Biochemical processes in peat soils of a mesotrophic bog

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Abstract. Microbial and enzymatic activities of peat soils in a mesotrophic bog of the Altai Republic were analyzed in 2013. Activities of catalase and polyphenol oxidase enzymes were found to depend on the botanical compositions of peat. Peroxidase was found to be more active in the lower part of the peat profile. Parameters of microbial biomass vary slightly with depth. The microflora is active throughout the profile. The peat soil was found to have a stable eco-physiological status.

1. Introduction
Peat soils are a natural formation with unique properties. The sustainable use of peat soils requires a special treatment. This is especially true for peat bogs in the Altai Republic (their area does not exceed 1% of the total area), which need to be studied comprehensively.

Microbial biomass is one of the most important components in the development and functioning of peat soils. Features, dynamics and functioning of microbiocenosis in bogs have not been studied sufficiently [1]. The substrate-induced respiration method can provide information on a relationship between the magnitude of microbial biomass, its respiratory activity and the eco-physiological status of a microbial community. The fact that there are only a few studies of biochemical processes in peat soils of the Altai Republic [2, 3] makes this work even more relevant.

The purpose of the study is to analyze biochemical processes in mesotrophic peat soils of the Altai Republic.

2. Materials and methods
The study was carried out at the Turochak Research Station of the Tomsk State Pedagogical University (Turochak District, the Altai Republic). Mesotrophic peat soils (Kutyushskoye bog) were chosen as targets of observation. The thickness of peat soils at a point of observation is about 3 m. A Sphagnum transition-moor peat (150–175 cm) occurs in the lower part of the peat profile. The upper part of the peat profile is composed of high-moor sphagnum peat. The degree of peat decomposition varies between 0 and 40%. The ash content is classified as low (6–8%). Peats are slightly acidic, with a soil pH of 3.82 to 4.22. The target of research is described in more detail in [4].

Soil samples were taken in May, July and September 2013 using a peat sampler depending on the botanical composition. Respirometric microbiological parameters, including basal respiration (BR), microbial biomass (MB) and microbial metabolic quotient (QR), were measured by substrate-induced respiration method [5]. The enzymatic activity was analyzed in crude samples in triplicate. The catalytic activity was measured by gasometric method modified by Yu. V. Kruglova and L. N.
Paromenskaya. The activities of polyphenol oxidase and peroxidase (hereinafter referred to as the “PPO” and “POD”, respectively) were analyzed by a method proposed by L. A. Karyagina and N. A. Mikhailovskaya [6]. Laboratory tests were carried out at the Test Laboratory of the Tomsk State Pedagogical University. Chromatographic tests were conducted using a Crystal-5000.1 gas chromatograph. Statistical processing of the results was performed in Microsoft Excel.

3. Discussion of Results
The growing season of 2013 is classified as wet (hydrothermal index—1.6). The season is featured by wet May, July and August, and a warm, very dry June. From May through July, bog water levels reduced to 30 cm from the surface. Later, bog water levels rose by 10 cm and remained almost unchanged until the end of the growing season. In the growing season of 2013, heating of the peat soils began in mid-May. The upper layers were warmed to a temperature of 10°C by the third decade of June. Summer temperatures (15°C) reached a depth of 60 cm in the late July and lasted until early September.

In such weather and hydrothermal conditions, the microbial biomass (MB) varied from 0.78 to 5.40 mg/g of dry peat. With depth, the MB declined. The basal respiration (BR) rate decreased with depth as well. Throughout the growing season, it varied between 0.98 and 1.79 µg C-CO₂/g*h. The BR rate in the near-bottom layer (250–275 cm) is higher than that in the surface layers. This finding is consistent with the data given in studies of other researchers and can be explained by the fact that the decomposition of the organic matter in anaerobic layers is more intense due to the simultaneous activation of facultative anaerobic and anaerobic microfloras [7]. In addition, it is known [8, 9] that sphagnum mosses are less susceptible to destruction, thereby reducing the activity of microorganisms in the upper layers. The findings support a hypothesis suggested by some researchers: the lower layers of a peat deposit cannot be considered “sterile”, while the concept of “peat soil” should include the entire peat deposit [10]. During the growing season, the highest MB values were recorded in May and September. The BR rate was slightly higher in July. Therefore, the most optimal conditions for microorganisms occur in July. This finding is supported by the microbial metabolic quotient (QR), a criterion for the stability of microbial communities and an indicator of how efficiently substrate is used. Throughout the growing season of 2013, the QR values did not exceed one, even when measured at a depth. This suggests that microbial communities in the studied soils are stable. In the aerobic layer, however, QR values were closest to zero. This indicates that the MB in the upper layers is less resistant to changes in natural factors.

In the studied soils, the total catalase activity varied from 1.49 to 16.16 of O₂/g*2 min throughout the growing period. In general, the upper layers of the peat profile (0–150 cm) had lower enzyme levels as compared to the underlying layers. This finding is consistent with the literature data according to which high-moor types of peat have a low catalase activity [8]. The catalase activity is higher at the bottom of the profile (150–175 cm). This is due to the fact that the peat changes its type to the Scheuchzeria transition-moor peat, as well as to a higher degree of peat decomposition (up to 35%) and higher ash content (up to 6.1%). The most noticeable seasonal changes in the enzymatic activity were observed in the lower part of the peat profile (150–175 cm). In these layers, the spring and autumn peaks were clearly recorded, with a minimum value in July.

Let us consider the activities of polyphenol oxidase (PPO) and peroxidase (POD) enzymes. These enzymes are involved in humification of the soil organic matter. The PPO activity in mesotrophic soils varied between 0.18 and 2.56 mg of 1,4-benzoquinone/g*30 min. The highest rates of activity were recorded in the upper layer (0–25 cm) in May. The middle part of the peat profile demonstrated the minimal enzymatic activity. In the lower part of the profile where the high-moor peat changes to the transition-moor peat, while the content of humic acids increased from 14 to 40% of the organic matter, the PPO activity increased again by 3–5 times. A higher PPO activity in the deep layers of the oligomesotrophic bog was observed by other researchers as well [11].

Throughout the observation period, the POD activity varied from 2.76 to 18.19 mg of 1,4-benzoquinone/g*30 min. The PDO activity tended to increase with depth. Significant changes in the
seasonal dynamics of the POD activity were recorded in some layers (25–50 and 75–100 cm). In July, the enzymatic activity demonstrated lower rates as compared to high rates in May and September.

4. Conclusions
The microbial biomass in mesotrophic soils of the Kutyushskoye bog was found to gradually decrease towards the bottom of the profile. The BR rate declined with depth and increased in the bottom layer. This is explained by the development of aerobic and anaerobic conditions at depth.

Catalase and polyphenol oxidase activities depend on the botanical composition of peats. The catalase activity increased with the degree of peat decomposition and the content of humic acids. The peroxidase activity was found to be higher in the lower layers of the peat profile.

Seasonal dynamics of microorganisms and enzymes are determined by weather and hydrothermal conditions. The microbial biomass and enzymatic activity were higher in the spring and autumn. The activity of the microbial biomass was higher in the summer. During this period, there were favorable conditions for anaerobic and facultative-anaerobic microorganisms.

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References
[1] Grodnitskaya I D, Karpenko L V, Knorre A A and Syrtsov S N 2013 Eurasian Soil Science 46 (1) 61-73
[2] Inisheva L I, Golovchenko A V, Bubina A B and Golubina O A 2009 TSPU Bulletin vol 11 (89) 207-11 (in Russian)
[3] Sergeeva M A, Porokhina E V and Golubina O A 2013 TSPU Bulletin 8 (136) 131-7 (in Russian)
[4] Inisheva L I, Vinogradov V U, Golubina O A, Larina G V, Porokhina E V, Shinkeeva N A and Shurova M V 2010 Bogs Research Station of the Tomsk State Pedagogical University (Tomsk: Tomsk State Pedagogical University Press) 118 (in Russian)
[5] Anderson J P E and Domsch K H 1978 Soil Biol. Biochem 10 (3) 314-22
[6] Inisheva L I, Ivleva S N and Shcherbakova T A 2003 Guidelines For Determining The Enzymatic Activity Of Peat Soils And Peat (Tomsk: Tomsk State University Press) 122 (in Russian)
[7] Grodnitskaya I D and Trusova M Yu 2009 Eurasian Soil Science 42 (9) 1021-8
[8] Savicheva O G and Inisheva L I 2000 Contemporary Problems of Ecology 5 607-14 (in Russian)
[9] Dobrovol’skaya T G et al. 2013 Of Microbial Complexes In Upland Peat Bogs Functioning - Analysis Of The Causes Of Slow Peat Destruction, ed I U Chernov (Moscow: Fellowship of Scientific Publications of KMC) 128 (in Russian)
[10] Golovchenko A V, Dobrovolskaya T G and Zvyagintsev D G 2008 TSPU Bulletin 4 (78) 46-53 (in Russian)
[11] Szajda L W and Styka K 2012 Phenol oxidase activity and the concentrations of total phenolic in peat profile of peatland by Nierybno lake in Tuchola forest national park (Necessity of peatlands protection) (Poznan: Wydawnictwo-Drukarnia „Prodruk”) pp 77-86