



Roinn Cumarsáide,
Fuinnimh & Acmhainní Nádurtha
Department of Communications,
Energy & Natural Resources

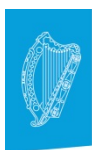


Geological Survey of Ireland Research Programme
- Short Call 2015, Final Report -

Name of Lead Investigator	Prof Laurence Gill
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Phone number	01 896 1047

Organisation name	Trinity College Dublin
Organisation type:	☒ HEI ☐ Public Sector (other) ☐ Private Sector
Department/section	Department of Civil, Structural and Environmental Engineering

Project Title	Characteristics of stable isotope fractionations during reactive transport of phosphate in groundwater discharging to a groundwater fed lake (Lough Gur, Co Limerick)
Contract No.	2015-sc-027



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Department/section	Department of Civil, Structural and Environmental Engineering
Address	Trinity College Dublin Dublin 2

Co-applicant name (Co-PI)	Dr David O'Connell Research fellow (Hydrology and Hydrogeology), Trinity College Dublin, Ireland. Adjunct Assistant Research Professor, University of Waterloo, Canada.
Role in the project	Co-ordinating/ carrying out/ Running / managing the project
Organisation name	Trinity College Dublin (TCD). Adjunct Assistant Research Professor, University of Waterloo (UW), Canada.
Organisation type:	☒ HEI ☐ Public Sector (other) ☐ Private Sector
Company Registration No. (if applicable)	Not applicable.
Department/section	Civil, Structural and Environmental Engineering (TCD) Department of Earth & Environmental Science (UW)
Address	Trinity College Dublin Dublin 2
Project Title	Characteristics of stable isotope fractionations during reactive transport of phosphate in groundwater discharging to a groundwater fed lake (Lough Gur, Co Limerick)
Contract No.	2015-sc-027
Total financial support requested from GSI (as per proposal)	€25,000

The details presented in this report are a true and accurate reflection of the work undertaken and the associated financial expenditure. All work was carried out within the GSI Terms and Conditions and as per the Contract (unless formally amended).

Signed: _____

Lead Investigator



1. Project information:

Title of project	Characteristics of stable isotope fractionations during reactive transport of phosphate in groundwater discharging to a groundwater fed lake (Lough Gur, Co Limerick)
Did you make any formal amendment to the project workplan / budget?	☐ yes ☒ no If yes, please specify:

Project Report

- Objectives and scientific/engineering targets beyond the state of the art

The primary goal of the project was to examine the isotopic effects during phosphate transport in soils and sediments in the form of $\delta^{18}\text{O}_\text{P}$ fractionations. These can then be used to identify any transient fluctuation in flow or later remobilization of PO_4^{2-} or impact of microbial reactions, in addition to identifying physio-chemical processes such as transport of PO_4^{2-} in groundwater. This research in the form of applying $\delta^{18}\text{O}_\text{P}$ analysis of phosphate is at the cutting edge and needs to be evaluated against the specific geochemical characteristics and dynamics of any specific field site. In our project, key locations were chosen for such $\delta^{18}\text{O}_\text{P}$ analysis to study a groundwater fed lake (Lough Gur, Co Limerick) under high flow (March 2016) and low flow (July 2016) conditions. This study aims to apply this knowledge in an attempt to identify different P sources to a groundwater fed lake, taking into account mixing and dilution which may occur due to P cycling processes, dilution from natural uncontaminated sediments and due to loosely sorbed P or surface precipitated P.

- Implementation (including reference to timelines, milestones, management)

Installation of in-situ field sampling and monitoring equipment for real-time monitoring of groundwater flow, and surface flow was undertaken in 2015 and early 2016 (early March). This equipment included piezometer installation for real time water level logging and installation of mini-piezometers for groundwater sampling. In addition, level loggers were installed in surface water channels to continuously measure stage and spot flow measurements have also been recorded for different flow conditions at the hydrometric stations, in order to develop a stage-discharge relationship for the channel.

Characterisation of catchment groundwater levels in surrounding dug wells and boreholes was undertaken under high flow (March 2016) and low flow (July 2016) conditions with groundwater and surface waters samples retrieved for ICP and spectroscopic analysis. Samples were taken for analysis of the isotope tracer $\delta^{18}\text{O}$ to assist trace sources of groundwater, together with $\delta^{15}\text{N}$ and $\delta^{18}\text{O}$ in dissolved NO_3^- and $\delta^{13}\text{C}$ composition in dissolved inorganic carbon (DIC).

Outputs

- Surface and groundwater samples under high (March 2016) and low (July 2016) flow conditions have been analysed and show fluctuations in seasonal phosphate and nitrate with higher concentrations generally observed under high flow conditions (March 2016). These results are being further developed and statistically analysed taking into account fluctuations in major cations under dynamic flow conditions in order to investigate biogeochemical transformations and impact on nutrient cycling and transformations (i.e. K/Na ratios).
- Preliminary isotope results show seasonal dynamics and fluctuations in values.
- Caffeine in the lake water in the vicinity of the sinkhole suggests a human contribution, in addition to wells along the flow pathway. The discharge spring of the lake did not show caffeine which might suggest cavities along the flow pathway from the lake as caffeine degrades under aerobic conditions.
- The artificial sweetener Acesulfame-K was detected in the lake outflow creamery spring (1.8 km from Lough Gur) but not at the sinkhole at the lake suggesting additional water sources along the conduit flow pathway from the lake.
- For the first time in an Irish context, it is expected that this research will reveal the role of groundwater surface water interactions in controlling discharge to a eutrophic lake using such multiple analytical methods including cutting edge isotope tracing.
- Results will be presented in a suitable high-ranking peer reviewed groundwater academic journal (i.e. Water Resources Research / Hydrogeology Journal / Vadose Zone Journal).

Impact/value of the project:

Skills have been developed throughout the project using a multi-isotopic methods for ground and surface water tracing which is lacking in Ireland. These methods could be used for other catchment science applications such as wetlands, surface water hydrology, natural/engineered systems, contaminant tracing (i.e. agricultural / septic tanks, industrial etc.) nutrient and metal cycling studies.

The ultimate results from this research and its **novel methodology should provide positive knock-on impacts for Ireland's freshwater ecosystems** in assisting water managers identify the source of P and applying management practices which will limit eutrophication, potentially harmful algal blooms on the water and increase water quality, thereby making them more usable for tourists and ordinary citizens (i.e. kayaking, boating etc.).

The nature of the collaborations developed in the project will ensure active interactions between Irish and European researchers, which will result in **long-term collaborations that will benefit future water research** even after conclusion of the project.

There has been significant transnational added-value through the research project by bringing international and Irish experts together for the first time. By working together on this GSI Griffith award all partners **gained some level of complementary scientific and technical skills and expertise**.

The project will produce **at least one academic paper** to be published in a prestigious international academic journal and so increase the profile of the GSI and partners in international hydrogeological research.

The project should indirectly **influence Policy & Governance by giving water managers** who liaise with policy makers more information on groundwater fed ecosystem behaviour in terms of P cycling. This new information will allow more scientifically informed decisions for better outcomes within the Water Framework Directive (WFD) for better water quality and reducing the impact on **(GWDTE) groundwater dependent terrestrial ecosystem** such as groundwater fed lakes (i.e. Lough Gur, Ireland).

2. GSI Funding programme

Please provide some comments on the GSI Short Call funding programme:

Positive:

- The GSI Short Call funding programme is a **dynamic initiative to gain funding to carry out focused and cutting-edge geoscience research for young academics** and foster national and international collaborations. It gives the opportunity to carry out preliminary but high impact studies, laying the foundations for larger grant proposals and research conglomerations to tackle issues of national and international geoscientific significance.
- The **project promoted the transfer of research skills and technologies** in the areas of advanced isotope water tracing and nutrient biogeochemistry, field hydrology, hydrochemistry. In addition, the researcher who co-ordinated the project was concurrently trained in the cutting edge isotope tracing of nutrients and water and the biogeochemical reactivity of nutrients under dynamic environmental conditions, which affects their stability and the mobility of associated macronutrient P.
- By working together on this GSI Griffith award all partners **gained some level of complementary scientific and technical skills and expertise**. Through the relationships development on this short project the foundations are laid for projects of longer duration where skills transferred and shared on this project can be applied.

Negative:

- The call is **over ambitious in its time-lines**, especially for field based research requiring later laboratory analysis and dissemination. Cutting edge techniques in geoscience and hydrogeology take longer than routine analysis and so the call should possible be 6 months longer or 18 months in its entirety at least. There could be short progress reports due every 6 months in order to keep projects on schedule but just giving the minimum of 12 months to carry out the work and publish in an international journal is not suitable or realistic for field based investigations.
- In addition, publication of an academic **research article from the project within 12 months is unrealistic** if national and international collaborations are to flourish and the science is to be of a high standard.

Appendix 1 – Publications & Presentations:

The project was presented in poster format at Geo2016 organised by the GSI and received good feedback. The poster title “Dynamics and Sources of Dissolved Inorganic Carbon within a Groundwater Fed Lake Catchment (Lough Gur, Co Limerick)” was well received and generated some questions and interest.