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Dangerous microbical pollution in workplace settings

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Micromycetes are important components of dust, their abudance and diversity of species often determine the degree of their destructive impact on objects of the surroundings, people and other bionts. In 2006–2008, studies on dust micromycetes contamination of the premises used for different purposes were carried out. *Penicillium, Aspergillus, Cladosporium, Mucor, Rhizopus* fungi comprise the largest mycobiotic portion of the indoor dust. The abundance of other micromycetes detected in dust (e. g. *Alternaria*, *Botrytis*, *Chrysosporium*, *Geotrichum*, *Paecilomyces*, *Scopulariopsis*, *Wallemia*, *Mycelia sterilia*) significantly increases during the plant vegetation season. Non-living mechanical parts of dust could be treated as components of microorganism substrate, which induces or inhibits vital functions of microorganisms propagules present in dust. Microelements (Co, Ti, Cr, Mn, Fe, Co, Zn) recorded in dust in small amounts, could become such indicators. During further development, majority of micromycetes are able to minimally supply α_{ω}. A great number of micromycetes of the same species were found in the composition of dust in different settings. Micromycetes capable of producing volatile substances, mycotoxins and allergens were detected in the dust of all the investigated settings.

Key words: dust, workplaces, settings, micromycetes, diversity, pollution, dangerous sources

INTRODUCTION

Dust is unstable spontaneously formed substrate of natural environment comprising many live and non-live components of various chemical origins. Every particular environment is characterized by specific dust composition, which is predetermined by dominant and existing natural and anthropogenic processes. Dust is an important ecological agent that often determines the quality of raw food and fodder materials and products, their value and impact upon the health of people and animals (Lugauskas et al., 2008). Fugitive dust emission, i.e. those air pollutants that enter the atmosphere without first passing through a confined flow stream, were thought to be relatively insignificant in terms of air quality impact (Cowherd, 1993). The sources of fugitive particulate emission may be separated into broad categories: process sources and open dust sources. Process sources of fugitive emissions are those associated with industrial operations that alter the chemical or physical characteristics of a feed material. Dust emissions strongly depend on the moisture level of the mechanically disturbed material. The evaporation rate depends on the degree of air movement over the surface, material texture and mineralogy, and crust presence. The moisture-holding capacity of the air is also important, and it correlates strongly with the surface temperature (Cowherd, 1993; Górny, Dutkiewicz, 2002).

The studies of aerosols in indoor air and the assessment of human exposure to aerosols are relatively recent activities. Several factors have influenced the apparent deterioration of indoor air quality. Changes in people's life-styles have introduced new contaminants into the indoor environment, including synthetic fibres and residues from spray propellants, deodorants, pesticides, and combustion particles from kerosene space heaters. The resulting reduction of the infiltration rate of air from outdoors to indoors has decreased the potential for diluting indoor pollutants. Dust particles indoors appear to contribute significantly to the problem. Principal outdoor aerosol contaminants include suspended particles from fugitive dust, soil, sea salt, reentrained road dust, combustion products from stationary and mobile sources (e. g. power plants and cars), forest fires, wood and crop burning; secondary aerosols from photochemical process; acid aerosols and biological aerosols (pollen, conidia, spores, bacteria, propagules, metabolites). Individual aerosol particles can be

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liquid or solid; organic or inorganic; visible or non-visible; spherical, fibrous, or irregular; acidic or alkaline, etc. Particles may adsorb materials as they are transported (Swan, Crook, 1995). Any collected particle mass reflects a heterogeneous mixture of materials with chemical properties ranging from inert to highly toxic, pH values from acidic to alkaline, and various degrees of reactivity.

Common types of indoor bioaerosols include molds (spores and toxins), bacteria, viruses, protozoa, algae, body parts and excreta of insects, acari and arachnids, dander and excreta from animals and pollen from higher plants. Bioaerosols can range from being pathogenic and toxigenic substances to mild allergens and inert particles. The fungi identified as the etiological agents for Building-Related Illness (BRI) and hypersensitivity reactions are *Aspergillus, Histoplasma, Penicillium* and *Cladosporium*. Mycotoxins have been found associated with toxigenic effects (Burge et al., 1989).

Many mycotoxins are immunosuppressive. These include the aflatoxins, in particular aflatoxin B_1, the nonmacrocylic trichothecenes, in particular T-2 toxin, deoxynivalenol and fusarenon X and the ochratoxins with their most abundant representative ochratoxin A produced by toxigenic *Aspergillus* and *Penicillium* fungi in a wide variety of climates and geographical regions. The contamination of food and feeds by this mycotoxin mostly occurs during the pre-harvest period. Almost all types of food can be contaminated (Yiannikouris, Jouany, 2002; Al-Amati, Petzinger, 2006).

The aim of the present work was to determine the diversity of dust, its contamination with microscopic fungi as well as their potential ability to synthesize mycotoxins, to evaluate the effect of dust upon the contamination of workplaces and show the harmfulness to the health of people.

MATERIALS AND METHODS

Dust settled on different surfaces in the agricultural product storage and processing facilities was gathered with a sterile brush into sterile glass vessels. Methods for evaluation of dust aerosols were applied (Yoshida, 1982). The dust was sampled in 9 different facilities: 1. Grain storehouses and their utility premises; 2. Elevator and its utility premises; 3. Bakery; 4. Potato storehouse; 5. Medicinal plant dryer; 6. Ethyl alcohol raw material processing premises; 7. Cow milking grounds, ventilation system; 8. Cow lodging on deep bedding premises; 9. Old wooden house in a village, the inhabitants of which are engaged in agricultural activities.

Two nutrient media were used for micromycete isolation: standard malt agar (DIFCO) and dicloran-glycerol agar (DG-18, OXOID). One gram of dust was suspended in 100 ml of saline (0.85% NaCl) with an addition of 0.1% Tween 80 supplement. This suspension was used to prepare a dilution series of 1 : 100; 1 : 1000; 1 : 10000. Later 0.1 ml of the suspension was set into a Petri dish and 15 ml (45 ± 0.5 °C) of the medium was poured over it. The dishes were kept in a thermostat at a temperature of 26 ± 2 °C. The developed colonies of microscopic fungi were calculated after 3, 5 and 7 days. The number of micromycete propagules was expressed as colony forming units (cfu) per 1 g of dust (Šveistytė et al., 2005; Krysińska-Traczyk et al., 2007). The morphological peculiarities of fungi were studied employing light and scanning electron microscope EVO 50 EP (Carl Zeiss SMT AG, Germany).

The isolates were ascribed to taxonomic groups following D. L. Hawsworth et al. (1995). Micromycetes were identified according to various manuals (Domsh et al., 1980; Ramirez, 1982; Klich, 2002; Lugauskas et al., 2002; Samson, Frisvad, 2004).

In order to detect the element composition, the dust was homogenized and pressed into tablets of 8 mm diameter and 1 mm thickness. The element composition of the dust tablets was analyzed employing a scanning electron microscope EVO 50 EP with X-ray spectrometer of energy dispersion. Measuring conditions: acceleration voltage 20 KV, electron flow 4 nA, pressure in the sample environment 60 Pa, measuring time 200 sec. In each sample the element concentration was measured in three 100 × 200 μm sites. Mean values of the measurements are presented.

Determination of toxins in the samples of dust was performed by the ELISA method (Samson et al., 1992; Smith et al., 2005; Lugauskas et al., 2006). Extraction of mycotoxins and the tests were performed accoding to manufacturers' instructions. The VERATOX®, Ochratoxin, Aflatoxin, T-2 toxin, z caralenone and RIDA CHREEN® Ochratoxin A test kits (R – Biopharm AG, Germany) were used for the analysis.

RESULTS

Dust is a part of geochemical environment. The background contents of elements in dust are formed by natural processes as well as global and regional transmission of technogenic chemical elements. Average values of element content, or clarcs, could be considered as approximate background contents of each element; they are recorded in soil, water, plants, dust, and other objects of the environment. It is important to consider the regional average value of a particular element; its value is determined by local environmental conditions and abundance of technogenic elements, as well as peculiarities of their transmission. Solid phase of dust is composed of minerals and organic matter. Solid particles of dust could be coarse-grained (larger than 0.001 mm) and fine-grained (smaller than 0.001 mm). Mineral composition of coarse-grained particles mostly predetermines background contents of P, Mn, Ti, Zn and other elements in dust. Most important part of the sorptive complex of dust is comprised of fine-grained particles; these are usually clay minerals and products of organic matter decay. Particularly high sorptive capacity is characteristic of fine-grained organic matter rich in Cu, Fe, Ti, Zn, Co and other elements. It forms conditions for survival of microorganism propagules in dust, therefore, under conditions of sufficient humidity, they start functioning and, thus, become an active source of microbial

contamination. Table 1 presents the data on the content of organic matter in the sampled dust.

The data of Table 1 shows that the highest contents of organic matter were in dust collected in ethyl alcohol raw material processing premises (95.3%), the bakery (93.8%), the elevator and its utility premises (86.7%), the medicinal plant dryer (81.8%), grain storehouses and their utility premises (79.9%).

Dust, as an ecological factor, can be considered in several aspects. First, dust serves as a transmission vehicle of various chemical elements. Aided by the airflow, dust can settle on every object and thus enrich it with various chemical elements (Table 2).

The impact of this process can be both positive and negative. When dust settles or otherwise penetrates partially or fully processed raw food materials and when the contamination continues for a longer period, thus changing the composition of the raw materials, the negative impact is unavoidable. In dust chemical elements are in the form of various organic and mineral substances. Many of them can induce functional capacities of microorganisms, accidentally getting into dust, and to stimulate and intensify their development. Therefore, dust can be regarded as a source of microbial contamination and spoiling agent of raw food materials and its products. Dust enriches food products with various microelements and thus makes them more suitable for nutrition of many microorganisms. This way the activity of microorganisms intensifies, the processes of the destruction of raw food materials and products are activated, raw food materials and products get contaminated not just with microorganism propagules (cfu) (Table 1) but also with metabolites of

Table 1. **Amount of organic matter (in dust mass %), abundance (cfu · g^{-1}) and number of species of microscopic fungi in dust from different agricultural workplace settings**

Number	Workplace settings	Number of samples	Mass, %	Abundance Cfu · g^{-1}	Number of species
1.	Grain storehouses and their utility premises	12	79.9	196 ± 21.3	43
2.	Elevator and its utility premises	15	86.7	93 ± 19.3	42
3.	Bakery	15	93.8	3.6 ± 1.3	48
4.	Potato storehouse	3	9.3	63.9 ± 11.5	18
5.	Medicinal plant dryer	12	81.8	27.6 ± 3.7	13
6.	Ethyl alcohol raw material processing premises	3	95.3	3.7 ± 0.8	15
7.	Cow milking grounds, ventilation system	9	27.8	23.4 ± 3.3	5
8.	Cow lodging on deep bedding premises	9	64.5	27.3 ± 4.6	6
9.	Old wooden dwelling house in a village	3	42.6	123 ± 7.3	10

Table 2. **Element composition of dust from different agricultural workplace settings (in mass %)**

Workplaces	Element								
	C	O	N	Na	Mg	Al	Si	P	S
1	51.8	39.3	0	0.09	0.30	0.62	3.69	0.42	0.29
2	48.3	42.7	0.37	0.06	0.24	0.45	2.78	0.31	0.21
3	48.4	46.2	0	1.17	0.12	0.19	0.91	0.16	0.21
4	3.5	49.7	0	0.51	0.43	4.11	32.6	0.17	0.11
5	40.7	39.9	0.48	0.23	0.66	1.23	8.5	0.52	0.62
6	524	43.3	0	0.02	0.06	0.15	0.46	0.15	0.24
7	51.7	31.4	5.39	0.18	0.51	0.54	2.70	0.87	0.97
8	53.9	36.5	0	0.07	0.41	0.33	4.02	0.51	0.32
9	44.4	35.2	0	0.35	0.28	1.50	10.4	0.26	0.42

Table 2 **(continued)**

Workplaces	Element								
	Cl	K	Ca	Ti	Cr	Mn	Fe	Co	Zn
1	0.14	0.97	1.14	0.03	0	0.01	1.13	0	0.03
2	0.11	0.87	0.76	0.04	0	0.02	0.71	0.01	0.01
3	0.42	0.28	0.86	0.01	0.05	0.01	0.71	0.01	0.21
4	0.08	2.41	1.40	0.17	0	0	1.95	0.00	0.02
5	0.15	1.14	2.39	0.13	0.02	0.06	2.94	0.02	0.25
6	0.15	0.24	0.23	0.01	0.01	0.02	0.79	0.01	0.02
7	0.18	0.67	2.49	0.02	0	0	0.38	0	0.57
8	0.26	0.82	2.04	0.04	0	0	0.76	0	0
9	1.78	1.92	1.97	0.10	0	0	1.78	0	0.06

microorganism activity of diverse chemical composition. Micromycete propagules are usually abundant in dust and their element composition is significant for general element composition of dust. In micromycete mycelium about 40% of carbon and oxygen are recorded as well as 7–8% of nitrogen, and 2–3% of hydrogen. Sulphur, phosphorus, potassium, magnesium, iron, zinc, copper, manganese are detected in sol. On the whole in fungal sol more than 50 elements could be detected, although their importance for fungi is not always identical. It should be mentioned that phosphorus and potassium comprise a large portion of fungal sol, about 50% and 25%, respectively; the remaining elements make about 25% of the sol weight. Phosphorus is a component of nucleoproteins and participates in protein synthesis and the processes of inheritance transmission; potassium is an active component of carbohydrate metabolism; sulphur participates in the processes of cell structure formation and substance reduction; magnesium is essential for oxidation processes. Other elements participate, catalyze or reduce various metabolic processes in microorganisms. The few mentioned examples show the importance of the elements, penetrating together with dust, for fungi developing on raw food materials or its products and define the ecological importance of dust in the issues of food safety (Поликар, 1976).

Mycobiota of dust in the investigated premises are characterized by certain features of anthropogenic community, which differ in structural organization, species diversity, their detection frequency, diversity of taxa and its temporal dynamics from myco-communities formed under natural conditions.

Dust mycobiota of each investigated setting of workplaces is characterized by high diversity of species (Fig. 1). In the dust of grain storehouses and their utility premises the amount of micromycetes was $196 \pm 21.3 \cdot 10^4$ cfu $\cdot g^{-1}$. Micromycetes of 42 species ascribed to 15 genera as well as *Mycelia sterilia* were isolated and identified (Table 1 and 3). Rather high amount of microscopic fungi ($93.0 \pm 19.3 \cdot 10^4$ cfu $\cdot g^{-1}$) was recorded in dust from various premises of the elevator. Micromycetes of 42 species ascribed to 16 genera as well as *Mycelia sterilia* were isolated and identified. In dust from the bakery micromycetes were less abundant ($3.6 \pm 1.3 \cdot 10^4$ cfu $\cdot g^{-1}$).

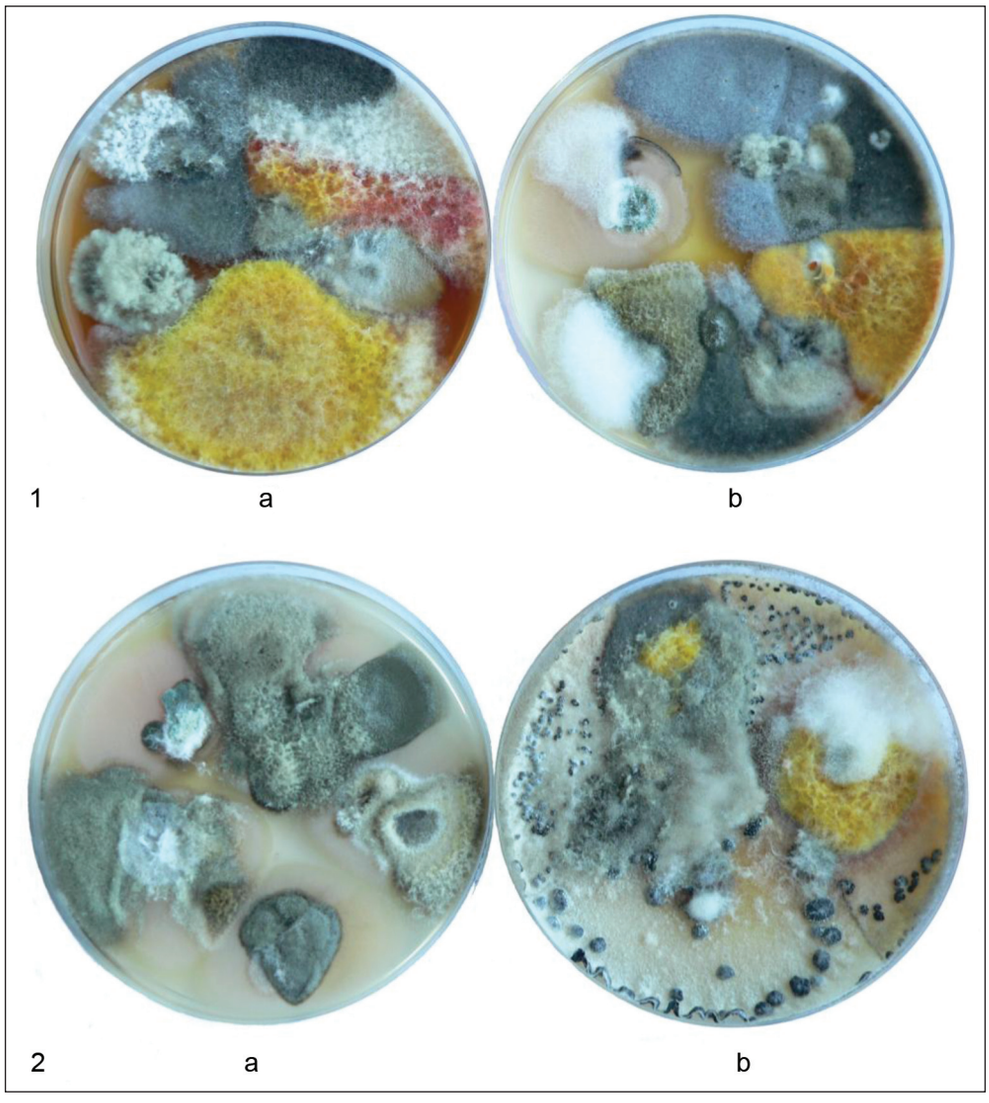

Fig. 1. Micromycete colonies isolated from dust: *a* – on malt agar, *b* – on dichloron-glycerol agar. *1* – Elevator and its utility premises, *2* – Medicinal plant dryer

Table 3. **Species diversity of fungi in dust from different agricultural workplace settings**

Setting of work places	Detection frequency (%)	Species
1.	< 20	*Cladosporium cladosporioides*, *Penicillium commune*, *P. cyclopium*
	< 10	*Aspergillus oryzae*, *Cladosporium herbarum*, *Penicillium chrysogenum*, *P. claviforme*, *P. expansum*, *P. viridicatum*, *Mycelia sterilia*
	< 5	*Alternaria alternata, Aspergillus clavatus, A. flavus, Mucor hiemalis, M. racemosus, Paecilomyces* spp., *Penicillium nalgiovense, P. variabile, P. verruculosum, Rhizomucor pusillus, Rhizopus oryzae, Rh. stolonifer*
	> 5	*Absidia spinosa, Acremonium strictum, Aspergillus* (= *Eurotium*) *chevalieri*, *A. clavatus, Chaetomium globosum*, *Exophiala jeanselmei*, *Fusarium moniliforme*, *F. avenaceum*, *F. culmorum*, *F. oxysporum*, *F. sporotrichioides*, *Mortierella alpina, M. humicola*, *M. polycephala, Penicillium brevicompactum, P. hordei*, *P. melanoconidium*, *P. melinii, P. palitans*, *P. piscarium*, *Rhodotorula rubra*
2.	< 20	*Penicillium cyclopium*, *P. verrucosum*, *P. viridicatum*
	< 10	*Aspergillus flavus*, *Cladosporium cladosporioides*, *Geotrichum candidum*, *P.commune*, *P. roqueforti*, *Rhizopus oryzae*
	< 5	*Aspergillus oryzae, Cladosporium herbarum, Fusarium oxysopium v. redolens, Penicillium hordei, P. palitans*, *Rhizomucor pusillus, Mycelia sterilia*
	> 5	*Acremonium charticola, A. strictum*, *Alternaria alternata*, *Athrobotrys oligospora*, *Aspergillus fumigatus, A. niger*, *A. terreus*, *Aureobasidium pullulans*, *Circinella circinans, Cladosporium sphaerospermum, Exophiala jeanselmei*, *Fusarium moniliforme, Mortierella alpina, Mucor circinelloides*, *M. hiemalis*, *M. racemosus*, *Penicillium aurantiogriseum*, *P. brevicompactum, P. diversum, P. islandicum*, *P. melinii*, *P. olsonii*, *P. palitans*, *P. purpurogenum, Rhizopus nodosus, Trichoderma viride*
3.	< 20	*Aspergillus oryzae, Penicillium cyclopium*, *P. expasum, P. verrucosum, Sacharomyces cerevisiae*
	< 10	*Aspergillus amstelodami*, *A. flavus*, *A. niger, Geotrichum candidum, Penicilluim commune, P. cyclopium, P. expasum, P. lanosum, P. verrucosum*
	< 5	*Aspergillus* (= *Eurotium*) *chevalieri*, *A. sulphureus, Botrytis cinerea, Candida albicans, Penicilluim aurantiogriseum, Rhizopus oryzae, Thamnidium elegans, Mycelia sterilia*
	> 5	*Alternaria dianthi, Arthroderma tuberculatum, Aspergillus clavatus, Aspergillus* (= *Eurotium*) *repens, A. silvaticus, Aureobasidium pullulans, Candida* spp. *Chaetopsina fulva*, *Exophiala jeanselmei, Mucor hiemalis, M. racemosus*, *Penicilluim adametzii*, *P. alli*, *P. atramentosum, P. godlewskii, P. roqueforti*, *P. thymicola*, *Rhizomucor pusillus, Rhizopus stolonifer, Tilachlidium brachiatum, Trichoderma aureoviride, T. hamatum, T. harzianum*, *T. viride*, *Verticicladium trifidum*, *Mycelia sterilia*
4.	< 20	*Penicillium cyclopium*, *P. expansum*
	< 10	*Aspergillus flavus*, *Cladosporium cladosporioides*, *Gliocladium catenulatum*, *Mortierella hyalina*, *Penicilluim atramentosum*, *P. funiculosum*, *Sporotrichum aurantiacum*
	< 5	*Aeremonium murorum*, *Mortierella hyalina*, *Penicilluim olsonii*, *Mycelia sterilia*
	> 5	*Aspergillus fumigatus*, *A. ustus, Leptodontium obscurum, Thielaviopsis basicola, Wallemia sebi*
5.	< 20	*Aspergillus oryzae*, *Geotrichum candidum*
	< 10	*Aspergillus niger*, *Penicilluim commune*, *P. piscarium*, *Rhizopus oryzae*, *Sporotrichum aurantiacum*
	> 5	*Aspergillus penicillioides*, *Cladosporium cladosporioides, Penicillium sclerotigenum, P. venetum, Rhizomucor pusillus, Mycelia sterilia*
6.	< 20	*Aspergillus amstelodami*, *A. penicillioides*, *Penicillium cyclopium*
	< 10	*Aspergillus tamarii*, *A. terreus*, *Cladosporium cladosporioides*
	< 5	*Aspergillus fumigatus, A. ochraceus, Aspergillus* (= *Eurotium*) *repens, Penicillium chrysogenum, P. expansum, P. roqueforti*
	> 5	*Mucor hiemalis*, *Penicillium islandicum*, *Mycelia sterilia*
7.	< 20	*Aspergillus niger, Aspergillus* spp. (*A. quercinus*?), *Rhizopus stolonifer*
	< 10	*Mucor circinelloides*
	> 10	*Mycelia sterilia*
8.	< 20	*Aspergillus niger*, *Rhizopus stolonifer*
	< 10	*P. hordei*, *P. nalgiovense*
	< 5	*Penicillium janthinellum*
	> 5	*Mycelia sterilia*
9.	< 20	*Aspergillus niger*, *Penicillium chrysogenum*
	< 10	*Aspergillus fumigatus*, *Geotrichum candidum*
	< 5	*Aureobasidium pullulans, Thamnidium elegans*, *Trichoderma viride*
	> 5	*Candida albicans*, *Exophiala jealselmei, Mycelia sterilia*

However, the species diversity, especially of the *Penicillium* genus, is rather high (14 species). Micromycetes of the *Aspergillus* genus were rather numerous (9 species) as well. In total, 48 micromycete species ascribed to 19 genera were isolated and identified in the bakery (Table 3). The abundance of fungal propagules in dust significantly differed in separate variants of the technical raw material processing and storage premises: from $3.7 \pm 0.8 \cdot 10^4$ cfu $\cdot$ g^{-1} (dust from the ethyl alcohol raw material processing premises) to $63.9 \pm 11.5 \cdot 10^4$ cfu $\cdot$ g^{-1} (chips potatoes 'Saturna' storing premises). Specific micromycete species composition was identified in dust of the premises of functioning of animals and people (Table 3). The lowest amount of micromycetes was detected in the ventilation system of cow milking grounds, which was constantly cleaned and disinfected with pM4 solution, i. e. $23.4 \pm 3.3 \cdot 10^4$ cfu $\cdot$ g^{-1} and $27.3 \pm 4.6 \cdot 10^4$ cfu $\cdot$ g^{-1} in cow lodging on deep bedding premises. In the dwelling premises of an old wooden house in a village the recorded amounts of micromycetes were $123 \pm 7.3 \cdot 10^4$ cfu $\cdot$ g^{-1}. Micromycetes of the *Aspergillus* and *Penicillium* genera: *Aspergillus fumigatus*, *A. niger*, *A. versicolor*, *Penicillium chrysogenum*, *P. expansum*, *P. nalgiovense*, and *P. roqueforti* dominated in the dust of the workplace settings.

The possibilities of dust to transport micromycete propagules capable of producing toxic secondary metabolites were investigated. Mycotoxins were recorded in the dust of almost all studied workplaces (Table 4). Micromycetes actively synthesizing patulin were most numerous in dust from grain storehouses; 6 species were isolated: *Penicillium cyclopium* (detection frequency 23.6%), *P. chrysogenum* (16.4%), *P. expansum* (12.1%), *P. claviforme* (12.0%), *Paecilomyces* spp. (8.2%), *Aspergillus clavatus* (3.4%). 3 micromycete species, potential producers of patulin, were determined in the dust from the elevator and its utility premises: *Penicillium cyclopium* (23.4%), *P. claviforme* (14.3%), *P. roqueforti* (13.5%). Micromycetes of the *Penicillium* genus dominated in the dust from the bakery: *P. cyclopium* (37.8%), *P. expansum* (31.8%), *P. lanosum* (15.4 %). *Aspergillus clavatus* fungi were also recorded in these premises, but their detection frequency reached only 2.7%. *Penicillium expansum* (38.9%) and *P. cyclopium* (20.4%) prevailed in the dust of the potato storehouse. Detection frequency of other *Penicillium* micromycetes was lower. *Penicillium piscarium* (19.3%) predominated in the dust of the medicinal plant dryer. The following micromycetes with their respective detection frequency were identified in the dust of ethyl alcohol raw material processing premises: *Penicillium cyclopium* (36.3%), *P. chrysogenum* (8.6%), *P. expansum* (6.8%), *P. roqueforti* (9.3%) and *Aspergillus terreus* (11.3%).

No potential producers of patulin were recorded in dust from the ventilation system of cow milking grounds and from cow lodging on deep bedding premises. Meanwhile, *Penicillium chrysogenum* (32.7%) dominated in the old wooden dwelling house in a village inhabited by people engaged in agricultural activities.

Most frequently recorded producers of ochratoxin A in the studied dust were *Penicillium cyclopium* and *Penicillium verrucosum* (Cole, Schweikert, 2003). It should be mentioned that these fungi were also abundant in the grain storehouses as well as the elevator and its utility premises. *Aspergillus niger, A. sulphureus* were recorded in the dust of the bakery. *A. niger, A. ochraceus*, *Aspergillus* (= *Eurotium*) *repens* were detected in the dust of the ethyl alcohol raw material processing premises. *Aspergillus niger, Aspergillus* spp. (*A. quercinus*?), found in the ventilation system of cow milking grounds, should be ascribed to ochratoxin A producers.

Aspergillus niger micromycetes were recorded in the studied dust. The ability of different isolates to synthesize and excrete ochratoxin A is not equal. This is also indicated in some literature references (Abarca et al., 1994; Halstensen et al., 2004). *Aspergillus niger* strain L-10 (Fig. 2), actively producing ochratoxin A on the malt extract agar medium, was recorded in the dust sampled from the dwelling house situated in a village.

Micromycetes widespread in dust are able to synthesize cyclopiazonic acid (Table 3). *Penicillium cyclopium* and *Aspergillus oryzae* were found to be most widespread in the dust of the grain storehouse, *Penicillium viridicatum*, *P. cyclopium* and *Aspergillus oryzae* in that of the elevator. *A. sulphureus* and *A. tamarii* from the dust of the ethyl alcohol raw material processing premises could produce cyclopiazonic acid. It is worth mentioning that in many dust samples *Aspergillus flavus* fungi were detected; they could produce not just cyclopiazonic acid but also actively synthesize and excrete aflatoxins.

Alternaria alternata (Fr.) Keissl. fungi were also frequently detected in dust; they are able to synthesize a wide range

Table 4. **Abundance of mycotoxins (μg $\cdot$ kg^{-1}) in dust from different agricultural workplace settings**

No.	Workplace settings	Mycotoxins, mg kg^{-1}		
		Aflatoxins	Ochratoxin A	Patulin
1.	Grain storehouses and their utility premises	2.07	12.23	21.53
2.	Elevator and its utility premises	5.01	20.64	31.16
3.	Bakery	3.47	4.83	16.41
4.	Potato storehouse	0.0	38.33	21.14
5.	Medicinal plant dryer	6.48	5.87	12.61
6.	Ethyl alcohol raw material processing premises	0.04	2.06	10.18
7.	Cow milking grounds, ventilation system	0.0	3.83	0.0
8.	Cow lodging on deep bedding premises	0.0	8.27	0.0
9.	Old wooden dwelling house in a village	0.0	13.83	4.48

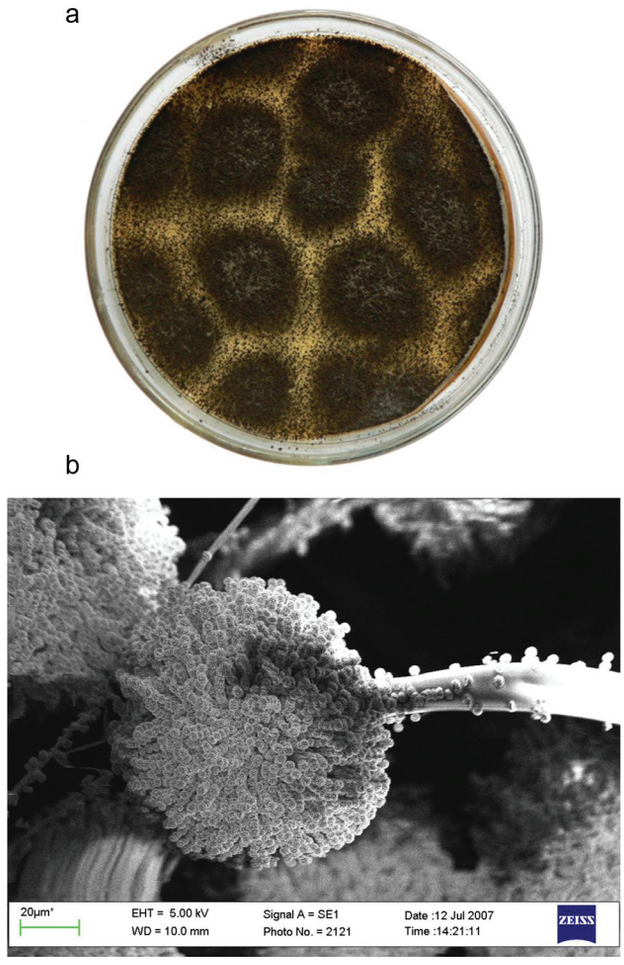

Fig. 2. a) *Aspergillus niger* L-10, active producer of ochratoxin A, colonies on MEA after 7 days; b) Conidiogenesis of *Aspergillus niger* L-10: conidial head, conidia

of toxic substances (Cole, Schweikert, 2003). Toxic substances chaetoglobosin A – M, emodin, cytochalasane, chaetomin, synthesized by dust-borne *Chaetomium globosun* Kunze micromycetes are little investigated. In the dust of the grain storehouse, rather frequent, although not abundant, were fungi of the *Fusarium* genus. These micromycetes are able to synthesize a lot of toxic substances of various chemical composition (Cole, Schweikert, 2003). The recorded micromycetes of the *Rhizomucor* and *Rhizopus* genera can synthesize and accumulate C_{28} sterols, ergosterol, lanosterol, obtusifaliol, C_{30} sterols, episterol and other toxic substances. Micromycetes of the *Trichoderma* genus isolated from dust (*T. viride*, *T. harzianum*) are able to synthesize virdin, viridiol, trichodermin, koninginin A, C. Therefore, the presence of toxin-producing micromycetes in dust makes the dust harmful to human and animal health because by direct or indirect interactions these two objects create ecological conditions unsuitable for productive functioning of live organisms (Roth et al., 1990; Cole et al., 2003; Lugauskas, 2004).

Recently, literature references regarding organic dust as an important ecologic factor inducing various diseases have become profuse. Back in 1980 (Sheridon et al., 1980) the relationship between exposure to cereal grain dust and pulmonary disfunction in grain workers was identified. A group of Polish researchers (Skórsko et al., 1998) noted the effects of exposure to grain dust in Polish farmers: work-related symptoms and immune response to microbial antigens associated with dust. Activity and aggressiveness of the dust impact on live organisms is related with the levels of fungi and mycotoxins in dust samples (Schwartz et al., 1995; Smith et al., 1995). Dust of a specific composition and extreme aggressiveness accumulates in the premises used for special purposes, e. g. production of hemp and poppy goods, processing of spices and medicinal plants, continuous trade of the imported grain, production of hay or other fodder, other long-time technological processes (Schwartz et al., 1995; Smith et al., 1995; Krysińska-Traczyk et al., 2007). Harmfulness of dust to people and animals largely depends on characteristics of the present micromycetes, their ability to produce, excrete and accumulate toxic and allergic substances (Zuskin et al., 1990; Smith et al., 1995; Larsen et al., 2001; Shong et al., 2001; Lugauskas et al., 2002, 2008). The above-mentioned researchers described the producers of these substances and peculiarities of the action of their metabolites. It is essential to determine the influence of elements, especially microelements, upon micromycetes because they can shift the micromycete metabolism, e. g. activate the ability to produce patulin or ochratoxin, excrete volatile substances, or inhibit their synthesis (Kharchenko et al., 1993; Kiviranta et al., 1999; Lugauskas, 2004). It is always important to know the reaction of other micromycetes, members of the same community, which are not characterized by toxicity or parasitism, towards such changes (Eduard, 1997).

CONCLUSIONS

1. Micromycetes are important components of the indoor dust; their abundance and species diversity often determinethe degree of their biodestructive impact on objects of the environment as well as influence on people and other bionts. *Penicillium*, *Aspergillus*, *Cladosporium, Mucor*, *Rhizopus* fungi comprise the largest mycobiotic portion of the indoor dust. Their abundance in dust little depends on the season. The abundance of other micromycetes detected in dust (e. g. *Alternaria*, *Botrytis*, *Chrysosporium*, *Geotrichum*, *Paecilomyces*, *Scopulariopsis*, *Wallemia, Mycelia sterilia*) significantly increases during the plant vegetation season.

2. Non-living mechanical parts of dust could be treated as components of microorganism substrate, which induces or inhibits vital functions of microorganism propagules present in dust. When dust comprises plenty of organic substances together with high amounts of microorganism propagules, indicators, activating vital processes, are necessary for the functioning of the latter. Microelements (Ca, Ti, Cr, Mn, Fe, Co, Zn), recorded in dust in small amounts could become such indicators. Certain dust components can enrich the

substrates, especially raw foodmaterials, with substances required by microorganisms and thus make them more suitable for the development of microorganisms. Most substrate-specific micromycetes always develop more intensively.

3. Humidity is necessary for assimilation of substrates. Especially significant are dust components that allow the humidity accumulation during initial stages of functioning and development of a microorganism. During further development, the majority of micromycetes are able to minimally supply α_w due to the processes of their functioning and are able to develop under rather extreme conditions that are considerably improved and made more favourable by ambient dust.

4. All micromycetes present in the substrate react towards substrate changes caused by ambient dust. However, micromycetes of the *Penicillium*, *Aspergillus*, *Alternaria*, *Rhizopus*, *Mucor* genera, which are fast-growing, not substrate-specific, and capable of excreting various toxic substances and thus suppress the development of other bionts, often become dominant. The same dust-borne element, depending on its concentration, can be characterized by different impact properties: induce, inhibit, change the development and metabolism of micromycetes, e. g. increase the synthesis of toxic secondary metabolites. Micromycetes capable of producing volatile substances, mycotoxins, and allergens were detected in the dust sampled in all the workplace settings. Dust provides the possibilities for potentially toxic microorganisms to penetrate into raw food materials and products and therefore form unfavourable conditions for people working in the contaminated premises; health risk is increased.

5. The obtained results suggest that the origin of functional settings of dust-dominating compounds has no significant impact upon the accumulation abundance and diversity of micromycetes. It is predetermined by sorption capacity of dust mass and external environmental factors. Differences in the composition of micromycete species in dust of different setting of workplaces were revealed. Peculiarities of mechanical composition of dust partly govern the taxonomic composition of micromycetes. Studies of the dust in workplace settings where animals and people function provide evidence of obvious differences in the composition of the micromycete species.

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PAVOJINGA DARBO PATALPŲ APLINKOS MIKROBINĖ TARŠA

S a n t r a u k a

Mikromicetai yra savitas dulkių komponentas, jų gausa ir rūšių įvairovė dažnai lemia destrukcijos galią ir poveikį aplinkai, žmonėms bei kitiems biotams. 2006–2008 m. tirti įvairios paskirties darbo patalpų dulkėse aptikti mikromicetai. Dažniausiai dalis išskirtų mikromicetų priklausė *Penicillium, Aspergillus, Cladosporium, Mucor, Rhizopus* gentims. Dulkėse aptikti *Alternaria*, *Botrytis*, *Chrysosporium*, *Geotrichum*, *Paecilomyces*, *Scopulariopsis*, *Wallemia*, *Mycelia sterilia* gentims priklausantys mikromicetai. Jų gausa aplinkoje ženkliai priklauso nuo metų laiko ir augalų vegetacijos. Dulkių negyvosios mechaninės dalelės yra mikroorganizmų substrato dalimi, kuri gali skatinti ar slopinti dulkėse esančių mikromicetų pradų gyvybines funkcijas. Todėl Co, Ti, Cr, Mn, Fe, Co, Zn mikroelementų gausa gali būti tokio poveikio indikatoriumi. Tolesniam vystymuisi daugumai grybų labai svarbus substrato α_{ω}. Skirtingų patalpų dulkėse aptikti daugelio tų pačių rūšių mikromicetai. Visų patalpų dulkėse rasti mikromicetai, galintys gaminti ir išskirti į aplinką lakiąsias medžiagas, mikotoksinus ir alergenus.

Raktažodžiai: dulkės, darbo patalpos, aplinka, mikromicetai, įvairovė, tarša, pavojaus šaltinis