Extended abstract No. 71

MITIGATION OF NITROUS OXIDE EMISSIONS FROM PEAT SOILS USED FOR FORESTRY OR AGRICULTURE BY CONTROLLING THE BIOGEOCHEMICAL PROCESSES

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SUMMARY

When natural peat soils are drained, emissions of nitrous oxide (N_2O), a strong greenhouse gas, may increase considerably. Estimation of N_2O emissions is challenging due to high variation in emissions and because many factors affect processes producing and consuming nitrogen and further to N_2O emissions. The aim of this work is to find explanations for the high spatial and temporal variation in N_2O emissions from peat soils under different land use. Biogeochemical processes in nine different study sites in Finland, Sweden and Iceland were studied with different techniques in the laboratory.

KEYWORDS: nitrous oxide, boreal, peat, agricultural, forested

INTRODUCTION

Natural peat soils are minor sources for nitrous oxide (N_2O) but after drainage of nutrient rich peat soils for agriculture or forestry N_2O emissions may increase substantially (Martikainen *et al.* 1993). Approximately one third of the land area of Finland is categorized as peatlands and from that over half are drained for forestry and nearly 1% for agriculture (Turunen 2008). Therefore, the N_2O emissions from drained peat soils have a great significance in Finland. The factors affecting N_2O production are complex causing high variation in the N_2O emissions (Martikainen *et al*. 1993; Groffman *et al.* 2000). Over 80% of the annual N_2O emissions may take place during winter (Maljanen *et al.* 2010a).

The C to N ratio of soil is suggested to be one of the key parameters to explain the variation in N_2O fluxes (Klemedtsson *et al.* 2005, Maljanen *et al.* 2010b). In the study of Maljanen *et al.* (2010b) the highest N_2O fluxes were found in soils where C to N ratio was in the range from 15 to 20. However, the variation in the N_2O fluxes within this C to N ratio was high. We studied what factors in addition to the C to N ratio could explain the high spatial and temporal variation in N_2O emissions from drained peat soils. We studied drained peatlands with C to N from 15 to 25 owing different land-use practices. It is important to find proper land-use options to minimize the N_2O emissions from peat soils.

MATERIALS AND METHODS

Laboratory experiments were carried out with peat soil samples taken from 9 different sites having different land-use. For 6 of the sites the annual N_2O emissions were already known. These sites include two afforested agricultural sites in Western Finland, a hay field and a drained field in Iceland and a peatland forest in Sweden. In addition, three peatland forest sites with different nitrogen availability were selected from Western Finland. In these sites the N_2O emissions are measured 1 to 3 times per month during the study period from May 2010 to September 2012. Laboratory experiments were done also for these soils. Production rates for N_2O and carbon dioxide (CO_2) were studied in the laboratory experiments. The contribution of denitrification and nitrification to the N_2O production were studied using acetylene (C_2H_2) inhibition technique. Substrate induced respiration (SIR) was used to estimate microbial biomass in soils. Microbial community structure was studied with phospholipid fatty acids technique (PLFA). Gross and net nitrogen mineralization and nitrification was studied with ^{15}N isotope techniques. In addition, soil physical and chemical characteristics were determined inclusively from different depths of peat profiles.

RESULTS AND DISCUSSION

The study sites represent four different land uses for peat soils: peat forest, cultivated peat soils, drained peat soils and afforested peat soils which have been under cultivation before. Collected soils samples represent almost all stages of decomposition in von Post scale starting from almost undecomposed to almost completely decomposed. Processing of the data is ongoing and only preliminary data is available.

In laboratory incubation experiments there was a high variation in emitted N_2O between study sites which cannot be explained by different land use. The microbial biomass determined with SIR technique were nearly similar for all other sites except for one cultivated Finnish peat soil which had the highest microbial biomass after scaling the results according to bulk density. The pH range of the studied sites is between 3 and 5 and organic matter content (OM%) from 40% to over 90%. The C to N ratio is between 15 and 25. However, pH, OM% or C to N ratio did not explain the variation in N_2O emissions. The ^{15}N labelling experiment and PLFA studies are expected to explain more the variation in N_2O emissions. However, analyzing of the samples of the ^{15}N labelling and PLFA experiments are in progress and will be completed during spring 2012.

ACKNOWLEDGEMENTS

This study is part of research project of MYRKLIMA (Mitigation of climate change impacts of cultivated peat soils). The research is funded by Ministry of Agriculture and Forestry in Finland.

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