Geophysical Research Abstracts
Vol. 20, EGU2018-9439, 2018
EGU General Assembly 2018

Using hydro-chemical and geophysical techniques to investigate dynamics and sources of DIC and Nitrate in a catchment possessing a Groundwater Fed Lake (Lough Gur, Ireland)

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Lake groundwater discharge (LGD) is often disregarded in many lake nutrient and eutrophication studies. Notwithstanding, water resource managers internationally and in Ireland now acknowledge the adverse impacts of high nutrient concentrations in lacustrine ecosystems resulting from groundwater discharge. Hence, understanding the temporal and spatial distribution of groundwater nitrate (NO_3-) and dissolved inorganic carbon (DIC) is important in understanding the nutrient biogeochemistry of groundwater dependent aquatic ecosystems.

Hydro-chemical species in conjunction with isotope techniques including δ18OH_2O and δ2HH_2O were used to constrain sources of water to the lake. In addition, other isotope tracers such as δ13C-DIC and δ15N-NO_3- and δ18O-NO_3- along with vertical lake-aquifer hydraulic gradients, catchment well-lake gradients, and geophysical surveys were used to trace groundwater seepage and biogeochemical processes impacting lake hydrochemistry and transformation of nutrients, while attempting to constrain recharge patterns and processes connected to the groundwater fed lake.

Hydrographs of wells and lake water levels showed a strong groundwater-surface water connection in the catchment. Rn surveys which identified areas within the lake possessing strong Rn anomaly temporal dynamics, suggesting groundwater discharge at these locations within the lake. ERT survey results measured lateral and vertical variations of subsurface electrical resistivity and have partially revealed the orientation and extent of a subsurface conduit system at Lough Gur. δ15N-NO_3- and δ18O-NO_3- suggested denitrification was a dominant process with seasonal variation with surface and groundwaters and in-lake piezometers at groundwater discharge locations. Seasonal DIC dynamics were identified with a negative correlation between δ13C-DIC (‰ and DOC (mg l-1) indicating dissolution of carbonates by carbonic acid in groundwater wells. In contrast, a positive correlation between δ13C-DIC (‰ and DOC (mg l-1) implies that oxidation of organic matter was a major source of DIC within the lake. Due to different sources of DIC and geological materials having different isotopic compositions, stable carbon isotopes of DIC are a useful tool to trace the source of DIC and the evolution of groundwater.

Few studies have attempted to combine isotopic, hydro-chemical, geophysical techniques to understand lacustrine groundwater discharge. This study demonstrates and exhalts how combining techniques including isotope tracing, hydrochemistry and physical hydrogeology can constrain groundwater evolution and source identification for lacustrine groundwater discharge.