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Fluorescence-based tracking of particles from domestic wastewater treatment system plumes discharging to springs in Karst aquifer systems

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Particulates can play a significant role in the transport of microbial contamination in karst aquifers. Significant knowledge gaps exist with respect to the movement of effluent from domestic wastewater treatment system (DWTS) through networks of fractured rock conduits in aquifer systems enabling extensive transport well beyond the source. This is particularly of concern in Ireland given that more than one third of the population (>500,000 homes) use DWTSs. During dry weather periods, when more diffuse flow is dominant, generally lower levels of contamination occur. However, after precipitation events karst groundwater is very susceptible to contamination from more point recharge pathways directly into the karst conduit network with little filtration en route. Thus, karst aquifer systems are prone to particulate contamination within conduits with long travel distances. Whilst there are abundant studies on the detection of contaminants in karst groundwater, few studies actually address transport of DWTSs particulate contaminants to karst springs or the linked direct quantification of human faecal pollution.

This study investigates the significance of DWTS particulate transport to karst springs with the aim to design a fluorescence based "early warning detection" technique based on flow regimes and associated pollutants using fluorescence excitation emission matrix (EEMs) and parallel factor analysis (PARAFAC). Preliminary results of non-conventional tracer techniques at other karst springs are being integrated into adaptive management strategies using advance fluorescence techniques to protect karst water resources under different population growth, changing climate and land use scenarios. Traditional faecal indicator bacteria analysis does not provide sufficient information with regards to sources of groundwater contamination, but a systematic investigation of other contaminants of anthropogenic origin in groundwater is providing important additional information for tracking human sourced contamination. Many methods now exist based on the detection of low concentrations of anthropogenic chemicals / biochemicals from on-site wastewater sources, but many are either complicated and slow or require expensive equipment and highly trained personnel. In this study, in-situ instrumentation for fluorescence-based tracking of particles is being evaluated with a selection of these more sophisticated techniques in order to assess the possibility for overcoming such issues in karst aquifer systems. Several springs representative of karst networks of different scale and morphometry are being investigated in order to compare contrasting groundwater vulnerabilities (Extreme versus Low / Moderate) and different karst systems (conduit flow dominated versus diffuse flow dominated) in catchment areas with high densities of DWTSs in the west of Ireland.

This research aims to be able to determine the impact of particulates in DWTS effluent discharging to springs in rural karst catchments for the first time in Ireland. In addition, findings will be beneficial on the international scale, by evaluating several techniques in different karst environments and under specific (climatic and hydrogeological) conditions, which will offer valuable experience across a suite of various methodologies to determine contamination sources.