Assessing the Risk of Nutrient Enrichment in Groundwater Dependant Ecosystems: The Role of Geochemistry

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Introduction:

Groundwater dependant ecosystems (GWDEs) occur widely in the area covered by the Tellus surveys (Tellus & Tellus Border). In areas of intense agriculture, excess levels of N and P can impact GWDEs. Current methods to assess risks of nutrients reaching GWDEs by groundwater pathways (risk) rely on vulnerability maps based on subsoil physical properties. However, geochemical conditions can influence nutrient attenuation. The Tellus Investigation of Wetland Ecology and Geochemistry (TIWEG) investigated the potential of Tellus geochemical data to improve current approaches to assessing risk of nutrient enrichment in GWDEs.

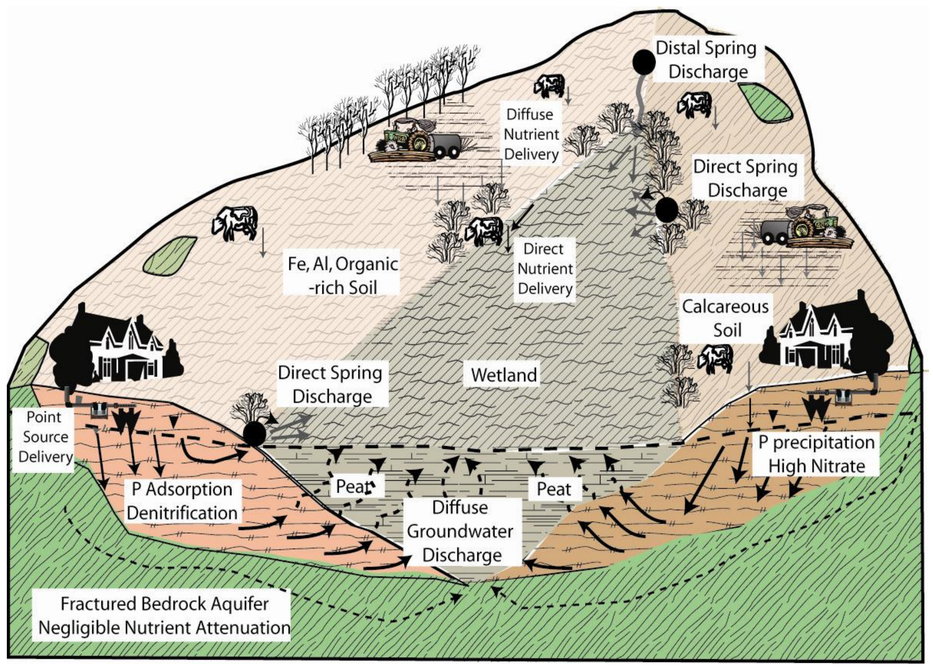


Plate 1 (Left) : Conceptual model of GWDEs in the Border Region. GWDEs receive groundwater through diffuse and/or point (spring) discharge. Nutrients applied in a catchment may leach to groundwater and to reach GWDEs. Groundwater flow regimes and geochemical conditions, particularly levels of **Ca, Fe** and **organic matter**, encountered along hydrological pathways influence the fate of nutrients, which may be removed by biological and chemical processes.

Objectives

- Develop and test a methodology for ranking risk posed by land use activity in GWDE catchments for both Northern Ireland and the Republic of Ireland.
- Investigate if elemental concentrations in soil may be used to predict concentrations in subsoils to better define subsurface geochemical conditions along groundwater pathways.
- Select representative GWDE sites encompassing the range of physical, geochemical and land use pressures encountered in the border region.
- Sample field sites to evaluate if (a) risk/impact relationships exist between loading and water quality and if (b) parameters concentration in soils resemble those encountered in Tellus datasets.

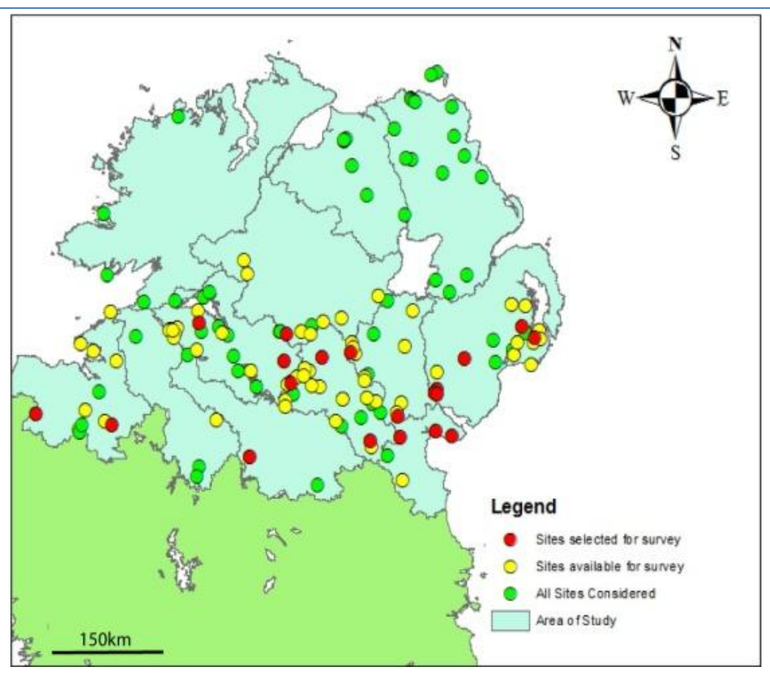
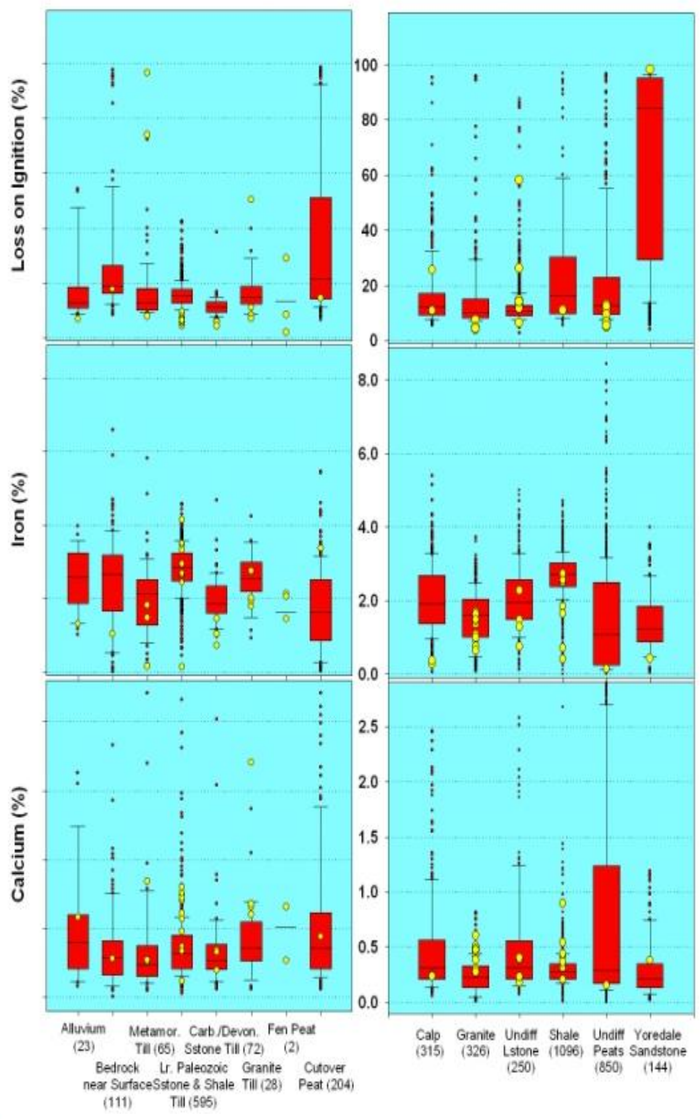


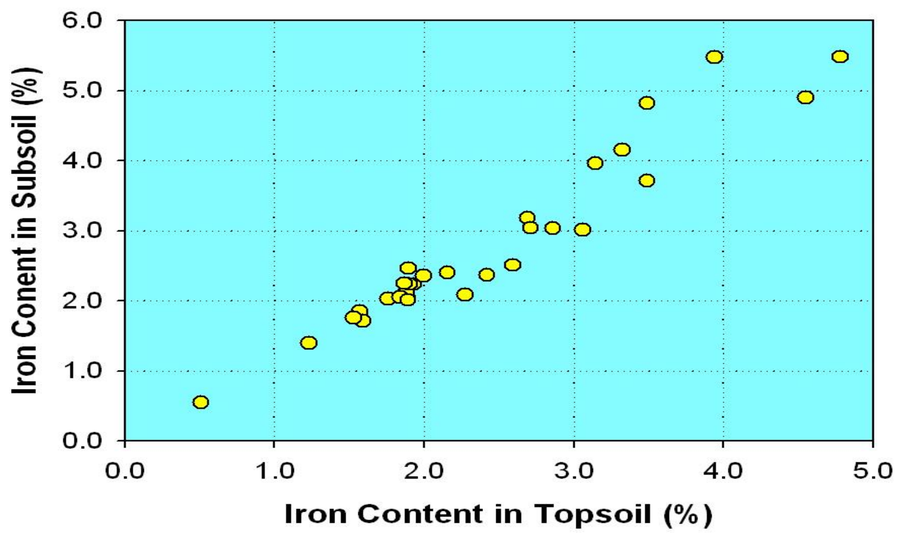
Fig. 1: Map showing148 sites considered, and 19 sites selected for field investigation.

Risk Assessment/Field Site Selection

Risk is the product of vulnerability and pressure. For the area surveyed, cross-border vulnerability and land use pressure schemes were developed to permit development of a common risk barometer for RoI and NI. Sites were selected based on having comparable risk factors but contrasting geochemistry. Field investigations involved mapping drainage, wetland boundaries and collecting representative water & soil within GWDE catchments in the 19 catchment selected (Fig. 1).

Results





- Concentrations obtained from field sampling correspond closely with the Tellus & Tellus Border survey results (Fig. 2).
- Elemental concentrations in Tellus soil and subsoil data display strong correspondence indicating that soil data could be used as surrogates for levels in subsoils in the Tellus Border dataset (Fig. 3).
- Water analyses show no significant correlation between risk ranking and concentration; greater variability occurs with higher risk sites (Fig. 4). Comparable responses are observed for phosphate. Concentrations observed in all cases are significantly lower than anticipated.

Fig. 2 (Left): Plots summarising the results of Loss on Ignition, Ca and Fe content in soil samples collected from field sites (yellow points) compared to the results of Tellus Border (left) and Tellus (right) surveys, both presented as Box-Whisker plots.

Fig. 3 (Left): Plot of median Iron concentrations in soil and subsoil categories sampled in Tellus (northern Ireland) Survey.

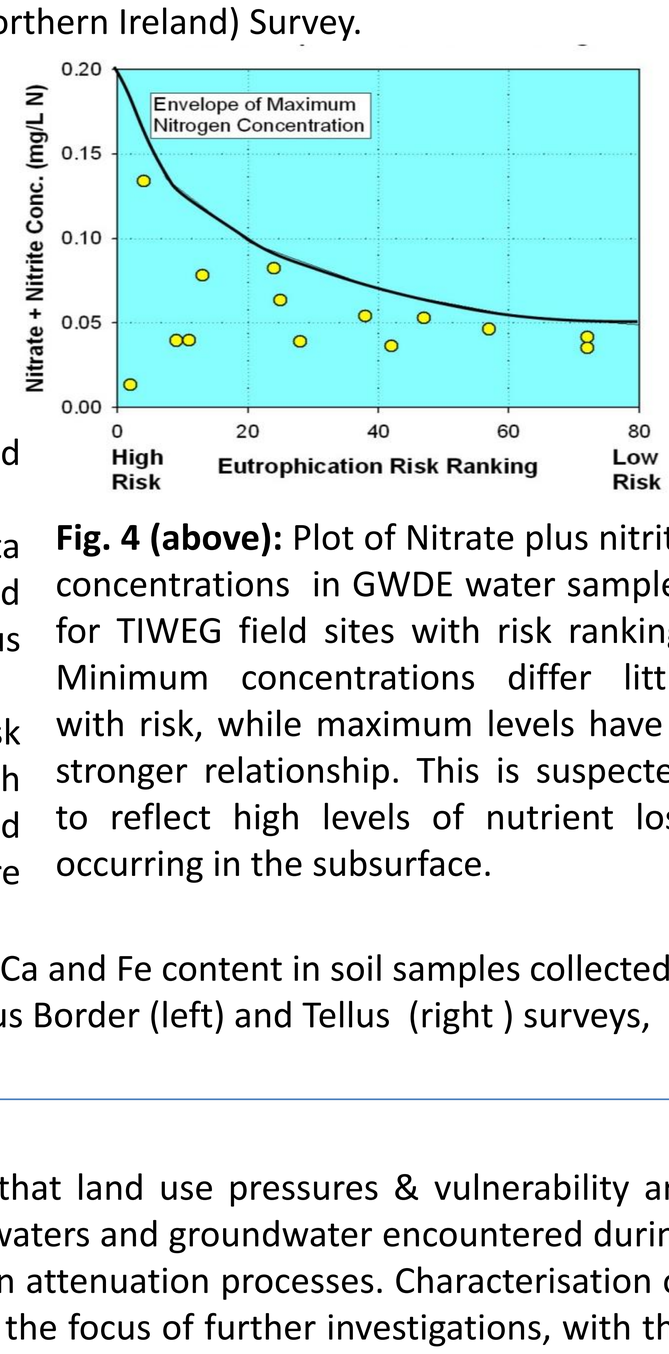


Fig. 4 (above): Plot of Nitrate plus nitrite concentrations in GWDE water samples for TIWEG field sites with risk ranking. Minimum concentrations differ little with risk, while maximum levels have a stronger relationship. This is suspected to reflect high levels of nutrient loss occurring in the subsurface.

Conclusions

The variation in nutrient levels observed in water samples collected during the TIWEG project suggests that land use pressures & vulnerability are insufficient to fully explain impacts observed at GWDE field sites. Contrasting levels of nutrients in surface waters and groundwater encountered during detailed studies of selected Tellus wetland sites suggest that geochemical processes play a significant role in attenuation processes. Characterisation of the protective role provided by given soil/subsoil types is complicated by natural variation. This issue forms the focus of further investigations, with the results of the TIWEG programme underpinning on-going research to further constrain the role played by geochemistry in mitigating against impacts to GWDEs.

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