THE XANTHINE OXIDASE AND PHENOL OXIDASE ACTIVITY OF NATURAL PEAT AND PEAT-MOORSH SOILS

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Introduction

The melioration of peatlands led to the biotic and abiotic changes, which implicated the degradation of organic matter and organic compounds. Decrease of water table in peatlands characterizes the differentiation of peptides and amino acids from hydrophilic to hydrophobic (Szajdak 2014). The process of muck formation includes the physical, chemical and physicochemical transformation of organic matter, particularly of its colloidal constituents. The organic mass undergoes partial mineralization as well as humification. Due to mineralization, a partial decrease of the organic matter takes place, reflected by a distinct decrease in the organic carbon content, followed by an increase in the ash content. Humification transforms part of the organic matter into humus compounds, although, according to most scientists, humic acids are not formed until the more advanced stages of muck development. Although they are linked with of peat decomposition, transformations taking place on the surface of the de-watered peats in the muck formation process should not be confused with decay of peat taking place deep in the marshes in saturated conditions (Myślińska 2003).

Decomposition of organic materials in raised-bogs is very slow because of the low pH and temperature of the soil. Cellulose and lignin are the two most important organic compounds found in peatlands. The bacteria play an important role in the degradation of these components. Both cellulose and lignin compounds come from plant residues and are degraded to mono- and disaccharides respective to phenol (Szentes et al. 2011).

The aim of the investigation is to compare the activity of xanthine oxidase and phenol oxidase in natural peat and peat-moorsh soils.

Materials and methods

Natural peatlands (Kusowo Bog, Stążka Mire, The Great Vasyugan Mire, Mukhrino Field Station, Tagan 1) and peat-moorsh (Zbęchy, Bridge, Shelterbelt, Hirudo, Tagan 2.) differing with the type of peat and hydrological regime situated in northern and central Poland and western Siberia (Russia) region have been investigated (Fig.). Kusowo Bog is located in the West Pomeranian Voivodship in Poland the Baltic type raised bog. It is Nature Reserve (2010-UNESCO Biosphere Reserve). Stążka Mire is the southern part of the Tuchola Landscape Park and part of the Stążka River Mires Reserve. The Great Vasyugan Mire is situated within boundary of four regions of Russian Federation: Tyumen, Omsk, Tomsk and Novosibirsk regions (mainly Tomsk and Novosibirsk regions) (Inisheva et al. 2011). Mukhrino Field Station is owned and run by the UNESCO Chair on Environmental Dynamics and Climate Change at the Yugra State University, Khanty-Mansiysk, Russia. It is located at the east bank of the Irtysh River near the confluence with the Ob River in the central taiga area of Western Siberia, 26 km west of the town of Khanty-Mansiysk. Tagan peatland is located 20 kilometers near Tomsk, West Siberia, Russia on the second flood-plain terrace of the river Tom of ancient flow channel. Zbęchy, Bridge, Shelterbelt and Hirudo placed in the Agroecological Landscape Park host D. Chłapowski in Turew (40 kilometers South-West of Poznań, West Polish Lowland).

The peat samples were taken for analyses from 2008 to 2012 from 0 to 50 cm (acrotelm) and from 50 to 100 cm (catotelm) depths in the stratigraphic profile of each peat deposit. Soil bulk density was determined in soil cores collected and porosity calculated. The total organic carbon was analyzed on Total Organic Carbon Analyzer (TOC 5050A) with Solid Sample Module (SSM-5000A) produced by Shimadzu (Japan). Total nitrogen was estimated by the Kjeldahl method. Xanthine oxidase activity was performed by Krawczyński method (Szajdak et al. 2011a, b). The absorbance of the solution was measured colorimetrically at λ_{max}=290 nm using a UV-VIS spectrophotometer Beckman DU®-68 USA. Phenol oxidase was analyzed by Perucci method (Szajdak et al. 2011a, b). The absorbance of the solution was assayed colorimerically at λ_{max}=525 nm using a UV-VIS spectrophotometer Beckman DU®-68 USA.

All chemical, biochemical analyzes were run in triplicate, and the results were averaged. The confidence intervals were calculated using the following formula: $\bar{x} \pm t_{\alpha(n-1)}$ SE, where: $\bar{x}$ - mean, $t_{\alpha(n-1)}$ - value

Fig. *Setting of the study site*
▲ *natural peat: B - Kusowo Bog; C - Stążka Mire; D - Mukhrino Field Station: KM1, KM2, KM3, KM4, KM10, KM15, KM16, KM17, KM18; E - Vasugan P2, Vasugan P3, F1 - Tagan 1*
● *peat-moorshes: A - Zbęchy, Bridge, Shelterbelt, Hirudo; F2 - Tagan 2*

of the Student test for α = 0.05, and n-1 degree of freedom, SE - standard error.

Results and discussion

It is known, that the macromolecules of complex organic compounds under the influence of enzymes, secreted by microorganisms, are exposed by destruction. The degradation products form the heterocyclic compounds, which interact with certain kinds of microorganisms and produce low and high molecular organic substances such as carbohydrates, and lignin as well as peptides (Szajdak, Inisheva 2014). Phenol oxidase and xanthine oxidase plays an important role in redox processes of peat soils. Polyphenol oxidases represent a group of copper-containing enzymes catalyzing oxidation of phenolic compounds in the presence of molecular oxygen. They are responsible for enzymatic browning reactions, participating in the formation of humic acids, and indicating the capacity of the microflora which degrade recalcitrant organic substances. Phenol oxidase is one of the few enzymes able to degrade recalcitrant phenolic materials as lignin. Whereas, xanthine oxidase oxidizes hypoxanthine and xanthine to uric acid in the purine catabolic pathway and participating in the cycle of nitrogen in soils (Benitez et al. 2006; Ayaz et al. 2008).

Our study showed significant higher differences of phenol oxidase and xanthine oxidase activity in natural than drained peat in both of layers (0-50 and 50-100 cm) (Table). Peat-moorsh soils had a lower mean value of phenol oxidase activities from 21.58 to 22.80 μmol h^{-1} g^{-1} compared to the natural peat from 41.55 to 41.87 μmol h^{-1} g^{-1}. However, xanthine oxidase activity ranged from 6.72 to 11.86 μmol h^{-1} g^{-1} in drained peat and from 19.95 to 23.04 μmol h^{-1} g^{-1} in natural peat. Fenner et al. (2005) suggested that enzymatic processes are likely to contribute to the differences in DOC (including phenolics) concentrations in wetlands, reinforcing physicochemical processes. Large increases in total phenol oxidase activities in the droughted wetland were also induced as a result of oxygenation. But Xiang et al. (2013) believed that the phenol oxidase activities along the vertical profile under drought conditions are significantly lower than the corresponding values under waterlogging.

Borren et al. (2004) have proved that the dry bulk density and carbon content were nearly constant with depth in natural peat. These studies were consistent with our results in natural peat. The measured values of bulk density were 0.11 g cm^{-3} in both layers (Table 1). This parameter reaches the values in the range from 0.16 to 0.26 g cm^{-3} in peat-moorshes. Anashari et al. (2010) reported higher TOC in undrained peat than in drained peat. Our investigations demonstrated significant differences between natural (470.62 g kg^{-1}) and drained peat (384.18 g kg^{-1}) for TOC in acrotelm (Table 1). Total nitrogen in drained peat is significantly different than in undrained (Anashari et al. 2010). Bieniek and Łachacz (2012) confirmed higher quantities of total nitrogen in surface horizon layer of peat-muck soils in comparison with peat soils. It was according to our results. Total nitrogen content in natural peat was from 14.99 to 15.14 g kg^{-1} and in peat-moorshes from 25.18 to 25.34 g kg^{-1}.

These investigations have shown that the C/N ratio in samples of strongly decomposed peat ranged from 15.67 to 19.28 in drained and from 36.78 to 38.01 in undrained peat, which suggests a low decomposition degree of organic residues in natural peat. The reason of the significant lower C/N in

Table. *Mean contents of chemical compounds, physical parameters, enzyme activities and factors of biochemical transformation for enzymes activities in natural and peat-moorsh soils in 0-50 cm and 50-100 cm layers*

Parameters	Natural peat		Peat-moorsh soils	
	0-50 cm	50-100 cm	0-50 cm	50-100 cm
POA [μmol h^{-1} g^{-1}]	41.55 ± 9.24	41.87 ± 8.98	21.58 ± 4.98	22.80 ± 5.04
XOA [μmol h^{-1} g^{-1}]	23.04 ± 4.19	19.95 ± 4.94	6.72 ± 2.27	11.86 ± 3.28
Moisture [%]	91.38 ± 1.59	88.57 ± 2.87	74.10 ± 2.80	83.28 ± 1.52
Bulk density [g cm^{-3}]	0.11 ± 0.03	0.11 ± 0.01	0.26 ± 0.01	0.16 ± 0.01
Porosity [%]	93.27 ± 1.22	92.93 ± 0.50	84.59 ± 0.68	89.75 ± 0.41
TOC [g kg^{-1}]	470.62 ± 37.19	493.48 ± 40.65	384.18 ± 29.07	483.73 ± 28.29
N_{total} [g kg^{-1}]	14.99 ± 2.80	15.14 ± 2.77	25.18 ± 2.23	25.34 ± 1.14
C/N	36.78 ± 7.27	38.01 ± 8.06	15.67 ± 1.73	19.28 ± 1.59

TOC - total organic carbon, N_{total} – total nitrogen, XOA – xanthine oxidase activity, POA – phenol oxidase activity

$\overline{x} \pm \Delta x$ – confidence interval of average at confidence level a=0.05 for n-1 degree of freedom

drained than in undrained peat soils is connected with the mineralization of drained peat soils (Bieniek, Łachacz 2012).

Anashari et al. (2010) concluded that bulk density, total nitrogen concentration and low C/N ratio (<20) in the drained and converted peats are important factors that indicate some processes of peat degradation.

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