Quantifying the nutrient inputs into karst conduit fed ephemeral Lakes (Turloughs) in Ireland.

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Turloughs are ephemeral lakes that are virtually unique to Ireland. They are groundwater dependant, seasonally inundated wetlands that occur in depressions in karst areas, primarily in the West of Ireland. They usually flood in early autumn and remain flooded until late spring or early summer. In most cases, the turlough has no surface outlet and instead fills and drains through swallow holes or estavella (Coxon 1987). The flooding of turlough basins could occur as a result of several different hydraulic configurations but for many it is due insufficient capacity of the underground karst system to cope with increased conduit flows following an intense rainfall event, causing the conduit network to surcharge.

Due to the distinct hydrologic nature of turloughs, they have a corresponding distinct ecology and biodiversity. For this reason, turloughs have been a continuous focus of research interest due to the unique flora and fauna in this type of aquatic environment but also due to the risks of localised flooding. Turloughs have been designated as Special Areas of Conservation in Ireland and are designated as a Priority Habitat in Annex 1 of the EU Habitats Directive (92/43/EEC) (EEC 1992). Also, under the Water Framework Directive (EC, 2000) turloughs are designated as Groundwater Dependant Terrestrial Ecosystems (GWDTE).

The aim of this project is to characterise a series of turloughs located in County Galway in the West of Ireland. The series of 5 turloughs are thought to be connected together in a linked conduit drainage network and have been monitored over several years. The turloughs are fed from water draining off the Slieve Aughty Mountains comprising of Old Red Sandstone. These rivers feed into rivers that disappear underground when they reach the karst bedrock. The water moves through the conduit system and eventually out to a partially submerged spring on the Galway coast.

The project has the following objectives:

- To develop a pipe-network model for the karst system which accurately models the fluctuating turlough water levels as well as the diffuse infiltration from the epikarst that can be used to predict future flood scenarios under different rainfall inputs.
- To evaluate the effect of a changing hydrological regime on corresponding hydrochemistry, in particular the nutrient sources and sinks for the turloughs.

This project involves extensive field instrumentation across both the karst catchment and Slieve Aughty Mountains (rain gauges, river depth gauges, borehole depth gauges and turlough depth gauges) as well as regular collection of water samples for retrieved from the rivers, turloughs, boreholes and spring approximately every three weeks.

A key component of this study is using a flood response model to investigate nutrient origin and nutrient flux through the turloughs (whether the turloughs act as sinks or producers for nutrients in groundwater). For example, the net fluxes from the rivers into the turloughs can be determined from which conclusions can be drawn as to whether the nutrients have been generated from outside or within the turlough as many of the turloughs are used as fields for cattle grazing during the summer months, when empty.

The pipe-network model will be used to estimate flow volumes and nutrient (N&P) concentrations within the turlough/conduit system. Based on detailed topographic surveying, this model will use data from measurement of precipitation, river stages, borehole groundwater levels and turlough depths for the purposes of validation and calibration.

An important factor in creating such a pipe-network model in a karst, predominantly conduit-flow, type system is also to include the contribution of diffuse flow (from the epikarst) into the network. This has been evaluated by monitoring the dynamic relationship between the water levels in the turloughs compared to groundwater levels in the areas adjacent to the turloughs by instrumenting nearby boreholes/wells.

The analysis of oxygen and carbon isotopes in the water samples is also being used for this purpose. For example, the ratio of ^{18}O to ^{16}O in water has been used to determine evaporation losses from the surface of the changing turlough surface areas over the seasons; the more evaporation that occurs, the more enriched the surface water becomes in O^{18} (as shown during a dry period in June 2010 in **Figure 1**- when the turloughs were almost empty and received no additional flow for several weeks). A mass balance of ^{18}O has thus been used to quantify the different flow inputs into the turlough water body. Similarly, the ratio of ^{13}C to ^{12}C can be used to determine the source of water in the karst catchment and its likely residence time. The analysis of this data has been used in conjunction with the pipe-network flow model to estimate the nutrient flux in the turloughs.

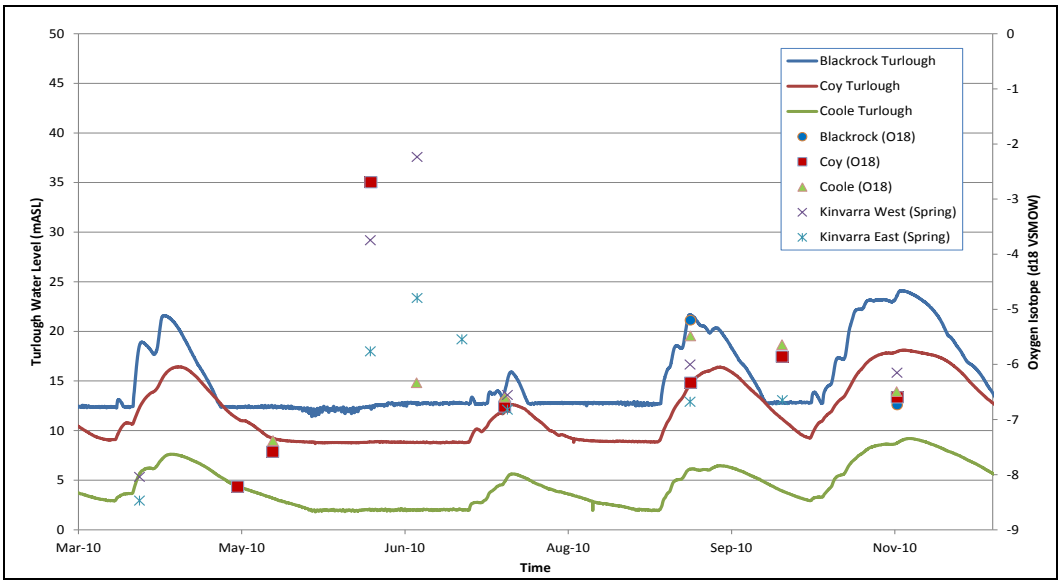

Figure 1: Turlough depth vs ^{18}O ratio. (Note enrichment of ^{18}O in summer when turlough levels low, indicating evaporation).

References

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