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Succession of fungi in the initial postindustrial soil

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The paper presents the results of 3-year mycological studies carried out in the reclaimed dumping ground of "Machów" sulphur mine. The stages of succession of soil fungi as well as their quantitative and qualitative composition in the initial soil of the dumping ground areas reclaimed for agriculture and forestry were determined.
Key words: Succession of fungi, postindustrial soils.

INTRODUCTION

Soilless areas of the outer dumping ground of the "Machów" Poland sulphur mine covering 880 ha are reclaimed and included into agricultural or forest production space.

Earlier studies carried out on the raw grounds of the waste dump showed that in general these areas were devoid of fungi (K o w a l i k, K o w a l i k, 1982). The development of young soils depends upon the composition of soil microorganisms which colonize the fresh biotope, inducing the growth of its fertility (R u s s e l l, 1974; R i c h a r d s, 1977).

The aim of the present work was to determine the succession of soil fungi and their qualitative and quantitative composition in the initial soil of the dumping ground reclaimed for forest and agricultural land use.

MATERIAL AND METHODS

The object of the study and the lithological-soil conditions were described by K o w a l i k (1993).

The investigated plots were established on:
- the top surface of the dumping ground formed in autumn of 1987 and seeded with alfalfa and grasses in spring of 1988 (field No I),

- the same top surface seeded with winter wheat in autumn of 1987 and with alfalfa and grasses sown into wheat in spring of 1988 (field No IB),
- the escarpment formed in spring of 1986, planted with young forest trees in 1987 and in spontaneously overgrown by herbaceous plant where common coltsfoot plants dominated of poor growth and low vitality (field No IV), and
- the same escarpment overgrown by herbaceous vegetation (where common coltsfoot plants dominated of abundant growth and great vitality (field No V).

The soil samples for mycological studies were taken according to the methods described by M a ń k a (1974).

Fungi were isolated from the soil in the separate fields of the dumping ground on the following sampling dates in 1988-1990: A – April 1-10, B – June 1-10, C – July 10-20, D – September 1-10, E – November 1-10.

The methods of isolation, culture, and identification of soil fungi were described by K o w a l i k (1993).

RESULTS

On the basis of the first isolation the raw grounds of the fields mentioned above were defined as mycologically poor (Table 1) since the number of isolated fungal colonies was 6-7 and that of species 3-5.

The freshly formed biotope of the escarpment was inicially colonized by *Doratomyces stemonitis, Gliocladium roseum, Mortierella vinacea, Penicillium expansum, Phoma exigua* v. *exigua, Pseudogymnoascus roseus, Scopulariopsis brevicaulis* and *S. brumptii*. In the first year of the investigation further isolations also showed the colonization of the two fields on the escarpment by *Cladosporium cladosporioides, Mortiella isabellina, Phoma eupyrena* and *P. herbarum*. The primary succession also consisted of fungi sporadically occurring in the two investigated fields, i.e. in the soil of the escarpment of poor vegetal cover four such species were identified: *Acrophialophora fusispora, Mucor racemosus, Penicillium jensenii* and *Thanatephorus cucumeris*, and in the soil overgrown with abundant vegetation nine species were identified: *Alternaria alternata, Humicola fuscoatra* v. *fuscoatra, Mucor hiemalis* f. *hiemalis, Penicillium restrictum, Phoma medicaginis, Pseudeurotium zonatum, Scopulariopsis chartarum, Trichurus terrophilus* and *Verticillium lecanii* (Tables 2 and 3).

In the second year of the investigation in the group of fungi colonizing the primitive soil of the escarpment eight new species were identified, among them 3 species were incommon in the two fields while on each plot 5 were different. The common species were *Cladosporium herbarum, Penicillium granulatum*, and *Trichoderma harzianum*. Moreover *Aspergillus versicolor, Gliocladium catenulatum, Penicillium lividum, Pseudeurotium zonatum* and *Torula graminis*, and were isolated from the poorly overgrown soil, whereas *Monilia geophila, Paecilomyces farinosus, Penicillium frequentans, Rhizopus stolonifer*, and *Talaromyces wortmanni* were identified from the soil with abundant plant coverage.

Table 1

The number of fungi isolated from initial soil of the reclaimed outer industrial waste dumpof the "Machów" sulphur mine

No field	No of isolates/species in particular years and time of isolation														
	1988					1989					1990				
	A	B	C	D	E	A	B	C	D	E	A	B	C	D	E
I	6/3	–	–	–	50/10	14/3	28/5	37/7	58/7	142/18	56/11	100/8	141/7	63/10	24/3
I B	6/3	–	–	–	26/9	40/7	144/10	49/9	54/6	141/8	71/8	246/6	237/4	15/3	42/5
IV	7/5	18/8	16/4	30/9	14/10	18/8	7/3	14/5	14/6	8/3	29/7	44/8	70/11	14/5	12/5
V	6/4	13/6	9/7	37/8	36/14	16/4	12/4	32/7	29/6	36/7	22/9	41/10	71/11	18/6	19/9

Dates of isolation: A – first decade of April
B – first decade of June
C – first decade of July
D – first decade of September
E – first decade of November

Table 2

Fungi isolated from the initial soil covered with herbaceous plants of poor growth on the escarpment of outer industrial waste dump of "Machów" sulphur mine

Species	Number of isolates in years		
	1988	1989	1990
Acrophialophora fusispora (Skansena) Samson	2	.	.
Arthrinium phaeospermum (Corda) M. B. Ellis	.	.	5
Aspergillus oryzae (Alburg) Cohn	.	.	2
A. versicolor (Vuill.) Tiraboschi	.	2	16
Chaetomium globosum Kunze et Steud.	.	.	20
Chrysosporium pannorum (Link) Hughes	.	.	10
Cladosporium cladosporioides (Fres.) de Vries	2	.	.
C. herbarum (Pers.) Link ex Gray	.	2	.
Doratomyces stemonitis (Pers. ex Steud.) Morton and G. Sm.	2	.	.
Gliocladium catenulatum Gilman et Abbott	.	4	.
G. viride Matr.	.	.	5
Mortierella isabellina Oudem.	7	.	.
M. vinacea Dixon-Steward	2	.	.
Mucor racemosus f. *sphaerosporus* (Hagem) Schripper	3	.	.
Penicillium expansum (Link ex Gray) Thom	6	1	.
P. granulatum Bain.	.	5	10
P. jensenii Zaleski	4	.	2
P. lividum Westling	.	3	.
P. odoratum Christensen et Backus	.	.	4
P. thomii Maire	.	.	4
P. verruculosum Peyronel	.	.	2
P. waksmanii Zaleski	.	.	5
Phoma eupyrena Sacc.	13	15	49
P. exigua Desm. v. *exigua*	2	.	.
P. herbarum Westend.	5	.	.
P. leveillei Boerema and Bollen	.	.	12
P. medicaginis Malbr. and Roum.	.	.	12
Pseudeurotium zonatum v. Beyma	.	8	2
Pseudogymnoascus roseus Raillo	4	.	.
Scopulariopsis brevicaulis (Sacc.) Bain.	2	2	6
S. brumptii Salvanet-Duval	2	.	.
Talaromyces wortmanii (Kloecker) C.R. Benjamin	.	.	2
Thanaterophorus cucumeris (Frank) Donk	1	.	.
Torula graminis Desm.	.	2	.
Trichoderma harzianum Rifai	.	17	.
T. viride Pers. ex Gray	.	.	1
Verticillium lecanii (Zimm.) Viégas	28	.	.
Total isolates/species	85/16	61/11	169/19

Table 3

Fungi isolated from the initial soil covered with herbaceous plants of vigorous growth on the escarpment of outer industrial waste dump of "Machów" sulphur mine

Species	Number of isolates in years		
	1988	1989	1990
Acremonium furcatum F. and V. Moreau ex W. Gams	2	.	2
Alternaria alternata (Fr.) Keissl.	3	.	.
Aspergillus oryzae (Alburg) Cohn	.	.	20
A. versicolor (Vuill.) Tiraboschi	.	.	18
Cladosporium cladosporioides (Fres.) de Vries	10	.	.
C. herbarum (Pers.) Link ex Gray	.	2	3
Gliocladium roseum Bain.	4	.	.
G. viride Matr.	.	.	12
Humicola fuscoarta Traaen v. *fuscoarta*	1	.	.
Monilia geophila Oudem	.	4	.
Mortierella isabellina Oudem.	11	.	6
M. vinacea Dixon-Stewart	.	.	4
Mucor hiemalis Wehmer f. *hiemalis*	6	.	.
Paecilomyces farinosus (Holm ex Gray) Brown	.	10	.
Penicillium chrysogenum Thom	.	.	6
P. decumbens Thom	.	.	9
P. frequentans Westling	.	38	.
P. granulatum Bain.	.	3	.
P. jensenii Zaleski	5	.	3
P. nigricans Bain. ex Thom	.	.	5
P. restrictum Gilman et Abbott	6	.	.
P. thomii Maire	.	.	2
P. waksmanii Zaleski	.	.	17
Phoma eupyrena Sacc.	1	6	13
P. herbarum Westend.	2	.	4
P. medicaginis Malbr. and Roum.	5	.	7
Pseudeurotium zonatum v. Beyma	3	2	.
Pseudogymnascus roseus Raillo	2	.	.
Rhizopus stolonifer (Ehrenb. ex Link) Lind	.	1	.
Scolecobasidium constrictum Abbott	.	.	9
Scopulariopsis brevicaulis (Sacc.) Bain.	1	.	.
S. brumptii Salvanet-Duval	19	6	18
S. chartarum (G. Sm.) Morton ex G. Sm.	4	.	.
Talaromyces wortmanii (Kloecker) C.R. Benjamin	.	9	.
Trichoderma harzianum Rifai	.	44	13
Trichurus terrophilus Swift et Povah	13	.	.
Verticillium lecanii (Zimm.) Viégas	3	.	.
Total isolates/species	101/19	125/11	171/19

In the third year of the investigation the number of fungi in the soil of the escarpment dramatically increased. In the soil of both fields the new species were: *Aspergillus oryzae, Gliocladium viride, Penicillium thomii* and *P. waksmanii*. In addition to the above species, in this stage of succession *Arthinium phaeospermum, Chaetomium globosum, Chrysosporium pannorum, Phoma leveillei* and *P. medicaginis* were more numerous in the soil of the poorly overgrown field (Table 2). In the field with vigorous growth species of the genus *Penicillium* were mainly encountered (Table 3).

The 3-year results of isolation of soil fungi from the two fields of the dumping ground escarpment indicated that as regards most species a slightly greater number of fungi colonies was isolated from fields overgrown by abundant herbaceous vegetation.

In the soil of both fields of the escarpment species of the genera *Aspergillus, Chaetomium, Mortierella, Penicillium, Phoma, Scopulariopsis, Trichoderma* and *Verticillium* dominated. In the final period of the investigation a more frequent occurrence of the species *Aspergillus oryzae, A. versicolor, Chaetomium globosum, Gliocladium viride, Penicillium waksmanii, Phoma eupyrena, P. leveillei, P. medicaginis* and *Scopulariopsis brumptii* was observed in the succession series of soil fungi of the two investigated fields. They were replacing pioneer fungi, such as *Cladosporium cladosporioides, Gliocladium roseum, Phoma exigua* v. *exigua, Pseudogymnoascus roseus*, and *Verticillium lecanii* which had initiated the colonization of raw grounds of the escarpment.

As in the case of above mentioned fields on the escarpment, *Gliocladium roseum, Pseudogymnoascus roseus* and *Phoma leveillel* were the first colonizers in the soil of the top surface of the dumping ground where agricultural reclamation had started (field I and I B).

The introduction of agricultural crops to these soils brought about a dynamic increase in the number of species and colonies of soil fungi and also affected the differentiation in the structure of the succession stages in the investigated fields. In the soil of field I a gradual steady increase in the number of colonies and species of fungi was observed after alfalfa with grasses were sown in. Apart from the three species mentioned above *Acremonium murorum, Coniothyrium sporulosum, Doratomyces stemonitis, Mortierella vinacea, Penicillium brevi-compactum, P. waksmanii, Phoma eupyrena, Scopulariopsis brumptii* and *Trichurus terrophilus* appeared towards the end of the first vegetative period (1988). In the soil of the analogical field seeded with winter wheat and alfalfa sown in (I B) *Alternaria alternata, Arthrinium phaeospermum, Epicoccum purpurascens, Fusarium avenaceum, F. oxysporum, Mortierella isabellina, M. parvispora, Penicillium waksmanii* and *Phoma medicaginis* were isolated in the same period.

In the second year of the study a 5 -fold increase in the number of colonies was observed and the number of new species increased to 24 in the soil of field I (Table 4). A higher dynamic of soil colonization was assessed in field I B (with the mixture of alfalfa and grasses introduced into winter wheat). In the second of cultivation the number of colonies increased 13 fold and that of species 2.5-fold compared to the first year (Table 5).

Table 4

Fungi isolated from the initial soil covered with a culture of alfalfa and grasses in field I of the outher industrial waste dump of "Machów" sulphur mine

Species	Number of isolates in years		
	1988	1989	1990
Absidia glauca Hagem	.	1	13
Acremonium murorum (Corda) W. Gams	2	12	23
Alternaria alternata (Fr.) Keissl.	.	.	3
Aspergillus clavatus Desm.	.	6	.
A. oryzea (Ahlburg) Cohn	.	.	34
A. versicolor (Vuill.) Tiraboschi	.	8	21
Botrytis cinerea Pers. ex Nocca and Balb.	.	.	12
Chaetomium globosum Kunze ex Steud.	.	1	.
Cladosporium cladosporioides (Fres.) de Vries	.	28	8
C. herbarum (Pers.) Link ex Gray	.	7	.
Coniothyrium sporulosum (W. Gams and Domsch) van der Aa	1	.	3
Doratomyces stemonitis (Pers. ex Steud.) Morton and G. Sm.	1	.	.
Gliocladium roseum Bain.	13	.	.
Humicola grisea Traaen v. *grisea*	.	2	.
Metarrhizium anisopliae (Metschn.) Sorok.	.	2	.
Minimedusa polyspora (Hoston) Weresub and Le Clair	.	4	.
Monilia geophila Oudem.	.	2	.
Mortierella isabellina Oudem.	.	.	6
M. parvispora Linnem.	.	12	5
M. vinacea Dixon-Stewart	4	.	7
Mucor hiemalis Wehmer f. *hiemalis*	.	13	.
Paecilomyces farinosus (Holm ex Gray) Brown	.	28	4
Penicillium brevi-compactum Dierckx	2	.	.
P. chrysogenum Thom	.	.	4
P. claviforme Bain.	.	2	.
P. expansum (link ex Gray) Thom	.	.	6
P. frequentans Westling	.	25	39
P. granulatum Bain.	.	14	99
P. jensenii Zaleski	.	.	2
P. raperi Smith	.	.	1
P. spinulosum Thom	.	14	1
P. waksmanii Zaleski	4	19	45
Pestalotia hartigii Tubeuf	.	10	.
Phoma chrysanthemicola Hollos	.	.	9
P. eupyrena Sacc.	1	9	.
P. exigua Desm. v. *exigua*	.	10	.
P. herbarum Westend.	.	6	.
P. leveillei Boerema and Bollen	2	.	.
Pseudeurotium zonatum v. Beyma	.	2	1
Pseudgymnoascus roseus Raillo	2	.	.
Scopulariopsis brevicaulis (Sacc.) Bain.	.	1	30
S. brumptii Salvanet-Duval	19	14	1
S. fusca Zach	.	.	3
Trichoderma harzianum Rifai	.	14	.
T. piluliferum Webster et Rifai	.	.	4
Trichurus terrophilus Swift et Povah	5	.	.
Non-sporulating strain Dematiaceae W I-3	.	13	.
Total isolates/species	56/12	279/28	384/26

Table 5

Fungi isolated from the initial soil covered with a culture of alfalfa and grasses (sown into winter wheat) in field I B of the outher industrial waste dump of "Machów" sulphur mine

Species	Number of isolates in years		
	1988	1989	1990
Absidia glauca Hagem	.	6	.
Alternaria alternata (Fr.) Keissl.	4	12	10
Arthrinium phaeospermum (Corda) M .B. Ellis	3	84	.
Aspergillus clavatus Desm.	.	2	.
A. oryzae (Alburg) Cohn	.	.	229
A. sydowii (Bain et Sart.) Thom et Church	.	.	5
A. versicolor (Vuill.) Tiraboschi	.	26	15
Chaetomium globosum Kunze ex Steud.	.	1	.
Cladosporium herbarum (Pres.) Link ex Gray	.	.	3
C. macrocarpum Preuss	.	.	6
C. sphaerospermum Penz	.	3	.
Doratomyces microsporus (Sacc.) Morton and G. Sm.	.	.	6
D. nanus (Ehrenb. ex Link) Morton and G. Sm.	.	1	.
Epicoccum purpurascens Ehrenb. ex Schlecht.	2	3	.
Fusarium avenaceum (Fr.) Sacc.	7	8	4
F. oxysporum (Schlecht.) Snyd. et Hans.	2	.	.
F. sambucinum Fuckel v. *coeruleum* Wollenw.	.	4	.
Gliocladium catenulatum Gilman et Abbott	.	4	.
G. roseum Bain.	2	.	.
Humicola fuscoatra Traaen v. *fuscoatra*	.	6	.
Memnoniella echinata (Riv.) Galloway	.	.	5
Minimedusa polyspora (Hoston) Weresub and Le Clair	.	42	.
Monilia geophila Oudem.	.	1	.
Mortierella isabellina Oudem.	1	.	18
M. parvispora Linnem.	3	11	.
Paecilomyces farinosus (Holm ex Gray) Brown	.	70	.
Penicillium botryosum Bat. et Maia	.	.	7
P. claviforme Bain.	.	17	46
P. frequentans Westling	.	24	.
P. funiculosum Thom	.	5	.
P. granulatum Bain.	.	32	.
P. herquei Bain. et Sartory	.	.	2
P. oxalicum Currie et Thom	.	.	3
P. waksmanii Zaleski	2	.	23
Phoma eupyrena Sacc.	.	.	2
P. herbarum Westend.	.	1	7
P. leveillei Boerema and Bollen.	2	.	.
P. medicaginis Malbr. and Roum.	2	.	.
Pseuderotium ovale Stolk	.	5	.
Pseudogymnoascus roseus Raillo	2	.	4
Rhizopus stolonifer (Ehrenb. ex Link) Lind	.	28	.
Scopulariopsis brumptii Salvanet-Duval	.	10	207
Staphylotrichum coccosporum J. Meyer and Nicot	.	4	.
Torula graminis Desm.	.	4	.
Trichoderma harzianum Rifai	.	13	.
T. piluliferum Webster et Rifai	.	.	8
T. viride Pers. ex Gray	.	1	.
Total isolates/species	32/12	428/29	611/21

In the second year of cultivation the common species in the initial soil of both agriculturally reclaimed fields were: *Peacilomyces farinosus, Penicillium frequentans, P. granulatum* and *Trichoderma harzianum* which prevailed and *Absidia glauca, Aspergillus clavatus, A. versicolor, Chaetomium globosum, Monilia geophila, Penicillium claviforme*, and *Phoma herbarum* characterized by a much smaller number of colonies. In the soil of field I the most numerous fungi were: *Cladosporium cladosporioides, Mortierella parvispora, Mucor hiemalis* f. *hiemalis, Penicillium spinulosum, P. waksmanii, Pestalotia hartigii* and *Phoma exigua* v. *exigua* and that of field I B: *Minimedusa polyspora, Rhizopus stolonifer* and *Scopulariopsis brumptii.*

In the third year of the reclamation cropping the new fungi species which had colonized the soils of the two investigated fields were: *Aspergillus oryzae* and *Trichoderma piluliferum.*

Apart from these species of *Botrytis cinerea, Mortierella isabellina, Penicillium expansum, P. raperi, Phoma chrysanthemicola*, and *Scopulariopsis fusca* were frequently noted in the soil of field I. Such species as *Aspergillus sydowii, Cladosporium herbarum, C. macrocarpum, Doratomyces microsporus, Memnoniella echinata, Penicillium botryosum, P. herquei, P. oxalicum*, and *Phoma eupyrena* were abundant in field I B.

In the communities of soil fungi isolated from fields reclaimed for agricultural use species of the genera *Acremonium, Arthrinium, Aspergillus, Cladosporium, Paecilomyces, Penicillium, Phoma* and *Scopulariopsis* dominated.

The succesSsion of fungi in the initial soils reclaimed for agricultural use shows a much higher of increase in the number of colonies and a slightly lower increase as regards the species than in the reclaimed soils for at forestation. Neverthless, in the two fields on the escarpment the communities of fungi do not show greater differences in this respect, contrary to agriculturally reclaimed fields, where pronunced differentiation, especially in the number of colonies was assessed.

The results obtained regarding the succession of soil fungi on the fields reclaimed for agricultural or forest use on the outer dumping ground of the "Machów" mine indicate that the species composition of the mycoflora changed more rapidly in the initial stages of the succession than in the later stages. The greatest variation of species was also observed in the first 2 years as the species randonily colonized the raw microbiologically poor grounds.

DISCUSSION

The results of the studies on the fungi colonization of raw dumping grounds indicate that in varied environments of initial soils the development of the populations of fungi depends upon a complex of interacting factors. R i c h a r d s (1977) suggests that the development of ecosystems is associated with the phenomena of ecological succession, i.e, the processes of general changes of biocenosis brought about by the modifying effect of microorganisms upon the physical environment. The above results confirm the opinions of G a r r e t t (1963) and A l e x a n d e r

(1975) that some species of fungi, mainly from *Zygomycotina* and *Deuteromycotina* play a role in the initial phase of colonization.

In the "Machów" waste dump the colonization of raw grounds reclaimed both for agricultural use and afforestation was initiated by fungi of the genera *Doratomyces, Gliocladium, Mortierella, Penicillium, Phoma, Pseudogymnoascus* and *Scopulariopsis.* In earlier studies conducted by the present author (1982, 1990) species of genera *Aspergillus, Cladosporium, Mortierella, Penicillium* and *Stysanus* were the primary colonizers of the reclaimed areas on this waste dump.

A number of authors classify fungi of the genera *Mortierella, Mucor, Absidia* and *Penicillium* in the group of primary colonizers (G a r r e t t, 1963; K r e u t z e r 1965; M a r s z e w s k a - Z i e m ę c k a, 1969; G o ł ę b i o w s k a 1982). These fungi are characterized by rapid growth, invasiveness, and ability of utilizing simple organic compounds. Their secretions inhibit the growth of other fungi and ensure their prevalence in the initial phase of colonization. F i s c h e r (1952) and G r i f f i n (1960) point out that species the genera *Gliocladium, Humicola* and *Chaetomium* are the first colonizers or they appear just after the above mentioned fungi *Mortierella, Mucor, Absidia* and *Penicillium* had invaded the environment.

Contradictory results are reported by different authors concerning the role of fungi of the genera *Mucor, Penicillium* and *Trichoderma* in succession. In the initial soil of the dumping ground escarpment fungi of the genus *Mucor* appeared at the beginning of in the early stages of succession. These findings are in agreement with those reported by B o r o w s k a (1969) and G o ł ę b i o w s k a (1982) who classified these fungi among the first colonizers of new environments. According to M a c a u l e y and T h r o w e r (1966) these fungi occur abundantly in the later stages of succession. In a study of "young" phosphogypsum M a d e j (1992) indicated fungi of the genera *Trichoderma* and *Penicillium* as the first organisms colonizing this environment. Similar results obtained from disinfected horticultural substrates were reported by B u r k o t - K l o n o w a (1978). In the case of the "Machów" dumping ground the colonization of the genus *Trichoderma* by fungi occurred in later stages of succession. This was possibly associated with their capacity of utilizing cellulose compounds produced in the course of accumulation of organic matter in the soil (A h m a d, B a k e r, 1987).

As the next stage of succession G a r r e t t (1963) mentions the phase of "sugar fungi". In his work he indicated that the final products of metabolism of *Zgomycotina* and *Deuteromycotina* induce the grouth of "secondary sugar fungi" (*Ascomycotina,* some *Basidiomycotina* and *Deuteromycotina*) active in cellulose decomposition. Fungi of the genera *Chaetomium, Humicola* (F i s c h e r, 1952), *Phoma, Botrytis, Graphium, Trichoderma* (D o m s c h, 1960), *Botryotrichum, Humicola, Chaetomium, Oidiodendron* (T r i b e, 1957), *Chaetomium, Stachybotrys* and *Fusarium* (G o ł ę b i o w s k a, 1982; M a r o i s, D u n n, P a p a v i z a s, 1983; B r o w e l l, S c h n e i d e r, 1985) belong to this group. K r e u t z e r (1965) claims that most "sugar fungi" occur only in the root zone of plants. This observation is in agreement with the results of mycological analysis in the initial soil of the dumping ground escarpment

abundantly overgrown by herbaceous vegetation and in the soil of alfalfa and grass culture. Fungi of the genera *Humicola, Fusarium, Chaetomium*, and *Phoma* were isolated from these soils. The genus *Phoma* was represented by a few species, two of which i.e. *Phoma eupyrena* and *P. leveillei* are reported as the first colonizing organisms, especially on mineral soils (D o m s c h, G a m s, A n d e r s o n, 1980). *Ascomycotina* fungi represented by the genera *Chaetomium, Pseudogymnoascus, Pseudeurotium*, and *Talaromyces* whose populations distinctly declined with the passage of time. Numerous colonies of fungi of the genera *Penicillium* (*P. claviforme, P. frequentas, P. granulatum, P. spinulosum*, and *P. waksmanii*) which are supposed to play an important role in cellulose decomposition (D o m s c h, 1960; M a c a u l e y, T h r o w e r, 1966; M a r s z e w s k a - Z i e m i ę c k a, 1969) were isolated from the area reclaimed for agricultural use in the 2nd and 3rd year of alfalfa and grass culture. Equally numerous were fungi of the genus *Aspergillus*, particularly *A. oryzae* and *A. versicolor*, which play a similar role in the decomposition of cellulose and lignin (D o m s c h, 1960).

Many authors indicate that cellulose-deccomposing fungi play an important role in the final stage of succession.

B o r o w s k a (1969) and G o ł ę b i o w s k a (1982) regarded as such the fungi of the genus *Trichoderma*, particularly *T. viride* whereas (F i s c h e r, 1952) also names *Alternaria alternata* and *Fusarium nivale*. In the dumping ground this role may also be played by *T. harzianum, T. piluliferum* and *A. alternata* whose numerous colonies were isolated from the soil with alfalfa sown in the protective crop. On the other hand D o m s c h (1960) claims that *Trichoderma viride, Botrytis cinerea, Mucor hiemalis, Chaetomium* sp. and *Metarrhizium anisopliae* (whose scarce populations were isolated from the of the dumping ground) are characterized by the lack of activity in lignin decomposition. According to this author *Verticillium lateritum, Phoma* sp., and *Scopulariopsis brumptii* a can play animportant role in this process.

In the soil of the dumping ground reclaimed for agricultural use the species of the genera *Phoma* and *Scopulariopsis*, especially *P. eupyrena, P. exigua* v. *exigua, P. chrysanthemicola, S. brevicaulis and S. brumptii* dominated in the 2nd and 3rd year of cultivation of alfalfa mixture with grasses.

Apart from the above-mentioned fungi regarded by some research workers as primary colonizers of different substrates (plough land, chemically or thermally disinfected soil, mulch, leaves, phosphogypsum) in the investigated soils of the dumping ground reclaimed for agriculture or afforestation the occurrence of certain fungi not reported in earlier works was assessed during the initial stages of succession. The fungi isolated in great numbers from this environment were: *Acremonium murorum, Arthrinium phaeospermum, Cladosporium cladosporoides, Minimedusa polyspora, Rhizopus stolonifer* and *Verticillium lecanii*.

Not all hypothetic stages of fungi succession reported by G a r r e t t (1963) and K r e u t z e r (1965) could be determined in the succession found for the raw and mycologically poor initial soil of the "Machów" dumping ground. According to R i c h a r d s (1977), the stages of dominance of the first saprophytic and "sugar"

fungi may be considerably reduced in different ecosystems or they may not appear at all. In the waste dump this was probably intensified by the lack or very low content of organic matter and highly deficient physical properties of grounds, especially their poor aeration in the first years of reclamation.

The results presenting the succession of fungi in the initial soil of the "Machów" dumping ground indicate that the stabilization of fungi communities occurs, after the increasing entropy in the first years of succession. This is in accordance with Odum's theses (1982).

CONCLUSIONS

1. Raw soils of dumping grounds are mycologically very poor. The rate of colonization and the abundance of fungi colonizing these types of soils depends upon the methods and period of reclamation.

2. In the initial stage of colonization of an initial soil the communities of soil fungi show a tendency towards an increasing entropy, while in further years the entropy diminishes and the communities gradually become stabilized.

3. In the reclaimed soils of dumping grounds the succession of soil fungi reflect the changes occuring in the environment of very compact soil and may serve to indicate the of increase in fertility of this soil.

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