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AIRBORNE FUNGI IN INDUSTRIAL ENVIRONMENTS - POTENTIAL AGENTS OF RESPIRATORY DISEASES

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Abstract: Investigations on airborne fungi in a poultry house, a swinery, a feed preparing and storing house, a grain mill, a wooden panel producing factory, and organic waste recycling facilities have been carried out in Lithuania. Low concentrations of fungal spores were detected in the wooden panel producing factory, the swinery, the feed preparing and storing house, and the poultry house; moderate concentrations were found in the organic waste recycling facilities; high concentrations were revealed at the grain mill. Species of *Aspergillus oryzae, A. nidulans, P. expansum, Penicillium olivinoviride, P. claviforme* and *Botryotrichum longibrachiatum* prevailed in the poultry farm; *Geotrichum candidum, Cladosporium cladosporioides, C. herbarum, Penicillium viridicatum* and *P. fellutanum* dominated in the swinery. Fungi of *Penicillium viridicatum, P. expansum, Staphylotrichum coccosporum* and *Aspergillus oryzae* prevailed in the feed preparing and storing house at the swinery. *Cladosporium cladosporioides, C. herbarum, Penicillium viridicatum* and *Geotrichum candidum* prevailed in the grain mill. Fungi ascribed as *Paecilomyces puntonii, Rhizopus nodosus* and *R. stolonifer* dominated in the wooden panel producing factory. Species of *Aspergillus raperi, P. paxilli, P. oxalicum,* and *Cladosporium herbarum* prevailed at the organic waste recycling facilities. According to published data, the majority of the identified fungal species are characterized as allergenic and an exposure to their spores may provoke adverse health effects (such as allergic rhinitis, bronchial asthma or extrinsic allergic alveolitis) in susceptible individuals.

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Key words: airborne fungi, poultry house, swinery, feed preparing and storing house, grain mill, wooden panel producing factory, organic waste recycling facilities.

INTRODUCTION

Filamentous fungi represent a large group of multicellular organisms naturally occurring in soil and various organic debris. Thus, high numbers of airborne fungi, along with other micro-organisms, solid particles and volatiles, are being aerosolised in industrial environments contaminated with organic materials. Industrial facilities, such as grain mills, sawmills, farms, barns, waste-recycling facilities, agricultural produce storehouses are widely known examples of such types of environments [10, 20, 26, 30]. There are numerous reports on health outcomes in occupants exposed to airborne micro-organisms and their biologically active products [1, 4, 6, 7, 8, 10, 20, 21, 23, 24, 27]. They may manifest as:

1) Mucous membrane irritation;

2) Immunotoxic diseases:

• organic dust toxic syndrome (synonyms: ODTS, inhalatin fever, grain fever, silo unloader's disease, toxic pneumonitis);

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• byssinosis;
• mycotoxicoses;
3) Allergic diseases:
• allergic alveolitis (synonyms: hypersensitivity pneumonitis, granulomatous pneumonitis);
• asthma;
• allergic rhinitis.

The objective of this study was a pilot investigation on airborne fungi in some of the industrial environments in Lithuania, and potential evaluation of possible risk of respiratory diseases in the occupants as a result of exposure to airborne fungi.

MATERIALS AND METHODS

Six industrial facilities located in Vilnius district, Lithuania, were chosen for the investigations on airborne fungi:

1. A poultry house. A building with layer hens kept in the cages, feed and water supply automated. Exhaustive ventilation was operating during taking the samples.

2. A swinery. A building where 1500 sows were confined. Feed and water supply automated, premises naturally ventilated during taking the samples.

3. A feed preparing and storing house at the swinery. Grain was milled; fodder was mixed and stored for different swine groups. Any activity was not performed during taking the samples.

4. A grain mill. Grain crashing shop equipped with modern grinding-mill. Winter rye grain was crashed during taking the samples.

5. A factory of wooden panel production. Workshop. Wood was sawn, planed off, wooden panels were stuck.

6. Organic waste recycling facilities. Remnants from public catering facilities and food production enterprises situated in Vilnius were recycled employing composting processes.

Four different techniques were applied for the airborne fungi trapping:

• air filtering through 47 mm cellulose membrane (Whatman plc, Kent, UK; pore size not specified) mounted on a plastic filter holder;
• solid plate impaction: slit-to-agar one stage Krotov 818 impactor (OJSC 'Krasnogvardeyec', Saint Petersburg, Russia, cut-off 0.50 µm);
• liquid impingement: AGI-30 all glass impinger (Ace Glass Inc., Vineland, N.J., USA; cut-off 0.31 µm);
• simultaneously, sedimentation method was applied.

Values, obtained by the settle plate method were considered to be inconsistent and are not provided. Filtering through the cellulose membrane and liquid impingement (into 20 ml of sterilized water) were performed at the flow rate of 0.001 m^3/min for 15 min. The Krotov 818 impactor was operated for 1 and 2 min at the flow rate 0.025 m^3/min. The exposure time for the sedimentation plates was 15 min [14, 31, 32]. After 3 prints onto the agar medium of each exposed cellulose filter, the filter itself was laid onto the agar medium for further incubation. 1 and 2 ml of the water from the impinger AGI-30 had been dispensed into sterile Petri plates and melted medium was poured over. A standard malt extract agar (DIFCO) and Sabouraud dextrose agar (BBL) media were used for fungi cultivation. Then the plates were incubated at 26 ± 2ºC, and after incubation the developed fungal colonies were counted after 3, 5, and 7 days. The concentrations of viable fungi were expressed as colony forming units per one cubic meter of the air (cfu/m^3). The obtained concentrations were regarded as low when values did not exceed 1×10^3 cfu/m^3; moderate - when values did not exceed 1×10^4 cfu/m^3; and high as values exceeded 1×10^4 cfu/m^3. For the identification of isolates, the purified fungal cultures were transferred onto malt extract, 'Czapek' and cornmeal agar media. Their cultural and morphological characteristics were studied employing light microscopy. Identification to the genus and/or species level was performed according to different manuals [5, 11, 12, 23, 25, 29, 33].

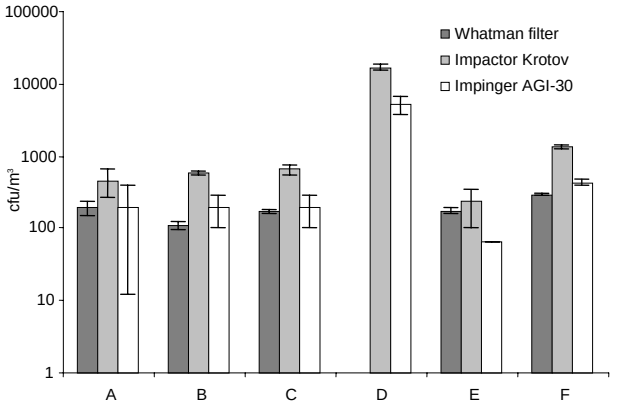

Figure 1. Concentrations of airborne fungi in the investigated industrial facilities (means and standard deviations): A - Poultry house; B - Swinery; C - Feed preparing and storing house; D - Grain mill; E - Wooden panel producing factory; F - Organic waste recycling facilities.

The obtained data were processed using Microsoft Excel XP and Statistica 5.1 software.

RESULTS AND DISCUSSION

Concentrations of airborne fungi. Concentrations of airborne fungi obtained by applying filtering through the cellulose membrane, solid impaction and liquid impingement techniques are presented in Figure 1. As can be seen, there are differences between the concentrations of airborne fungi at the same site and the same time, this probably depends on the method applied. The Krotov 818 impactor proved to be the most efficient in collecting viable fungal spores. The values obtained by this method were considerably higher compared to that obtained by liquid impingement in the swinery, the feed preparing and storing house, the grain mill, and the organic waste recycling facilities ($p < 0.05$). This is probably because of the principle of solid impaction technique ensuring minimum losses of airborne particles, as there is no need of subsequent plating procedures. According to published

data, over-representation of the airborne fungi is a characteristic of liquid impingement because of the splitting up fungal mycelium or conidia aggregates in the liquid when operating [15].

The maximum concentrations of airborne fungi - 1.7×10^4 cfu/m^3 - were detected at the grain mill during rye grain crushing. According to the data obtained by other authors, concentrations of viable fungi during grain milling vary within the range of 1.0–2.7×10^5 cfu/m^3 [10, 30]. The values obtained by using the impinger AGI-30 were at least 3 fold lower compared to that obtained by using the impactor. The maximum detected value was 5.2×10^3 cfu/m^3. None of the data obtained by filtering air through the membrane at the grain mill is presented in Figure 1, because fungal overgrowth did not allow counting developed colonies.

The concentrations of airborne fungi were moderate at the poultry house, swinery, the feed processing and storing house, with the values not exceeding 1×10^3 cfu/m^3; and only in the organic waste recycling facilities concentrations were as high as 1.3×10^3 cfu/m^3 when based on the results of the solid impaction. The lowest concentrations of airborne fungi were detected at the wooden panel producing factory (maximum 2.3×10^1 cfu/m^3), although the activities at the production shop were being carried out during taking the samples.

The results obtained show that the air at the investigated industrial environments was not heavily loaded with fungi. Increased concentrations of airborne fungi were detected in the grain mill only during rye grain crushing.

Species diversity

Grain mill. Forty-nine species ascribed to 20 fungal genera were isolated and identified from the air at the grain mill. Species from the genera of *Penicillium* Link, *Aspergillus* P. Micheli., *Mortierella* Coem., and *Mucor* P. Micheli. made up a vast majority of the identified isolates. Single species attributed to the genera of *Absidia* Tiegh., *Acremonium* Link ex Fr., *Alternaria* Nees ex Fr., *Cladosporium* Link ex Fr., *Cochliobolus* Drechsler, *Dendrodochium* Bonord., *Fusarium* Link ex Fr., *Geotrichum* Link ex Fr., *Oidiodendron* Robak, *Olpitrichum* G. F. Atk., *Phoma* Sacc., *Rhizopus* Ehrenb., *Spegazzinia* Sacc., and *Torula* Pers. ex Fr. were also encountered. Isolates of *Cladosporium cladosporioides* and *Penicillium viridicatum* prevailed among all the identified fungi and made up 17.0% and 11.5% respectively (Tab. 1). Fungi of *C. herbarum* species made up 8.9%, the others were presented by single isolates.

Ten species were isolated and identified from the genus *Aspergillus*, with species *A. candidus*, *A. oryzae* and *A. versicolor* predominating among them (4.7, 3.4 and 2.1% respectively). According to published data, the inhalation of large amounts of the *Aspergillus candidus* spores caused Organic Dust Toxic Syndrome in a group of Polish students after shovelling grain [8]. *A. versicolor* was identified as a cause of allergic alveolitis [21]. Single isolates of opportunistic pathogens *Aspergillus fumigatus*, *A. niger*, and *A. flavus* were also detected in the air at the grain mill.

Other investigators have reported *Cladosporium* and *Alternaria* genera fungi as being among dominant species in freshly harvested grain. During the grain storage process, the changes in fungi species composition occur and isolates from the genera of *Aspergillus*, *Penicillium*, and *Eurotium* become prevalent in the grain [27]. All these fungi have proved to be causative agents of fungal allergy [1, 23].

The class of Zygomycetes was represented by fungi from the genera of *Absidia*, *Mortierella*, *Mucor*, *Rhizomucor* and *Rhizopus*, with no evident dominants among them. Single isolates from the genus *Fusarium* identified as *Fusarium moniliforme* and *F. oxysporum* were detected in the grain mill air.

Poultry house. Thirty-one species attributed to 13 fungal genera were isolated from the poultry house air. Overall, 6 species ascribed to the genus *Aspergillus* were isolated and identified, species *Aspergillus oryzae* and *A. nidulans* prevailed and made up 15.1 and 9.7% of all the identified isolates, respectively. *Penicillium* genus fungi were represented by 12 species. *Penicillium expansum*, *P. olivinoviride*, *P. claviforme*, and *P. viridicatum* prevailed among them. *Rhizopus oryzae*, *R. stolonifer* and *R. nodosus* species fungi - agents of zygomycosis were also isolated. Keratinophylic fungus *Trichophyton mentagrophytes* var. *gypseum* were isolated from the poultry house air. This fungus may be a cause of dermatophytosis in farm workers [28].

According to the data obtained by other authors, fungi from the genera of *Penicillium* and *Cladosporium* have been prevalent in poultry houses. Fungi *Scopulariopsis* and *Aspergillus* were also listed among them [13]. Presence of opportunistic pathogens from the genus of *Aspergillus* poses a risk of invasive aspergillosis in farm workers [16].

Swinery. Thirty-three species from 15 fungal genera were isolated and identified from the air of the swinery. Yeast-like fungus *Geotrichum candidum* prevailed among other identified micro-organisms. Seven species from the genus *Aspergillus* were detected, *Aspergillus oryzae* and *A. niger* were dominant among them and made up 6.7 and 3.4% of all the identified isolates, respectively. Ten species were attributed to the genus *Penicillium*, species *Penicillium viridicatum*, *P. fellutanum*, *P. meleagrinum*, and *P. tardum* prevailed. Fungi ascribed to *Cladosporium cladosporioides* and *C. herbarum* species and characterised as prevailing in outdoor air, appeared to be among dominants in the swinery air as well. Single isolates of class *Zygomycetes* identified as *Mortierella polycephala*, *Mucor circinelloides* and *Rhizomucor pusillus* have been also detected.

According to Chang *et al.* [2], *Cladosporium* genus fungi prevail in the open-air of swine houses in subtropical

Table 1. Dominant fungal species in the air of the investigated industrial facilities.

Fungus species	Poultry house	Swinery	Feed preparing and storing house	Grain mill	Factory for wooden panel production	Organic waste recycling facilities
	% among identified isolates (n)					
	n = 93	n = 59	n = 72	n = 235	n = 36	n = 125
Absidia coerulea Bainier		1.7	2.7			
A. spinosa Lendn.				0.4		
Acremonium murorum (Corda) W. Gams					2.8	
A. strictum W. Gams		1.7		0.4		
Alternaria alternata (Fr.) Keissl.	2.1	1.7		3.4	5.5	2.4
Aspergillus amstelodami (L. Mangin) Thom et Church	1.1					
A. candidus Link	2.1		4.2	4.7		
A. casiellus Saito					2.8	
A. chevalieri (L. Mangin) Thom et Church	1.1			1.3		
A. flavus Link				0.4		
A. fumigatus Fresen.		1.7		0.4	2.8	0.8
A. granulosus Raper et Thom		1.7				
A. nidulans (Eidam) G. Winter	9.7	1.7				
A. niger Tiegh.	2.1	3.4	4.2	0.4	2.8	
A. oryzae (Ahlb.) Cohn	15.1	6.7	5.5	3.4		
A. paradoxus Fennell et Raper		1.7		0.9		
A. pseudoglaucus Blochwitz et Thom				0.4		
A. raperi Stolk		1.7	2.7			21.6
A. repens de Bary				0.4		
A. restrictus G. Sm.						1.6
A. ustus (Bainier) Thom et Church						1.6
A. versicolor (Vuill.) Tirab.				2.1		
Botryosporium longibrachiatum (Oudem.) Maire	6.5	1.7				0.8
Chrysosporium inops J. W. Carmich.						1.6
C. keratinophilum D. Frey ex J. W. Carmich.		1.7				
C. lobatum Scharapov	2.1	1.7				
C. xerophilum Pitt			1.4			
Cladosporium cladosporioides (Fresen.) G. A. de Vries	3.2	6.7	1.4	17.0	2.8	3.2
C. herbarum (Pers.) Link ex Gray		5.1	2.7	8.9	5.5	5.6
Cochliobolus sativus (S. Ito et Kurib.) Drechsler ex Dastur				3.8		
Cochlonema verrucosum Drechsler			1.4			
Dendrodochium toxicum Pidopl. et Bilai				0.4		
Dimorgaris verticillata Benjamin	2.1					
Dipodascus armillariae W. Gams						0.8
Doratomyces stemonitis (Pers. et Stend.) F. J. Morton et G. Sm.						3.2
Fusarium moniliforme J. Sheld.				0.4	2.8	
F. oxysporum Schltdl.				0.9		
F. solani (Mart.) Appel et Wollenw.					2.8	
Geotrichum candidum Link ex Pers.		15.3	2.7	6.8		4.0
Gliocladium varians Pidopl.						0.8
Hyalodendron lignicola Diddens						0.8
Myceliophthora vellerea (Sacc. et Speg.) van Oorschot			2.7			
Microsporum ferrugineum Ota	1.1					
Mortierella alpina Peyronel				2.1		
M. hyalina (Harz) W. Gams						0.8
M. isabellina Oudem.				2.6		
M. polycephala Coem.		1.7	2.7	1.7		2.4
Mucor circinelloides Tiegh.		3.4				
M. globosus A. Fisch.						0.8
M. hiemalis Wehmer	2.1			1.3		
M. laxorhizus L. Ling						0.8
M. mucedo Fresen.					2.8	
M. parasiticus Bainier					2.8	
M. piriformis A. Fisch.			1.4			

Table 1. Dominant fungal species in the air of the investigated industrial facilities (continuation).

Fungus species	Poultry house	Swinery	Feed preparing and storing house	Grain mill	Factory for wooden panel production	Organic waste recycling facilities
	% among identified isolates (n)					
	n = 93	n = 59	n = 72	n = 235	n = 36	n = 125
M. plumbeus Bonord.				0.4		
M. pusillus Lindt = Rhizomucor pusillus (Lendt.) Schipper	1.1	1.7	1.4			
M. racemosus Fresen.	2.1		1.4	2.1	5.5	
M. silvaticus Hagem				0.9		
Oidiodendron echinulatum G. L. Barron			1.4	2.1		
O. griseum Robak		1.7				0.8
Olpitrichum macrosporum (Farl. ex Sacc.) Sumst.			1.4	0.4		
Paecilomyces puntonii (Vuill.) Nann.					13.8	
Penicillium adametzii K. M. Zalessky	1.1			0.4		
P. capsulatum Raper et Fennell		1.7	4.2	0.9	5.5	2.4
P. chrysogenum Thom	2.1		2.7	1.3		1.6
P. claviforme Bainier	5.4		1.4			0.8
P. corylophilum Dierckx					2.8	
P. decumbens Thom				0.4		
P. digitatum Sacc.						0.8
P. expansum Link	8.6	1.7	6.9	1.7	5.5	1.6
P. fellutanum Biourge		5.1				
P. funiculosum Thom	1.1			2.1		
P. godlewskii K. M. Zalessky				0.4		0.8
P. granulatum Bainier		1.7		0.9		
P. imlicatum Biourge			1.4	1.3		
P. lanosoviride Thom		1.7	1.4	0.4		1.6
P. meleagrinum Biourge		3.4	1.4			0.8
P. olivinoviride Biourge	6.5	1.7				
P. oxalicum Currie et Thom	1.1		1.4	0.4	5.5	6.4
P. palitans Westling	1.1		4.2	0.9		0.8
P. pallidum Smith		1.7		0.9		
P. paxilli Bainier	1.1			0.4	2.8	7.2
P. roquefortii Thom						4.8
P. spinulosum Thom	2.1			0.9		
P. steckii K. M. Zalessky						0.8
P. tardum Thom		3.4	2.7			
P. verruculosum Peyronel				0.4		
P. viridicatum Westling	4.3	6.7	11.1	11.5		4.0
Phoma exiqua Desm.	1.1			0.4		
Rhadiomyces spectabilis Embree			1.4			
Rhinotrichum curtisii Corda		1.7				
Rhizopus nodosus Namysl.	2.1				8.3	
R. oryzae Went ex Prins. Geerl.	4.3		1.4	0.4		
R. stolonifer (Ehrenb. ex Fr.) Vuill.	3.2		1.4		8.3	0.8
Scytalidium lignicola Pesante					5.5	1.6
Scopulariopsis acremonium (Delacr.) Vuill.			1.4			0.8
Syncephalastrum racemosum Cohn ex J. Schrot.		3.4				
Spegazzinia tessarthra (Berk. et M. A. Curtis) Sacc.				0.4		
Spiromyces minutus Benjamin						0.8
Staphylotrichum coccosporum Meyr et Nicot			8.3			
Stylopage lepte Drechsler						2.4
Thamnidium elegans Link ex Gray			4.2			
Torula herbarum (Pers.) Link ex Gray			1.4	2.1		
Trichophyton gypseum Bodin	1.1					
Trichosporiella cerebriformis (G. A. de Vries et Kleine-Natrop) W. Gams						1.6
Trichothecium roseum (Pers.) Link ex Gray		1.7				
Wardomyces anomala Brooks and Hansford						3.2

Taiwan, while in the studies of other authors, the presence of the fungus *Aspergillus fumigatus* is stressed and the health risk of farm workers emphasized [3]. Our findings revealed that *Aspergillus* genus fungi are among the dominant species in the farm air. *A. oryzae* and *A. niger* are well known opportunistic pathogens.

Feed processing and storing house. Thirty-five fungal species ascribed to 18 genera were isolated and identified from the air of the swinery feed processing and storing house. *Penicillium* genus fungi made up 38.8% of all the identified isolates; 11 species were revealed. Species *Penicillium viridicatum* and *P. expansum* prevailed in the samples, making up 11.1% and 6.9% of all the identified isolates respectively. *Aspergillus* genus fungi made up 16.6% of all the identified fungi isolated at this location. Fungi identified as *A. candidus*, *A. niger*, *A. oryzae*, and *A. raperi* Stolk were spread in almost equal proportions. Single isolates from the genera of *Mortierella*, *Mucor*, and *Rhizopus* were also isolated from the air. According to the data obtained by Kharchenko *et al.*, *Aspergillus* and *Penicillium* fungi prevail in different sorts of foodstuff (coarse fodder, grain forage, mixed fodder, premixes, silo). Moreover, a large part of fungal strains investigated by those authors were capable of producing kojic acid, implicated in animal toxicosis [17]. Fungi *Staphylotrichum coccosporum* made up a significant part of identified fungal isolates as well. The class of *Zygomycetes* have been represented by single cases of fungal species from the genera *Mortierella*, *Mucor*, *Rhizomucor* and *Rhizopus*. None of them considered the being among as dominants.

Wooden panel producing factory. A total of 21 fungal species ascribed to 10 genera were isolated and identified from the air at the wooden panel producing factory. Fungi *Paecilomyces puntonii*, *Rhizopus nodosus* and *R. stolonifer* prevailed in the samples; they made up 13.8%, 8.3%, and 8.3%, respectively. Some investigators have isolated *Paecilomyces* genus fungi from wood processing facilities, although these fungi are not listed among dominants [6]. According to published data, *Paecilomyces* genus fungi are implicated in immune system disorders resulting from the exposure to airborne spores of this fungus [9]. According to other literature sources, *Rhizopus* genus fungi are known to be agents of Organic Dust Toxic Syndrome among wood trimmers [8].

Organic wastes recycling facilities. Forty species from 21 fungal genera were isolated from the air at the organic waste recycling facilities. Fungi from the genera of *Penicillium* and *Aspergillus* prevailed and made up 34.4% and 25.6% of all the identified isolates respectively. Species *Aspergillus raperi*, *Penicillium paxilli* and *P. oxalicum* dominated. *Cladosporium herbarum* and *Geotrichum candidum* fungi comprised 5.6% and 4.0% of all the identified isolates respectively; the other fungal genera were represented by single isolates, and none of them could be listed among the dominants. Results of the investigation complement the results obtained by other authors. Kiviranta *et al.* claims that fungi *Aspergillus*, *Penicillium*, and *Cladosporium* dominated among airborne fungi during waste handling, but fungi from the genera of *Mucor* and *Rhizopus* have been isolated as well [18]. Polish researchers revealed that fungi *Aspergillus fumigatus* were abundant in waste landfills where they formed on average 79.4% of the total strains isolated from the air [19]. Moreover, *A. fumigatus* is among the main agents of both invasive and non-invasive aspergillosis in humans [22].

CONCLUSIONS

The obtained results show that some of the investigated industrial environments were heavily polluted by airborne fungi. The concentrations of viable fungal spores in the air of the grain mill during rye grain crushing was 1.7×10^4 cfu/m^3. The lowest concentrations of airborne fungi were detected at the wooden panel producing factory - 2.3×10^1 cfu/m^3.

A total of 107 species ascribed to 42 fungal genera were isolated and identified from all the investigated sites. Species from the genera of *Penicillium*, *Aspergillus*, and *Mucor* made up the majority of identified isolates. Species of *Aspergillus oryzae*, *A. nidulans*, *P. expansum*, *Penicillium olivinoviride*, *P. claviforme* and *Botryotrichum longibrachiatum* prevailed in the poultry farm; *Geotrichum candidum*, *Cladosporium cladosporioides*, *C. herbarum*, *Penicillium viridicatum* and *P. fellutanum* dominated in the swinery. Fungi of *Penicillium viridicatum*, *P. expansum*, *Staphylotrichum coccosporum* and *Aspergillus oryzae* prevailed in the feed preparing and storing house at the swinery. *Cladosporium cladosporioides*, *C. herbarum*, *Penicillium viridicatum* and *Geotrichum candidum* prevailed in the grain mill. Fungi ascribed as *Paecilomyces puntonii*, *Rhizopus nodosus* and *R. stolonifer* were most frequently isolated from the air of the wooden panel producing factory. Species of *Aspergillus raperi*, *P. paxilli*, *P. oxalicum*, and *Cladosporium herbarum* prevailed at the organic waste recycling facilities.

According to published data, majority of identified fungal species are characterised as potential allergens and exposure to their spores may provoke immune responses in the susceptible individuals. As a result, diseases such as allergic rhinitis, bronchial asthma, or extrinsic allergic alveolitis may develop in certain occupants.

The pollution of occupational environments by fungi is an important factor affecting health. Therefore, the search and creation of measures, which could limit the spreading of fungi in occupational premises is one of the major tasks of present day science.

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