

The analysis of mycological air pollution in selected rooms of student hostels

Analiza mikologicznego zanieczyszczenia powietrza w wybranych pomieszczeniach domów studenckich

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ABSTRACT

Introduction: Public rooms are characterised by different concentrations and species composition of fungi, depending on the particular purpose which they serve and on their age.

Aim of the study: The research objective was to evaluate the extent of mycological air pollution in selected student hostels at Wrocław, through the determination of the species number and species composition of the fungi assemblages found there, using different culture media.

Material and methods: Air samples were taken from 15 selected rooms of the student hostels at Wrocław. To examine the air, the impact method was used in Air Ideal 3P sampler, using two different culture media: Sabouraud Agar and Czapek-Dox Agar.

Results: Mycological air pollution analysis has shown that CFU (Colony Forming Unit) values for different culture media varied, and that in many cases these differences were statistically significant. For Sabouraud Agar the CFU values in 1 m³ ranged from 184 to 889, and for Czapek-Dox Agar – they were 139 to 978. The most ubiquitous fungi isolated from both the culture media were *Aspergillus niger*, *Cladosporium herbarium* and *Candida albicans*. The temperature in the rooms from which the air was sampled oscillated between 22.3 and 24.5°C, whereas their humidity was 35.5 to 49.2%.

Conclusions: The applied culture medium does influence the species composition and quantity of the fungi isolated from the air, e.g. the Czapek-Dox Agar can be useful, to the greatest extent, for the isolation of yeast-like fungi, including human pathogens such as *Candida* spp. and *Rhodotorula* spp. In the studied rooms of the student hostels, the mycological pollution standards for the places of accommodation and for the public rooms have not been exceeded.

KEY WORDS: fungi, air pollutions, public use buildings

STRESZCZENIE

Wprowadzenie: Pomieszczenia użytku publicznego charakteryzują się różną koncentracją i składem gatunkowym grzybów, który zależy od rodzaju użytkowego obiektu i jego wieku.

Cel pracy: Ocena stopnia mikologicznego zanieczyszczenia powietrza wybranych pomieszczeń domów studenckich przez określenie liczebności i składu gatunkowego grzybów, z wykorzystaniem różnych podłoży hodowlanych.

Materiał i metody: Materiał do badań stanowiło powietrze pobrane z 15 pomieszczeń domów studenckich jednej z wrocławskich uczelni wyższych. Analizę powietrza przeprowadzono metodą zderzeniową (urządzenie Air Ideal 3P) z użyciem podłoża hodowlanego Sabourauda i Czapek-Dox Agar.

Wyniki: Analiza mikologiczna pobranych próbek powietrza wykazała, że wartości CFU (*colony forming unit* – j.t.k.) w m³ powietrza były zróżnicowane i zależały od rodzaju użytego w doświadczeniu podłoża, a uzyskane wyniki w wielu przypadkach były istotne statystycznie. Dla podłoża Sabourauda wartość CFU/m³ wahała się w przedziale od 184 do 889, a dla podłoża Czapek-Dox Agar od 139 do 978. Najczęściej izolowanymi gatunkami grzybów na obu podłożach były: *Aspergillus niger*, *Cladosporium herbarium* i *Candida albicans*. Temperatura w badanych pomieszczeniach wahała się od 22,3 do 24,5°C, a wilgotność powietrza – od 35,5 do 49,2%.

Wnioski: Zastosowany rodzaj podłoża hodowlanego ma wpływ na skład gatunkowy i liczebność grzybów izolowanych z powietrza. Pożywka Czapek-Dox Agar w największym stopniu nadaje się do izolacji grzybów drożdżakowych, w tym patogenicznych dla ludzi (*Candida* spp., *Rhodotorula* spp.). W badanych

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pomieszczeniach domów studenckich nie zostały przekroczone normy dla pomieszczeń mieszkalnych i użytku publicznego w zakresie zanieczyszczeń mikologicznych powietrza.

SŁOWA KLUCZOWE: grzyby, zanieczyszczenia powietrza, budynki użytku publicznego

Introduction

The atmospheric air contains the fixed amounts of oxygen, nitrogen and carbon dioxide, as well as various contaminants including biological ones [1]. These include viruses, protozoa, bacteria, cells and tissue fragments of plants and animals, fragments of fungal mycelia and fungal spores [2]. Microbial air contaminants may emit secondary metabolites such as mycotoxins, endotoxins, enterotoxins and enzymes, that may adversely affect human organism and its health [3].

According to World Health Organization (WHO) roughly 3 billion people around the world suffer from diseases caused by indoor air pollution [4]. Most health problems associated with indoor air quality relate to fungi. As demonstrated by the results of mycological air analyses conducted in selected buildings in the USA and Brazil, fungi represent circa 70% of all microbial pollution of indoor air. Results from these studies have shown that the air in different rooms is mainly polluted by *Penicillium* spp., *Aspergillus* spp. and *Cladosporium* spp. [5, 6]. Moreover, in many cases the concentration of microbial air contaminants in the internal environment of a building is higher compared to the external environment [7]. As on average people stay indoor on 87% of time, it is important to monitor the air quality and its microbial status [8].

One of the most universally used techniques to study microbial air pollution is the impact method. It uses air samplers and Petri dishes containing solidified culture medium and involves colliding the sampled air with a layer of medium. The impact force causes the microorganisms and their spores stick to the medium [9].

The type of culture medium is a very important factor in determining microbial air pollution by means of impact method. The type of medium have directly affects the number and species composition of fungi and bacteria isolated from the air. This effect is related to the variable availability of nutrients, such as sources of carbon, nitrogen and micronelements, to the sampled and cultured microorganisms, in different types of media. It has been demonstrated by the study of Ogórek, *et al.* [10, 11], who had used different culture media (PDA medium – Potato Dextrose Agar, Biocorp, MEA medium – Malt Extract Agar, Sabouraud medium – glucose 4%, agar 2%, peptone 1% and Czapek-Dox Agar medium) to determine the mycological quality of air. The results have shown that, depending on the culture medium, different numbers and species composition of fungi were obtained from the air samples taken in the same room. The best medium for the isolation of dermatophytes were Czapek-Dox Agar medium.

Aim of the study

The research objective was to evaluate the extent of mycological air pollution in selected student hostels at Wrocław, through the determination of the species number and species composition of the fungi assemblages found there, using different culture media.

Material and methods

Air samples were taken in May 2011 from 15 selected rooms (women's room, men's room, bathroom, kitchen and corridor) of the student hostels at Wrocław. To examine the air, the impact method was used and two different culture media: Sabouraud Agar (glucose 4%, agar 2%, peptone 1%) and Czapek-Dox Agar (1.2% agar, Biocorp) (tab. I-VIII). (Air Ideal 3P) was programmed for sample volumes of 50 or 100 L. Measurement in each room was performed in triplicate. The sampler was positioned 1.5 m above the floor. All windows and doors were closed during the measurements. The incubation of cultures on Petri dishes (90 mm diameter) was carried out at room temperature ($\pm 22^{\circ}\text{C}$) for 2-7 days. After the incubation the the number of CFU/1 m³ (Colony Forming Unit/1 m³ of air) was calculated. The temperature and relative humidity was measured using thermo-hygrometer AB-171 Data Logger (Abtronic).

The specific identification of the isolates of the sampled fungi was performed using macro- and microscopic observations of the colonies that had grown on culture media, according to the commonly accepted methods used in mycological laboratories. The fungi were identified using diagnostic keys [12-14].

The obtained results were analyzed by ANOVA in Statistica 9.0 package. Means were compared using Fisher's least significant difference (LSD) test at $\alpha \leq 0.01$.

Results

The temperature prevalent in the investigated rooms ranged between 22.3 and 24.5°C, being therefore advantageous for the development of fungi. On the contrary, the air relative humidity was too low and as such was disadvantageous for them (tab. I).

Mycological analysis of air samples have shown that the microbial air pollution varied between the studied rooms. Furthermore, the number of fungal colonies isolated from the sampled air depended significantly on the type of media used in the experiment – tab. VIII. The highest numbers of colony forming units (CFU/1 m³) on both media were recorded from the corridor air samples in the student hostel – 1, while the lowest number was seen from the samples taken in the corridor in the student hostel – 2, on Sabouraud Agar, and from the women's room in student hostel – 3, on Czapek-Dox Agar. For Sabouraud Agar the CFU/m³ value ranged between 184 and 889, whereas for Czapek-Dox Agar – between 139 and 978. In respective of the studied rooms, the higher total number of CFU were isolated from the sampled material on Czapek-Dox Agar (6040) and lower number – on Sabouraud Agar (5694) – tab. II-VIII.

More species of fungi were obtained on Sabouraud Agar – 18 species, and slightly less on Czapek-Dox Agar, where there were only 15 species. The fungus most often isolated on both the media used in the experiment was *Aspergillus niger*. Its proportion was 34.45% of all the isolated colonies on Czapek-Dox Agar, and 39.64%, respectively, on Sabouraud Agar. The least isolated species on Sabouraud Agar was *Alternaria alternata* (0.16%) and on Czapek-Dox Agar – *Rhizopus stolonifer* (0.10%). Compared to

Table I: Temperature and humidity of air in chosen rooms during measurements
Tabela I: Temperatura i wilgotność powietrza pomieszczeń podczas pomiarów

Name of the room Nazwa pomieszczenia		Average air temperature [°C] Średnia temperatura powietrza [°C]	Average relative humidity of air [%] Średnia wilgotność względna powietrza [%]
Student house – 1 Dom studencki – 1	Women's room Pokój damski	23.6	39.5
	Men's room Pokój męski	24.5	35.5
	Bathroom / Łazienka	23.5	37.2
	Kitchen / Kuchnia	23.8	49.2
	Corridor / Korytarz	23.4	40.2
Student house – 2 Dom studencki – 2	Women's room Pokój damski	24.0	37.4
	Men's room Pokój męski	24.2	40.8
	Bathroom / Łazienka	23.2	41.3
	Kitchen / Kuchnia	24.3	48.5
	Corridor / Korytarz	22.8	40.2
Student house – 3 Dom studencki – 3	Women's room / Pokój damski	23.4	39.4
	Men's room / Pokój męski	24.0	47.8
	Bathroom / Łazienka	22.3	41.3
	Kitchen / Kuchnia	22.4	36.9
	Corridor / Korytarz	23.1	36.2

Sabouraud Agar, the Czapek-Dox Agar did not allow isolation of three species of fungi (*Alternaria alternata*, *Penicillium purpogenum* and *Sclerotinia sclerotiorum*) from the air in the investigated rooms (fig. 1).

The per cent proportion of *Penicillium* spp. fungi ranged from 17.14 on Sabouraud Agar to 18.18% on Czapek-Dox Agar and that of *Aspergillus* spp. – from 34.45 on Czapek-Dox Agar to 39.64% on Sabouraud Agar. Fungi such as *Candida* spp., *Epidermophyton* spp. and *Rhodotorula* spp. had grown well on both substrates. However, the Czapek-Dox Agar medium appeared to be better substrate than Sabouraud Agar for the isolation of yeast-like fungi, including those that are pathogenic to humans (tab. II-VIII).

Discussion

The chemical and microbiological properties of the air inside the properly maintained public buildings should hardly differ from the outside atmosphere. Humans spend a significant portion of their life time indoors. It is therefore critical to human health in general, that the air quality inside public buildings and rooms is adequate. On the contrary, the poor building maintenance practice may lead to considerable fluctuations in the chemical and microbial composition of the indoor atmosphere, and to the problems related to solid suspended particles floating in the air [15].

A number of different factors affect the microbial content of the indoor air, including the geographical area of the building location, the season of the year, and the utility type of the room in question [16]. However, the most important factors affecting the survival of fungi in any environment include the temperature and humidity. Development of all microorganisms is faster in

Table II: Evaluation of air mycological pollutions in selected rooms on Sabouraud Agar in the Student hostel – 1

Tabela II: Ocena zanieczyszczeń mikologicznych powietrza na podłożu Sabourauda badanych pomieszczeń w domu studenckim – 1

Fungus species Gatunek grzyba	CFU/m ³ of air CFU/m ³ powietrza	Total number of CFU/m ³ of air Ogólna liczba CFU/m ³ powietrza	Participation of species [%] Udział gatunków [%]
<i>Penicillium expansum</i>	30	343 d*	8.75
<i>Aspergillus niger</i>	190		55.39
<i>Cladosporium herbarum</i>	41		11.95
<i>Cladosporium cladosporioides</i>	6		1.75
<i>Candida albicans</i>	3		0.87
<i>Alternaria alternata</i>	6	210 e	1.75
<i>Rhizopus stolonifer</i>	67		19.53
<i>Penicillium chrysogenum</i>	8		3.81
<i>Penicillium expansum</i>	6		2.86
<i>Penicillium citrinum</i>	10		4.76
<i>Aspergillus niger</i>	33	690 b	15.71
<i>Cladosporium herbarum</i>	73		34.76
<i>Cladosporium cladosporioides</i>	22		10.48
<i>Candida albicans</i>	20		9.52
<i>Rhodotorula rubra</i>	6		2.86
<i>Rhodotorula glutinis</i>	12		5.71
<i>Acremonium strictum</i>	6		2.86
<i>Botrytis cinerea</i>	4		1.90
<i>Rhizopus stolonifer</i>	10		4.76
<i>Penicillium expansum</i>	60		8.70
<i>Penicillium citrinum</i>	46	584 c	6.67
<i>Aspergillus niger</i>	92		13.33
<i>Cladosporium herbarum</i>	200		28.99
<i>Cladosporium cladosporioides</i>	272		39.42
<i>Candida albicans</i>	20		2.90
<i>Penicillium chrysogenum</i>	5	889 a	0.86
<i>Penicillium expansum</i>	43		7.36
<i>Aspergillus niger</i>	388		66.44
<i>Cladosporium herbarum</i>	39		6.68
<i>Candida albicans</i>	109		18.66
<i>Penicillium chrysogenum</i>	26		2.92
<i>Penicillium expansum</i>	25		2.81
<i>Aspergillus niger</i>	541		60.85
<i>Cladosporium herbarum</i>	36		4.05
<i>Candida albicans</i>	125		14.06
<i>Acremonium strictum</i>	10	14.17	1.12
<i>Rhizopus stolonifer</i>	126		14.17

*Means followed by the same letter do not differ significantly. Fisher's least significant difference (LSD) test, $\alpha \leq 0.01$ / Wartości oznaczone tą samą literą nie są istotne statystycznie. Test Fishera poziomu istotności (LSD), $\alpha \leq 0.01$

moist conditions [17]. In the present experiment the air temperature ranged from 22.3 to 24.5°C and relative humidity – from 35.5 to 49.2%. These microclimatic factors had no significant effect on the mycological contamination of air.

The microbial contamination did not, in any of the tested rooms in the student hostels at Wrocław, exceed the recognized

Table III: Evaluation of air mycological pollutions in selected rooms on Czapek-Dox Agar in the Student hostel – 1

Tabela III: Ocena zanieczyszczeń mikologicznych powietrza na podłożu Czapek-Dox Agar badanych pomieszczeń w domu studenckim – 1

Name of the room Nazwa pomieszczenia	Fungus species Gatunek grzyba	CFU/m ³ of air CFU/m ³ powietrza	Total number of CFU/m ³ of air Ogólna liczba CFU/m ³ powietrza	Participation of species [%] Udział gatunków [%]
Women's room / Pokój damski	<i>Penicillium expansum</i>	12	337 e*	3.56
	<i>Aspergillus niger</i>	239		70.92
	<i>Cladosporium herbarum</i>	14		4.15
	<i>Cladosporium cladosporioides</i>	13		3.86
	<i>Candida albicans</i>	53		15.73
	<i>Rhodotorula glutinis</i>	6		1.78
Men's room / Pokój męski	<i>Penicillium expansum</i>	6	349 d	1.72
	<i>Penicillium citrinum</i>	6		1.72
	<i>Penicillium lividum</i>	10		2.87
	<i>Penicillium vermiculatum</i>	6		1.72
	<i>Aspergillus niger</i>	30		8.60
	<i>Cladosporium herbarum</i>	148		42.41
	<i>Cladosporium cladosporioides</i>	26		7.45
	<i>Candida albicans</i>	53		15.19
	<i>Rhodotorula rubra</i>	6		1.72
	<i>Rhodotorula glutinis</i>	40		11.46
	<i>Acremonium strictum</i>	6		1.72
	<i>Botrytis cinerea</i>	6		1.72
	<i>Rhizopus stolonifer</i>	6		1.72
Bathroom / Łazienka	<i>Penicillium expansum</i>	46	876 b	5.25
	<i>Penicillium lividum</i>	40		4.57
	<i>Penicillium vermiculatum</i>	60		6.85
	<i>Aspergillus niger</i>	92		10.50
	<i>Cladosporium herbarum</i>	566		64.61
	<i>Cladosporium cladosporioides</i>	26		2.97
	<i>Candida albicans</i>	26		2.97
	<i>Epidermophyton floccosum</i>	20		2.28
Kitchen / Kuchnia	<i>Penicillium vermiculatum</i>	26	504 c	5.16
	<i>Aspergillus niger</i>	340		67.46
	<i>Candida albicans</i>	86		17.06
	<i>Rhodotorula glutinis</i>	20		3.97
	<i>Epidermophyton floccosum</i>	32		6.35
Corridor / Korytarz	<i>Penicillium vermiculatum</i>	26	978 a	2.66
	<i>Aspergillus niger</i>	800		81.80
	<i>Candida albicans</i>	86		8.79
	<i>Epidermophyton floccosum</i>	66		6.75

*Means followed by the same letter do not differ significantly. Fisher's least significant difference (LSD) test, $\alpha \leq 0.01$ / Wartości oznaczone tą samą literą nie są istotne statystycznie. Test Fishera poziom istotności (LSD), $\alpha \leq 0.01$

standard for housing and public use rooms, which, according to Gołofit-Szymczak and Skowron [18] amounts to 5000 CFU/m³ of air. It was probably caused by little favorable conditions for development of fungi indoors.

The current data analysis confirmed the results reported earlier by Ogórek, *et al.* [10] that Czapek-Dox Agar medium is the best substrate for isolation of yeast-like fungi, including human pathogenic yeasts *Candida* spp. and *Rhodotorula* spp., from air. According to the results presented in this paper, the use of different media resulted in a different value of CFU/m³. Therefore, the type

of substrate must always be taken into account in studies concerning the determination of air pollution.

Among the fungi isolated from the air samples of student hostels' rooms there were both the species causing serious illness as well as those being allergens. The first group includes fungi such as *Aspergillus* spp. (aspergillosis of the lungs, sinuses, cornea, orbit, skin, nails, and of ear canal), *Rhizopus* spp. (mucormycosis of lungs, sinuses and generalized), *Fusarium* spp. (generalized fusariosis) and *Candida* spp. (candidiasis of the mucosal membranes of the mouth and throat, genital and systemic candidiasis) [19,

Table IV: Evaluation of air mycological pollutions in selected rooms on Sabouraud Agar in the Student hostel – 2

Tabela IV: Ocena zanieczyszczeń mikologicznych powietrza na podłożu Sabourauda badanych pomieszczeń w domu studenckim – 2

Name of the room Nazwa pomieszczenia	Fungus species Gatunek grzyba	CFU/m ³ of air CFU/m ³ powietrza	Total number of CFU/m ³ of air Ogólna liczba CFU/m ³ powietrza	Participation of species [%] Udział gatunków [%]
Women's room Pokój damski	<i>Penicillium chrysogenum</i>	3	245 b*	1.22
	<i>Penicillium expansum</i>	16		6.53
	<i>Penicillium citrinum</i>	17		6.94
	<i>Aspergillus niger</i>	67		27.35
	<i>Cladosporium herbarum</i>	21		8.57
	<i>Cladosporium cladosporioides</i>	3		1.22
	<i>Candida albicans</i>	115		46.94
	<i>Rhodotorula glutinis</i>	3		1.22
Men's room Pokój męski	<i>Penicillium chrysogenum</i>	26	550 a	4.73
	<i>Penicillium expansum</i>	26		4.73
	<i>Aspergillus niger</i>	460		83.64
	<i>Cladosporium herbarium</i>	12		2.18
	<i>Candida albicans</i>	26		4.73
Bathroom Łazienka	<i>Penicillium expansum</i>	15	253 b	5.93
	<i>Penicillium citrinum</i>	20		7.91
	<i>Aspergillus niger</i>	41		16.21
	<i>Cladosporium herbarium</i>	25		9.88
	<i>Cladosporium cladosporioides</i>	22		8.70
	<i>Candida albicans</i>	82		32.41
	<i>Rhodotorula glutinis</i>	39		15.42
	<i>Acremonium strictum</i>	6		2.37
	<i>Alternaria alternata</i>	3		1.19
Kitchen Kuchnia	<i>Penicillium expansum</i>	25	249 b	10.04
	<i>Aspergillus niger</i>	66		26.51
	<i>Cladosporium herbarium</i>	40		16.06
	<i>Cladosporium cladosporioides</i>	8		3.21
	<i>Candida albicans</i>	19		7.63
	<i>Rhodotorula rubra</i>	6		2.41
	<i>Rhodotorula glutinis</i>	60		24.10
	<i>Acremonium strictum</i>	5		2.01
	<i>Sclerotinia sclerotiorum</i>	20		8.03
Corridor Korytarz	<i>Penicillium expansum</i>	23	184 c	12.50
	<i>Aspergillus niger</i>	36		19.57
	<i>Cladosporium herbarium</i>	46		25.00
	<i>Cladosporium cladosporioides</i>	26		14.13
	<i>Rhodotorula rubra</i>	9		4.89
	<i>Rhodotorula glutinis</i>	20		10.87
	<i>Epidermophyton floccosum</i>	12		6.52
	<i>Botrytis cinerea</i>	12		6.52

*Means followed by the same letter do not differ significantly. Fisher's least significant difference (LSD) test, $\alpha \leq 0.01$ / Wartości oznaczone tą samą literą nie są istotne statystycznie. Test Fishera poziom istotności (LSD), $\alpha \leq 0,01$

20]. The second group are the microbial agents causing allergies. The fungi classified above, in the first group, belong here as well, but apart from them there are also such taxa as *Alternaria* spp., *Acremonium* spp., *Cladosporium* spp. and *Penicillium* spp. [21].

The most commonly isolated fungal species was *Aspergillus niger*, which accounted, on average, for more than 34% of all the

air mycological pollution across the all tested rooms and on both the culture media. Ogórek, *et al.* [11] obtained similar results. They studied, on different media, the mycological quality of air in selected rooms of the Clinic of Dermatology. A large number of *A. niger* could be caused by the advanced age of the building. Krzysztofik [17] reported that there are more than favourable conditions for

Table V: Evaluation of air mycological pollutions in selected rooms on Czapek-Dox Agar in the Student hostel – 2

Tabela V: Ocena zanieczyszczeń mikologicznych powietrza na podłożu Czapek-Dox Agar badanych pomieszczeń w domu studenckim – 2

Name of the room Nazwa pomieszczenia	Fungus species Gatunek grzyba	CFU/m ³ of air CFU/m ³ powietrza	Total number of CFU/m ³ of air Ogólna liczba CFU/m ³ powietrza	Participation of species [%] Udział gatunków [%]
Women's room Pokój damski	<i>Penicillium expansum</i>	65	392 c*	16.58
	<i>Aspergillus niger</i>	109		27.81
	<i>Cladosporium cladosporioides</i>	5		1.28
	<i>Candida albicans</i>	171		43.62
	<i>Rhodotorula glutinis</i>	29		7.40
	<i>Epidermophyton floccosum</i>	13		3.32
Men's room Pokój męski	<i>Penicillium expansum</i>	342	587 a	58.26
	<i>Aspergillus niger</i>	173		29.47
	<i>Cladosporium herbarium</i>	6		1.02
	<i>Candida albicans</i>	40		6.81
	<i>Acremonium strictum</i>	6		1.02
	<i>Epidermophyton floccosum</i>	20		3.41
Bathroom Łazienka	<i>Penicillium expansum</i>	26	416 b	6.25
	<i>Penicillium citrinum</i>	10		2.40
	<i>Aspergillus niger</i>	43		10.34
	<i>Cladosporium herbarium</i>	11		2.64
	<i>Cladosporium cladosporioides</i>	52		12.50
	<i>Candida albicans</i>	218		52.40
	<i>Rhodotorula rubra</i>	6		1.44
	<i>Rhodotorula glutini</i>	40		9.62
	<i>Acremonium strictum</i>	5		1.20
	<i>Botrytis cinerea</i>	5		1.20
Kitchen Kuchnia	<i>Penicillium expansum</i>	11	237 d	4.64
	<i>Penicillium verniculatum</i>	26		10.97
	<i>Aspergillus niger</i>	42		17.72
	<i>Cladosporium herbarium</i>	31		13.08
	<i>Cladosporium cladosporioides</i>	16		6.75
	<i>Candida albicans</i>	48		20.25
	<i>Rhodotorula rubra</i>	32		13.50
	<i>Rhodotorula glutinis</i>	11		4.64
	<i>Epidermophyton floccosum</i>	20		8.44
Corridor Korytarz	<i>Penicillium expansum</i>	23	252 c	9.13
	<i>Penicillium lividum</i>	6		2.38
	<i>Penicillium verniculatum</i>	6		2.38
	<i>Aspergillus niger</i>	6		2.38
	<i>Cladosporium herbarium</i>	59		23.41
	<i>Cladosporium cladosporioides</i>	26		10.32
	<i>Candida albicans</i>	46		18.25
	<i>Rhodotorula rubra</i>	17		6.75
	<i>Rhodotorula glutinis</i>	35		13.89
	<i>Epidermophyton floccosum</i>	3		1.19
	<i>Botrytis cinerea</i>	25		9.92

*Means followed by the same letter do not differ significantly. Fisher's least significant difference (LSD) test, $\alpha \leq 0.01$ / Wartości oznaczone tą samą literą nie są istotne statystycznie. Test Fishera poziom istotności (LSD), $\alpha \leq 0.01$

the microorganisms to develop in all the old buildings , namely abundant substrate in the form of the shed epidermis, hair, various secretions and excretions, bits of wood, fabric, faeces of dust mite

and insects, fungal spores and prevalent relative air humidity exceeding the minimum of 20% required for germination of fungal spores. The authors report that the *Aspergillus* spp. and *Penicillium*

Table VI: Evaluation of air mycological pollutions in selected rooms on Sabouraud Agar in the Student hostel – 3

Tabela VI: Ocena zanieczyszczeń mikologicznych powietrza na podłożu Sabourauda badanych pomieszczeń w domu studenckim – 3

Name of the room Nazwa pomieszczenia	Fungus species Gatunek grzyba	CFU/m ³ of air CFU/m ³ powietrza	Total number of CFU/m ³ of air Ogólna liczba CFU/m ³ powietrza	Participation of species [%] Udział gatunków [%]
Women's room Pokój damski	<i>Penicillium expansum</i>	15	296 c*	5.07
	<i>Penicillium citrinum</i>	6		2.03
	<i>Penicillium lividum</i>	20		6.76
	<i>Penicillium vermiculatum</i>	26		8.78
	<i>Aspergillus niger</i>	101		34.12
	<i>Cladosporium herbarum</i>	63		21.28
	<i>Cladosporium cladosporioides</i>	10		3.38
	<i>Candida albicans</i>	11		3.72
	<i>Rhodotorula rubra</i>	6		2.03
	<i>Rhodotorula glutinis</i>	6		2.03
	<i>Acremonium strictum</i>	6		2.03
	<i>Botrytis cinerea</i>	26		8.78
Men's room Pokój męski	<i>Penicillium chrysogenum</i>	40	310 ab	12.90
	<i>Penicillium expansum</i>	80		25.81
	<i>Penicillium citrinum</i>	60		19.35
	<i>Penicillium lividum</i>	10		3.23
	<i>Penicillium purpurogenum</i>	20		6.45
	<i>Aspergillus niger</i>	70		22.58
	<i>Cladosporium herbarum</i>	30		9.68
Bathroom Łazienka	<i>Penicillium chrysogenum</i>	70	300 bc	23.33
	<i>Aspergillus niger</i>	60		20.00
	<i>Cladosporium herbarum</i>	50		16.67
	<i>Cladosporium cladosporioides</i>	60		20.00
	<i>Candida albicans</i>	40		13.33
	<i>Rhodotorula rubra</i>	15		5.00
	<i>Rhodotorula glutinis</i>	5		1.67
Kitchen Kuchnia	<i>Penicillium chrysogenum</i>	70	268 d	26.12
	<i>Penicillium expansum</i>	50		18.66
	<i>Aspergillus niger</i>	100		37.31
	<i>Cladosporium herbarum</i>	38		14.18
	<i>Candida albicans</i>	10		3.73
Corridor Korytarz	<i>Penicillium expansum</i>	23	323 a	7.12
	<i>Penicillium citrinum</i>	18		5.57
	<i>Penicillium lividum</i>	6		1.86
	<i>Penicillium vermiculatum</i>	32		9.91
	<i>Aspergillus niger</i>	12		3.72
	<i>Cladosporium herbarum</i>	130		40.25
	<i>Candida albicans</i>	12		3.72
	<i>Rhodotorula glutinis</i>	10		3.10
	<i>Botrytis cinerea</i>	20		6.19
	<i>Rhizopus stolonifer</i>	60		18.58

*Means followed by the same letter do not differ significantly. Fisher's least significant difference (LSD) test, $\alpha \leq 0.01$ / Wartości oznaczone tą samą literą nie są istotne statystycznie. Test Fishera poziom istotności (LSD), $\alpha \leq 0.01$

spp. fungi belong to the group of indoor pathogens, the main source of which is the microenvironment of the closed rooms [7].

Conclusions

1. The applied culture medium affects the species composition and quantity of fungi isolated from the air.

Table VII: Evaluation of air mycological pollutions in selected rooms on Czapek-Dox Agar in the Student hostel – 3

Tabela VII: Ocena zanieczyszczeń mikologicznych powietrza na podłożu Czapek-Dox Agar badanych pomieszczeń w domu studenckim – 3

Name of the room <i>Nazwa pomieszczenia</i>	Fungus species <i>Gatunek grzyba</i>	CFU/m ³ of air <i>CFU/m³ powietrza</i>	Total number of CFU/m ³ of air <i>Ogólna liczba CFU/m³ powietrza</i>	Participation of species [%] <i>Udział gatunków [%]</i>
Women's room <i>Pokój damski</i>	<i>Penicillium expansum</i>	6	139 d*	4.32
	<i>Penicillium vermiculatum</i>	12		8.63
	<i>Aspergillus niger</i>	5		3.60
	<i>Cladosporium herbarum</i>	43		30.94
	<i>Cladosporium cladosporioides</i>	10		7.19
	<i>Candida albicans</i>	12		8.63
	<i>Rhodotorula rubra</i>	13		9.35
	<i>Rhodotorula glutinis</i>	12		8.63
	<i>Epidermophyton floccosum</i>	23		16.55
	<i>Acremonium strictum</i>	3		2.16
Men's room <i>Pokój męski</i>	<i>Penicillium expansum</i>	39	198 c	19.70
	<i>Penicillium citrinum</i>	43		21.72
	<i>Penicillium lividum</i>	23		11.62
	<i>Penicillium vermiculatum</i>	27		13.64
	<i>Aspergillus niger</i>	14		7.07
	<i>Cladosporium herbarum</i>	30		15.15
	<i>Candida albicans</i>	13		6.57
	<i>Rhodotorula rubra</i>	3		1.52
	<i>Rhodotorula glutinis</i>	6		3.03
Bathroom <i>Łazienka</i>	<i>Penicillium chrysogenum</i>	20	280 a	7.14
	<i>Penicillium expansum</i>	20		7.14
	<i>Aspergillus niger</i>	40		14.29
	<i>Cladosporium herbarum</i>	35		12.50
	<i>Cladosporium cladosporioides</i>	40		14.29
	<i>Candida albicans</i>	80		28.57
	<i>Rhodotorula rubra</i>	25		8.93
	<i>Rhodotorula glutinis</i>	20		7.14
Kitchen <i>Kuchnia</i>	<i>Penicillium chrysogenum</i>	60	250 b	24.00
	<i>Penicillium expansum</i>	30		12.00
	<i>Aspergillus niger</i>	65		26.00
	<i>Candida albicans</i>	45		18.00
	<i>Rhodotorula rubra</i>	10		4.00
	<i>Rhodotorula glutinis</i>	40		16.00
Corridor <i>Korytarz</i>	<i>Penicillium expansum</i>	31	245 b	12.65
	<i>Penicillium citrinum</i>	12		4.90
	<i>Penicillium lividum</i>	6		2.45
	<i>Penicillium vermiculatum</i>	16		6.53
	<i>Aspergillus niger</i>	83		33.88
	<i>Cladosporium herbarum</i>	36		14.69
	<i>Candida albicans</i>	18		7.35
	<i>Rhodotorula glutinis</i>	20		8.16
	<i>Epidermophyton floccosum</i>	15		6.12
	<i>Botrytis cinerea</i>	8		3.27

*Means followed by the same letter do not differ significantly. Fisher's least significant difference (LSD) test, $\alpha \leq 0.01$ / Wartości oznaczone tą samą literą nie są istotne statystycznie. Test Fishera poziom istotności (LSD), $\alpha \leq 0.01$

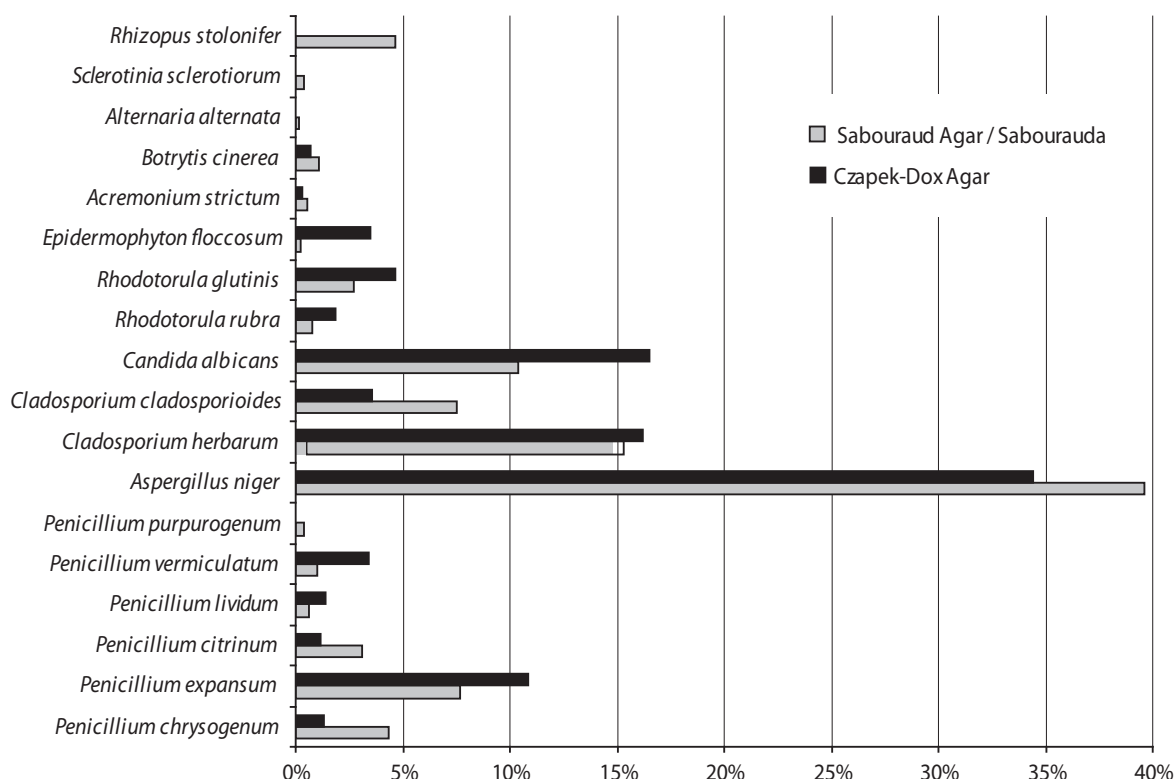


Fig. 1. Fungi species isolated from selected rooms on Sabouraud Agar and Czapek-Dox Agar

Ryc. 1. Gatunki grzybów wyizolowanych z badanych pomieszczeń na podłożu Sabourauda i Czapek-Dox Agar

Table VIII: Statistical comparison of culture mediums used for evaluation of air mycological pollution selected rooms

Tabela VIII: Porównanie statystyczne podług hodowlanych wykorzystanych do oceny zanieczyszczeń mikologicznych powietrza wybranych pomieszczeń

Name of the room Nazwa pomieszczenia		Total number of CFU/m ³ of air Ogólna liczba CFU/m ³ powietrza	
		Potato Dextrose Agar PDA	Czapek-Dox Agar
Student hostel – 1 Dom studencki – 1	Women's room Pokój damski	343 a*	337 a
	Men's room / Pokój męski	210 b	349 a
	Bathroom / Łazienka	690 b	876 a
	Kitchen / Kuchnia	584 a	504 b
	Corridor / Korytarz	889 b	978 a
Student hostel – 2 Dom studencki – 2	Women's room Pokój damski	245 b	392 a
	Men's room / Pokój męski	550 b	587 a
	Bathroom / Łazienka	253 b	416 a
	Kitchen / Kuchnia	249 a	237 b
	Corridor / Korytarz	184 b	252 a
Student hostel – 3 Dom studencki – 3	Women's room Pokój damski	296 a	139 b
	Men's room / Pokój męski	310 a	198 b
	Bathroom / Łazienka	300 a	280 b
	Kitchen / Kuchnia	268 a	250 b
	Corridor / Korytarz	323 a	245 b

*Means followed by the same letter do not differ significantly; they refer to means along the rows. Fisher's least significant difference (LSD) test, $\alpha \leq 0.01$ / Wartości oznaczone tą samą literą nie są istotnie statystycznie; odnosi się do wartości wzdłuż wierszy. Test Fishera poziom istotności (LSD), $\alpha \leq 0.01$

2. Czapek-Dox Agar medium can be useful for isolation of yeast-like fungi, including human pathogenic yeasts (*Candida* spp., *Rhodotorula* spp.).

3. In none of the tested rooms in the student hostels at Wrocław, did the microbial contamination exceed the recognized standard for the mycological pollution in housing and public use rooms.

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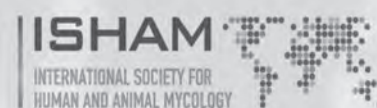
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