Microbial characteristics, carbon and nitrogen content in cambisols and luvisols

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ABSTRACT

Tested soils (1991–2002) were defined by chemical, textural and microbial characteristics. From the tests which describe cambisols, the following parameters have to be stressed. The higher level of C\textsubscript{org} (1.20–1.76%), which resulted in quite high microbial biomass carbon content (396–625 µg/g dry soil), high control respiration (0.45–0.80 mg CO\textsubscript{2}/100 g dry soil) and potential nitrification with (NH\textsubscript{4})\textsubscript{2}SO\textsubscript{4} (6.7–18.4 mg N-NO\textsubscript{3}/8 days/100 g dry soil). Studied luvisols reached typical levels: C\textsubscript{org} (0.97–1.22%), C\textsubscript{MB} (398–503 µg/g dry soil), control respiration (0.46–0.57 mg CO\textsubscript{2}/100 g dry soil), potential nitrification with (NH\textsubscript{4})\textsubscript{2}SO\textsubscript{4} (3.2–9.9 mg N-NO\textsubscript{3}/8 days/100 g dry soil). Lower levels of organic carbon and a medium level of microbial biomass raised in higher ratio C\textsubscript{MB}/C\textsubscript{org} (average 4.0%). Highly significant differences (p < 0.01) between cambisols and luvisols were determined for C\textsubscript{org}, pH(KCl), C\textsubscript{MB}, C\textsubscript{MB}/C\textsubscript{org}, C\textsubscript{E}, control respiration and potential nitrification, while the difference in potential ammonification with peptone was at level p < 0.05. With the exemption of ratio C\textsubscript{MB}/C\textsubscript{org}, all cambisol characteristics were higher than luvisol ones. Studied soils were evaluated by six biological criteria (C\textsubscript{MB}; ratios: C\textsubscript{MB}/C\textsubscript{org}, C\textsubscript{E}/C\textsubscript{MB}, potential/control respiration, potential/control ammonification, potential/control nitrification). These criteria distinguished tested soils into three groups. The first one includes two localities in the mountain region (Červená Voda 809, 810; altitude 565–590 m) defined as stagnic cambisols with higher content of C\textsubscript{org} (1.40, respective 1.76%) and simultaneously with the highest biomass of micro-organisms from all tested soils (C\textsubscript{MB} 625, respective 621 µg/g dry soil). It is not surprising that microbial activities (respiration, nitrification) at these localities were also high. The majority of the studied localities (one eutric cambisol and four luvisols) belongs to the medium group. The third group includes two localities (Neumětely – haplic luvisol, Čistá u Rakovníka – eutric cambisol) where biological criteria was mostly the worst. In the period 1993–2002 microbial biomass carbon was for both sites in the range of 357–458 µg/g dry soil which are not so bad values, but in comparison with localities in mountain wet region they are low. This status was issued in the lower ratio C\textsubscript{MB}/C\textsubscript{org} (2.71–3.77%).

Keywords: cambisols; luvisols; microbial biomass carbon; K\textsubscript{2}SO\textsubscript{4} extractable carbon; respiration; ammonification; nitrification
literature several recommendations could be found. In the U.S.A. Soil Working Group (Pappendick 1991) proposed framework of eight tests for determination of the soil biological characteristics: soil organic carbon, soil microbial biomass carbon, respiration/biomass ratio, N-mineralization, labile organic carbon, soil respiration, composition of vegetation and an abundance of earthworms. Filip (2001) in his review paper stressed the following ecologically important soil parameters: microbial biomass, composition of microflora (ratio bacteria/fungi, microflora of the C-cycle and N-cycle), mineralization processes (CO$_2$, and NH$_4^+$ release), and synthesising processes. This author underlined that there is no doubt that firm linkages exist between microbial communities, their activities, and ecologically important processes. Developments of defined species in soil population and composition of soil microbial community have specific importance for the sustainable biodiversity in soil ecosystems. On the other hand the level of soil microbial processes, such as decomposition, transformation and organic matter synthesis has a specific importance for the functional sustainability of soil ecosystem Černý et al. (2003). Having used two parameters (microbial biomass nitrogen and extractable organic nitrogen) to evaluate different fertilisation in long-term experiments with maize. Volfíšek et al. (2002) studied the influence of grassing and harvest management using three respective eight parameters (microbial biomass carbon [C$_{MB}$]; ratio C$_{MB}$/C$_{org}$; ratio C$_{E}$/C$_{MB}$; potential respiration with glucose; potential ammonification with peptone; potential nitrification with ammonium sulphate and two model predicted values).

This article evaluates the twelve-year results of microbiological parameters of selected Czech cambisols and luvisols.

**MATERIAL AND METHODS**

Cambisols, haplic and albic luvisols belong to main soil types in Czech Republic because they form important parts (58, respective 10.5%) of agricultural and afforested soils. During the years 1991–2002 soil samples were collected at four cambisol localities (a total of 185 samples) and five luvisol localities (a total of 234 samples). The localities description can be found in Tables 1 and 2.

Soil samples from the profile (0–200 mm) were collected using sampler Eijkelkamp agrisearch equipment in spring and autumn months during the period 1991–2002, respective 1993–2002. The samples were transported in the cooling box (temperature 6–12°C); they were adjusted, sieved (mesh 2 mm) and stored in a refrigerator (4–6°C). 24 hours before analyses the samples were pre-incubated at room temperature (22 ± 2°C).

The list of tests used for soil samples characterisation and microbial activity determination:

- organic carbon (C$_{org}$) – colorimetric determination (Sims and Haby 1971)
- microbial biomass carbon (C$_{MB}$) – rehydration method (Blagodatskiy et al. 1987)
- K$_2$SO$_4$ extractable carbon (C$_{E}$) – extraction with 0.5 mol/l K$_2$SO$_4$ (Badalucco et al. 1992)
- total nitrogen (N$_{t}$) – Kjeldahl method
- pH(H$_2$O), pH(KCl)
- respiration: basal, potential with glucose – interpherometric CO$_2$ detection (Novák and Apfelthaler 1964)
- actual content of NH$_4^+$
- ammonification: potential with peptone – titrimetric method (Pokorná-Kozová et al. 1964)
- actual content of NO$_3^-$
- nitrification: potential with ammonium sulphate – ion-selective electrode detection (Löbl and Novák 1964)

The following ratios were calculated:

- (C$_{MB}$/C$_{org}$) × 100
- (C$_{E}$/C$_{MB}$) × 100
- potential/basal respiration
- potential ammonification/actual content of NH$_4^+$
- potential nitrification/actual content of NO$_3^-$

Results (46 replications during the years 1991–2002) were statistically evaluated using the analyses of variance (multiple range test) including Fisher’s LSD method.

**RESULTS AND DISCUSSION**

**Cumulative characteristics (Tables 1 and 2)**

Soil organic carbon (C$_{org}$): Cambisol was characterised with high C$_{org}$ level (average 1.46%, SD 0.34%) with the range of 1.20–1.76%. The extreme variant (Čistá u Rakovníka, 1.20%) was highly statistically different from others. It is not surprising that the average of luvisols (1.14%) was lower, and the range (0.97–1.22%) was more compact and resulted in lower frequency of statistical differences among luvisols and the lowest locality Sloupnice (0.97%) was also statistically highly different.

Soil microbial biomass carbon (C$_{MB}$): For the study of environmental and anthropogenic influences on living part of soils the determination of C$_{MB}$ is widely used (Pappendick 1991, Shibahara and Inubushi 1997, Filip 2001, etc.). Expected high level of biomass was determined in cambisols (average 556 µg/g dry soil, SD 167), while three
localities in the mountain area were quite high in biomass (599–625 µg/g dry soil). The fourth one in a hilly country was lower (396 µg/g dry soil). The average of luvisols $C_{MB}$ was 455 µg/g dry soil with low SD (98), which is a sign for homogeneity of tested localities.

**Ratio $C_{MB}/C_{org}$**: This ratio gives the information about metabolic active carbon in a total soil organic matter; 3% is a usual level for arable soils (Insam and Domsch 1988). Our tested localities were quite active because they ranged from 3.3% (both luvisols and cambisols) to 4.4% (luvisol) with the average for cambisols 3.8% (SD 0.7) and 4.0% (SD 0.8) for luvisols. The difference between luvisols and cambisols reaches statistical significance ($p < 0.05$). Albic luvisols, with the highest ratio (4.4%), are statistically different not only from other luvisols but also from all cambisols. The same could be said for the lowest ratio (3.3%; haplic luvisol, eutric cambisol), which is statistically different from the rest of soils.

**$K_{2}SO_{4}$ extractable carbon ($C_{E}$)**: $C_{E}$ is a trophically easily usable organic carbon of microbial origin (Škoda et al. 1997). Luvisols were more active in the use of $C_{E}$ (40 µg/g dry soil) than cambisols (48 µg/g dry soil); this difference was significant.

**Respiration**: Control respiration of cambisols (0.65 mg CO$_2$/h/100 g dry soil) statistically significantly differs from luvisols (0.50 mg CO$_2$/h/100 g dry soil), while in potential respiration with glucose this activity was similar (3.77, respective 3.68 mg CO$_2$/h/100 g dry soil). The lowest values of $C_{E}$ both for cambisols (Červená Voda 810) and for luvisols (Neumětely), were connected with the highest level of potential respiration. The statement could be issued that trophically available carbon

<table>
<thead>
<tr>
<th>Locality/Parameter</th>
<th>Čistá 125</th>
<th>Červený Potok 808</th>
<th>Červená Voda 809</th>
<th>Červená Voda 810</th>
<th>Average ± SD</th>
<th>LSD² d as min</th>
</tr>
</thead>
<tbody>
<tr>
<td>$C_{org} (%)$</td>
<td>1.20 ± 0.09</td>
<td>1.50 ± 0.19</td>
<td>1.40 ± 0.26</td>
<td>1.76 ± 0.44</td>
<td>1.46 ± 0.34</td>
<td>0.11 (0.14)</td>
</tr>
<tr>
<td>$N_{t} (%)$</td>
<td>0.14 ± 0.02</td>
<td>0.16 ± 0.03</td>
<td>0.16 ± 0.04</td>
<td>0.18 ± 0.04</td>
<td>0.16 ± 0.04</td>
<td>0.02 (0.02)</td>
</tr>
<tr>
<td>pH KCl</td>
<td>6.0 ± 0.1</td>
<td>5.9 ± 0.4</td>
<td>6.9 ± 0.0</td>
<td>5.8 ± 0.2</td>
<td>6.1 ± 0.5</td>
<td>0.1 (0.1)</td>
</tr>
<tr>
<td>$C_{MB}$ (µg/g)</td>
<td>396 ± 45</td>
<td>599 ± 125</td>
<td>625 ± 166</td>
<td>621 ± 177</td>
<td>556 ± 167</td>
<td>57 (75)</td>
</tr>
<tr>
<td>Ratio ($C_{MB}/C_{org}$) $\times 100^3$</td>
<td>3.3 ± 0.4</td>
<td>4.0 ± 0.5</td>
<td>4.3 ± 0.7</td>
<td>3.5 ± 0.5</td>
<td>3.8 ± 0.7</td>
<td>0.2 (0.3)</td>
</tr>
<tr>
<td>$C_{E}$ (µg/g)</td>
<td>43 ± 8</td>
<td>56 ± 17</td>
<td>56 ± 23</td>
<td>40 ± 19</td>
<td>48 ± 19</td>
<td>7 (10)</td>
</tr>
<tr>
<td>Control respiration$^4$</td>
<td>0.45 ± 0.24</td>
<td>0.63 ± 0.18</td>
<td>0.72 ± 0.33</td>
<td>0.80 ± 0.35</td>
<td>0.65 ± 0.31</td>
<td>0.12 (0.16)</td>
</tr>
<tr>
<td>Potential respiration$^5$</td>
<td>3.56 ± 1.55</td>
<td>3.66 ± 0.84</td>
<td>3.58 ± 0.75</td>
<td>4.31 ± 1.29</td>
<td>3.77 ± 1.19</td>
<td>0.48 (0.64)</td>
</tr>
<tr>
<td>Potential ammonification$^6,7$</td>
<td>148 ± 35</td>
<td>188 ± 44</td>
<td>190 ± 50</td>
<td>181 ± 50</td>
<td>176 ± 48</td>
<td>19 (25)</td>
</tr>
<tr>
<td>Potential nitrification$^8$ with (NH$_4$)$_2$SO$_4$</td>
<td>6.7 ± 3.2</td>
<td>8.9 ± 7.5</td>
<td>18.4 ± 14.6</td>
<td>14.1 ± 16.5</td>
<td>12.0 ± 12.5</td>
<td>4.9 (6.4)</td>
</tr>
</tbody>
</table>

1state number of locality, ²Fisher’s Least Significant Difference, ³in per cent of $C_{org}$, ⁴mg CO$_2$/h/100 g dry soil, ⁵with glucose, ⁶mg N-NH$_4$/24 h/100 g dry soil, ⁷with peptone, ⁸mg N-NO$_3$/8 days/100 g dry soil
Table 2. Studied luvisols (1991–2002)

<table>
<thead>
<tr>
<th>Locality/Parameter</th>
<th>Neumětely 111&lt;sup&gt;1&lt;/sup&gt; haplic luvisol altitude 325 m</th>
<th>Mostek 806 haplic luvisol altitude 370 m</th>
<th>Mostek 807 stagnic luvisol altitude 410 m</th>
<th>Nový Dům 127 albic luvisol altitude 430 m</th>
<th>Sloupnice 805 albic luvisol altitude 390 m</th>
<th>Average ± SD</th>
<th>LSD&lt;sup&gt;2&lt;/sup&gt;</th>
</tr>
</thead>
<tbody>
<tr>
<td>C&lt;sub&gt;org&lt;/sub&gt; (%)</td>
<td>1.22 ± 0.14</td>
<td>1.16 ± 0.10</td>
<td>1.14 ± 0.21</td>
<td>1.16 ± 0.10</td>
<td>0.97 ± 0.15</td>
<td>1.14 ± 0.17</td>
<td>0.07 (0.09)</td>
</tr>
<tr>
<td>N&lt;sub&gt;i&lt;/sub&gt; (%)</td>
<td>0.15 ± 0.03</td>
<td>0.13 ± 0.03</td>
<td>0.13 ± 0.03</td>
<td>0.13 ± 0.04</td>
<td>0.12 ± 0.04</td>
<td>0.13 ± 0.03</td>
<td>0.01 (0.02)</td>
</tr>
<tr>
<td>pH KCl</td>
<td>6.1 ± 0.1</td>
<td>6.0 ± 0.1</td>
<td>6.1 ± 0.2</td>
<td>4.9 ± 0.2</td>
<td>5.9 ± 0.0</td>
<td>5.8 ± 0.5</td>
<td>0.1 (0.1)</td>
</tr>
<tr>
<td>C&lt;sub&gt;MB&lt;/sub&gt; (µg/g)</td>
<td>398 ± 53</td>
<td>483 ± 98</td>
<td>459 ± 117</td>
<td>503 ± 57</td>
<td>428 ± 113</td>
<td>455 ± 98</td>
<td>38 (50)</td>
</tr>
<tr>
<td>Ratio (C&lt;sub&gt;MB&lt;/sub&gt;/C&lt;sub&gt;org&lt;/sub&gt;)&lt;sup&gt;3&lt;/sup&gt; × 100</td>
<td>3.3 ± 0.4</td>
<td>4.1 ± 0.8</td>
<td>4.0 ± 0.6</td>
<td>4.4 ± 0.5</td>
<td>4.4 ± 0.8</td>
<td>4.0 ± 0.8</td>
<td>0.3 (0.4)</td>
</tr>
<tr>
<td>C&lt;sub&gt;E&lt;/sub&gt; (µg/g)</td>
<td>33 ± 9</td>
<td>49 ± 12</td>
<td>37 ± 17</td>
<td>37 ± 11</td>
<td>45 ± 18</td>
<td>40 ± 15</td>
<td>6 (8)</td>
</tr>
<tr>
<td>Control respiration&lt;sup&gt;4&lt;/sup&gt;</td>
<td>0.48 ± 0.32</td>
<td>0.49 ± 0.16</td>
<td>0.57 ± 0.33</td>
<td>0.47 ± 0.27</td>
<td>0.46 ± 0.31</td>
<td>0.50 ± 0.29</td>
<td>0.12 (0.16)</td>
</tr>
<tr>
<td>Potential respiration&lt;sup&gt;5&lt;/sup&gt;</td>
<td>4.42 ± 1.77</td>
<td>3.54 ± 1.28</td>
<td>3.75 ± 1.49</td>
<td>3.30 ± 1.59</td>
<td>3.31 ± 1.39</td>
<td>3.68 ± 1.57</td>
<td>0.64 (0.85)</td>
</tr>
<tr>
<td>Potential ammonification&lt;sup&gt;6,7&lt;/sup&gt;</td>
<td>164 ± 41</td>
<td>182 ± 42</td>
<td>170 ± 41</td>
<td>134 ± 46</td>
<td>189 ± 43</td>
<td>167 ± 46</td>
<td>18 (24)</td>
</tr>
<tr>
<td>Potential nitrification&lt;sup&gt;8&lt;/sup&gt; with (NH&lt;sub&gt;4&lt;/sub&gt;)&lt;sub&gt;2&lt;/sub&gt;SO&lt;sub&gt;4&lt;/sub&gt;</td>
<td>8.2 ± 2.5</td>
<td>7.3 ± 5.0</td>
<td>9.9 ± 8.3</td>
<td>3.2 ± 1.8</td>
<td>7.4 ± 6.0</td>
<td>7.3 ± 5.7</td>
<td>2.2 (2.9)</td>
</tr>
</tbody>
</table>

<sup>1</sup>State number of locality; <sup>2</sup>Fisher’s Least Significant Difference; <sup>3</sup>in per cent of C<sub>org</sub>; <sup>4</sup>mg CO<sub>2</sub>/h/100 g dry soil; <sup>5</sup>with glucose; <sup>6</sup>mg N-NH<sub>4</sub>/24 h/100 g dry soil; <sup>7</sup>with peptone; <sup>8</sup>mg N-NO<sub>3</sub>/8 days/100 g dry soil
could be a limitation for microbial activities but the potential activities were kept in good repair.

**Potential ammonification with peptone:** Similarly as for respiration there were no significant differences among cambisols (176 mg N-NH$_4$/24 h/100 g dry soil) and luvisols (167 mg N-NH$_4$/24 h/100 g dry soil). Our data also confirmed that in soils with neutral and alkaline pH there is a close relationship between high microbial biomass C content and high potential ammonification.

**Potential nitrification with (NH$_4$)$_2$SO$_4$:** Extreme differences were observed between cambisols (12.0 mg N-NO$_3$/8 days/100 g dry soil) and luvisols (7.3 mg N-NO$_3$/8 days/100 g dry soil). Acid albic luvisol (locality Nový Dům) was very different from other luvisol localities especially in the lowest nitrification (3.2 mg N-NO$_3$/8 days/100 g dry soil) and potential ammonification (134 mg N-NH$_4$/24 h/100 g dry soil) activities. Similar tendency (low activity) was in glucose mineralization tested by potential respiration. These negative changes of microbial metabolism are surely connected with very low pH(KCl) (4.9).

### Soil quality evaluation with biological criteria

(Table 3)

For complex soil evaluation the use of several criteria or their ratios is recommended (Pappendick 1991, Filip 2001). Six biological criteria (C$_{MB}$ and five ratios: C$_{MB}$/C$_{org}$; C$_E$/C$_{MB}$ potential/control respiration; potential/control ammonification; potential/control nitrification) were applied in this study. These criteria (Table 3) distinguished all tested soils into three groups.

The first one includes two localities in the mountain region (Červená Voda 809, 810; altitude 565–590 m) defined as stagnic cambisols with higher content of C$_{org}$ (1.40, respective 1.76%) and simultaneously with the highest biomass of microorganisms (C$_{MB}$: 625, respective 621 µg/g dry soil). It is not surprising that microbial activities (respiration, nitrification) of these localities were also high. The ratio C$_{MB}$/C$_{org}$ (2.6–5.1%, average 4.3%, respective 3.5%) in several analyses was extremely high.

The majority of studied localities (one eutric cambisol and four luvisols) belongs to the medium group (C$_{org}$: 0.97–1.50%; C$_{MB}$: 428–599 µg/g dry soil; ratio C$_{MB}$/C$_{org}$: 4.0–4.4%).

The third group includes two localities (Neumětely – haplic luvisol; Čistá u Rakovníka – eutric cambisol) where biological criteria was mostly the worst. In the period 1993–2002 microbial biomass carbon was for both sites in the range 357–458 µg/g dry soil (average for Neumětely 398 µg/g dry soil; average for Čistá 396 µg/g dry soil) which are not very bad values. But in comparison with localities in the mountain wet region they are low. This status issued in lower ratio C$_{MB}$/C$_{org}$ (2.7–3.9%, average both localities 3.3%).

### Ten (respective twelve) years’ dynamics of selected three parameters (Figures 1–3)

**Soil microbial biomass carbon (C$_{MB}$) (Figure 1):**

It could be stated that there are some differences at all tested localities, which were characterised with the decrease of C$_{MB}$. This decline in the soils of central Bohemia region was very gentle while soils of mountain region were characterised with marked C$_{MB}$ decrease. Formerly (1970–1990) the soil management in this region was based on high input of organic fertilisers (> 25 tons/hectare/year of farmyard manure and/or slurry) supplemented with mineral fertilisers. The highest values of C$_{MB}$ determined in the years 1991–1992 were probably connected with the mentioned soil management.
The significant changes in agriculture practice after 1989 resulted in the strong decrease in cattle breeding what induced low production of organic fertilisers and simultaneously with the use of mineral fertilisers dropped dramatically down. These changes resulted in massive $C_{MB}$ decrease in 1995 with the tendency $C_{MB}$ stabilisation during future years at this new level.

**Ratio $C_{MB}/C_{org}$** (Figure 2): In all tested soils (exception locality Čistá – eutric cambisol) a decrease was observed. In some localities it was quite remarkable: Červená Voda 809; Mostek 806 – both decrease about 40%. These changes are connected with two typical tendencies: [1] decrease of $C_{MB}$ content (see paragraph above); [2] relatively stable level of $C_{org}$.  

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Figure 1. Dynamics of microbial biomass ($\mu$g/1 g dry soil)

● – expected $y$
Figure 2. Dynamics of ratio \( \frac{C_{MB}}{C_{org}} \times 100 \) (in per cent)

**Ratio** \( \frac{C_{E}}{C_{MB}} \) (Figure 3): This ratio is important for the better understanding of soil microbial metabolism. Higher levels mark deprivation of the use of this labile easily accepted carbon source as a result of the stressed soil microflora or of a high input of organic fertilisers (Badalucco et al. 1992). Similarly, like for \( C_{MB} \), the general decreasing tendency was also observed for \( C_{E}/C_{MB} \) ratio, usually from about 10 to 7%. This development is a sign for good soil microbial population status because as a result of its active metabolism only a low amount of \( C_{E} \) is resting out of microbial cells. It should be stressed again that in all localities the input of organic fertilisers was lowered.
Figure 3. Dynamics of ratio \( \frac{C_E}{C_{MB}} \times 100 \) (in per cent)

\( y \), expected \( y \)

REFERENCES


ABSTRAKT

Microbiologické charakteristiky a obsah uhlíku a dusíku v kambizemích, hnědozemích a luvizemích

Testované půdy (1991–2002) byly charakterizovány chemickými, zrnitostními a mikrobiologickými parametry. Pro kambizem je charakteristický vyšší obsah C_{org} (1,20–1,76 %). Odráží se ve vyšší biomase půdních mikroorganismů (396–625 µg C_{MB}/g sušiny), vyšší bazální respiraci (0,45–0,80 mg CO_{2}/h/100 g sušiny) a ve vyšší potenciální nitrifikaci se síranem amonný (6,7–18,4 mg N-NO_{3}/8 dni/100 g sušiny). Hnědozemě a luvizemě dosahují u sledovaných parametrů následujících hodnot: C_{org} (0,97–1,22 %), C_{MB} (398–503 µg/g sušiny), bazální respirace (0,46–0,57 mg CO_{2}/h/100 g sušiny), potenciální nitrifikace s (NH_{4})_{2}SO_{4} (3,2–9,9 mg N-NO_{3}/8 dni/100 g sušiny). Nižší hladina uhlíku půdní organické hmoty společně se středním obsahem mikrobiální biomassy vedou k vyššímu poměru C_{MB}/C_{org} (průměr 4,0 %). Statisticky vysoce významný rozdíl (p < 0,01) mezi kambizemími na straně jedné a hnědozemími a luvizemími na straně druhé byl zjištěn u osmi chemických a mikrobiologických parametrů \[C_{org} \times \text{Np}, \text{pH(KCl)}, C_{MB}, C_{MB}/C_{org}, C_{MB}/C_{PS}, \text{bazální respirace} \text{a potenciální nitrifikace}\], zatímco rozdíl u potenciální amonifikace s peptónem byl pouze na hladině významnosti p < 0,05. S výjimkou poměru C_{MB}/C_{org} všechny parametry kambizemí byly statisticky významně vyšší než parametry hnědozemí a luvizemí. Celkově zhodnocení bylo provedeno za pomoci šesti biologických kritérií (C_{MB} a pěti poměrů: C_{MB}/C_{org}, C_{MB}/C_{PS}, potenciální/bazální respirace, potenciální/kontrolní amonifikace, potenciální/kontrolní nitrifikace). Tato kritéria rozdělila monitorované půdy do tří skupin. Nejlepší skupina zahrnovala dvě lokality v horské oblasti (Červená Voda 809, 810; v nadmořské výšce 565–590 m) definované jako pseudogleje kambické s vyšším obsahem půdní organické hmoty (1,40, resp. 1,76 % C_{org}) a současně nejvyšším obsahem mikrobiální biomassy z monitorovaných půd (625, resp. 621 µg C_{MB}/g sušiny). Není překvapením, že minerálizační a nitrifikáční aktivita byla na těchto lokalitách také vyšší. Střední skupina zahrnovala pět lokalit: modální humusové, modální nitrifikaci, modální kambizem, modální hnědozem, pseudogleje luvické, modální a dystrickou luvizem. Třetí skupina, u níž biologické parametry byly nejhorší, tvořily dvě zbyvající lokality: modální hnědozem na lokalitě Neumětely a modální kambizem na lokalitě Čistá u Rakovníka. V období 1993–2002 uhlík mikrobiální biomassy dosahoval na těchto lokalitách průměrně úrovně: 357–458 µg/g sušiny, avšak významně nižší úrovně ve srovnání s lokalitami ve vltavské horské oblasti. Tato skutečnost se odrazila i v poměru C_{MB}/C_{org} (2,71–3,77 %).

Klíčová slova: kambizem; hnědozem; luvizem; uhlík biomassy mikroorganismů; organický uhlík extrahovatelný do K_{2}SO_{4}; respirace; amonifikace; nitrifikace

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