Some Aspects of Microbial Activity in Anthropogeneous Soils with Reference to Specific Reclamation Projects

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The organic substances in the soil are extraordinarily important for the solution of problems connected with the reclaiming of dumps and tailing ponds after the mining, processing and treatment of polymetallic ores, which are toxic because of their high contents of sulphide components. Due to the shortage of topsoil, some selected beaches of tailing ponds at the State Enterprise Rudné doly Jesenik were covered with a layer of soil available from excavations after intensive building activities. Therefore, the soil used was not fertile, but fertilizable, and contained no undesirable toxic substances. Many examinations were carried out to discover how the soil-forming processes on this coverage could be positively affected. This included a determination of the microbial activities of the soils.

The following method was selected for testing the activity of soil microflora: macroscopically visible non-decomposed organic substance admixtures were removed from the soil samples before testing. 20 g of dry soil substances, moisturized to 50% maximum capillary capacity, with the addition of 1 ml of special testing solution M, were used for each testing variant. A glucose-containing solution was prepared from solution M with the addition of 18 mg C of glucose to 1 ml.

Test cultivation /at 28 °C/ was carried out in respirometers which enabled O_2 consumption to be monitored. The experimental data obtained were re-calculated for normal conditions. The amount of mineralized carbon was determined by titration from the CO_2 volumes absorbed in the lye. Initial and final NH_3, NO_3 and NO_2 content were determined in the soil leachate using 1% K_2SO_4.

Three samples were taken from each location /Horni Benesov and Zlaté Hory/ and subjected to laboratory examinations an evaluation of the data obtained are shown in Table 1.

Results

The microflora in the soil samples was at a state of low activity, as was evident from the retarded reaction to the addition of an easily accessible organic substance /glucose/, with the exception of sample Z_3, taken from Horni Benesov. The soil of sample Z_3 had a very high base metabolic rate, which witnessed a relatively high content of organic substances available to the microflora. In relation to samples from Zlaté Horny, the situation in Horni Benesov appears to be microbiologically more active.

Table 1

O_2 consumption, in ml /101325 Kpa, 273.15 K/

Sample No.	Without organic addition /M/					With glucose				
	16th	22nd	40th hours	46th	64th	16th	22nd	40th hours	46th	64th
				A. Horni Benesov						
Z_1	0.02	0.07	0.18	–	0.25	1.91	6.65	1.98	14.22	16.12
Z_2	0.04	0.13	0.32	–	0.56	4.13	6.96	12.79	14.18	16.24
Z_3	1.39	2.04	3.56	4.03	5.39	11.84	13.96	17.27	18.33	21.43
				B. Zlate Hory						
Z_4	0.80	1.17	2.07	2.36	3.19	5.17	10.21	13.82	14.60	17.16
Z_5	0.05	0.12	0.33	–	0.59	1.50	4.94	12.37	13.04	15.15
Z_6	0.51	0.88	2.09	2.51	3.75	2.57	8.25	13.33	14.08	16.01

The values of respiration quotients /RQ/ for the tested soil samples showed that the substrates used in basal metabolism in samples Z_3 /Horni Benesov/ and Z_6 /Zlaté Hory/ differed markedly from the other samples.

As regards the nitrogen metabolism, the tested locations showed an extraordinary biological sorption of ammoniacal nitrogen /except for the M variants of sample Z_5 Zlaté Hory/. No nitrification bacteria, the occurrence of which is usually correlated with soil fertility, were functionally demonstrable in the tested samples, as explicitly shown by the balance of nitrates /Table 2/.

The microbiological functional characteristics of soil samples from Horni Benesov indicate that this soil can be regarded as standard arable land. It can be assumed, on a consideration of soil-microbiological aspects that greater or lesser changes will occur in the microflora and microfauna species in the microbial sphere of this soil after transfer to a new site in comparison with the previous site due to probable microclimatic and stratigraphic changes. Provided the new situation does not cause a substantial impairment in their physico-chemical properties, these changes should not cause too great a decrease in their biological quality.

In fact the proportion of gravel and sand is left out of account, the soil samples from Zlaté Hory show a marked biological activity which, admittedly, is not yet of the standard of cultivated soil, but considerably surpasses the level which can be identified as rock detritus. A continuous rise in the level of microbial and humification processes can be expected after enrichment with other organic material from the growth for which this soil will be used as substrate.

Table 2

Mineralized C, CO_2 production, NH_3, NO_3 and NO_2 contents of the experimental soils, after 64 hours

Parameters		Horni Benesov			Zlaté Hory		
		Z_1	Z_2	Z_3	Z_4	Z_5	Z_6
Mineralization, mg C	G	9.84	10.41	13.47	12.21	9.21	9.69
	M	0.42	1.05	3.57	4.17	0.87	1.83
CO_2 production, ml	G-M	17.53	17.36	18.37	14.91	15.47	14.58
NH_3 balance, mg N	G	-1.42	-1.47	-1.39	-1.47	-1.51	-1.49
	M	-1.06	-1.44	-0.74	-0.65	-0.29	-0.63
Balance NO_3 + NO_2 mg N	G	-0.05	-0.08	-0.26	-0.08	-0.07	-0.09
	M	-0.04	-0.07	-0.06	-0.04	-0.06	-0.07
RQ $/CO_2/O_2/$	M	3.12	3.48	1.23	2.43	2.73	0.904

G = testing solution with glucose; M = mineral testing solution only;
All values are related to 20 g of dry soil substances

Conclusions

The decomposition and synthesis of organic substances and the process of soil mixing result from the activities of soil organisms under natural conditions. The organisms /for instance algae, lichens and bacteria/ settle first on coarse substrates and use mineral substances to obtain nutrients, thus facilitating the subsequent settlement with higher plants. In this way, the quantity of organic substances increasingly accumulates. Thus, the dynamics of the transfer of soil-forming material in the substrate and soil is determined by the joint influence of higher plants and microorganisms. If the substrate is in a state enabling it to be grown through by the roots of higher plants, the lithotropic microflora, the expansion of which represents only a restricted enrichment of the mineral material with organic matter, will quickly be complemented by heterotrophic microflora, especially within the zone influenced by the roots. This is represented by the so-called rhizospheric microflora which is adapted to the exploitation of root exudates. The species composition of this population of microbes is determined by the host plant, which is, in turn, appreciably influenced by this microflora. The composition of the microflora species in the rhizosphere varies according to the biochemical changes in this medium. If root hairs wither forms which are able to metabolize the withered organic residues gradually develop. In this way, the enrichment of the rock substrate with organic substances and the consequent rapid destruction of the degradable components of the rock material may take place much more intensively.

It is possible to imagine a gradual transition from rock material to soil according to this scheme, which, however, proceeds in an unlimited number of variants as regards material, function and time.

The microbial processes which will probably take place in a medium formed in this way, for instance, in tailing ponds, are in the nature of soil-forming processes of the third phase, i.e. the phase of displacement /soil mixing, filtration displacement/ in the case of Horni Benesov, and of the second phase, i.e. the phase of construction /formation of clayey materials, humus formation/ in Zlaté Hory.

After an evaluation of all the pedogenetic factors and the conditions described above and taking into account the specific deposition and combination of both soil-forming substrates, automorphous and hydromorphous processes can be detected in the development of soils. Basic pedogenesis will lead to the formation of brown soil and acid brown soil with the local presence of the gleization and illimerization processes. The physical process of turning brown will take place in the lower part /from 50 cm/, affected by chemical and physical changes taking place in the tailing pond sediment. All this will be valid presuming that the toxicity of the tailing pond sediment substrates will not be permanent and dominating.