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Original Research

Soil of Recreational Areas as a Reservoir of Keratinolytic Mould Fungi and Dermatophytes Potentially Pathogenic for Humans

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Abstract

The aim of our study was to determine the prevalence of keratinophilic and keratinolytic fungi in the soil of recreational areas in Lodz, with a particular emphasis on species potentially pathogenic for humans.

The material consisted of 104 soil samples collected from the surface layer and 10-15 cm below the surface at 26 recreational areas in Lodz. Soil samples were inoculated on Sabouraud, Czapek-Dox, and PDA media. In order to isolate the common dermatophytes from the collected soil, hair bait tests were prepared.

From the collected soil samples, 83 species of fungi belonging to 53 genera were isolated. The most numerous were those of the genera *Penicillium*, *Fusarium*, and *Cladosporium*. Dermatophytes were isolated from 79 out of 104 of soil samples from 24 examined sites. They were classified into eight species from five genera. The most numerous was the genus *Trichophyton*.

The presence of dermatophytes and mould fungi with keratinolytic properties in the soil of recreational areas may pose a significant risk to human health, especially for children and young teenagers. The results obtained in this study and an analysis of the literature suggests the need for monitoring the soil of places of active leisure for potentially pathogenic fungi species.

Keywords: keratinophylic fungi, dermatophytes, soil, recreational areas

Introduction

Fungi are one of the most common organisms on earth. Most species are cosmopolitan organisms found in any climate, and are present in every ecosystem. In the structure of the biocenosis they usually represent a group of decomposers responsible for the re-inclusion of chemical elements in the cycle of matter. Most of the processes of destruction of dead organic matter is carried out in the soil. The surface layer of the soil is humus, rich in organic compounds and minerals. Reducers, the bacteria and fungi, are responsible for the natural decomposition of dead animal and plant organisms. Especially in the case of plants, decay processes can be started by participating fungi that produce enzymes that degrade the cellulose contained in the plant cell walls. A few bacteria also possess cellulase, yet decomposition of plant debris depends on the presence of fungi [1].

Some species of saprotrophic fungi found in the soil are parasitic for other organisms. Many fungi of the genus *Fusarium* often invade corn and wheat, the genus of *Alternaria* is seen on the leaves and fruits of tomato plants, and *Penicillium* invade fruit. In addition to the destruction of tissue, these fungi can produce several mycotoxins which are not destroyed at high temperatures and can be accumulated in the bodies of the animals consuming them,

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leading to toxicosis. Zearalenone, produced by the genus *Fusarium*, causes the so-called estrogenic syndrome, and aflatoxins produced by fungi of the genus *Aspergillus* and ochratoxin A produced by *Penicillium* and *Aspergillus* have carcinogenic properties. Fumonisins — genus *Fusarium*, and penitrem — genus *Penicillium*, demonstrate neurotoxic effects, and trichothecenes produced by *Fusarium* have haemorrhagic, dermatotoxic, and cytotoxic activity [2].

Fungi occurring in the soil may also be responsible for superficial and systemic infection. Because of their ability to cause lesions, fungi are classified into three levels of biosafety (BSL) to humans. BSL 1 includes saprotrophes and plant pathogens, which can cause mild superficial infections on rare occasions. Group BSL 2 are pathogens responsible for superficial and deep opportunistic infections in patients with disorders of the immune system. The last class, BSL 3, are fungi capable of inducing severe systemic infections in healthy individuals [3].

Infections associated with fungi present in the soil often concern people who come into contact with the soil, mainly farmers, gardeners, and people who dig. Dermatomycosis can affect up to 55% of farmers [4]. The most common etiological agents of fungal infections associated with the soil are keratinophilic fungi that can break down epidermis, hair, and nails [5], and this group includes such common dermatophytes as *Trichophyton*, *Microsporum*, *Epidermophyton*, and *Keratinomyces* genera that, under natural conditions, can survive for several months or years in the lithosphere. These genera are responsible for the majority of fungal infections of glabrous skin, scalp, feet, hands, and nails [6]. Similar capabilities are also shown by some mould fungi, although they more often penetrate the human body through small mechanical damage to the skin. Hialohyphomycosis caused by species belonging to *Fusarium*, *Acremonium*, and *Penicillium* pose a significant danger, especially for people with severely weakened immune systems [7-9].

The appearance of developmental forms of fungi in the soil is associated with the presence of animals. Bird droppings can contain cells and spores of *Cryptococcus* and *Histoplasma*, while epidermal products such as fur, claws, and feathers found in the soil can act as substrates for species with keratinolytic properties. Cycling and skateboarding, jogging, and other recreational activities can result in falls and abrasions soiled with sand, through which fungi can easily penetrate into the body. Minor and major injuries can also occur on the playing fields and children's playgrounds, and in many cases children ignore the injury and don't disinfect the wound. Recreational areas such as fields and parks contain not only the remains of pet dogs and cats, but also the feces, hair, and feathers of wild mice, hedgehogs, squirrels and birds, and, in areas on the outskirts of cities, also the footsteps of foxes and wild boar. This availability of organic material (keratinized animal tissues and various plant tissues) favors the occurrence of pathogenic fungi in recreational areas, which may pose a threat to the health and vitality of people.

The aim of our study was to determine the prevalence of keratinophilic and keratinolytic fungi in the soil of recreational areas in Lodz, with a particular emphasis on species potentially pathogenic for humans.

Materials and Methods

The material consisted of 104 soil samples collected from the surface layer and 10-15 cm below the surface at 26 recreational areas in Łódź in the districts of Polesie, Bałuty, Śródmieście, Widzew, and Górna: 2 beaches located in the areas of recreational facilities, unfenced and public; 2 residential playgrounds, public, with a low fence; 13 school fields, including one partially enclosed and one unfenced; 8 public playgrounds located in parks, including two unfenced; and one lane park, adjacent to a fenced playground. At the same time, sand from sandpits located in parks, playgrounds, residential areas, and schools in Lodz was analyzed [10].

Soil samples were collected in two research seasons: spring and autumn. Soil samples weighing 0.5 g were diluted in 10 ml of sterile distilled water, shaken, and then 0.5 ml was inoculated on Sabouraud medium and incubated at 23ºC for 7 to 14 days. Colonies of mould fungi were passaged on Czapek-Dox and PDA (potato-glucose agar) media to obtain axenic strains of morphology typical for the species. From the obtained colonies, microscope preparations in lactophenol were prepared according to Gerlach [11]. In order to isolate the common dermatophytes from the collected soil, hair bait tests were prepared using sterile hair from children, and these were evaluated after 4-8 weeks of incubation at 23ºC. Positive cultures were passaged onto Mycoline medium. Fungi were identified to species or genus on the basis of macro- and microscopic characteristics using the DeHoog et al. [12] and Fassatiova [13] keys. Taxonomy was determined on the basis of a list of species according to Index Fungorum. The biosafety assessment of the fungi was based on the International Classification of BSL [3].

Statistical analysis of the data was performed using Student's t test with a significance level of $p<0.05$ with STATISTICA 10 software.

Results

From the collected soil samples, 83 species of fungi were isolated belonging to 53 genera. The most numerous were those of the genera *Penicillium*, *Fusarium*, and *Cladosporium* (Table 1).

Most frequently isolated was *Fusarium oxysporum* (8.06%), occurring also in the largest number of localities, followed by *Cladosporium herbarum* (6.05%) and *Penicillium chrysogenum* (5.54%). *Haematonectria haematococca* = *Fusarium solani* constituted 4.53% of the total number of identified species, *Sarocladium kiliense* syn. *Acremonium kiliense* 4.28%, *Alternaria alternata* 4.03%, *Paecilomyces variotii* and *Sarocladium strictum* syn. *Acremonium strictum* 3.78%, while *Purpureocillium lilacinum* syn. *Paecilomyces liliacinus* constituted 3.53%

Table 1. Taxonomic spectrum of isolated fungi according to Index Fungorum.

No.	Species	Total		Autum		Spring		Number of posts	BSL
		Number	%	Number	%	Number	%		
1	*Acremonium alabamense*	2	0.50	2	0.80	0	0	2	1
2	*Alternaria alternata*	16	4.03	9	3.61	7	4.73	11	1
3	*Alternaria chlamydospora*	2	0.50	1	0.40	1	0.68	2	1
4	*Alternaria tennuissima*	1	0.25	0	0	1	0.68	1	1
5	*Aphanoascus keratinophilus* = *Chrysosporium keratinophilum*	2	0.50	2	0.80	0	0	1	2
6	*Apophysomyces elegans*	2	0.50	2	0.80	0	0	1	2
7	*Arthrinium phaeospermum*	5	1.26	3	1.20	2	1.35	3	1
8	*Arthrographis kalrae*	2	0.50	1	0.40	1	0.68	2	2
9	*Aspergillus flavus*	6	1.51	6	2.41	0	0	4	2
10	*Aspergillus fumigatus*	1	0.25	0	0	1	0.68	1	2
11	*Aspergillus niger*	2	0.50	1	0.40	1	0.68	2	1
12	*Aureobasidium pullulans*	3	0.76	3	1.20	0	0	3	1
13	*Bipolaris* sp.	2	0.50	1	0.40	1	0.68	2	-
14	*Bothrytis* sp.	6	1.51	1	0.40	5	3.38	4	-
15	*Chamaeleomyces viridis* syn. *Paecilomyces viridis*	6	1.51	4	1.61	2	1.35	5	1
16	*Chrysosporium* sp.	1	0.25	1	0.40	0	0	1	-
17	*Chrysosporium tropicum*	12	3.02	9	3.61	3	2.03	8	2
18	*Chrysosporium zonatum*	2	0.50	0	0	2	1.35	1	1
19	*Cladophialophora carrioniii*	1	0.25	0	0	1	0.68	1	2
20	*Cladorrhinum bulbillosum*	1	0.25	0	0	1	0.68	1	1
21	*Cladosporium herbarum*	24	6.05	12	4.82	12	8.11	12	1
22	*Cladosporium pannicola*	1	0.25	1	0.40	0	0	1	-
23	*Cladosporium* sp.	7	1.76	6	2.41	1	0.68	5	-
24	*Cladosporium sphaeospermum*	1	0.25	1	0.40	0	0	1	1
25	*Curvularia spicifera* syn. *Bipolaris spicifera*	1	0.25	0	0	1	0.68	1	1
26	*Conidiobolus coronatus*	1	0.25	1	0.40	0	0	1	2
27	*Exophiala phaeomuriformis* syn. *Sarcinomyces phaeomuriformis*	2	0.50	2	0.80	0	0	2	2
28	*Fusarium chlamydosporum*	4	1.01	2	0.80	2	1.35	3	1
29	*Fusarium incarnatum*	2	0.50	1	0.40	1	0.68	2	1
30	*Fusarium napiforme*	7	1.76	4	1.61	3	2.03	5	1
31	*Fusarium oxysporum*	32	8.06	26	10.4	6	4.05	21	2
32	*Fusicolla aquaeductuum* syn. *Fusarium aquaeductuum*	3	0.76	2	0.80	1	0.68	2	1
33	*Gibberella nygamai* = *Fusarium nygamai*	2	0.50	2	0.80	0	0	2	1
34	*Haematonectria haematococca* = *Fusarium solani*	18	4.53	4	1.61	14	9.46	9	2
35	*Hormographiella* sp.	2	0.50	1	0.40	1	0.68	2	-
36	*Hortaea werneckii*	1	0.25	0	0	1	0.68	1	1
37	*Humicola grisea*	1	0.25	1	0.40	0	0	1	-

Table 1. Continued.

No.	Species	Total		Autum		Spring		Number of posts	BSL
		Number	%	Number	%	Number	%		
38	*Hypomyces chrysospermus* syn. *Sepedonium chrysospermum*	5	1.26	4	1.61	1	0.68	3	-
39	*Isaria fumosorosea* syn. *Paecilomyces fumosoroseus*	1	0.25	1	0.40	0	0	1	1
40	*Isaria javanica* syn. *Paecilomyces javanicus*	2	0.50	2	0.80	0	0	2	1
41	*Lecythophora mutabilis*	7	1.76	6	2.41	1	0.68	5	1
42	*Lichtheimia corymbifera* syn. *Absidia corymbifera*	3	0.76	3	1.20	0	0	2	2
43	*Microascus brevicaulis* = *Scopulariopsis brevicaulis*	1	0.25	0	0	1	0.68	1	2
44	*Monographella cucumerina* = *Plectosporium tabacinum*	3	0.76	2	0.80	1	0.68	3	1
45	*Mucor hiemalis*	7	1.76	4	1.61	3	2.03	6	1
46	*Mucor racemosus*	8	2.02	7	2.81	1	0.68	7	1
47	*Mucor ramosissimus*	4	1.01	3	1.20	1	0.68	3	1
48	*Mucor* sp.	1	0.25	1	0.40	0	0	1	-
49	*Ochrocladosporium elatum* syn. *Cladosporium elatum*	1	0.25	1	0.40	0	0	1	1
50	*Paecilomyces variotii*	15	3.78	10	4.02	5	3.38	11	2
51	*Penicillium aurantiogriseum* syn. *Penicillium cyclopium*	1	0.25	0	0	1	0.68	1	1
52	*Penicillium chrysogenum*	22	5.54	14	5.62	8	5.41	13	1
53	*Penicillium citreonigrum* syn. *Penicillium citreoviride*	1	0.25	1	0.40	0	0	1	1
54	*Penicillium citrinum*	3	0.76	0	0	3	2.03	2	1
55	*Penicillium expansum*	7	1.76	6	2.41	1	0.68	5	1
56	*Penicillium ochrosalmoneum*	2	0.50	2	0.80	0	0	2	-
57	*Penicillium* sp.	5	1.26	4	1.61	1	0.68	5	-
58	*Penicillium spinulosum*	3	0.76	2	0.80	1	0.68	2	1
59	*Penicillium waksmanii*	1	0.25	0	0	1	0.68	1	-
60	*Phaeoacremonium parasiticum*	1	0.25	1	0.40	0	0	1	2
61	*Phialemonium curvatum*	1	0.25	0	0	1	0.68	1	2
62	*Pleurostomophora repens* syn. *Phialophora repens*	1	0.25	1	0.40	0	0	1	1
63	*Polypaecilum insolitum*	4	1.01	4	1.61	0	0	3	1
64	*Pseudallescheria boydii* = *Scedosporium apiospermum*	3	0.76	0	0	3	2.03	2	2
65	*Purpureocillium lilacinum* syn. *Paecilomyces lilacinus*	14	3.53	10	4.02	4	2.70	12	1
66	*Sarocladium kiliense* syn. *Acremonium kiliense*	17	4.28	10	4.02	7	4.73	11	2
67	*Sarocladium strictum* syn. *Acremonium strictum*	15	3.78	10	4.02	5	3.38	12	1
68	*Scedosporium prolificans*	1	0.25	1	0.40	0	0	1	2
69	*Scopulariopsis acremonium*	3	0.76	3	1.20	0	0	2	1

Table 1. Continued.

No.	Species	Total		Autum		Spring		Number of posts	BSL
		Number	%	Number	%	Number	%		
70	*Scopulariopsis brumptii*	3	0.76	3	1.20	0	0	1	2
71	*Scopulariopsis* sp.	1	0.25	0	0	1	0.68	1	-
72	*Scytalidium infestans*	1	0.25	0	0	1	0.68	1	1
73	*Scytalidium lignicola*	8	2.02	4	1.61	4	2.70	5	2
74	*Staphylotrichum coccosporum*	4	1.01	2	0.80	2	1.35	2	1
75	*Talaromyces verruculosus* syn. *Penicillium verruculosum*	1	0.25	0	0	1	0.68	1	1
76	*Torula herbarum*	4	1.01	4	1.61	0	0	3	2
77	*Trichocladium asperum*	3	0.76	0	0	3	2.03	2	1
78	*Trichoderma koningii*	1	0.25	1	0.40	0	0	1	1
79	*Trichoderma longibrachiatum*	1	0.25	0	0	1	0.68	1	-
80	*Trichoderma viride*	10	2.52	2	0.80	8	5.41	9	1
81	*Trichothecium roseum*	3	0.76	3	1.20	0	0	2	-
82	*Ulocladium botrytis*	1	0.25	0	0	1	0.68	1	1
83	*Verticillium* sp.	9	2.27	5	2.01	4	2.70	8	-

(Table 1). Other species were observed less frequently. A significantly greater diversity of species ($p<0.05$) was found in the autumn than in the spring (Fig. 1). Forty-five species occurred in both research seasons, 19 only in autumn and 26 only in spring. *Fusarium oxysporum* and *Chrysosporium tropicum* were isolated twice as frequently in the autumn, while *H. haematococca = F. solani* and *Trichoderma viridae* were found six and four times more often in spring, respectively ($p <0.05$). For the other species present in both seasons, differences in the prevalence were not statistically significant ($p <0.05$).

A statistically significant difference was noted in the prevalence of fungi in soil from different recreational areas ($p<0.05$). The largest taxonomic diversity was observed in samples from sports fields (total 55 species): on average 4.38 (±2.5) in the surface layer and 5.23 (±3.27) 10-15 cm below the surface in autumn, and 2.0 (±2.38) in the surface layer and 2.15 (±2.76) below 10-15 cm deep in the spring (Table 2). On the playgrounds, 52 species were detected, on average between 3.87 (±3.14) and 4.5 (±2.62), depending on the season and the depth of sampling. In the samples from residential and school playgrounds, 32 species were

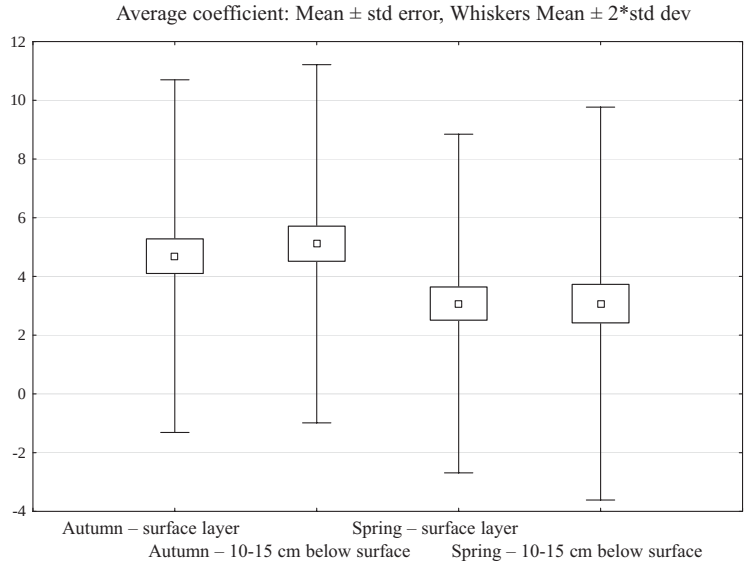

Fig. 1. Occurrence of filamentous fungi according to the seasons and the depth.

Table 2. Number of species of filamentous fungi isolated according to the types of collection localities.

No.	Type of collection localities	Number of species							
		Autum				Spring			
		Surface layer		Layer 10-15 cm below surface		Surface layer		Layer 10-15 cm below surface	
1	Beach	5	3.0±2.83	2	3.5±2.12	1	0.5±0.71	0	0
2		1		5		0		0	
3	Residential playground	13	9.0±5.66	10	6.5±4.95	8	6.5±2.12	12	8.0±5.66
4		5		3		5		4	
5	School field	3	4.38±2.5*	4	5.23±3.27*	0	2.0±2.38*	0	2.15±2.76*
6		0		2		0		0	
7		3		4		0		0	
8		6		2		1		5	
9		3		5		0		2	
10		5		9		0		0	
11		5		4		5		0	
12		7		5		0		0	
13		2		1		4		3	
14		2		4		3		1	
15		7		10		2		4	
16		5		6		4		4	
17		9		12		7		9	
18	Playground in park	4	4.37±3.02*	3	4.5±2.62*	3	4.0±2.72*	1	3.87±3.14*
19		1		2		3		2	
20		4		3		4		8	
21		2		3		1		0	
22		3		3		5		4	
23		5		9		2		2	
24		11		8		10		6	
25		5		5		4		8	
26	Lane park	6	6.0	9	9.0	8	8.0	5	5.0

* differences significance at $p<0.05$

found, on average from 6.5 (±2.12) to 9.0 (±5.66), while 20 were found in the soil from park lanes, ranging from 5 to 9 species at each site (Table 2). The least variety was found in sand from beaches: 9 species, no difference being found in the number of taxa between the surface layer and 10-15 cm below the surface.

Among the isolated species, as many as 22 belong to BSL 2, and 45 to BSL 1. Other species are not graded on a BSL scale (Table 1).

Dermatophytes were isolated from 79 out of 104 (76%) of soil samples from 24 examined sites (92.3%). They were classified to eight species from five genera. The most numerous was genus *Trichophyton* at 4 species (Table 3). Fewer species were recorded from the genus *Microsporum* (2), and *Keratinomyces* and *Nannizja* (1 species each). The dominant species was *Trichophyton ajelloi*, constituting 49.4%, detected in 39 samples from 19 localities. Also very common was *Microsporum gypseum* (26.6%): 21 samples from 11 localities. In six cases, two species were observed: *Keratinomyces ceretanicus* – in five and *Nannizja cajetana* – in four localities. Other species were noted rarely: *Trichophyton terrestre* in three localities, *Microsporum nanum* in two, and *Trichophyton tonsurans* and *Trichophyton schoenleinii* only once each (Table 3). Most species, except for *Microsporum gypseum* and *Microsporum nanum*, were reported more often in autumn than in spring.

Table 3. Taxonomic spectrum of isolated dermatophytes according to Index Fungorum.

No.	Species	Total		Autum		Spring		Number of posts	BSL
		Number	%	Number	%	Number	%		
1	*Keratinomyces ceretanicus*	6	7.59	0	0	6	13.3	5	1
2	*Microsporum gypseum*	21	26.6	12	35.3	9	20.0	11	2
3	*Microsporum nanum*	2	2.53	2	5.88	0	0	2	2
4	*Nannizja cajetana* syn. *Microsporum cookei*	6	7.59	2	5.88	4	8.89	4	1
5	*Trichophyton ajelloi*	39	49.4	16	47.1	23	51.1	19	1
6	*Trichophyton terrestre*	3	3.80	2	5.88	1	2.22	3	2
7	*Trichophyton tonsurans*	1	1.27	0	0	1	2.22	1	2
8	*Trichophyton schoenleinii*	1	1.27	0	0	1	2.22	1	2

Apart from *Microsporum gypseum*, the dermatophytes were more commonly isolated from samples taken from the surface layer, while *Trichophyton tonsurans* and *Trichophyton schoenleinii* were only occasionally seen. No difference was seen in the prevalence of dermatophytes, depending on type of localities (Table 4). The greatest diversity of dermatophyte species was found in the spring season in one residential and one park playground (four species each).

Dermatophytes were observed more frequently in the samples collected in spring and originating from the surface layer: the differences were not statistically significant ($p < 0.05$; Fig. 2). *Microsporum gypseum* was the most frequently isolated in autumn, from the layer below 10-15 cm depth. The most commonly detected dermatophytes belonged to common geophilic species, and only two species, *T. tonsurans* and *T. schoenleinii*, were classified as anthropophilic. As many as five of the detected dermatophyte species were classified as BSL 2: *M. gypseum*, *M. nanum*, *T. terrestre*, *T. tonsurans*, and *T. schoenleinii*. The others are assigned to BSL 1 (Table 3).

Discussion

Pathogens found in soil may invade the human organism through inhalation of soil dust, through a damaged epidermis or dermis, and by ingestion with plant products contaminated with sand. Therefore, the sanitary analysis of the soil is limited to detecting the presence of indicator bacteria, particularly fecal bacilli and streptococci, and usually concerns agricultural areas [14]. Studies that evaluate the presence of fungi are usually based on determining the type and degree of mycorrhizal fungi and their impact on plant growth and cropping [15]. Studies concerning the presence of mould fungi are rare.

Studies of the fungi of urban recreational areas such as parks, playgrounds, and squares have, however, been published. Deshmukh and Verekar [16] report the prevalence of fungi to be between 63 and 100% in playgrounds and 70-100% on squares. The authors identified 11 species: *C. queenslandicum* predominated (25%), while less frequent were *C. indicum* (11%) and *M. gypseum* (9%). Da Silva Pontes and Oliveira [17] detected the presence of six

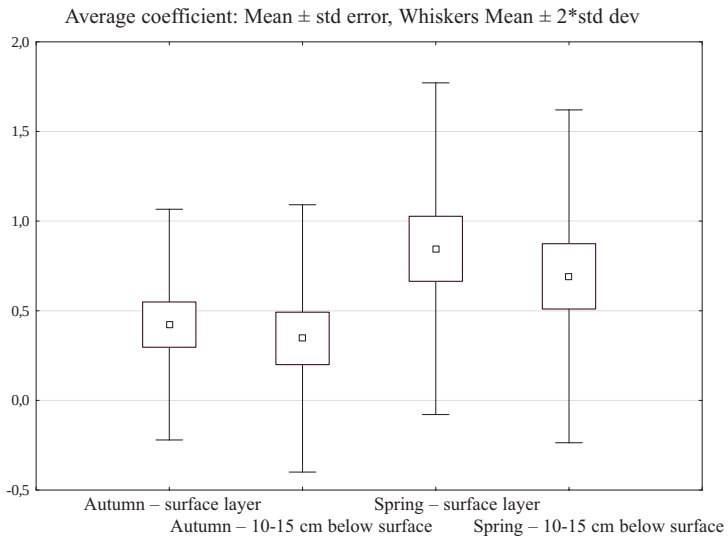

Fig. 2. Occurrence of dermatophytes according to the seasons and the depth.

Table 4. Number of species of dermatophytes isolated according to the types of collection localities.

No.	Type of collection localities	Number of species							
		Autum				Spring			
		Surface layer		Layer 10-15 cm below surface		Surface layer		Layer 10-15 cm below surface	
1	Beach	0	0	0	0	1	0.5±0.71	0	0
2		0		0		0		0	
3	Residential playground	0	0	0	0	0	1.0±1.41	2	0
4		0		0		2		2	
5	School field	1	0.61±0.77	2	0.54±0.88	1	1.0±0.82	2	0.69±0.85
6		0		0		0		2	
7		0		0		2		0	
8		1		0		1		0	
9		2		2		2		0	
10		2		2		1		1	
11		0		0		1		1	
12		1		1		0		0	
13		0		0		2		1	
14		0		0		2		2	
15		0		0		1		0	
16		1		0		0		0	
17		0		0		0		0	
18	Playground in park	1	0.37±0.52	0	0.25±0.71	0	0.75±1.16	0	0.62±1.06
19		0		0		0		0	
20		0		0		0		0	
21		0		0		1		0	
22		1		0		0		0	
23		0		0		3		3	
24		1		0		2		1	
25		0		2		0		1	
26	Lane park	0	0	0	0	0	0	0	0

species of dermatophytes, constituting 55.7% of positive samples, on school courtyards, squares, and in slums. *T. mentagrophytes* was isolated most frequently (37.5%). In the parks in Ahvaz (Saudi Arabia) *T. schoenleinii*, *M. gypseum*, *T. verrucosum*, and *T. mentagrophytes*, and keratinophilic fungi of the genus Chrysosporium were found [18]. Fungi occurred much more often in soils derived from the park where the zoo was located.

Maruthi et al. [19] reported the presence of 12 species of fungi in the soil sampled from areas of schools with playgrounds. *F. oxysporum* dominated (81.25%); *F. moniliforme* and *P. funiculosum* (68.7% each) and *A. flavus* (56.2%) also were commonly observed. Among dermatophytes, most frequently *M. audouinii* was isolated (43.7%). As the authors suggest, a high prevalence of fungi with keratinolytic properties may pose a risk of infection for children, therefore the soil of the school environment should be subject to sanitary inspection with regard to potentially pathogenic species. The soil of school grounds, hospitals, and squares was investigated by Ganaie et al. [20]. Fungi were most frequently isolated from squares (65%), but less from the back yards of schools (52%), and least often from areas of hospitals (30%). Of the 23 species found, *M. gypseum*, *A. flavus*, and *C. tropicum* predominated, with 59%, 57%, and 55%, respectively.

Rizwana et al. [21] analyzed the soil mycobiota of zoos, school playgrounds, and parks. Fungi were most frequently found in the playground soil, being isolated from 93% of the samples taken and slightly less often in the park (89%), while they were found in 81% of samples from the zoo. The greatest diversity was found at the zoo (19 species), with less being seen in the park (17 species) and on the playground (11 species). *C. indicum* dominated, being found in 33.7% of samples.

Głowacka et al. [22] conducted research on select sites in urban forests in Lodz used for recreation for residents. Nine species of mould fungi genera were found, *Fusarium*, *Mucor*, *Penicillium*, and *Scedosporium*, as well as two species of dermatophytes: *T. schoenleinii* and *T. terrestre*. *F. aquaeductum* and *P. citrinum* dominated, with 19% each. Wójcik et al. [10] isolated 69 species of filamentous fungi, including 4 dermatophytes, from sand from sandpits in Lodz. *C. herbrarum* (93.1%) and *P. chrysogenum* (76.5%) dominated, while the most frequent dermatophytes were *T. ajelloi* and *M. gypseum* (17.6% each). These authors also found a higher incidence of dermatophytes in school sandpits than in residential and park sandpits.

Genus *Fusarium*, one of the dominants in the present study, causes hialohyphomycosis of the lower limbs, genitourinary tract, nasal cavity, lungs, gastrointestinal tract, eye, and skin [7-9, 23]. *F. oxysporum* and *F. solani* are listed among the most common pathogens in this genus. Genus *Penicillium*, occupying a large share of soil mycobiota, can be the etiologic agent of respiratory, gastrointestinal, and skin infections [24, 25]. *Paecilomyces variotii* and *P. liliacinus* were isolated from patients with inflammation of the vagina or after caesarean section [26, 27]. The literature describes cases of CNS or pulmonary aspergillosis, mostly related to infection caused by *A. flavus* and *A. fumigatus*, but also increasingly *A. terreus* [28, 29]. Guarro et al. [30] presented individual cases of fatal invasion of *T. harzianum* in a kidney transplant recipient and in diabetic patients. Genus *Acremonium*, especially *A. kiliense*, *A. strictum*, and *A. sclerotigenum*, is isolated from biological materials of human origin (blood, BAL, sputum, nails, eyes) [31, 32].

All dermatophytes isolated in the studies above have been reported in cases of superficial fungal infections. The frequently found soil fungus *M. gypseum* is isolated in cases of mycosis of the scalp, glabrous skin, and eyelids [33, 34]. *T. ajelloi* can be the etiological agent of superficial mycosis of glabrous skin [35]. Genus *Trichophyton*, especially the anthropophilic species *T. rubrum* and *T. mentagrophytes*, can cause infections mixed with yeast-like fungus, such as *C. albicans* and *C. krusei* [6].

Mycoses caused by mould fungi generally affect people with a strongly weakened immune system [7, 9, 24, 25, 28, 29, 31, 32]. Their widespread presence in the environment favors the spreading of fungal propagules to a healthy human body. Biedunkiewicz [36] reported the presence of nine species of mould fungi, including one dermatophyte, in the nasal cavities, mouths, and throats of healthy students of veterinary medicine (27%). These fungi more often occurred in spring than in autumn and *P. chrysogenum* dominated (41%). The large percentage of filamentous fungi in healthy people is alarming; it may suggest decreased immunity of the examined group, or an increased affinity of these fungi for human tissue.

The presence of dermatophytes and mould fungi with keratinolytic properties in the soil of recreational places may pose a significant risk to human health, especially for children and young teenagers. The presence in playgrounds and parks of pets (dogs, cats) and wild animals (squirrels, foxes, birds) increases the amount of keratinized organic matter, which is a food source for fungi and promotes the survival of species pathogenic to the human body. The results obtained in this study and an analysis of the literature emphasize the need for monitoring the soil of places of active leisure for potentially pathogenic fungi species.

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