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Original Article

Diversity and Distribution Patterns of Culturable Airborne Fungi in Jiroft City

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ABSTRACT

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Background and Aims: Fungal spores constitute a significant portion of primary biological aerosol particles, and large amounts have been identified in the air. They are present in the atmosphere throughout the year, and their concentration varies due to meteorological factors such as temperature, relative humidity, location, construction conditions, and vegetation. Exposure to airborne fungi has been linked with diseases such as allergic respiratory symptoms, rhinitis, asthma, and various infections. This study investigates the diversity and distribution of airborne fungal spores in Jiroft City, located in the southern region of Iran.

Materials and Methods: Airborne fungal composition was sampled from indoor, outdoor, and hospital air using the sedimentation plate method. Grown fungi were identified using standard mycological techniques, including determining macroscopic and microscopic characteristics.

Results: A total of 230 colonies belonging to 11 genera of fungi were isolated from all culture media. Fungi were isolated from 53 (80.3%) samples. The highest and lowest percent of positive samples were found in outdoor (100%) and hospital (64.3%) air samples, respectively. *Cladosporium* (43.9%) and *Aspergillus* (36.4%) were the most common fungi isolated from the samples. *Rhodotorula*, *Syncephalastrum*, *Paecilomyces*, *Mucor*, and *Acremonium* were the least isolated fungi (1.5%).

Conclusion: This study showed the difference in the diversity and distribution of fungi in different environments. *Cladosporium* and *Aspergillus* were the most common fungi isolated, which need to be considered due to their ability to cause various diseases.

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Introduction

Fungi are eukaryotic, non-chlorophyllous, and heterotrophic microorganisms that depend entirely on external nutrients for survival [1]. Fungal spores are everywhere in nature [2]. Fungal spores can be passively released from natural and anthropogenic sources [3]. Air is an important channel for the transporting and dispersal of biological particles such as fungi [4]. Most spores are released into the air and remain for some time before being transported over different distances (short or long). Fungal spores can be aerosolized from the surfaces of their colonies by rainwater drops and transported over short distances. Spores are carried by wind over long distances. Forests, green spaces, and decaying plant material are the primary sources of airborne fungal spores [1]. Fungal spores can cause various human, animal, and plant diseases [2]. For example, humans can cause infection, autoimmune reactions, and allergies such as allergic bronchopulmonary aspergillosis, severe asthma with fungal sensitization, and allergic fungal rhinosinusitis [2, 5]. The size of fungal spores determines the depth of their penetration and deposition in the human respiratory system, which seriously affects health [4]. Tiny spores can penetrate the alveolar region during inhalation, whereas large spores are deposited in the nasopharynx [6]. The abundance of spores in the air can be affected by geographical location, weather, use of fungicides, season, and time of day [4,7,8]. Interest in fungal spores has been increasing in recent decades [1]. Due to the potential risks of airborne fungal spores to human health and other organisms, it is necessary to regularly monitor the presence and diversity of fungal spores in the atmosphere [4, 9]. Several studies have investigated airborne fungi in various parts of the world and reported different results [9-11]. So far, a comprehensive study has not been conducted on airborne fungi in Jiroft city. Therefore, this study was carried out to investigate the diversity and distribution patterns of airborne fungi in Jiroft city in the south of Iran.

Materials and Methods

The present study was conducted in the spring of 2023 at Jiroft University of Medical Sciences. Jiroft is located approximately 1375 kilometers from Tehran at 690 m above sea level. This study collected fourteen air samples from the hospital, forty-two indoor samples (14 kitchen air samples, 14 hall air samples, 14 bathroom air samples), and 10 outdoor samples. The open plate sedimentation method was used to collect the samples. This way, plates containing Sabouraud dextrose agar (SDA) were opened for at least two minutes. Then, the plates were sealed, transferred to the mycology laboratory, and incubated at 27 °C. Cultures were periodically examined for fungal growth. The number of grown colonies was recorded. Grown fungi were identified using standard mycological techniques, including determining macroscopic and microscopic characteristics.

Statistical analysis

Data were analyzed using descriptive statistics and a one-sample t-test. All statistical analyses were performed in SPSS (version 16) and at a significance of 0.05.

Results

In this study, a total of sixty-six air samples were collected. Fungi were isolated from 53 (80.3%) samples. The highest and lowest percent of positive samples were found in outdoor (100%) and hospital (64.3%) air samples, respectively (Fig. 1). A total of 230 colonies were isolated from all culture media. The highest and lowest percent of isolated colonies were from indoors (53%) and hospital (12.2%), respectively (Fig. 2). The number of colonies isolated from the hospital was significantly less than the colonies isolated from outdoors and indoors ($p = 0.000$). The number of colonies recovered from the hall air samples was significantly less than those recovered from the kitchen air samples ($p = 0.004$). The number of colonies recovered from the bathroom air samples was significantly less than those recovered from the kitchen air samples ($p = 0.04$). No significant difference was observed between the number of colonies isolated from the bathroom and hall ($p > 0.05$). The number of colonies recovered from the bathroom and hall air samples was significantly less than those isolated from outdoor ($p = 0.000$). No significant difference was observed between the number of colonies isolated from the kitchen and outdoor air samples ($p = 0.2$). A total of eleven fungal genera were identified. *Cladosporium* (43.9%) and *Aspergillus* (36.4%) were the most common fungi isolated from the samples. *Rhodotorula*, *Syncephalastrum*, *Paecilomyces*, *Mucor*, and *Acremonium* were the least isolated fungi (1.5%). *Penicillium*, *Bipolaris*, *Alternaria*, and *Rhizopus* were other isolated fungi genera. In this study, some yeasts and some unrecognizable fungi were isolated (Table 1).

Table 1. Diversity, absolute and relative abundance of fungal genera recovered from the air of Jiroft city

Fungus	Outdoor N(%)	Hospital N(%)	Hall N(%)	Bathroom N(%)	Kitchen N(%)	Total N(%)
Cladosporium	5(17.23%)	5(17.23%)	6(20.7%)	6(20.7%)	7(24.1%)	29(100%)
Aspergillus	7(29.2%)	3(12.5%)	5(20.8%)	6(25%)	3(12.5%)	24(100%)
Alternaria	3(21.4%)	2(14.3%)	2(14.3%)	4(28.6%)	3(21.4%)	14(100%)
Unrecognizable	1(7.6%)	2(15.4%)	4(30.8%)	2(15.4%)	4(30.8%)	13(100%)
Penicillium	1(25%)	2(50%)	0(0%)	1(25%)	0(0%)	4(100%)
Yeasts	0(0%)	1(25%)	0(0%)	1(25%)	2(50%)	4(100%)
Bipolaris	1(33.3%)	1(33.3%)	0(0%)	0(0%)	1(33.3%)	4(100%)
Rhizopus	1(50%)	0(0%)	1(50%)	0(0%)	0(0%)	2(100%)
Rhodotorula	0(0%)	0(0%)	0(0%)	0(0%)	1(100%)	1(100%)
Syncephalastrum	0(0%)	1(100%)	0(0%)	0(0%)	0(0%)	1(100%)
Paecilomyces	0(0%)	0(0%)	0(0%)	0(0%)	1(100%)	1(100%)
Mucor	0(0%)	0(0%)	0(0%)	1(100%)	0(0%)	1(100%)
Acremonium	0(0%)	0(0%)	0(0%)	0(0%)	1(100%)	1(100%)

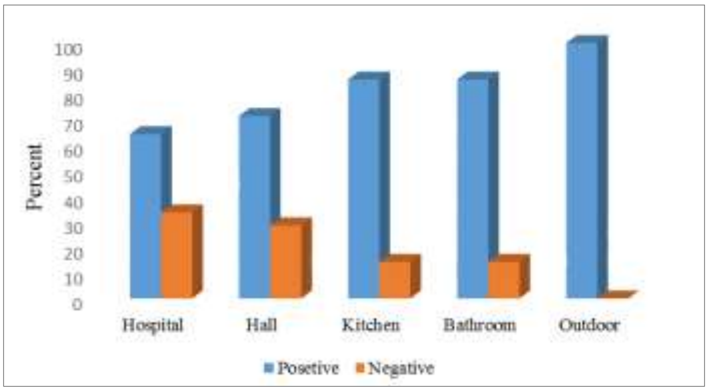

Fig. 1. Relative frequency of positive air samples in Jiroft city

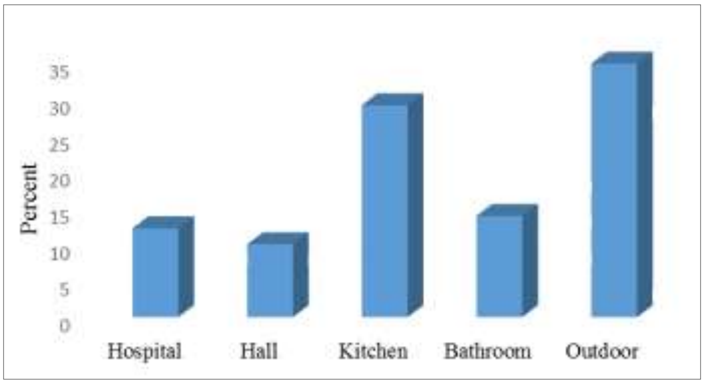

Fig. 2. Relative abundance of isolated colonies from air samples in Jiroft city

Discussion

It seems that this is the first comprehensive study that investigated culturable airborne fungi in Jiroft city. The present study isolated fungi from 80.3% of air samples. The difficulty of some fungi growing in artificial mediums and the need for some particular nutrients may be the reason for the negative effects of some media [12, 13]. The highest and lowest percent of positive samples were found in outdoor and hospital air samples, respectively. Many different nutrient sources outdoors, such as different types of plants, trees, and grasses, can cause various fungi to grow [14]. The type of building materials, ventilation, humidity control, special cleaning, the absence of flowers and plants in the hospital's interior, and the restriction of different people entering the hospital may be among the reasons for the low percentage of positive samples of hospital air. In the current study, the highest and lowest percent of isolated colonies were from indoor and hospital, respectively. Some indoor fungal spores originate from persistent moisture in household structures; most have an outdoor source [14, 15]. Sometimes, it is impossible to accurately determine whether airborne spores have an internal origin or are imported from outdoors. The present study allowed us to identify 11 genera from airborne spores that constitute part of the environmental mycobiota of Jiroft City.

Cladosporium and *Aspergillus* were the most common fungal genera isolated in all locations. These two fungal genera were also among the dominant fungi in other studies such as Kamali et al. [11], Shams-Ghahfarokhi et al. [15], Sepahvand et al. [16] and Garcia-Cruz et al. [17] studies. Although in some of the studies mentioned above [11, 16], *Penicillium* was also among the dominant fungi, this fungus was not significantly prevalent in our study. *Alternaria* was also significantly prevalent in the current study, consistent with the results of Sepahvand et al. [16] and Garcia-Cruz et al. [17]. However, it was inconsistent with the result of Shams-Ghahfarokhi et al. [15] study. The difference in the results of different studies can be related to the geographical region, the method of experimenting, the technician's skill in identifying fungi, temperature, humidity, vegetation, human and animal population, and the type of building materials. Air exposure to fungal material can significantly affect the health of individuals in a specific environment, especially in hospitals. Several fungi, like *Aspergillus*, *Penicillium*, *Cladosporium*, *Alternaria*, and *Fusarium*, are highlighted in the air quality of hospitals. The present study recovered *Cladosporium*, *Aspergillus*, *Penicillium*, and *Alternaria* from hospital air samples. *Cladosporium* involves fungi with wide distribution around the world, and the existence of this fungus has been confirmed in the literature as one of the most common fungi in hospital air and indoor air [18]. *Cladosporium* is aero-allergenic and can cause sinusitis, lung infections, severe allergic reactions in the respiratory tract, and intrabronchial lesions [19]. *Alternaria* is an outdoor fungus that spreads its spores in warm and dry weather. However, it can also be found in damp and poorly ventilated houses [20]. In our study, the highest number of *Alternaria* was isolated from the bathroom. The presence of *Alternaria* in hospital air samples has been mentioned [21]. The genus *Alternaria*, like *Cladosporium*, is often associated with allergic respiratory diseases [20]. In the present study, *Aspergillus* was the second most common fungus isolated from air samples. The fungus can cause various respiratory allergic symptoms and infections in immunocompromised and non-immunocompromised individuals [9, 22]. *Penicillium* was another fungus isolated in the present study. This fungus is important in producing various allergens, toxins, and volatile organic compounds [18, 23, 24]. In the present study, 13 colonies could not be identified due to the production of sterile mycelium and the lack of production of sporulation apparatus, as well as the indiscernibility of some conidia under a light microscope. *Rhodotorula*, *Syncephalastrum*, *Paecilomyces*, *Mucor*, *Rhizopus*, and *Acremonium* were other fungi isolated from air samples that do not seem to play an essential role in air quality due to their low prevalence.

Conclusion

This study elucidated the highly diverse community of airborne fungi in hospital, indoor, and outdoor air samples of Jiroft city in south Iran**.** In addition, this study showed the difference in the distribution of fungi in different environments and provided a baseline for future research on the air quality of this city. In addition, the results of this study can help evaluate potential health risks, especially in susceptible and immuno-compromised individuals. In this study, *Cladosporium* and *Aspergillus* were the most common fungi isolated, which need to be considered due to their ability to cause various diseases.

Ethical Consideration

Not applicable.

Funding

No financial interests are involved.

Conflict of Interest

The authors declare that there is no conflict of interest.

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Authors' Contributions

Convincing and designing: M.K and M.T; collecting the data: M.K and M.T; analysis tools: M.K and M.T; performing the analysis: M.K and M.T; writing the article: M.K and M.T.

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