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FACTORS CONTROLLING GREEN HOUSE GAS TURNOVER IN NORWEGIAN CULTIVATED PEAT LAND SOILS

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SUMMARY

The aim of this PhD study is to study factors controlling Greenhouse Gas (GHG) emissions from cultivated peat lands in Norway. To this end, selected aspects of C and N cycling will be studied in a range of soils representing different climatic zones and drainage/degradation regimes, with the ultimate aim of arriving at better predictions for GHG responses to changing management practices, including those of abandonment and rewetting. To accomplish this, our research will examine carbon and nitrogen mineralisation rates and GHG production potentials and correlate these with various indices of carbon and nitrogen quality.

KEYWORDS: Peat quality; Greenhouse gas emissions

INTRODUCTION

Peatlands cover only 2-3% of the world's land area, but store approximately a third of the world's organic carbon (Joosten and Clarke 2002). This makes peatlands both an important store and a potentially significant source for atmospheric carbon. Peatlands are formed over millennial timescales by the slow deposition of partially decomposed biomass. Carbon accretion rates in undisturbed boreal ombrotrophic sphagnum peatlands are in the range of 29-83 g m^{-2} yr^{-1} (Gorham 1991, Thormann et al. 1999) and depend on temperature, hydrology and site productivity (Laiho 2006). Once deposited, the Soil Organic Matter (SOM) is protected from complete decomposition by the interaction of additional, only partially understood, chemical and biological factors (e.g. "*enzymic latch*" (Freeman et al. 2001)) that contribute to the stabilization of organic matter.

In order to cultivate peatlands, it is necessary to lower the water table by drainage and to increase the pH by liming. In addition, cultivation requires nutrient additions and the sowing of economically interesting plant species. Together, this leads to changes in hydrology, pH and nutrient status of the soil and removes the protection afforded to the stored organic matter. As a result, greatly accelerated mineralization rates of soil organic carbon and nitrogen reported (Maljanen et al. 2010).

This has significant implications for the GHG balance of peatlands changing them from a long term sink to a significant source of CO_2. Increased N cycling (by increasing SOM mineralization or adding extraneous N) may lead to high N_2O emissions. N_2O emissions, in turn, may be offset by a reduction in CH_4 emissions (Kasimir-Klemedtsson et al. 1997, Maljanen et al. 2010) or by changing the soils to a sink for atmospheric CH_4.

While there is increasingly discussion regarding the importance of mitigation strategies for the protection of carbon in organic soils (Grønlund et al. 2008, Smith 2008), little is known about the direct physical, chemical and biological factors controlling GHG turnover in drained peat soils and their dependency on long term cultivation. This PhD project addresses this knowledge gap by studying GHG turnover in a broad range of degradation states encountered in Norwegian cultivated land where organic soils cover 7-10% of the total cultivated area (Grønlund et al. 2008).

The study will consist of 3 main components,

1. Examination of intrinsic soil organic matter quality as a function of peat type and cultivation age.
2. Examination of C and N mineralization as well as CH_4, CO_2 and N_2O production potentials.
3. Field gas fluxes in an abandonment gradient.

These components will be used to test the hypotheses that cultivation significantly impacts soil organic matter quality with consequences for mineralisation rates of carbon and nitrogen and associated GHG turnover.

MATERIALS AND METHODS

Sampling strategy

The study will be carried out on soil samples obtained during campaigns in 2011 and 2012. Sampling sites will be chosen as to provide relatively undisturbed peat soils alongside cultivated peat. The rationale behind this is that the common origin of adjacent undisturbed and disturbed sites should allow for assessing cultivation effects statistically in paired samples. Sites will be chosen to represent a spectrum of peatland types, climatic zones and cultivation histories.

Examination of soil properties

Intrinsic properties of the sampled soil will be studied in order to identify the key parameters that explain variability in GHG production potentials and mineralisation rates between sites and within pairs. To accomplish this we intend to use a range of techniques to examine first the structure of the soil followed by a more detailed assessment of the quality of the soil organic matter.

Alongside basic measures of bulk density, pH and total C and N, biologically important microelements will be measured by atomic absorption. Basic fractionation techniques (cold water, hot water and acid hydrolysis) will be used initially to examine the relative quality of carbon between the sample sites and pairs (Ghani et al. 2003, Silveira et al. 2008). This should enable us to draw simple conclusions regarding the relative concentrations of bioavailable and recalcitrant forms of organic matter.

Samples will be further analysed using Mid Infra-Red (MIR) utilizing diamond attenuated total reflectance (DATR) spectroscopy on a Nicolet iS10 FT-IR Spectrometer (Thermo Fisher Scientific Inc., Madison, WI, USA) combined with multivariate statistics in order to analyse the spectra against indices of carbon quality.

Carbon mineralization rates

Mineralisation will be explored through multiple approaches both in long term and short term incubations. Long term mineralisation potentials will be measured using soda lime traps (Keith and Wong 2006); for short term assays, an automated incubator with headspace GC analysis will be used (Molstad et al. 2007). C mineralization will be measured as CO_2, CH_4, and fermentation products.

Nitrogen cycling

Rates and stoichiometry of N mineralization, nitrification and denitrification will be linked to pertinent soil variables such as carbon quality, C:N ratios and cultivation history. It is expected that soils with a high C:N ratio will produce less N_2O due to the constraint on available nitrogen. Denitrification requires the presence of labile carbon and should therefore be impacted by the carbon quality. Most of this work will be done by incubation techniques (Molstad et al. 2007).

Isotopic signature profile

Delta ^{13}C signatures in CO_2 and CH_4 will be measured by Isotope-ratio mass spectrometry (IRMS) and/or Tunable Diode Laser (TDL) to explore its use as a measure for peat decomposition

SUMMARY

This work will be undertaken in 2012 and 2013 and will contribute to our understanding of GHG turnover in peats and cultivated peat soils. The project will aim to examine the relationship between carbon and nitrogen quality where quality refers to the rate at which SOM is mineralized. Environmental factors such as pH, oxic status and presence of other electron acceptors will be compared with the recalcitrance of SOM in an attempt to find valuable proxies for peat quality and GHG emission potential. It is considered that SOM recalcitrance is influenced by ecosystem properties (Schmidt et al. 2011) and therefore that environmental change and management can impact the rates of mineralisation, with implications for the global warming potential of disturbed peat soils. Ultimately, the results from this study might be of benefit to projects which consider the restoration of disturbed peat soils to mitigate GHG emissions.

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