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Evidence on Anaerobic Methane Oxidation (AOM) in a boreal cultivated peatland with natural and added electron acceptors

Maxim Dorodnikov (1,3), Hanna Silvennoinen (2,4), Pertti Martikainen (3), and Peter Dörsch (4)

(1) Soil Science of Temperate Ecosystems, Büsgen-Institute, Georg August University of Göttingen, Göttingen, Germany (mdorodn@gwdg.de), (3) Biogeochemistry Research Group, Department of Environmental Science, University of Eastern Finland, Kuopio, Finland (pertti.martikainen@uef.fi), (2) Bioforsk, Norwegian Institute for Agricultural and Environmental Research, Aas, Norway (hanna.silvennoinen@bioforsk.no), (4) Department of Plant and Environmental Sciences, Norwegian University of Life Sciences, Aas, Norway (peter.doersch@nmbu.no)

Anaerobic oxidation of methane (AOM) is a process of methane (CH4) consumption under anoxic conditions driven by microorganisms, which oxidize CH4 with various alternate electron acceptors (AEA): sulfate, nitrate, nitrite, metals-(Fe, Mn, Cu), organic compounds. AOM is common in marine ecosystems, where microbial sulfate reduction (SR) consumes most of the CH4 produced in sediments. Despite the global significance of AOM, the exact mechanisms and relevance of the process in terrestrial ecosystems are almost unknown. In the current study the occurrence of AOM was tested for two organic soil horizons (30 and 40 cm depth) and one mineral sub-soil (sand, 50 cm depth) of a cultivated boreal peatland (Linnansuo, Eastern Finland, energy crop Phalaris arundinacea – reed canarygrass) under controlled conditions with the addition of 13C-labeled CH4 and two common AEAs – SO4-2 and Fe+3. Concentrations of CH4, CO_2 and O_2 were continuously measured during 10 days of incubation and CO_2 was sampled periodically under anaerobic conditions for stable 13C analysis. Oxygen dynamics revealed negligible O_2 contamination during incubation and its trace amounts (0.05-0.8% from the atmospheric) were accounted in the net CH4 uptake. Application of 13C-enriched CH4 (4.9 atom%) allowed to track the label in CO_2 as the end-product of AOM. The highest $13CO_2$ enrichment (up to 60‰ was observed in mineral sub-soil, however AOM was quantitatively more pronounced in the upper 30 cm horizon (2.1 vs. 0.2 μg CO_2 g soil DW-1 in the 50 cm sub-soil). The highest AOM rate of 8.9 ng CO_2 g soil DW-1 h-1 was estimated for the control treatment where no AEAs were added indicating sufficient amount of naturally available AEAs, likely organic compounds. This rate was 50 times more intensive (on the C basis) than the CH4 production potential of the same soil. In contrast, external AEAs decreased AOM rates but added Fe+3 stimulated decomposition of native SOM (as seen from the most depleted $13CO_2$ signatures). Thus, the experiments revealed that this organic soil had capacity for AOM with its natural electron acceptors. Further AOM assessments may change the existing concept of carbon/CH4 cycling in terrestrial ecosystems and will improve current process-based models of regional and global carbon balance.