Original Research Article
ISSN: **3041-5357**
Journal homepage: https://diversity.researchfloor.org/

Journal of Diversity Studies

Intramural Aeromycological Study of Two Places of Desaiganj Wadsa, District Gadchiroli Maharastra of India

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ABSTRACT

The present study was conducted to investigate the indoor aeromycoflora of Maharashtra State Warehouse and A A Energy Ltd. factory of Desaiganj Wadsa located in Gadchiroli district of Maharashtra state. Aeromycoflora sampling was carried out for two years, from February, 2023 to January, 2025 at an interval of 15 days. Samples were collected from different sections of both sites such as, Return Area, Storage Section and Farmers Section of Warehouse and Visit room, DM plant and Generator room of A A Energy Ltd factory. Air sampling was done by two methods, the Exposure petriplate method and Hi Air Sampler (Mark II) manufactured by Hi Media Laboratories, India. In the exposure petriplate method Czapek's Dox Agar (CDA) was used as the culture medium, while Rose Bengal strips were used in the Hi Air Sampler. A total of 3235 fungal colonies in Warehouse and total 2919 colonies in A A Energy factory recorded by using the exposure petriplate method, whereas 17315 CFUs/m^3 in Warehouse and 15800 CFUs/m^3 in A A Energy factory was trapped using the Hi Air Sampler method. The concentration of aeromycoflora was observed to be highest during the rainy season due to increased humidity and lower temperature while lowest during summer season. Fungal spores exhibited monthly and seasonal variation. In the month of July and August fungal concentration was high and in month of May fungal concentration was low. The growth of fungi directly proportional to the Humidity and inversely proportional to temperature. The genera like Aspergillus, Alternaria, Cladosporium, Penicillium, Fusarium, Mucor, and Rhizopus were reported in both the sites.

Keywords: *Indoor Aeromycoflora, Warehouse, Energy factory, Hi Media Air Sampler, Desaiganj Wadsa, Concentration.*

Citation: Dhanshri R. Bangalkar, Shankar G. Kukreja, and Arvind J. Mungole [2026]. Intramural Aeromycological Study of Two Places of Desaiganj Wadsa, District Gadchiroli Maharastra of India. *Journal of Diversity Studies.*
DOI: https://doi.org/10.51470/JOD.2026.5.1.115

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Article History: *Received 10 December 2025 | Revised 07 January 2026 | Accepted 10 February 2026 | Available Online March 09, 2026*

INTRODUCTION

Aerobiology is the study of movement, passive transport, dispersion and deposition of material and particles of biological origin (endotoxins, mycotoxins, cells and spores of bacteria, fungal spores, aerosols, algal filaments, protozoan cysts, pollen), as well as airborne microorganisms, such as fungi, bacteria, viruses and mites, released in the atmosphere both outdoors and indoors, and potentially dangerous to animal, plants and human systems [1–6]. Aeromycology is a subfield of aerobiology that investigates the dispersion of fungal spores and other fungal elements in both indoor and outdoor air. It studies the variations in their concentrations and the factors influencing these changes [7, 8]. Fungi are able to grow on almost all natural and synthetic materials, especially if they are hygroscopic or wet. Inorganic materials get frequently colonized as they absorb dust and serve as good growth substrates for Aspergillus fumigates and Aspergillus versicolor [9, 10, 11]. The distribution of these fungal spores with respect to their number and type in the environment vary with time of the day, weather, and also differs from place to place attributed to variation in weather conditions from season to season remarkably because of seasonal fluctuations and diversity of vegetation [12, 13].

Maharashtra state warehouse of Desaiganj Wadsa which is selected for this study located near Police station of Desaiganj wadsa and spread in 5 acers. It provides facility to stored agriculture product such as paddy, rice, wheat, grain. Peoples around the city of Desaiganj stored grain, paddy in the warehouse. Indoor environment of Warehouse is rich in organic dust and stored material which make potential hotpots for fungal growth and that can affect health of people and stored commodities.

A Energy Ltd. factory which is another site selected for the indoor aeromycological study because of it is a biomass power generation plant that uses agricultural residues such as rice husk as fuel. During the storage, handling, and combustion of such organic materials, large quantities of dust get released into the indoor environment. These conditions provide a suitable site to study indoor air quality, fungal spore growth, concentration and their possible impact on workers' health and the surrounding environment. Coal is other raw material of the plant and coal trap the moisture, organic debris which is the micronutrients for the fungi.

The present study was conducted to investigate the intramural aeromycoflora of the Maharashtra State Warehouse and A A Energy Ltd., both located in Desaiganj Wadsa, Gadchiroli District. Gadchiroli District experiences a tropical climate characterized by high humidity, particularly during the rainy season. Such environmental conditions favour the growth and spread of fungi. Therefore, this location is ideal for studying the concentration and proliferation of airborne fungal spores. The aim of the present study is to determine the intramural aeromycoflora, their concentration, and seasonal variation in the indoor environment. Intramural aeromycoflora refers to the study of fungi present in indoor environments. Many fungal species are responsible for the biodeterioration of stored materials and equipment, and they may also adversely affect human health [14].

Materials and Methods

l. Study area – The Maharashtra State Warehouse (Lat. 20.6170690, Long. 79.965540) and A A Energy Ltd. factory (Lat. 20.6024020, Long. 79.960884) were selected as sampling sites for the present study. Within the Maharashtra State Warehouse, samples were collected from the Godown 1, Godown 2 and Godown 3. In A A Energy Ltd., sampling was conducted in the Visit Room, D.M. Plant, and Generator Room. Air samples were collected over a two-year period, from February 2023 to January 2025. For the present study following methodology were applied.

ll. Exposure Petri plate method - Czapek's Dox Agar (CDA) was used in Petri plate method. This media prepared by using 12.24 gm of Czapek's Dox Agar (CDA) suspended in 250ml distilled water with streptomycin. Heat to boiling to dissolved media completely. Sterilized by autoclave for 15min. and cool down. Mix well and poured into Petri plates. Petri plates containing sterilized CDA were exposed in the Warehouse and Energy source factory in three different sections for 5 to 10 min. by keeping them at the height of five feet from the ground level. After that petri plates were sealed with cello tape and brought into laboratory. Petri plates incubated at room temperature for 3 to 8 days [15].

lll. Hi-media Air Sampler Method – In this method Rose Bengal strips were used in Hi Air Sampler (Mark ll), Hi Media Laboratories, India. Hi air sampler was moving in different sections of warehouse and Energy source factory for 5 to 10 min. After that Rose Bengal strips sealed, marked and brought into laboratory and incubated at room temperature [16].

After 6 to 8 days fungal colonies were appeared on petri plates and rose Bengal strips. Number of colonies were counted. Fungus from the colony was picked up with needle and slide was prepared by using cotton blue and observed under microscope. The identification of spores caught was based on i. microscopic character, ii. Morphological character, iii. Rate of growth, colony colour, size and shape of colony and other diagnostic feature of the spores.

In Hi air sampler method, the fungal colonies per unit volume of the air were then calculated as under, [17].

$$CFUs/m3 = \frac{\text{colonies on agar strips } \times 25}{sampling\ time\ in\ minutes}$$

The meteorological data was collected from District Agromet Unit of Krishi Vigyan Kendra Sonapur Gadchiroli. The District Agromet Unit (DAMU) for Gadchiroli is located at the Krishi Vigyan Kendra (KVK) Sonapur. This unit is a part of the Indian Council of Agriculture Research (ICAR) network through Dr. Panjabrao Deshmukh Krishi Vidyapeeth, Akola and works in collaboration with the India Meteorological Department (IMD) to provide weather-based advisories to farmers.

Result and Discussion

Maharashtra State Warehouse

Intramural aeromycological study in Maharashtra State Warehouse Desaiganj Wadsa district Gadchiroli of Maharashtra state was conducted from Feb. 2023 to Jan. 2025. For this study three sections of Warehouse were selected and air samples were collected for two years at an interval of 15 days. In Warehouse a total 3235 fungal colonies were recorded in two years by exposure petri plate method (Table 1 & 2). Hi Media Air Sampler method recorded total 17315 CFUs/m3 in two years of sampling at Warehouse (Table 3 & 4).

In Warehouse, Seasonal variation showed more concentration of fungal spore in rainy season (41 to 44%) followed by winter season (33 to 35%) and minimum in summer season (21 to 23 %) by both the methods (Table 1, 2, 3 & 4) [18]. Exposure Petri plate method and Hi Air sampler method revealed the Monthly variation and recorded maximum fungal concentration in month of July and August was 12 to 14% followed by September, December, October, January, February, June, November, March, April, and minimum in month of May was 3 to 4% [19]. Out of three sections of Warehouse, godown 1 section recorded more concentration of fungal spores, followed by godown 2 and minimum in godown 3section by both the methods.

A A Energy Ltd.

An intramural aeromycological study was conducted in A A Energy Ltd. at Desaiganj Wadsa, District Gadchiroli, Maharashtra, from February 2023 to January 2025. Three sections of the Energy source were selected for the study, and air samples were collected at 15 days intervals over a period of two years using exposure petriplate method and Hi air sampler method. During the entire study period, a total of 2919 fungal colonies were recorded by exposure petri plate method from the energy source environment (Table 5 and 6) and Using the Hi Air Sampler method, a total of 15,800 CFU/m^3 were recorded during the two-years sampling period (Table 7 & 8).

Seasonal variation revealed that the highest fungal spore concentration occurred during the rainy season (42–45%), followed by the winter season (31–35%), while the lowest concentration was observed during the summer season. Monthly variation in fungal concentration showed fluctuations throughout the year. The maximum concentration was recorded in the months of August and July (11–14%), followed by September, December, January, October, February, March, June, November, and April, whereas the minimum concentration was observed in the month of May (3 to 4 %) by both methods (Table 5, 6, 7 & 8), [20]. Among the three sections of the Energy source, the Visit room recorded the highest concentration of fungal spores, followed by the DM Plant, while the Generator room showed the minimum concentration by both sampling methods. In the study period from February 2023 to January 2025, there was a higher rainfall recorded in month of July and also high humidity in month of July and August. Temperature was maximum in month of May (Fig. 1 and 2).

Maharashtra State warehouse
Exposure Petriplate Method

Table 1: Total number of fungal colonies recorded in three different sections of Maharashtra State Warehouse in different months of investigation. (Feb. 2023-Jan. 2024)

Season	Month	Number of Colonies					
		Godown 1	Godown 2	Godown 3	Total Fortnightly	Total Monthly	%
Summer	February 2023	24	21	20	65	118	7.42
		20	17	16	53		
	March 2023	17	15	14	46	85	5.32
		15	12	12	39		
	April 2023	15	13	12	40	76	4.77
		14	11	11	36		
	May 2023	11	9	7	27	52	3.27
		10	8	7	25		
Total						331 (20.81%)	
Rainy	June 2023	21	18	18	57	126	7.92
		25	23	21	69		
	July 2023	36	33	32	101	213	13.39
		40	37	35	112		
	August 2023	38	35	32	105	200	12.57
		35	30	30	95		
	September 2023	32	28	27	87	170	10.69
		30	27	26	83		
Total						709 (44.59%)	
Winter	October 2023	27	25	23	75	146	9.18
		25	24	22	71		
	November 2023	22	20	18	60	110	6.91
		19	16	15	50		
	December 2023	30	26	24	80	154	9.68
		27	25	22	74		
	January 2024	26	24	23	73	140	8.80
		25	22	20	67		
Total						550 (35.59%)	
	Total	584 (36.72%)	519 (32.64%)	487 (30.62%)	1590	1590	

Table 2: Total number of fungal colonies recorded in three different sections of Maharashtra State Warehouse in different months of investigation. (Feb. 2024-Jan. 2025)

Season	Month	Number of Colonies					
		Godown 1	Godown 2	Godown 3	Total Fortnightly	Total Monthly	%
Summer	February 2024	26	23	22	71	136	8.26
		24	21	20	65		
	March 2024	22	20	19	61	112	6.80
		18	17	16	51		
	April 2024	15	13	12	40	71	4.31
		12	10	9	31		
	May 2024	11	9	8	28	52	3.16
		10	6	8	24		
Total						371 (22.55%)	
Rainy	June 2024	20	18	17	55	119	7.23
		23	20	21	64		
	July 2024	35	33	32	100	216	13.13
		40	39	37	116		
	August 2024	40	37	36	113	211	12.82
		34	32	32	98		
	September 2024	32	29	28	89	176	10.69
		30	29	28	87		
Total						722 (43.89%)	
Winter	October 2024	26	25	23	74	142	8.63
		25	22	21	68		
	November 2024	22	20	19	61	110	6.68
		18	16	15	49		
	December 2024	30	28	27	85	162	9.84
		28	25	24	77		
	January 2025	25	24	22	71	138	8.36
		25	22	20	67		
Total						552 (33.55%)	
	Total	591 (35.92%))	538 (32.70%)	516 (31.36%)	1645	1645	

Hi Air Sampler Method

Table 3: Total CFUs/m³ trapped in three different sections of Maharashtra State Warehouse of Desaiganj Wadsa (Feb. 2023-Jan. 2024)

Season	Month	CFUs/m³					
		Godown 1	Godown 2	Godown 3	Total Fortnightly	Total Monthly	%
Summer	February 2023	130	115	105	350		
		120	110	100	330	680	7.87
	March 2023	105	100	100	305		
		90	75	70	235	540	6.25
	April 2023	80	70	70	220		
		75	70	65	210	430	4.97
	May 2023	60	50	45	155		
		50	45	45	140	295	3.41
Total						1945 (22.52%)	
Rainy	June 2023	110	100	90	300		
		125	110	100	335	635	7.35
	July 2023	185	175	170	530		
		210	200	190	600	1130	13.08
	August 2023	200	185	180	565		
		190	175	170	535	1100	12.73
	September 2023	170	155	140	465		
		160	145	135	440	905	10.48
Total						3770 (43.65%)	
Winter	October 2023	135	120	110	365		
		125	115	115	355	720	8.33
	November 2023	100	100	105	305		
		100	90	85	275	580	6.71
	December 2023	160	145	140	445		
		140	130	120	390	835	9.66
	January 2024	155	140	135	430		
		130	120	105	355	785	9.09
Total						2920 (33.81%)	
	Total	3105 (35.95%)	2840 (32.88%)	2690 (31.15%)	8635	8635	

Table 4: Total CFUs/m³ trapped in three different sections of Maharashtra State Warehouse of Desaiganj Wadsa (Feb. 2024-Jan. 2025)

Season	Month	CFUs/m³					
		Godown 1	Godown 2	Godown 3	Total Fortnightly	Total Monthly	%
Summer	February 2024	140	125	100	365		
		125	110	105	340	705	8.12
	March 2024	120	105	100	325		
		100	90	80	270	595	6.85
	April 2024	90	75	65	230		
		60	50	50	160	390	4.49
	May 2024	55	45	45	145		
		45	40	40	125	270	3.11
Total						1960 (22.58%)	
Rainy	June 2024	105	95	90	290		
		125	115	110	350	640	7.37
	July 2024	190	175	165	530		
		220	205	200	625	1155	13.30
	August 2024	205	195	190	590		
		175	170	165	510	1100	12.67
	September 2024	165	155	150	470		
		160	150	145	455	925	10.65
Total						3820 (44.00%)	
Winter	October 2024	125	115	110	350		
		120	110	105	345	695	8.00
	November 2024	105	100	90	295		
		100	90	85	275	570	6.56
	December 2024	165	155	150	470		
		150	140	135	425	895	10.31
	January 2025	140	130	120	390		
		125	115	110	350	740	8.52
Total						2900 (33.41%)	
	Total	3110 (35.82%)	2855 (32.89%)	2705 (31.16%)	8680	8680	

A A Energy Ltd.

Exposure Petri plate Method

Table 5: Total number of fungal colonies recorded in three different sections of A A Energy Ltd. in different month of Investigation. (Feb. 2023-Jan. 2024)

Season	Month	Number of Colonies					
		Visit Room	D. M. Lab	Generator Room	Total Fortnightly	Total Monthly	%
Summer	February 2023	20	19	18	57	106	7.44
		18	16	15	49		
	March 2023	15	12	10	37	83	5.82
		16	15	15	46		
	April 20232	14	12	10	36	68	4.77
		12	11	9	32		
	May 2023	10	9	7	26	48	3.37
		9	7	6	22		
Total						305 (21.41%)	
Rainy	June 2023	12	11	10	33	77	5.40
		16	15	13	44		
	July 2023	30	28	27	85	175	12.28
		32	30	28	90		
	August 2023	32	30	28	90	187	13.13
		35	32	30	97		
	September 2023	32	30	27	89	170	11.93
		28	27	26	81		
Total						609 (42.76%)	
Winter	October 2023	25	24	21	70	130	9.12
		22	20	18	60		
	November 2023	18	17	15	50	91	6.39
		15	14	12	41		
	December 2023	27	25	26	78	157	11.02
		28	27	24	79		
	January 2024	26	24	21	71	132	9.26
		22	20	19	61		
Total						510 (35.81%)	
	Total	514 (36.09%)	475 (33.35%)	435 (30.54%)	1424	1424	

Table 6: Total number of fungal colonies recorded in three different sections of A A Energy Ltd. in different month of Investigation. (Feb. 2024-Jan. 2025)

Season	Month	Number of Colonies					
		Visit Room	D. M. Lab	Generator Room	Total Fortnightly	Total Monthly	%
Summer	February 2024	25	22	20	77	138	9.23
		23	20	18	61		
	March 2024	18	17	15	50	93	6.22
		16	14	13	43		
	April 2024	12	11	10	33	61	4.08
		10	9	9	28		
	May 2024	9	8	7	24	46	3.07
		9	7	6	22		
Total						338 (22.60%)	
Rainy	June 2024	20	15	14	49	106	7.09
		22	18	17	57		
	July 2024	30	28	27	85	184	12.30
		35	33	31	99		
	August 2024	32	30	30	92	180	12.04
		32	29	27	88		
	September 2024	30	28	27	85	167	11.17
		30	27	25	82		
Total						637 (42.60%)	
Winter	October 2024	26	25	24	75	142	9.49
		24	22	21	67		
	November 2024	20	18	17	55	99	6.62
		17	14	13	44		
	December 2024	30	25	24	79	148	9.89
		25	23	21	69		
	January 2025	25	23	22	70	131	8.76
		22	20	19	61		
Total						520 (34.78%)	
	Total	541 (36.18%)	485 (32.44%)	469 (31.37%)		1495	

Hi Air Sampler Method

Table 7: Total CFUs/m³ trapped in three different sections of A A Energy Ltd. of Desaiganj Wadsa (Feb. 2023-Jan. 2024)

Season	Month	CFUs/m³					
		Visit Room	D. M. Lab	Generator Room	Total Fortnightly	Total Monthly	%
Summer	February 2023	120	115	100	335	640	8.10
		110	100	95	305		
	March 2023	100	90	85	275	500	6.33
		85	75	65	225		
	April 2023	70	55	50	175	335	4.24
		60	50	50	160		
	May 2023	55	50	50	155	290	3.67
		50	45	40	135		
Total						1765 (22.35%)	
Rainy	June 2023	90	80	80	250	550	6.96
		115	95	90	300		
	July 2023	180	175	165	520	1100	13.93
		200	190	190	580		
	August 2023	190	180	175	545	1070	13.55
		180	175	170	525		
	September 2023	165	155	150	470	895	11.33
		150	140	135	425		
Total						3615 (45.78%)	
Winter	October 2023	120	105	100	325	575	7.28
		95	80	75	250		
	November 2023	75	60	60	195	440	5.57
		90	80	75	245		
	December 2023	130	110	105	345	745	9.43
		140	135	125	400		
	January 2024	150	135	130	415	755	9.56
		125	115	100	340		
Total						2515 (31.85%)	
	Total	2845 (36.03%)	2590 (32.80%)	2460 (31.15%)	7895	7895	

Table 8: Total CFUs/m³ trapped in three different sections of A A Energy Ltd. of Desaiganj Wadsa (Feb 2024-Jan 2025)

Season	Month	CFUs/m³					
		Visit Room	D. M. Lab	Generator Room	Total Fortnightly	Total Monthly	%
Summer	February 2024	110	100	90	300	585	7.40
		100	95	90	285		
	March 2024	100	85	80	265	530	6.70
		90	90	85	265		
	April 2024	85	75	70	230	415	5.24
		70	65	50	185		
	May 2024	50	50	40	140	270	3.41
		50	45	35	130		
Total						1800 (22.77%)	
Rainy	June 2024	80	75	70	225	500	6.32
		100	90	85	275		
	July 2024	160	150	140	450	935	11.82
		175	160	150	485		
	August 2024	175	170	160	505	1040	13.15
		190	175	170	535		
	September 2024	165	150	140	455	880	11.13
		150	140	135	425		
Total						3355 (42.44%)	
Winter	October 2024	125	120	110	355	675	8.53
		115	105	100	320		
	November 2024	95	90	80	265	495	6.26
		85	75	70	230		
	December 2024	160	150	140	450	855	10.51
		150	125	130	405		
	January 2025	140	120	130	390	725	9.17
		120	115	100	335		
Total						2750 (34.78%)	
	Total	2840 (35.92%)	2615 (33.08%)	2450 (30.99%)	7905	7905	

Meteorological Data

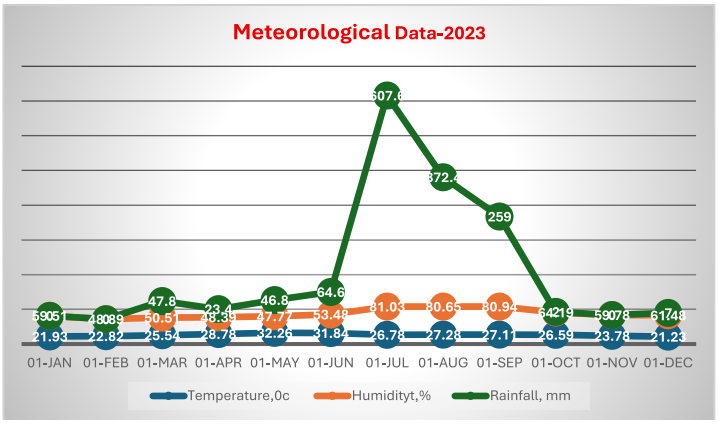

Fig 1: The Figure shows minimum, maximum and average temperature, relative humidity and rainfall from Feb-2023 to Jan-2024 in Gadchiroli district

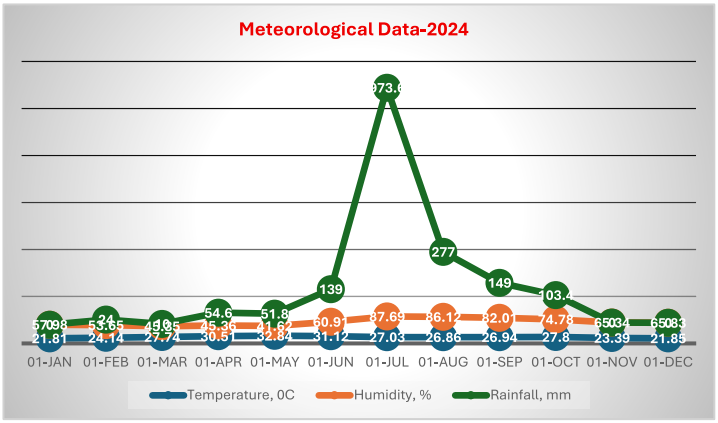

Fig 2: The figure shows minimum, maximum and average temperature, relative humidity and rainfall from Feb-2024 to Jan-2025 in Gadchiroli district

Source: *District Agromet Unit of Krishi Vigyan Kendra Sonapur Gadchiroli.*

CONCLUSION

The present study revealed significant seasonal as well as monthly variations in the concentration of airborne fungal spores within the Warehouse and Energy source of Desaiganj Wadsa. The highest spore concentrations were recorded during the humid months, clearly indicating the strong influence of meteorological parameters on the proliferation and distribution of airborne fungi. Environmental factors such as humidity, temperature, and rainfall play a crucial role in fungal growth, as fungal spores generally require relative humidity above 75% and an optimum temperature range of 20 °C to 25 °C for their development. During the rainy season, particularly from July to September, increased rainfall and elevated humidity levels create favorable conditions for fungal multiplication, resulting in higher concentrations of airborne spores. Consequently, a marked increase in indoor aeromycospora was observed in the Warehouse and Energy source with peak spore concentrations occurring during the months of July and August. In the aeromycological study, higher fungal concentration observed in the warehouse than A A Energy source factory may be attributed to the availability of stored substratum such as grains, bags, packaging materials, and other organic substrates, which provide suitable nutrients for fungal growth. Warehouses generally maintain moderate temperature and higher relative humidity due to limited air circulation and moisture retention, creating favorable conditions for the proliferation and accumulation of airborne fungal spores. In addition, frequent human movement and handling of stored materials can resuspend settled spores into the air, thereby increasing fungal concentration, lower fungal concentration in the energy source area may be due to the continuous operation of machines and generators generates heat and vibrations that reduce spore viability and prevent their settlement, the detection of potentially harmful fungal species emphasizes the importance of regular aeromycological monitoring and the implementation of effective air quality management practices to minimize health risks and prevent biodeterioration within warehouse and energy source environments. Dominant genera found in this study are *Aspergillus, Alternaria, Cladosporium, Cercospora, Penicillium, Fusarium, Mucor,* and *Rhizopus.*

Acknowledgement

I would like to express my sincere gratitude to my Research Center Director/Principal Dr. S. M. Shekokar sir and my research supervisor Dr. S. G. Kukreja sir for supporting my research and creating supportive environment for my research work. Also, my research center Department of Botany Nevjabai Hitkarini College Bramhapuri to providing necessary equipment's for my research. I wish to acknowledge the generous financial support of the Mahatma Jyotiba Phule Research Fellowship (Mahajyoti Nagpur), without their funding this research work not possible. I would also like to express my special thanks to my husband, my parents, and all my family members for their continuous support and understanding throughout the course of my research and the writing of this paper.

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