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Assessing the Hydraulics of Water Heaters by Adding Fluoride as a Tracer to Inform its Overall Effect on Water Quality

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ABSTRACT

As residential water heaters are the primary source of waterborne disease outbreaks in the U.S. there is a need to better understand how they are contributing to decreased water quality in buildings. Previous work has indicated that intermittent stagnation, low disinfection residual and operation temperatures promote the growth of pathogens in water heaters. The overall effect of hydrodynamics of water heaters on these factors remains unclear. Therefore, a tracer study was performed to determine the effect of and characterize hydraulics of the typical residential water heater on water quality. Controlling temperature and flow rate, a pilot-scale hot water system (50 gal) with specially adapted fittings was used. The fittings allowed for injection of fluoride as a tracer. 4.40 mg/L fluoride solution was injected at room temperature into the inlet line, set at 2.50 gal/min, to derive a step input fluoride concentration. Samples were obtained at the outlet of the tank, then fluoride concentration was measured by ion chromatography. A model was derived numerically in Matlab to validate if the experimental data reflected the behavior of a continuous stirred tank reactor. The data was consistent with the model but deviated at high flow rate and temperature conditions indicating that dispersion effects may be a factor. Additional tests with this tracer can help to better evaluate hydrodynamics of the system and thus its impact on water quality before it reaches the point of use.

KEYWORDS

Water heater, premise plumbing, tracer study, hydraulics, numerical model.