Emerging organic contaminants and their threats to freshwater biodiversity

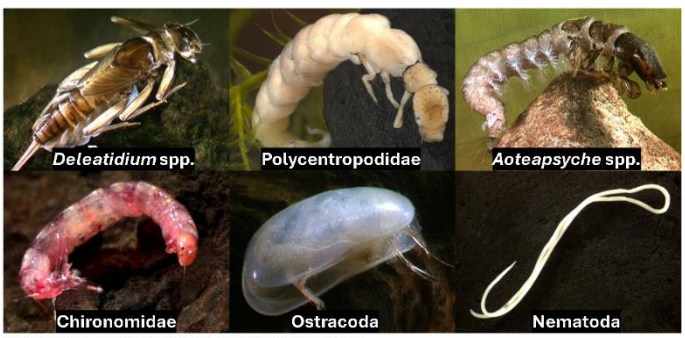
Ibuprofen appears to pose a lower risk to freshwater invertebrates and algae compared to imidacloprid (an insecticide) which reduced some sensitive invertebrate populations and promoted thicker algal mat growth. To best protect freshwater biodiversity, we suggest prioritising regulatory management of insecticide contamination over certain pharmaceuticals.

What we know

Emerging organic contaminants (EOCs), such as pharmaceuticals and pesticides, are chemicals that are often inadequately removed by conventional wastewater treatment and are thus discharged into aquatic ecosystems. Much of the existing toxicological research is based on short-term exposure studies in laboratory conditions, often using chemical concentrations far in excess of those typically found in the natural environment. In contrast, we aimed to test lower chemical levels (concentrations found in the natural environment) using the *ExStream* system, which simulates natural streams. Specifically, we characterised the impacts of environmentally relevant exposures to two commonly detected EOCs in global rivers – ibuprofen and imidacloprid.

What we found

Ibuprofen had minimal negative effects on both invertebrate and algal communities.



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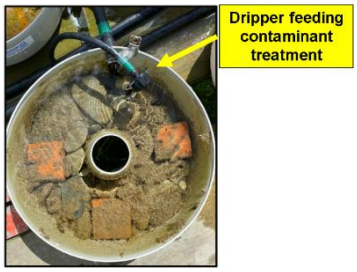
In contrast, imidacloprid increased drift rates in several sensitive invertebrate taxa, including *Deleatidium* spp. (Ephemeroptera), and Polycentropodidae and *Aoteapsyche* spp. (Trichoptera). It also caused an overall decline in benthic invertebrate taxon richness and diversity, reducing abundances of *Deleatidium* spp., Chironomidae, Ostracoda and Nematoda, and reduced emergence in Chironomidae. Channels treated with imidacloprid developed extensive algal mats, likely due to reduced invertebrate grazing.

Fast flow velocity amplified several of imidacloprid's effects on invertebrates and algae, likely due to more uniform distribution of the contaminant with increased turbulence compared to pooling in slow-flow channels.

Pollution sensitive algal species did not respond consistently to ibuprofen or imidacloprid, suggesting limited utility of these indices in assessing algal sensitivity to emerging organic contaminants.

Emerging Organic Contaminants (EOCs)

EOCs, including pharmaceuticals and pesticides, are increasingly recognised as a priority concern for freshwater ecosystems, which are already under significant stress from other pressures. EOCs are frequently detected in freshwaters globally but their impacts on freshwater ecosystems and species remain inadequately understood. Regulation of EOCs remains limited, primarily due to the complexity of characterising the hazards they present across diverse non-target taxa and different ecological contexts.



What we did

We used 64 channels of the *ExStream* mesocosm system to manipulate flow velocity (fast vs. slow), ibuprofen (0 vs. 32 µg/L), and imidacloprid (0 vs. 0.7 µg/L). The ibuprofen concentration reflects the highest reported in global rivers, while the imidacloprid concentration represents the average detected in surface waters.

Prior to contaminant addition, all channels underwent a 14-day colonisation period by invertebrates and algae, during which only flow velocity was manipulated. Ibuprofen and imidacloprid were then introduced, with the organisms in each channel exposed for 30 days. Drifting and emerging insects were sampled at the beginning, middle and end of the exposure period. Benthic invertebrates were sampled on the last day of the experiment. Algal mat thickness was measured weekly.

Conclusions

The minimal effects observed for ibuprofen reflect its specific mode of action, and while we found low sensitivity in invertebrates and algae, further research is needed to determine the risk to fish.

Imidacloprid exhibited pronounced toxicity in invertebrates, consistent with its intended biological use, which led to an increase in algal communities released from grazing pressure.

A more comprehensive understanding of EOCs is essential to inform effective management and regulatory frameworks aimed at safeguarding the ecological integrity of freshwater systems that provide vital life-supporting ecosystem services.

This research was conducted by PhD candidate Niña Sarah Batucan with supervision from Prof. Christoph Matthaei at the University of Otago, and Dr. Louis Tremblay (formerly at Cawthron Institute, now at Manaaki Whenua | Landcare Research), and Dr. Grant Northcott at Northcott Research Consultants Limited.

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A scientific paper is being prepared from this research. Please contact Niña (batni629@student.otago.ac.nz) in the interim for any questions.

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University of Otago ŌTĀKOU WHAKAIHU WAKA

Department of Conservation Te Papa Atawhai