Nitrogen effluents from mine sites: Environmental effects and removal of nitrogen in recipients

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- ***Roger Herbert***, senior researcher

Focus area

Decreased environmental effects from mining operations

The project is directed towards ***Decreased environmental effects from mining operations***, which is one of five focus areas defined by the Swedish mining industry regarding research and development

VISION OF THE FOCUS AREA

The environmental effects from present and future mines are sustainable in a long-term perspective

Research within the focus area

Research within the focus area is directed towards:

- Improving the understanding of the distribution and natural variations of concentrations of metals, nutrients and other elements that are common in mineralized areas

- A better understanding of ecosystem adaptation and resilience regarding environmental effects from elements occurring in mineralized areas

Studies of nitrogen effluents from mine sites are a part of this focus area

Why study nitrogen in mining recipients?

Nitrogen sources in the mining industry

- Ammonium nitrate based explosives (ANFO) used in mining operations
- Sodium cyanide (NaCN) used in gold extraction from sulphide ores

Potential problems with nitrogen in mine water recipients

- Nitrogen is released into streams and lakes in forms that are available as nutrients to plants and algae (ammonium and nitrate)

- The added amount of nutrients will increase plant growth to undesired levels (eutrophication), and the species composition in plant and algae communities may change

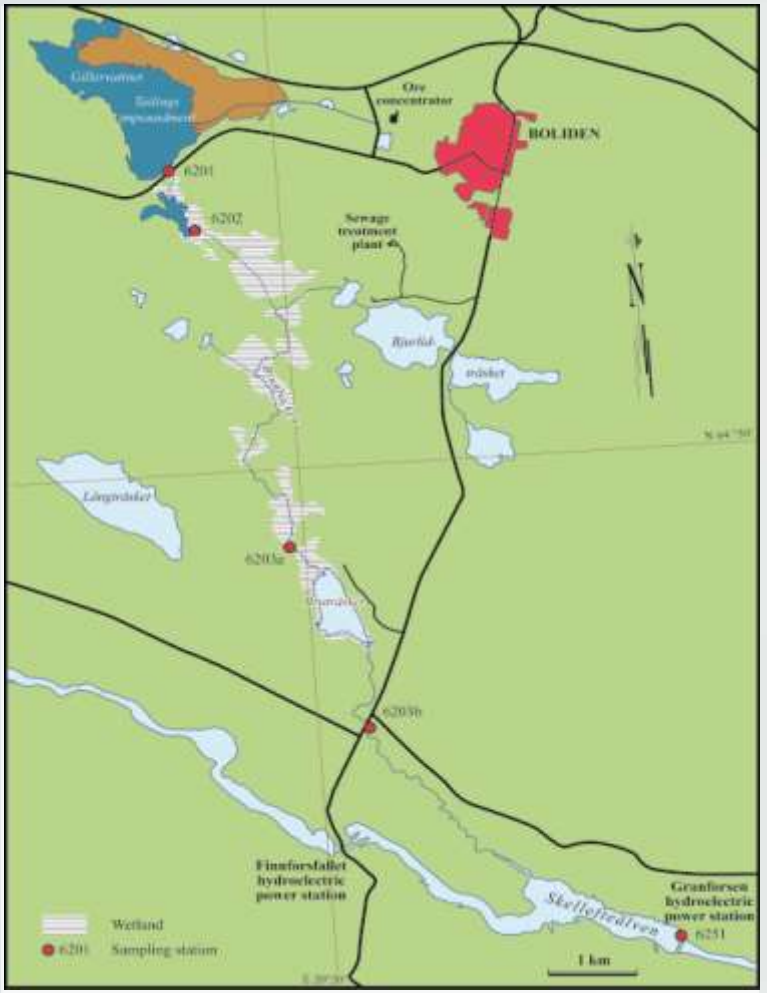
Aquatic plants in eutrophicated lake

There is a need to reduce nitrogen effluents from mine sites and to increase nitrogen removal in mine water recipients

Field area at Boliden

Boliden–Brubäcken–Skellefte-River

- Nitrogen effluents are dominated by ammonium (~5 mg/l) from the Boliden plant
- Nitrate: ~1 mg/l
- Phosphorus: ~300 µg/l
- Dilution ~400 times from Brubäcken to Skellefte River

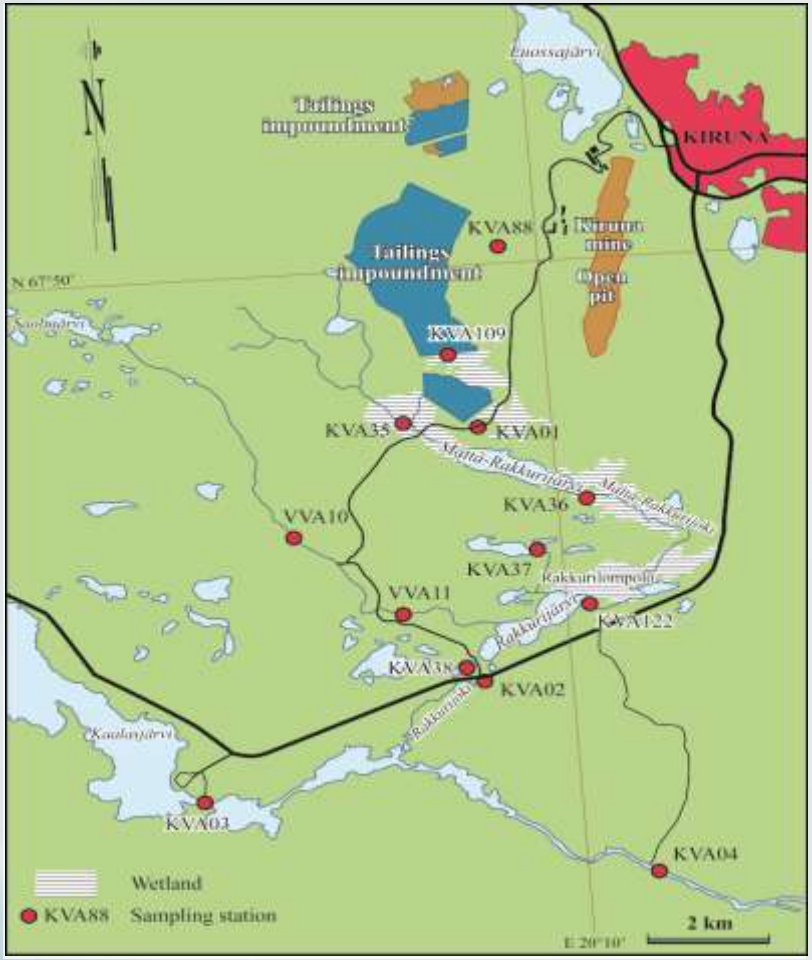


Sampling at 5 locations along Brubäcken

Field area at Kiruna

Kiruna–Rakkurijoki–Kalix-River

- Nitrogen effluents are dominated by nitrate (≤20 mg/l) from the Kiruna mine
- Ammonium: ~0.1 mg/l
- Phosphorus: ~30 µg/l
- Dilution ~100 times from Rakkurijoki to Kalix River



Sampling at 13 locations in the Rakkurijoki system

Four main research topics

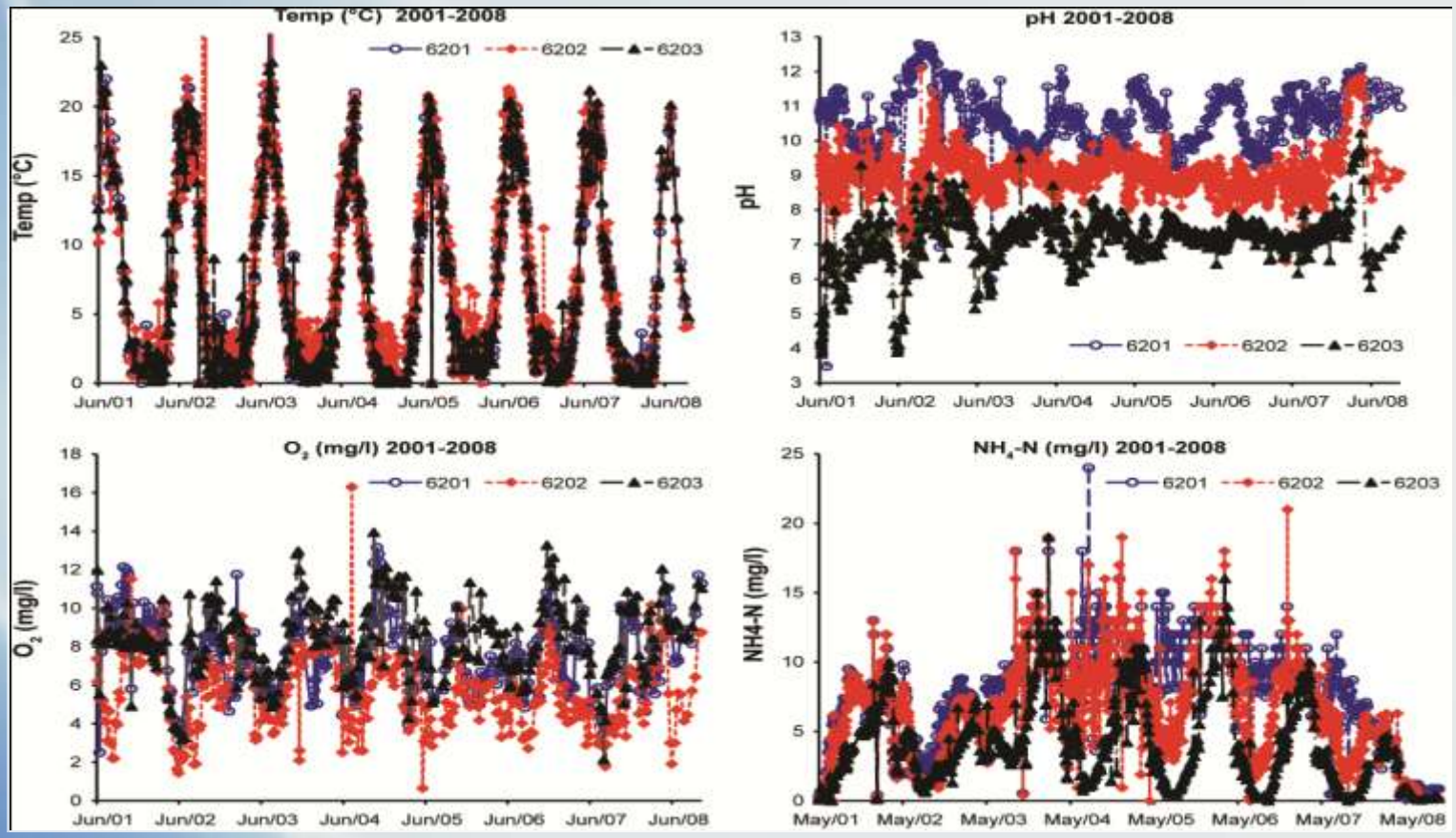
1. Forms of nitrogen, environmental effects and natural removal of nitrogen in mine water recipients at Kiruna and Boliden

2. Installation of a pilot-scale reactive barrier for nitrogen removal at the Malmberget iron mine

3. Studies of the relative importance of nitrogen and phosphorus for eutrophication in mine water recipients

4. Studies of nitrogen concentrations and transport in the Kalix and Skellefte Rivers downstream of Kiruna and Boliden

Field data Boliden (2001-2008)

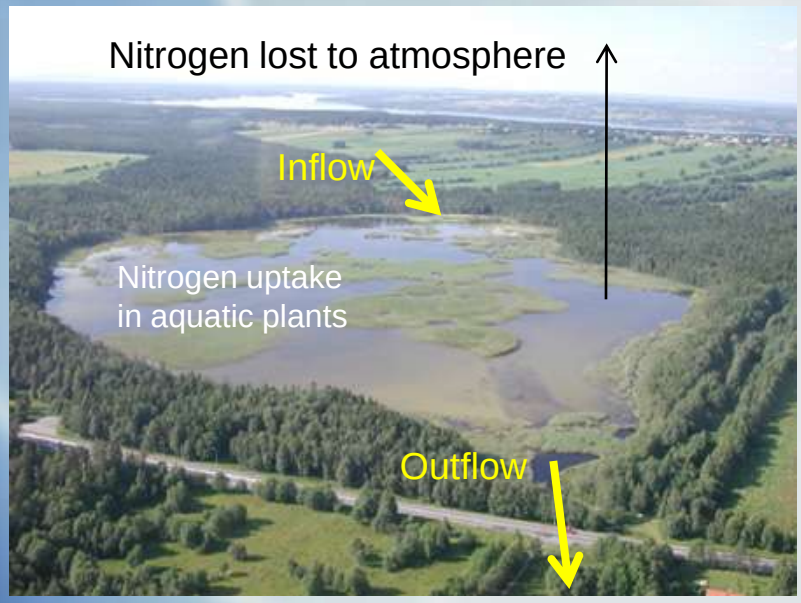


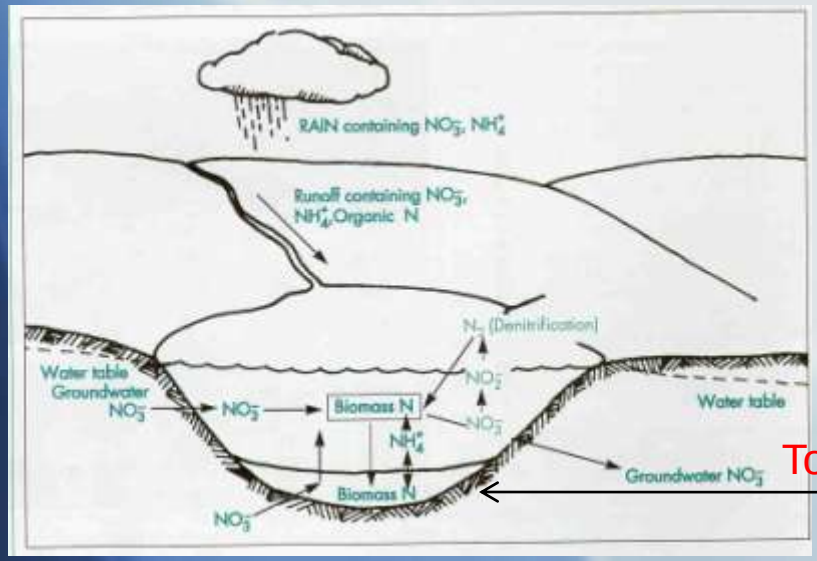
Clear seasonal variations, with lower ammonium concentrations during

summer.

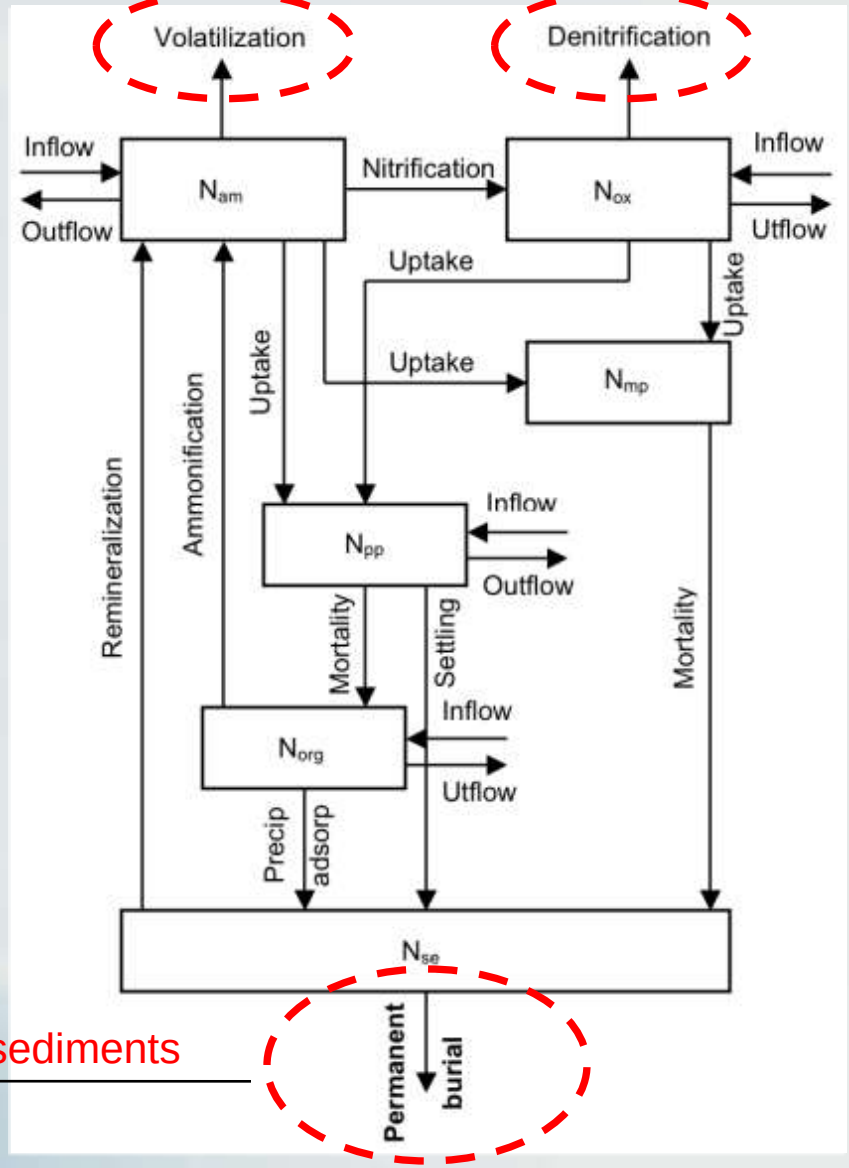
Possible explanations: dilution during springflood, biological uptake by aquatic plants, and oxidation of ammonium into nitrate

Conceptual model of nitrogen transformations in lakes





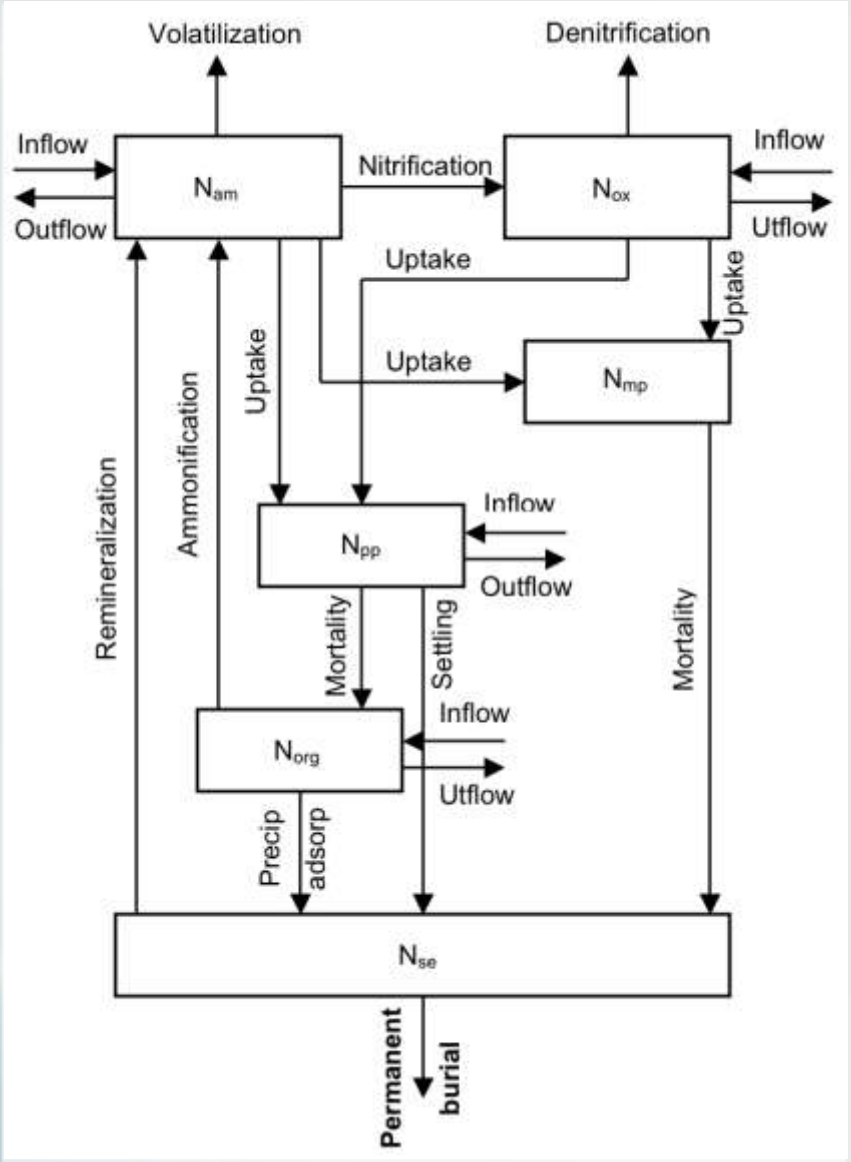
To atmosphere



To sediments

Computer simulation of nitrogen transformations in lakes

- The model is calibrated using field data from lakes at Boliden and Kiruna
- Nitrogen transformations by different processes can be quantified
- The model will be tested in lakes of different size and in systems dominated by ammonium or nitrate

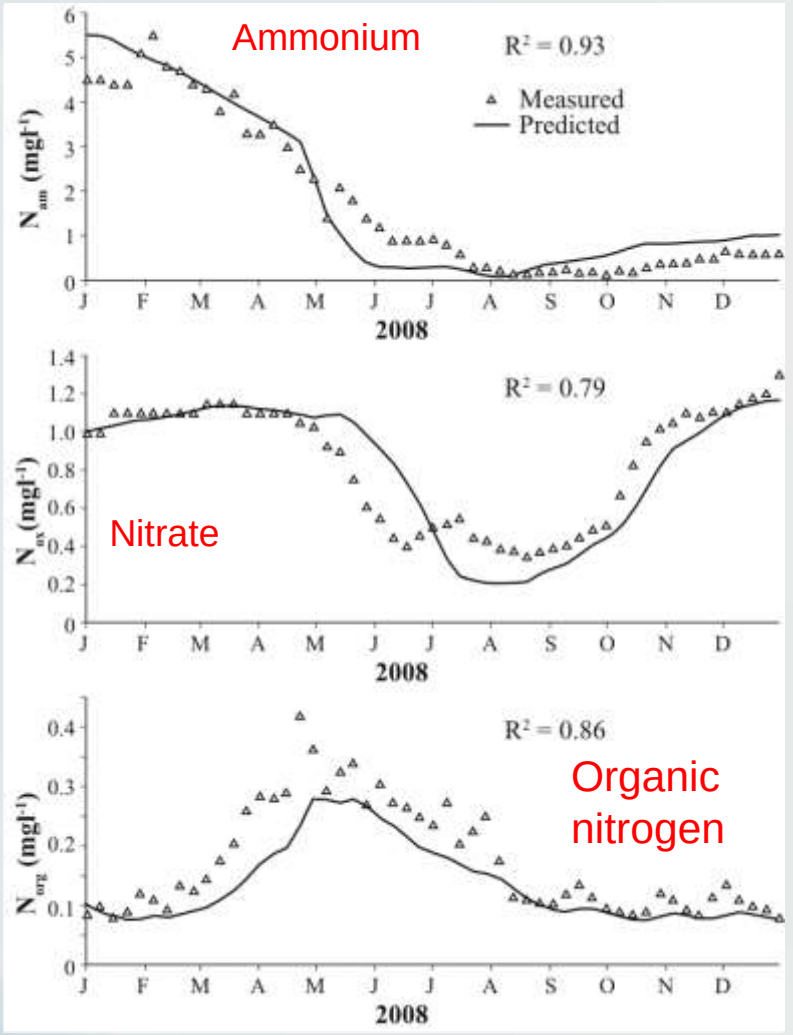


Comparison between measured data and simulations for Nya Sjön, Boliden

Simulation of ammonium and nitrate concentrations in the lake during 2008

Good correlation between measured and predicted ammonium, nitrate and organic nitrogen

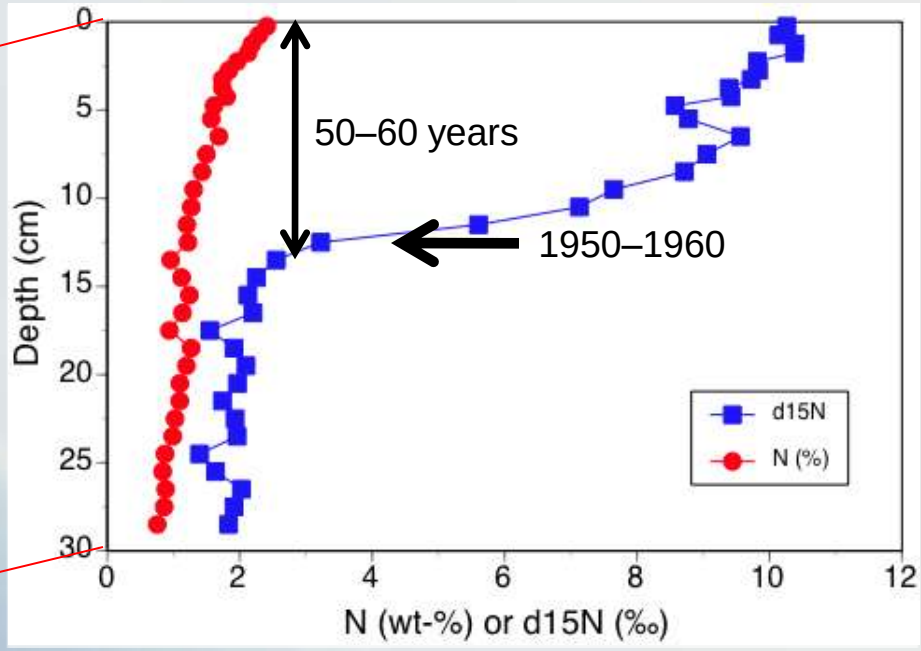
Simulations will be performed also for lakes in the Kiruna area



Measured (Δ) Predicted (——)

Studies of lake sediments at Boliden and Kiruna

- Sediments dated with a radiometric method (the isotope ^{210}Pb)
- At Kiruna, nitrogen isotopes ($d^{15}N$) show that the source of nitrogen in lake sediment changed about 50–60 years ago
- Probably related to the use of ammonium nitrate-based explosives in the Kiruna mine

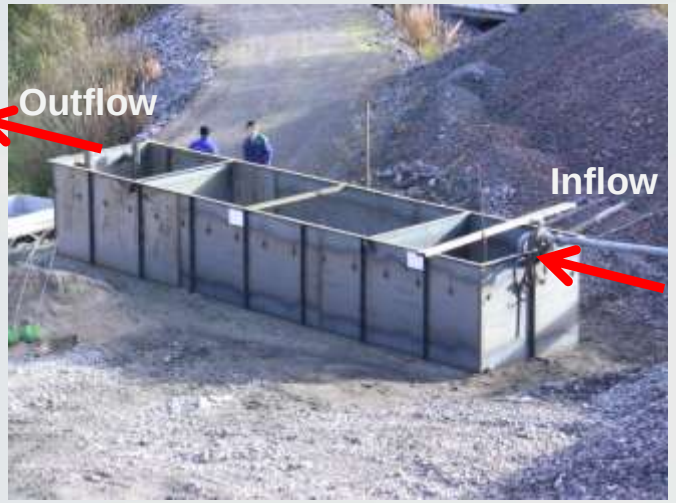


Nitrogen removal at the Malmberget mine
Pilot-scale reactive barrier

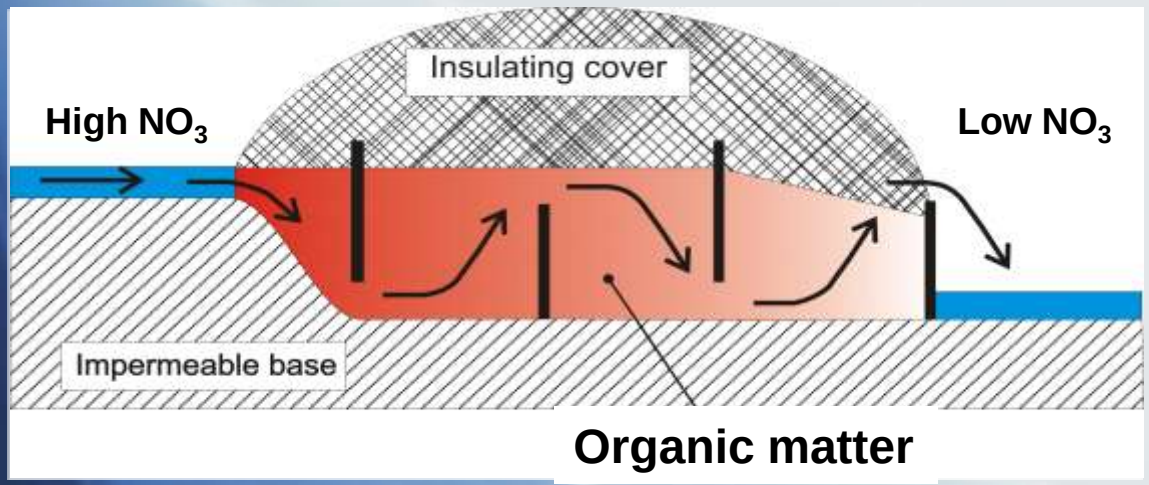
The possibility to remove nitrate by transforming it into nitrogen gas in an engineered, reactive barrier is investigated

A nitrate removal capacity of ca 50 % was achieved during the summer of 2010

Barrier installation



$$5CH_2O + 4NO_3^- \rightarrow 2N_2 + CO_2 + 4HCO_3^- + 3H_2O$$



May be useful for minor water discharges with high nitrate concentrations

Expected outcomes

- Development of a quantitative model for nitrogen and phosphorus in mining recipients, that will be useful as a decision support tool for development of strategies to prevent eutrophication
- Quantification of nitrogen removal in natural recipients and engineered reactive barriers
- Determination of the relative importance of nitrogen and phosphorus for eutrophication in mine water recipients