Global change impacts on greenhouse gas emissions from aquatic ecosystems

Sarian Kosten
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Team-work

Ralf Aben
Ernandes Sobreira
Gijs van Dijk
Stefan Weideveld
Mandy Veldhuis
Christian Fritz
Tatiana Stepina
Importance of inland waters for global carbon cycle

- Transport carbon to the ocean
- Process large amounts of terrestrial organic matter
- Outgas terrestrial CO$_2$
- Incorporate CO$_2$ in biomass
- Bury organic matter
- **They are also strong CO$_2$ – biomass – CH$_4$ converters**

Pg, $10^{15}$ g

Tranvik et al. 2009
Strong increase in atmospheric methane concentrations

- Methane has a higher global warming potential than CO₂
- ~20% of global warming caused by methane
Close to home: Dutch Ditches
$\text{CH}_4$ ebullition and diffusion
Close to home: Dutch Ditches

- Dutch ditches emit 3 – 16% of the Dutch total CH$_4$ emission!

- Quantification is still rough due to spatial and temporal variability
Global change

Physical
- Warming
- Drought

Chemical
- Salinisation
- Eutrophication

Biological
- Fish
- Primary producer
Effect of warming

Aben et al. Nature communications 2017
Van Bergen & Barros et al. in prep
6–20% increase in CH$_4$ ebullition per 1°C increase

\[ E_T = E_{20} + \theta_s (T - 20) \]
Experimental evidence for temperature effect on CH₄ ebullition
Experimental evidence for temperature effect on CH$_4$ ebullition

Aben et al. Nature communications 2017
Warming

Aben et al. Nature communications 2017

Strong increase in methane ebullition with temperature

- 4 °C warming led to 51% higher total annual CH₄ ebullition
- Attributable to temperature effect on methanogens (and not on increase of OM and barely on decreased solubility)
- CH₄ diffusion did not increase
Eutrophication
Impact of eutrophication on GHG emissions

**hypotheses**

- **CH₄** gas exchange
- **CO₂**

Eutrophication leads to:
- More **CO₂** uptake
- More **CH₄** emission due to higher substrate availability

**Eutrophication**

Radboud University
Impact of eutrophication on GHG emissions

hypotheses

Eutrophication leads to:
- More CO₂ uptake
- More CH₄ emission due to higher substrate availability
- BUT possibly higher MOX on plant surfaces (periphyton)
Effect of eutrophication
Effect of eutrophication

Eutrophication indeed leads to:
• More CH$_4$ emission
• (no plant effect)
Effect of eutrophication

Eutrophication indeed leads to:
- More GHG emissions
- Higher CO$_2$ uptake could not compensate for higher CH$_4$ and N$_2$O emissions
Fish
Impact of benthic fish on methane emissions

hypothesis

\[ \text{CH}_4 \rightarrow \text{MOX} \]

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\[ \text{CH}_4 \rightarrow \text{MOX} \]
Impact of benthic fish on methane emissions

• Presence of *Cyprinus carpio* results in strong decrease CH$_4$ ebullition
• Also CH$_4$ diffusion decreases
• Possibly bioturbation decreases methanogenesis..
• Or enhances methane oxidation
Salinisation
Effect of salinisation

Range of 0.9 up to 9.0 PSU
6 years
Effect of salinisation

- Increase in salinity results in strong decrease CH$_4$ ebullition
- Also CH$_4$ diffusion increases

Possible causes:
- Sulphate reduction
- Sulphide toxicity
- Ionic stress
- Other physiochemical and biogeochemical processes

Van Dijk et al. in prep.
Large global change impact on methane emission from aquatic ecosystems

- Warming: +4°C
- Eutrophication: x200 P
- Fish: + benthic fish
- Salinisation: 6 → 64 mM/L Cl⁻, 0.9 → 9 PSU
Methane emission from aquatic ecosystems

• Emissions from global (and Dutch) aquatic systems are still poorly quantified

• New insights in biotic and abiotic impacts on emissions will improve quantification

• New insights also provide tools for managers to reduce emissions