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The fate and effect of pharmaceuticals in boreal surface waters

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Abstract
Traces of pharmaceuticals are often found in streams, rivers, and lakes as the result of effluent water discharge. This dissertation aims to create a better understanding of the fate of drugs in aquatic ecosystems and how oxazepam, an anxiolytic pharmaceutical commonly detected in surface waters, affects the behavior of perch (Perca fluviatilis). To address these issues, I used a series of large-scale field experiments to evaluate predictions made in controlled laboratory experiments. My dissertation shows that small-scale incubations commonly used to assess the persistence of pharmaceuticals (trimethoprim, diclofenac, hydroxyzine, diphenhydramine and oxazepam) in aquatic environments effectively predicts the fate of dissolved drugs in freshwater during the first week of contamination. However, these experiments and the conceptual models failed to predict that pharmaceuticals can remain dissolved in freshwater for months. In addition, the results suggest that the drugs remain bioactive for months and that the uptake of different drugs varied widely between trophic levels. For example, benthic species generally had a higher affinity to accumulate the studied drugs than species in higher trophic levels; however, the anxiolytic drug oxazepam was found in perch. To test the effect of oxazepam on perch behavior, I used acoustic telemetry to track the perch in situ (i.e., in the ponds). The in situ behavior of perch correlated with laboratory behavior when findings from several trials were merged into multidimensional behavioral profiles of the studied individuals, although oxazepam did not conclusively affect perch behavior in line with earlier theories, when though concentrations were much higher than concentrations measured in any contaminated environments. I conclude that simplified laboratory experiments have some predictive power regarding the fate and effects of pharmaceuticals in complex natural ecosystems, but laboratory environments may underestimate persistence of drugs in aquatic ecosystems and fail to detect important social drivers of animal behavior in natural settings.

Keywords
Aquatic ecosystems, behavioural effects, ecotoxicology, acoustic telemetry, field verification, social network

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