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The integrated CH_4 grassland project: Methane consumption by indigenous grassland microflora

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Abstract

Soil samples were taken from the test farm in *Zegveld*. In batch cultures the kinetics of methane oxidation by soil from different depths were investigated. Soil was incubated in 300 ml flasks with 1, 10, 100 and 10.000 ppmv methane, respectively. All 4 applied concentrations of methane were biologically degraded by this type of grassland soil. The highest oxidative activities, especially for lower concentrations (1-100 ppmv), were observed between 5 and 20 cm soil depth. Most importantly, these experiments demonstrated that this soil acts as a sink for methane even at concentrations well below 1 ppmv. In continuous cultures soil was incubated in columns receiving a continuous gas-flow of 4 ml/min containing methane at 4 different concentrations. Thereby, all concentrations of methane were degraded continuously by this type of soil.

1. INTRODUCTION

In soils not only the formation of methane but also its degradation has an important function in the net production of this greenhouse gas. While the formation of CH_4 is a strictly anaerobic process performed by methanogenic bacterial consortia, the degradation is oxygen dependent and therefore occurs only in the upper, aerobic regions of soils. For net fluxes of CH_4 in many types of soil, methanotrophic bacteria can play a very important role, because up to 80 % of the formed CH_4 can be degraded in the aerobic zones (2,5). Methanotrophic bacteria not only oxidize methane formed in the anaerobic parts of soil. Recently, it was found that some types of soil can function as sinks for atmospheric methane (1,5). In the global CH_4 budget the microbial degradation of atmospheric methane is believed to amount to about 10-20% of the sink strength (1). In kinetic studies it was shown that bacteria with different affinities for methane are responsible for degradation of high (methanogenic) and low (atmospheric) concentrations of methane in soils, respectively (1).

Within the integrated grassland project we investigate the ability of Dutch grasslands to consume both methanogenic and atmospheric methane and we try to isolate and describe the methanotrophic bacteria responsible for this degradation.

2. RESULTS

Kinetic experiments.

Soil samples from different depth were taken from the test farm in *Zegveld*. The soil was placed in bath cultures in 300 ml flasks with gas tight septa and incubated with 1, 10, 100 and 10.000 ppm methane, respectively, in artificial air with 1 % (v/v) CO_2, according to the method described by Bender and Conrad (1).

All 4 applied concentrations were biologically degraded by this type of grassland soil. The time course of methane degradation is plotted in Fig. 1 for initial concentrations of both 100 (A) and 1 (B) ppmv methane. The highest oxidative activities, especially for lower concentrations (1-100 ppmv), were observed between 5 and 20 cm. There were no great differences between the oxidation profiles and kinetics between soil samples taken in autumn, spring or summer.

A linear correlation between CH_4-concentration and degradation rates was observed (0,003 - 30 nmol g soil^{-1} h^{-1} = 0.19 nmol - 1.9 μmol g dry soil^{-1} d^{-1} for 1 - 10.000 ppmv, respectively). But most importantly, it is demonstrated that this soil acts as a sink for methane even at concentrations well below 1 ppmv.

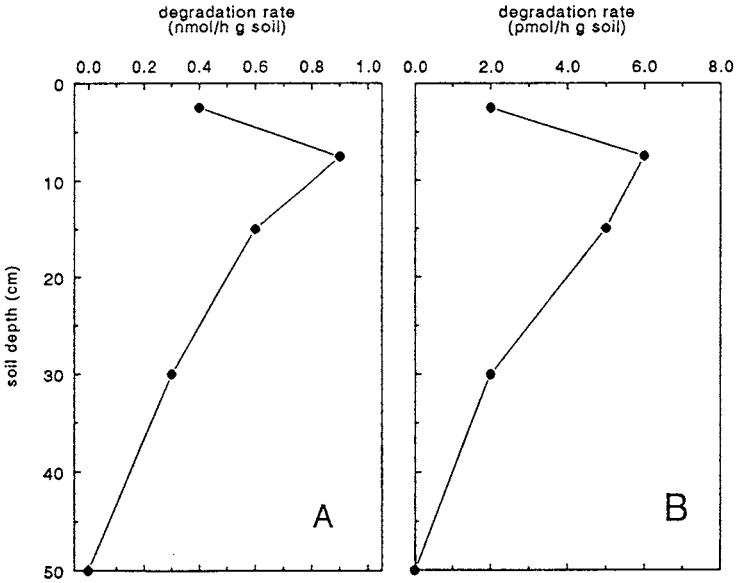

Fig. 1: Depth profile of the degradation rates of 100 (A) and 1 ppmv (B) CH_4 in batch cultures.

Continuous experiments.

For the enrichment of methanotrophic bacteria with low affinity for methane, soil (100 g) was incubated in column systems receiving a continuous gas-flow of 4 ml/min. Methane was supplied at 4 different concentrations (1; 10; 100; 10,000 ppmv). A decrease of the efflux concentration was observed after 14 days of incubation in the columns incubated with 10,000 ppmv (data not shown). In the column incubated with 1, 10 and 100 ppmv, respectively, the efflux gas concentrations remained constant for about 30 days, but then these methane concentrations were also degraded (Fig. 2).

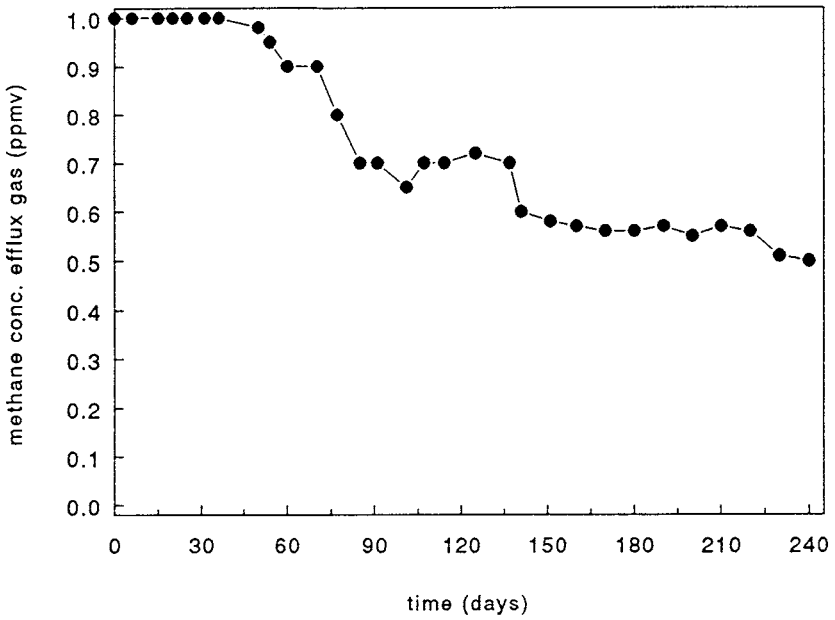

Fig. 2: Time course of the degradation of 1 ppmv CH_4 in a soil column filled with 100 g soil with a continuous gas flow of 4 ml/min.

These installations were continuously running for about 300 days and demonstrated that also very low concentrations of methane were continuously degraded by this type of grassland soil. These enrichment cultures will be taken to isolate methanotrophic bacteria which are responsible for the degradation of methane at different concentrations.

3. DISCUSSION

A relatively high methanotrophic activity was observed in depths between 5 and 20 cm. Similar results have also been reported by other authors (3,6). Such depth profiles of methanotrophic activities can be explained by the high density of organisms in the higher layers and/or by simultaneous presence of sufficiently high concentrations of the two substrates, oxygen and methane in the region of the soil were the greatest activities are measurable.

The fact that the fluxes measured for *Zegveld* soil are very low and even negative can be explained by the fact that there is a balance between CH_4 formation and degradation in this grassland soil (see reports of the other members of the *Integrated grassland project*).

The evidence for different types of methanotrophic bacteria, a low affinity type for the degradation of high concentrations of methane and a high affinity type for the degradation of low (atmospheric) concentrations of methane were described in kinetic studies by Bender and Conrad (1). But until yet, the high affinity strains could not be isolated and described (4). Therefore, isolation and identification of the strains enriched in the continuous enrichment systems especially at low CH_4-concentrations will be the aim of the second part of our work.

4. REFERENCES

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