Geophysical Research Abstracts
Vol. 14, EGU2012-9031, 2012
EGU General Assembly 2012

Direct measurements of the tile drain and groundwater contributions to surface water contamination: from field-scale concentration patterns in groundwater to catchment-scale dynamics in stream water nutrient concentrations

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Enhanced knowledge of water and nutrient pathways in catchments improves the understanding of dynamics in water quality and supports the selection of appropriate water pollution mitigation options. For this study, we physically separated tile drain effluent and groundwater discharge from an agricultural field before it entered a 43.5 meter ditch transect. Through continuous discharge measurements and weekly water quality sampling, we directly quantified the flow route contributions to surface water discharge and solute loading. Our multi-scale experimental approach allowed us to relate these measurements to field-scale NO_3 concentration patterns in shallow groundwater and to continuous NO_3 records at the catchment outlet.

Our mapping of nutrient concentrations in shallow groundwater at the experimental field revealed a highly variable spatial pattern, with NO_3 concentrations ranging from 0 to 219 mg/l. Our measurement setup allowed us to compare NO_3 concentrations of the individual tile drains to the spatial NO_3 concentration pattern in shallow groundwater. These results show that tile drain effluent sampling is an efficient way to obtain information on shallow groundwater composition. The catchment-scale monitoring revealed a large spatial heterogeneity in tile drain effluent NO_3 concentrations, which ranged from 0 mg/l up to 390 mg/l. A distinct similarity was found between the temporal patterns in NO_3 concentrations in tile drain effluent at the field-scale, in tile drain effluent throughout the catchment, and in stream water at the catchment outlet. They all showed a seasonal pattern with higher concentrations in winter, which is related to the increased contribution of near-surface flow routes to the tile drain and stream discharge in winter.

Our measurements indicated that tile drains play a major role in lateral water and solute transport from the agricultural field towards the surface water system. On average, the tile drains contributed 80% of the discharge and 90-92% of the annual NO_3 loads from the experimental field to the ditch. For nutrients and heavy metals, the concentrations in tile drain effluent were significantly higher than in discharged groundwater, and in our pilot area tile drain discharge was unambiguously the main transport mechanism towards the surface water system. Considering their crucial role in water and solute transport, enhanced monitoring and modeling of tile drainage is important for adequate water quality management.