Attenuation of phosphorus transfers in an agricultural karstic spring zone of contribution

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Introduction

Defining the chemical and ecological status of water bodies are key requirements of the European Union Water Framework Directive (WFD; Official Journal of the European Community, 2000). Phosphorus (P) and nitrogen (N) transfers from land have been recognised as one of the major influences on water quality deterioration, causing eutrophication, and subject to a series of regulatory mitigation efforts. In Ireland the qualitative status of karstic groundwater bodies has been assessed by routine monitoring of discharge and water quality from emergent springs. If the mean annual molybdate reactive P (MRP) concentration exceeds 0.035mg L^{-1} (the Environmental Quality Standard (EQS) for good water quality status, EPA (2009) - based on an average of 6 years data with 4 samples per year) and the groundwater contributes at least 75% of the receiving river's flow, the aquifer is defined as being of 'poor status'. The main hydrological mechanisms for phosphorus transfer from land surface to the groundwater body of a karstified aquifer are considered to be conduit and other karstic quick flows. In order to test the assumptions of groundwater risk, and to explore the nutrient sources and delivery patterns from moderate to intensive agriculture over a karstic landscape in western Ireland, we used the nutrient transfer continuum model and applied a high spatiotemporal resolution approach. The soil P source and pathway components were defined at a high spatial resolution. The inferred risk of P transfer was defined by high temporal resolution of observed P delivery to the emergent spring.

Methods

Soil source of P was defined by field-by-field measurements of soil P status. The pathways of P transfer from source to spring were defined by firstly creating a groundwater vulnerability map based on a field-by-field scale survey over a 46 km^2 area using the methodology developed by the Geological Survey of Ireland (Fitzsimons *et al.*, 2003). This included mapping of depth to bedrock and all surface karst features. Further to this a P susceptibility map was developed. Phosphorus delivery and water discharge was monitored in the emergent spring at a sub-hourly basis for over a year. Rainfall was monitored at four sites and meteorological parameters, for estimating potential evapotranspiration, at two sites within the spring zone of contribution (ZoC). Flow regimes were characterised from simple recession curve analysis of emergent spring hydrographs.

Results

Even though the ZoC had moderate to intensive agriculture, the soil P had varying status with a high proportion of elevated soil P concentrations and the connectivity potential was high, the background P concentrations in the emergent groundwater were low and indicative of being insufficient to increase the water P status of receiving surface waters. However, episodic P transfers *via* the conduit system increased the P concentrations during spring storm events (but not above the EQS). That process is similar to other catchments where the predominant transfer is *via* episodic, surface flow pathways; but with high buffering potential over karst due to delayed and attenuated flow. The proportion of slow flow within the small fissures during a winter flow event was high.

Discussion and Conclusions

There are clearly buffering processes related to combinations of soil, geology and hydrology that preclude high transfers of P from an apparently 'vulnerable' landscape and which, possibly counter-intuitively, are probably increased as potential for agricultural intensity increases on thicker soils (as all soil chemistry and hydrology buffering components increase). It appears that the proportion of slow flow and its chemical status is an important component to consider when defining the vulnerability of a karst aquifer. However, the groundwater body also appears to be bypassed by rapid and episodic conduit flows. We suggest that the definitions of risk and vulnerability for phosphorus delivery to receiving surface waters should be re-evaluated at the source and pathway component of the nutrient transfer *viz*. where and when the linked trophic impact manifests in the receptor water body.

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