The role of hyporheic exchange in the environmental fate of lampricides

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ABSTRACT:

In this project, we combined laboratory experiments, mid-scale field experiments, full field campaigns, and modeling to better understand the processes that impact the fate of 3-trifluoromethyl-4-nitrophenol (TFM) when it is applied during planned tributary treatments. We investigated the susceptibility of TFM to undergo biodegradation and photodegradation, as well as its ability to sorb to sediment, under laboratory conditions. Midscale field experiments in a flow-through sediment mesocosm were used to investigate TFM-sediment interactions. In addition, outdoor sunlight experiments were used to relate laboratory photodegradation rates to field observations.

Intensive field campaigns were conducted at the Lincoln River in 2020 and the Driggs River in 2022. In each case, we measured TFM at multiple sites to quantify TFM loss over the study reach. We also measured TFM in the hyporheic zone and over long time periods in the Lincoln River. In addition, we conducted multi-tracer experiments in the same systems. This approach allowed us to make direct comparisons between TFM and bromide (a conservative tracer), uranine (a tracer that undergoes relatively rapid photolysis), and rhodamine WT (a tracer that is highly sorptive).

There was modest loss of TFM (15%) in the north branch of the Lincoln River and negligible loss in the studied reach of the Driggs River. Although we observed uranine photolysis under field conditions, there was no evidence of TFM photolysis in either system. In the hyporheic zone, TFM is weakly sorptive. Biodegradation over longer timescales (days to weeks) in the hyporheic zone is also possible. We observed direct evidence of TFM concentrations within the hyporheic zone of the Lincoln River, indicating storage of TFM. Release of TFM back into the surface water was also observed after a big storm event. This exchange of TFM with the hyporheic zone likely results in lingering, low-level TFM concentrations observed weeks after treatment. We concluded that hyporheic exchange and storage plays an important role in the fate and transport of TFM.

We also validated that commercially available fluorescent dissolved organic matter (fDOM) sensors can be used to quantify TFM in real time. This finding may be of use to field agents to complement their existing approaches to measure TFM in the field.