



## **How to distinguish natural and anthropogenic arsenic emissions? - A case study of Kittilä Suurikuusikko gold mine in Finland**

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Areas with bedrock abundant in ore minerals have naturally high amount of harmful elements in soil as well as in ground and in surface waters. After the beginning of the mining also the anthropogenic contamination tends to increase. Thus it is important to compare this load to the natural background when assessing the contamination of mine area and surrounding environment. Arsenic is common element in extractive and industrial minerals, and due to its relatively high mobility and toxicity, one of the most important local scale pollutants in the environments of mine areas in Finland.

In this study natural and anthropogenic arsenic geochemistry in Suurikuusikko gold mine at Kittilä, Finland was characterized by using hot aqua regia, ammonium acetate and oxalate extractions. In total 35 samples of humus, peat, glacial till and bedrock were analyzed. In addition 11 water samples were analyzed for total and soluble metal and metalloid concentrations, anions, DOC, TOC, pH, redox and alkalinity. The metal speciation in surface and ground waters was modeled by PHREEQC.

Due to gold bearing arsenopyrite ore, the arsenic concentrations in the Kittilä municipality and Central Lapland are naturally high. According to the geochemical analysis the percentage of oxalate and especially acetate extractable arsenic fractions in soil and bedrock samples indicates an increase in anthropogenic arsenic pollution. The results show higher aqua regia extractable arsenic concentrations and percentage of oxalate and acetate extractable fractions (30–97 %; 10–30 %) in glacial till and humus near the tailings and waste rock areas, but above all in samples taken from wetlands receiving tailings seepage waters. The background samples of humus and glacial till contained only 0–3 % of acetate and 17–77 % of oxalate extractable arsenic. The weathered bedrock samples in the mine area contained higher aqua regia extractable arsenic concentrations and acetate extractable arsenic fractions (14–20 %) than the unweathered bedrock (4%) and the background bedrock samples (4 %). The oxalate extracted arsenic fractions were similar in all bedrock samples. The results show that the arsenic chemically adsorbed in weathered bedrock and glacial till have significant impact in the arsenic emissions from the Suurikuusikko mine.

The difference in natural and mining affected water quality was seen in dissolved and total arsenic and as well as in alkali and alkali earth metal (e.g. Li, Na, K, Mg and Mn) concentrations in water samples. Due to reducing conditions in studied water samples arsenic was present mainly as pentavalent arsenate-compounds ( $\text{H}_2\text{AsO}_4^-$  and  $\text{HAsO}_4^{2-}$ ). Although arsenic concentration in the tailings seepage water was high compared to background concentrations in ground and surface waters, arsenic was adsorbed in the wetland soil and the mining activity did not influence the arsenic concentrations in the nearby river Seurajoki.