Summary

Decomposition of plant organic matter is a fundamental biogeochemical process allowing for cycling of key elements in the biosphere. Peatlands are specific types of terrestrial ecosystems, where retarded decomposition leads to strong accumulation of (undecomposed) plant organic matter. High water table levels and resultant anoxic conditions which inhibit growth and activity of decomposers, are regarded as the main factors responsible for accumulation of peat. Research from the last 15 years has shown that peatlands are inhabited by species-rich communities of fungi, however their role in the decomposition processes in these ecosystems is still poorly known. What is more, virtually nothing is known of the contribution of mycorrhizal fungi to decomposition in peatlands, even though they are very abundant in these habitats. Better understanding of these interactions is of utmost importance, given the huge carbon-sequestering potential of peatlands, and their vulnerability to global climate change and anthropogenic pressure.

Therefore the main objectives of this interdisciplinary study were as follows: (a) determination of the role fungi play in decomposition of plant organic matter differing in chemical composition (Sphagnum moss and vascular plants), in different nutrient- and hydrological regimes of two types of peatland habitats; (b) determination of the influence of habitat conditions (groundwater level, temperature, soil and water pH, nutrient regime and availability) on decomposition of plant organic matter; (c) determination of interrelationships between abiotic (habitat conditions) and biological factors during decomposition of Sphagnum moss and vascular plants in peatland habitats.

Research was carried out in 2010-2013 on two different types of peatlands located in the Pojezierze Mazurskie Lakeland. Decomposition study was conducted employing the litter-bag method. Top fragments of Sphagnum fallax stems in nutrient-poor sites, dead leaves of Phalaris arundinacea and Carex acutiformis in nutrient-rich sites, and cellulose filter paper as a standard material were used for decomposition study. Litter-bags were retrieved from the field in spring, summer and autumn in 2011-2012, and in spring and autumn in 2013; total period of decomposition was 1097 days. Following investigations were carried out during the course of this study: (1) assessment of changes of habitat conditions (air temperature, groundwater level,
physical and chemical properties of water and soil) during decomposition, (2) assessment of decomposition dynamics of plant litter (mass loss, decay rate) and standard material (cellulose mass loss), (3) assessment of changes in selected elements concentrations and changes in stoichiometric ratios of C, N, P during decomposition of plant litter, (4) assessment of fungal colonization of plant litter during decomposition (fungal biomass expressed as ergosterol concentrations), (5) assessment of root biomass colonizing plant litter during decomposition and gross assessment of taxonomic diversity of root-colonizing mycorrhizal fungal communities, (6) assessment of taxonomic diversity and potential successional changes of plant litter-colonizing microfungal communities, (7) gross assessment of taxonomic diversity of macrofungi in studied habitats.

Results of this study have shown that the decomposition processes of two types of plant material (Sphagnum moss and vascular plants) in respective peatlands of contrasting nutrient regimes are different not only because of the different chemical composition of native plant material or changing environmental conditions, but also because of fundamental differences in the composition of decomposer communities, including various contribution of mycorrhizal fungi.

Investigated nutrient-poor peatlands were characterized by relatively high diversity of communities of saprotrophic and mycorrhizal fungi, which in turn resulted in very high fungal biomass in decomposing Sphagnum moss, and consequently, potentially high contribution of fungal N and P to the total content of these elements in decomposing plant litter. It was also shown that, most probably due to the colonization of decomposing Sphagnum moss by mycorrhizal fungi, N concentrations decreased and C/N ratios increased during decomposition, and this phenomenon, if common in peatland ecosystems, may lead to inhibition of decay on later stages and increase the potential for peat accumulation. Results of this study have shown that very similar environmental parameters (mainly connected to nutrient availability) are correlated both, with decomposition-related parameters and with fungal colonization-related parameters. Therefore it was assumed that biological factors influencing the decomposition were masked by environmental factors, and taking into account abovementioned results, the role of fungi (saprotrophic and mycorrhizal) in decomposition processes in nutrient-poor peatland ecosystems is extremely important and most probably responsible for the specificity of these processes.
Investigated nutrient-rich peatlands were characterized by species-poor communities of macrofungi, but relatively high diversity and biomass of plant litter-colonizing microscopic fungi. This high biomass in turn resulted in potentially high contribution of fungal N and P to the total content of these elements in decomposing plant litter. Due to the negligible contribution of mycorrhizal fungi, decomposition process progressed according to typical scheme, with ongoing accumulation of N and consequent decrease of C/N ratio with time. This could potentially have negative consequences for accumulation of peat, at least in regard to decomposition of aboveground plant biomass in such specific habitats. Moreover, in contrast to investigated nutrient-poor peatlands, in both nutrient-rich sites diverse and abundant communities of soil invertebrates were observed, which could affect decomposition directly, by fragmenting and mixing plant material. Very similar environmental parameters (mainly connected to nutrient availability) were correlated with decomposition-related parameters, as well as with fungal colonization-related parameters, and this also suggests masking of biological factors controlling decomposition by environmental factors. In conclusion, it was assumed that the role of (saprotrophic) fungi in decomposition processes in nutrient-rich peatlands is also important, but the specificity of these processes results rather from the composition, diversity and activity of the whole decomposer community – bacteria, fungi and soil invertebrates.