Geophysical Research Abstracts
Vol. 13, EGU2011-12657, 2011
EGU General Assembly 2011

Validation of a catchment conceptual model considering overland flow, interflow, shallow groundwater flow and deep groundwater flow pathways for diffuse contaminant transport and attenuation from land-surface to aquatic receptors

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To date catchment management tools and water quality models have largely considered pollutant fluxes from shallow and deep groundwater pathways to surface water in catchments underlain by poorly productive aquifers to be negligible, focusing instead on overland flow and interflow flow as principal contributing pathways. Groundwater pathways are normally lumped, with little attention given to the varying contaminant attenuation potential of hydrogeological pathways with depth. However, the implementation of the Water Framework Directive (WFD) requires a fuller understanding of the contribution of all contaminant transport pathways from land surface to aquatic receptors to ensure appropriate water quality models and catchment management tools are developed in order to achieve good WFD status.

To validate a proposed conceptual model of flow and contaminant transport along four pathways (overland flow, interflow, shallow groundwater flow and deep groundwater flow) cross-disciplinary investigations into hydrological processes in poorly productive catchments have been initiated in Northeastern Ireland in a 5 km2 test catchment. Subsoil and bed-rock mapping, land-use surveys, and hydrogeological testing have been completed to evaluate contaminant transport and attenuation with depth. Additionally, in order to consider scale-related hydrological processes, geophysical methods were employed to characterise the groundwater pathways and support and integrate data from hydrogeological testing and sampling. In addition to monthly surface water quality and macro-invertebrate sampling, monitoring and sampling of water quality in surface water, overland flow and shallow and deep groundwater pathways have been undertaken in response to rainfall events. Stream flow, surface water physio-chemical parameters (temperature and electrical conductivity), groundwater levels in four borehole clusters, rainfall and evapotranspiration are monitored continuously. Results to date highlight that diffuse nutrients impact both surface water and groundwater quality, and the catchment's ecological status. Preliminary contaminant load duration curves indicate that during and directly after rainfall events contaminant transport is dominated by overland flow/ interflow pathways, while elevated concentrations of nitrate detected in shallow groundwater indicate that this pathway is likely to contribute significantly to stream flow at base-flow when ecological stress may be greatest. Results from hydrogeological testing and geophysical investigation indicate that the catchment bedrock displays hydraulic properties typical of a fractured system with fracture density decreasing with depth and associated increases in groundwater mineralisation reflecting greater residence times. Findings suggest limited contributions from deep groundwater pathways to contaminant loads in surface water, although the possibility of persistent releases of recalcitrant compounds over prolonged period may impact the ecological status when most sensitive at base-flow, even following implementation of any programmes of measures.

Study findings to date have permitted improved conceptual models to be developed. The data collected, will permit quantification of pollutant transport and attenuation rates, particularly from critical source areas (CSAs) and their impact on aquatic ecosystems to be better evaluated and will provide a basis for development of a catchment management tool capable of considering ecological impacts (in addition to nutrient losses) relevant to the WFD in the Irish context.