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Original Article

Changes of Urease Activity in Peat Profile of Peatland By Nierybno Lake in ”Bory Tucholskie” National Park

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Abstract

The role of extracellular enzymes in controlling the rate of decomposition has long been recognized. The aim of our investigations was to evaluate the urease activity of peat profile in the region of „Bory Tucholskie” National Park, UNESCO - Natural Reserves. Peat samples were collected from four depth: 0-20 cm, 20-50 cm, 50-70 cm and 70-100 cm. The obtained results have revealed the impact of four depths of peat profile on urease activity and of pH values, the concentrations of TOC, DOC and total nitrogen. These studies confirmed that within the peat profile the content of DOC declines with soil depth similar to urease activity. However, the increase concentration of pH, TOC, total nitrogen at the depth from 70-100 cm were observed.

Keywords: urease activity, peatland

1. Introduction

Peatlands have long been recognized as unbalanced ecosystems, in which the rate of production of organic material exceeds that of its decomposition. The vast accumulation of peat (partially decayed plant remains) within these peatlands attest to an ecosystem with exceptionally low rates of decomposition [5].

Decomposition is a fundamental process in ecosystem carbon flux and nutrient cycling. In nutrient limited environments, such as many wetlands, the continued availability of nutrient resources depends on microbial decomposition of detritus. Soil enzyme activities have widely been studied to assess organic matter decomposition rates in various ecosystems [1, 2, 6, 8].

These enzymes are required to catalyze the processing of high-molecular-weight organic matter into assimilable subunits, thus enabling heterotrophic bacteria to obtain suitable substrates. The acquisition of nutrients released by extracellular hydrolysis depends to a large degree on the quality of the decomposing detritus. This degradation requires the involvement of many hydrolytic enzymes [11, 12]. The aim of our investigations was to evaluate the urease activity of peat profile in the region of „Bory Tucholskie” National Park, UNESCO - Natural Reserves [14, 17, 18].

2. Materials and Methods

The investigations were carried out of peatland by the Nierybno Lake, located in the „Bory Tucholskie” National Park in northern Poland (53°49´ N, 17°34´ E). Lake Nierybno is situated in the central part of National Park. Lake Nierybno is an oligo- mesotrophic, smal land shallow lobelia lake. The vegetation of peatland by Nierybno Lake is dominated by: *Ledum palustre, Vaccinium*

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oxycoccos, V. myrtillus, V. vitis-idaea, Hydrocotyle vulgaris, Juncus bulbosus, Drosera rotundifolia, Lobelia dortmanna, Sphagnum, Eriophorum vaginatum, Lysimachia thyrsiflora, Menyanthes trifoliata, Carex lasiocarpa, C. rostrata (16].

The peat samples were taken for analyses in December 2008 with the peat profile from peatland by Nierybno Lake. Peat samples were collected from four depth: 0-20 cm, 20-50 cm, 50-70 cm and 70-100 cm. Peat from each collection was treated separately; the surface layer of vegetation was removed and the peat gently homogenized by hand for 10 min in order to reduce spatial heterogeneity. The peat material was air-dried and crushed to pass through a 1 mm mesh sieve and pH (in 1N KCl), total organic carbon, dissolved organic carbon, total nitrogen and total phenolic compounds were determined. Soil pH was measured in soil 1 N KCl (1:5 v/v) suspensions by potentiometric method. The total organic carbon (TOC) was analyzed on Total Organic Carbon Analyzer (TOC 5050A) with Solid Sample Module (SSM-5000A) produced by Shimadzu (Japan). Dissolved organic carbon (DOC) was evaluated on TOC 5050A equipment produced by Shimadzu (Japan). For the investigation of DOC, soil sample were heated in redistilled water in 100ºC for two hours under a reflux condenser.

Extracts were separated by the mean filter paper and analyzed on TOC 5050A facilities. Twice-distilled water from silica glass equipment was used [15]. Total nitrogen was evaluated by the Kjeldahl methods. The urease activity was determined spectrophotometrically by the method of Hoffmann & Teicher [20].

3. Results and discussions

Peatlands are reservoirs of organic soils and peat, in which significant amounts of carbon have been accumulated since the last glacial retreat. Natural organic matter (NOM) is a major constituent of the organic substances in soil, sediment, peat and fossil fuel; and it comprises the largest pool of carbon on the earth. NOM consists of organic material in the following phases: partially degraded but still identifiable plant tissues; microbial biomass; organic coatings of mineral phases; identifiable organic substances of low molecular weight; and the refractory part of organic matter - humic substances (humic acid, fulvic acid, and humin).

Extracellular enzymes mediate the degradation, transformation and mineralization of soil organic matter [4, 3, 7].

In our studies we measured of pH values, and the concentrations of total organic carbon, dissolved organic carbon, total nitrogen, C/N ratio, urease activity of peat profile in the region of „Bory Tucholskie" National Park, UNESCO - Natural Reserves (table 1).

The soil pH is one of the most important factors to know the availability of most nutrients in soil solution in a given environment Soil pH also affects the activity of soil enzymes through its controls on microbial enzymatic production, ionization-induced conformational changes of enzymes, and/or availability of substrates and enzymatic co-factors [14, 21].

Table 1. pH value, total organic (TOC), dissolved organic carbon (DOC), total nitrogen (N_{total}), C/N ratio, and urease activity in peat soil of Nierybno Lake

Sampling sites depth (cm)	pH	TOC g kg^{-1}	DOC g kg^{-1}	N_{total} g kg^{-1}	C/N	***Urease activity*** ***µmol*** $h^{-1}g^{-1}$
0-20	2.72	434.30	14.18	10.64	41	55.62
20-50	2.71	441.65	11.17	9.24	48	13.56
50-70	2.91	434.90	7.52	8.96	49	11.20
70-100	3.01	454.65	9.66	15.40	30	5.76

In the present research pH was acidic and increased slightly through the depth of profile of the peat deposits. The pH values was amounted from 2.71 to 3.01 between the depth of 0-100 cm.

Peat soils represent an important carbon (C) reservoir because their organic components decompose slowly, and mires are amongst the most important ecosystems for sequestering C at the earth's surface (Ukonmaanaho et al. 2006; Azkorra et al. 2008-2010). This investigation was confirmed high content of TOC on the depth of 70-100 cm (454.65 g kg^{-1}) and low between of depth of 0-70 cm (from 434.30 to 441.65 g kg^{-1}).

Dissolved organic carbon (DOC) is an important component of the carbon cycle within peat soils are a vital store of terrestrial carbon. Dissolved organic matter is involved in a number of biogeochemical processes, including pH buffering, nutrient cycling, ionic balance, metal leaching, pollutant toxicity, mobility and bioavailability (Marschner & Bredow 2002, Gregorich et al. 2003, Dou et al. 2007, Worrall et al. 2008). This study showed the highest concentration of DOC on the depth of 0-20 cm (14.18 g kg^{-1}) and the lowest on the depth of 50-70 cm and 70-100 cm (7.52 and 9.66 g kg^{-1}). According to Kalbitz et al. (2003) DOC concentrations in deep soil horizons are typically low.

Nitrogen content indicates the trophic or nutrient status for plant growth and microbial activity [19]. In all analyzed peat samples the amount of total nitrogen ranged from 8.96 to 15.40 g kg^{-1}. However, the highest concentrations of the total nitrogen were determined at the depth of 70-100 cm (15.40 g kg^{-1}).

C/N ratios are used to determine the degree of humification and the amount of N available to plants and microbes [19]. In the present work C/N ratio ranged from 30 to 49 between of the depth from 0 to 100 cm.

Urease activity is important enzyme involved in organic matter mineralization in soil and in N cycle. This enzyme release $N\text{-}NH_4^+$ through urea hydrolysis and are essential in the chain of hydrolysis of amino compounds which are supplied to the soil from plants and to a lesser extend from animals and microorganisms. Soil ureases are microbial products that can accumulate in cell free forms in the soil because they are highly resistant to environmental degradation

Soil urease originates mainly from plants and microorganisms found as both intra- and extra-cellular enzymes. Urease activity in soils is influenced by many factors: cropping history, organic matter content of the soil, soil depth, soil amendments, heavy metals, and temperatures [9, 13]. In our investigation the urease activity decreased slightly through the depth of profile of the peat deposits. This studies showed the highest urease activity at the depth 0-20 cm and the lowest at the depth of 70-100 cm. In the peat profile activity of urease ranged from 5.76 to 55.62 μmol $h^{-1}g^{-1}$. Makoi & Ndakidemi (2008) revealed decreased urease activities with increased soil depth with soil samples taken from horizons of different soil profiles [9]. Extracellular urease associated with soil organo-mineral complexes is more stable than urease in the soil solution and those humus-urease complexes extracted from soil are highly resistant to denaturing agents such as extreme temperatures and proteolytic attack. On the other hand, urease extracted from plants or microorganisms is rapidly degraded in soil by proteolytic enzymes. This suggests that a significant fraction of ureolytic activity in soil is carried out by extracellular urease, which is stabilised by immobilisation on organic and mineral soil colloids[9, 10]. Furthermore, this study showed that urease activity was similar for the changes in DOC in the peat profile.

4. Conclusions

The obtained results have revealed the impact of four depths of peat profile on urease activity and of pH values, the concentrations of TOC, DOC and total nitrogen. The study confirmed that within the peat profile the content of DOC declines with soil depth similar to urease activity. However, the increase of pH and the concentrations of TOC, total nitrogen at the depth from 70-100 cm were observed.

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