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Effects of grassland management on the emission of methane from grassland on peat soils

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Abstract

Net methane (CH_4) emissions from managed grassland on peat soils in the Netherlands have been monitored with vented closed flux chambers in the period January - June 1994. Net CH_4 emissions from two intensively managed grasslands were low, in general less than 0.1 mg CH_4 m^{-2} d^{-1}. On these sites, the effect of management was negligibly small. CH_4 emission from three extensively managed grasslands in a nature preserve ranged from 0 to 185 mg CH_4 m^{-2} d^{-1}. The results presented here indicate that CH_4 emissions are 2-3 orders of magnitude higher on extensively managed grasslands than on intensively managed grasslands.

1. INTRODUCTION

Methane (CH_4) is a greenhouse gas and as such it contributes to the greenhouse effect. Soils can either be a source of CH_4, for example in the case of wetlands and rice paddies, or a sink, for example in the case of well-drained soils (Van Amstel, 1993).

Grasslands are generally considered to be a net sink for atmospheric CH_4, especially when they are well-drained. The CH_4 consumption rate depends on grassland management (Mosier et al., 1991) and environmental conditions (Bartlett and Harris, 1993).

Peat soils often show CH_4 emission, as they have a high organic matter content and are anoxic at some depth (Bartlett and Harris, 1993). Agricultural utilized peat soils are partially drained, so the oxic top layer is much thicker than in undrained peat soils. As a consequence, the sink-source balance of these soils for CH_4 alters drastically.

In the Netherlands, about 30% of the grasslands are situated on peat soils. It is unknown whether these sites emit or consume CH_4. To assess the effects of grassland management on CH_4 emission rates from grassland on peat soils, a monitoring study was conducted. This study investigates both intensively and extensively managed grasslands.

2. METHODS

Five grassland sites in the major peat soil area of the western part of the Netherlands have been investigated (for a more detailed site description: see Segers and Van Dasselaar, this volume):

* two typical sites on intensively managed, reasonably well-drained grassland at the experimental farm ROC Zegveld:
  * site 8B, with a mean ground water level of 35 cm;
  * site Bos 6, with a mean ground water level of 50 cm.

  At both sites there were three different treatments: (i) mowing, no nitrogen (N) application; (ii) mowing, N application; (iii) grazing, N application.
* three typical sites on extensively managed grassland in a nature preserve, the Nieuwkoopse Plassen area:
  * Koole, with a mean ground water level of 5 cm;
  * Brampjesgat, with a mean ground water level of 10 cm;
  * Drie Berken Zudde, with a mean ground water level of 15 cm.

  The vegetation of these three sites is quite diverse, but consists mainly of grass, moss, sedges, rushes and reed. They are mown once every year in summer.

Net CH_4 emissions have been monitored with vented closed flux chambers (Hutchinson & Mosier, 1981) from autumn 1993 onwards. In general measurements took place once every week or every two weeks with six flux chambers at each site. In the Nieuwkoopse Plassen area, boardwalks and steelen frames were installed to prevent artificially induced fluxes due to the very soft topsoil. Gas samples were taken from the headspace of the chambers with glass syringes and analysed for CH_4 by gaschromatography (relative standard deviation: 0.08%).

Monitoring will continue till November 1995. Results obtained in the period January - June 1994 are presented here.

3. RESULTS

3.1. Intensively managed, drained grasslands in Zegveld

In Zegveld, net CH_4 emissions were low, in general less than 0.1 mg CH_4 m^{-2} d^{-1}. Effect of mean ground water level in the range of 35 to 50 cm was negligible; site 8B gave equal or only slightly higher net CH_4 emissions than site Bos 6 (Figure 1). There were also no clear effects of N fertilization and grazing versus mowing on net CH_4 emissions from the soil (not shown).

3.2. Extensively managed grasslands in a nature preserve

Net CH_4 emissions from extensively managed grasslands in the Nieuwkoopse Plassen area ranged from 0 to 185 mg CH_4 m^{-2} d^{-1} (Figure 2). Differences between the different sites were quite large, as were the spatial variations at each of the sites. Drie Berken Zudde, the site with the lowest CH_4 emission, had a lower ground water level than the two other sites.

4. DISCUSSION

Net CH_4 emissions were low on the intensively managed grasslands (Figure 1). Literature data for comparable sites range from 0.1 for a poorly drained grassland soil in winter (Jarvis et al., 1993) to 0.8 mg CH_4 m^{-2} d^{-1} for an unfertilized pasture (Mosier et al., 1991). Soil analyses in Zegveld showed relatively high nitrate and sulphate concentrations in the soil, especially in the top soil. Both nitrate and sulphate will have blocked CH_4 production. Low

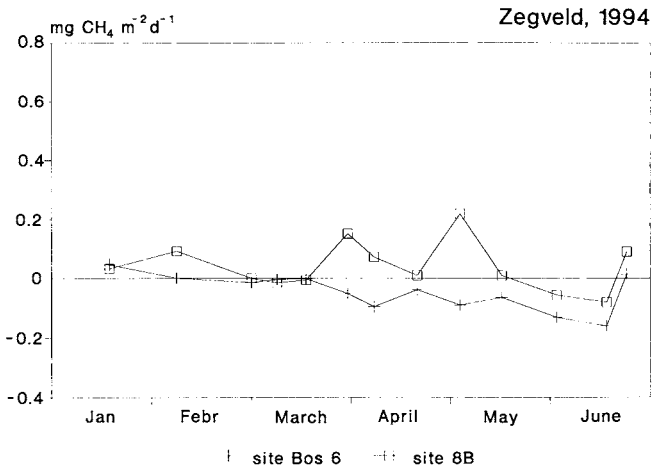

Figure 1. Time course of mean CH_4 emissions (in mg CH_4 m^{-2} d^{-1}) from intensively managed grassland with a mean ground water level of 50 cm (site Bos 6) and 35 cm (site 8B).

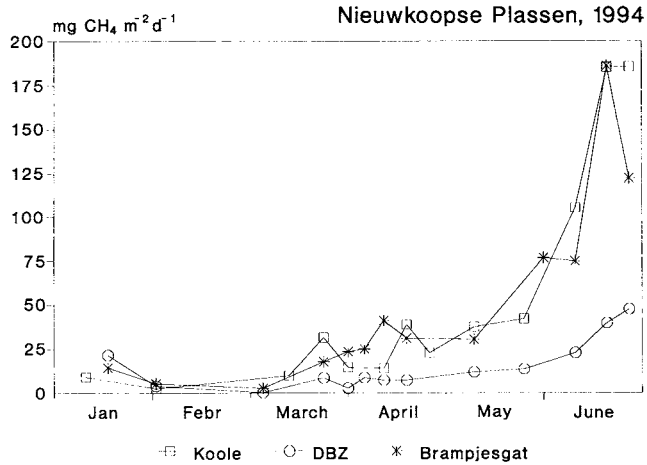

Figure 2. Time course of mean CH_4 emissions (in mg CH_4 m^{-2} d^{-1}) at three different sites in the Nieuwkoopse Plassen area: Koole, Drie Berken Zudde (DBZ) and Brampjesgat.

soil temperatures in winter and spring will also have contributed to low microbial activities in the soil.

Grassland soils with a high ground water level generally have a relatively thin aerobic layer. These soils are expected to emit more CH_4 than grassland soils with a relatively low ground water level and a relatively thick aerobic layer. However, site 8B in Zegveld (relatively high ground water level) gave equal or only slightly higher net CH_4 emission than site Bos 6 (relatively low ground water level) (Figure 1).

Nitrogen fertilization may decrease CH_4 consumption (Mosier et al., 1991; Hütch et al., 1993); mowing or grazing could affect CH_4 emissions by influencing the amount of organic material and nitrogen that is added to the soil annually. However, there were no clear differences between the treatments at the two sites. It has to be emphasized that CH_4 production by cattle is not included in these estimates.

Results presented here indicate that, for intensively managed grasslands, the effect of management on CH_4 emissions is negligibly small.

Compared to the intensively managed grasslands, net CH_4 emissions from the extensively managed grasslands in the Nieuwkoopse Plassen area were 2-3 orders of magnitude higher. In the period January - June 1994, CH_4 production ranged from 0 to 185 mg CH_4 m^{-2} d^{-1} (Figure 2). Literature data also show great variations in CH_4 emissions from wetlands. In a review, Bartlett and Harris (1993) arrive at a mean estimate of 87 mg CH_4 m^{-2} d^{-1} for boreal wetlands (standard error of mean: 18; range 0-664 mg CH_4 m^{-2} d^{-1}. Even in a relatively small area as the Nieuwkoopse Plassen differences between sites were quite high. The data suggest that ground water level is a major controlling factor.

The national government intends to set aside intensively managed grasslands and turn them into more natural ecosystems. The ground water level of these grasslands will then be raised again. As the CH_4 emission from extensively managed, 'natural' grasslands was 2-3 orders of magnitude higher than from intensively managed grasslands, the contribution of peat soils in the Netherlands to the total CH_4 emission will then increase significantly.

5. ACKNOWLEDGMENTS

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6. REFERENCES

- Bartlett, K.B. and R.C. Harris, Chemosphere 26 (1993) 261-320.
- Jarvis, S.C., D.R. Lockyer, G. Warren, D.J. Hatch and G. Dollard, In: L. 't Mannetje and J. Frame (Eds.), Proc. of the 15th Gen. Meeting of the Eur. Grassl. Fed. (1994) 408-412.
- Hütch, B.W., C.P. Webster and D.S. Powlson, Soil Biol. Biochem. 25 (1993) 1307-1315.
- Hutchinson, G.L. and A.R. Mosier, Soil Sci. Soc. Am. J. 45 (1981) 311-316.
- Mosier, A., D. Schimel, D. Valentine, K.Bronson and W.Parton, Nature 350 (1991) 330-332.
- Van Amstel, A.R., R.J. Swart, M.S. Krol, J.P. Beck, A.F. Bouwman, K.W. van der Hoek, Methane the other greenhouse gas, RIVM report 481507001, Bilthoven, 1993.