Environmental characterisation and mine water monitoring

Päivi Kauppila

GTK

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Content

• Need and content of a baseline study
• Characterisation of mining wastes – potential sources of mine drainage
• Water quality monitoring during mining activities
• Post-closure water monitoring
• Focus on mine waters
Before mining / Baseline study (1)

- Studying the natural state / baseline of the proposed (exploration/) mine site and it’s surroundings is needed to:
  - define requirements and pre-conditions set by the environment of the mine site for the implementation and the methods of implementation
  - define the baseline to observe and assess potential environmental impacts of the activities
    - e.g. quality of waters, soils and sediments, biota; water levels
Baseline study (2)

• Is needed to:
  – plan placement of mining and processing activities
    • Quaternary deposits, groundwater aquifers, catchments
  – to design management actions
    • e.g. detailed mapping of the type and structure of Quaternary deposits, groundwater conditions and bedrock properties in proposed waste disposal areas
    • e.g. carrying capacity of the downstream water bodies – water treatment requirements
  – to define objectives for mine closure
Baseline study (3)

- Should be made latest before any larger changes to the site
  - Smaller scale before exploration
  - More detailed and large scale before initiating preparations for mining
- Is the basis for the EIA
- Should include all parameters
  - on which mining activities may have an impact
    - e.g. complete water chemistry of waters
  - that may be significant with regard to the generation of impacts
    - e.g. hydrogeology properties of the site
Overall content of the baseline study

• Climate
• Landscape, topography, land use
• Socio-economic factors
• Natural landscape, nature, biota
• Conservation areas and sites
• Geology and geochemical baseline
• Waters and their quality
  – Seasonal changes should be included
  – Upstream, downstream of the mine site
  – Complete water geochemistry
• Air quality
• (Characterisation of waste)
Characterisation of mining waste-Requirements in legislation (1)

• Potential waste types:
  – waste rock, tailings, overburden
  – mineral precipitates
    • from water treatment,
    • from mineral processing
• Characterization is needed for the
  – EIA, and
  – the environmental permit application
    • waste management plan
  – during operation as part of emissions monitoring
  – for closure planning of waste facilities
• Waste legislation: requirement to decrease the amount of waste
Characterisation – Requirements in legislation (2)

- Government Decree on Extractive waste (GD 190/2013)
  - amendments to existing Acts and Decrees
- Characterisation should include/define:
  - background data of the:
    - mining and milling processes
    - exploited ore deposit,
  - the processes generating the waste, the type and amount of the waste material, and the chemicals used in the processing,
  - geotechnical behaviour of the waste, and
  - geochemical properties and behaviour of the waste.
Characterisation of mining wastes

• Why characterisation is needed?
  – During and after mining, wastes are potential sources of mine drainage
    • Properties affecting surface water or groundwater quality are important
  – To evaluate optimal use of mineral materials (eco-efficiency) – decreasing the amount of waste
  – To evaluate future drainage quality
    • Long-term chemical alteration of the waste
  – To design disposal facilities and their closure
Characterisation of mining wastes

Geological description of ore deposit

Sampling and pretreatment

Mineralogical and chemical composition ± chemical residues

Geotechnical characteristics (tailings, mineral precipitates)

Determination of acid-generation potential

Assessment of the solubility of harmful substances

Assessment of the risk of major accident for the waste area

Non-sulphide mining waste

Sulphide mining waste

Fe-sulphide mining waste

Inert waste

NP/AP < 3 and S < 1%

NP/AP > 3 and S > 1%

S < 0.1%

S > 0.1%

Kauppila et al. 2013: BEP in Metal Ore Mining
Characterisation methods (1)

• Mineralogy
  – Sulphide minerals and other acid producing minerals, neutralising minerals, potential contaminant sources
  – Optical microscopy, SEM + MLA, XRD

• Chemical composition
  – Potential contaminants (including processing chemical residues) and solubility of harmful substances (metals, oxyanions, salts)
  – Total methods: XRF, total extraction method
  – Solubility: e.g. selective extractions, leaching test, percolation test
    • Also: chemical analysis of process water from concentration tests
Characterisation methods (2)

- Potential to produce acid mine drainage (AMD)
  - Acid production potential (i.e. NP vs. AP)
    - Static tests (e.g. CSN EN 15785, NAG-test)
    - Calculation based on carbonate C –content vs. sulphide S –content
  - AMD quality in long-term
    - Kinetic test methods (e.g. Humidity cell tests)
  - Drainage from waste material of similar ore types with similar processing (analogues)
Water quality monitoring during mining activities (1)

• Operational monitoring
  – Performance of the water treatment systems
    • e.g. active systems, overland flow areas, wetlands

• Emissions monitoring
  – Quality of emissions from operations
  – Process water, dewatering water from the mine workings, seepage waters from the waste facilities
    • Main metals, pH, SO$_4$, N-emissions
    • Toxicity of waste waters (SFS-standards)
  – Sanitary waters
    • T, O$_2$, pH, EC, COD$_{Cr}$, BOD$_7$, TP, TN, NH-N$_4$, bacteria, suspended solids
Water quality monitoring during mining activities (2)

- Environmental impact monitoring
  - Impacts of mining on environment
  - Surface waters
    - the physico-chemical conditions,
    - biological monitoring of surface water
    - monitoring of fish populations and fishing
    - and the monitoring of (aquatic) sediment composition
  - Groundwaters
    - Groundwater monitoring wells, household wells and springs at the mine site and in its’ surroundings
    - Physico-chemical quality and level of the groundwater table
Water quality monitoring during mining activities (3)

• Important!
  – Complete water chemical analysis e.g. once a year
  – Site-specific
  – Should include all potential contaminants
    • process chemical residues
    • residues from explosives
    • those from ore deposit / waste material
  – Monitoring points should be located in potential flow routes of mine drainage
Water quality monitoring during mining activities (4)

• Important!
  – Seepage quality of the waste piles
  – Field measurements + filtration of the samples in the field
  – On-line monitoring
  – Processing and follow-up of the monitoring data
    • actions if negative changes observed
Post-closure water quality monitoring (1)

• To ensure that the mine site poses no environmental or health risks
• To ensure the performance of the closure structures, and to facilitate rapid detection and response in case of failure
  – Waste facilities
    • Seepage water volume and quality
  – Open pit / underground mine
    • Flooding, water quality, discharge quality
  – Water treatment systems
    • Minimum: Inflowing water, out flowing water
Post-closure water quality monitoring (2)

• To monitor the impact on the environment
  – Surface water and groundwater quality at the mine site and its’ surroundings
  – Both upstream and downstream from discharge points
  – Similar parameters to monitoring during active mining

• Site-specific requirements
  – Monitoring programme to be accepted by environmental authorities