Conceptual models of the geological controls on the fate and transport of nitrate and phosphorus in groundwater for the Upper Bann catchment, Northern Ireland

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Introduction

Groundwater provides an important nutrient transport pathway in agricultural river catchments delivering Nitrate (N) and Phosphorus (P) to human and ecological receptors. This project aims to improve our understanding of the hydrogeological controls on groundwater nutrient fate and transport to improve the management of diffuse nutrient pollution. The preliminary conceptual models presented here have been developed from a literature review of hydrogeological controls on groundwater nutrient transport and a desk study of the Upper Bann field site.

Geochemical controls

Phosphorus (P): Poor mobility in groundwater due to reversible adsorption to clays and metal (oxy)hydroxides, and potential for long term storage through mineral precipitation. Higher risk of groundwater P transport associated with: (1) low pH; (2) reducing conditions; and (3) saturation of P sorption sites.

Nitrate (N): Highly mobile in groundwater but can be fully degraded through denitrification reactions requiring: (1) low dissolved oxygen; (2) source of electron donors (e.g., organic carbon, Fe²⁺ etc.); and (3) sufficient time for reactions to proceed.

Hydrogeological controls

The hydrogeological setting of river catchments will dictate the distribution of groundwater flow pathways and therefore how nutrients are transported through the subsurface, and the different geochemical environments nutrients encounter. The key hydrogeological factors influencing groundwater nutrient transport include:

- Groundwater flow type: intergranular vs fracture.
- Depth to groundwater table.
- Position of groundwater system i.e., recharge vs discharge area.
- Flow pathway length and residence time.
- Connection and compartmentalisation between different aquifers.

Field site: Upper Bann, Co. Down

- Lowland drumlinised landscape dominated by grassland agriculture.
- High groundwater P and high baseflow P.
- N impacts vary between sub-catchments.
- In this project, two contrasting headwater sub-catchments will be investigated for hydrogeological controls on groundwater nutrient transport.

Conclusions

- Redox conditions play a key role on N and P transport in groundwater.
- Granitic aquifers are expected to attenuate more agricultural P, but agricultural activities may contribute to P production from enhanced weathering.
- Granitic aquifers are expected to be more vulnerable to N pollution relative to argillaceous metasedimentary aquifers.

Further work

1. Ground-based geophysical surveys to characterise hydrostratigraphy and hydrogeological parameters.
2. Collect groundwater samples for nutrient and residence time indicator analysis.
3. Test conceptual models with numerical modeling.