3 Methanogenic Microbial Communities Associated with Aquatic Plants

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1 Introduction

Methanogenic microbial communities are typically active at anoxic sites that are depleted in electron acceptors other than CO$_2$ and H$^+$. At these sites CH$_4$ is one of the major products of degradation of organic matter. The degradation products of cellulose, for example, which has an oxidation state of zero, would be CH$_4$ and CO$_2$ in a ratio of 1:1. Organic matter with a higher or lower oxidation state would yield respectively less or more CH$_4$ (Yao and Conrad 2000). Consequently, anoxic methanogenic habitats can be significant sources in the global CH$_4$ cycle. The global CH$_4$ cycle is important with respect to atmospheric chemistry and climate, since CH$_4$ is an important greenhouse gas and has tripled in abundance over the last two centuries (Cicerone and Oremland 1988; Ehhalt 1999). The most important individual source for atmospheric CH$_4$ is wetlands (including flooded rice fields), which account for about 175 Tg CH$_4$ per year or 33% of the total atmospheric CH$_4$ budget (Conrad 1997; Aulakh et al. 2001). The general microbiology and that of methanogenic microbial communities in flooded soils has recently been reviewed in detail (Kimura 2000; Liesack et al. 2000; Conrad and Frenzel 2002). In the following I will concentrate on methanogenic microbial communities associated with aquatic plants.

2 Role of Plants in Emission of CH$_4$ to the Atmosphere

Aquatic plants are an integral part of wetland ecosystems that emit CH$_4$ into the atmosphere. Aquatic plants interact in three different ways with the microbial CH$_4$ cycling, i.e., by serving as gas conduits, by supplying O$_2$ to the rhizosphere and by supplying organic substrates to the soil (Fig. 1).

Aquatic plants live in anoxic soil habitats and thus have to make sure that their roots are supplied with O$_2$. The supply of O$_2$ is accomplished by vascular gas transport and aerenchyma systems. These systems and their mode of
operation can be different in the different plant species (Armstrong 1979; Grosse et al. 1996; Jackson and Armstrong 1999). However, they all allow for transport of O2 to the roots and vice-versa allow for the transport of CH4 from the anoxic soil into the atmosphere. In rice fields, up to about 90% of total CH4 emission can be accomplished by ventilation through the rice plants (Holzapfel-Pschorn et al. 1986; Aulakh et al. 2001). The exact contribution of rice plants to the transport of CH4 from the soil into the atmosphere depends on the size of the rice plants and their capacity for gas transport (Aulakh et al.