Extended abstract No. 41

EVALUATION OF MEASURES FOR THE MITIGATIONOF GREENHOUSE GAS RELEASE FROM PEATLANDS IN THE GERMAN BALTIC REGION

Stephan Glatzel, University of Rostock, Faculty of Agricultural and Environmental Sciences, Landscape Ecology and Site Evaluation, Justus von Liebig- Weg 6, 18059 Rostock, Germany, Tel. 0049-381-4983220, email: stephan.glatzel@uni-rostock.de
Franziska Koebsch, University of Rostock, Faculty of Agricultural and Environmental Sciences, Landscape Ecology and Site Evaluation
Juliane Hahn, University of Rostock, Faculty of Agricultural and Environmental Sciences, Landscape Ecology and Site Evaluation
Sascha Beetz, University of Rostock, Faculty of Agricultural and Environmental Sciences, Landscape Ecology and Site Evaluation
Gerald Jurasinski, University of Rostock, Faculty of Agricultural and Environmental Sciences, Landscape Ecology and Site Evaluation

SUMMARY

In the NE German state of Mecklenburg-Vorpommern, various measures as withholding fertilization on agricultural peatlands, raising the groundwater table and flooding are taken to reduce greenhouse gas emissions on a variety of peatland types. Additionally, flooding the area between dikes has been suggested to contribute to greenhouse gas (GHG) mitigation. We present data from projects where we monitored the GHG exchange of peatlands that have been subject to the mentioned measures. We employ laboratory, closed chamber and eddy covariance techniques. Results show that flooding with fresh water leads to a temporary, plant specific, strong increase of methane (CH_4) release of ca. 1 t ha^{-1} yr^{-1}. To the contrary, flooding with brackish water reduces CH_4 release from coastal peatlands.

KEYWORDS: Greenhouse gas mitigation, peatland restoration, methane release, coastal peatland, rewetting

INTRODUCTION

The NE German federal state Mecklenburg-Western Pomerania (MV) has a peatland area of 290.000 ha (Zak *et al.*, 2008) of which 171.000 ha are agricultural land. Thus, more than 60% of peatlands in MV are drained (Ministerium für Landwirtschaft, Umwelt und Verbraucherschutz, 2009), making carbon dioxide (CO_2) from these ecosystems a major greenhouse gas (ghg) source in MV (Jensen *et al.*, 2010). In order to decrease the greenhouse gas (GHG) release from peatlands, the state government of MV is rewetting 40.000 ha of drained peatlands (Ministerium für Landwirtschaft, Umwelt und Verbraucherschutz 2009). In this contribution, we report on projects from our group on mitigation options of GHG release from peatlands in MV. These options include lowering land use intensity of intensively managed meadows on shallow Histosols, rewetting coastal brackish fens by closing drainage ditches as well as supporting the intrusion of Baltic Sea water by discontinuing dike support.

Closing ditches is a common method of rewetting. Although it may lead to increased CH_4 release, the mitigation of CO_2 release and lower nitrous oxide (N_2O) emission rates may lead to a lower total GHG release, commonly expressed as global warming potential (GWP). Mean CH_4-C release and CO_2-C storage rates from close to natural fens are 24 g and 46 g CO_2-C m^{-2} yr^{-1} (Höper, 2007). However the large CO_2-C release rates from drained fens, averaging 460 g yr^{-1} (Höper, 2007) underline the positive effect of a high water table on GWP.

However, there is no universal and reliable information on CH_4 release as a consequence of rewetting or flooding of previously drained peatlands. Under unfavourable flooding conditions, extremely high CH_4 emissions of up to 3.7 t C ha^{-1} yr^{-1} have been reported by Augustin & Chojnicki (2008). As the intrusion of Baltic Sea water causes increased sulfate concentrations in peat pore water, methanogenesis will be supressed competitively (Lovley & Klug 1983). Several studies have shown that addition of salt water inhibits methane (CH_4) release (Blodau and Moore, 2003, Gauci *et al.* 2002, Dise and Verry, 2001). On the other hand, these results were not supported by some other sudies; for example, Weston *et al.* (2010) noticed increased CH_4 release following addition of artificial sea water.

Here, we report about following examinations on the success of measures to mitigate methane and nitrous oxide release from coastal fens in MV: a) Laboratory examinations on possible consequences of rewetting of a coastal fen with salt water and b) flooding of a coastal fen with sweet water.

MATERIALS AND METHODS

Experimental sites

Detailled information on the examination sites is given in Glatzel *et al.*, (2011). Briefly, the examined coastal fen (termed "Rodewiese" hereafter) is located in the NE of the city of Rostock, in the nature reserve "Heiligensee and Hütelmoor" (54°12' N, 12°10' E). The fen successively experienced drainage, peat extraction, and agricultural use starting in 1770 until 1990, when the drainage ditch was closed. In 2009, the drainage was further impeded, creating continuous flooding with a water table of 10 to 80 cm above ground throughout the year. Summertime evapotranspiration and wintertime water recharge leads to seasonal fluctuation in groundwater salinity. Episodically, most recently in 1995, and probably more often in the future, Baltic Sea water intrudes the fen. As coastal protection authorities have given up management of the dune dike the brackish fen will soon be fed by brackish water. Peat depth is 1 to 3 m, of which the uppermost 1 to 5 dm are strongly degraded (H10 on the von Post scale) and the deeper peat is moderately degraded (H5 to H8 on the von Post scale). C/N ratio of the peat is 16 to 32 and pH in the shallow peat is 6.8 and 4.6 to 7.6 in deeper layers. Vegetation is dominated by *Bolboschoenus maritimus* (L). Palla, *Schoenoplectus tabernaemontani* (C.C.Gmel.) Palla, *Phragmites australis* (Cav.) Trin. ex Steud. and *Carex acutiformis* (Ehrh.) In dry regions close to the mineral soils, *Lolium perenne* L. still prevails.

Field and laboratory methods

Detailed information on the laboratory and field examinations examination sites is given in Glatzel *et al.*, (2011).

In May 2008, we sampled plant litter from two transsects from the top 10 cm of peat from the Rodewiese from stands of *Bolboschoenus maritimus*, *Schoenoplectus tabernaemontani*, *Glyceria fluitans* (L.) R. Br., *Carex riparia* Curtis und *Phragmites australis*. 10 g of plant litter were incubated at room temperature in open 250 mL flasks in Baltic Sea and fresh water for 36 days until CH_4 production leveled off. For determination of CH_4 production rates, the flasks were closed for 1 min and the concentration of CH_4 was determined following before and after 1 min of sealing the flask with a Perkin Elmer Autosystem XL gas chromatograph.

In situ gas flux determinations were carried out with closed chambers following Drösler (2005). Air inside the chambers was sampled 0, 7, 14 and 21 min following closure. Gas samples were analyzed with a Perkin Elmer Autosystem XL gas chromatograph. All gas flux calculations were carried out using an R package by Jurasinski and Koebsch (2011). Gas flux determinations took place on the Rodewiese from October 2008 to September 2009 and from October 2009 to September 2010 biweekly. In 2008/2009 following vegetation types were examined: *Carex acutiformis*, *Bolboschoenus maritimus*, *Schoenoplectus tabernaemontani*. In 2009/2010, we had to move to alternative plots, discontinuing measurements on the *Schoenoplectus tabernaemontani* plot and establishing measurements on *Phragmites australis* plots.

RESULTS

Potential CH_4 release rates of incubated litter were between -80 und 340 µg CH_4 g^{-1} (Fig. 1). Litter of *Schoenoplectus*, *Carex* und *Bolboschoenus* from the southern transect produced more CH_4 than litter from the northern transect. *Phragmites* litter from the northern transect realeased more CH_4. The mean CH_4 procduction potential from *Bolboschoenus*, *Lolium perenne*, *Phragmites* und *Schoenoplectus* was higher than the one from *Carex*. Addition of Baltic Sea water lowered potential CH_4 release from all vegetation types (Fig. 2), although the strength of this effect was vegetation specific.

Mean CH_4 emissions from all vegetation types in 2008/2009 were low (7.9 kg CH_4-C ha^{-1} yr^{-1}). Blocking of the drainage ditch increased the water table considerably (mean groundwater table 38 cm above ground). This led to an increase in CH_4 release to 976.5 kg CH_4-C ha^{-1} yr^{-1} in 2009/2010 (Fig. 2).

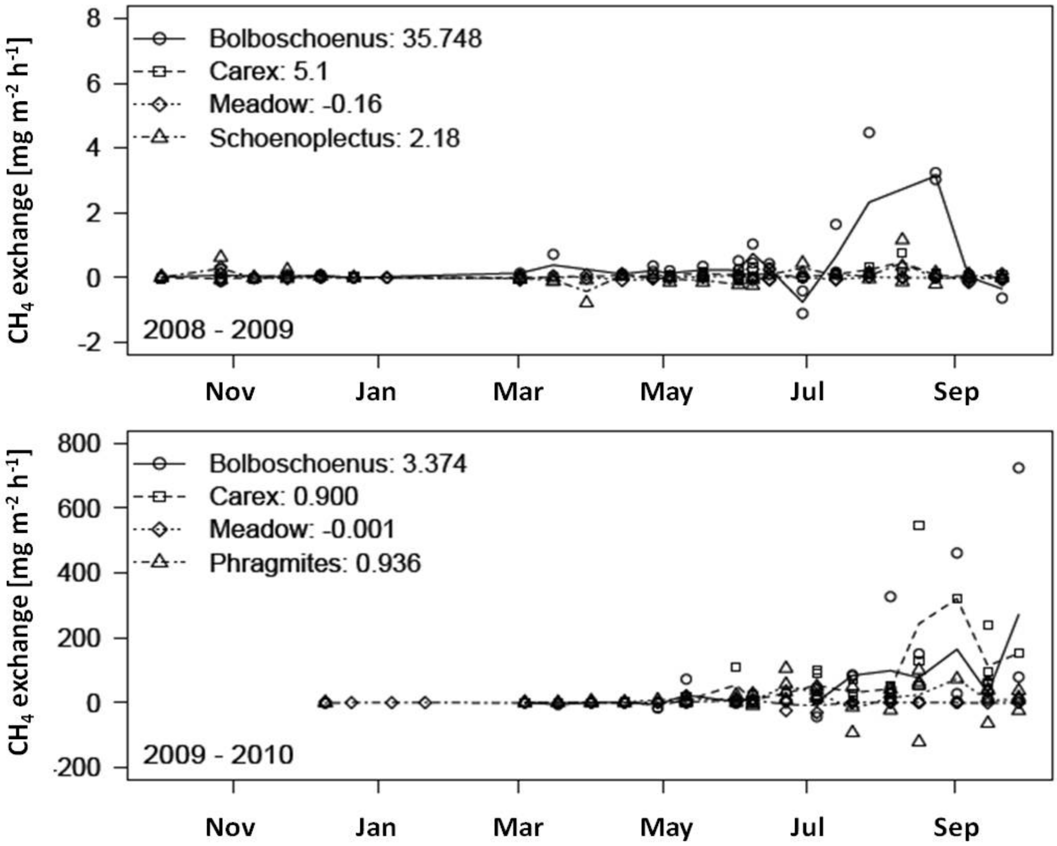

Fig. 1. Methane emissions from litter incubated in the laboratory. Samples are from two different locations and two treatments (peat pore water: black symbols vs. Baltic sea water: grey symbols). Large dots represent the median of 5 replicates of each category (X-axis). White dots represent mean values. The fat bars illustrate the limits given by the first (bottom) and third (top) quartiles. Thin bars indicate extreme values of the distribution. Outliers are shown by small crosses. Stars at the top of the graph represent the significance of the difference between added peat pore water and Baltic sea water (*** $p < 0.001$, ** $p < 0.01$, * $p < 0.05$). Adapted from *Glatzel et al.* (2011).

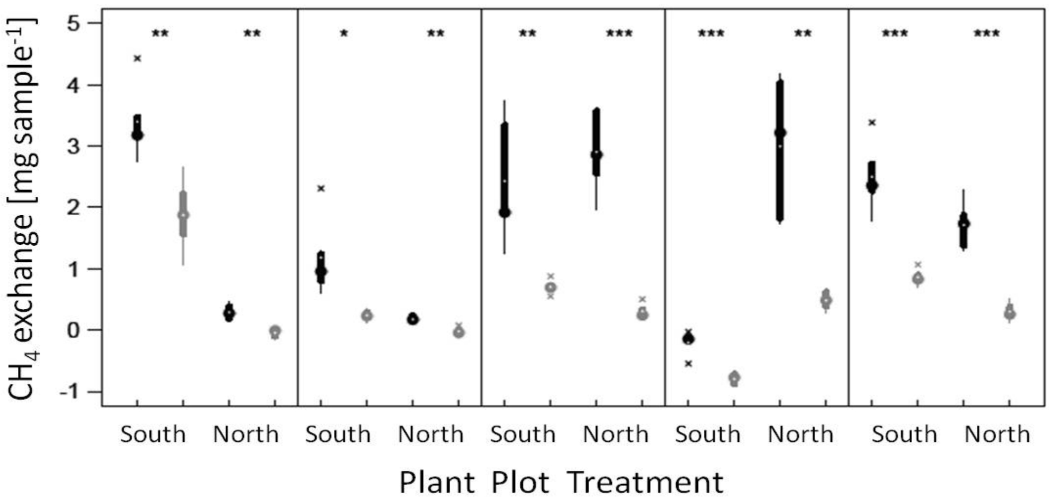

Fig. 2. Annual course of methane release in the Hütelmoor investigation area. Every single CH_4 flux value is illustrated with a symbol. Different symbols explain different vegetation types (cf. legend). Lines connect mean emissions per vegetation type. Top: Measurement period Oct.2008 – Sept.2009. Bottom: Measurement period Dec.2009 – Sept.2010. Total emission sums are given in kg $ha^{-1}yr^{-1}$ for each vegetation type. Adapted from *Glatzel et al.* (2011).

DISCUSSION

The incubation experiment shows that flooding with Baltic Sea water would strongly decrease methane release from the peatland regardless of the vegetation cover. The low CH_4 fluxes in the Rodewiese in 2008/2009 are probably due brackish water influx in Dec. 2008. Moderate rewetting with sulfate loaded brackish water in 2008/2009 impedes methane release from the humified and relatively recalcitrant peat. Closure of the ditch in 2009 led to the senescence of many plants; especially *Carex*. This supplied a lot of labile substrate, which was a methane source in very high CH_4 release. This is consistent with the hypothesis on the positive relation between methane release and water table (e.g. Hargreaves and Fowler, 1998, Macdonald *et al.*, 1998), but most studies are based on short-term experiments or space for time substitutions. Our observations point to a changing system from a sulfate limited, moderately dry peatland to a highly productive shallow lake, which has (at least temporarily) ideal conditions for high methane efflux.

Our investigations underline the significance of vegetation for CH_4 release. In both years, *Bolboschoenus* plots released the highest amount of methane. It is well known that this plant possesses an extensive aerenchymatic tissue (Rozema *et al.*, 1991). Convective gas transport pathways could not be identified by Brix *et al.* (1992). Boschker *et al.* (1999) observed intensive root exudation by *B. maritimus*, which can be a precursor of rhizospheric CH_4. Especially in a substrate limited environment, where sulfate reducers compete with methanogens, a close relationship between plant and soil organisms could be decisive for high methane efflux. This notion is also confirmed by the laboratory incubations, where brackish water lowered the CH_4 release potential from 300 to 200 mg g^{-1}. To the contrary, in areas with dominant *Carex* cover high CH_4 fluxes were restricted to 2010, caused by dying *Carex*.

REFERENCES

Augustin, J. and Chojnicki, B. (2008): Austausch von klimarelevanten Spurengasen, Klimawirkung und Kohlenstoffdynamik in den ersten Jahren nach der Wiedervernässung von degradiertem Niedermoorgrünland. In: Gelbrecht, J., Zak, D. and Augustin, J.: *Phosphor- und Kohlenstoffdynamik und Vegetationsentwicklung in wiedervernäßten Mooren des Peenetals in Mecklenburg-Vorpommern.* pp. 50-67. Berichte des IGB. Heft **26**. Berlin.

Blodau, C. and Moore, T. (2003): Microscale CO_2 and CH_4 dynamics in a peat soil during a water fluctuation and sulfate pulse. *Soil Biol. Biochem.* **35**, 535–547.

Boschker, H., de Brouwer, J. and Cappenberg, T. (1999): The contribution of macrophyte-derived organic matter to microbial biomass in salt-marsh sediments: Stable carbon isotope analysis of microbial biomarkers. *Limnol. Oceanogr.* **44**, 309–319.

Brix H., Sorrel B. K. and Orr, P. T. (1992): Internal pressurization and convective gas flow in some emergent freshwater macrophytes. *Limnol. Oceanogr.* **37**, 1420–1433.

Dise, N. and Verry, E. (2001): Suppression of peatland methane emission by cumulative sulfate deposition in simulated acid rain. *Biogeochemistry* **53**, 143–160.

Drösler, M. (2005): *Trace gas exchange and climatic relevance of bog ecosystems, Southern Germany.* Dissertation Technische Universität München, 179 S. published online: urn:nbn:de:bvb:91-diss20050901-12494310.

Gauci, V., Dise, N. and Fowler, D. (2002): Controls on suppression of methane flux from a peat bog subjected to simulated rain sulfate deposition. *Glob. Biogeochem. Cy.* **16**, 10.1029/2000GB001370

Glatzel, S., Koebsch, F, Beetz, S.; Hahn, J., Richter, P. and Jurasinski, G., (2011): Maßnahme zur Minderung de Treibhausgasfreisetztung von mooren im Mittleren Mecklenburg. *Telma* **Beiheft 4**, 85-106.

Hargreaves, K. and Fowler, D. (1998): Quantifying the Effects of Water Table and Soil Temperature on the Emission of Methane from Peat Wetland at the Field Scale. *Atmos. Environ.* **32**, 3275–3282.

Höper, H. (2007): Freisetzung von Treibhausgasen aus deutschen Mooren. *Telma* **37**, 85–116.

Jensen, R., Couwenberg, J. and Trepel, M. (2010): Bilanzierung der Klimawirkung von Moorböden in Schleswig-Holstein. *Telma* **40**: 215–228.

Jurasinski, G. and Koebsch, F (2011): flux: flux rate calculation from dynamic closed chamber measurements. R package version 0.1-2. http://CRAN.R-project.org/package=flux

Lovley, D. and Klug, M. (1983): Sulfate reducers can outcompete methanogens at freshwater sulfate concentration. Appl. *Environ. Microb*. **45**, 187–192.

MacDonald, J., Fowler, D., Hargreaves, K., Skiba, U., Leith, I. and Murray, M. (1998): Methane Emission Rates from a Northern Wetland; Response to Temperature, Water Table and Transport. *Atmos. Environ*. **32**, 3219–3227.

Ministerium für Landwirtschaft, Umwelt und Verbraucherschutz (2009): *Moorschutzkonzept Mecklenburg-Vorpommern.* 80 p. Schwerin.

Rozema, J., Dorel, F., Janissen, R., Lenssen, G., Broekmann, R., Arp, W. and Drake, B. (1991): Effect of elevated atmospheric CO_2 on growth, photosynthesis and water relations of salt marsh grass species. *Aquat. Bot.* **39**, 45–55.

Weston, N., Vile, M., Neubauer, S. and Velinsky, D. (2010): Accelerated microbial organic matter mineralization following salt-water intrusion into tidal freshwater marsh soils. - *Biogeochemistry* **102**, 135-151.

Zak, D., Augustin, J. & Gelbrecht, J. (2008): Moore – einstige Verbreitung und Verlust landschaftsökologischer Funktionen. - In: Gelbrecht, J., Zak, D. and Augustin, J.: *Phosphor- und Kohlenstoffdynamik und Vegetationsentwicklung in wiedervernäßten Mooren des Peenetals in Mecklenburg-Vorpommern.* pp. 8-10. Berichte des IGB. Heft **26**. Berlin