INTRODUCTION

Methane (CH₄) is the second most important greenhouse gas, and the increase of atmospheric CH₄ concentrations has accelerated significantly in recent years. One suspected reason is an increase in emissions from natural sources such as freshwater sediments or wetlands. Rivers are not only an important contributor to atmospheric CH₄, but also such as methanol were present. 

METHODS

1) Measurement and modelling of geochemical profiles
Geochemical profiles were measured to get depth-distributions of CH₄ and important reactants. Modeling and stable isotope analyses were used to identify production and consumption zones and reaction pathways.

2) Analysis of microbes in the sediment
The microbial community distribution was studied with 16S-rRNA sequencing. The abundance of microbial groups helped to understand the relevance of certain processes.

3) Gas trapping and diffusive flux estimation
Gas traps were built and monitored for a full year to quantify ebullition. For a comparison, diffusive fluxes were calculated from dissolved CH₄ concentrations in surface water.

TRANSPORT OF METHANE TO THE ATMOSPHERE MAINLY BY EBULLITION

Ebullition released more CH₄ from the river bed to the atmosphere than calculated diffusive transport. One site showed active methane production even during winter. Highest gas emissions were observed in the central section of the river. Diffusive fluxes at these test sites were similar to fluxes measured in tropical reservoirs.

AEROBIC AND ANAEROBIC METHANE OXIDATION

The methane oxidation zone was identified through an enrichment in isotopically heavier CH₄ and modeling. Gradients of O₂ and NO₃ were too steep to clearly identify which reduction reaction was coupled to CH₄ consumption. Organisms using O₂ reduction and denitrification were present.

In-situ labeling experiment
To clarify the role of nitrate (NO₃) for CH₄ oxidation, CH₄ with isotopically labeled carbon was injected into the streambed through filter tubes, with and without NO₃. Recovery of the labeled carbon in CO₂ would show CH₄ oxidation. Until now, dilution of the input signal in the open system was too large to quantify differences. The experiment will be repeated with a stronger label.

CONCLUSIONS

1.) Methane production in the riverbed was substantial, but concentrations varied in space. Methane was actively produced during winter at one site.

2.) Methane released more methane to the atmosphere than diffusive fluxes. Methane was largest in the center of the river.

3.) Isotopic enrichment and modeling results showed methane oxidation. Quantifying which reduction reactions were coupled to the CH₄ oxidation was not possible due to very steep geochemical gradients, but there was a potential for CH₄ oxidation coupled to O₂ reduction and denitrification. CH₄ oxidation did not significantly reduce emissions, because most CH₄ escaped as gas bubbles.