Geophysical Research Abstracts
Vol. 13, EGU2011-3503, 2011
EGU General Assembly 2011

Measurement of contaminant fluxes in the soil during snowmelt, at high spatial resolution

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De-icing chemicals are used at Oslo airport during winter time, to remove snow and ice from airplanes before departure. The de-icing chemical used at this airport contains propylene glycol. Most of the used de-icing chemical is collected on a platform, but part of it contaminates the snow around the runway. When the contaminated snow melts in spring, the de-icing chemical can infiltrate rapidly in the sandy glacial deposits on which the airport is located. To protect the large groundwater body in this area, knowledge of the fate of de-icing chemicals in the soil is essential. Previous experiments near the airport have shown that part of the de-icing chemicals degrades before it reaches the groundwater.

Soil heterogeneity and heterogeneous melting of the snowpack can lead to preferential flow in the soil. Therefore, a measurement campaign was conducted to quantify the effect of soil heterogeneity and melt heterogeneity on contaminant fluxes in the soil at a local scale. The fluxes of melt water and contaminant were measured with a multi-compartment sampler, 50 cm below the soil surface. On top of the instrument was a horizontal porous plate to which variable pressure was applied. The plate consisted of 100 separate cells and the drainage was collected in 100 corresponding cells in the instrument. Samples were taken at least once a day. With this instrument and sampling scheme, a high spatial and temporal resolution in water and solute fluxes was obtained. Both propylene glycol (nonadsorbing and degradable) and a tracer (nonadsorbing and nondegradable) were applied to the snow or soil surface at the start of the experiment. During, and in between three experiments, the instrument remained in the same position in the soil.

Measurements were taken during natural snowmelt in the springs of 2009 and 2010. Most of the collected water drained through a small area of the instrument. The location of the area with high drainage was similar for both years. So, preferential flow paths did not change in one year. Also most of the leached tracer drained through a small area of the instrument. The locations of these areas with high water drainage and tracer leaching were overlapping, but not exactly the same. So, besides the water fluxes, the concentrations of the tracer were needed to determine the tracer fluxes. The temperature was low during snowmelt, therefore bioactivity was low, and propylene glycol did not degrade

A similar experiment was done in late spring by means of irrigation with a lower average infiltration rate than with snow melt. With irrigation, the water drained more equally in space than with snowmelt, except for a few cells with high drainage. The leaching of the tracer and propylene glycol had a similar spatial pattern as the drainage of the water. During the irrigation experiment, the propylene glycol concentration decreased compared to the tracer concentration, indicating degradation.

From the three experiments it can be concluded that preferential flow at this scale during snowmelt is dominated by soil heterogeneity, while with lower infiltration rates during irrigation, the drainage was spread more equal in space with a few high draining cells.

Data from this measurement campaign serve as ground truth for geophysical measurements that were done at the same time as the water sampling. Therefore, the experiments will contribute to the development of methodologies to monitor contaminants in the soil.