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A comparison of emerging contaminant fingerprinting techniques to assess the impact of human wastewater on karst groundwater quality

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Lowland karst aquifers in Ireland are extremely complex to understand and are considered to be highly vulnerable to pollution (e.g. low-lying karst catchments exhibit a lot of surface water – groundwater interactions which makes them very susceptible to direct contamination). These aquifers are impacted by multiple contamination sources on land (in particular, rural sources from agriculture and on-site domestic wastewater effluent) which makes their protection and management challenging. Human wastewater effluent is identified as significant threat to groundwater quality in such lowland Irish karst environments, since approximately one-third of the population in Ireland is relying on decentralized wastewater treatment systems for the treatment of domestic wastewater. However, it is difficult to distinguish between human wastewater effluent and agricultural pollution impacts on karst aquifers using only traditional water quality parameters or any single environmental tracing method. Hence, the impact of microbial and chemical contaminants of human wastewater origin on groundwater quality must be assessed using a multiple-tracer approach, ideally targeting source-specific tracers. This paper presents an overview of the results obtained during the research conducted throughout the last several years at nine karst catchments in Ireland using a range of methodologies in order to determine and quantify domestic wastewater pollution impacts on karst springs. Microbial pollution was assessed using flow cytometric fingerprinting and faecal indicator bacteria, while chemical pollution impact assessment included the analysis of fluorescent whitening compounds (FWCs; well-known indicators of human contamination since their origin is mostly from laundry detergents), specific anion ratio signatures (Cl/Br), quantification and identification of microplastic particles using Fourier-transform infrared spectroscopy (FTIR), and faecal sterol and stanol profiles and ratios. A thorough analysis of the results obtained using a multiple-tracer approach has been conducted and methodologies have been evaluated in terms of applicability and sensitivity in a range of different karst catchments. The ability of these methodologies and techniques to determine and quantify human faecal pollution impacts on karst springs will be discussed. The results show a significant correlation between microplastic particle counts and detected FWCs

signals at different springs, which helps to understand the contribution of household-derived contaminants to this environmental problem. Moreover, our results indicate that faecal sterols and stanols can be useful faecal source tracking method in karst aquifer systems despite the fact that concentrations of sterols and stanols of interest were usually low which makes the interpretation of results challenging.