WATERPRO

Good Practices
Pilot sites: Luleå University of Technology

Removal of mine-water nitrogen by wetlands in cold climate


A natural wetland at the Kiruna site


Field mesocosms at the Kiruna site

Summary: This study was performed by Swedish University of Agricultural Sciences. The efficiency of native, subarctic macrophyte species growing in cold-climate wetlands was studied at the Kiruna mine site in northern Sweden. Macrophytes are important not only for plant N accumulation, but also for facilitating denitrification. Mixtures of emerging-bryophyte species were the best-performing growth form combination.

Operation and applicability: Nitrogen removal in cold-climate wetlands is feasible by using native, subarctic macrophyte species despite adverse growth conditions.
Efficiency of method: Depending on species, nitrogen accumulation in emerging macrophytes ranged between 1.1–30 mg N/m^2/day. Higher N accumulation rates were observed for macrophytes grown in constructed floating wetlands (8–107 mg N/m^2/day).

Background

- Ammonium nitrate based explosives are a major nitrogen source in the mining industry. At many mines, undetonated explosives are the main source for nitrogen leaching into mine waters.
- Nitrogen release, mainly as nitrate, should be reduced to minimize eutrophication of receiving waters.
- Active treatment of large water volumes from mines is expensive and difficult to achieve.
- Natural and constructed wetlands are widely used for nitrogen removal from water, but the potential of constructed wetlands for nitrogen removal in cold climates needs further research.
- A project was conducted at the Kiruna iron mine in Sweden to investigate the potential for removal of mine-water nitrogen in cold-climate wetlands relying on macrophyte uptake and denitrification.

Research questions

- What is the phytoremediation potential of native, subarctic plant species in cold climate?
- What is the relative contribution of N uptake vs. denitrification in the rhizosphere for N removal in cold-climate wetlands?
- Does macrophyte growth form richness affect plant N uptake and plant-associated denitrification in wetlands?
- Which abiotic factors and plant traits explain N uptake and plant-associated denitrification in wetlands?
- Is the application of constructed wetlands feasible for long term N removal at the local scale in cold climate?

Wetlands and cold climate: While constructed wetlands are common in temperate, subtropical, and tropical regions, their functioning is less well understood in subarctic and arctic regions. Prevailing temperature and light regimes are among the major challenges for successful nitrogen removal in these regions. In addition, several of the most studied macrophyte species such as *Phragmites australis* and *Typha* spp. are either rare with low biomass or do not occur in subarctic and arctic regions.

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Mesocosm and field measurements at the Kiruna mine site

Constructed floating wetlands in lake receiving mine effluents

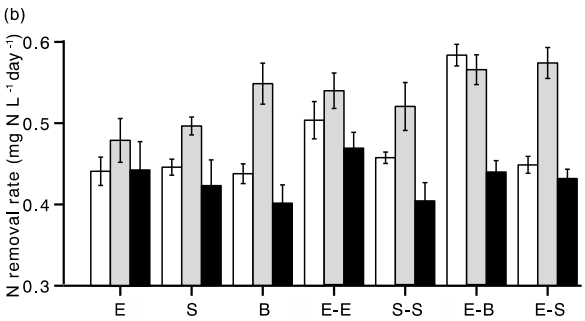
Detail of floating wetland with macrophytes

Methods

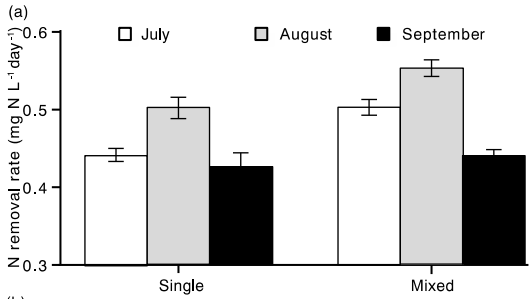
- Measurements were conducted in mesocosms (growth chambers, greenhouse, field mesocosms) and in the field (Kiruna mine site).
- Macrophytes from the mine site were cultivated in mesocosms with sediment and water from wetlands at the site.
- Dried plant samples were ground until passing through a 1 mm mesh sieve, and analyzed for total C and N.
- Potential denitrification activity (PDA) was measured on macrophyte roots and bryophyte shoots.
- Constructed floating wetlands planted with macrophytes were deployed in field mesocosms and in a lake receiving mine effluents.
- Plant standing biomass, N accumulation in above ground biomass, and PDA were measured in the constructed floating wetlands.

Results

- Growth form combinations can be a useful guide to select macrophyte species for enhanced N removal in constructed wetlands.
- Mixtures of emerging-bryophyte species were the best-performing growth form combination, followed by emerging-emerging species.
- Macrophytes are important not only for plant N accumulation, but also for facilitating denitrification.
- Denitrification gene abundance on roots and shoots can predict denitrification potential.
- The relative dominance of plant N accumulation and plant-associated denitrification depends on the combinations of macrophyte species.
- Extrapolation of mesocosm-scale results to wetland-scale can be facilitated by using drones with high-resolution remote sensing equipment.



N removal rates with different growth form combinations. E: emerging species. S: submerged species. B: bryophytes.



N removal rates in single- and two-species cultures.

MORE INFORMATION
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