MICROBIOLOGICAL SOIL PROPERTIES OF THE FLOODPLAIN FORESTS NEAR GABČÍKOVO. I. POPLAR STANDS

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Abstract

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Microbiological analyses, establishment of biomass and biological activity of microbial communities in the monocultures of poplar stands were carried out. Their age moved from 10 to 40 years (T1–T4). The results show that microbial communities are less stable in variants T1–T2 than in variants T3–T4 (in the year 1994). The comparison of the years 2001–2005 showed that microbial communities are more stable and the differences between stands T1–T2 and T3–T4 are minimum.

Key words: microbial biomass, biological activity, poplar stands

Introduction

Man and his activities cause positive or negative changes in the landscape and character of climate. Their result is also the endangerment of biodiversity of plant and animal communities. Human influences on the pedosphere are more and more intensive. Many problems are of regional to global significance, e.g. amplification of the green-house effect, reduction of the ozone layer, soil acidification, grubbing of rain forests, gradual aridation and desertification of the area, extent soil erosion etc.

At present the existing floodplain forest ecosystems are only their remnants not only in Slovakia but in Europe, too. The pressure of man on floodplain forests and landscape near the rivers was intensive even in the past and it was continually increased. First of all water management measures, as e.g. building of flood control dams, drainage, amelioration, flood elimination etc., limited the area of floodplain forest to the minimum. In the 20th century within these negative phenomena appeared also large change in tree species composition,

i.e. disturbance of natural biological diversity of floodplain forest ecosystems. Species rich composition was substituted by monocultures founded by man (clones I 214, Robusta, Mrila, Heidemij, Pannonia etc.). Poplar monocultures are ecologically unstable and their biological diversity is extremely low.

At present there are efforts to change the poplar monocultures to forest ecosystems with natural biodiversity. It is a very much complex and time-consuming process. A part of the project dealing with the problem of ecological renaturation of floodplain forests is also the study of soil microbial communities in poplar monocultures and their comparison with the conditions in a natural ecosystem of floodplain forests.

Material and methods

The model plots are situated in the Žitný ostrov area in sites Sporná sihoť, Dolný prievoz, Kráľovská lúka and Topoľové hony. The sites Sporná sihoť, Kráľovská lúka and Dolný prievoz are influenced by human activity – construction of the Gabčíkovo hydroelectric power plant and they lie near the village Baka, between the main course of the Danube river and the new channel of the Gabčíkovo power plant. The last site, Topoľové hony, is situated in the cadastre of the municipality Dunajská Lužná between the dam and main course of the Danube.

In all sites can be found Eutric Fluvisols classified according to the Morphogenetic Soil Classification System of Slovakia (Collective, 2000). From among plant associations can be found *Salici - Populetum* (R. T x. 1931) and in control plots willow, white poplar, ash and oak. Poplar stands are of 10 to 40 years old:

T1 - Sporná sihoť, 10 years old stand
T2 - Dolný prievoz, 20 years old stand
T3 - Kráľovská lúka, 30 years old stand
T4 - Kráľovská lúka, 40 years old stand
K - Topoľové hony, control plot.

Soil samples were collected from surface horizons to the depth of 1–20 cm from May to October in the years 2001–2005. V roku 1995 bol vykonaný odber naviac v mesiaci november ale chýba v mesiaci august. V rku 2001 pre nepriazeň počasia nebol vykonaný odber v mesiaci október. Samples were riddled through a 2 mm sieve and stabilized at 4–6 °C. In samples prepared in this way the active and exchange soil reaction have been potentiometrically identified (Fiala et al., 1999) with evaluation according to Čurlík et al. (2003). Percentage of C_{ox} has been identified according to the Walkey-Black method modified by Novák and Pelíšek (Klika et al., 1954), percentage of N_{tot} according to Jodlbauer (Fiala et al., 1999) with evaluation according to Bielek (1998). From microbiological parameters we established carbon of microbial biomass C_{bio} by SIR method (Schinner et al., 1993) as well as basal and potential respiration activity (Števlíková et al., 2002).

Results and discussion

From floristical aspect the mentioned plots are studied since their foundation. In these plots the first microbiological study of terrestrial ecosystems started in 1994–1995 and then it was continued since 2001 to 2005. The contribution includes a comparing analysis of changes of selected microbiological parameters studied in the years 1994 and 2001–2005.

All sites are formed by Eutric Fluvisols with carbonate content and belong to the group of younger Holocene soils that were developed from flood sediments of loamy to clay soil texture. They are erosional sediments and are accumulated in the Danube river alluvium. The soil profile

is heterogenous. The accumulation of biological and mechanical humus during floods appeals to the development of Fluvisols. The cause of the mechanical accumulation of organic materials are not only floodwaters but also the processes of deluviation of material accumulation of surface horizons of slopes. Regarding the specific regime of the soil forming process of Fluvisols the difference in depth of the humus horizon is significant (Sotáková, 1982).

The studied soils of the Žitný ostrov area have neutral to slight alcalic soil reaction. Their pH_{H2O} value moves within 7.4–7.6 and pH_{KCl} within 7.0–7.2. Comparing the values from 1994 it can be stated that in the ten years period the values of pH remain unchanged. Organic materials supply, i.e. $\%C_{ox}$ and $\%N_{tot}$ is relatively high and during the last ten years it changed only minimally or remain unchanged. Unambigously the terrestrial ecosystem has most organic material in the oldest, i.e. 40 years old poplar stand, where the widest C/N ratio was also identified. Inversely, in the control plot (K) the content of carbon is very slight, and the ratio of C/N is very narrow. In comparison with other samples it is less by 3 to 5 times (Table 1).

T a b l e 1. Average values of soil reaction and content of organic materials in soil samples from 1994 and 2004.

Sample	**Year 1994**				
	pH_{H2O}	pH_{KCl}	% Cox	% N_{tot}	**C:N**
T1	7.4	7.0	3.2	0.24	13.3
T2	7.6	7.2	3.2	0.21	15.2
T3	7.5	7.1	3.2	0.21	15.2
T4	7.5	7.1	5.0	0.24	20.8
	Year 2004				
T1	7.4	7.1	2.9	0.21	13.8
T2	7.6	7.2	3.2	0.22	14.5
T3	7.5	7.1	3.4	0.24	14.2
T4	7.5	7.1	4.8	0.23	20.9
K	7.5	7.1	1.5	0.34	4.3

Notes: T1 – Sporná sihoť, T2 – Dolný prievoz, T3 and T4 – Kráľovská lúka, K – Topoľové hony

Large amount of energy is accumulated in soil as organic material and microbial biomass. The community of microorganisms sensitively reacts to the changing biotic, abiotic and anthropogenic environmental factors. Due to the high species diversity and wide enzymatic scale the microorganisms have homeostatic ability. It enables to partially compensate the oscillation of the environment. The energy of living soil components is assessed according to the biological circulation of carbon in single ecosystems of the biosphere. Establishment of soil microorganisms biomass defines the share of microorganisms in change of material and energy, defines the dynamics and intensity of nutriment mobilization for plants and quantifies the penetration of organic material to soil unavoidable for conservation and restoration of the biocoenosis (Tesařová, 1992).

During the studied years 2001–2005 the values of biomass of soil microorganisms C_{bio}.100g^{-1} of dry matter changed in dependence on the seasons narrowly connected with the influence of primary ecological factors, especially of moisture and soil temperature. During the dry period of 2001–2004 we recorded lower values of microbial biomass than in 2005, which distinguished from the previous years by higher total precipitation during the whole vegetation period (Table 2).

T a b l e 2. Biomass of microorganisms in mg C_{bio}.100 g^{-1} of dry matter in soils of poplar monocultures and control plot.

Sample/month	April	May	June	July	August	September	October
	Year 2001						
T1	92.1	63.2	101.7	50.4	54.3	112.2	132.6
T2	88.9	97.3	97.8	69.8	60.2	99.7	123.4
T3	100.1	96.9	112.5	6.3	79.8	126.9	135.8
T4	89.7	111.1	134.8	128.7	109.7	104.7	114.1
K	100.1	265.7	259.5	197.7	197.7	135.6	148.1
	Year 2002						
T1	100.5	157.7	176.2	125.5	114.3	134.9	149.3
T2	96.5	114.5	357.9	199.9	163.7	156.1	169.4
T3	87.3	54.8	126.5	200.1	196.5	168.8	173.5
T4	127.4	146.4	224.2	187.3	176.8	155.5	169.8
K	199.8	245.8	260.0	200.2	123.3	138.5	161.1
	Year 2003						
T1	97.6	126.5	436.8	321.3	201.6	154.5	99.8
T2	110.1	357.9	399.6	215.7	100.3	146.1	139.9
T3	85.4	67.3	363.7	196.8	225.4	144.4	158.2
T4	126.7	296.1	326.3	176.5	155.5	121.5	110.1
K	98.9	196.9	178.8	87.6	100.1	148.7	166.4
	Year 2004						
T1	101.7	117.2	376.9	131.6	284.5	135.2	109.3
T2	117.5	142.3	268.5	215.4	125.8	222.7	138.9
T3	299.6	235.8	305.7	286.6	221.6	143.2	157.1
T4	116.5	125.4	287.6	235.2	130.7	103.4	125.4
K	111.9	273.9	255.5	200.7	223.7	156.2	170.7
	Year 2005						
T1	128.5	151.5	468.2	397.5	366.9	186.3	141.7
T2	236.8	203.3	351.5	289.1	178.4	166.2	180.6
T3	131.1	187.9	384.3	398.7	308.4	172.8	199.7
T4	139.7	157.7	181.3	333.6	188.5	140.0	158.8
K	345.7	687.4	550.1	298.5	256.5	225.1	268.2

Notes: T1 – Sporná sihoť, T2 – Dolný prievoz, T3 and T4 – Kráľovská lúka, K – Topoľové hony

The complex process of microbial biomass during the year correlates with the present knowledge, when the values of biomass cumulating into the so called spring maximum increase. It is conditioned by the supply of organic material and humidity at the present increase of air and soil temperature. In preponderance of samples the spring minimum was recorded in June or in May. Subsequent reduction lasts the whole summer period with the lowest values in August. Slight increase of microbial biomass, the so called autumn maximum, was recorded in October (Table 2).

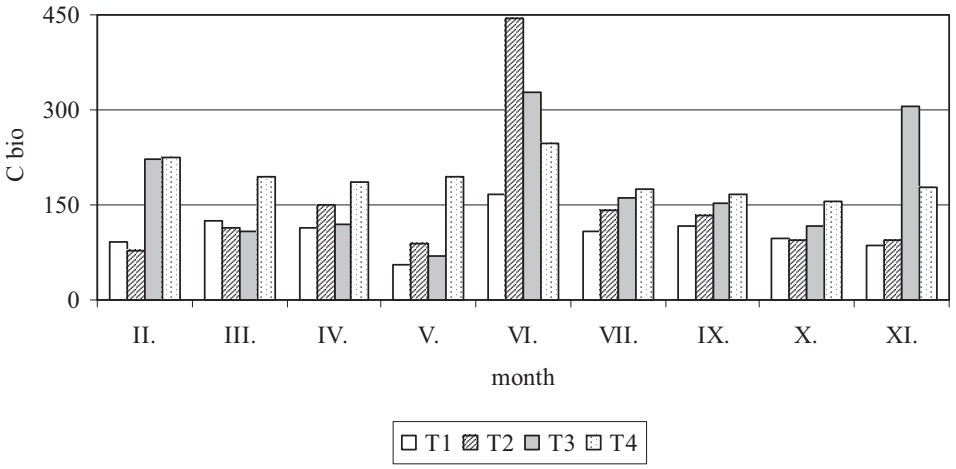

Fig. 1. Biomass of microorganisms in mg C_{bio}.100 g^{-1} of dry matter in poplar monocultures T1–T4 in 1995.

Comparing the total biomass of soil microorganisms in 1995 is almost equal with significant maximum in June and slightly small in November. In evaluation of the age categories of poplar stands we can find significant differences among the youngest (T1 and T2) and older stands (T3 and T4) (Fig. 1). Later analyses show much smaller to negligible differences in relation of microbial biomass and age category of poplar monocultures.

CO_2 production, reflecting the intensity of breathing of soil microorganisms, is not a special process of one group of microorganisms but of the complex microbial soil community. Its quantity depends on the intensity of all microbial processes appearing in soil. In evaluation of CO_2 production the interrelation of potential (P-CO2) and basal (B-CO2) respiration gives some idea of utilization of organic soil materials and ecosystem stability.

In 1994 the biological activity of soil microorganisms was studied in each second month from April to December. Similarly, as in case of establishment of microbial biomass (Fig. 1), on the basis of ration P/B is evident that the stand of older age category (T3 and T4) is more stable than younger stands (T1 a T2) (Table 3).

T a b l e 3. Basal (B-CO_2) and potential (P-CO_2) biological activity in mg CO_2.kg.24 h. and rate P/B in poplar monocultures in 1994.

Sample	April		
	B - CO_2	P - CO_2	P/B
T1	190.5	1 768.8	9.3
T2	146.6	1 843.6	12.6
T3	254.3	2 054.8	8.1
T4	199.8	1 438.8	7.2
	June		
T1	170.7	2 244.0	13.1
T2	206.4	1 925.9	9.3
T3	201.5	2 145.0	10.6
T4	248.2	1 617.9	6.5
	August		
T1	265.3	1 909.6	7.2
T2	330.0	1 716.0	5.2
T3	291.3	1 887.6	6.5
T4	308.0	1 966.8	6.4
	October		
T1	110.4	156.9	1.4
T2	131.1	728.6	5.6
T3	150.9	818.8	5.4
T4	161.5	1 379.4	8.5
	December		
T1	265.3	1 758.7	6.6
T2	306.2	1 714.2	5.6
T3	315.9	1 909.6	5.2
T4	364.3	1 909.6	5.2

Notes: T1 – Sporná sihoť, T2 – Dolný prievoz, T3 and T4 – Kráľovská lúka, K – Topoľové hony

The biological activity of soil microorganisms in the control plot is relatively balanced. It is proved by the values of ratio P/B moving from 4.6 to 8.2 (year 2001), from 3.7 to 5.9 (year 2002), from 4.3 to 6.0 (year 2003), from 3.8 to 7.1 (year 2004) and from 3.8 to 5.9 (year 2005). The highest stability of microbiocoenosis was identified in 2003 when the difference in P/B values was the lowest. The amount of accessible organic materials is sufficient, so we can assume a relatively stable microbial community in this terrestrial ecosystem. (Table 4).

T a b l e 4. Basal (B-CO_2) and potential (P-CO_2) biological activity in mg CO_2.kg.24 h. and relation of P/B in the control sample in 2001 to 2005.

Month	**Year 2001**		
	B-CO_2	P-CO_2	P/B
April	204.3	1 624.7	7.9
May	386.1	1 775.2	4.6
June	275.4	1 556.8	4.6
July	196.4	1 605.1	8.2
August	300.6	1 852.2	6.2
September	245.3	1 200.9	4.9
	2002		
April	321.1	1 823.5	5.6
May	456.2	1 900.1	5.9
June	322.3	1 429.8	4.4
July	275.7	1 008.4	3.7
August	299.8	1 110.6	3.7
September	245.4	909.7	3.7
October	100.2	733.3	7.3
	2003		
April	265.2	1 598.6	6.0
May	377.5	1 629.1	4.3
June	280.1	144.3	5.0
July	275.3	1 362.4	4.9
August	336.8	1 538.6	4.9
September	267.7	1 223.3	4.6
October	197.2	1 191.2	6.0
	2004		
April	124.3	885.6	7.1
May	303.6	1 221.7	4.0
June	289.2	1 112.4	3.8
July	275.5	1 096.9	4.0
August	312.4	1 457.0	4.7
September	256.4	1 377.1	5.4
October	198.6	1 302.3	6.7
	2005		
April	268.1	1 019.7	3.8
May	456.4	1 979.9	4.3
June	426.7	2 114.5	4.9
July	368.9	1 798.7	4.9
August	222.2	1 118.4	5.0
September	265.3	1 567.3	5.9
October	288.6	1 628.8	5.6

Comparing the values of biological activity of poplar monocultures in 1994 and then 2001–2004 we get similar conclusions as in case of establishment of microbial biomass. In a span of ten years the changes in CO_2 production among younger (T1 and T2) and older stands (T3 and T4) were gradually settled or decreased.

T a b l e 5. Basal (B-CO_2) and potential (P-CO_2) biological activity in mg CO_2.kg.24 h. and ratio of P/B in poplar monocultures in 2001.

Area	B-CO_2	P-CO_2	P/B
	April		
T1	213.5	1 501.4	7.0
T2	207.9	1 699.8	9.1
T3	249.6	1 753.3	9.8
T4	197.4	1 753.3	8.9
	May		
T1	165.5	1 998.6	12.0
T2	197.2	2 100.8	10.6
T3	201.5	2 098.9	10.4
T4	258.6	1 757.1	6.8
	June		
T1	204.7	2 645.7	12.9
T2	210.3	2 237.9	10.6
T3	197.6	2 046.1	10.3
T4	277.2	1 955.3	7.1
	July		
T1	156.3	1 721.1	11.0
T2	173.4	1 853.7	10.5
T3	165.6	1 649.8	10.0
T4	197.5	1 697.9	8.5
	August		
T1	114.3	1 257.4	11.0
T2	127.2	1 286.1	10.1
T3	98.5	980.6	9.9
T4	156.9	1 458.8	9.2
	September		
T1	242.2	1 431.7	5.9
T2	196.6	958.8	4.8
T3	150.9	1 034.5	6.8
T4	131.4	1 338.6	10.2

Notes: T1 – Sporná sihoť, T2 – Dolný prievoz, T3 and T4 – Kráľovská lúka, K – Topoľové hony

T a b l e 6. Basal (B-CO_2) and potential (P-CO_2) biological activity in mg CO_2.kg.24 h. and ratio of P/B in poplar monocultures in 2004.

Area	B-CO_2	P-CO_2	P/B
	April		
T1	265.3	2 656.7	10.0
T2	310.4	2 098.3	6.8
T3	209.7	3 070.2	14.7
T4	321.5	3 117.9	9.7
	May		
T1	424.3	2 894.1	6.8
T2	389.2	3 066.6	7.9
T3	416.4	2 911.6	7.0
T4	397.1	2 845.9	7.2
	June		
T1	326.9	2 678.5	8.2
T2	355.4	2 907.6	8.2
T3	306.1	3 079.3	10.1
T4	297.2	2 986.7	10.0
	July		
T1	179.4	2 402.6	13.4
T2	180.5	2 184.3	12.1
T3	207.3	2 675.9	12.9
T4	154.2	2 253.8	14.6
	August		
T1	112.5	1 497.3	13.3
T2	154.7	1 617.1	10.4
T3	136.1	1 122.5	8.2
T4	146.4	946.8	6.5
	September		
T1	214.5	1 990.9	9.3
T2	205.3	2 125.8	10.3
T3	186.2	2 014.7	10.8
T4	181.1	1 459.0	8.1
	October		
T1	238.9	2 008.8	8.4
T2	245.6	2 425.7	10.0
T3	199.1	2 113.2	10.6
T4	189.5	1 909.2	10.1

Notes: T1 – Sporná sihoť, T2 – Dolný prievoz, T3 and T4 – Kráľovská lúka, K – Topoľové hony

In 2001 the least difference in the ratio of P/B (1.8) was identified in August and the greatest (5.8) in June (Table 5). In 2004 a relatively large difference in establishment of ratio of potential and basal respiration activity was identified just at the beginning of the vegetation period, i.e. in April (7.9) and in August (6.8). In other months this ratio was low (May = 1.1; June = 1.9; July = 2.5; September = 2.7 and October = 2.2) and relatively stable (Table 6).

Conclusion

The monitoring of the microbial biomass and microbiological activity of terrestrial ecosystem of poplar monocultures founded by man showed gradual stability in a 10 years period. Within a span of 10 and more years the differences in the studied parameters were gradually settled as reflections of soil microbiocoenoses among poplar stand of younger (T1 and T2) and older age categories (T3 a T4).

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