Effect of forest restoration on greenhouse gas concentrations in a small headwater stream, Eifel/Lower Rhine Valley (TERENO Network, Germany)

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Introduction

Riverine systems are distinct components of the natural environment which have significant roles in storing and processing terrestrial carbon. While processing organic matter, rivers release large amount of greenhouse gasses to the atmosphere. In this light, headwater streams are particularly interesting. Due to their high connectivity with the surrounding landscapes, these small streams are strongly influenced by terrestrial inputs of carbon and groundwater inflow. Therefore, despite smaller surface area, their role in carbon cycling is crucial. The first order streams have a disproportionate effect on terrestrial carbon budgets. The amount and character of carbon inputs to headwater streams is highly dependent on vegetation types, especially between spruce and beach forests.

The aim of this research is to characterize dissolved organic carbon and greenhouse gas emissions in two headwater streams from a spruce and newly restored beach forest.

Figure 1: Norway spruce forest with replanted beech trees

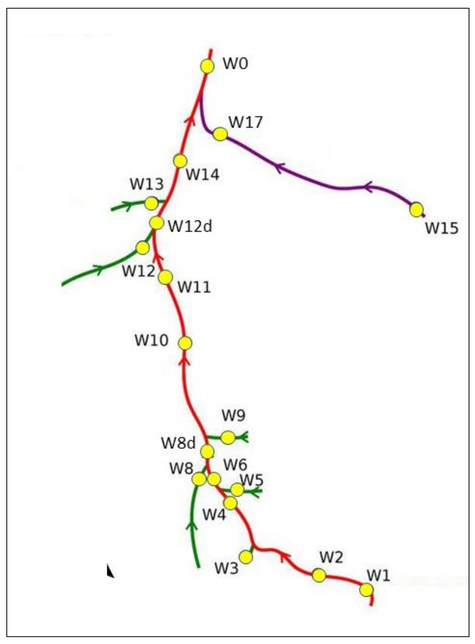


Figure 2: Schematic representation of sampling points along Wüstebach streams[1]

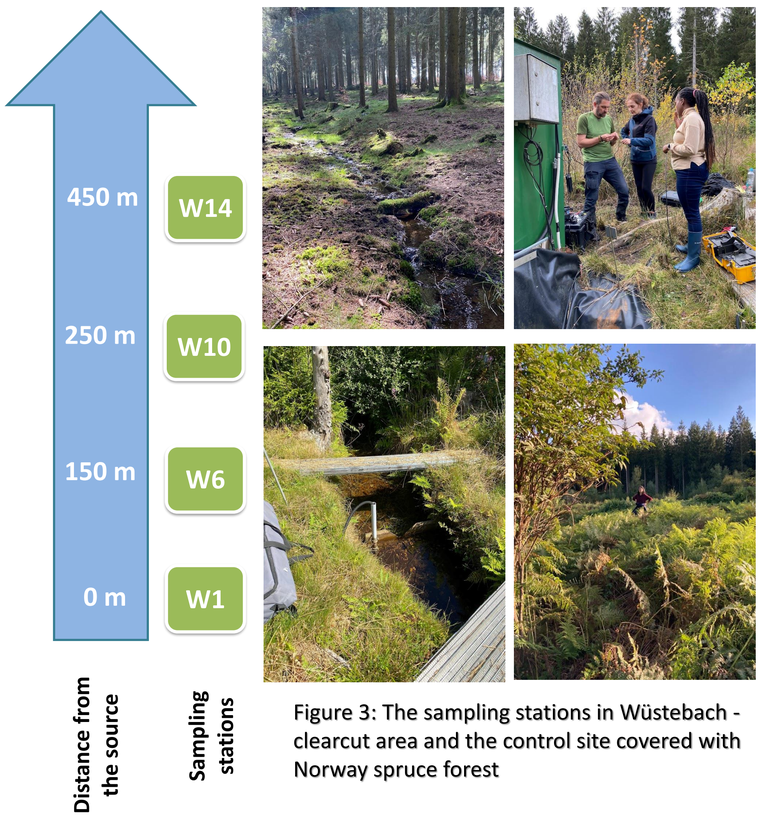


Figure 3: The sampling stations in Wüstebach - clearcut area and the control site covered with Norway spruce forest

Materials and Methods

The present study is carried out in the Wüstebach stream (Eifel/Lower Rhine Valley), which is a part of the Terrestrial Environmental Observatory (TERENO) network. The stream flows through the forest in which 9 ha of Norway spruce was cleared in 2013 and has been replanted with original beech.

The sampling strategy of the study considers collection of three GHG (CO_2, CH_4 and N_2O) samples weekly, at eighteen sampling points in Wüstebach, for a year. The water samples are being collected as a part of TERENO monitoring program.

The GHG samples are analyzed using gas chromatograph, PerkinElmer GC, equipped with FID and ECD. DOC and nutrient concentration are measured using Shimadzu TOC-VCPN with a coupled total nitrogen analyzer (TNM-1) and ion chromatography.

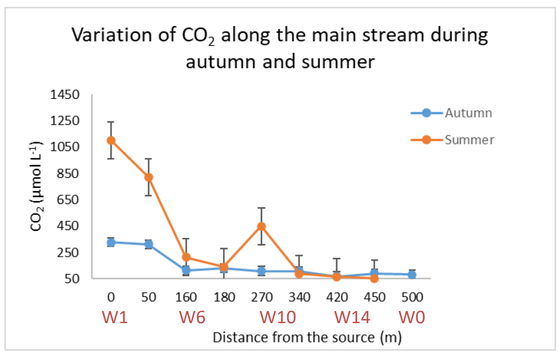
In October – November 2022 and July – August 2023 a preliminary sampling campaign was carried out. During this period, GHG samples were collected five times and four times, respectively. The poster presents results of this study.

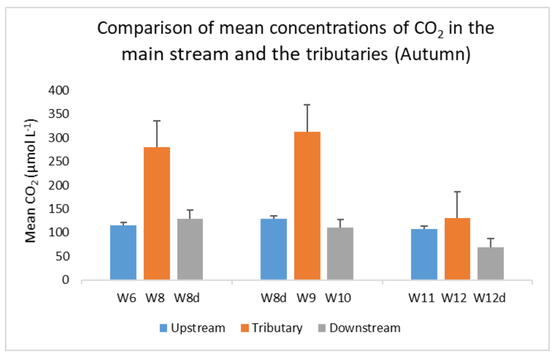
Results of the Preliminary Study

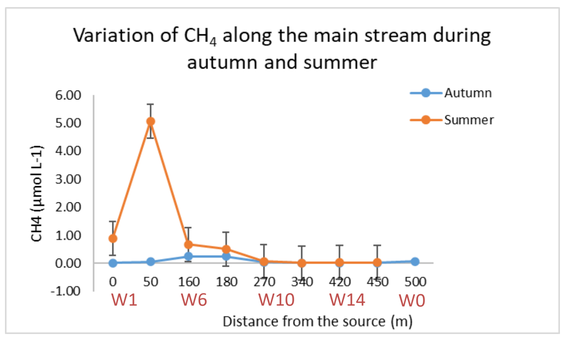
The graphs below show the spatial variation of CO_2, CH_4 and N_2O concentrations along the main stem of the Wüstebach and influences of organic inputs from the tributaries to the GHG emissions of the mainstem during two season (autumn and summer).

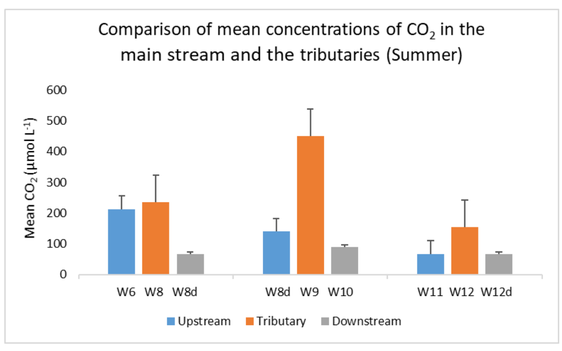
There is a clear decreasing pattern of CO_2 concentrations along the river gradient in both seasons. In autumn, three methane "hotspots" (two at the tributaries and one at the main stem) were recorded. This could be explained by low flow velocity at two of the sites (W8 and W15) and visible higher amounts of organic matter. The CH_4 concentrations at the third site - W8d (the main stem) could be influenced by the higher DOC inputs from the tributary W8. In summer, CH_4 hotspots were identified at four sites along the main stem and one at the tributary. The reason was also low flow of the stream. The N_2O concentrations were low during both seasons. There was only one spot with higher concentrations of this GHG at the control site in autumn. The N_2O concentrations were higher at several points in July. There is no noticeable trend along the stream, but generally, N_2O concentrations are decreasing further from the source. The concentrations of CO_2 and N_2O are higher in tributaries compared to the point right after the inflow (could be explained by the higher discharge). The relationship between quality and quantity of DOM and GHG concentrations varied along the stream.

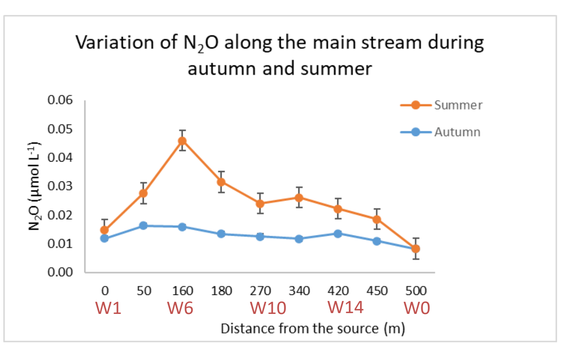
Variation of GHG concentrations along the stream during autumn and summer seasons



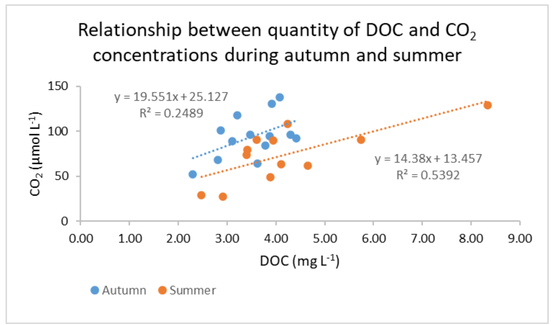


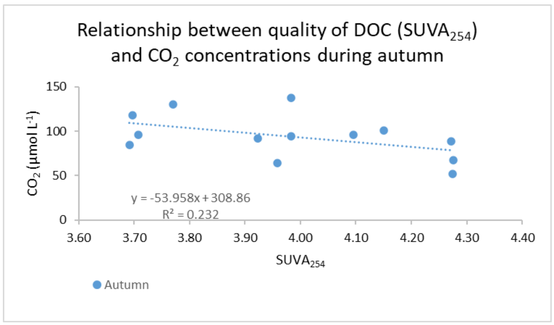


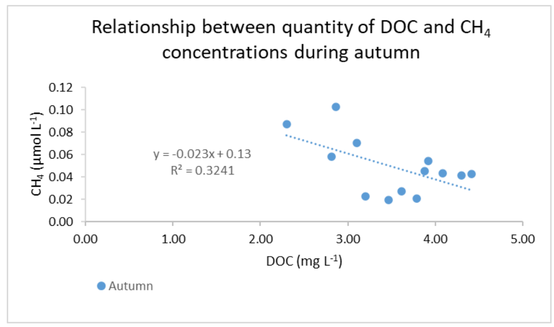


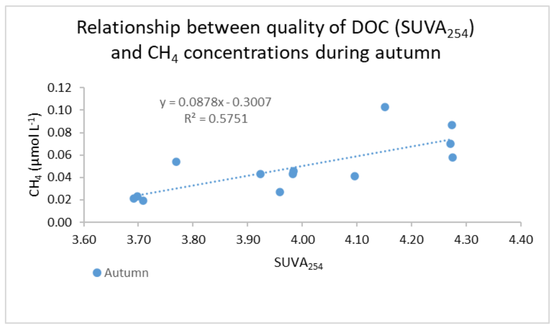


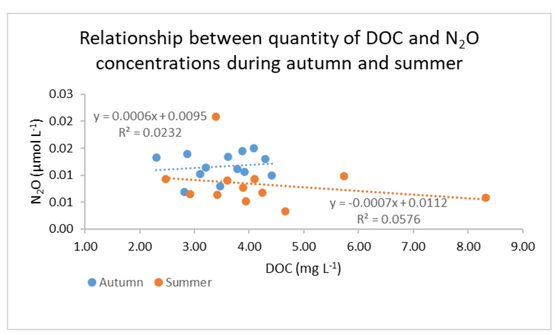
Relationship between quality and quantity of DOC and GHG concentrations at stations W10, W14 and W17 during autumn and summer

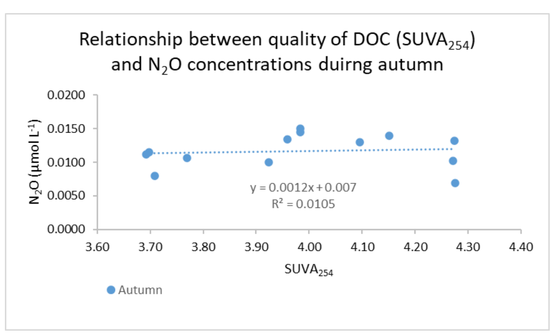






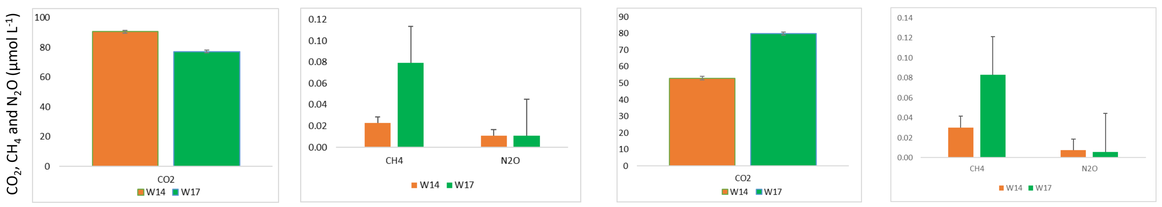






Comparison of GHG concentrations in the clearcut area (W14) and Norway spruce forest (W17) during autumn and summer

October-November 2022 July-August 2023



Preliminary Conclusions

- The Wüstebach and its tributaries most likely are net sources of GHG to the atmosphere.
- The concentrations of CO_2 decline along the 500 m study reach from the spring source, indicating a significant source of groundwater to CO_2 in the stream and physical control on CO_2 evasion along the reach.
- In contrast, CH_4 shows more spatial variability with hot spots corresponding to a wider, vegetated pool, suggesting localized controls.
- In both seasons, CH_4 concentrations were higher in the control stream (W17) compared to the clearcut area (W14), CO_2 concentrations were higher at W14 in autumn but lower in summer and N_2O concentrations did not differ much.
- DOC quantity and quality appear to influence CO_2 and CH_4 concentrations, however, no clear relationship was observed in case of N_2O.

References

[1] Weigand, S. et al. (2017). doi:10.2136/vzj2016.09.0077

Acknowledgements

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