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DOC Affinity as a Key Parameter for Explaining the Transport Patterns of U, Th and Other Elements in the Boreal Landscape

F. Lidman (1), S. Köhler (2), L. Björkvald (3), M. Mörth (3), and H. Laudon (4)

(1) Department of Ecology and Environmental Science, Umeå University, Sweden, (2) Institute of Applied Geosciences, Graz University of Technology, Austria, (3) Department of Geology and Geochemistry, Stockholm University, Sweden, (4) Department of Forest Ecology and Management, Swedish Agricultural University, Sweden

The 68 km2 Krycklan Catchment located in Northern Sweden has been studied intensely for more than 30 years. This has resulted in a good understanding of among all hydrological and biogeochemical processes. Currently, 18 sites within the catchment are regularly sampled and analyzed for major elements and other hydrochemical parameters. 10 of these sites have also been monitored for a wide range of trace elements, among all uranium and thorium, during a two-year period. Hence, there is a comprehensive dataset describing the export of a wide range of elements from these sub-catchments.

For uranium and thorium large differences in stream water concentrations and, consequently, annual export from the different sub-catchments were observed. In order to explain these differences air-borne gamma spectrometry was used to measure uranium and thorium concentrations in the soils over the entire catchment. It could be expected that high concentrations in the soils of the sub-catchment would lead to a high export, but it turned out that the correlation was not particularly strong. Instead it was found that the export was strongly correlated to the wetland/lake coverage within each sub-catchment for both uranium and thorium. High wetland/lake coverage would lead to a low export, while high forest coverage would lead to a high export. In the case of uranium, for instance, the data show that a mire that covers 50% of a catchment will reduce the uranium export by approximately 90% as compared to the export from a completely forested catchment. This indicates that uranium is being accumulated in mires.

If more elements are included in the analysis and the export of each element is compared to the landscape characteristics, some elements, e.g. cesium and potassium, turn out to be completely unaffected by the forest or mire coverage, while other elements such as lanthanum and copper behave similarly to uranium and thorium. Thermodynamic modeling using PHREEQC and Visual MINTEQ has been used to estimate the percentage of each element bound to DOC in these waters and this shows a strong correlation to how elements are affected by wetlands/lakes in the catchments. Experiments, e.g. using flow field-flow fractionation, in the Krycklan Catchment have demonstrated that DOC is important for many elements in the transport from soils to streams, and as it appears these processes will also have an impact on the catchment scale. The general picture is that the variation between sub-catchments is small for elements that do not bind strongly to DOC, while there is a considerable and systematic variation for elements with a high DOC affinity. This suggests that DOC affinity is a key parameter for understanding the fate and transport patters for elements in the boreal region. The results could also be used to predict the long-term fate of artificial elements from nuclear waste such as neptunium, plutonium or americium, since it relates fundamental biogeochemical processes to patterns on the catchment scale.