Scientific Report

Long-term exchange visit at the Bioemco Laboratory (France) for PhD student Annelene Pengerud.

A 5 months exchange visit at the Laboratory for Terrestrial Ecology and Biogeochemistry (Bioemco) in Grignon-Paris (France) was undertaken during the period January-June 2010. Initially, a 6 months stay was planned, and funding to cover costs related to the stay were granted by the Norwegian Research Council (4 months; NFR *grant no* 196330/S30) and the ESF Molter Network (2 months). As the visit lasted one month shorter than initially planned, funding for 1 month will be reimbursed to the ESF/Molter.

As described in the project description submitted with the application for funding, the purpose of the visit was to learn analytical methods for characterizing soil organic matter (SOM) molecular composition, and perform analyses on samples from permafrost-affected soil profiles under the supervision of Dr. Marie-France Dignac at Bioemco. Also, the intention was to write a draft paper in cooperation with the Bioemco group during the stay. This draft was not completed during the stay, but is under preparation and will be submitted and included in the PhD thesis.

Soil samples from 8 different sites/soil profiles in permafrost-affected areas were analysed for lignin, non-cellulosic sugar and lipid contents. The profiles include 2 profiles from each of the areas Neiden in Finnmark (Norway) and Adventdalen at Svalbard (Norway), and 4 profiles from Vorkuta in north-west Russia. The 3 areas differ with respect to several important factors, such as soil type (mineral vs. organic soil), organic carbon pools, pedogenesis and cryoturbation. All profiles have been sampled in active/upper and permafrost/deeper layers. The investigated samples were bulk samples from upper and deeper layers, giving a total of 16 investigated samples. All analyses were performed in triplicates.

The release of CO_2 to the atmosphere from the mineralization of soil organic matter (SOM) in thawing permafrost is one of the largest potential feedback mechanisms on the climate system. This positive feedback, i.e. it will aggravate climate changes, is due to the fact that SOM decomposes faster at higher temperatures. The key question is how much faster. Recent research suggests that it might not decompose at the same speed as non-frozen soils because of contrasting molecular composition. A characterization of the soil organic matter at a molecular level (*here;* analysis of lignin, non-cellulosic sugar and lipid molecules) could be an important tool in predicting the potential mineralization of the carbon stored in these soils with increasing temperatures. Determination of lignin contents and alteration degree and non-cellulosic sugar contents gives a direct picture of the behavior in the cryosols samples of molecular structure reputed recalcitrant (lignin) vs. labile (sugars). Detailed information on lipid contents is an important tool to determine the sources of organic matter in soils. Although the solvent extractable lipids usually comprise less than 10% of SOM, they are indicative of the source vegetation because they contain characteristic molecular markers (biomarkers) that provide information about the nature and origin of the SOM (Otto and Simpson, 2005).

Lignin monomers were analysed by the CuO oxidation method (Kögel and Bochter, 1985), as implemented by Dignac et al. (2005). Sugar monomers were released by acid hydrolysis and transformed into acetate alditols before their gas chromatographic separation as described by Rumpel and Dignac (2006), modified slightly adding EDTA instead of ammonia to avoid interference by Fe, as described by Eder et al. (2010). For identification of lipids in the soil samples, all soils (2 g for organic and 10 g for mineral soils) were extracted with 50 mL DCM:MeOH (1:2). Soils and extractant were put in ultrasound for 20 min to disrupt aggregates and shaken for 4 h using an end-over-end shaker. The soil residue and the total solvent extracts were separated by centrifugation at 2200 rpm for 10 min. The extracted lipids were dried in a SpeedVac, and redissolved in 4 ml DCM. All extracts from organic soils were filtered through glass fiber filters (Whatman GF/A) before drying in the SpeedVac. 0.5 mL of the re-dissolved lipids was methylated for identification on a GC/MS.

The results from the molecular analyses indicate slightly more degraded OM in perma/deeper layers compared to active layers. Lignin concentrations are generally slightly higher in perma/deeper layers compared to active layers, whereas concentrations of non-cellulosic sugars are equal to or slightly lower in perma/deeper layers, except for one of the organic profiles (Neiden 2) where the deeper layer is not frozen. The ratio VSC-C/non-cellulosic sugar-C generally increases with depth, indicating more degraded OM in perma/deeper layers (Fig. 1).

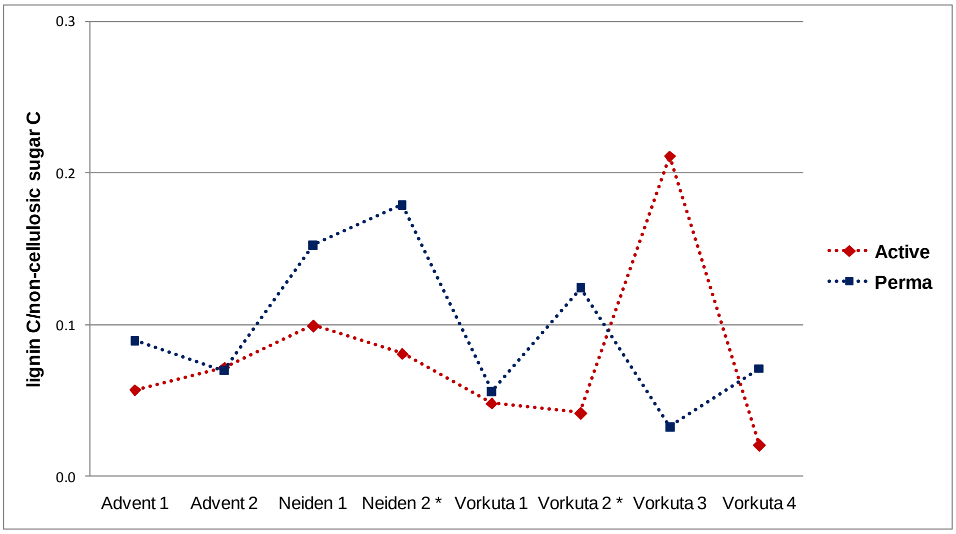

Fig. 1: Ratio of lignin C to non-cellulosic sugar C in the 8 investigated profiles. This ratio generally increases with biodegradation of the SOM.

The (Ac/Al)v ratios are lower in the perma/deeper layer compared to active layer for organic soils, indicating less degraded lignins. This could be explained by the conservation of lignin under anaerobic conditions as is expected in the deeper layers of organic soils. In all active layers except Vorkuta 3, sugars are mostly microbial (C6/C5 ~ 2). There is little variation with depth and between sites. Only for Neiden 1, Vorkuta 2 and 4 the sugar quality changes with depth (Fig. 2). The increase in plant-derived sugars with depth (decrease in C6/C5 ratio) in Neiden 1, Vorkuta 2 and Vorkuta 4 might be related to the increase in lignin, i.e. preservation of ligno-cellulosic material.

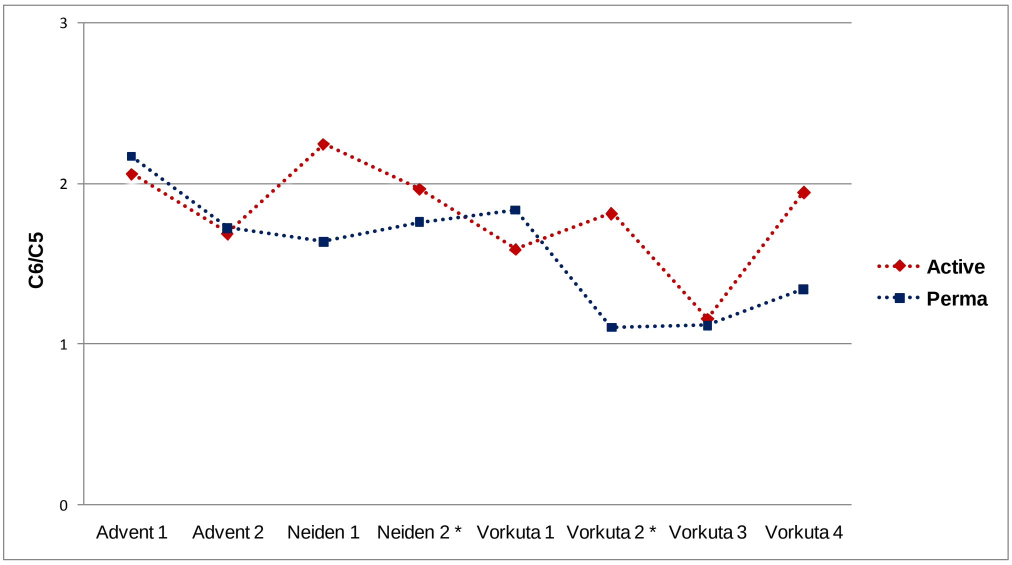

Fig. 2. Ratio of hexose to pentose monosaccharides in the 8 investigated profiles.

The results obtained during the stay will be investigated further and analysed in more detail. It is hoped to have a manuscript prepared for submission by the end of 2010. The preparation of this manuscript will be done in cooperation with Dr. Marie-France Dignac at Bioemco. The funding received from both the NFR and the ESF/Molter which made this exchange visit possible is highly acknowledged.

References

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