Catalase Activity — an Indicator of Biological Activity in Forest Soils

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Hydrogen peroxide is formed during the metabolism of cells. This substance is a cytotoxine. It is the catalase enzyme that breaks down this cytotoxic substance. Anaerob microorganisms lack for catalase enzyme. Since the majority of the soil bacteria live in aerobic conditions the rate of catalase activity can be considered as one of the adequate indicators of the biological status of the soil.

The aim of this paper is to compare the catalase activities in forest soil samples taken from various sites under different tree species.

Materials and methods

The samples were collected from three Scotch pine stands, two sessile oak and a beech forest stand located in various regions of the country /Table 1/.

Investigations were started in the summer of 1987, and the samples were collected in May, August and early November in 1988. The samples were taken from the decomposing litter /A_{oo} layer/, the top 8 cm and 8-16 cm layers of the soil. Three sampling points were randomly selected on each site within an area of approximately 80 by 50 m.

Each sample was put into a polyethylene bag, carefully avoiding contamination, then in laboratory the three point-samples were mixed. From all the sites each set of samples was collected, as far as possible, within one week.

Catalase activity was determined by the gasvolumetric method /BECK, 1971/. Since catalase activity showed a slight change in time, the enzyme assays were uniformly carried out on the 90th day after sampling on air-dried samples.

For separating microbial catalase activity from that of plant origin, parallel samples were run simultaneously with each sample which were treated with sodium azide, a bactericide agent.

For estimating the rate of catalase activity the Catalase Activity /C. A./ index was used, which represents the volume of O_2 in ml released from the soil suspension within 3 minutes under standard circumstances /BECK, 1971/. The coefficient of variation for Beck's method was 3.3%.

Table 1

The parameters of the sampling sites

Sampling site	Tree species	Age /years/	Soil type	Climate category*
Farkasfa	Scotch pine	20	pseudogley brown forest soil	hornbeam-oak
Gödöllő	Scotch pine	20	rusty brown forest soil	oak-Turkey oak
Kerekegyháza	Scotch pine	20	humic acid	forest steppe
Farkasgyepü	beech	120	lessivated brown forest soil	beech
Mátrafüred	oak	51	lessivated brown forest soil	hornbeam-oak
Sopron	oak	80	acid non-podzolic brown forest soil	hornbeam-oak

*Climate categories are determined in compliance with the Hungarian site--type classification system. Under Hungarian conditions a climate can be characterized by forest associations and their prevailing tree species called "climatic test plants". The climate categories are as follows: beech, hornbeam-sessile oak, sessile oak or Turkey oak and forest steppe.

Results and discussion

Comparison of soil catalase activities in deciduous and coniferous stands

The results obtained are summarized in Table 2. The indices of catalase activity in the decomposing litter /A_{oo} fermentation layer/ of the deciduous stands were higher by 21-65% than in those of the same activity in the corresponding layer under the coniferous ones. In the top 8 cm of the soil the C. A. indices ranged from 9.3 to 16, i. e. they were 65-75% lower than in the fermentation layer exhibiting the most intensive microbial activity.

Simultaneously, in the coniferous stands C. A. indices ranged from 1.8 to 4.7, i. e. were lower by 84-91% than those of the deciduous stands. The difference between the C. A. indices of the samples from soil layers was not so large as that of the decomposing litter but it was significant. In the lower layer of the soil /8-16 cm/ the C. A. index was between 4.4 and 11.5, which represented a decrease of 30-53% compared to the upper soil layer, while in the case of pine stands the decrease of the C. A. index was 25 to 45%.

There is a strong correlation between the humus content and the C. A. index of soils. The highest C. A. index /23/ was obtained for oak stands at Sopron and Mátrafüred where the humus content of the soil ranged from 8.1% to 9.5%, whereas the smallest figure /C. A. = 1/ was obtained for the pine stands at Kerekegyháza and Gödöllő, where the humus content was 1% and 2%, respectively.

The C. A. indices found in the literature ranged between 5 and 65 and these were obtained during investigations of forest and agricultural areas /BECK, 1971; 1984; BOSCH and AMBERGER, 1983; HOFMANN and PFITSCHER, 1982; DUTZLER-FRANZ, 1977a,b/. The catalase indices for the soil surface with high humus content assessed by us are in agreement with the C. A. indices determined for intensively cultivated agricultural fields.

Table 2

The indices of catalase activity /C. A./ in decidous and coniferous stands at various sites in Hungary

Sampling sites	Depth of sampling cm	Humus %	C. A. - indices 1987 summer	1987 autumn	1988 spring	1988 summer	1988 autumn	$\bar{X}$	σ	CV%
Farkasfa	A_{oo}	43.0	34	31	20	32	29	29	13.7	47
	0-8	2.9	4	4	4	6	6	4.7	1.0	21
	8-16	1.7	2	2	2	2.3	2.6	2.2	0.3	14
Gödöllő	A_{oo}	45.8	16	37	9	11	8	16.1	12.0	75
	0-8	2.1	2	1	2	2.1	3	2.0	0.7	35
	8-16	1.8	1	1	1	2.1	2.6	1.5	0.7	47
Kerekegyháza	A_{oo}	50.3	21	23	19	20	20	20.8	1.5	7
	0-8	1.0	2	1	2	2.1	1.6	1.8	0.4	22
	8-16	0.5	1	1	1	1	1	1	0	0
Farkasgyepü	A_{oo}	27.3	23	44	33	35	48	36.5	9.8	27
	0-8	5.6	8	13	7	5.6	13	9.3	3.6	39
	8-16	3.6	6	6	3	2.7	5.9	4.4	1.7	39
Mátrafüred	A_{oo}	47.0	52	30	54	48	46	46	8.5	18
	0-8	8.2	16	18	19	23	10	17.2	4.3	25
	8-16	4.4	19	8	9	13	10	11.8	4.0	34
Sopron	A_{oo}	41.5	54	49	52	45	30	46	7.5	16
	0-8	10.4	16	22	22	14	6	16	5.9	37
	8-16	5.9	11	14	11	10	5.7	11.5	3.8	33

C. A. = ml O_2 release in the percent of the maximum O_2 release; A_{oo} = fermentation layer; CV = coefficient of variation

In contrast to the humus content the amount of the litter accumulated on the soil surface is inversely proportional to the C. A. index. In those cases when the C. A. index was high /23/ the amount of the accumulated organic matter /553 t/ha/ was less than in the case of the lowest C. A. index where the amount of organic matter per hectare was the highest /931 t/ha/. This can be explained by the fact that the rate of mineralization is higher in a biologically more active soil than in a less active one and it depends on environmental conditions, too.

Catalase activities in the soils of coniferous stands of a different climate category

The basis of the comparison was the climate category to which the individual pine stands belong to. From among pine stands with the same stock parameters but in climates of a different category the C. A. index was higher where the environmental conditions /precipitation, temperature, air humidity, etc./ were more favourable for microbial activity. Under the pine stand under the sessile oak - Turkey oak climate category at Gödöllő we obtained higher C. A. indices for both the 0-8 cm and 8-16 cm layers of the soil by 10% and 32%, respectively, compared to the pine stand in the forest steppe climate category at Kerekegyháza.

At the same time, in the soil of the third pine stand of similar age at Farkasfa under a hornbeam - oak climate, the C. A. indices were higher in the fermentation layer by 30-45% and in the top 8 cm of soil by 55-62% as well as in 8-16 cm of soil by 35-55%, than in the same layers under the pine stands of the other climate category. The loamy texture of the forest soil at Farkasfa may favourably contribute to this increased activity level.

Conclusions

For all forest stands investigated the C. A. index was the highest /9-54/ in the decomposing litter and it gradually decreased with the soil depth.

We found three times as intensive catalase activity in soil and the decomposing litter on the sites covered by deciduous stands than in the corresponding layers under the pine stands.

There was no difference between the enzyme activities assayed in samples from oak and beech stands, while in the case of Scotch pine stands the enzyme activity was higher in the stand planted under the hornbeam - oak climate than in that under forest steppe climate.

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