 2; Fig. 4a, 4b). The distribution of aeromycoflora was found heterogeneous during study in CL, BG, KF and RT/NV. But other study sites were dominated by only few aeromycobiota. *A. niger*, *Cladosporium* sp. and

A. flavus occupied 74.41% of total aeromycoflora of BRD, similarly, 70.36 % aeromycoflora by *Cladosporium* sp., *A. niger* and *A. flavus* in AIIMS, 67.24 % by *A. niger*, *Cladosporium* sp. and *A. flavus* in GT, and 72.13 % by *Cladosporium* sp., *A. niger* and *A. flavus* in FF (Fig. 4a, 4b). The aeromycoflora at different study sites of Gorakhpur district was found dominated by *Aspergillus niger, Cladosporium* sp. and *Aspergillus flavus*.

4. Discussion

Several literatures on aeromycoflora and their connection to associated environment have been published worldwide (Ianovici & Tudorica, 2009; Ababutain, 2013; Upadhyay et al., 2018; Karmakar et al., 2020). However, literature on aeromycoflora diversity in relation to their environment in Gorakhpur is still silent. The purpose of our study was to obtain the exact information about the fungal occurrences in air in relation to temperature and relative humidity fluctuation along with human disturbance in selected worthy sites.

In this investigation, total eight study sites were selected on the basis of their variable environment, location in Gorakhpur district and human disturbance. A modified gravitational plate method with movement at study sites was used to capture more aeromycoflora in lesser time. The overall lower number (1506) of fungal isolates in the morning in comparison to the late afternoon (2287) may be due to significant increase in temperature (Manikpuri et al., 2018), which possibly influence air velocity, bringing fungal spores along with it. Among study sites, the higher percent occurrence frequency in morning (19.46%) and late afternoon (22.60%) in KF supports the findings of earlier workers (Kunjam & Jadhav, 2020; Wagner et al., 2022; Ali et al., 2024), where forest soil, decomposing materials and phyllosphere fungi contributed in aeromycoflora diversity and lacking such conditions along with cleaning and sanitation processes, BRD and AIIMS exhibited least percent occurrence frequencies of aeromycoflora.

With significant raise in mean temperature and relative humidity from morning to late afternoon showed an increase in number of all fungal isolates from morning to late afternoon except *Colletotrichum* sp. and *Fusarium nivale*. The finding exhibited a direct correlation between increase in temperature and humidity with increase in number of fungal isolates (Crandall & Gilbert, 2017; Ajikah et al., 2023). Some aspergilli i.e. *Aspergillus niger, Aspergillus flavus, Aspergillus fumigates* along with *Cladosporium* sp. and *Penicillium* sp. were dominated in all samples in Gorakhpur due to their thermotolerance, rapid spore dispersal, and ability to thrive in diverse organic substrates. Their small lightweight conidia (spores), easily get dispersed by wind, ensuring their widespread presence in such climates. High humidity promotes their germination and growth on decaying plant material, soil, and indoor as well as outdoor surfaces, whereas warm environment enhance their sporulation and dissemination (Chiranjeevi et al., 2012; Crandall & Gilbert, 2017; Ajikah et al., 2023).

The total number of aeromycoflora isolates in indoor sites in morning (612) and late afternoon (794) was lesser than outdoor sites in morning (894) and late afternoon (1393). Such significant variation in indoor and outdoor aeromycoflora may occur due to differences in environmental conditions, sources of fungal spores, and human influence. Indoor aeromycoflora is primarily influenced by factors such as humidity, ventilation, building materials, and human activity. Whereas, outdoor aeromycoflora are influenced by temperature, humidity, soil disturbance, wind velocity and several anthropogenic factors (Ajikah et al., 2023). Seasonal fluctuations significantly affect outdoor aeromycoflora diversity, with higher concentrations in warm and humid conditions (Kakde et al., 2001).

Except KF and BG human hustle-bustle increased with passing time on rest of the other study sites. Along with other factors, human hustle-bustle also influence aeromycoflora population especially in indoor places i.e. CL, BRD, AIIMS and GT, outdoor mycoflora of settled dust may brought inside (Hicks et al., 2005). Most of the materials in the old libraries i.e. several literatures including books, journals, magazines, newspapers, wooden racks etc. are cellulosic and favors the growth of *Aspergillus* and other cellulolytic fungi (Díaz et al., 2020; Camargo Caicedo et al., 2023; Kujović et al., 2024), which could adversely affect student's health throughout the world (Valeriani et al., 2017). Aeromycoflora recovered from GT, FF and RT/NV was influenced by meteorological factors especially temperature, relative humidity and wind speed along with anthropogenic factors which influence aeromycoflora

diversity by affecting fungal growth, sporulation, and airborne spore dispersal. High humidity and warm temperatures promote fungal proliferation, while wind aids in the transportation of spores across regions. Pollution, agricultural activities, and construction activities also influence aeromycoflora diversity by modifying habitat conditions (Grinn-Gofroń et al., 2015; van Rhijn et al., 2021).

Several aerobiological evaluations have identified the presence of airborne fungi in indoor environments as one of the major health challenges experiencing India and other countries (Khan & Karuppayil, 2012; Singh & Mathur, 2012). However, earlier studies showed that fungus concentrations and the severity of the sickness in respiratory diseases, allergies, and infections especially in immunosensitive individuals were positively correlated (Rick et al., 2020). Through their interactions with internal human organs like as the lung, they raise the risk of respiratory disorders (Rick et al., 2020; Tiew et al., 2021; Palmieri et al., 2022). Additionally, airborne fungi also contribute to biodeterioration of various surfaces, artworks, and food products, leading to structural damage, along with allergies and mycotoxicosis in humans. Biomonitoring of airborne microfungal spores is a key to unlocking the information about sensitivity to bioaerosol in the environment of different locations, and our findings may be helpful in diagnosis and preventive measures of allergic illnesses caused by aeromycoflora.

5. Conclusion

The present study on the fluctuation of aeromycological diversity across different sites in Gorakhpur district, Uttar Pradesh, highlights the dynamic nature of airborne fungal populations influenced by temperature, humidity and human disturbance. Our analysis revealed a remarkable occurrence of several aeromycoflora with certain genera exhibiting higher prevalence in all the study sites including indoor and outdoor spaces. Some of them are well known as pathogens of plants and allergens to human, emphasizes the potential health risks associated with airborne fungal allergens and opportunistic pathogens. Many isolated fungal species are harmful and could cause respiratory disorders like asthma in visitors to libraries, temples, hospitals and other places. Therefore, suitable safeguards by identification and monitoring of aeromycoflora diversity is essential for assessing air quality, mitigating health hazards, and developing effective fungal control strategies.

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Conflict of interest

The authors declare that they do not have any conflict of interest in this study.

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