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Study of speciation and size fractionation of trace element between soil solution, bog, river and lake within a boreal watershed (North Karelia, NW Russia) using fractional filtration

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This work is aimed at studying the evolution of migration forms of true dissolved compounds and colloidal entities using an integrated approach of molecular mass distribution and differences in the association of trace elements (TE) with organic matter (OM) or Fe colloids in the system soil water-bog-river-lake. Characterization of TE speciation with colloids during TE migration from the site of colloids origin (bog and soil solutions) towards the transit zone (river) and finally to the deposition, accumulation or transformation zone (lake) is a main fundamental task of this problem.

The objects of study include a small stream watershed Vostochniy and the river Palayoki (North Karelia, Russia). The water samplings were performed in July and August 2008 and 2009 and included soil solution, nourishing bog, the middle part of the brook originated from the swamp, the mouth of the brook and the lake Zipringa. We sampled large volumes (50 - 100 liters), and we applied, directly in the in-field-installed "clean laboratory" the sequential frontal filtration and ultrafiltration of samples through the filters of progressively decreasing poresize 100, 20, 10, 5, 0.8, 0.4, 0.2 and 0.1 microns; 100 kDa (0.0065 micron), 10 kDa (0.003 micron) and 1 kDa (0.0014 micron). This allowed separation of organic matter, coarse and fine particulate matter and colloids. All filtrates and selected retentates were analyzed for a wide range of macro-and micronutrients using ICP-MS.

In filtrates of the river water, a significant decrease of iron concentration occurred in the range of 5 micron to 0.22 micron and from 100 kDa to 1 kDa. For alkali and alkaline earth elements (Mg, K, Ca), as well as for Cu, Ni, Cr the concentrations changed after passing through the 10 kDa membrane. Na concentration remains constant in all filtrates. The filtrates of the soil solution are characterized by a significant decreases in Na, K, after 0.1 micron, Ca, Cu in the range of 0.22 micron - 100 kDa and Mg, Ni in the range of 0.1 micron - 100 kDa.

The changing of REEs concentrations occurred in the fraction smaller than 100 kDa for river water and in the fraction larger than 100 kDa in the soil solution.

Concerning the evolution of element concentration in the system "soil solution – nourishing bog - river - lake", the concentration of Ca and Mg increases (with a little decrease in the stage "the nourishing bog - the middle current - the mouth"), and the concentration of Cu, Ni, Cr, Ti, Al decreases (with a slight increase in the interval "the nourishing swamp – the middle current - the mouth). The lanthanides have a maximum of their concentration in the river mouth and the minimum in the lake. Concentration of Fe, Zn in the soil solution is an order of magnitude higher than in the river and lake water. The ratio Fe / Me (where Me = Al, Cu, Zn, Ni, Co, Cr, Mn) naturally decreases in the course of filtration, whereas the ratio of Fe to Ti increases in a series of consecutive filtrates of soil solution.

These observations can be interpreted as a result of interplay between the processes of TE leaching from soil and peat, complexation with colloids in the lake water and microbiological transformation of colloids in the course of the river flow and in the lake water. Results of the present study allow straightforward evaluation of the transformation of TE colloidal status between the site of their origin, migration and consumption (deposition)

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