# Nitrogen effluents from mine sites – environmental effects and removal of nitrogen in recipients

*Anders Widerlund[1], Sara Chlot[1], Roger Herbert[2], Björn Öhlander[1]*
*Affiliations: [1]Divison of Geosciences, Luleå University of Technology*
*[2]Department of Earth Sciences, Uppsala University*

In most mining regions in Sweden, natural total nitrogen concentrations (sum of concentrations of all species) are usually below 0.3 mg/L, which is the upper limit of low concentration suggested by the Swedish Environmental Protection Agency. In contrast, nitrogen concentrations in waters discharged from mine sites often greatly exceed the 5 mg/L suggested as the lower limit of extremely high concentrations. Ammonium nitrate-based explosives and sodium cyanide (NaCN) used in gold extraction are two major nitrogen sources at mine sites. As nitrogen is an essential nutrient in aquatic ecosystems, high levels of nitrate and/or ammonium may be associated with eutrophication of surface waters. This presentation provides an overview of a Swedish research programme addressing the discharge, transformation and attenuation of nitrogen in mining recipients (Frandsen et al., 2009). The programme runs during the period 2008–2011, and is financed by The Swedish Governmental Agency for Innovation Systems (VINNOVA), the mining companies LKAB, Boliden Mineral AB and The Adolf H Lundin Charitable Foundation.

## Main goals of the research programme

The main goals of the research programme are:

- To quantify the environmental significance of nitrogen effluents from the mining industry in relation to the natural load of nitrogen in streams and rivers. The knowledge gained will be used to address the question to what extent the status assessment of waters according to the EU Water Framework Directive is affected by the nitrogen load from mine sites.
- To improve the possibilities to reduce nitrogen discharge through efficient water management at mine sites (optimized conditions in clarification ponds and nitrogen removal in natural wetlands and/or constructed wetlands/barriers).

## Methods

Fieldwork is carried out in two recipients receiving waters with high nitrogen concentrations from the Kiruna and Boliden mine sites in northern Sweden (Figure 1). Data from the two recipients includes regular monitoring data collected by LKAB and Boliden Mineral AB, as well as data collected within the VINNOVA project. At the two field sites, total nitrogen, ammonium, nitrite, nitrate, total phosphorus, phosphate, chlorophyll-a and main and trace elements are determined. Biogeochemical computer simulation models based on system dynamics modelling will be developed for the two studied recipient systems. At the Malmberget iron mine, a pilot-scale barrier for nitrate removal through denitrification has been in operation from April to October 2010.

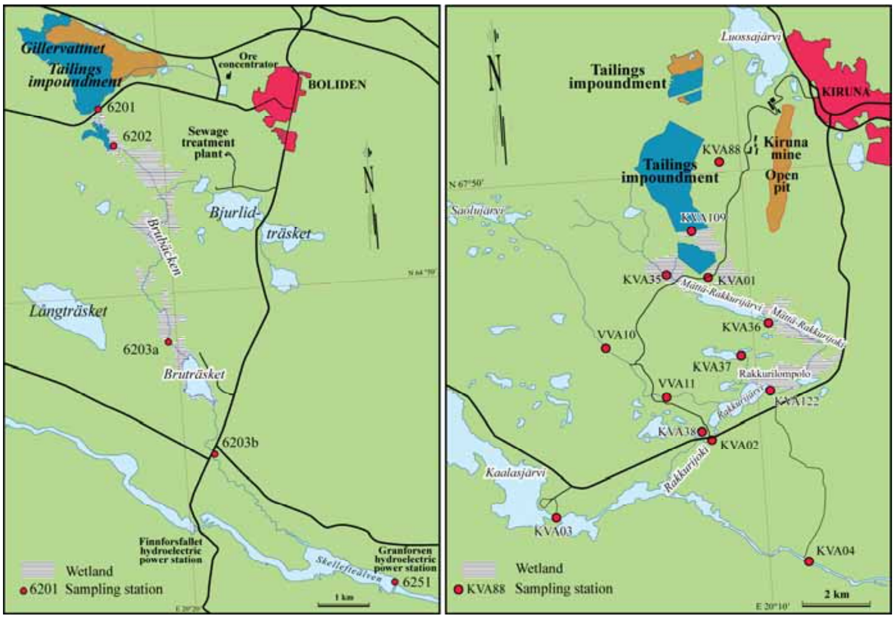


***Figure 1.*** *Study areas at Boliden (left) and Kiruna (right)*

## Results

Samples of water, sediments and plankton have been collected in the recipients at Boliden (Brubäcken) and Kiruna (Rakkurijoki) from April 2008 to October 2009 (in addition to regular monitoring data from the mining companies). The analytical data is of good quality, and clear seasonal trends are evident in both recipients.

Development of a computer simulation model has been in progress since January 2009, and preliminary model results from the Boliden site show good correlation between measured and simulated nitrogen concentrations (Siergieiev, 2009). There are signs of eutrophication with increased biomass growth in both the Brubäcken and Rakkurijoki systems. Depending on the nitrogen load, the Brubäcken system appears to vary between nitrogen and phosphorus limitation.

Laboratory experiments show that denitrification can be initiated and maintained in mesocosms containing an organic substrate (Herbert Jr, 2011). Results from the pilot-scale barrier at Malmberget show that on average ~50 % of the influent nitrate was removed at mean daily temperatures of 5–10 °C. Adding a source of reactive carbon to the barrier could possibly improve the nitrate removal efficiency.

## Conclusions

System dynamics modelling suggests that 1) denitrification and 2) nitrogen uptake by aquatic plants followed by permenent nitrogen burial in lake sediments are the two main nitrogen sinks in the Brubäcken recipient (Siergieiev, 2009). Modelling of nitrogen transformation pathways will be performed also in Rakkurijoki, the mine water recipient at the Kiruna site.

By varying the input data, the model can be used to simulate possible future scenarios and final nitrogen concentrations in the receiving waters at mine sites. Computer simulations based on the developed nitrogen transformation model thus will be useful as a decision support tool in the work towards reduced nitrogen effluents from mine sites.

## References

**Frandsen, S., Widerlund, A., Herbert, R., Öhlander, B., 2009.** Nitrogen effluents from mine sites in northern Sweden – environmental effects and removal of nitrogen in recipients. Abstract, Securing the Future and 8th ICARD International Conference on Acid Rock Drainage, Skellefteå, Sweden, June 23–June 26, 2009 (http://www.securing.skelleftea.se).

**Herbert Jr, R. B., 2011.** Implications of non-equilibrium transport in heterogeneous reactive barrier systems: Evidence from laboratory denitrification experiments. J. Contaminant Hydrology, 123, 30–39.

**Siergieiev, D., 2009.** Simulation of nitrogen transformations in the mine water recipient at Boliden, Sweden, using system dynamics modeling. Master's Thesis, Luleå University of Technology, 2009:096 PB.