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MICROBIOLOGICAL AND ORGANIC CHARACTERISATION OF PEAT

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Activity during the first phase of this SUOSILMU subproject was mainly focused on the development of methods for the fractionation of peat into its organic components and for the determination of microbial biomass. It is now possible to characterise peat using some fifty organic compounds. Using these methods, the effects of drainage intensity and fertilization on the organic character of the peat have been investigated. From the preliminary results, it appears that these methods can be used to determine more exactly the effects of such amelioration practices on the decomposition of peat. During the next phase of the project (1993–1995), the production and decomposition rates of different organic compounds will be determined in long-term incubation experiments.

Keywords: Decomposition, microbiological analysis, organic compounds, peatland

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INTRODUCTION

Because of the harsh climate, acidic nature and high water content of the soil, and lignin-rich litter, the rate of decomposition of plant residues in boreal peatlands is low. Slow decomposition leads to the accumulation of organic matter as peat and immobilization of nutrients. Drainage and fertilization change the activity of microorganisms and the decomposition pathways of organic compounds and so by affect the release of methane and carbon dioxide to the atmosphere.

Decomposing residues from a wide range of plant species release water-soluble chemical compounds into the environment. These substances are complex mixtures of well defined, low-molecular-weight compounds, e.g carbohydrates, amino acids, and phenolic acids (Nykvist 1963, Jalal & Read 1983, Kuiters & Sarink 1986), and of high molecular weight polyelectrolytes of indefinite structure (Vedy & Bruckert 1982). The leaching of humic material and nutrients from drained peatland areas is associated with the production of these water-soluble compounds.

Although peat consists of organic residues, very few studies have dealt with the organic constituents of organic matter in peat (Jörgensen & Richter 1992). In our SUOSILMU subproject (1991–1992), we tested and used new analytical techniques for the organic and microbiological characterisation of peat. Such characterisation will help to describe the carbon and nitrogen cycles in peatlands and the interaction between mires and the atmosphere.

In this paper the organic and microbiological characterisation of peat and methods are briefly outlined. Some preliminary results of applying the methods to study the effect of drainage and fertilization on the organic chemical properties of peat are also presented.

MICROBIOLOGICAL CHARACTERISATION OF PEAT

Determination of microbial carbon

The carbon content of the microbial biomass is determined by a modification of the original fumigation method of Jenkinson and Powlson (1976). This method is based on the release of microbial cell constituents after exposure to chloroform vapor. It has since been developed to estimate the microbial biomass of soils with a high organic matter content (Vance et al. 1987) and recently used on Finnish forest soils (Martikainen & Palojärvi 1990). The technique has also been successfully used to determine the carbon content of the microbial biomass in peat samples.

Amino acid analysis of microbial biomass

A problem in soil microbiology has been lack of a method to separate microbes from soil material. We have a new and very promising method under development to determine the nature of amino acids specific to microbial cell walls. With this new method, about 20 different amino acids can be qualified and quantified after first breaking down the cell walls of the microbes.

Estimation of fungi and bacteria biomasses

The biomass of fungi is to be estimated using a method based on the determination of ergosterol concentration (Zelles et al. 1990). The method to estimate the biomass of bacteria is based on the determination of muramic acid concentration (Zelles et al. 1990).

Available carbon

The activity of microbes is dependent on many factors including the quality of organic matter. Available carbon is defined as that fraction of the soil organic C that heterotrophic microorganisms can readily utilize as an energy and carbon source (Davidson et al. 1987). For available carbon analyses, cold and hot water extractions will be compared.

ORGANIC COMPOUNDS PRESENT IN PEAT

Free amino acids

Free amino acids are an available energy source for soil micro-organisms and a source of available nitrogen for plant growth. Both the qualitative and the quantitative composition of free amino acids vary with the physical, chemical and biological properties of soils. The amino acid com-

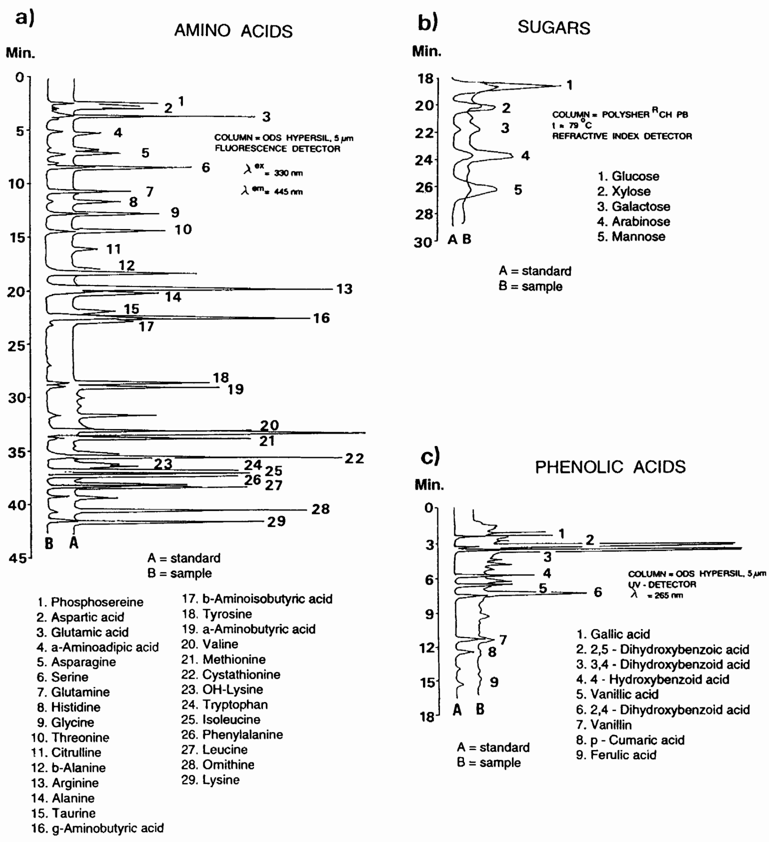

Fig. 1. An example of a chromatogram of a peat sample for: (a) amino acids, (b) sugars and (c) phenolic acids.

position of plant material reflects the nutrient status of soil. After extraction with water, the amino-acid derivatives can be separated on a reversed-phase high performance liquid chromatographic column (Schuster 1988). An example of this kind of results we obtain is presented in Fig. 1a.

Soluble sugars

Micro-organisms provide an input of non-cellulose carbohydrates, particularly glucose, mannose, and galactose, during litter decomposition. Microbially produced carbohydrates are more resistant to decomposition compared to plant-derived polysaccharides. Soluble sugars are measured with cation exchange chromatography (Fig. 1b).

Phenolic compounds

Due to their central role in the humification process, free phenolic acids in soil are assumed to reflect the biochemical status of soil. During the decomposition of plant material, many phenolic compounds are released by microbial breakdown or are synthesized by microbial activity. Phenolic acids are extracted with water and after purification measured with high performance liquid chromatography (Fig. 1c).

The phenol composition of the soil is considered to be largely influenced by the vegetation (Shindo et al. 1978, Whitehead et al. 1982) and the soil environment. Davies (1971) found that the biosynthesis of polyphenols in leaves depended on the nutrient status of the soil — higher polyphenolic contents were associated with soils deficient in N or P.

Cellulose

Cellulose from organic soils is similar to plant cellulose. A method, which enables us to extract cellulose from peat, is to be used to estimate soil biodegradability. Peat cellulose and hemicellulose are hydrolyzed to sugars (Cheshire et al. 1992) which are then quantified using liquid chromatography.

AN APPLICATION AND SOME RESULTS

Some preliminary results of applying the new characterisation methods to study the effects of drainage and fertilization on peat are presented in Fig. 2. The study was initiated at the old Vilppula water table regulation trials regulated since 1964, cf. Huikari and Paarlahti (1967). In this experiment, the effects of four water table regulation levels (10, 30, 50, and 70 cm) in unfertilized and fertilized treatment areas are studied.

While conventional total carbon analyses of the peat (Fig. 2a) showed little difference between water table and fertilization treatments, the or-

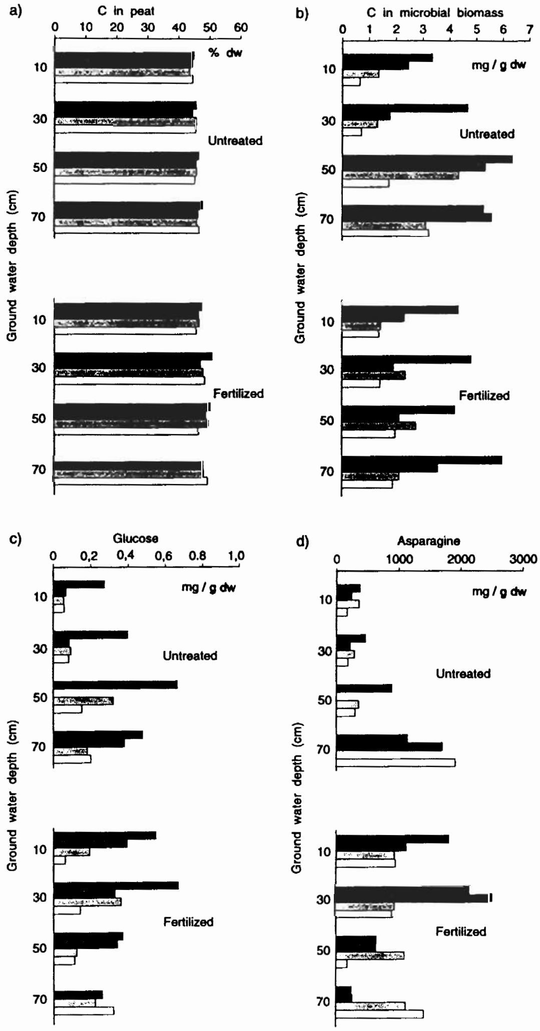

Fig. 2. The effects of drainage and fertilization on: (a) peat total carbon, (b) carbon in microbial biomass, (c) soluble glucose, and (d) water extractable asparagine (a soluble amino acid) at the Vilppula water table regulation experiment. Peat horizons in all figures are 0–5 cm, 5–10 cm, 10–15 cm, and 15–20 cm layers.

ganic and microbiological analyses (Fig. 2b–d) showed very clear differences between treatments. By characterising the peat in such a way it is hoped to obtain a more exact description of the amelioration effects.

During the next phase of the study (1993–1995) the production and decomposition rates of different organic compounds will be determined using long-term incubation experiments. The results will be connected to the other SUOSILMU subprojects to help to build a general model of carbon cycling in peatlands.

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