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Retention of contaminants in northern natural peatlands treating mine waste waters

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The mining industry in Finland is growing, leading to an increasing number of working and proposed mine sites. As a consequence, the amount of mine waste waters created is likewise increasing. This poses a great challenge for water management and purification, as these mine waste waters can lead to severe environmental and health consequences when released to receiving water bodies untreated. In the past years, the use of natural peatlands for cost-effective passive waste water treatment has been increasing.

In this study, the fate of mine water contaminants in a treatment peatland receiving process waters from the Kittilä gold mine was investigated. Special attention was paid to the fate of potentially harmful substances such as arsenic, antimony or nickel. During the 4 years of operation, the peatland removed contaminants from process waters at varying efficiencies. While arsenic, antimony and nickel were retained at high efficiencies (>80% retention), other contaminants such as zinc, sulfate or iron were not retained or even leaching from the peatland. Soil samples taken in 2013 showed a linear increase of arsenic, antimony and nickel concentration in the peatland as compared to earlier sampling times, in agreement with the good retention efficiencies for those contaminants. Measured concentrations exceeded guideline values for contaminated soils, indicating that the prolonged use of treatment peatlands leads to high soil contamination and restrict further uses of the peatlands without remediation measures.

Soil and pore water samples were taken along a transect with varying distance from the process water distribution ditch and analyzed for total and more easily mobile concentrations of contaminants (peat soil) as well as total and dissolved contaminants (water samples). Concentrations of contaminants such as arsenic, manganese or antimony in peat and pore water samples were highest near the distribution ditch and decreased with increasing distance from the ditch. Moreover, ratios of dissolved and total concentrations in pore water and of mobile and total concentrations in peat changed along the transect. Higher ratios of dissolved contaminants in water in greater distance from the distribution ditch indicate a decrease of particulate matter. Additionally, higher ratios of mobile contaminants in peat at greater distance from the distribution ditch indicate efficient immobilization of contaminants by chemical adsorption or sedimentation of particulate contaminants near the distribution ditch.

Other contaminants such as sulfur/sulfate, sodium, magnesium and zinc showed similar concentrations in peat and pore water at all points of the transect, as well as similar concentration ratios, indicating that there is only minor net retention of those contaminants. This is in good agreement with the low retention efficiencies obtained for those contaminants.

In conclusion, the study revealed that (i) removal efficiencies are variable depending on the individual contaminant, (ii) major contaminants are enriched to a degree which exceeds guideline values for contaminated soils, (iii) concentrational changes with distance from the process water distribution ditch can give further insights on the fate of individual contaminants. Even though the dominant processes involved in contaminant removal are not clearly identified to date, further analysis of the data obtained in this study will provide new insights on the fate of mine water contaminants in treatment peatlands and help evaluate potential consequences of the use of peatlands for mine water treatment.