ISSN 1392–1320 MATERIALS SCIENCE (MEDŽIAGOTYRA). Vol. 13, No. 1. 2007

Microbiological Destruction of Constructional and Decoration Materials of Buildings

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Received 05 September 2006; accepted 07 November 2006

Factors stimulating the development and spread of micromycetes in buildings used for different purposes were investigated. A variety of materials are used for reconstruction and building: timber, shied-shaped assembled houses, air-entrained concentrate, other local materials, monolithic (expanded clay concrete) houses, large-slab houses, silicate bricks, ceramic building bricks, including special front trim (clinker, restoration, etc.). Resistance of the construction materials to biological factors is not evaluated; the interest is raised only when some concrete damage is encountered. Dampness in buildings is a common reason for a variety of health symptoms in the inhabitants. From inside walls of such buildings the fungi of the *Aspergillus* genus, mostly *A. fumigatus, A. niger*, *A. penicillioides* less frequently of other species were isolated. They are active producers of various metabolites, able to participate in decay processes of various materials. Conditionally pathogenic fungi were found in all the buildings investigated. Their abundance and the variety of species depended on the physical condition of the buildings, their age and the nature of the specific activities which were carried out in them.
Keywords: buildings, materials, fungi, destruction, human health.

INTRODUCTION

Newly built, reconstructed and many times repaired blocks of flats get damp and start to mold due to different reasons. Walls and ceilings of newly built or recently repaired flats become damp as a consequence of various overflows [1 – 3]. In one such flat an increased contamination with micromycete propagules formed as a result of flooding; the ceiling got damp and micromycetes started developing, their spores started to spread in the environment. The patches formed on the ceiling and they were increasing in size. A small break of a pipe and water leakage was revealed one floor higher. Under conditions of sufficient humidity micromycetes form colonies and conidiophores, conidia and other organs, spread in the environment as propagules (cfu) and gradually with dust settle of various objects. With airflow they enter all the premises, contaminate the air, settle on various objects and get into food. Some allergic people are sensitive to this contamination. Fungi recorded in these premises are not evident pathogens, but they could not be considered safe either, especially those of the *Aspergillus, Penicillium, Cladosporium* genera because literature sources [4 – 6] name them as possible agents of respiratory and other diseases [7 – 9].

Occupants of newly built blocks of flats sometimes realize the presence of excess humidity and mold odor as well as coating and stains on walls and ceilings after they have moved in. In the air of such flats low amount of micromycete propagules is determined. Bacteria and yeasts comprise the majority of the recorded microorganisms [10 – 12].

The aim of this study was to investigate the concentrations and species of fungi on different materials which are used for built and decoration, to determine their sensitivity to various external factors and chemical substances; to elucidate the hazard of the detected fungi to human health, especially respiration diseases and allergy.

MATERIALS AND METHODS

For the research, buildings of different destination of the Vilnius were chosen. A variety of materials are used for reconstruction and building: timber, shied-shaped assembled houses, air-entrained concentrate, other local materials, monolithic (expanded clay concrete) houses, large-slab houses, silicate bricks, ceramic building bricks, including special front trim (clinker, restoration, etc.). Laboratory samples for microbiological investigations were taken in the following ways: a slit-to-agar single stage impactor "Krotov 818" was used for the total airborne fungal spore sampling. At the same time the settle plate method for the direct isolation of fungi was carried out [6, 13].

RESULTS AND DISCUSSION

Under local climatic conditions, conditionally hazardous micromycetes recorded in new flats are widely distributed in the environment. Therefore, their penetration into the flats is predetermined by many factors. Further mycological condition of the flats depends upon their exploitation. Builders should regard the resistance towards microorganisms of construction materials used for inside decoration as well as their transporting and storing before use so that materials would be the least infected with microorganisms present in the environment.

While repairing many residential houses, where flats are damp due to various reasons, most important sources of humidity penetration are often neglected: leaking roofs, cracked blocks, crumbled bricks, decayed adhesive materials, improper rain-pipes. For routine repairs the materials not resistant to microbiological infection are often employed: oil paint and

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emulsion paint, various kinds of facing, Bustilat glue, plywood, various plasters, insulation materials (Fig. 1), sometimes even old newspapers, floor planks, clinker. From such materials used in the repairs various micromycetes were isolated: from paint – *Aspergillus carbonarius*, *A. niger;* from emulsion paint – *Penicillium expansum*, *P. godlewskii*, *Penicillium spp*., *Phoma exiqua*; from carpeting – *Aspergillus niger*, *Paecilomyces variotii*, *Chaetomium globosum*, *Penicillium cyclopium;* from carpeting covered with Bustilat glue – *Aspergillus niger;* from plywood used in repairs – *Aspergillus niger, Cladosporium cladosporioides, Candida utilis, Trimmatostroma salicis*, *Botrytis cinerea, Penicillium aurantiogriseum*, *P. paxilli*, *Scytalidium lignicola*, *Chrysosporium merdarium*.

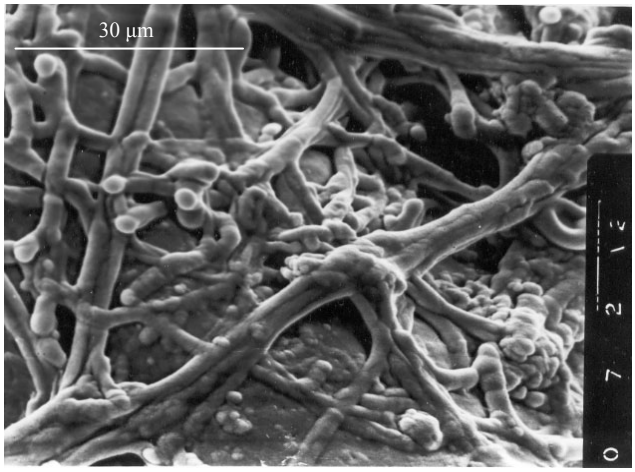

Fig. 1. Insulation material infected by micromycetes

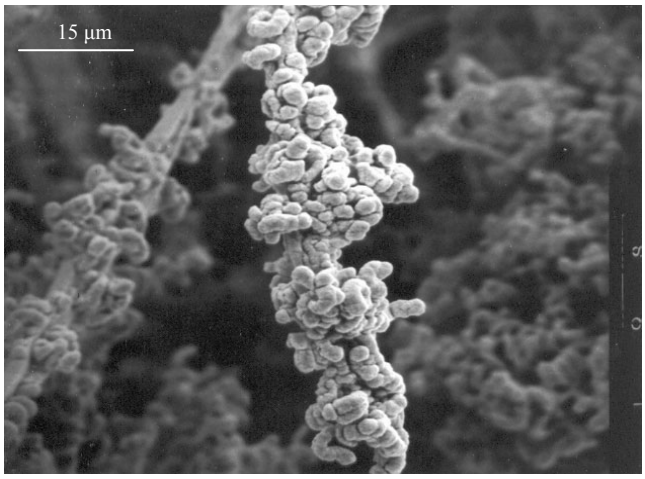

Fig. 2. Aureobasidium pullulans microscopic view

Micromycetes are especially abundant in plaster, particularly in seldom cleaned places, e.g. beneath the pipes. Beside the airflow in such places is limited and temperature is favorable for fungi development. Fifteen micromycete species were isolated: *Aureobasidium pullulans* (Fig. 2)*, Arthrinium phaeospermum, Aspergillus candidus, A. niger, Botrytis cinerea, Cladosporium cladosporioides, C. herbarum, Penicillium chrysogenum, P. crustosum, P. verruculosum, Trichosporiella hyalina*. When newspaper has been used as an insulation material, *Penicillium* micromycetes dominated accompanied by *Trichoderma viride*, *Cladosporium herbarum, Sporotrichum aurantiacum, Acladium spp, Geomyces pannorum* and *Candida utilis* fungi were isolated from clinker. *Aspergillus niger, Penicillium brevicompactum*, *P. aurantiogriseum*, *P. stoloniferum*, *Cladosporium cladosporioides* were isolated from concrete slabs. In all samples sterile mycelium *(Mycelia sterila)* was present.

It should be mentioned that at the moment of the research, the humidity of the object was not high – 58 %, and temperature – 17 °C, therefore majority of fungal propagules were dormant. The mycological condition of such building cannot be evaluated positively because high potential of mycological contamination is present and it can become evident if the humidity of the environment increases.

The air contamination with micromycete propagules in the new built flats did not exceed the allowable rates. The most undesirable in these premises are fungi of some *Aspergillus* and *Microsporum* genera. These fungi can be hazardous to the health of people, especially children. In the investigated flat the bedroom was mostly contaminated; 13 species of micromycetes, yeast-like fungi and yeasts as well as bacteria of 4 species were isolated from the walls. It is a serious warning to the occupants. The existing conditions should be immediately corrected. First of all, it is necessary to determine the rising dump in wall. In the air, dust, wall scrapings in this room the following micromycetes were determined: *Ulocladium oudemansii* (Fig. 3), *Alternaria alternata*, *Cladosporium herbarum, C. cladosporioides, Cryptococcus albidus*, *Penicillium paxilli, P. expansum. P. verrucosum, Aspergillus niger, Acremonium roseum, Candida albicans, Microsporum spp., Mycelia sterilia*. The disinfection of the wall should be started with the spraying of walls and the environment with fungicidal and bactericidal preparations, later the walls should be scraped and repeatedly treated with other preparation with analogous properties.

Sometimes on balcony walls and ceilings of new flats *Cladosporium herbarum, Ulocladium chartarum* and some *Penicillium* fungi develop.

Micromycetes often infect houses before people move in. It happens in warm rainy weather in summer when building materials not resistant to the action of micromycetes and other microorganisms get damp and the drying is slow due to high relative humidity. Due to humidity, temperature, dustiness, intensity of ventilation, movement of technical means and people and many other environmental factors, micromycetes start developing in the newly built flats. The coating appears on the walls and stains on the ceilings. In the research site in one of the newest precincts of Vilnius, micromycetes were isolated from plaster crump fallen from window frames, inside partitions made of gypsum blocks that are produced in Moldova by a certain Moldavian-German company, plaster, insulation material, construction foam, cardboard, various daub, brick wall from the inside and outside, various plastic coverings, various kinds of glues.

From inside walls made of gypsum blocks, which are not damp-proof and dampened before use, the following micromycetes were isolated: *Aspergillus chewalieri*, *Fusarium moniliforme*, *Penicillium expansum, P. fellutanum*, *Mycelia sterilia* (slowly growing tangle of white mycelium). These fungi were accompanied by slowly growing whitish bacteria. From the damp-proof gypsum blocks *Alternaria alternata, Acremonium charticola*, *Chaetomium crispatum*, *Mucor silvaticus*, *Paecilomyces variotii*, *Penicillium*

lanosocoeruleum, P. oxalicum, P. stoloniferum, P. variabile were isolated. The development of these fungi on gypsum blocks was somewhat suppressed by 3 times performed disinfection using dispersed aquatic suspension of H_2O_2. Considering the facts that construction work was in progress, technical means were working, elevators and other equipment were being installed, intensive movement of people was present it could be stated that general contamination of the block of flats with micromycete propagules did not exceed the recommended rates [14].

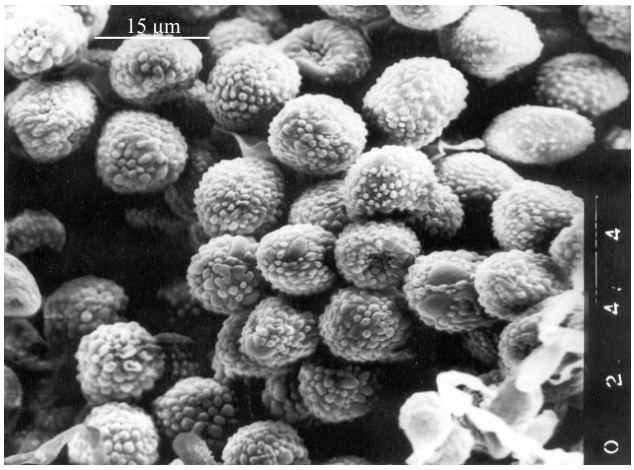

Fig. 3. Ulocladium oudemansii microscopic view

Analysis of the data obtained while investigating the contaminated buildings revealed the betterment of mycological condition due to changed weather and turned on heating. Then relative humidity in the flats reduces, blocks, plaster, and other materials began to dry, and, consequently, the contamination with micromycete propagules reduces. But propagules of *Alternaria alternata, Rhizopus stolonifer, Paecilomyces variotii, Aspergillus fumigatus* (Fig. 4)*, Penicillium stoloniferum, P. variabile* and other micromycetes conditionally hazardous to human health survive. These micromycetes were not abundant in the investigated flats, most frequently isolated in toilets, bathrooms, scrapings of corridor walls, i.e. places where humidity is higher and the ones hardly accessible for fungicidal substances sprayed in the premises.

Nothing could yet be stated about permanent contamination of new houses because this process is constantly progressing and changing. It could be only stated that certain building materials are not resistant towards the microorganism infection (daub, gypsum blocks) and increased humidity stimulates active development of microorganisms.

Laundry and bathhouse are established in a 19th century one-storey building that has been many times reconstructed. At the moment of investigation the walls were not infected by the microorganisms from outside. In some places, closer to the ground and where rain-pipes are in bad order, algae and lichens grow on the walls, but their growth is not intensive and causes no real danger to the building. The repair of roofs and rain-pipes can suppress or eliminate the development of biological objects. In order for outside walls to remain dry and to prevent the formation of favourable conditions for the development of microorganisms, algae, lichens and moss, the roof should be not flat, as it is at present, but sloping and extended so that rain and snow could not get on the walls.

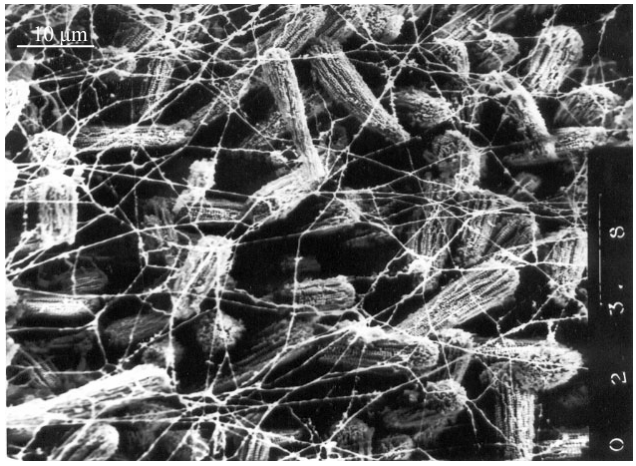

Fig. 4. Aspergillus fumigatus microscopic view

The mycological condition of the inside was bad; the building is rather neglected, dirty, walls in some places damp, flaking, moldy, plaster is crumbling. Wooden window-frames and door jambs are rotten, black. Under such conditions the mycological infection of the premises was rather evident. In the air of the former laundry the amount of micromycete propagules was 57.906 cfu m^{-3}, in showers – 13.797 cfu m^{-3}, in changing room – 5.984 cfu m^{-3}. In the air of all mentioned premises fungi of the *Cladosporium* genus prevailed, mostly *Cladosporium cladosporoides* and *C. herbarum.* In the premises of former laundry the propagules of these fungi comprised 96.8 %, in the changing room – 51.2 % of all isolated micromycetes. The fungi of these species can develop in a wide temperature range (from 0 °C to 40 °C). Optimum temperature for their development is about 25 °C. They are very resistant towards negative influence of the environment. They can survive under extreme conditions, penetrate into deeper layers of plaster and while growing and developing form small black blotches on plaster; part of them is submerged into substrate. Beside the mention *Cladosporium* fungi, from the infected places dark coloured *Ulocladium chartarum* fungi were also isolated; they cover the plaster surface with fuzzy, thin coating. On wall plaster *Penicillium* fungi, which are typical soil inhabitants in Lithuania, were abundant. They get inside with dust, are able to rapidly adapt, intensively destroy and assimilate various substances. High species diversity, ability to assimilate various substrates and survive under extreme conditions: at a low temperature, deficiency of nutrients, humidity and sometimes even air make these fungi rather hazardous destroyers of various substances under natural conditions of temperate maritime climate areas, especially when they develop in humid premises used by people.

From inside walls of the building the fungi of the *Aspergillus* genus, mostly *A. fumigatus, A. niger*, *A. penicillioides* less frequently of other species were isolated. They are active producers of various enzymes, able to participate in decay processes of various materials.

In the wall plaster damaged by fungi, the communities of micromycetes, yeast-like fungi and bacteria able to function

under unfavourable conditions of low temperature have formed. The vast majority of the isolated bacteria belong to the spore-producing ones, which are also rather resistant to unvafourable environmental factors. Humidity is a rather important factor limiting their development. At the moment of the investigation, relative humidity and especially temperature inside the building were not favourable for the development of some fungi; therefore the growth of some fungi was suppressed. Species diversity of the isolated micromycetes confirms that many fungal propagules have survived rather long in the suppressed condition under unfavourable conditions of the building. Under such conditions the development of yeast-like fungi and other micromycetes of similar functional properties is particularly intensive. Part of the recorded micromycetes of this group are ascribed to pathogens of the warm-blooded animals and humans and are considered as conditional parasites. *Microsporum*, *Candida*, *Chrysosporium*, *Exophiala*, *Arthroderma*, *Blastomyces*, *Acremonium*, *Hormonema*, *Trichophyton*, *Myceliophthora* etc. isolated from the laundry building are also ascribed to these fungi. The fungi of these genera get into the building of specific use with visitors at various times and from different places. Probably, their propagules had survived and as they got on malt extract and Sabouraud agar media they began their development, formed characteristic colonies and developed conidia.

Actinomycetes, which were also present in the premises, mostly belonged to the *Streptomyces* group. Their biological peculiarities allow the assimilation of various substances and sometimes even parasitising the warm-blooded. In the premises of a laundry and bathhouse, as they are established in the unsuitable building, the propagules of micromycetes and other microorganisms can survive and remain viable for a long time.

Each of the explored objects had quite a lot of wooden constructions: windowsills, floors, ledges of vaults and ornamental parts. Fifty-nine species of micromycetes were isolated from the surface of wooden constructions of old buildings. Taking into account that before its exploitation the wood was impregnated and processed with various fungicidal substances, different in each of the explored object, the composition of the micromycetes species found in there different substantially. A diversity of micromycetes species were found in the former boundary and bath-house building which is also to be renovated.

CONCLUSIONS

1. Presently for construction of buildings materials of very diverse chemical origin and composition are used. Part of them are susceptible to humidity and when damp become easily damaged by microorganisms. Generally indoor fungi are a mixture of those that have entered from outdoors and those from indoor sources.
2. Under climatic conditions of Lithuania, building and decoration materials are most frequently damaged by fungi of the *Penicillium, Aspergillus, Trichoderma, Phoma, Cladosporium, Scytalidium, Chrysogenum, Alternaria, Ulocladium, Verticillium* and other genera.
3. In order to preserve people-friendly microbiological conditions in industrial, occupational and dwelling premises their constant microbiological control is essential, especially in those where materials suitable for microorganism development are present or where relative humidity and temperature are higher. Construction materials used for inside decoration should be evaluated considering their resistance towards microorganisms.

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Presented at the National Conference "Materials Engineering'2006" (Kaunas, Lithuania, November 17, 2006)