



UPPSALA
UNIVERSITET

Nitrogen removal from waste rock drainage in northern Sweden with denitrifying woodchip bioreactor

Roger Herbert^a, Maria Hellman^b, Sara Hallin^b

^aDepartment of Earth Sciences, Uppsala University

^bDepartment of Forest Mycology and Plant Pathology, Swedish University of Agricultural Sciences



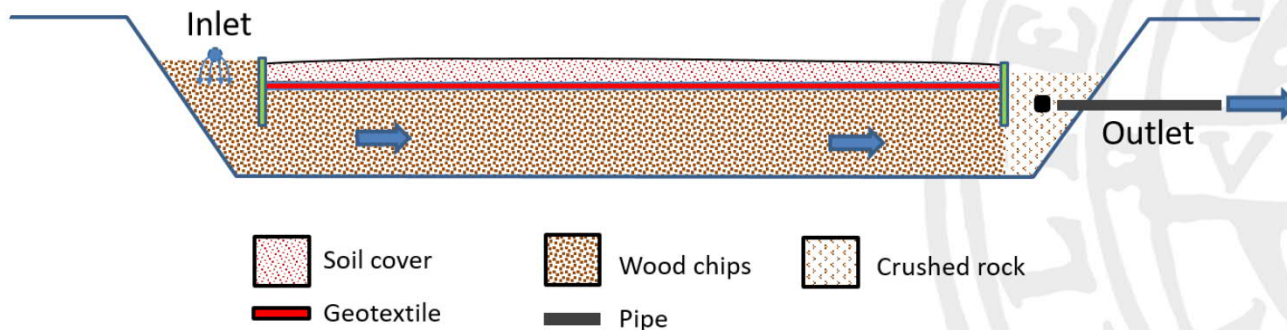
Nitrem

Nitrogen removal from mine drainage



Central component in Nitrem service: Bioreactor technology

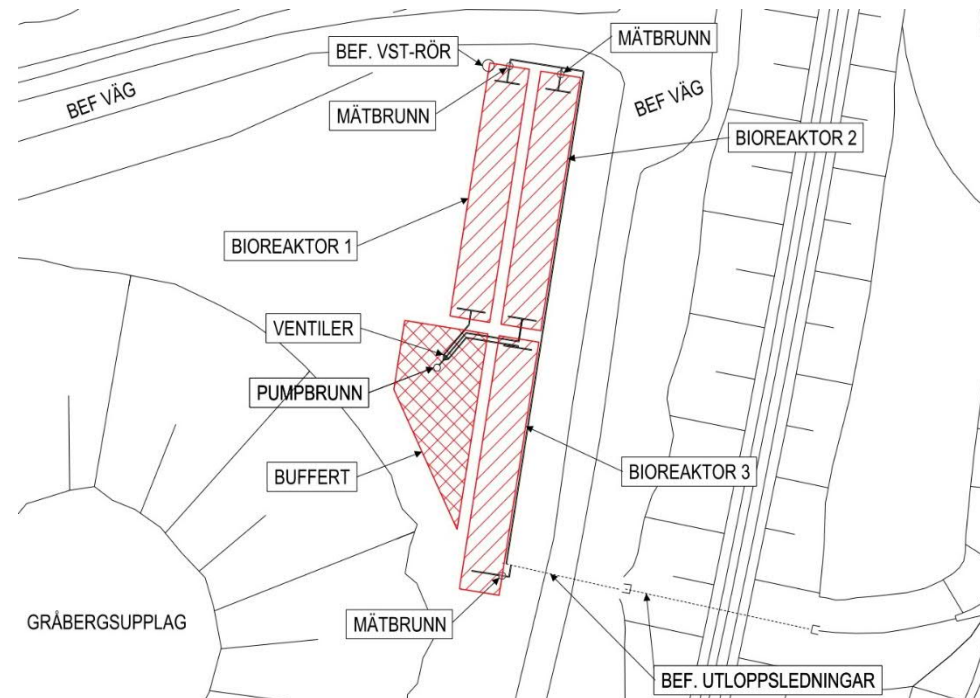
- “Denitrifying woodchip bioreactor”
- Addresses the need for nitrate removal from mine drainage
- Denitrifying bacteria promote the reduction of dissolved nitrate to harmless nitrogen gas.
- Excavation lined with an impermeable geomembrane (HDPE plastic) and filled with pine wood chips and a small amount of activated sewage sludge.
- Organic material functions as a carbon and energy source for the denitrifying bacteria.





Bioreactor system

- Water reservoir (*buffert*) collects groundwater seepage, which consists almost exclusively of leachate from waste rock dump (*gråbergssupplag*)
- Water pumped from a pumping chamber (*pumpbrunn*) through gate valves (*ventiler*) to the bioreactors.
- Water discharges from each bioreactor through a 1600 mm diameter) monitoring chamber (*mätbrunn*) and further to a drainage ditch (*Bef. Utloppsledning*)





Bioreactor operations

- A full-scale woodchip denitrifying bioreactor has been in operation since September 2018 in Kiruna for the removal of nitrate (NO_3^-) from waste rock leachate
- Drainage from the waste rock pile is pumped at an average rate of $22 \text{ m}^3/\text{d}$ into the bioreactor
- Leachate characterized by
 - neutral pH (average pH 7)
 - moderate alkalinity (108 mg/L HCO_3^-)
 - sulfate, chloride and NO_3^- (average concentrations 670 , 61 and 102 mg L^{-1} respectively) from mineral dissolution and explosive residues, respectively

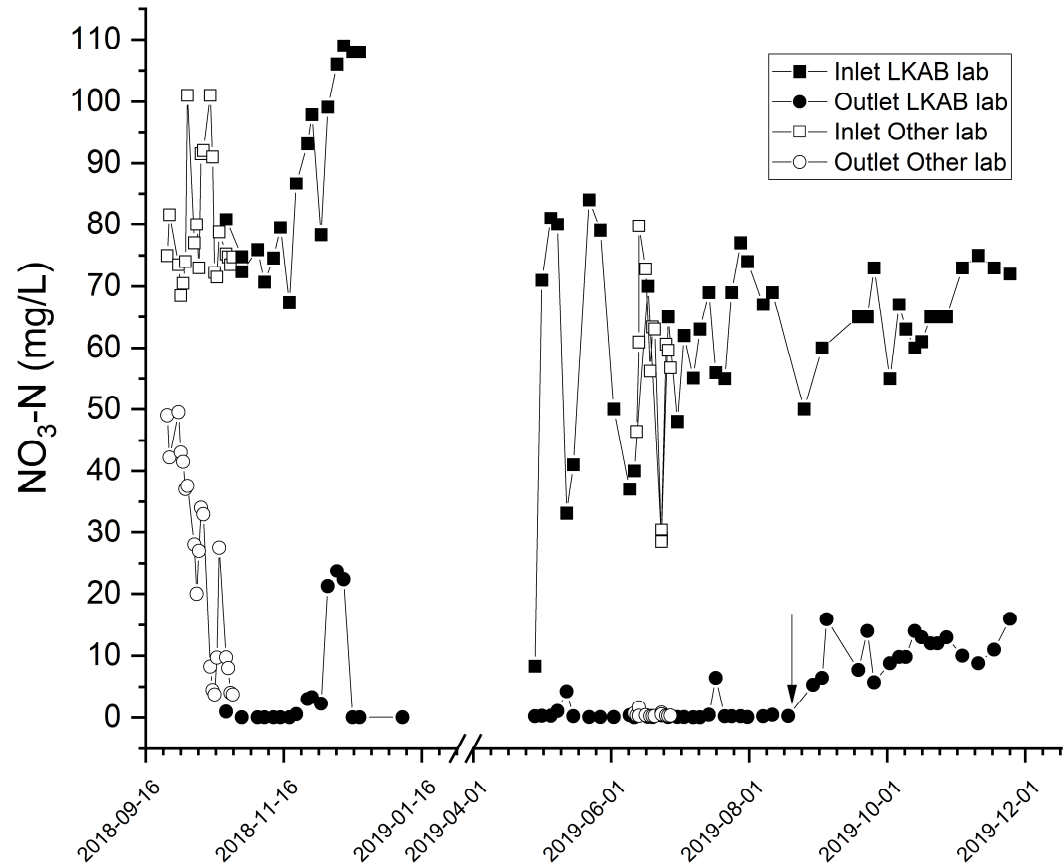


Nitrate removal

Nitrate concentrations in pumping chamber (“Inlet”) and bioreactor monitoring chamber (“outlet”) since start of operations.

Samples are analyzed by LKAB’s lab or by summer interns (“other lab”).

Arrow marks date when H_2S was detected in bioreactor effluent.





Nitrogen fluxes

Calculated nitrogen fluxes at bioreactor inlet and outlet. Calculations use average daily flows and biweekly nitrogen analyses. For calculations, concentrations are assumed to remain constant until next nitrogen analysis.

For measurement period:
Influent: 221 kg NO₃-N
Effluent: 23 kg NO₃-N, 26 kg NO₂-N, 1.6 kg NH₄-N.
0.5 kg N₂O(g) emitted.
Overall N removal efficiency of bioreactor is ca. 77%

