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Mobilization of radionuclides and heavy metals from mill tailings in a northern boreal environment

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There is increasing awareness of the radiological impact of non-nuclear industries that extract and/or process ores containing naturally occurring radioactive material (NORM). These industrial activities may result in significant environmental problems if the waste generated during processing is not adequately managed. In 2010, a new project was launched in Finland, the object of which is to study the mobility of radionuclides and heavy metals from diverse mill tailings in a northern boreal environment. The project is funded by the Academy of Finland and involves the Universities of Helsinki and Loughborough, the Geological Survey of Finland and the Finnish Radiation and Nuclear Safety Authority. Three sites are being investigated: Talvivaara nickel mine, a former phosphate mine in Sokli, Lapland and a former pilot scale uranium mine in Paukkajanvaara.

The Talvivaara deposits in Sotkamo comprise one of the largest known sulphide nickel resources in Europe. It is an operational, open cast mine where Talvivaara Mining Company applies bioheap leaching to extract the metals from the ore. The leaching process has been shown to be heat generating and therefore suitable for the sub-arctic climatic conditions of Eastern Finland. In heap leaching, uranium dissolves in the pregnant leach solution (PLS) along with main base metals. Currently, the uranium is diverted into a gypsum pond. The radioactive progeny from the 238U series are also mobilized and fractionate depending on chemical properties and the ambient conditions.

The Sokli complex is the westernmost deposit in the Devonian Kola alkaline rock province (ca. 365 Ma) and was discovered by Rautaruukki Oy in 1967. At the end of the 1970s, pilot scale mining and mineral processing took place at the site. The latter did not include chemical treatment of the apatite ore; processing was limited to removal of gangue minerals by physical methods. The mill tailings were deposited adjacent to the enrichment facility. The deposit is presently being developed by Yara International for beneficiation of the regolithic phosphate ore which overlies the magmatic carbonatite. In addition to the phophorus ores themselves, the carbonatite massif contains other minerals, such as niobium, iron and vermiculite. Apatite, which is known to exhibit elevated concentrations of uranium and thorium, is especially rich in the niobium ore.

The Paukkajanvaara mining site started operation in 1959. The mine was basically a test site for assessing the feasibility of larger scale uranium mining. The ore was milled and enriched at the mining site. Mining proved to be uneconomic, and the operations ceased in 1961. In the late 1970's the entrance of the mining shaft was covered with a concrete slab and the rest of the area including tailings, waste-water ponds etc., were abandoned. They were left untouched for nearly 30 years until Finnish Radiation and Nuclear Safety Authority initiated a review. Their results indicated that ambient radiation levels at the site had increased by 0.5 μSv/h as a direct result of the earlier mining operations. Rehabilitation was completed by 1994 after which the area was released for outdoor use without restrictions.

The aim of the project is to generate new data from these three mines leading to a better understanding of the mobilization of radionuclides especially 226Ra, 210Pb and 210Po and heavy metals in a northern boreal environment. The results will also play an important role in estimating radiation doses to the local population resulting from past and anticipated disposal of mill tailings. A short summary of the results gained to date from each site is given in the poster presentation.

Primary author: Ms TUOVINEN, Hanna (University of Helsinki, Laboratory of Radiochemistry)

Co-authors: Prof. READ, David (Loughborough University); Dr SOLATIE, Dina (Finnish Radiation and Nuclear Safety Authority); Mr POHJOLAINEN, Esa (Geological Survey of Finland); Prof. LEHTO, Jukka (University of Helsinki)

Presenter: Ms TUOVINEN, Hanna (University of Helsinki, Laboratory of Radiochemistry)

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