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Effects of land use on the distribution of stable isotopes of water (18O/2H) in a deep unconfined aquifer and its role for recharge estimates.

Sascha Müller (1), Søren Jessen (2), Peter Engesgaard (3), and Jari Jari Leskelä (4)

(1) Department of Geosciences and Natural Resource Management, Section Geology, University of Copenhagen,Denmark (samu@ign.ku.dk), (2) Department of Geosciences and Natural Resource Management, Section Geology, University of Copenhagen,Denmark (soeren.jessen@ign.ku.dk), (3) Department of Geosciences and Natural Resource Management, Section Geology, University of Copenhagen,Denmark (pe@ign.ku.dk), (4) Department of Geosciences and Natural Resource Management, Section Geology, University of Copenhagen,Denmark (jari.leskela@gmail.com))

Soil evaporation, transpiration and interception varies with land use, such as forest, heath and agriculture, encountered within a catchment. Therefore land use variations may give rise to different isotopic compositions of water recharging an aquifer. We investigated the distribution of stable isotopes of water in an unconfined aquifer at Rabis Creek, Denmark, consisting of up to $\sim$100 m glacio-fluvial sand overlying a clay aquitard. The aquifer has an unsaturated zone of 15 m, assumed to effectively dampen out any seasonal variation in the isotopic composition of recharging water once it arrives to the groundwater table. In addition, the aquifer is situated under different land uses; arable land, forest and heath, and does not receive infiltrating water from surface water bodies. Water samples, analyzed for stable isotopes of water and major ion concentrations, were obtained from eight multi-level wells, sampling up to 21 m below the water table along a 3 km long transect parallel to the general groundwater flow direction. Groundwater derived from recharge in arable areas could be easily traced by its elevated NO_3 concentrations (typically 30 to 80 mg/L), whereas NO_3 was almost absent in groundwater derived from forest and heath areas. NO_3 enriched water formed plumes extending with the flow direction into the deeper parts of the aquifer covered by forest and heath. The δ18O values in the aquifer varied up to 1‰ between 7.5‰ and 8.5‰Highest depletion values occurred in the proximity of the NO_3 plumes. This indicates a certain signal in the δ18O originating from agricultural sites. Furthermore, within the first meters a steady depletion downwards was observed where at a certain depth a jump in depletion occurred. This δ18O distribution suggests a zone dominated by vertical flows influenced by diffuse mixing with horizontal flowing groundwater in the upper part of the aquifer and beneath a zone of dominating horizontal flows with stronger mixing. The 18O/2H signal for the Rabis Creek aquifer is slightly displaced from the GMWL with a slope of 7.8. Slopes for each single well reveal that groundwater areas under agricultural and heath areas have lower slopes between 6 and 7 indicating stronger effects of soil evaporation on the recharged water. Groundwater derived from forest areas show slopes close to 8 and, thus seem to be less affected by soil evaporation. Recharge estimates based on the offset of 18O/2H from the GMWL differ between the land use types by 150 mm, but are generally overestimated by a factor of 1.5-2 compared to recharge values estimated for the area from earlier studies. This suggest that a) flow zonation in aquifer plays a role for the recharge estimate or b) estimates based on the offset from a local meteoric water line (LMWL) could result in more appropriate recharge values. Generally, the study shows that the δ18O in groundwater can be used to trace land use from recharging areas. However, refined recharge estimates are subject to ongoing research.