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Decomposition dynamics and biological activity in a floodplain forest

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Abstract

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The submitted work presents preliminary results of study evaluating the values of humus ratio in a hardwood floodplain forest situated near Lednice na Moravě, Forest Enterprise Židlochovice. The basic characteristics of surface humus layer in the mixed growth of the examined forest are assessed. The research locality is situated at an altitude of 151–153 m. The average of annual temperature is approximately 9–10 °C, average of annual rainfall is 500–550 mm. In samples of litter fall (oak, ash), the contents of carbon, nitrogen, dry matter and C/N ratio were determined and the microscopic pictures of foliage decomposition were made.

Key words

floodplain forests, humus, litter fall

Introduction

Floodplain forests of Central Europe represent exceptional forest geobiocoenoses. In the Czech Republic, floodplain forests occupy only a small percentage (1.4%) of the total area. From the aspect of production, there represent sporadic plant formations, the remnants of which is worth of total protection and conservation. Floodplain forests are unique ecosystems ranking among the richest-in-species ecosystems in our country.

Water is undoubtedly the most important factor affecting the biome of floodplain forests (Klimo, 2001). The first turnover in the hydrological regime of the Morava and Dyje rivers was caused by the extensive colonization of the landscape entailing gradual deforestation of the whole basin area. The runoff conditions were disturbed, there followed soil erosion, and the soil from higher locations was transported downwards and deposed in lower situated ones. This process was repeated in several waves related to the development of pasturage and agriculture from the Middle Ages up to the present time (Prax, 2004). In the 70s and 80s of the 20th century, other marked changes occurred there, namely the construction of dikes and integrated water-management measures. The aim of these measures was to protect the land, villages and towns from floods (Veselý, 2004). Changes in the water regime resulted in particular changes in the dynamics of available water and air in soil. In course of recent years, the project of floodplain forest revitalization was gradually implemented in southern Moravia, through artificial flooding with water from the Nové Mlýny reservoirs (Klimo, 2001). In this study we present preliminary results of evaluation of values of C/N ratio in a hardwood floodplain forest in Lednice na Moravě. The basic characteristics of surface humus in mixed growth of the studied forest are assessed.

Material and methods

At the experimental locality, a research plot was established in autumn 2005. On the plot, there was sampled only oak and ash litter for determining the content of carbon, nitrogen and C/N ratio. Apart from this, the content of carbon, nitrogen and C/N ratio as well as soil reaction were determined in soil samples taken from various depths of soil (soil pit). Moreover, the course of decomposition in randomly selected leaf samples was documented with photo-records.

The next year and in the same season, samples of litter were taken, using a sampling plate 50 × 50 cm in

size, with the aim to determine the reserves of humus and nutrients per one hectare, namely in L1, L2 and F layers. These samples were not separated any more, that means that all the litter occurring on the plot was involved in the sample = mixed sample (containing, in addition to oak and ash, also hornbeam, maple and lime).

Description of the study area

The locality is situated in Lednice na Moravě, Forest Enterprise Židlochovice. The most part of the floodplain above the confluence of Dyje and Morava Rivers is covered with forest representing about 4,200 ha, which is 84% of the total territory. The research plot was established in the part called "Horní les" in autumn. The wide floodplain of the Dyje and Morava rivers is situated at an altitude of 151–153 m. The mean annual temperature ranges between 9–10 °C, mean annual precipitation is about 500–550 mm (Danihelka, 2002). The whole area belongs to the Dolnomoravský úval (the Low Morava river valley basin) (Collective, 1996) ranking among the Pannonian basins (Demek et al., 1987). From aspect of geology and morphology, it refers to the youngest formation of the rivers consisting of sediments gradually deposited in course of particular stages of flooding (Činčura et. al., 1983). Here soils of these locations are arenic Fluvisols (Němeček, 2001) with a high-quality layer of mull humus. The locality ranks among the geobiocoene type group *Ulmi-fraxineta carpini* belonging to the driest hard-wood floodplain forest with groundwater table below 150 cm. The geobiocoene type group is characterized by a considerable presence of grove species in its undergrowth. In the tree layer occur *Carpinus betulus, Tilia cordata* and *Acer campestre* (Maděra, 2004).

Determination of the content of C, N and C/N ratio in samples of forest floor

The content of C and N was determined in finely ground samples of litter in a LECO CNS-2000 (MI USA) automatic analyser. To determine C, the standard of LECO Co., viz. sulfamethazine (502–298, Lot No. 1032) with the declared carbon content of 51.78% was used. To determine nitrogen, the standard of LECO Co., viz. Alfalfa (502-273, Lot No. 1008) with the declared nitrogen content of 3.29% was used. The temperature of sample combustion was 1,100 °C. Particular charges amounted to about 0.2 g.

Evaluation of the soil reaction

For determining the soil reaction we used samples dried with ventilation. From the dried soil, larger parts of soil skeleton, plant and animal residues were removed and the pulverized earth sieved though a sieve with a mesh size of 2 mm to separate soil skeleton particles > 2 mm. An average amount of 5 g was taken from the soil sample, pulverized in an agate and passed through a sieve with a mesh size of 0.25 mm. The values of actual and exchangeable soil acidity were determined using potentiometry according to Zbíral (1995).

Determination of the content of C, N and C/N ratio in the soil profile

The content of C and N was determined in finely ground soil samples using a LECO CNS-2000 (MI USA) automatic analyser. To determine C, the standard of LECO Co. viz. sulfamethazine (502-209, Lot No. 1032) with the declared carbon content of 51.78% was used. To determine nitrogen, the standard of LECO Co, viz. Tobacco (502-082, Lot No. 1008) with the declared nitrogen content of 2.45% was used. The temperature of sample combustion was 1,000 °C. Results are the arithmetic mean of two or three parallel determinations. Particular charges amounted to about 0.5–1.0 g.

Humus reserves per one ha

To determine the mean reserve of humus, a sampling plate 50 × 50 cm in size was used. The plate was placed on the soil surface and trimmed with a knife, surrounding litter and humus was removed aside to prevent contamination (mixture). All determinations were carried out in 5 repetitions. The litter under the plate was collected into bags and transported to the laboratory where the samples were weighed and subsequently dried in an oven at 60 °C to a constant weight. After the drying, the samples were weighed again, and the mean dry weight was determined. Based on the obtained value, the weight reserves of the forest floor per one ha were calculated.

Nutrient reserves per one ha

To determine the content of nutrients, the samples were sent to an external laboratory (EKOLA s.r.o. Bruzovice) where the nutrients were determined using wet mineralization. The results obtained were consequently converted to the reserves of nutrients per one ha.

Photo-documentation of the course of decomposition

Across the research area, leaves were sampled randomly from litter and the rate of decomposition was monitored in them. In the biometric laboratory of the Department of Forest Management Planning, Faculty of Forestry and Wood Technology, Mendel University of Agriculture and Forestry in Brno, microscopic images were taken by means of the Hitachi HV – C20 camera and a Navitar microobjective. Morphometric characteristics were processed with Lucia G program that provides the computer-based image analysis.

Release of CO_2 by the soil in natural conditions

Production of CO_2 was determined using the absorbing method provided with Sodasorpu (new title for "Natrokalcit"). The experiment was carried out in full summer weather (end June, beginning July). Sodasorp granules were filled to Petri dishes in quantities 15 g per one vessel, and before exposition, the desiccation run for one-and-half hour at a temperature of 105 °C. Thereafter, the dishes were closed, cooled and weighted on an analytical scale.

The studied soil surface was cleared of the leaf litter and green herbal cover. Open Petri dishes with absorbers were placed on soil surface, together with soil sensors (on surface and in depth of 5 cm) for monitoring changes in temperature. Each set was covered with a metal basket (diameter 23 cm, height 31 cm), with margins inserted into the soil (5 cm deep). Surface of the baskets was covered with aluminium folia, to avoid superheating the inner space. The experiment ran in five repetitions. To enable comparison of temperature inside and outside the baskets, there were installed outside sensors too. Because the production of CO_2 also depends on soil moisture, soil samples were taken for moisture assessment with the help of Kopeckého roller, in 6 repetitions. Sodasorp granules placed for 24 hours on the soil surface absorbed CO_2 released by the soil. From the differences between the weight before and after the exposition we can calculate the quantity of released CO_2.

Results and discussion

Determination of the content of C, N and C/N ratio in forest floor samples

C/N ratio is the tool for evaluation of decomposition rate of organic matter. The higher is C/N ratio, the slower is organic matter decomposition. In the oak litter, the C/N ratio was found 42.7, in ash litter 24.4 (Fig. 1). At slow decomposition of organic matter, the latter is accumulated on the soil surface, which results in lowering the rates of mineralization and humification processes and slowing down also the nutrient cycle. Litter rich in nitrogen (C/N ratio < 30) is decomposed usually fast (Klimo, 2001). In both variants of the stand (oak and ash), the content of carbon ranged about 50%, unlike the content of nitrogen, which was almost double (2.05%) in ash litter compared to the oak litter (1.18%).

Evaluation of the soil reaction

Soil reaction affects forest stands, because it influences biochemical processes in their soils as well as processes of the nutrients uptake by particular autotrophic organisms. The soil reaction in the studied area changed from medium acid to neutral in potentially exchangeable soil reaction, and from slightly acid to slightly alkaline in actual soil reaction (Fig. 2). The pH values increased with the increasing soil depth.

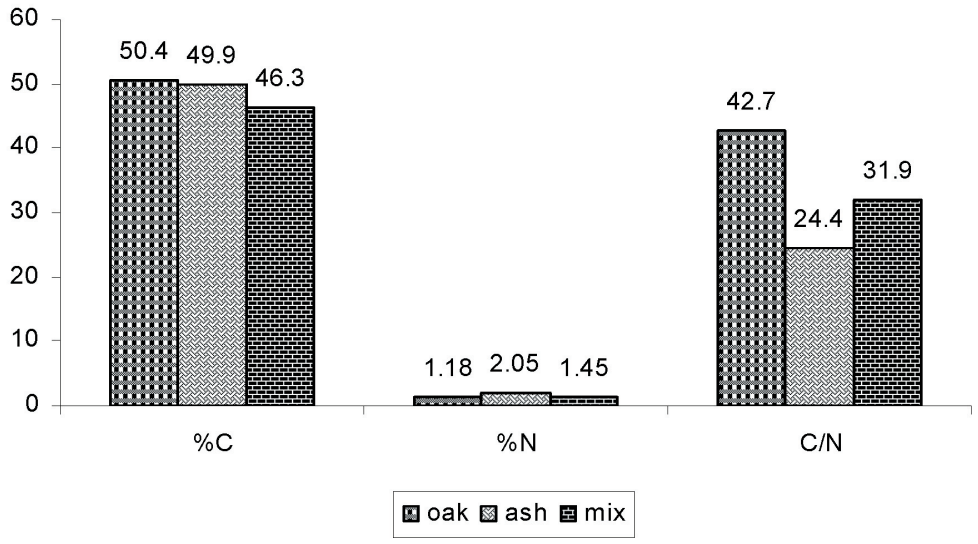


Fig. 1. Determination of the content of C, N and C/N ratio in samples of forest floor

Determination of the content of C, N and of C/N ratio in the soil profile

Nitrogen occurs predominantly in organic soil constituents. Soil organic matter is the main reservoir of nitrogen for plants and soil micro-organisms. The results obtained show that the content of carbon and nitrogen decreased with the soil depth (Fig. 3). The highest values were determined at depths of 5 and 10 cm. On the contrary, the lowest values were determined at a depth of 100 cm below the soil surface. The most marked drop in the content of carbon and nitrogen was noted only at a depth of 10–30 cm where the values decreased by half, elsewhere their content decreased more slowly. Quantity of carbon and nitrogen in the soil is influenced above all by two factors – temperature and moisture. At higher temperatures, decomposition of organic matter is faster, and thereby there is also lower content of organic soil matter. Higher soil moisture content is associated with higher organic matter content in soil.

Humus reserves per one hectare

Humus layers have a different function and also different character Therefore, it is possible to differentiate between the litter L (in our case L1 = the current year's litter without signs of decomposition, L2 = last year's litter subjected to slight decomposition) and horizon F (in which the decomposition of organic matter is evident, but with remnants still keeping their original form and structure). Conversion of organic matter to soil is associated with creation of humus – in process that is an important dynamic component of floodplain forests´ environment. The concern is about the mull type that is characteristic with distinct changes in its nutrient concentration over the year (Gartner and Cardon, 2004). Litter decomposition is "vital to nutrient cycling and the productivity of forests"(Didham, 1998) and "is an important component of the global carbon budget'" (Aerts, 1997). The biggest reserves of humus are in the humic layer F.

Nutrient reserves per one hectare

Soil-forming and biological processes influence the course of bio-geochemical cycles in ecosystems. Biogenic elements, as carbon, nitrogen, sulphur and phosphorus, are the main building stones of cells and tissues of organisms. In process of cells necrotising, organic compounds are decomposed; inorganic nutrients are released and can again be received by other organisms (Šimek, 2003). From above diagrams follows, that the highest reserve of all nutriments we can find in layer F and last year's litter L2 (Figs 5, 6).

Photo-documentation of the course of decomposition

On the surface of oak leaves, pupated damaged (dead) eggs of small butterflies (Microlepidoptera, Tineidae)

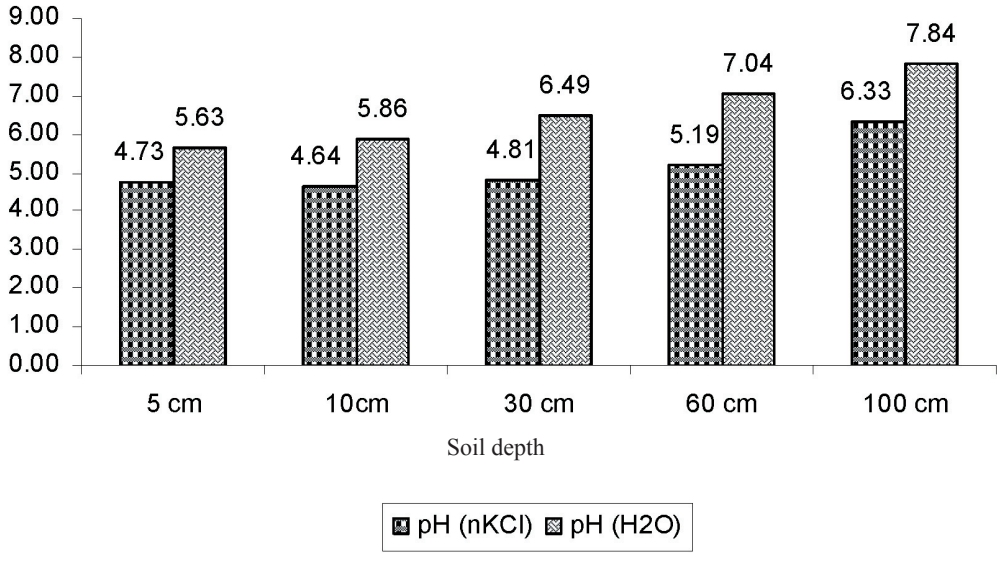


Fig. 2. Evaluation of the soil reaction in various soil depths

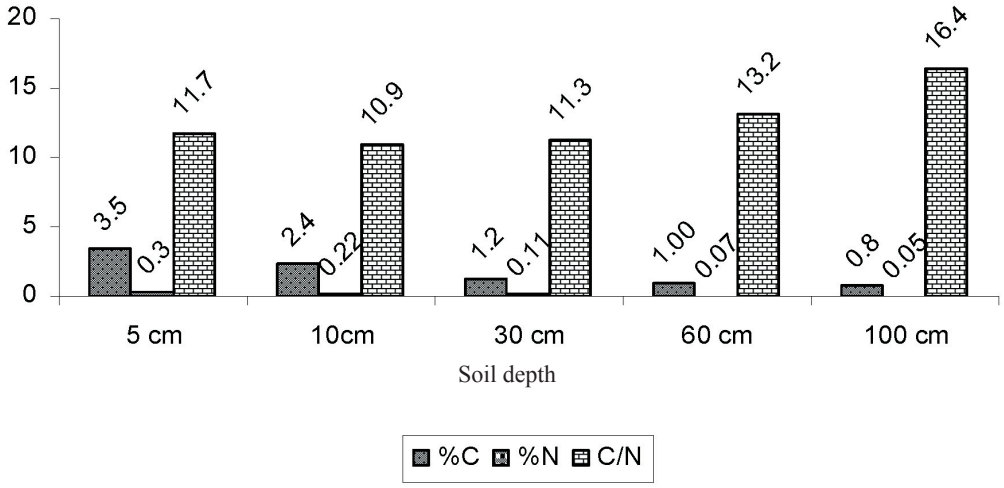


Fig. 3. Determination of the content of C, N and C/N ratio in the soil profile

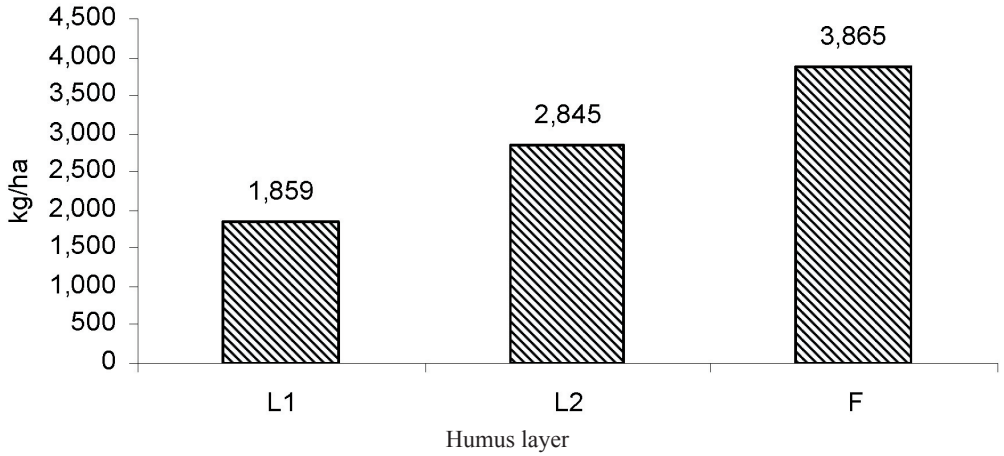


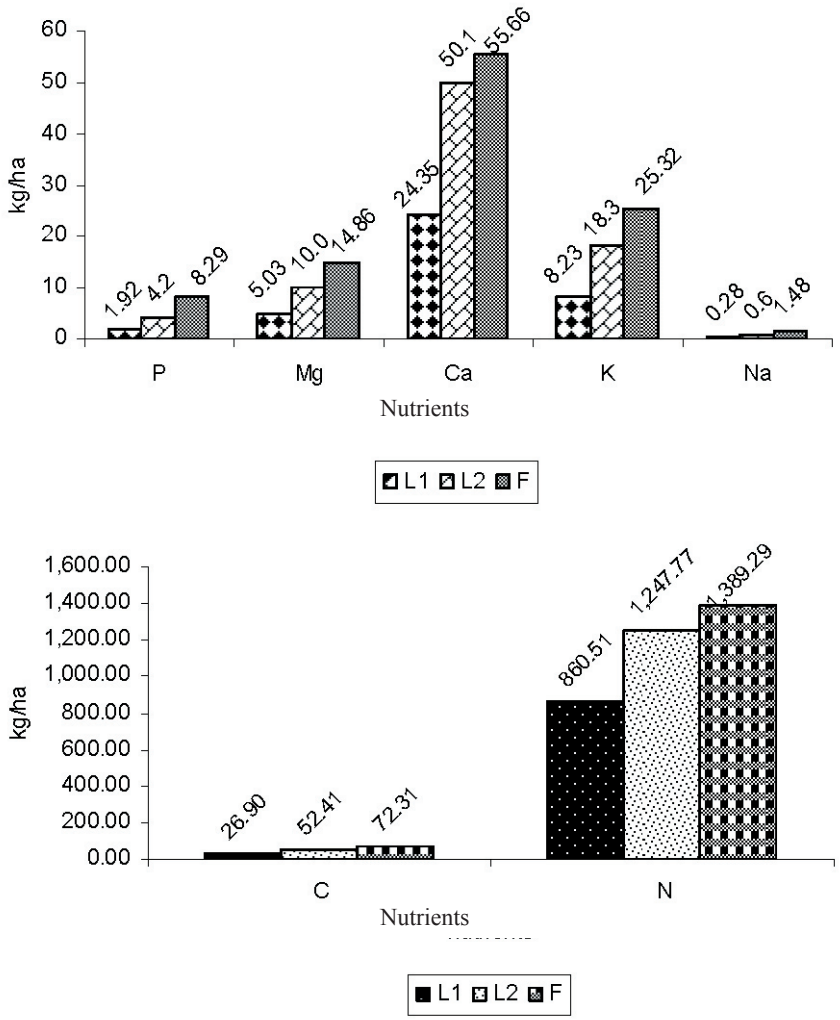
Fig. 4. Humus reserves per one hectare in different humus layers

were found. Pupae (Fig. 7) occurred only on the leaf surface, consequently, they do not seem to have any effect on the rate of leaf decomposition. Also a gall of *Neuropterus numismalis* was observed (Figs 8, 9).

The examined ash leaves were in more advanced phase of decomposition than oak leaves. On the abaxial leaf side, there was found white dusty spongy growth with surface scattered with tiny yellow to black-coloured fruiting bodies – cleistothecia – *Phyllactinia guttata* (Figs 10, 11).

Release of CO_2 by the soil in natural conditions

Soil respiration together with respiration of the plant cover represent the main way of releasing carbon from ecosystems. Average quantities of CO_2 released from soil surface ranged in intervals 0.46–0.57 g CO_2 m^{-2} per day. The specific soil moisture content was found to be 38.7%. The data obtained with sensors manifest that during the exposition time, there were no expressive changes in temperature of the inner



Figs. 5, 6. Nutrients reserves per one hectare in different humus layers

Fig. 7. Microscopic photo of oak leaf. Pupa with dead eggs of small buterflies (*Microlepidoptera, Teneidae*) were found. The surface of pupa is 3.07 mm^2.

environment. The differences between the temperature measured inside the closed baskets, both on soil surface and in a depth of 5 cm, and the temperatures recorded by outside sensors were max. about 1 °C, mainly during the night.

Region of floodplain biotopes of Dyje and Morava Rivers is significant in such degree that it has been assigned to the category of wetland ecosystems of international importance: RS 9 – Wetland Ecosystem of lower Podyjí (Heteša, 2004).

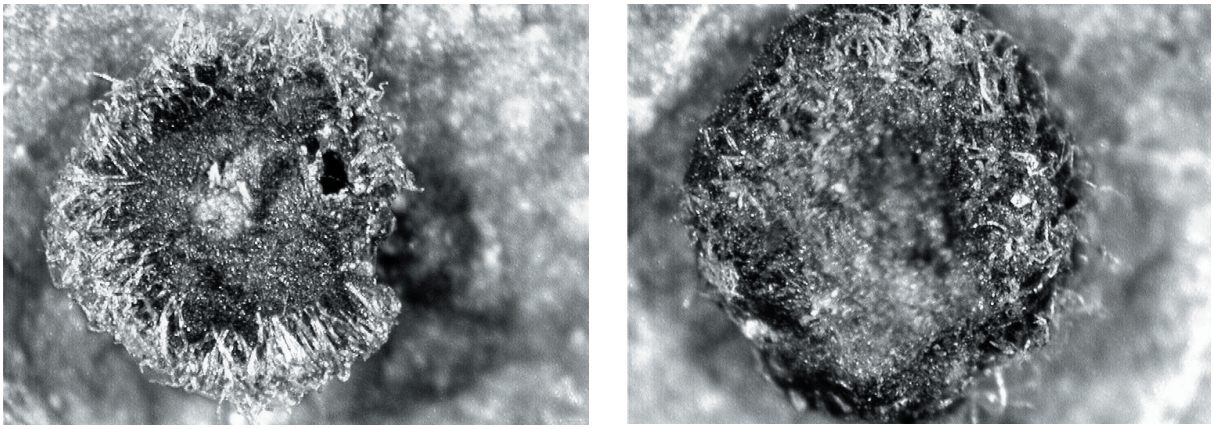


Fig. 8, 9. Microscopic photo of oak leaf. A gall of *Neuropterus numismalis* was found.

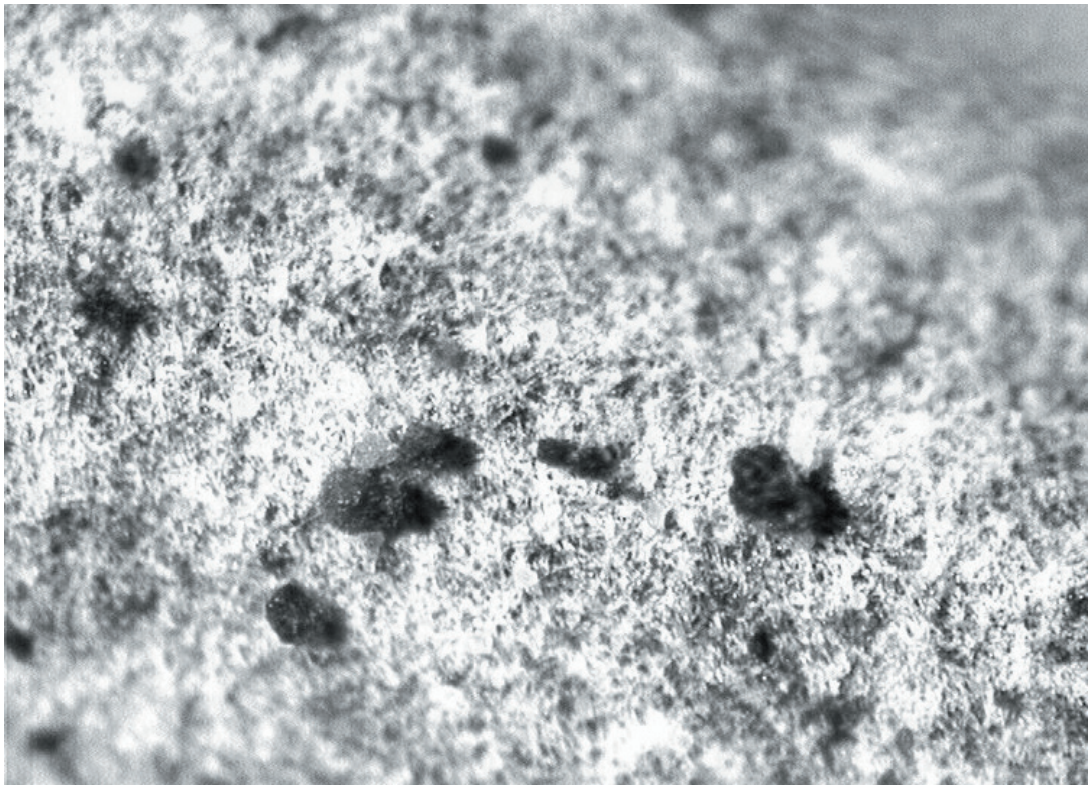


Fig. 10. Microscopic photo of ash leaf. The back side of leaf with white dusty growth, with yellow to black fruiting bodies (cleistothecia) of *Phyllactinia guttata*

Fig. 11. Microscopic photo of ash leaf with cleistothecium of *Phyllactinia guttata*. The diameter of this cleistothecium is 0.17 mm.

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Humusové poměry a biologická aktivita lužních lesů

Souhrn

Lužní lesy střední Evropy představují vyjímečné lesní geobiocenózy. Lužní lesy zaujímají v České republice zanedbatelné procento (1,4 %) z celkové lesní plochy Během 70. a 80. let 20. století došlo k výstavbám hrází a dalším vodohospodářským úpravám, jejichž cílem byla protipovodňová ochrana pozemků a obcí. Lužní les byl však na povrchové rozlivy záplavových vod adaptován a díky těmto změnám začal les vysychat a měnit svůj charakter.

Předkládaná studie přináší předběžné výsledky hodnocení humusových poměrů v lužním lese v Lednici na Moravě. Konkrétně jsou zde hodnoceny základní charakteristiky povrchového humusu ve smíšeném porostu tvrdého luhu, které budou později doplněny o charakteristiky mikrobiální aktivity půd.

U dubového opadu byl poměr C/N 42,7 a u jasanového opadu 24,4. U smíšeného vzorku se hodnota C/N pohybuje někde uprostřed dvou předešlých výsledků, což je způsobeno příměsí opadu dalších druhů dřevin. Je zřejmé, že opad jasanu je nejbohatší na dusík, proto zde rozklad probíhá nejrychleji a dusík, který je nevyužitý mikroorganismy je uvolňován do prostředí. Na zkoumaných plochách se půdní reakce mění od středně kyselé po neutrální, u půdní reakce potenciální výměnné, a od mírně kyselé až po mírně alkalickou u půdní reakce aktuální. Hodnoty pH stoupají spolu s rostoucí hloubkou půdy. Z výsledků vyplývá, že obsah uhlíku i dusíku klesá s rostoucí hloubkou půdy. Nejvyšší hodnoty byly zjištěny v 5 a 10 cm hloubce. Největší zásoba humusu se nachází v humusové vrstvě F. Z výsledků také vyplývá, že nejvyšší zásoba všech živin se nachází ve vrstvě F a loňském opadu L2. Z pořízené fotodokumentace byla na povrchu dubového listu nalezena zakuklená poškozená (odumřelá) vajíčka drobných motýlů (Microlepidoptera) – molovití (Tineidae). List jasanu byl v pokročilejší fázi rozkladu než list dubu. Na zadní straně listu byl nalezen bílý prachový houbovitý růst, na němž byly zachyceny žluté až černé pohlavní plodící struktury-cleistothécia čeledi padlí – *Phyllactinia guttata*.

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