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Indoor fungal contamination as a biological risk factor

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Abstract

Aim. To assess the degree of fungal contamination and the species composition of the fungal microbiota of residential apartments in Kazan

Methods. A mycological study of 90 air samples and 60 samples from sites of fungal biodeterioration from the residential buildings of Kazan was carried out using cultural and microscopic methods.

Results. The presence of micromycetes fungi were detected in 90% of air samples and 100% of samples from sites of biodeterioration. Higher fungal species diversity was noted in the sites, compared with air samples. Fungal concentrations in indoor air varied between 8 and 360 CFU/m^3. Fungal community composition analysis of the sites of biodeterioration showed that the surfaces were more frequently contaminated by undemanding and capable of growth at different moisture levels fungal species (*Penicillium spp*., *Aspergillus spp*., *Rhizopus stolonifer*). The resulting fungal plaque can create conditions favorable for aggressive fungal species that actively damage materials (*Chaetomium spp*., *Acremonium spp*., *Aureubasidium spp*). Allergenic fungi, as well as potentially pathogenic and toxin-forming species, were widespread in the air that can be a health risk factor. A quantitative assessment of air mycobiota indicated the moderate level of fungal contamination.

Conclusion. The presence of potentially pathogenic, allergenic and biodegradable fungal species in the sites of biodeterioration has been confirmed, as well as the relationship between airborne fungal contamination and the spread of fungi in indoors, confirming the need to prevent fungal biodeterioration and control indoor air quality.

Keywords: fungal contamination, micromycetes, mycobiota, biodestructive fungi, biodeterioration.

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Background

Mycogenic contamination of the modern urban environment, or the spread of microscopic fungi in the human environment, has become an important biological risk factor within the last few years. According to the World Health Organization, exposure to microbiological pollutants, particularly fungi, can contribute to a wide range of health disorders, including respiratory disorders, asthma, allergies, and other pathological immune system reactions [1].

Microscopic fungi (micromycetes), whose natural reservoir is soil, are always present everywhere in a person's surrounding environment [2]. They are present on the surface of various structures, and they colonize agricultural, pharmaceutical, and cosmetic products. Their spores move easily with windblasts, allowing them to enter the human body during respiration. At the same time, some fungi can have pathogenic, toxic, and allergenic qualities that are dangerous for human health [2–4]. Many types of fungi have all these qualities and, in addition, are able to colonize and assimilate various substrates, causing their biodegradation. Such processes, called fungal biodegradation, not only cause significant damage to the economy, but also can significantly affect human health.

An important biological risk factor is the complex nature of exposure to fungal spores and their metabolites. Such exposure contributes to the appearance and aggravation of respiratory symptoms and mycoallergoses [1, 5]. Prolonged exposure to even low concentrations of mycotoxins and other fungal metabolites can lead to systemic disorders,

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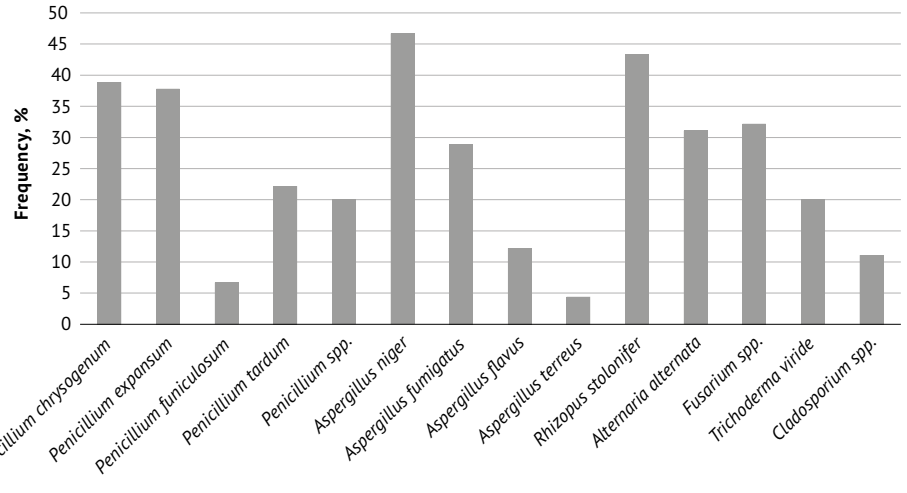

Fig. 1. Frequency of fungi micromycetes in the air of homes in Kazan (% of the total number of air samples)

including those of the reproductive system [6], and may also have cytotoxic and neurotoxic effects [7, 8].

In addition, air contamination by fungal spores, and the probability of the contact with micromycetes, increases the risk of fungal infections, especially among people with impaired immune systems and populations with increased vulnerability due to health or age [9]. For these reasons, research on mycogenic contamination remains very relevant [10–13].

In the modern urban environment, when a person is indoors up to 80%–100% of the time, the most acute problem is mycogenic air contamination [11–13]. The source of this contamination is not limited to atmospheric air polluted with fungal spores; it can also include ventilation and air conditioning systems, as well as nodules of fungal biodegradation presenting in the rooms [1, 5, 13].

Aim

In this regard, the aim of this work was to assess the level of mycogenic contamination and the species composition of fungal microbiota in homes of Kazan.

Materials and methods

Thirty homes were surveyed where 90 air samples were taken. The surveyed homes included brick (33.3%, n = 10), panel (60%, n = 18) and solid-brick (6.7%, n = 2) buildings constructed from 2000 to 2018. There are 11 (36.7%) apartments on the upper floors, 13 (43.3%) on the middle floors, and six (20%) apartments on the ground floor. Sampling was carried out by sedimentation and aspiration methods using a PU-1B sampler and Saburo and Chapek–DOX media. The sample volume is 250 L.

At the same time, visual assessment of the presence of nodules of a fungal biodeterioration and sampling of the nodules using smears and scrapes were made. Sixty samples were taken. A culture study of all selected samples was conducted. Seeding of the samples was conducted on Wednesday using Saburo. They cultivated at 28°C±2°C for 7–16 days. Fungi were identified using classical methods based on cultural and morphological characteristics [14, 15].

Statistical processing of the obtained results was made using the Microsoft Office application package. The average values (M) and the standard error of the average (m) were determined. To assess the prevalence of microorganisms in the studied samples, the frequency of microorganisms (P) was calculated, i.e., the ratio of positive samples for the content of this type of microorganism to the total number of samples studied, expressed as a percentage.

Results and discussion

The presence of fungi micromycetes was detected in all the surveyed homes. The total number of positive samples was 81 (90%). Analysis of the species composition showed the predominance of *Penicillum* and *Aspergillus* in the air of apartments, with various representatives of the genera. Other species identified included *Rhizopus stolonifer*, *Alternaria alternate,* and *Fusarium spp.* (Fig. 1). At the same time, the majority of samples (83.3%, n=75) showed the presence of mixed mycobiota, which included representatives of several genera or several species of the same genus. It should be noted that most of the identified fungi species have expressed allergenic qualities, contributing to the development of mycoallergoses [16, 17].

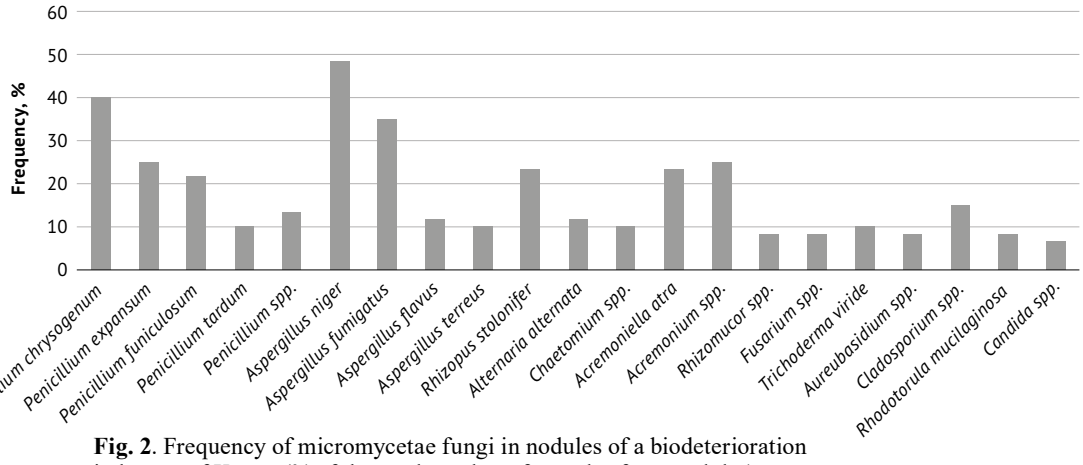

Fig. 2. Frequency of micromycetae fungi in nodules of a biodeterioration in homes of Kazan (% of the total number of samples from nodules)

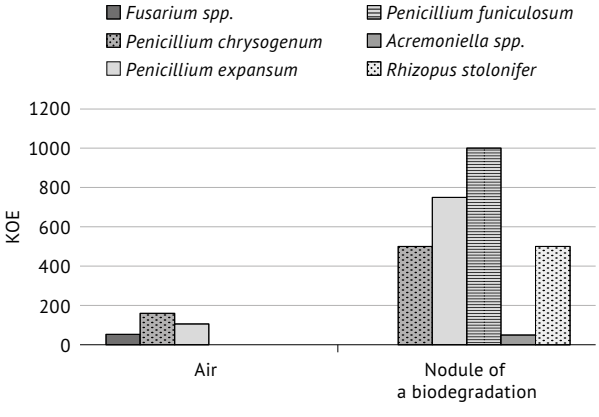

Fig. 3. Comparison of the qualitative and quantitative composition of air mycobiota (colony forming units, CFU/m3) and the nodule of a biodegradation (CFU/dm2).

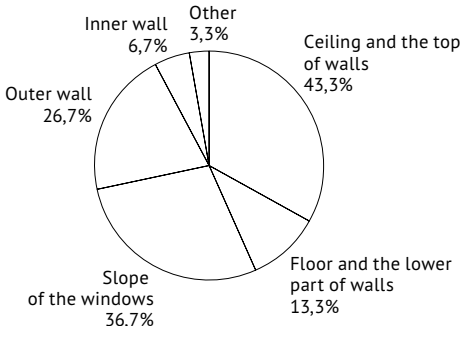

Fig. 4. Localization of nodules of a fungal biodegradation (% of the number of surveyed homes)

The number of fungi in the air of the homes varied from 8 to 360 colony forming units (CFU) per m^3, which does not exceed the values that are recommended as the threshold of the relative norm (500 CFU/m^3) [1]. However, it was noted that in rooms with nodules of fungal biodeterioration of a large area, the number of fungi in the air was higher on average than in rooms with local limited nodules (252 ± 36 and 184 ± 29 CFU/m^3, accordingly).

The high frequency of detection of allergenic fungi in the air indicates a potential health risk for people who stay in these homes for a long time. In addition, *A. flavus, A. fumigatus,* and some *Fusarium* species have toxin-forming qualities [3], which can also contribute to a reduction in air quality.

Analysis of the results of the study of samples from the nodules of a biodeterioration confirmed the presence of fungi in 100% of cases. The species composition of fungi detected in the nodules was much broader than in air samples and significantly different (Fig. 2).

Analysis of the species composition of the fungal microbiota in the nodules of a biodeterioration showed that contamination is most often present on the surface of the nodules of a biodeterioration, and includes fungi species that are able to grow at different levels of humidity (*Penicillium spp., Aspergillus spp., Rhizopus stolonifer*). The resulting fungal plaque can create favorable conditions for more aggressive fungi that actively damage materials (*Chaetomium spp., Acremonium spp., Aureubasidium spp.*) [18].

The nodule of a fungal biodegradation formed in these conditions is characterized by a higher mycogenic air contamination (on average 1.4 times) in rooms with an extensive nodule of a fungal biodegradation, and also the presence of the same types of fungi on visually safe sections of walls in the surveyed room, including representatives of various genera. Along with active biodestructors, the presence of species similar to those found in the air samples was noted in the composition detected on the surface of the nodules of a biodegradation.

The typical ratio of the composition of air mycobiota and the nodule of a biodegradation is shown in Fig. 3. The detection of an increased mycogenic air contamination (on average 1.4 times) in rooms with extensive foci of fungal biodeterioration, and presence of the same types of fungi as in the air on visually intact areas of the walls, enables to assume a relationship between mycogenic air contamination and the spread of fungi in the buildings.

According to literature data, the factors contributing to the development of nodule of a fungal biodegradation in homes are increased humidity, limited air exchange, and violation of thermal insulation. In our study, the nodules of a biodegradation were located mostly on the slopes of windows, external walls, and ceilings of apartments located on the upper floors (Fig. 4). In some cases, the occurrence of nodules of a biodegradation was caused by accidents of heat supply systems, water, or sewerage systems.

Conclusion

1. The conducted research confirmed the presence of micromycetae fungi in the air of all surveyed homes with a predominance of species that have allergenic properties. Quantitative assessment of air mycobiota characterized the level of a detected mycogenic contamination as moderate.

2. A large variety of mycobiota species was detected in the nodules of a biodegradation, including potentially pathogenic and allergenic fungi species. The presence of species with expressed biodegradable qualities, as well as species similar to the composition of air mycobiota, in the nodules of a biodegradation has been confirmed. At the same time, in rooms with large areas of a biodegradation, a greater number of fungi were observed in the air.

Authors' contributions. E.V.H.—the analysis and processing of the results, writing an article, a manager of the study; N.I.G. и S.A.L.—realization of the research, the analysis of the results; V.R.P. и G.G.H.—collecting of the material, making the research.

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Conflict of interest. The authors declare no conflict of interest.

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