Using multiple tracers to distinguish between municipal drinking water and wastewater inputs to streams

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Releases of municipal waters, like drinking water and wastewater, can considerably alter urban critical zones. However, the relative contributions of drinking water versus wastewater to streams have not been quantified previously and are therefore the focus of this study. We sampled streams along a land use gradient that included watersheds with impervious surface areas (ISA) ranging from 1.6 to 62.6%. Samples were analyzed for F^-, total B, $\delta^{11}B$, and optical brighteners to determine municipal water inputs to streams. We observed low F^- (75 ± 20 µg/L), total B (29 ± 6 µg/L), and optical brightener (3.66 ± 0.76 RFU) levels in rural streams, but their concentrations increased with urbanization (up to 475 µg/L, 227 µg/L, and 22.09 RFU, respectively). The $\delta^{11}B$ values for drinking waters (16.52 ± 0.39‰) and wastewaters (influent = 6.06 ± 0.88‰ and effluent = 6.46 ± 0.93‰) were distinct. However, there was poor correlation between $\delta^{11}B$ and ISA for the streams ($R^2 = 1\times10^{-5}$; $p = 0.99$), likely due to variable lithology in the study area. We used inverse and three-component mixing models to quantify municipal water inputs to the streams. In densely urbanized watersheds, drinking water and wastewater can respectively contribute up to 54% and 16% of the total streamflow. In addition to our spatial sampling, we collected weekly samples at a suburban stream (watershed ISA = 28.0%) to test the effects of discharge and seasonality on municipal water tracer behavior. We found that tracer levels did not change significantly ($p \geq 0.28$) with discharge or season, suggesting that municipal inputs are fairly constant over time. Understanding the relative proportions of differing municipal water types to streams is crucial in guiding infrastructure improvements to conserve drinking water and reduce harmful wastewater releases. The unique chemical signatures of municipal waters aid in the widespread applicability of our multi-tracer method for identifying water sourcing to urban streams.