Will carbon capture plants contaminate drinking water?

Norwegian Institute for Water Research

Biodegradation potential of nitramines in lake water.

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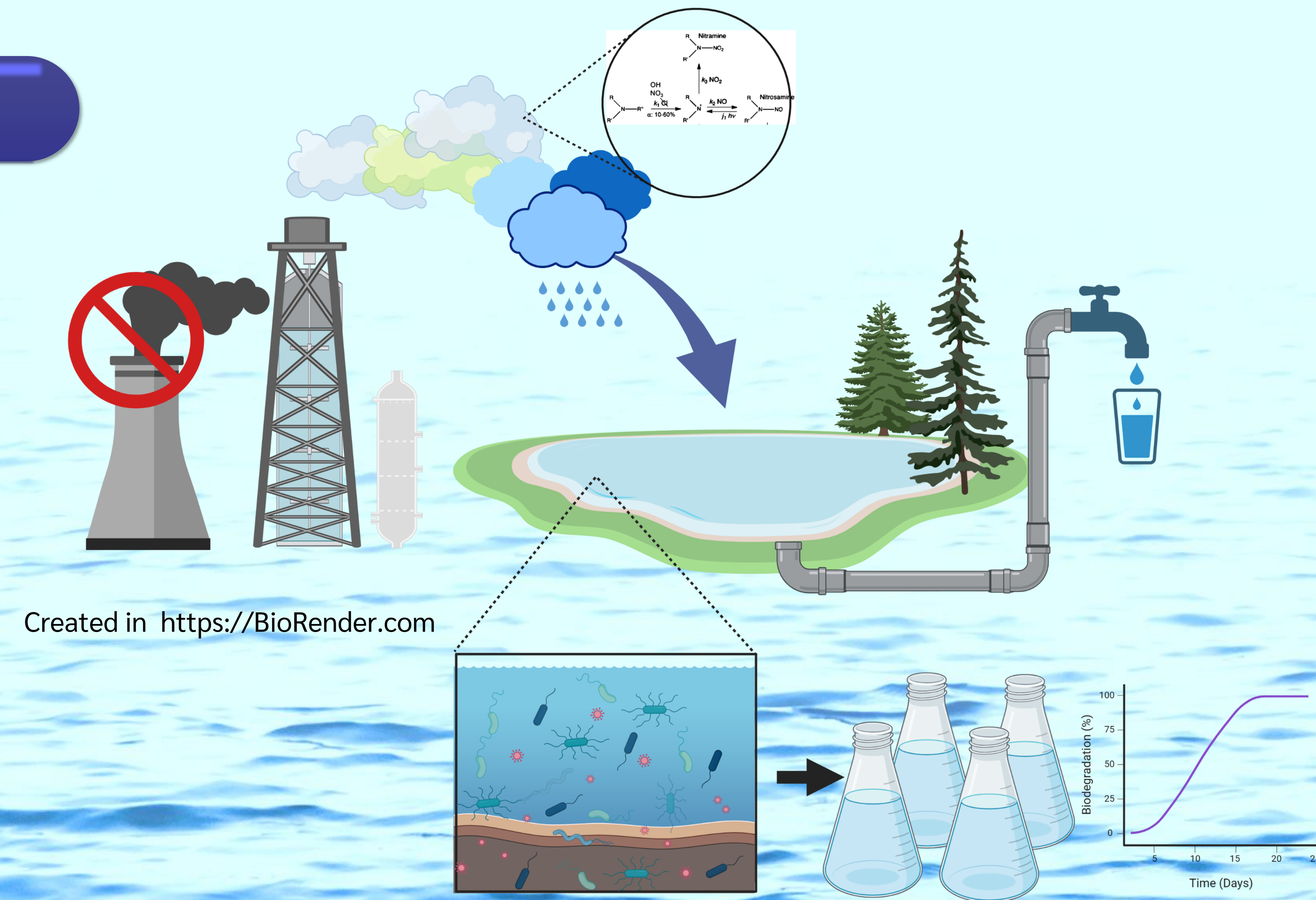
→ Biodegradation potential of nitramines depends on their structure.

→ Bacteria from lake sediments are better degraders than from water alone.

→ Adaption of inoculum only improved biodegradation marginally.

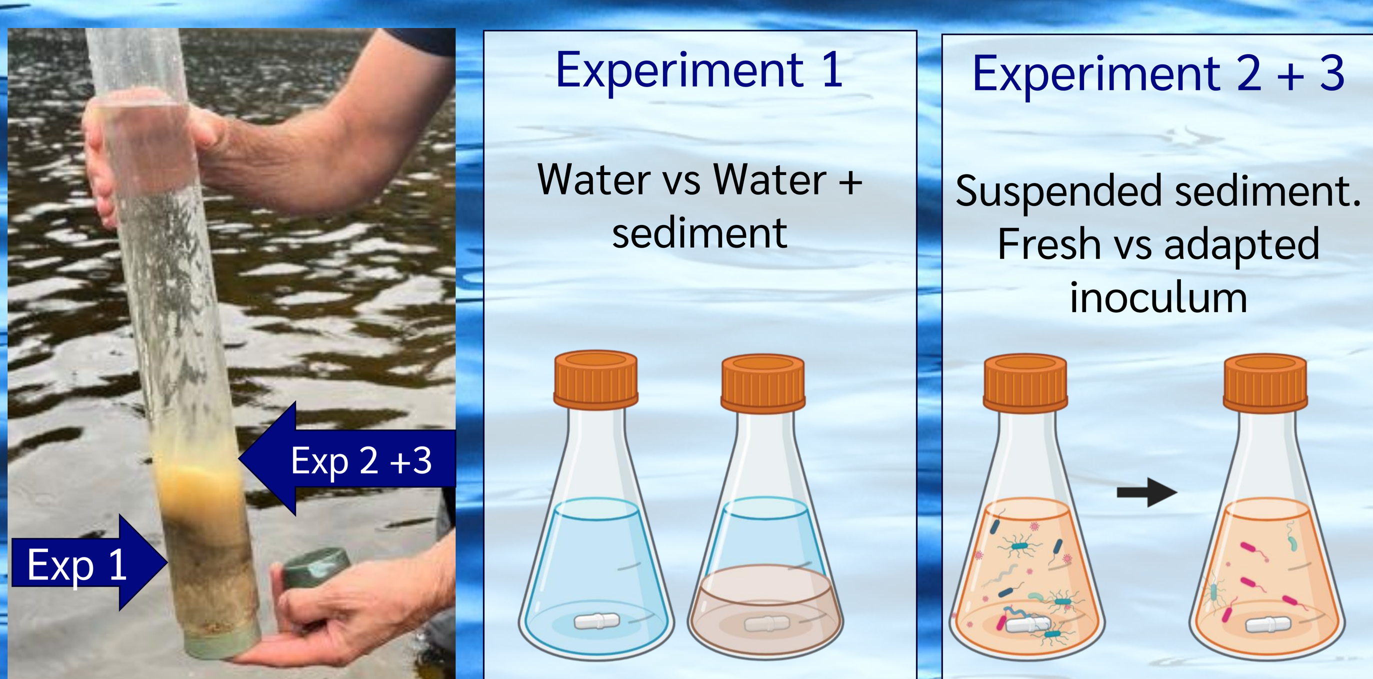
→ Amine used for CO_2 capture will determine which nitramines are formed and thereby their persistence time in drinking water.



BACKGROUND

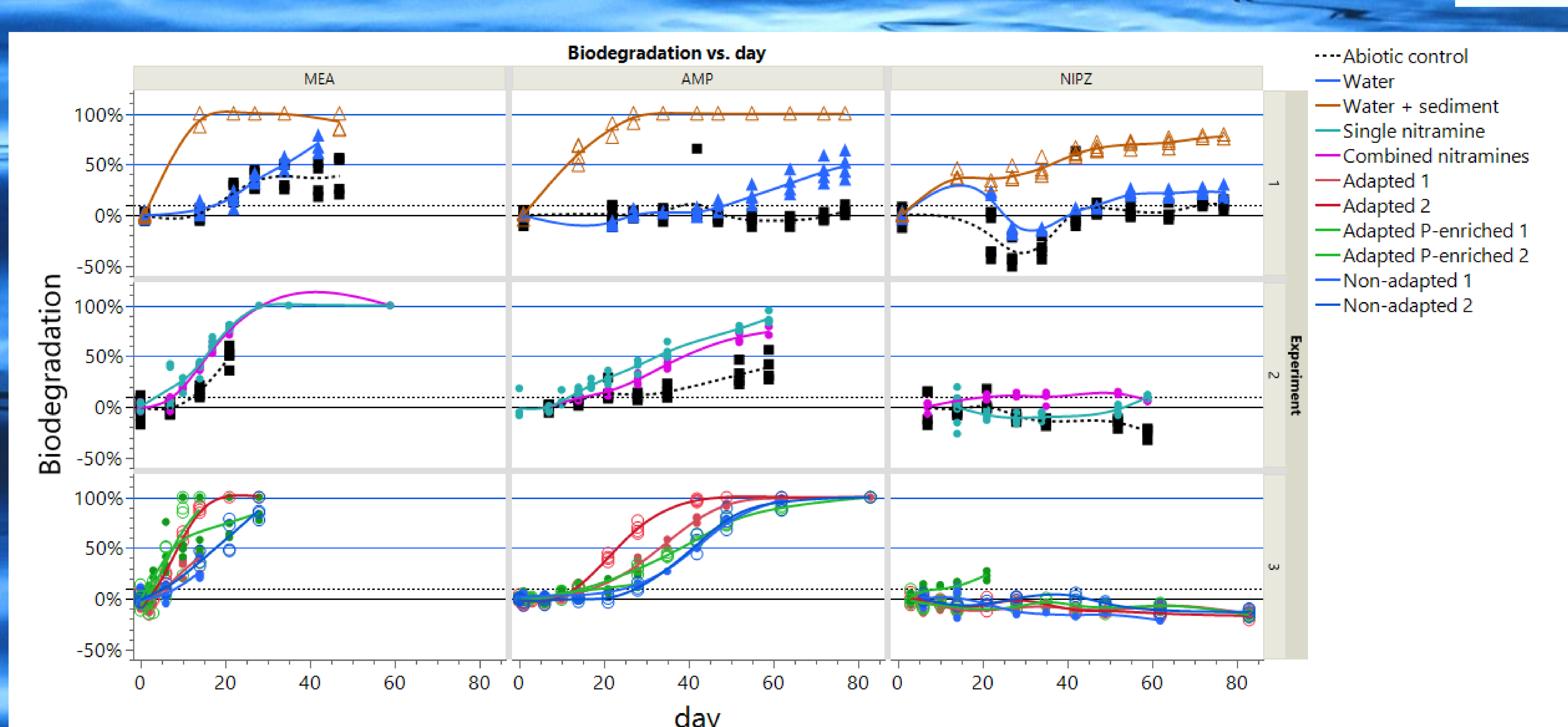
- Carcinogenic nitrosamines (NSAs) and potentially carcinogenic nitramines (NAs) can form in the atmosphere from amines escaping amine-based carbon capture plants (CCP).
- These are mobile substances that can end up in drinking water sources.
- A dynamic modelling tool is under development to guide the industry and regulators to ensure that the drinking water threshold limit (4ng/L) will not be exceeded.
- The major removal mechanism for NSAs is photodegradation, while biodegradation is the dominant removal mechanisms for NAs.
- **Reliable biodegradation rates for NAs are needed to realistically simulate future levels in the water compartment.**

EXPERIMENTAL DESIGN



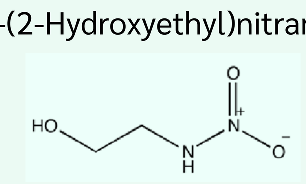
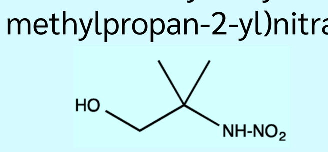
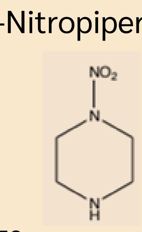
- A modified OECD 309 simulation test.
- 3 different nitramines either separately or together at 100 µg/L.
- Inoculum was either water alone, water and sediment, or water with suspended sediment from a lake used as drinking water source.
- Fresh inoculum and adapted inoculum (5 mg/L for 2 months)
- Primary degradation was measured in 4 replicate bottles by LC-MS/MS and compared to the abiotic control.

RESULTS



- Biodegradation rates varied for the different compounds.
- MEA faster degradation than AMP, NIPZ had limited or no biodegradation within 60 days.
- Adding sediment to the surface water increased biodegradation rates.
- MEA had rapid degradation in abiotic control with sediments.
- Adaption of inoculum improved biodegradation rates.

Table 1: Primary biodegradation rates of nitramines in three experiments. Results are presented as mean of four replicates. DT_{50}: time to reach 50% biodegradation. T_{lag}: time to reach 10% biodegradation. ND: not determined due to no degradation. Experiment 2 had two parallel inoculums (P1 and P2) with four replicates each. P1 for adapted inoculum P-enriched and P1 non-adapted inoculum was discontinued on day 28 due to technical failure.

		MEA N-(2-Hydroxyethyl)nitramide 		AMP N-(1-Hydroxy-2-methylpropan-2-yl)nitramide 		NIPZ 1-Nitropiperazine 	
		DT_{50}	T_{lag}	DT_{50}	T_{lag}	DT_{50}	T_{lag}
Exp 1	Water	34	18	77	47	ND (>77)	47
	Water + sediment	7	2	12	2	35	2
	Abiotic control	>47	18	ND (>77)	ND (>77)	ND (>77)	72
Exp 2	Single compound	15	3	34	12	ND (>59)	59
	Combined exposure	15	7	40	14	ND (>59)	21
	Abiotic control	21	14	>59	17	ND (>59)	ND (>59)
Exp 3	Adapted inoculum	p1: >14 p2: 9	p1: 6 p2: 4	p1: 34 p2: 23	p1: 17 p2: 14	p1: ND(>83) p2: ND(>83)	p1: ND(>83) p2: ND(>83)
	Adapted inoculum P-enriched	p1: 8 p2: 8	p1: 2 p2: 3	p1: x p2: 38	p1: 21 p2: 14	p1: x p2: ND(>83)	p1: 10 p2: ND(>83)
	Non-adapted inoculum	p1: >14 p2: 17	p1: 4 p2: 4	p1: x p2: 42	p1: x p2: 28	p1: x p2: ND(>83)	p1: x p2: ND(>83)

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