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GREENHOUSE GAS EMISSIONS FROM TWO REWETTED PEATLANDS IN SWEDEN

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SUMMARY

Two rewetted, former cut-over peatlands were investigated for their greenhouse gas (GHG) emissions. The closed-chamber method was used. In the nutrient-rich Västkärr fen, CO_2-fluxes decreased along the moisture gradient from vegetated soil towards open water. CH_4 emissions varied with seasons: highest in June 2009 and in the open water with a decreasing trend towards the vegetated soil. N_2O emissions were observed occasionally: highest in October 2008 and in the driest parts of the lake littoral zone with a decreasing trend towards the open water.
In the nutrient-poor Porla wetland CO_2- and CH_4-fluxes followed a seasonal cycle at all sites, from low fluxes in spring over high emissions in summer to low outputs in autumn. The bare peat emitted no CH_4 whereas the wet *Eriophorum vaginatum* tussocks released the highest amounts during summer.

KEY WORDS: CO_2, CH_4, N_2O, reclamation, transects

INTRODUCTION

The reclamation of peatlands after peat harvesting is a worldwide issue with focus on both regional and local levels. Since peat extraction causes considerable changes in site conditions, restoration to its original state will be impossible. An after-use-management could instead focus on restoring the wet status in the peatland. This would provide new conditions for peat producing plant growth, biogeochemistry and biodiversity.
The GHG balance of a peatland depends on climate and various local site parameters, like mean annual ground water table (Couwenberg et al. 2011), vegetation cover (Mahmood & Strack 2011) and nutrient condition (von Arnold et al. 2005, Glatzel et al. 2008).
Wetland restoration by rewetting changes the CO_2 emissions that are supposed to decrease while CH_4 emissions may increase (Alm et al. 2007). Nutrient poor wetlands could turn to sinks but nutrient rich ones could still be emitters.

The aim of this study is to investigate how different site conditions (vegetation cover and soil-water conditions) affect GHG emissions in rewetted, former cut-over peatlands in the south-western part of central Sweden.

MATERIALS AND METHODS

Study sites

The GHG measurement study was carried out in two different peatlands. In the nutrient-poor Porla wetland, the *Sphagnum* and fen peat have been excavated down to the bottom of the peat material, i.e. to the till mineral soil surface. The cut-over area was prepared for rewetting in 1999.The nutrient-rich Västkärr fen, which originally formed a lagg area to the Skagerhult bog, was earlier used for agriculture and peat cutting. In 1999, the rewetting started. A detailed description of the two wetlands regarding hydrology, biology and chemistry is given by Lundin & Lode (2004).

In Porla, 6 different sites, each with 8 GHG measuring points, were investigated (12 occasions between 2007 and 2010): a natural *Sphagnum* mire (subdivided into low depressions and hummocks); a drained bare peat area; dry *Eriophorum vaginatum* tussocks within the drained bare peat area; a wet *E. angustifolium* area with soil surface water level; wet *E. vaginatum* tussocks and open water from a permanently inundated area.

In Västkärr, GHG emissions were measured along 3 transects (each with 8 measuring points) in the lake littoral zone from vegetated soil towards open water (5 occasions between October 2008 and October 2009). Due to strong surface water table fluctuations the transects experienced periods with large water and moisture content variation.

Methods

Permanent round collars were installed in the peat and CO_2, CH_4 and N_2O were sampled after closure of dark cuvettes (cf. Forbrich et al. 2010). Field determinations of CO_2 were carried out by an infra-red gas analyser (GMP 343 with M170, Vaisala, Finland). Each chamber was sampled for 5 min with an interval of 30 sec. For CH_4 and N_2O determinations, five 20 ml gas samples per collar were collected from the chamber headspace in septum bottles at 10, 20, 30, 40 and 50 min after chamber closure. The gas samples were then brought to the laboratory for Gas Chromatography analyses (Perkin Elmer, Clarus 500).

On each GHG measurement point soil temperature at 10 cm depth was measured. In the non-inundated areas, soil moisture was detected with a Thetaprobe (Type ML1, Delta-T Devices Ltd, Cambridge, UK). In the inundated areas, depth of surface water was measured.

RESULTS AND DISCUSSION

GHG fluxes from the nutrient-poor wetland

In Porla CO_2- and CH_4-fluxes followed a seasonal cycle at all sites, from low fluxes in spring over high emissions in summer to low output in autumn. Vegetation and peat type were the crucial factors for GHG emissions. The drained bare peat, the open water and the natural *Sphagnum* mire showed lowest emissions for both CH_4 and CO_2, whereas the bare peat emitted no CH_4. Emissions from dry *Eriophorum vaginatum* tussocks, the wet *E. angustifolium* area with soil surface water level and the wet *E. vaginatum* tussocks were remarkable higher and were highest for CH_4 within the wet *E. vaginatum* tussocks (15.8 g m^{-2} d^{-1} CO_2-C-equivalent) and for CO_2 within dry *E. vaginatum* tussocks (9.6 g m^{-2} d^{-1} CO_2-C-equivalent). Since Porla is a nutrient-poor peatland no N_2O emissions were observed.

GHG fluxes from the nutrient-rich fen

In Västkärr fen, CO_2-fluxes decreased along the moisture gradient from vegetated soil towards the open water (from 2.7 g m^{-2} d^{-1} CO_2-C-equivalent to 0 g m^{-2} d^{-1} CO_2-C-equivalent in October 2008 and from 5.1 g m^{-2} d^{-1} CO_2-C-equivalent to 1.4 g m^{-2} d^{-1} CO_2-C-equivalent in June 2009). This pattern is obtained due to a high plant cover leading to higher autotrophic respiration.

Methane emissions varied by season, with a strong relation to water table conditions. During stable water table conditions, as in October 2008, the peak of CH_4 emission (3.8 g m^{-2} d^{-1} CO_2-C-equivalent) occurred in the semi-dry vegetated part of the transects. In June 2009, when the water table was low, the largest CH_4 emissions (2.7 g m^{-2} d^{-1} CO_2-C-equivalent) were measured in the open water with a decreasing trend towards the vegetated soil (0.1 g m^{-2} d^{-1} CO_2-C-equivalent). One month later, in July 2009, the shore of the lake littoral zone was inundated and CH_4 emissions were observed from the vegetated land (1.7 g m^{-2} d^{-1} CO_2-C-equivalent). No trend was observed in April 2009 because soil and water temperatures were low and the vegetation barely started growing.

N_2O emissions were observed occasionally. In October 2008, the highest N_2O emissions (0.9 g m^{-2} d^{-1} CO_2-C-equivalent) were observed in the driest parts and decreased along the gradient toward the open water (0.1 g m^{-2} d^{-1} CO_2-C-equivalent).

CONCLUSION

This GHG gas study shows that the emissions of CO_2, CH_4 and N_2O from open water in Västkärr were very low and are in the same order as those from the natural *Sphagnum* mire in Porla. The CH_4 emissions from the vegetated sites and from the shore of the lake littoral zone are much larger than from the natural *Sphagnum* mire, though. This could imply higher emissions of CH_4 from the total area when the riparian zone of the total rewetted area will expand.
Another conclusion is that vegetation can partly be a prerequisite for high CH_4 emissions because they act as efficient gas transporters. *Eriophorum vaginatum* tussocks emitted

substantially more CH_4 than the bare peat adjacent to the tussocks, despite similar conditions in temperature and moisture level.

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