Extreme gas production from fibrous sediments: a potentially overlooked greenhouse gas source

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Introduction

Fiberbanks are fibrous sediments of anthropogenic origin, which formed on the seafloor from the accumulation of fibrous wastes discharged by pulp and paper mills before prohibition in 1969. Fiberbanks have a high organic content and are heavily contaminated with persistent organic pollutants and metals.

The decomposition of the wooden fibers leads to anoxic conditions, which in turn leads to the formation of methane (CH_4) and carbon dioxide (CO_2), which are potent greenhouse gases. A majority of the fiberbanks that have been surveyed in Sweden (76%) shows signs of gas ebullition in the form of pockmarks on the sediment surface.

***Figure 1**. Pockmarks at the fiberbank surface and bubbles release.*

Underwater camera photo from the Geological Survey of Sweden (SGU).

Aims

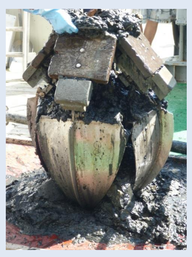
- How much greenhouse gas is formed and released from fiberbanks?
- How does this gas production compares to other types of organic-rich sediments?
- Do the bubbles assemble and accumulate within the sediment?

Methods

1. Sampling fiberbanks

Grab samples of fiberbanks were collected from two sites (Väja and Sandviken) in the Västernorrland county, Sweden. The Väja sediment consists of fine fibers whereas the Sandviken sediment is composed of wood chips.

SGU's vessel

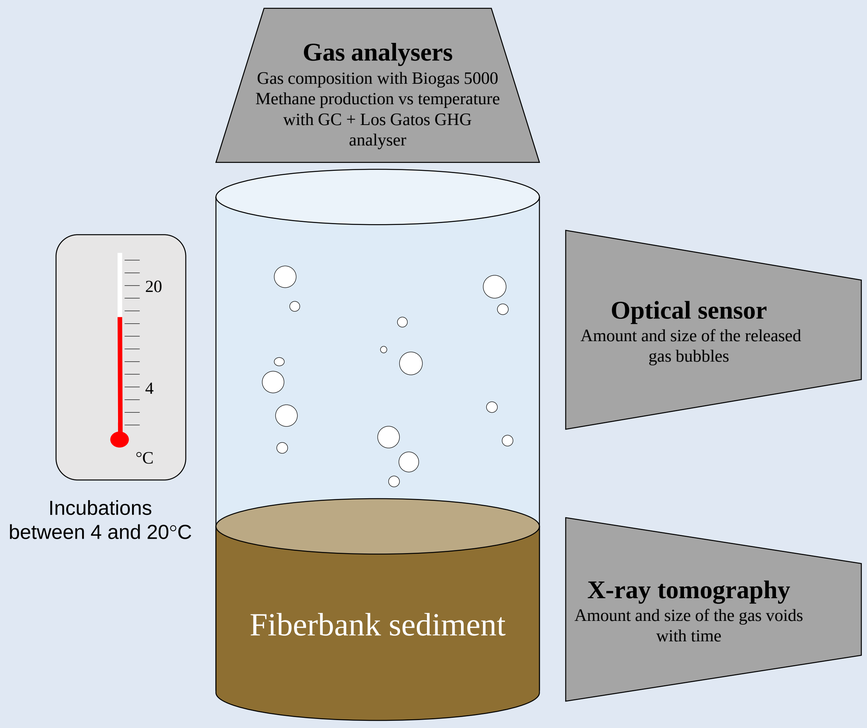


Grab sampler

Väja's fiberbank (fine cellulose fibers)

Sandviken's fiberbank (coarse wood chips)

2. Laboratory experiments



Results & discussion

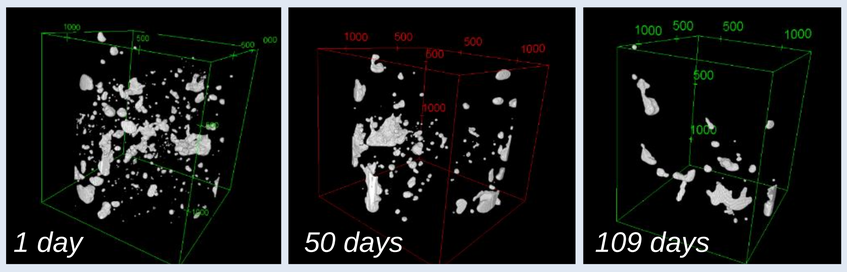


***Figure 2**. X-ray images of the gas voids in the same Väja fiberbank sediment sample measured over time at 4°C.*

→ Bubbles accumulated and grew in size, the total gas volume decreased in Sandviken and Väja fiberbank sediments over time.

→ Larger and fewer bubbles in Väja than in Sandviken → impact of the sediment structure.

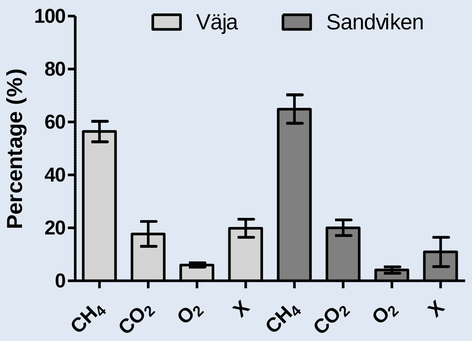


***Figure 3**. Gas composition from both fiberbank sediments*

- The gas released from the fiberbanks is mainly composed of CH_4, but also CO_2 and other gases such as hydrogen sulfide (between 0 and 400 ppm). Both sediments show similar composition.
- Comparison with literature shows that CH_4 production is much higher in fiberbanks than in other types of sediments.
- This high production might be due to the high TOC content, the type of organic matter and/or the high rate of accumulation over a short period of time.

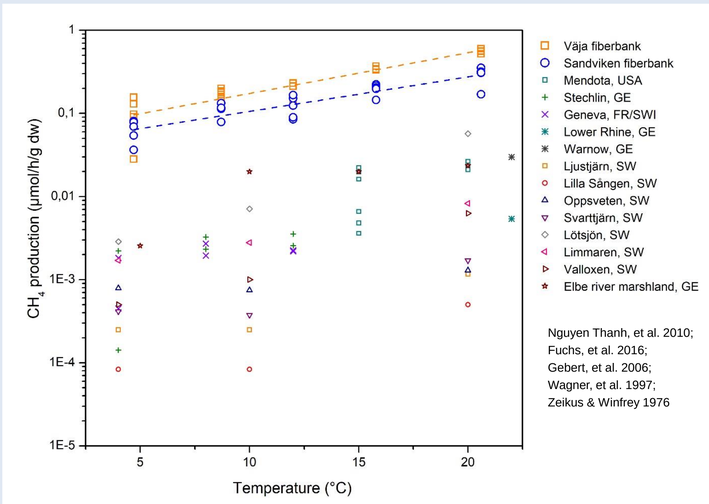


***Figure 4.** CH_4 production from both fiberbank sediments as a function of temperature and compared with literature*

Conclusions & implications

- Gas bubbles are partly trapped in the sediment (Figure 2).
- Gas bubbles grow and merge easier in the fine fibrous sediment (Väja fiberbank).
- Fiberbank sediments release greenhouse gases (mainly CH_4, Figure 3).
- CH_4 production is 1-3 orders of magnitude higher in the fiberbanks than in other sediments reported in the literature (Figure 4).
- The CH_4 production is temperature dependent. Thus increasing seasonal temperature variations, linked to climate change and its effects on local conditions, may enhance future gas production.

Implications:

- Fiberbanks are potentially important greenhouse gas sources within Sweden (over 380 sites potentially contaminated) and over the world. In Sweden, it could be as high as 7% of Sweden's total anthropogenic GHG emissions for 2019.
- Gas transport can enhance contaminant transport to the aquatic environment.

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