Матеріали
III Міжнародного науково-практичного круглого столу
«Екологія водно-болотних угідь і торфовищ», м. Київ, 3.02.2014 р.

УДК 631:504

Екологія водно-болотних угідь і торфовищ (збірник наукових статей) // Головний редактор В.В. Коніщук. – Київ: ТОВ «НВП «Інтерсервіс», 2014. – 300 с.

PROCESSES IN MELIORATED PEAT SOILS

[1]Szajdak L.W., [2]Inisheva L.I.
[1]Institute for Agricultural and Forest Environment,
Polish Academy of Sciences. Poznań, Poland, szajlech@man.poznan.pl
[2]Tomsk State Pedagogical University. Tomsk, Russia, inisheva@mail.ru
szajlech@man.poznan.pl, inisheva@mail.ru

The long-term cultivation and agricultural use of peatlands has an impact on their environment such as: decrease of ground water level, changes of aerobic conditions, changes in communities, and root exudates of cultivated plants as well as degradation and mineralization of peat [2,3,4,7,9]. Kalbitz et al., (1999) showed that the land use of peatlands effects on fulvic acids (FAs) properties, which account for the major fraction of dissolved organic matter. The above mentioned authors suggested that long-term intensive land use (from 50 to above 200 years) resulted in larger proportion of the aromatic structures and a larger degree of polycondensation of FAs [7]. However it is unknown what changes in the units of the structure of FAs they cause. Leinweber et al. (2001) reported that in water -soluble FAs, which are the main component (about 60%) of dissolved organic matter, the proportion of carbohydrates and phenols together with lignin monomers increased with increasing intensity of soil tillage, aeration and peat degradation.

A great number of biochemical and chemical processes in peat require aqueous conditions. The drainage as a result of agricultural use of peatlands results in intensive changes of biotic and abiotic properties, which leads to the degradation of the peat organic matter. Peat organic matter which regulates long-term C storage and the nutrient availability to plants and microbes. The content of moisture, dissolved organic matter (DOM) seems to be closely associated with microbial activity, because this fraction of the organic carbon can be vulnerable to microbial degradation. The quantities of dissolved organic matter are sensitive to land management, especially agricultural use which reduces inputs to the soils organic matter evolution through removal of plant biomass [5,6,9,10]. The mechanism of the degradation DOM depends on the aromaticity and complexity of dissolved organic matter molecules whereas carbohydrates and amino acids increase this process. DOM degradation results also in a relative enrichment of lignin-derived moieties, which affects the thermal behaviour of individual compounds classes and increases thermal stability of residual dissolved organic matter. A number of countries are characterized by rich deposits of organic resources but at the same time the industrial production of organic fertilizers, organomineral mixtures and potting soils based on organic resources (peat, sapropel, and brown coal) is still not satisfied. Using natural organic fertilizers from raw materials such as peat, sapropel and brown coal during last decades increased. Peat extraction for the production of growing substrates and gardening is a multi – million dollar industry in North America and Europe. For instance, the Netherlands import 150 million euro worth of peat every year as a substrate for horticulture.

Soil organic matter represents and equilibrium system, which plays a major role in supplying nutrients to plants grown thereon. Transformation of fresh organic matter to stable humic compounds effects the cation and anion exchange capacity. 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 [1,11,12,16].

Among the chemical properties of organic soils, particularly attention is paid on the nitrogen. Variation in nitrogen gives these soils a specific character. Its content is important as any quantitative and qualitative conversions and also transformations in the nitrogen concentrations are distinctly reflected in chemical and indirectly in the physical properties of soil formations that exert a decisive impact on their fertility. From a large number of works on the peat soil nitrogen it appears that the organic nitrogen occurs in forms that are both easily decomposed and resistant to decomposition [1,8,13,15,17].

The cultivation of fens leads to the mineralization and humification of peat. Process such as mineralization of mineral and organic carbon or organic nitrogen (peptides, amino acids, amino sugars, amides, alkaloids, plant hormones) to gases products can be carried out by a variety of microbial species. Due to these managements some evolution of greenhouse gasses CH_4, CO_2, NO, N_2O and N_2 are observed. The evolution of these gases is negative. They are greenhouse gases which cause significant depletion of the Earth’s stratospheric ozone layer and contribute to the warming of the Earth’s surface. The increase of mineralization processes is accompanied of the biotic system. Many groups of organism inhabiting fens are generally grouped, according to their size and structure, into macrofauna, microfauna, mesofauna and microbiota my contributed significantly to the physical fragmentation of fen and also nutrient cycling. Its dynamics are affected by the rate of mineralization, immobilization, leaching, root exudates and plant uptake. The following biochemical and chemical processes such as degradation, polycondensation, polymerization and polyaddition of organic substances are responsible for the formation of humic micromolecules, which are characterized by a complex macromolecular structure with aromatic and aliphatic units. They are representing macromolecular polydisperse biphyllic systems including both hydrophobic domains (saturated hydrocarbon chains, aromatic structural units) and hydrophilic functional groups, i.e having amphiphilic character. Various biochemical and chemical mechanisms are involved in the process of the degradation or cleavage of these macromolecules.

Several physicochemical parameters such as temperature, moisture, the content of oxygen and H^+, soil density and biochemical activity impact on the conversion of organic matter. This makes the study of organic matter even more important. A conceptual view of biochemical transformation of organic matter in soil concerns the amount of organic matter going through different stages of degradation, from coarse dead plant materials to evolved humified organic matter. Many of the functional groups of organic matter are acidic and deprotonated, resulting in anionic charged matter which facilitates its solubility and ability to complex with metals and biologically active substances. These processes result in quality and quantity changes of physicochemical properties fens and also to the spatial allocation of mineral post-fen soils. The decrease the rate of mineralization process and inhibit loss of organic matter quantity, which may have an impact on the availability of nutrients for plant growth, limiting the adverse effects associated with their cultivation [9].

Several investigations dealt with the problem of the changes of amphiphilic character humic substances of peat-muck soils. Amphiphilic properties of humic substances are responsible for their solubility, viscosity, filtration, conformation, surfactant-like character, dispersion forces, electrostatic interaction, hydrogen bonding and a variety of physicochemical properties of considerable practical significance. These properties are strongly connected with water holding capacity and are depended on secondary transformation of peat muck soils. In particular, the process of secondary transformation of peat muck soils was significantly linked-up with water holding capacity, surface charge and differentiation of bounded amino acids. The amino acids present in the form of protein, peptides, and heterocycles can be bound to humic substances via hydrogen bonds and/or phenolic products of lignin degradation usually surrounded by protein coats. Therefore, attractive interactions between proteins and amino acids and soils colloids are those (dispersion forces, electrostatic interactions, hydrogen bonding and hydrophobic interaction) of proteins and amino acids with organic colloids. Different kinds of functional groups have been identified in natural organic matter, including carboxylic, phenolic and hydroxyl groups. Nitrogen- and sulphur-containing functional groups, such as amino, amide, imines, sulfamino, thiol, sulphinic and sulphonic acid groups may also be present in smaller quantities. Functional groups of humic substances play a significant key in the adsorption of water molecules. Therefore, the values of monolayer (or specific surface area) may provide information about these functional groups.

The relative amphiphilic character of organic colloids of humic substances can be important in modifying the structure of water films and in affecting the interactions of microorganisms with organic colloids. Hydrophilic or hydrophobic regions, which are the result of the presence in the organic matter of lipids, waxes, amines, amino sugars, sugars, polysaccharides, amides, amino acids, aromatic structural units and other moieties, can interact with amphiphilic regions of the microbial surface or may render inorganic particles, such as clay minerals, hydrophobic centers when complexes between these inorganic and organic components are formed. The stabilization and degradation of soil structure depends on biologically activity. In response to the formation of soil structure, pores of different size are created and they can reveal different functions. Macropores (diameter>2x10-5m) are responsible for drainage and aeration of soils and are characterized by the presence of roots, and live meso- and macrofauna. However, mesopores (1x10-7–2x10-5 m) contain the available plant water, bacteria, fungi, and root hairs and micropores (<1x10-7m) for the adsorbed and intercrystalline water. Finally all these in-depth processes and parameters as soon as properties are focused on load of shrinkage and swelling behavior of peat soils.

The analysis of a peat ecosystems provide a case study in which the balance between production and decomposition of organic matter is the product of a series of past and present environmental factors, particularly geology, climate and topography. Slight variations in time and space in one or other of these factors have resulted in a mosaic of blanket peat with *Calluna*, *Eriophorum* and *Sphagnum* interspersed with grassland swards on a variety of mineral soils. Waterlogging plus the lower temperatures reduced the rate of decomposition and caused an increased accumulation of organic matter which gradually incorporated the remains of the birch woodland. The organic matter accumulation increased the water-holding capacity and acidity of the soil, and with the cool wet climate, bog vegetation of *Calluna*, *Eriophorum* and *Sphagnum* developed. The litter from these species has an intrinsically low rate of decomposition (i.e. low resource quality) and thus contributed to the accumulation of peat to its depth which varies from 0.5 to 4 m. Some peat accumulation probably occurred on the scarp but was unstable because of the slope and has mainly been lost through erosion.

The processes of decomposition and the decomposer populations have influenced, and been influenced by, the developing soil conditions. Analysis of the prevailing state emphasize the processes the interaction of resources quality and physical environment in determining processes and populations within the same general climatic regime. On the blanket bog, primary production is 660 ± 53 m_2 yr_{-1} from a standing crop of 1500-2500 g m_{-2}, about half of which is above grounds. The dwarf shrub *Calluna vulgaris* produces about 120 g m_{-2} of green shoots and about 200 g m_{-2} yr_{-1} of woody tissues about half of which is in the form of below ground stems in the 10 cm of the peat. Less than 5% of the shoot production is eaten by grouse and the remainder falls to the bog surface as litter. On death, the stems of *Calluna* remain standing of canopy for the number of years. Tussocks of *Eriophorum vaginatum* produce about 130 m_{-2} yr_{-1} distributed among leaves, leaf and stem bases, rhizomes and roots, some of which penetrate to 50 cm in the peat. *Sphagnum* production varies from 45 g m_{-2} yr_{-1} on the drier parts of the bog to 300 g m_{-2} yr_{-1} in pool-lawn-hummock complexes. With its characteristic apical growth *Sphagnum* dies its base and the stems and leaves enter the decomposition subsystem 5-10 cm below the surface of the sward. Production of herbs such as *Narthecium ossifragum* and *Rubus chamemorus* is usually less than 10 g m_{-2} yr_{-1}.

The two regulating varables then act in the following ways:

A/ The organic matter for decomposition varies from *Calluna* with low nutrient (0.5% N, 0.04% K) and high holocellulose (50-70%) and lignin (30-50%) concentrations, to leaves of *Rubus* with high concentrations of nutrients (1.3% N, 0.07 P, 0.09% K), low holocellulose (34%) and lignin (6%). The leaves of *Rubus* however have a high concnrtation of soluble tannins (27%).

B/ The range of resources is deposited by plants in a variety of microhabitants which, because of shading and wetness, show market differences in microclimate as indicated by seasonal pattern of maximum and minimum temperatures. Temperatures in the *Eriophorum* litter are often 10_oC higher than those in *Calluna* litter but although this associated with higher evaporation. Even in the wet climate the decomposition in the litter is occasionally retarded by low moisture, for example about 20% of *Rubus* leaf samples collected from the field had moisture levels which were suboptimal for respiration.

The rates of weight loss of the main surface litter, measured in litter- bags over 6-10 years, approximate to annual constant fraction losses of between 0.05 for *Calluna* stems and 0.19 for *Rubus chamemorus* leaves. Measurement of litter respiration shows that the rate of catabolism is directly related to weight loss. The rate of respiration however declines as the litter ages as a result of decomposition of the more readily decomposable fraction and an increasing proportion of resistant compounds [14].

The older litter is overlain be new litter production and moves down the peat profile, at about 0.5 cm yr_{-1}, entering an increasingly waterlogged environment. The below ground parts of the plants, particularly the roots of *Eriophorum*, are also deposited in waterlogged conditions. The slow rate of oxygen uptake by microbial respiration, results in a increasingly anaerobic environment with depth. The redox potential (Eh_4) declines from about – 100 mV in the surface litter to a peak of about – 400 mV at 10-20 cm, the depth at which the water table frequently occurs. Samples of litter and pure cellulose placed at different depths within the peat profile show a decline in rate of decomposition with depth, relative to the rate at the surface, loss rates declining by 3-5% cm_{-1} (Inisheva 2009).

The low initial rates of decomposition relate to the low quality of the resource. Even when corrected for a decline in rate with ageing, the loss rates, given current inputs primary production, cannot account for the observed peat accumulation of about 100 kg m^{-2}.

It is only when the retarding of decay rate through waterlogging and the development of the anaerobic conditions at below the water table is simulated that calculations of the current peat profile characteristics approximate to observed values. The overall decay rate in the aerobic zone' (0-20 cm) is of the order of 0.02-0.04 g g^{-1} yr^{-1} but below the water table it is of the order of 1 x 10^{-3} to 1 x 10^{-8} g g^{-1} yr^{-1}.

Feedback mechanism regulating primary production and decomposition processes ca be identified in this system; the products of anaerobic decomposition increase acidity and thereby retard decomposition and nutrient mobilization; the increasing accumulation of peat restricts access to mineral soil by plant roots and limits nutrient availability to the component recycled from decomposition or entering the system in rain. As a result the plants tend to conserve nutrients by perennial growth and the concentration of elements in the litter is low. The distribution of the glacial boulder clay initiated the inexorable chain of events in which waterlogging plays a key role in determining the rate of decomposition and thence the pattern of vegetation.

The high loss rate on the peat bog is a result of the higher nutrient concentration and the lower proportion of high molecular organic compounds in the organic matter plus the aerobic soil conditions with pH about 5.0. The difference in resource and soil conditions results not only in grater herbivory and decomposition rate but in greater soil fauna diversity and productivity compared to the bog. Lumbricid populatins make a major contribution to the faunal standing crop of about 23 g m^{-2} with a production of about 12 g m^{-3} yr^{-1} compared to a standing crop and production of less than 1 g m^{-2} yr^{-1} on the bog where enchytraeids and tipulid larvae predominate.

Acknowledgements

This study was supported by the grants:

- No: N N310 310139 on "The location and function of phytohormone indole-3-acetic acid and the biochemical, physical and chemical properties of peat substrates", supported by the Foundation of the Polish Science.
- 2013/09/B/NZ9/03169 on "Impact of peat type and species of upland mires on the change of enzymatic, chemical and physical properties", supported by the Polish National Sciences Centre.
- "Impact of arctic zone on the chemical and biochemical processes, conversions and transformations in peat layers (Peat – AcroCato)", supported by the FP7 Interact – Transnational Access.

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