Geophysical Research Abstracts, Vol. 9, 00727, 2007
SRef-ID: 1607-7962/gra/EGU2007-A-00727

Incorporating spatial pattern of exchange fluxes and nitrate attenuation in the hyporheic zone in model representations of the riparian zone hydrochemistry

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Water balance and groundwater nitrate dynamics within the riparian floodplain of several lowland river catchments were investigated by experimental analyses as well as by simulations using a coupled soil water balance and groundwater model approach. The model simulations performed indicated a substantial impact of exchange fluxes across the groundwater - surface water interface on the riparian water balance, the river discharge as well as the riparian zone nitrate dynamics. Experimental and model based results give evidence that the impact of riparian buffering on the nitrate contributions from diffusive sources is significant and crucial for the lowland rivers eco-hydrological conditions during low flow periods in summer. Sensitivity analyses of the model parameters proved the high impact of the leakage factor which represents the hyporheic zone control on the exchange fluxes across the groundwater - surface water interface. As the parameters characterising the leakage factor are represented by spatial means only and usually approximated during the calibration process the representation of the exchange patterns on a sub reach scale in the model is quite uncertain. Experimental investigation are undertaken on several stream reaches within the riparian zones of two rivers in order to test how intensive exchange fluxes between groundwater and surface water are controlled by physical riverbed conditions and how this effects hyporheic pathways, travel and residence times as well as the streambed redox conditions and the attenuation of nitrate. The pore water of the hyporheic zone is analysed in a nested piezometer network, within sediment cores as well as by DET (Diffusive Equilibrium of Thin Films) gel probes for its nitrate, ammonia and total nitrogen contents in order to investigate the impact of specific geomorphic features, preferential flow paths and redox conditions on the hyporheic zone nitrogen metabolism. The results of these investigations provide evidence that pool - riffle sequences especially with long riffle bars, due to its influence on travel time, redox conditions and denitrification capacity, induce characteristic spatial patterns of nitrate concentrations. Furthermore vegetated islands and sandy bars are found to have significant impact on nitrate removal from the pore water which is attributed to increased denitrification rates and plant uptake. The experimentally gained results are compiled for a regionalisation using transfer functions based on geo-morphological river surveys. Comparative simulations of model setups incorporating the identified spatial pattern of hyporheic influences on exchange fluxes and of a model representation based on calibrated spatial means allow the evaluation of the impact of hyporheic zone heterogeneity on the riparian hydro-chemical conditions on a regional scale.