The use of pharmaceuticals and personal care products, the gadolinium anomaly, and $\delta^{11}B$ in the evaluation of impacted California groundwaters

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The development of new methods to identify and quantify wastewater contributions to California groundwater is driven by 1) the need to use reclaimed water in managed aquifer recharge operations to enchance California's water supply; and 2) the need to identify the source of regulated compounds such as nitrate to contaminated aquifers. Quantifying the wastewater component in groundwater is essential to interpreting the presence or absence of emerging contaminants in groundwater in the context of transport through the vadose and saturated zone. Being able to distinguish the source of wastewater as urban, residential septic, agricultural, or animal operation allows effective regulation of nutrient loading to drinking water aquifers.

In this study we evaluate a suite of pharmaceuticals and personal care products (PPcPs), the gadolinium anomaly (Gd *), and the isotopic composition of dissolved boron ($\delta^{11}B$) for suitability as wastewater indicators (WWIs). These analyses are complementary and use different analytical approaches: the presence or absence of anthropogenic compounds using LCMS; the identification of anomolous REE patterns using Q-ICPMS; and the quantification of isotopic composition using HR-ICPMS.

We measured these analytes in wastewater treatment plant (WWTP) effluents and in groundwater recharged by landscape irrigation with treated wastewater in the San Francisco Bay region of California. The WWTP effluent and affected groundwaters are mildly enriched in tritium from Lawrence Livermore National Laboratory (LLNL) sewage discharge – the activity levels are low and within permit but are sufficiently above ambient activities to provide an independent assessment of wastewater component using a known conservative tracer. We assess WWI suitability for groundwater studies by quantifying transport losses due to degradation or sorption in the vadose and saturated zone and by quantifying sensitivity to wastewater component as affected by analytical sensitivity and by mixing and dilution of affected groundwater.