Pharmaceuticals and personal care products in wastewaters

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Emily Warrender September 17, 2025

Despite progress in wastewater treatment, PPCPs like medications and personal care products continue to enter ecosystems, threatening aquatic life. Since 2020, the Bow River Ecosystem Health Assessment project in Alberta, Canada, has been evaluating the impact of treated wastewater on the Bow River

Investments to improve wastewater treatment have led to tremendous improvements in water quality and ecosystem health. (1) However, even with tertiary effluent treatment, a diversity of contaminants that include pharmaceuticals and personal care products (PPCPs) continue to enter the environment and have the potential to disrupt the normal growth, development, and reproduction of aquatic organisms. The ongoing development and introduction of new chemicals continuously raise further concerns. The Bow River Ecosystem Health Assessment project has been assessing the impact of treated municipal wastewater discharges from the City of Calgary on the Bow River in central Alberta, Canada, since 2019.

What are PPCPs?

PPCPs are a diverse group of environmental contaminants that include human and veterinary medicines, as well as active ingredients in diverse personal care products (e.g., antimicrobials, fragrances, cosmetics, sunscreens, hygiene products, etc.). They are part of a broader group of thousands of organic micropollutants that include natural and synthetic hormones and industrial chemicals introduced through waste and wastewater discharges. Although more than 17,000 documents have been published on pharmaceuticals in the environment over the last two decades, (2) the consequences of their discharge to aquatic ecosystems remain poorly understood. Many of these compounds are known to interact with each other and with environmental stressors and can cause adverse biological responses in organisms at trace levels found in the environment.

How do they enter the environment?

Many PPCPs used by humans or for animal health ultimately enter municipal wastewater treatment systems. Although these systems can be very effective at removing solids (primary treatment), and organic material and ammonia (secondary treatment), they were not specifically designed for chemicals such as PPCPs, so many of these compounds are not fully removed by current conventional treatment. Although some form of tertiary treatment is often employed to reduce nutrient and pathogen concentrations, few

treatment systems in Canada have advanced quaternary treatment focused on the removal of trace organics. PPCPs enter the aquatic environments as complex mixtures and represent an undefined risk because of their biological activity.

Prioritizing PPCPs in the Bow River

In addition to detailed field studies on fish, benthic invertebrates, and lower trophic level communities, our Bow River Ecosystem Health Project has included experimental stream exposures and an evaluation of long-term water quality monitoring data produced by The City of Calgary's Watershed Monitoring Program. The City has maintained a forward-thinking monitoring program that represents one of the most comprehensive efforts by a Canadian water or wastewater utility to track microcontaminants (e.g., PPCPs) across multiple locations at a consistently high sampling frequency. Analysis of these data (3) has allowed the City of Calgary to prioritize a subset of six key substances for continuous future monitoring, allowing for more efficient allocation of resources and freeing capacity to address additional emerging substances of concern as they arise. Adaptive monitoring improves operational efficiency and positions the utility to make faster, more informed decisions as new contaminants and regulatory pressures emerge. Early investments in robust data collection can catalyze long-term planning and help Canadian municipalities safeguard aquatic resources and public wellbeing.

Continued risk of trace contaminants

Despite many microcontaminants, including PPCPs, being found at low concentrations, they can be very biologically active and have subtle yet important effects on aquatic organisms. (4) For well-developed and managed wastewater systems, with high dilution, the environmental risks are likely low. However, many aquatic environments are associated with low flows, multiple outfalls, sensitive species/ecosystems, and are influenced by multiple stressors. PPCPs may play a role in reducing the resiliency of ecosystems and their ability to respond to cumulative effects. Monitoring of high-risk sites (5) using established or modified approaches, such as Canada's Environment Effects Monitoring Program (under the Fisheries Act) (6), may help identify risks and inform future local and national infrastructure investments and remedial actions.

Emerging regulations

Although certain jurisdictions in Canada have surface water quality guidance on select PPCPs, there are currently no enforceable national regulatory standards for these substances in treated municipal wastewater and their receiving environments. This contrasts with the European Union (EU), where the Urban Wastewater Directive 2024/3019 (L_202403019EN.000101. fmx.xml) mandates that all WWTPs serving >150,000 inhabitants must achieve a minimum 80% removal of 12 identified micropollutants (Part C, Table 3). This EU directive also emphasizes the application of the precautionary principle in combination with a risk- based approach to guide decision-making in wastewater management. Member States in the EU are now required to assess the risk that discharge of micropollutants in urban wastewaters (agglomerations of

>10,000 people) poses and employ quaternary treatment (by 2045) to remove them (e.g., ozonation, activated carbon) where they represent a risk for the environment or to public health.

What does this mean for the future?

Canada's current regulatory framework only requires a minimum of secondary treatment (2012 Wastewater Effluent Regulations). Although Canada may generally benefit from large receiving environments, the capacity of these ecosystems to assimilate wastes is not infinite, and many municipalities discharge into small rivers, lakes, or estuaries. Adequate evaluation of existing receiving water impacts in terms of ecological responses will allow municipalities to evaluate their risk profile and to prioritize their receiving environment concerns. Proactive investment in advanced treatment technologies, guided by both scientific evidence and the precautionary principle, would position communities across Canada to better safeguard water resources. Promoting investments in water quality at high-risk sites will reduce future resource limitations and conflicts, while enhancing both environmental and human wellbeing.

Risk assessment requires understanding the contributions of seasonal trends, sporadic releases, and factors influencing environmental fate, as well as hydrological profiles and dilution. Risk management requires a combination of source control, improved treatment, focused monitoring, water conservation, and the development of appropriate regulations. Assessing ecological impacts provides a backstop for detecting and managing cumulative effects, and can prioritize sites requiring management decisions.

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