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ISO-MECH: Development of a groundwater isoscape for mechanistic recharge estimation and bacterial fingerprinting

Shane Regan (1) and Paul Hynds (2)

(1) Trinity College Dublin, Civil, Structural and Environmental Engineering, Dublin, Ireland (regans@tcd.ie), (2) Environmental Sustainability & Health Institute (ESHI), Dublin Institute of Technology, Dublin, Ireland (hyndsp@tcd.ie)

In recent years, the concept of "isoscapes" has been used to describe spatiotemporal stable isotope distributions within natural environments including groundwater systems at multiple scales. They have effectively improved our understanding of the complex interactions between hydrological and biogeochemical cycles. Precipitation isoscapes drive isotopic patterns in surficial waters, however, less is known about the geological influence of recharge processes on stable isotopes in the subsurface. A recent study of the oxygen-18 (δ18O) groundwater isoscape in the Republic of Ireland (RoI) found that δ18O composition is primarily driven by location with respect to prevailing wind direction and annual precipitation volume, with a bias towards winter recharge. Results also indicate that local/regional (hydro)geology exerts a secondary influence via infiltration/recharge mechanisms. While the aforementioned study was the first of its kind undertaken in RoI, a region characterised by high precipitation and significant (hydrog)geological diversity, the study was limited by the absence of deuterium (δD) measurements and temporal data. Seasonal monitoring is considered necessary to confidently discern temporal patterns, while δD is required for quantification of evapotranspiration (δD excess). Accordingly, a new study, ISO-MECH, has been initiated and comprises seasonal monitoring seasonal of δ18O and δD variations from spatially distributed groundwater and rainfall stations across Ireland, in addition to installation of and isotopic analyses from several new rainfall collectors. The aim of this study is to i) improve the understanding of precipitation origin, evaporative effects and estimated recharge rates, and ii) use results to conservatively trace bacterial (E. coli) ingress mechanisms with respect to the Irish groundwater environment i.e. source attribution of faecal indicators via isotopic correlation. The long-term effective conservation and management of the 'natural' groundwater resource in Ireland, and indeed globally, represents a key challenge in the face of on-going pressures including projected climate change, urbanisation, and shifting landuse patterns. ISO-MECH represents a direct and timely response to these drivers by significantly improving our knowledge of recharge mechanisms in the Irish subsurface environment, in addition to piloting a novel method for microbial source attribution and transport in the aquatic environment.