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Indoor Air Quality in College Laboratories: Exposure to Airborne Fungi

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Abstract- The present study was undertaken to identify and find out the airborne viable fungi and their concentrations in indoor environment of college laboratories. Air sampling was conducted in Chemistry, Zoology, Botany, and Geology laboratories by using Hi-Air Sampler (Hi-media LA-002); two media strips were used for isolation of airborne fungi (PS-290 & PS-640). The average counts of total fungi isolated on two media strips were recorded maximum in chemistry laboratory (4088 CFU/m^3), followed by Botany (2681 CFU/m^3), Zoology laboratory (2300 CFU/m^3), and the lowest recorded in geology laboratory (1622 CFU/m^3). While comparing the total CFU counts of isolated fungi on two media strips, the maximum counts were recorded on PS-640 media strips (13618.75 CFU/m^3), and (9,637.50 CFU/m^3) recorded on PS-290 media strips. In chemistry laboratory total 31 species isolated along with Yeast and Non-sporulating fungi, followed by 29 species from Botany laboratory, 26 from Zoology and only 17 species from Geology laboratory. The total fungal counts of all the fungal species isolated from the studied laboratories were considered and found maximum CFU counts of *Curvularia clavata*, which is most predominant species followed by the species of *Cladosporium herbarum, Curvularia geniculata, Alternaria alternata, Aspergillus niger, Alternaria solani, Curvularia lunata, Yeasts, Aspergillus flavus, Penicillium lutem, Penicillium purpurogenum, Aspergillus fumigatus, Penicillium glabrum, Alternaria brassicicola, Alternaria tenuissima, Curvularia brachyspora, Rhizopus, Mucor,* and *Cladosporium oxysporum.*

Keywords – Indoor, Air-quality, Laboratories, Airborne, Fungi, *Curvularia spp.*

I. INTRODUCTION

Air contaminants, which includes fungus, mold, bacteria, inorganic and organic matter, cause many health-related problems. Many small size fungal spores are respirable into the alveoli of lung, and release soluble toxins contained in the spores enter the blood stream. Fungi are well known to colonized and caused diseases in skin, nails, sinuses or airways [1]. *Aspergillus flavus* and *A. fumigatus* are the second most important species causing human infections particularly fungal sinusitis, aspergillosis and lower proportion of pulmonary infections [2]. Occupational allergy is nothing but the any kind of clinical or physio-pathological event due to hypersensitivity prompted by allergens found in working indoor environments. The dust, dirt, moisture level, minimum and maximum temperature normally provide sufficient nutrients to support extensive fungal growth on various substrates. The Non-Infectious Fungal Indoor Exposure syndrome (NIFIES) has been proposed to described the illness typically first called SBS. Symptoms include eye, nose and throat irritation/inflammation, respiratory symptoms such as cough and chest tightness, fatigue, popular rash, and neurocognitive symptoms such as short-term memory loss and concentration problems [3]. The presence of Aspergillus species in the air is a major risk factor for both invasive and allergic aspergillosis [4]. Most students, faculties and laboratory staffs spend their maximum time in laboratories while performing practical's in college hours. However, poor indoor air quality has adversely affected not only known allergy sufferers, but also others who experience more frequent aggressive symptoms. The present study specifically monitors college laboratories to evaluate the indoor air quality in reference to presence of airborne viable fungi.

II. MATERIAL AND METHODS

SAMPLING SITE AND SAMPLING OF AIR:

The study was carried out in various laboratories of Shri Mathuradas Mohota College of Science, Nagpur city. Air sampling was conducted randomly in Chemistry, Botany, Zoology and Geology laboratories from December, 2013 to April, 2015. Air sampling was conducted by using Hi-Air sampler (Hi-Media Ltd. LA-002). Two media strips were used to sample the indoor air of laboratories (PS-640 and PS-290) for total CFU counts. Air sampler was run 4 minutes during working hours of college (11.30 am to 2.30 pm). The minimum and maximum temperatures, relative humidity was recorded during sampling hours by temperature-hygrometer (Figure 1).

COLONY FORMING UNITS (CFUs) AND SPECIES IDENTIFICATION:

The exposed media strips were brought back and incubated in an inverted position in laboratory. After 4 to 7 days of

incubation colony forming units (CFUs) were counted for each genus and also sub cultured for species level identification. Colony forming units calculated per cubic meter of air (CFU/m^3). The isolated fungal genera and species were identified by their colony texture, colour of colony, hyphal characteristics, morphology, and microscopic examinations by using standard published literatures [5,6,7,8]. The average of dominant fungal species was counted and considered only above the 100 CFU/m^3, below the 100 CFU/m^3 not considered as dominant as per the guideline for indoor mould concentrations (Figures 3, 4, 5 & 6). The fungi detected per unit volume of air calculated as under:

$$\text{CFU/m}^3 = \frac{\text{Colonies on agar strip x 25}}{\text{Sampling time in minutes (4)}}$$

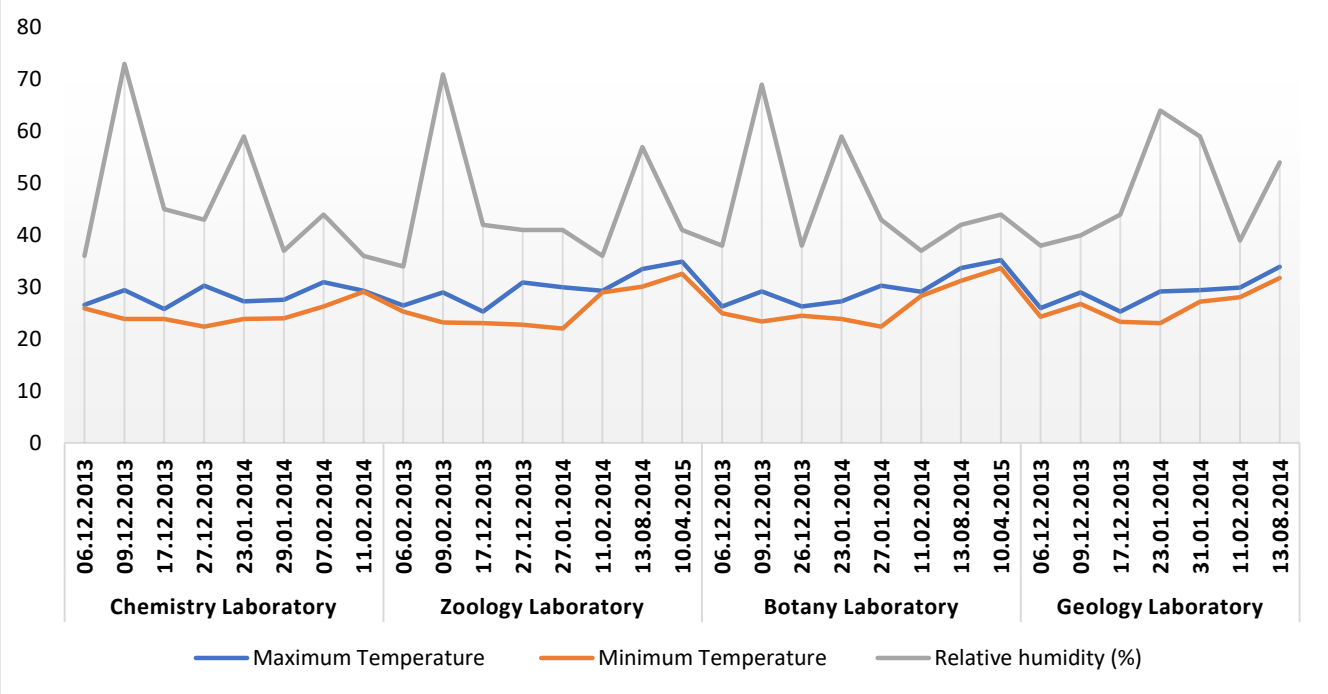


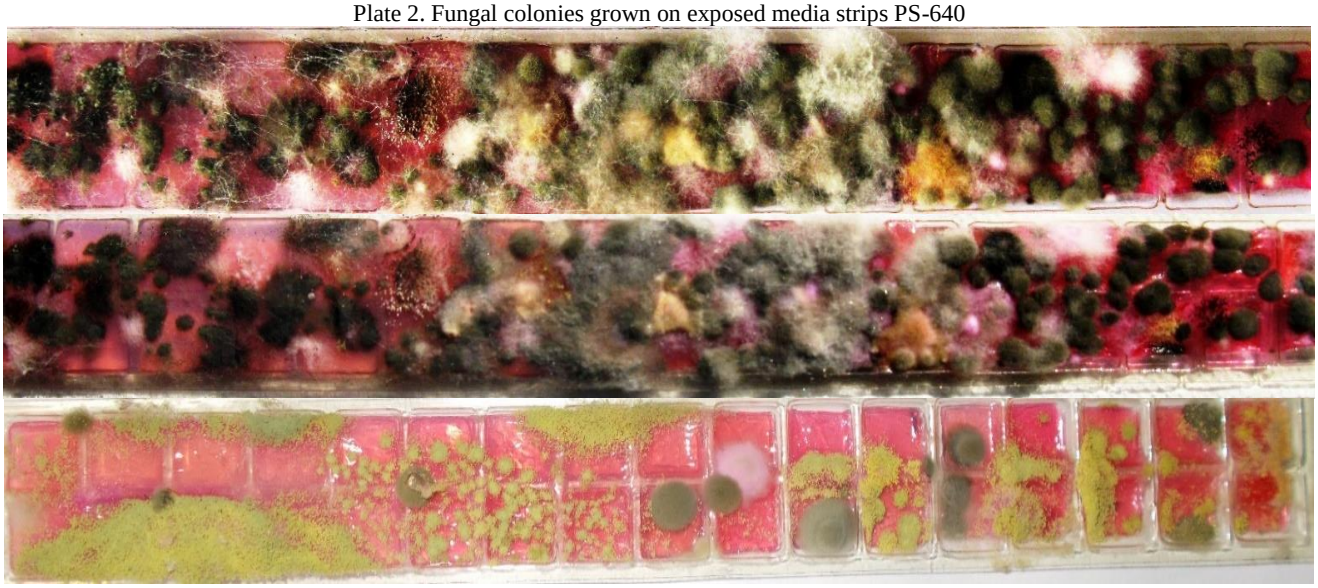
Figure 1. Maximum, minimum temperatures0C & relative humidity (%) recorded during sampling hours in indoor environments of college laboratories by Temperature-hygrometer

Plate 1. Air sampling was conducted in college laboratories

Chemistry laboratory Zoology laboratory

Botany laboratory Geology laboratory

Plate 2. Fungal colonies grown on exposed media strips PS-640



Fungal colonies grown on exposed media strips PS-290

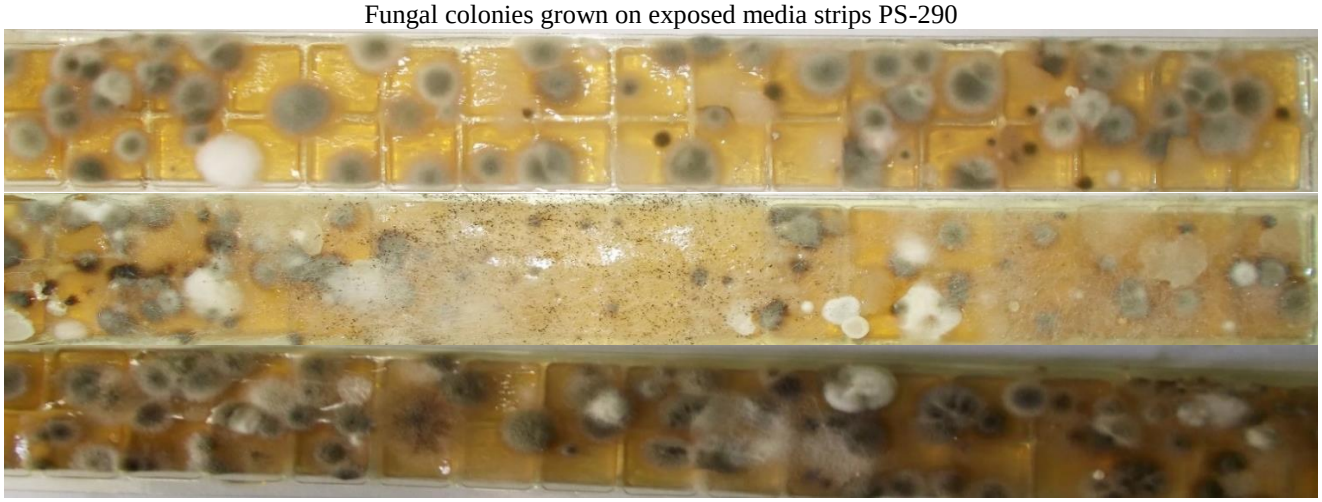
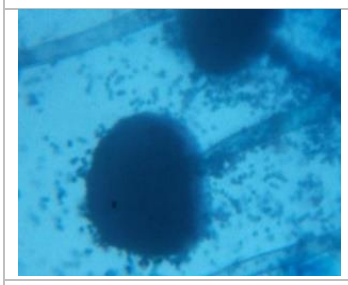
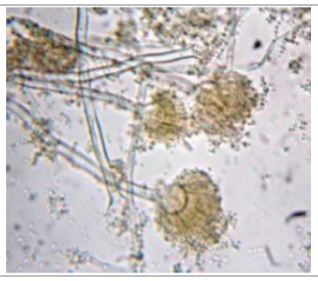
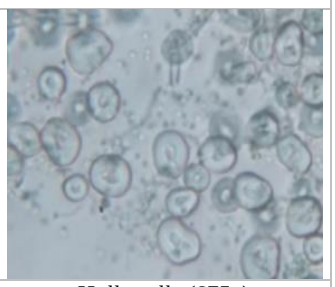
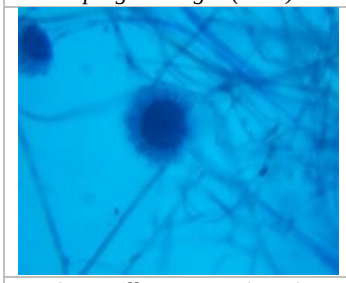
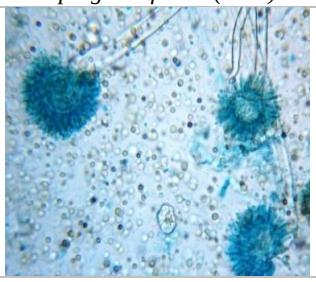
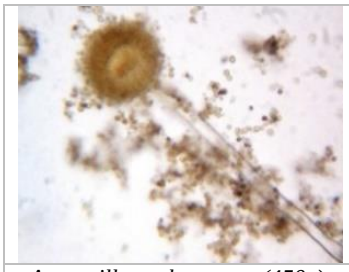
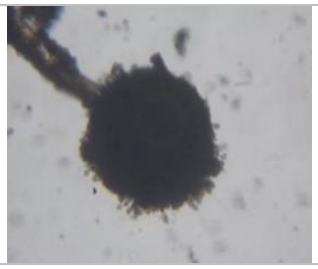
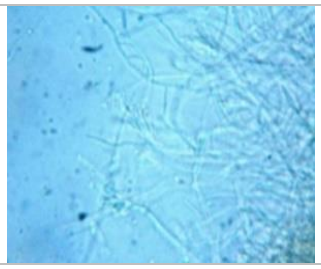
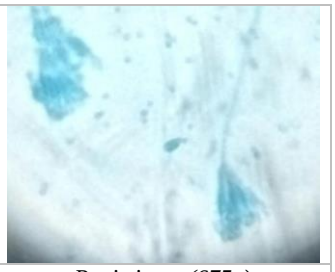
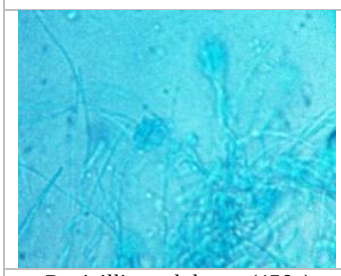
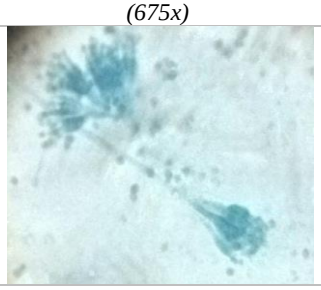
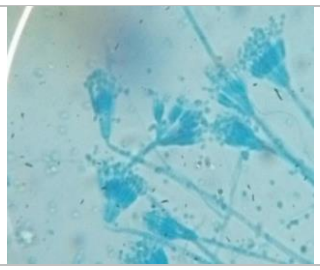
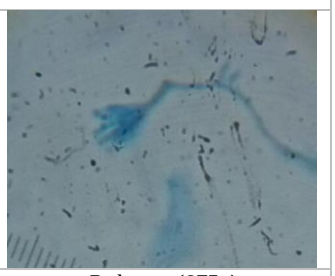
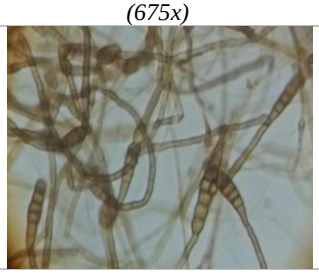
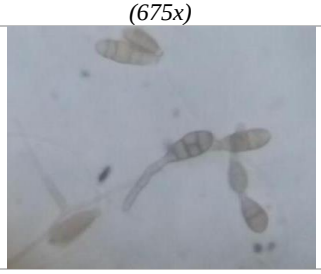
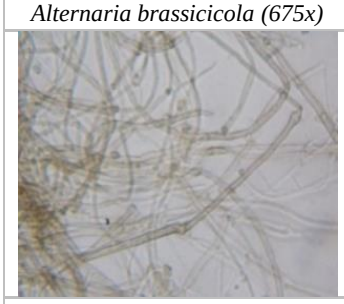
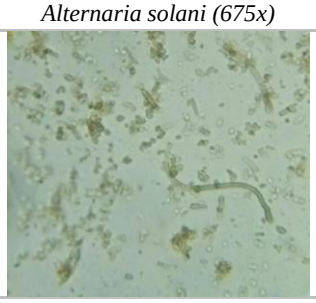
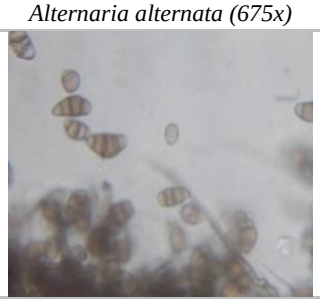
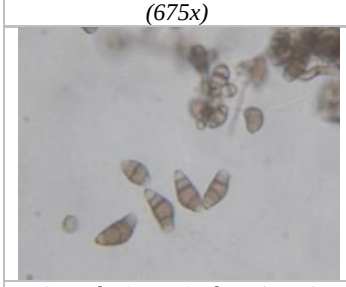
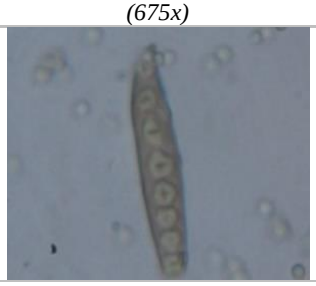
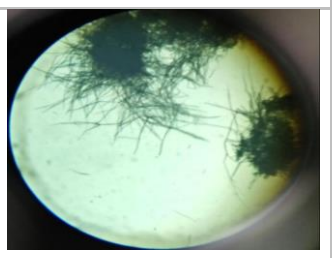
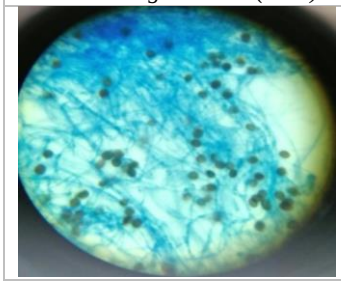
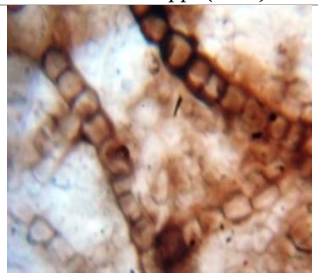
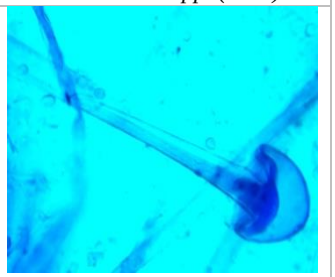


Plate 3. Micro-photographs of isolated fungal species from indoor environments of college laboratories

			
Aspergillus niger (450x)	*Aspergillus flavus (450x)*	*Aspergillus fumigatus (675x)*	*Hulle cells (675x)*
			
Aspergillus terreus (675x)	*Aspergillus candidus (675x)*	*Aspergillus tamerri (675x)*	*Aspergillus oryaza (675x)*

			
Aspergillus ochraceous (450x)	*Aspergillus carboniferus (675x)*	*Penicillium spp. (450x)*	*P. citrinum (675x)*
			
Penicillium glabrum (450x)	*Penicillium purpurogenum (675x)*	*Penicillium chrysogenum (675x)*	*P. lutem (675x)*
			
Alternaria brassicicola (675x)	*Alternaria solani (675x)*	*Alternaria alternata (675x)*	*Alternaria tenuissima (675x)*
			
Cladosporium oxysporum (675x)	*Cladosporium herbarum (675x)*	*Curvularia lunata (675x)*	*Curvularia clavata (675x)*
			
Curvularia geniculata (675x)	*Drechslera spp. (675x)*	*Rhizopus spp. (675x)*	*Chaetomium spp. (450x)*
			
Nigrospora spp. (450x)	*Torula spp. (675x)*	*Fusarium spp. (675x)*	*Mucor spp. (450x)*

III. RESULTS AND DISCUSSION

SPECIES COMPOSITIONS:

Total 31 fungal species were recovered from indoor environment of chemistry laboratory, of which species of *Alternaria* contributes total 493 cfu/m^3 and 12.8% with 3 species. *Aspergillus* recorded total 9 species and contributes 703 cfu/m^3 and 17.19% contribution. *Cladosporium* 2 species with 319 cfu/m^3 contribution and 7.79%, while the 4 species of *Curvularia* recorded 872 cfu/m3 with 21.33% contribution. Four species of *Penicillium* recovered and contributes 557 cfu/m^3 with 13.6% contribution to all the species. Non-sporulating fungi recorded 416 cfu/m^3 and contributes 10.17%. while the other species recovered singly and contributes their cfu/m^3 and percent contribution to the total species composition recorded (Table 1).

In Botany laboratory total 29 fungal species were recorded, out of which species of *Alternaria* contributes total 347 cfu/m^3 and 12.94% with 3 species. *Aspergillus* recorded 9 species which contributes 487 cfu/m^3 and 18.18%. *Cladosporium* recorded 2 species and contributes 434 cfu/m^3 and 16.2%, while *Curvularia* recorded 3 species and contributes 597 cfu/m^3 with 22.26%. Three species of *Penicillium* recorded and contributes 235 cfu/m^3 & 8.73% contribution to the species composition. Non-sporulating fungi recorded only 28 cfu/m^3 with 1.05%, which is very lowest as compare to all other laboratories. However, other fungal species recovered singly and contributes their cfu/m^3 and percent contribution to the total species composition (Table 1).

While in laboratory of Zoology department, total 26 fungal species were recovered from indoor environment. Out of which species of *Alternaria* contributes 178 cfu/m^3 and 7.74%. *Aspergillus* recorded 9 species and contributes 438 cfu/m^3 and 19.01%. *Cladosporium* recorded 2 species with 250 cfu/m^3 and 10.85%, the 3 species of *Curvularia* recorded 747 cfu/m^3 with 32.47%. *Penicillium* recovered 3 species and contributes 172 cfu/m^3 with 7.47% contribution. Non-sporulating fungi recorded 122 cfu/m^3 and contributes 5.3%. The other species recovered singly and contributes their cfu/m^3 and percent contribution to the total species composition recorded (Table 1).

17 fungal species were recorded in Geology laboratory, which ever lowest than the others. Out of which species of *Alternaria* contributes 181 cfu/m^3 and 11.18% with 2 species. *Aspergillus* recorded lowest species from others, only 5 species contributes 168 cfu/m^3 and 9.06% contribution. Single species of *Cladosporium* recorded and contributes 213 cfu/m^3 and 13.1%, *Curvularia* recorded 2 species with 319 cfu/m^3 with 19.65% contribution. Only 2 species of *Penicillium* recovered and contributes only 110 cfu/m^3 with 6.74%. Whereas, non-sporulating fungi recorded only 53 cfu/m^3 with 3.28% contribution. The other species recovered singly and contributes their cfu counts and percent contribution to the total species composition recorded is shown in (Table 1).

AVERAGE CFU COUNTS:

The average fungal counts were recorded maximum in Chemistry laboratory (4088 cfu/m^3), followed by Botany (2681 cfu/m^3), Zoology (2300 cfu/m^3), and the lowest recorded in Geology laboratory (1622 cfu/m^3). While comparing the fungal counts on two media strips, the maximum cfu counts (13618.75 cfu/m^3) was recorded on PS-640 media strips, and (9,637.50 cfu/m^3) on PS-290 media strips (Figure 2 & 3). In the laboratory of chemistry department *Curvularia clavata* recorded dominant and their average CFU counts was found to be (362.5 cfu/m^3), followed by *Cladosporium herbarum* (215.63), *Curvularia lunata* (203.13), *Curvularia geniculata* (184.38), *Alternaria alternata* (181.25), *Alternaria solani* (178.13), *Penicillium lutem* (171.88), *Aspergillus niger* (168.75), *Yeasts* (162.5), *Penicillium purpurogenum* (150), *Penicillium glabrum* (140.63), *Aspergillus fumigatus* (140.63), *Alternaria brassicicola* (134.38), *Aspergillus flavus* (125), *Rhizopus* (121.88), *Curvularia brachyspora* (121.88), *Mucor* (106.25), and *Cladosporium oxysporum* (103.13 cfu/m^3), (Table 1 & Figure 4).

Santra and Chanda [9] studied and reported the incidence of airborne fungal spores in Botany and Chemistry laboratory of Presidency College Calcutta. They recorded allergenic and mycotoxin producing fungi *Aspergillus niger, A. flavus, A. terreus, A. fumigatus, Penicillium glabrum, P. micynskii, Rhizopus nigricans, Alternaria alternata, Cladosporium herbarum, Helminthosporium oryzae, H. sativum, Curvularia tuberculata, Curvularia lunata, Fusarium,* and *Trichoderma lignorum*. In the present study all the above mentioned allergenic and mycotoxins producing fungal species were isolated predominantly in all the studied laboratories except *Penicillium micynskii, Helminthosporium oryzae, Helminthosporium sativum, Curvularia tuberculata,* and *Trichoderma lignorum.*

Levetin et al., [10] studied and reported the viable fungi *Cladosporium, Penicillium, Alternaria, Aspergillus, Yeast* and Non-sporulating fungi. In present study also recorded the genera of *Cladosporium, Penicillium, Alternaria, Aspergillus, Yeast* and Non-sporulating fungi. The most common fungal species recorded in both type of building frameworks (wooden and concrete/bricks) are *Curvularia clavata, Cladosporium herbarum, Curvularia geniculata, C. lunata, C. brachyspora, Alternaria alternata, A. solani, A. brassicicola, A. tenuissima, Penicillium lutem, P. glabrum, P. purpurogenum, P. chrysogenum, Aspergillus niger, A. flavus, A. fumigatus, Rhizopus, Mucor, Yeasts* and *Fusarium.* The growth of various fungi on both wooden, concrete bricks and stone-based materials is possible and frequent growing on damaged building materials [11]. In earlier study were revealed that, total 36 fungal species belonging to 17 genera isolated from indoor and outdoor environment of Botany laboratory. Mean concentration of airborne fungi isolated from indoor environment was (174.96 cfu/m^3) while it was (125.69 cfu/m^3) in outdoor air (control). Dominant fungi were isolated from indoor air was *Aspergillus, Penicillium,*

Alternaria, *Cladosporium*, *Curvularia*, *Trichoderma*, *Rhizopus*, *Mucor*, *Phoma*, *Scopulariopsis*, *Torula herbarum*, *Helminthosporium*, and *Chaetomium* [12]. Whereas, in present investigation *Curvularia clavata* was the most predominant species followed by the species of *Cladosporium herbarum*, *Curvularia geniculata*, *C. lunata*, *C. brachyspora*, *Alternaria alternata*, *A. solani*, *A. brassicicola*, *A. tenuissima*, *Penicillium lutem*, *P. glabrum*, *P. purpurogenum*, *P. chrysogenum*, *Aspergillus niger*, *A. flavus*, *A. fumigatus*, *Rhizopus*, *Mucor*, *Yeasts* and *Fusarium (*Table 1 & Figure 5).

While in laboratory of Zoology department recorded maximum average CFU counts of dominant fungi *Curvularia clavata* (465.63 cfu/m^3), followed by the species of *Cladosporium herbarum* (193.75), *Curvularia geniculata* (184.38), *Alternaria alternata* (178.13), and the lowest is *Aspergillus niger* (121.88 cfu/m^3). (Table 1 & Figure 6). In Geology laboratory, maximum CFU counts reported by fungus *Rhizopus* (218.75 cfu/m^3), followed by *Cladosporium herbarum* (212.50), *Curvularia clavata* (200), *Mucor* (178.13), *Alternaria solani* (128.13), *Curvularia geniculata* (118.75), and the minimum recorded by *Fusarium* (100 cfu/m^3). Infections caused by *Mucor* and *Rhizopus* reported [13].

The total CFU counts of dominant fungi isolated from all the studied laboratories showed their maximum counts recorded by the species of *Curvularia clavata* (1413 cfu/m^3), followed by *Cladosporium herbarum* (932), *Curvularia geniculata* (487), *Alternaria alternata* (468), *Aspergillus niger* (429), *Alternaria solani* (422), *Curvularia lunata* (319), *Yeasts* (282), *Aspergillus flavus* (241), *Penicillium lutem* (172), *P. purpurogenum* (150), *Aspergillus fumigatus* (141), *Penicillium glabrum* (141), *Alternaria brassicicola* (134), *Alternaria tenuissima* (122), *Curvularia brachyspora* (122), *Rhizopus* (122), *Mucor* (106), and *Cladosporium oxysporum* (103 cfu/m^3). Here only average counts above 100 CFU/m^3 considered as dominant as per the guidelines of indoor mould counts (Figure 8). Exposures to these fungi may be indoors, outdoors or both. The genera *Alternaria*, *Aspergillus*, *Cladosporium*, *Curvularia*, and *Penicillium* are involved in allergic reactions [14].

Yuriko et al., [15] studied and reported *Cladosporium*, *Penicillium*, *Aspergillus*, Thanatephorus, *Absidia*, Eurotium, Paraphaeosphaeria, and *Tritirachium* from clinical microbiological laboratories. In present investigation the above-mentioned genera were recorded predominantly except *Thanatephorus*, *Absidia*, *Eurotium*, *Paraphaeosphaeria*, and *Tritirachium*. Ulea et al., [16] studied and reported *Penicillium*, *Cladosporium*, *Aspergillus*, *Alternaria*, *Botrytis*, *Trichoderma*, *Verticillium*, *Fusarium*, *Stemphyllium*, *Rhizopus*, and *Mucor* in the indoor air of university laboratory and high school class room. (Table 1 and Figure 2 & 3). Ahmed Atya et al., [17] studied and reported *Penicillium chrysogenum*, *Alternaria alternata*, *Aspergillus niger*, *Cladosporium cladosporoides*, Aspergillus *flavus* and *A. fumigatus* by open plate method from 12 rooms of laboratories in faculty and hospital buildings. Present results showed the dominance of *Curvularia clavata* followed by the species of *Cladosporium herbarum*, *Curvularia geniculata*, *C. lunata*, *C. brachyspora*, *Alternaria alternata*, *A. solani*, *A. brassicicola*, *A. tenuissima*, *Penicillium lutem*, *P. glabrum*, *P. purpurogenum*, *P. chrysogenum*, *Aspergillus niger*, *A. flavus*, *A. fumigatus*, *Rhizopus*, *Mucor*, *Yeasts* and *Fusarium* (Table 1, Figures 4, 5, 6, & 7).

In earlier study 34 fungal species excluding yeasts and non-sporulated fungi were reported from the reading & stock sections of college library. The dominant fungi were *Curvularia lunata* recorded 706 CFU/m^3, *followed by Curvularia geniculata* 612.5, *C. tetramera* 537.5, *Aspergillus niger* 468.75, *Aspergillus flavus* 431.25, *Aspergillus fumigatus* 475, *Alternaria alternata* 350, *Cladosporium herbarum* 287.5, *Alternaria soloni* 281.25, *Alternaria tenussima* 262.5, *Cladosporium spp.* 245.75, *Penicillium chrysogenum* 450, *P. citrinum* 456.25, *P. glaucus* 556.25, *Penicillium spp*. 331.25, and Non-sporulating fungi 737.5 CFU/m^3 in reading and stock sections of library. The total mean concentrations of airborne fungi in reading section of library were 7618.75 CFU/m^3, which is minimum as compare to the stock section of library 10306.25 CFU/m^3 [18]. The average fungal counts were recorded maximum in Chemistry laboratory (4088 cfu/m^3), followed by Botany (2681 cfu/m^3), Zoology (2300 cfu/m^3), and the lowest recorded in Geology laboratory (1622 cfu/m^3). While comparing the fungal counts on two media strips, the maximum cfu counts (13618.75 cfu/m^3) was recorded on PS-640 media strips, and (9,637.50 cfu/m^3) on PS-290 media strip. In present study a greater number of CFU counts recorded as compare to the library environments (Table 1 & Figure 2, 3 & 5).

Hedayati et.al., [19] reported several species of *Aspergillus* are allergenic, including *A. fumigatus, A. niger, A flavus* and *A. oryzae*. There are no established guidelines available for the permissible limits of exposure to airborne fungi to assess the health impact, since due to the complexity of their composition, variations in human response to exposure, and difficulties in recovering microorganisms that can pose a hazard during routine sampling [20]. However, there are some recommended concentrations of fungi reported in indoor environments. For clean areas the normal level of airborne fungi should be under 550 CFU/m^3. Rooms with airborne fungi between 550 and 700 CFU/ m^3 are regarded as contaminated, while those with CFU/m^3 greater than 700 were regarded as highly contaminated [21]. Exposure to these fungi does not always result in health problems, but measures should be taken to prevent fungal growth on interior substrates; because some people are, or may become allergic to it. Although most students, faculty members, laboratory staffs of college spend their 3-7 hours of the day during practical hours. Very meager work was carried out specifically to examine the air quality of this type of indoor environments.

Table 1. Average CFU/m^3 of isolated fungal species and their percent contribution recorded in indoor environments of college laboratories

Sr. No.	Fungal species	Chemistry		Zoology		Botany		Geology	
		Average CFU/m^3	%	Average CFU/m^3	%	Average CFU/m^3	%	Average CFU/m^3	%
1	*Alternaria alternata*	181	4.43	178	7.74	109	4.08	53	3.28
2	*Alternaria brassicicola*	134	3.29	0	0	0	0	0	0
3	*Alternaria solani*	178	4.36	0	0	116	4.31	128	7.9
4	*Alternaria tenuissima*	0	0	0	0	122	4.55	0	0
Total CFU/m^3 & Percentage		**493**	**12.08**	**178**	**7.74**	**347**	**12.94**	**181**	**11.18**
1	*Aspergillus candidus*	31	0.76	38	1.63	9	0.35	0	0
2	*Aspergillus carboniferous*	59	1.45	50	2.17	31	1.17	38	2.31
3	*Aspergillus flavus*	125	3.06	75	3.26	116	4.31	44	2.7
4	*Aspergillus fumigatus*	141	3.44	50	2.17	59	2.21	0	0
5	*Aspergillus niger*	169	4.13	122	5.3	138	5.13	34	2.12
6	*Aspergillus ochraceous*	75	1.83	31	1.36	56	2.1	33	0.77
7	*Aspergillus oryzae*	66	1.61	34	1.49	34	1.28	0	0
8	*Aspergillus tamerri*	31	0.76	13	0.54	28	1.05	0	0
9	*Aspergillus terreus*	6	0.15	25	1.09	16	0.58	19	1.16
Total CFU/m^3 & Percentage		**703**	**17.19**	**438**	**19.01**	**487**	**18.18**	**168**	**9.06**
*	*Candida albicans*	25	0.61	31	1.36	3	0.12	0	0
1	*Cladosporium herbarum*	216	5.27	194	8.42	309	11.54	213	13.1
2	*Cladosporium oxysporum*	103	2.52	56	2.43	125	4.66	0	0
Total CFU/m^3 & Percentage		**319**	**7.79**	**250**	**10.85**	**434**	**16.2**	**213**	**13.1**
1	*Curvularia geniculata*	184	4.51	184	8.02	97	3.61	119	7.32
2	*Curvularia lunata*	203	4.97	97	4.21	116	4.31	0	0
3	*Curvularia brachyspora*	122	2.98	0	0	0	0	0	0
4	*Curvularia clavata*	363	8.87	466	20.24	384	14.34	200	12.33
Total CFU/m^3 & Percentage		**872**	**21.33**	**747**	**32.47**	**597**	**22.26**	**319**	**19.65**
*	*Drechslera*	0	0	0	0	31	1.17	0	0
*	*Fusarium*	78	1.91	63	2.72	197	7.34	100	6.17
*	*Helminthosporium*	66	1.61	0	0	0	0	0	0
*	*Mucor*	106	2.6	38	1.63	88	3.26	178	10.98
*	*Nigrospora*	91	2.22	19	0.82	19	0.7	31	1.93
1	*Penicillium chrysogenum*	0	0	66	2.85	88	3.26	0	0
2	*Penicillium citrinum*	94	2.29	34	1.49	88	3.26	22	1.35
3	*Penicillium glabrum*	141	3.44	72	3.13	59	2.21	88	5.39
4	*Penicillium lutem*	172	4.2	0	0	0	0	0	0
5	*Penicillium purpurogenum*	150	3.67	0	0	0	0	0	0
Total CFU/m^3 & Percentage		**557**	**13.6**	**172**	**7.47**	**235**	**8.73**	**110**	**6.74**
*	*Rhizopus*	122	2.98	94	4.08	41	1.52	219	13.49
*	*Torula*	47	1.15	28	1.22	28	1.05	0	0
*	*Trichoderma*	31	0.76	28	1.22	28	1.05	0	0
*	*Yeasts*	163	3.98	94	4.08	119	4.43	72	4.43
*	Non-sporulating fungi	**416**	**10.17**	**122**	**5.3**	**28**	**1.05**	**53**	**3.28**
Total CFU/m^3 & Percentage		**4088**	**100**	**2300**	**100**	**2681**	**100**	**1622**	**100**

*** Marked species recorded singly**

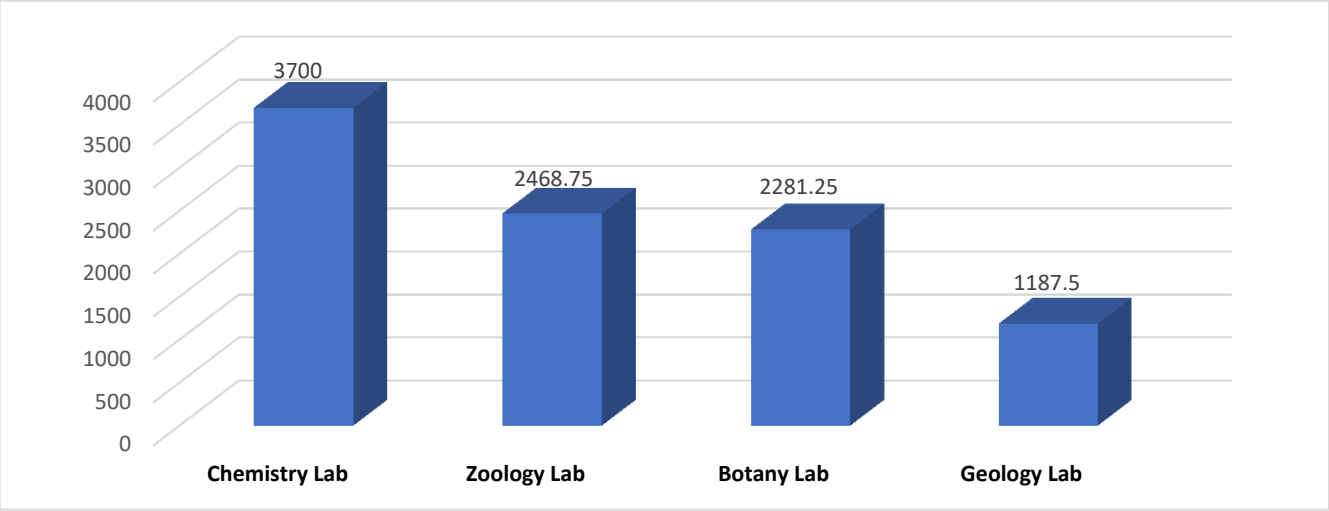


Figure 2. Total CFU counts of fungi recovered on PS-290 media strips

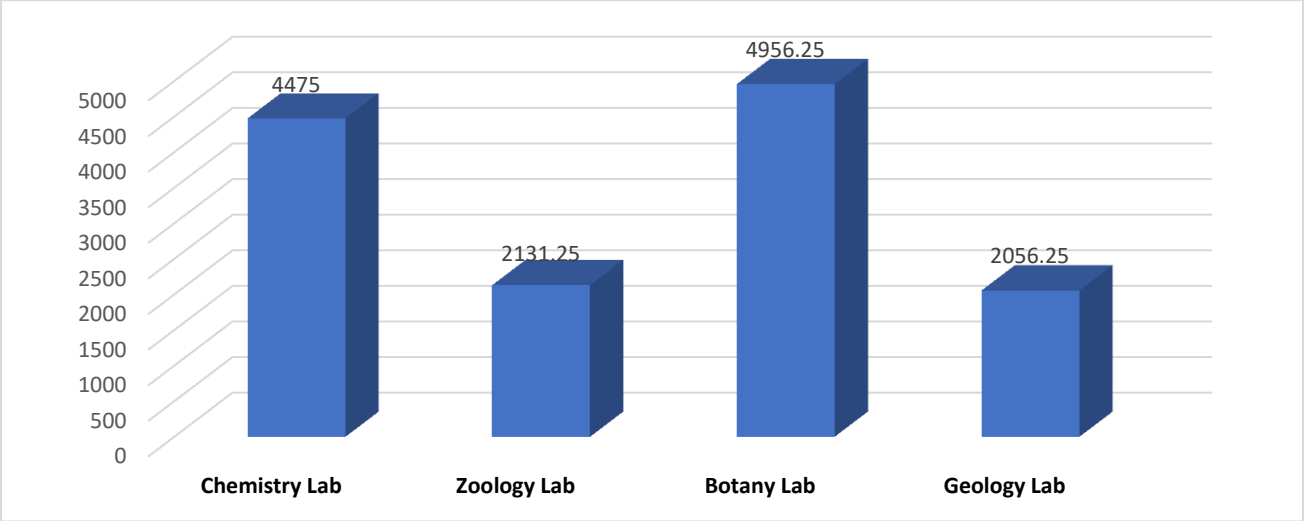


Figure 3. Total CFU counts of fungi recovered on PS-640 media strips

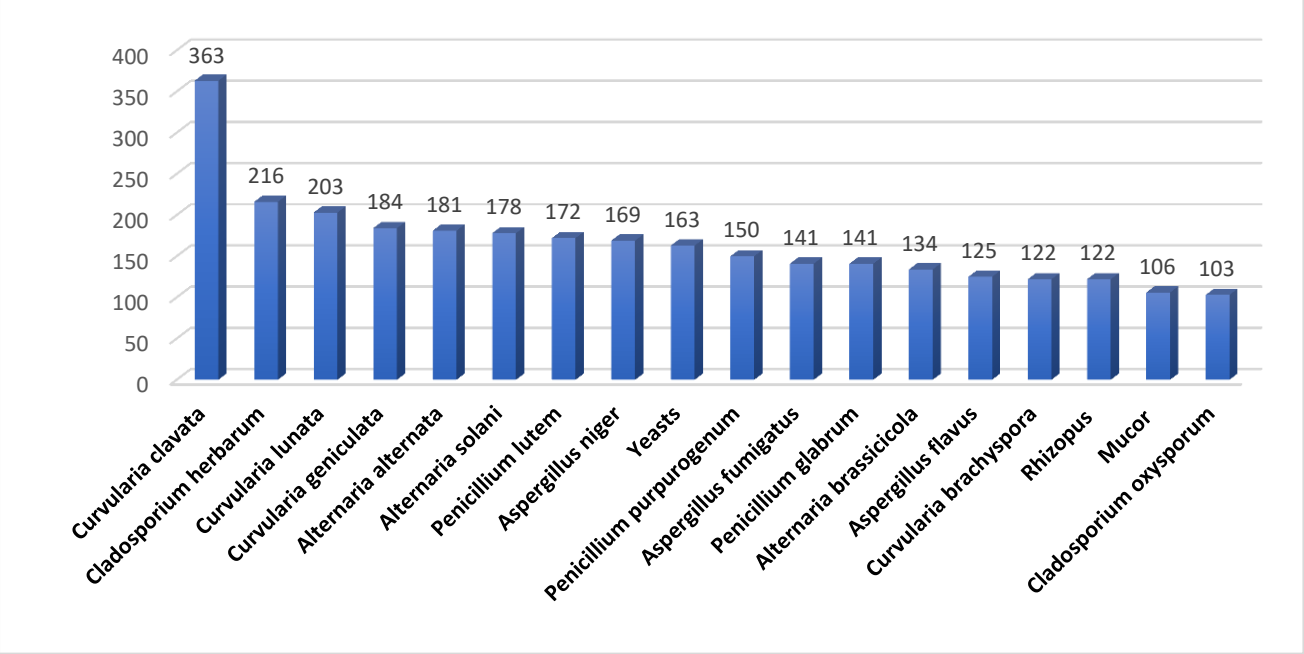


Figure 4. Average CFU counts of dominant fungi isolated from indoor environments of Chemistry laboratory

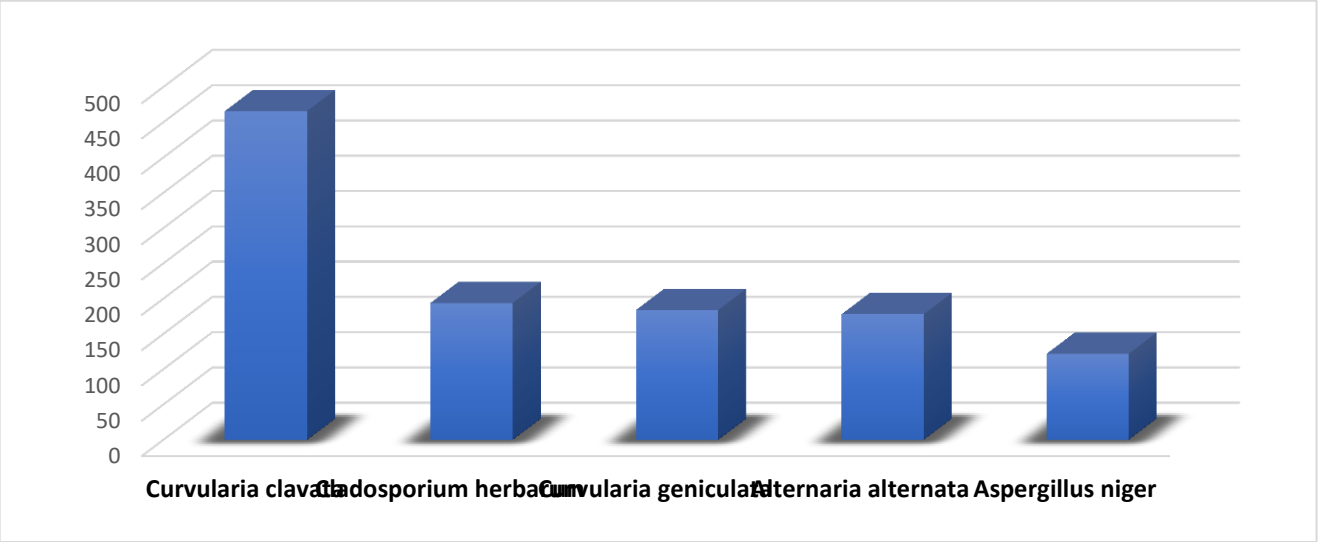


Figure 5. Average CFU counts of dominant fungi isolated from indoor environments of Zoology laboratory

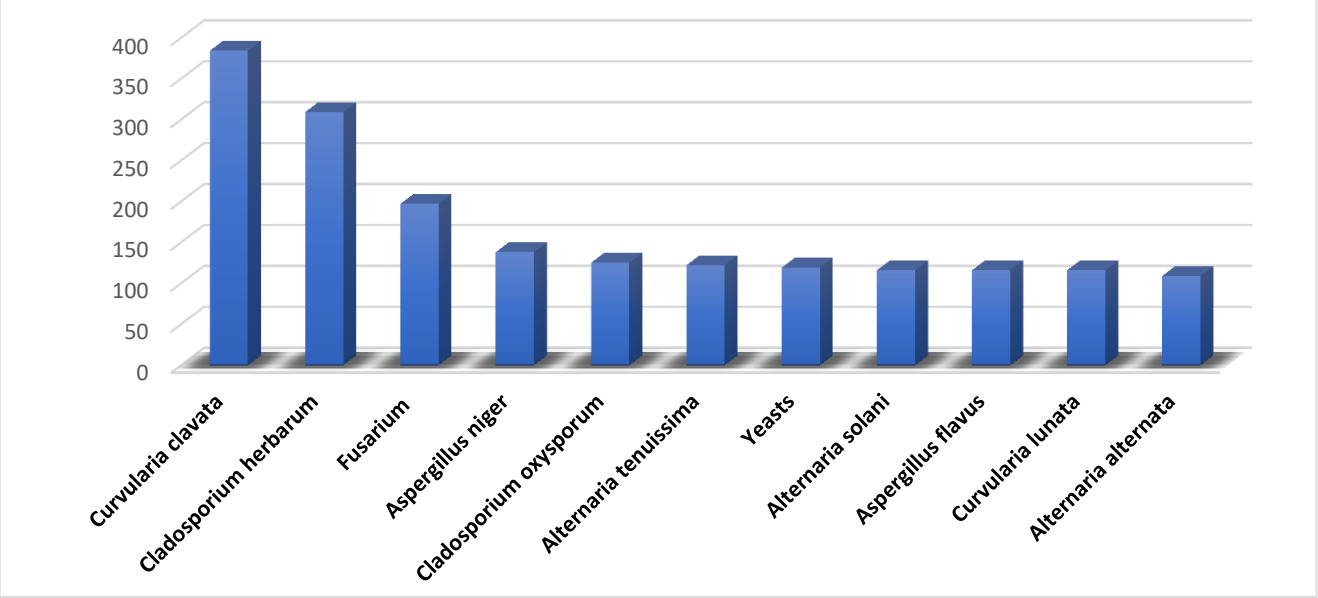


Figure 6. Average CFU counts of dominant fungi isolated from indoor environments of Botany laboratory

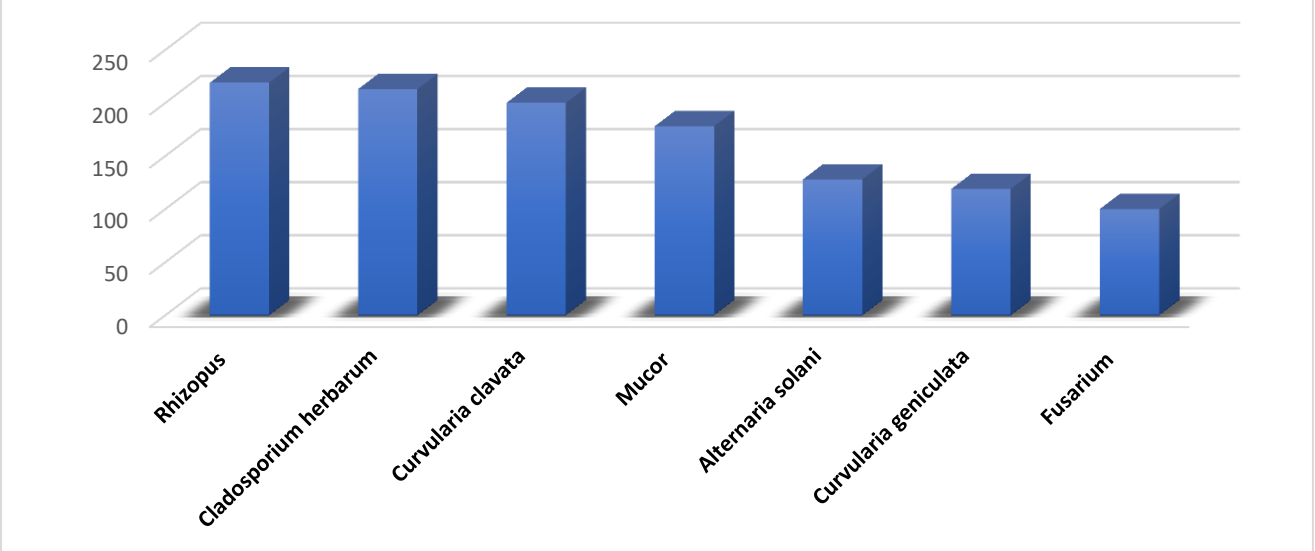


Figure 7. Average CFU counts of dominant fungi isolated from indoor environments of Geology laboratory

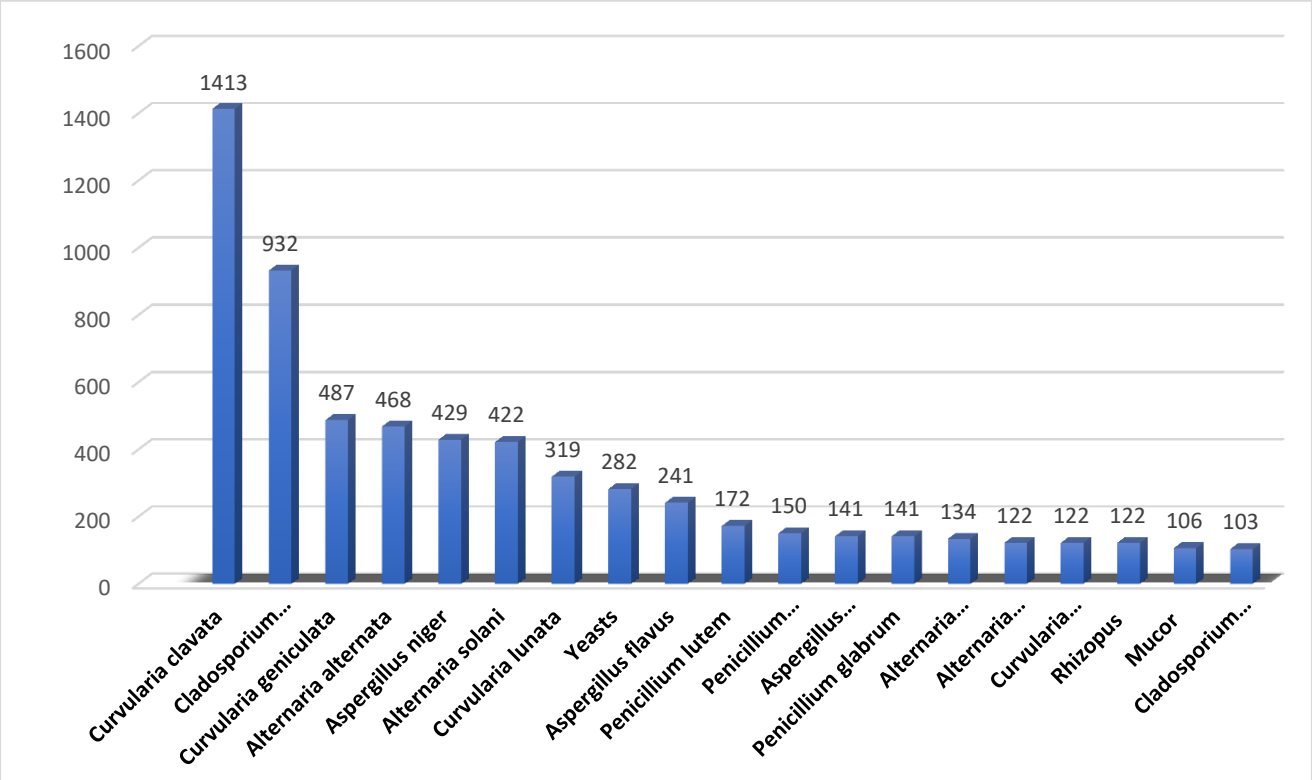


Figure 8. Average CFU counts of total dominant fungi isolated from indoor environments of college laboratories

IV. CONCLUSION

Curvularia clavata was found predominant species in all the studied indoor environments of college laboratories. Fungal spores may come from outdoor sources and also originate from indoor sources; due to this reason large number of fungi isolated from chemistry laboratory as compare to other laboratories. Since the chemistry laboratory have wooden framework and the others have concrete/brick structure. The maximum, minimum temperatures and relative humidity percentage were also found optimum for the growth of fungi in indoor niches. The building frame material greatly influenced the fungal concentrations of *Curvularia*, *Cladosporium*, *Alternaria*, *Aspergillus*, *Penicillium*, *Yeasts*, *Rhizopus* and *Mucor* were found higher in chemistry laboratory as compare to others, suggesting that the wooden framework provides the congenial environments to the growing fungi. Fungi isolated from Botany laboratory were recorded more as compare to Zoology and Geology laboratory; it might be due to variety of plant materials were used in regular practicals of undergraduate and graduate classes. Since, the fungal spores might be airborne from various plant materials and also coming from outdoor and indoor sources. Most of fungal genera were isolated from indoor environments of laboratories counted 550 to 700 CFU/m^3 and are regarded as contaminated rooms, while those with CFU/m^3 greater than 700 were regarded as highly contaminated. Further study needs to evaluate the allergenicity of fungal types isolated from indoor environments of college laboratories. All these findings will contribute to the well-being of many allergic, immunocompromised students, non-teaching and teaching staff members who spend their maximum time in laboratories.

COMPETING INTERESTS

The author has no competing interests.

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