

# Primordial radionuclides in pit lakes in Sweden

## Akademisk avhandling

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## Avhandlingen baseras på följande delarbeten

- I. Mantero, J, Thomas, R, Isaksson, M, Forssell-Aronsson, E, Holm, E, García-Tenorio, R. Quality Assurance via internal tests in a newly setup laboratory for environmental radioactivity. JRNC (2019) 322: 891-900.
- II. Mantero, J, Thomas, R, Holm, E, Rääf, C, Vioque, I, Ruiz-Canovas, C, Garcia-Tenorio, R, Forssell-Aronsson, E, Isaksson, M. Levels of natural radioactivity and heavy metals in pit lakes from Southern Sweden. Submitted.
- III. Thomas, R, Mantero, J, Ruiz-Canovas, C, Holm, E, García-Tenorio, R, Forssell-Aronsson, E, Isaksson, M. Levels of natural radioactivity and heavy metals in pit lakes from Northern Sweden. Manuscript.
- IV. Thomas, R, Piñero García, F, Forssell-Aronsson, E, Holm, E, Mantero, J, Isaksson, M. Natural radioactivity and heavy metal distribution in pit lakes in Sweden analysed by principal component analysis. Manuscript.
- V. Thomas, R, Mantero, J, Perez-Moreno, S, Ruiz-Canovas, C, Isaksson, M, Forssell-Aronsson, E, Holm, E, García-Tenorio, R.  $^{226}\text{Ra}$ ,  $^{210}\text{Po}$  and Lead isotopes in a pit lake water profile in Sweden. Submitted.

**SAHLGRENKA AKADEMIN**  
**INSTITUTIONEN FÖR KLINISKA VETENSKAPER**



# Primordial radionuclides in pit lakes in Sweden

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## Abstract

In Sweden, there are many pit lakes, originating from limestone quarries and metal mines, with unknown status in regard to the activity concentration of radionuclides. Such knowledge is generally available only for pit lakes from uranium mining activities. However, since naturally occurring radionuclides such as  $^{238}\text{U}$ ,  $^{232}\text{Th}$  and  $^{40}\text{K}$  are always present in the environment, is it possible that, for example, a copper mine might contain radioactivity levels to warrant concern? For non-uranium mines, which characteristics are typical among those that contain higher amounts of radionuclides, and how should such characteristics be determined? These are some of the questions that are dealt with in this work.

In the course of this work, radiochemical procedures were set up and validated, and sampling of pit lake water and sediments were carried out and analyzed by gamma and alpha spectrometry, mass spectrometry and fluorescence techniques. Statistical analyses were employed to explore similarities among the different pit lakes. One site was more thoroughly studied for vertical distribution of water quality parameters, stable elements and radionuclides.

All of the pit lakes in this work had an activity concentration of naturally occurring radionuclides well below the recommendations for drinking water. Furthermore, the activity concentrations found in lakes in Northern Sweden were about a factor of ten lower for U isotopes and a factor of three lower for  $^{210}\text{Po}$  and Th isotopes, compared to the southern part of Sweden. This geographical contrast coincided with the difference in ambient dose equivalent rate that was measured at each site, where the higher dose rates were found in the southern part of Sweden. Furthermore, in a stratified lake, the concentration of stable elements and radionuclides in the surface water were many times lower than the concentration found in the deeper part of the lake. Thus, the concentration measured in surface water ought to be viewed as an underestimation of the average concentration in a pit lake.

**Keywords:** non-uranium mines, water, sediment, radiochemistry, principle component analysis