Environmental impacts of mining activities and methods to reduce such impacts

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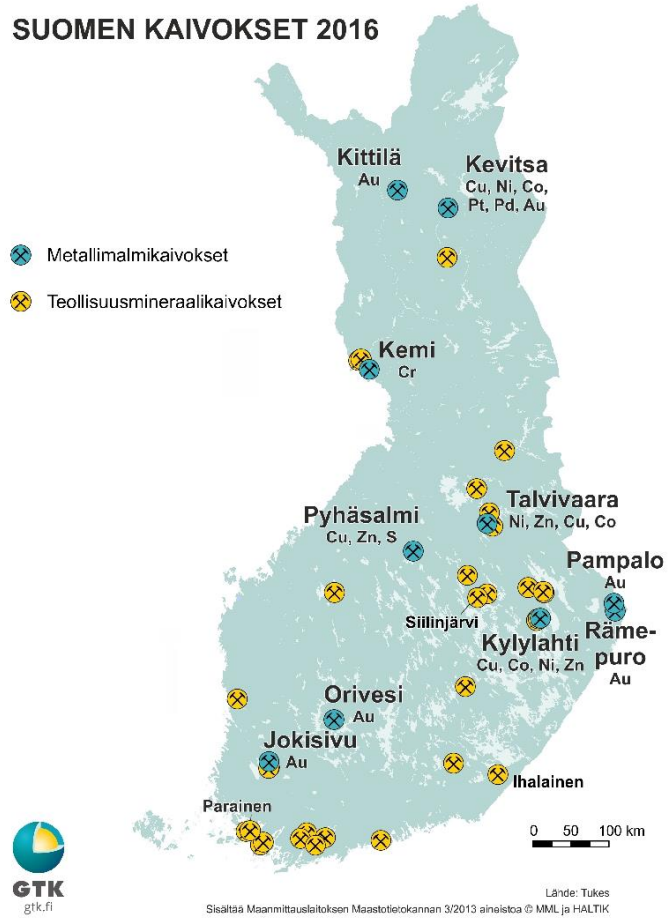
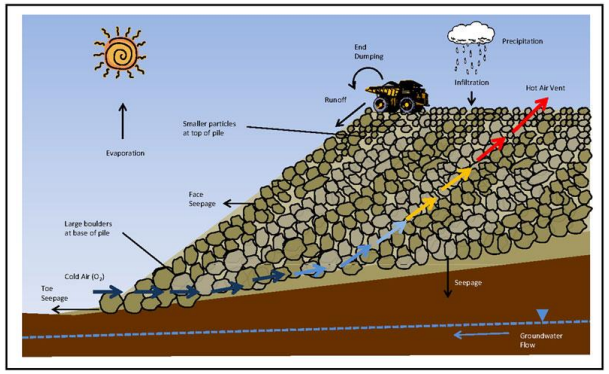


CONTENT OF PRESENTATION

- Mining pollutant and effluents
- Water impact assessment
- Purification methods and control

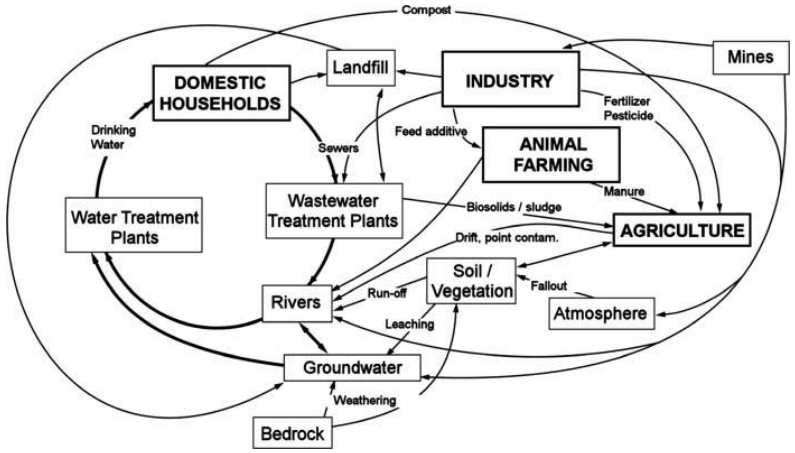
Metals and non-metals

Mining related pollutants and efffluents



Sources:

- mining process
- weathering of rocks
- explosives
- Industry fallout
- Settlements related to mining communities



Balderacchi et al. 2013

Pathways:

- Surface water (sediments, dissolved compounds, reactive compounds)
- Groundwater and vadoze zone
- Air

Receptors:

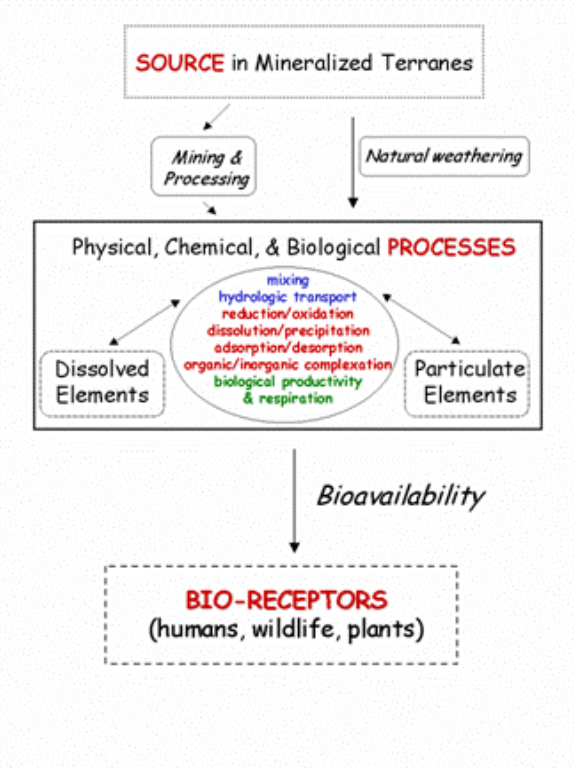
- River and lake systems and their habitats
- Vegetation
- Wells etc.

https://minerals.usgs.gov/west/projects/pathdel.htm

Mining water and effluents

- Unique composition which depends on bedrock (ore), process used, water purification techniques, climate etc. Mines can effect nearby water systems, so treatment required..
- Metals, metalloids, pH, suspended sediments, nitrogen from explosives, chemicals (process residue), salinity
- pH influence mining water classification (metal solubility)
- Some metals are toxic some have other indirect negative impacts if in excess in the environment
- Saline waters: pristine, natural surface waters draining Precambrian rocks in Scandinavia are typically low-ionic strength waters with specific conductivities below 100 µS/cm. In contrast, specific conductivities of effluents from major Swedish mine sites may exceed 2000 µS/cm (Öhlander et al.).

Water impact assessment approches and methods



- **BACI: Before-After Control-Impact assessment**
  - Sampling before and after mining
  - Control sites not affected by mining
- **Upstream - downsteream monitoring**
  - Upstream pristine
  - Downstream affected by effluents
- **Expert opinions**
  - Sound and diverse knowledge needed (hydrology, geochemistry, ecology, environmental sciences and engineering, social sciences)
  - Precautionary principle should apply. Level of expertise on the topic should be provided. Several independent sources, if possible.
- **Assess expected chemistry and treatment options from mines**
  - Equilibrium chemistry etc.
- **Mathematical (numerical) modeling**
  - Assumptions must be relevant and correct
  - Data, knowledge and time needed
  - Uncertainty assessment or discussion
  - Scenarios and forecasts useful
- Monitoring and follow up

Numerical flow modellig

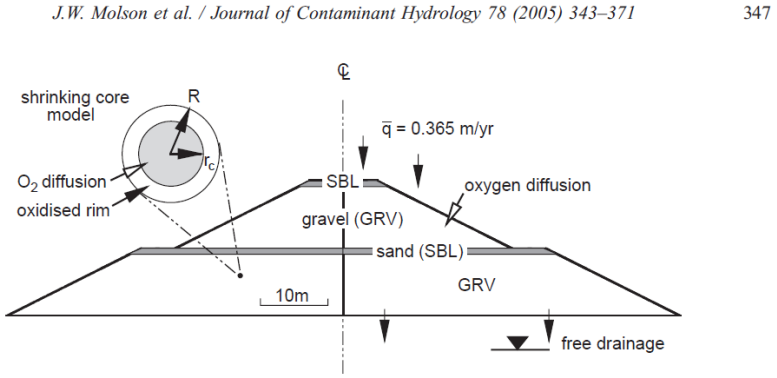
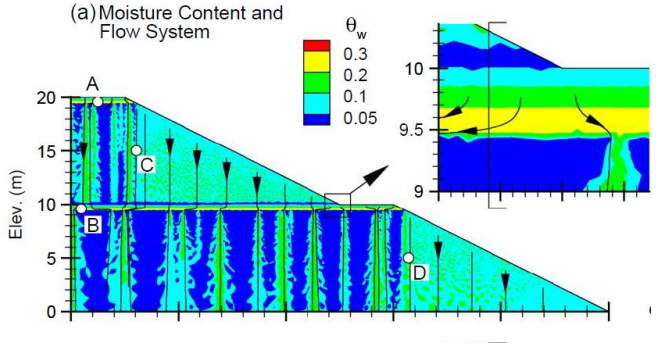
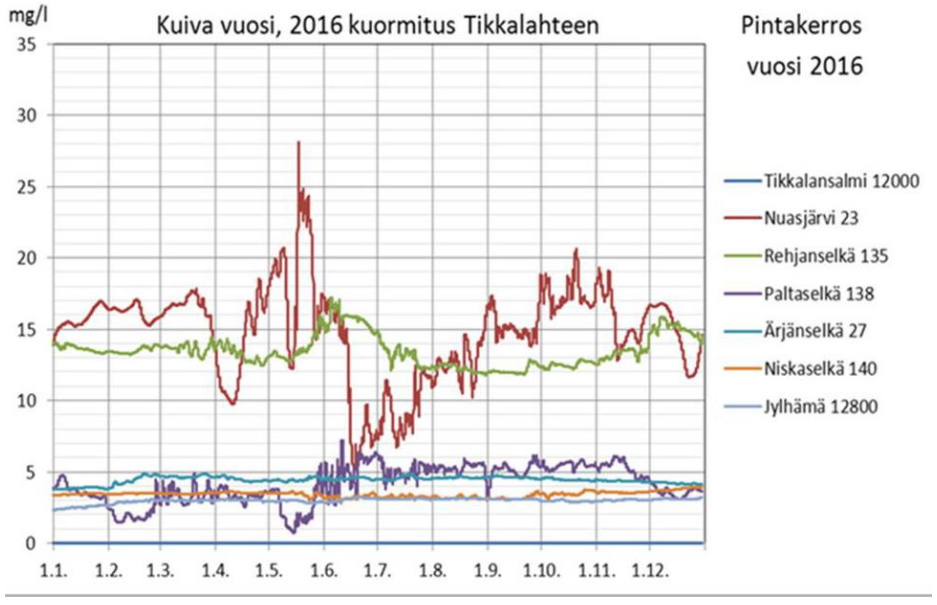


Fig. 1. Conceptual model developed for flow and transport simulations of waste rock piles. The simulations consider only the right-side symmetric 2D Cartesian section.

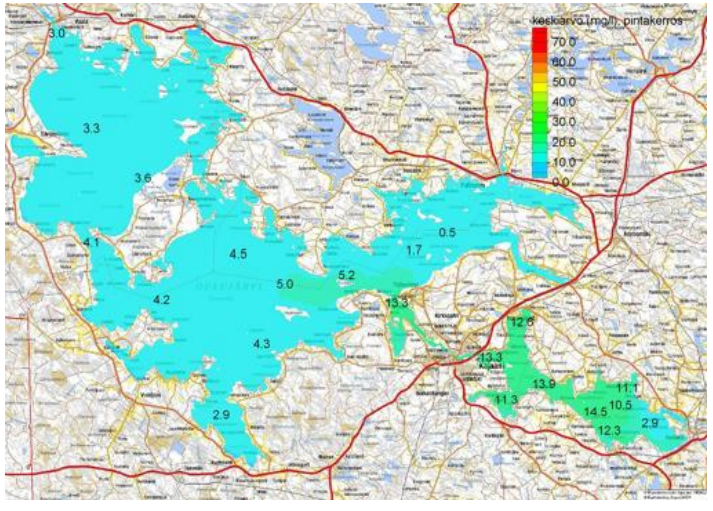


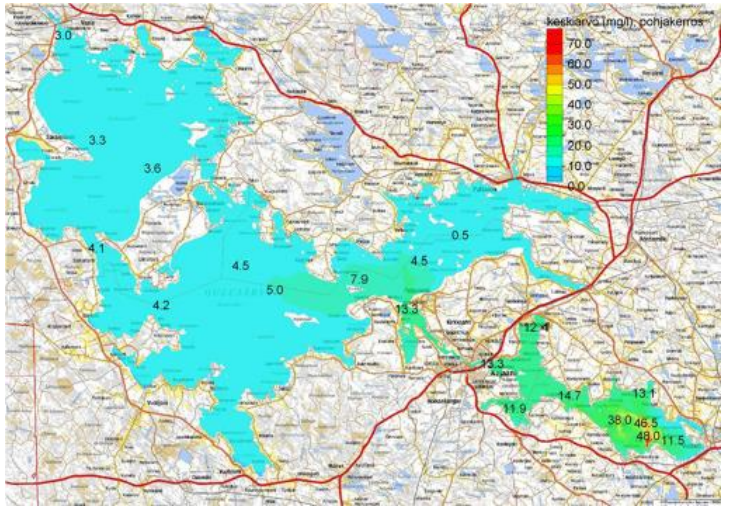
- **Data requirements: climate, hydrology (discharge, hydraulic heads, land use), geology (Ground water), reactions, effluent discharge point and type, water chemistry, mining discharge time series, concentration in water systems)**
- **Mathematical modelling approaches**
  - Stochastic (data driven) or process based models (process and hydrology driven)
  - Coupled or fully integrated models
  - Scenario modelling, process operation modelling, support to observations and impact assessment (e.g. plume spreading)
  - Commericial models or tailor made models
- **Transport process in water quality models**
  - Complex chemistry or simple reactions
  - Density effects included or not (depends on model used, if can be included or partly included)
  - Sediments (90 % of metal pollutions transported as bound to sediments) and humic substance important

Example: modelling Nuasjärvi (impact of new dischage pipe from Talvivaara mine)



- **Observed**
  - Surface water 15 mg/l in 2016
  - Bottom layer 110-130 in some places
  - Loading 13 600 tonns sulphate in 2016
- **Mixing and reactions**

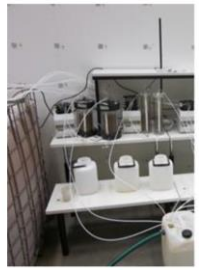




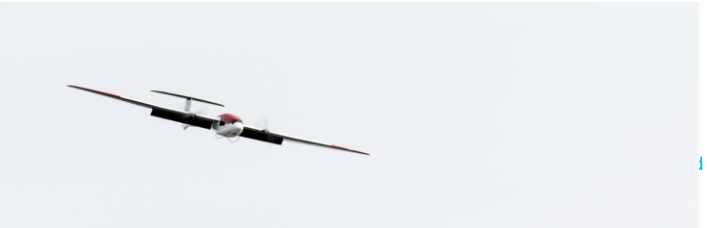
Pöyry Oy - YVA related modelling

Treatment options

Min-North



Resem



Several treatment processes can be used to ensure mine water meets regulatory standards prior to being discharged:

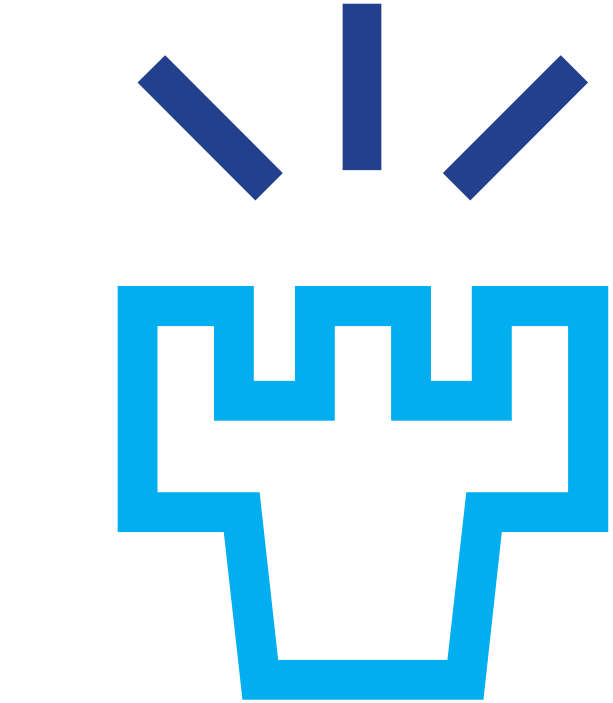
- Intercepting and diverting surface water (rain and snowmelt runoff, streams, and creeks) from entering the mine site (water balance studies)
- Recycling water used for processing ore in order to reduce the volume of water requiring treatment
- Installing liners and covers on waste rock and ore piles to reduce the potential for contact with precipitation and contamination of groundwater
- Chemical precipitation by adding e.g. lime to raise the pH and precipitate metals by settling. Add coagulants for precipitation and sedimentation
- Constructed wetlands and filter systems
  - Constructed wetlands
  - Reactive filters
  - Wetlands and peatlands as buffers
- New solutions
  - Should be tested carefully, also in full scale and real operation conditions
  - Several on-going projects at Univ.Oulu (Resem, Min-North, AoF, Nessling, MVTT etc.) and elsewhere

Pollution, impacts, risks, env. control

- **Mining water**
  - **Different mining phases (life cycle)**
  - **Normal operation vs unusual events and even accidents**

→ Should environmental permitting consider variable conditions?

- **Methods should be known and tested (BAT)**
- **Precautionary principle in assessment**
  - Consider underlying uncertainties
  - Do not extrapolate findings (caution)
- **Other issues to consider (environmental assessment and operation)**
  - Fair and open information and communication
  - Research supporting impact assessment and to build up knowledge
  - Report pollution in relation to proportion of impact (do not underestimate or overestimate)



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Thank you for your attention