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The efficiency of turn-over processes in degraded peat as investigated under continuous flow conditions

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Nitrate removal from run-off from agricultural land is in general required to reach a "good chemical status" of surface and groundwater bodies according to the European Water Framework Directive. Removing nitrates via heterotrophic denitrification is highly effective but requires stable anoxic environmental conditions as well as available organic carbon as an electron donator. Constructed wetlands, established on peat soils, through which the nitrate-loaded water is routed, may provide denitrification favorable conditions. A long-term flow experiment (mesocosm) was conducted employing a laboratory container set-up filled with decomposed peat aiming at quantifying the nitrate removal efficiency at various nitrate influx rates. The redox potential was measured at different depths to determine the spatial distribution of denitrificating zones. This new methodological approach allows the observation of biological nitrate turn over without interrupting the adjusted flow rate. We investigated the hydraulic properties and derived transport parameters for the mesocosm by analyzing experimental data from tracer tests. The obtained bromide breakthrough curves (BTC) were subjected to model analysis using the CXTFIT routine of the STANMOD software package. It could be demonstrated that the degraded peat has a dual porosity structure with roughly 40% of the pore water not participating in convective flow and transport processes. Further, the first flushing of mineralized nitrate upon rewetting and onset of flux may compromise any positive clean-up and nitrate removal effects occurring during long-term operation of peat wetlands. The development of the spatial sequence of bacterial cultures is characterized by the redox potential. It is dominated by the available substrates that serve as electron acceptors in bacterial respiration and occurs in a thermodynamically determined top-down order. The zonal development of the nitrate-consuming bacteria was observed and used to describe the removal efficiency of the mesocosm.