Biogeochemical processes in the subsurface determining inert gas concentrations in recharging groundwater

SIMON MAYER*[1], FLORIAN JENNER[1], WERNER AESCHBACH[1], BERNHARD PEREGOVICH[2] AND CARLOS MACHADO[3]

[1]Institute of Environmental Physics, Heidelberg, Germany (smayer@iup.uni-heidelberg.de)
[2]Instituto de Engenharia e Geociências, Universidade Federal do Oeste do Pará, Santarém, Brazil
[3]Instituto de Ciências da Educação, Universidade Federal do Oeste do Pará, Santarém, Brazil

Applications of inert gases in groundwater hydrology require a profound understanding of underlying biogeochemical processes. Some of these processes are, however, not well understood and therefore require further investigation. This is the first study simultaneously investigating soil air and groundwater in the context of noble gas tracer applications, accounting for seasonal effects in different climate regions. Based on an extensive data set, a comprehensive overview is given about the underlying biogeochemical processes determining dissolved gas concentrations in recharging groundwater. Sampled data confirm a solubility-controlled description of excess air formation and a permanent temperature-driven equilibration of shallow groundwater with entrapped air bubbles, even some years after recharge. Minor groundwater degassing, e.g. as a consequence of microbial activity, is found to challenge existing excess air model approaches, depending on the amount and the fractionation of excess air. The equilibrium composition of dissolved gases is directly related to soil air composition. Based on numerical simulations, varying noble gas mixing ratios in soil air are found to be predominantly induced by varying contents of O_2+CO_2, as a consequence of microbial oxygen depletion and a preferential dissolution of CO_2. Mass-dependent diffusive transport mechanisms turn out to have a minor impact on soil air composition, compared to advective transport. Caused by the observed seasonalities, an actual impact of varying noble gas contents in soil air on the equilibrium component of recharging groundwater depends on the typical time of recharge. Findings of this study contribute to the reliability of noble gas tracer applications in hydrology, in particular with regard to paleoclimate reconstruction and an understanding of subsurface gas dynamics.