Wastewater effluent is one source that increases the concentration of contaminants of emerging concern in the environment.

Contaminants of Emerging Concern

Pharmaceuticals pose challenges for wastewater treatment. What solutions are available?

BY KIMBERLEY GILBRIDE

THROUGHOUT THE LAST DECADE, the definition of 'contaminants of emerging concern' (CECs) has morphed into an open ended and ambiguous term. Currently, any compound that is not currently monitored in the environment but might enter the environment and potentially cause an adverse effect to the ecosystem or human health can be considered a CEC. The uncertain nature of the term reflects the emergent state of scientific research on the characteristics and classification of these contaminants that can include compounds such as pesticides, illicit drugs, synthetic and natural hormones, personal care products, antibiotic resistant bacteria and genes, and pharmaceuticals.

Thirty to 90 per cent of oral pharmaceuticals or their degradation products are estimated to be excreted in urine and faeces. There has been a large increase in the quantity of these drugs that enter our sewage systems since wastewater treatment plants (WWTP) were not designed to eliminate many of these compounds. Aging populations and the desire to improve the quality of life worldwide will continue to increase the consumption of pharmaceuticals, and without suitable best available technologies, wastewater effluent will become the major pathway for CECs to enter our environment. For example, the use of therapeutic drugs increased at an annual rate of 12 per cent in Canada between 1985 and 1992. Likewise, between 1998 and 2007 spending on prescription drugs used outside of hospitals grew from $8.0 billion to $19.0 billion. It is estimated that the global pharmaceutical market will exceed $1.5 trillion by 2023.

Research has shown that pharmaceuticals discharged from WWTPs are present in downstream freshwater sources that are relied upon for drinking water, irrigation, and fish habitats. In general, scientific research on CEC has characterized these contaminants as discrete chemicals. However, the cumulative and synergistic impacts of these chemicals upon human and ecological health is overlooked and is not well understood. As a consequence, CEC scientific knowledge has not yet been translated to support the development of evidence-based decision-making tools, new wastewater technologies, and legal regulations that could protect freshwater sources, ecosystems, and human health, and be relied upon by municipalities operating WWTPs.

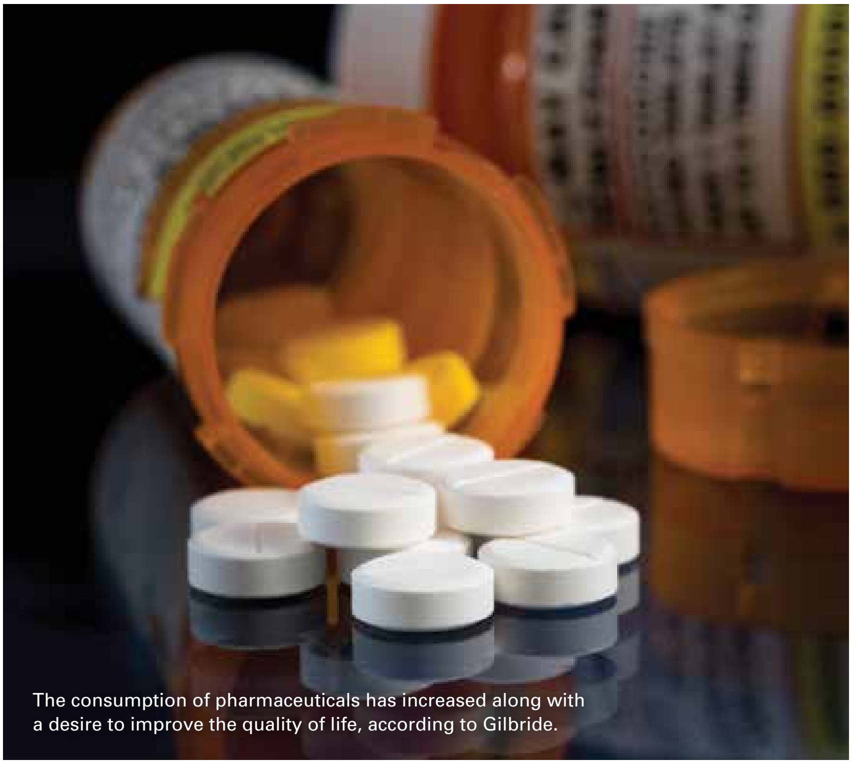
In 2018, the Canadian Water Network published a comprehensive pan-Canadian public awareness report affirming the regulatory gap and the WWT challenges facing federal and provincial governments. The report leaves open for further research the task of identifying and prioritizing CEC from the growing list that are "most significant health risks to receiving waters and environments."

A report published by Pollution Probe in 2019 examined the sources, pathways, and impacts of pharmaceuticals in the Great Lakes. It identified that a gap existed in "ecotoxicology data on active pharmaceutical ingredients and mixtures." It also highlighted the absence of federal and Ontario wastewater regulations on "the management of pharmaceutical pollutants." The report recommended prioritizing research on "active pharmaceuticals" as well as site-specific monitoring of wastewaters at "pharmaceutical manufacturers" and healthcare institutions while also considering "pre-treating on site prior to release to WWT facility."

In practice, environmental monitoring at a WWTP should provide stakeholders data to assess the risk not only of each contaminant but also of the cumulative impacts and removal rates of CECs. However, WWT operators face the problem of deciding what data to collect and what to measure when assessing the risk of CECs. The need to determine the occurrence, seasonal timing, and spatial distribution of CECs in order to monitor, predict and migate the health and ecological impact complicates monitoring protocols. Research from the United States' EPA demonstrated that CECs sampling concentrations often vary significantly and appear dependent on sampling locations and season of the year.

The traditional analytical approach to monitoring CEC applies targeted screening with techniques such as HPLC and GC coupled with mass spectrometry. However, the requirement for precise sample preparation and the low levels of the contaminants can produce misleading test results raising doubt as to the efficacy of this approach for WWTP operators. It has been shown that these misleading results can be explained by chemicals acting as transformation products, which may exhibit similar chemical activity and toxicity levels to the parent CEC compound, and then, can become undetected in the WWT monitoring of influents and effluents. These findings not only demonstrate the inadequacy of the current contaminant-by-contaminant classification system that informs the traditional monitoring approach but also support water policymakers call for a precautionary and adaptive management approach for developing suitable and standardized sampling protocols.

In Canada, a legislative gap exists regarding the safe regulation of CEC effluents from WWTPs stemming from a shared constitutional responsibility for water resources and wastewater treatment that is divided between federal, provincial, and municipal authorities. At the federal level, Environment and Climate Change Canada administers the legislative instrument (i.e., the Wastewater Systems Effluent Regulations (SOR/2012-139)) that falls under the Fisheries Act. This 2012 non-binding regulation sets a quality baseline for monitoring effluent discharges. However, both CEC and influents into wastewater systems from industrial, commercial, and institutional sites are overlooked.


The consumption of pharmaceuticals has increased along with a desire to improve the quality of life, according to Gilbride.

However, in the end, WWTPs are managed at a municipal level. If regulations on the release of CECs are legislated, the WWTPs will be responsible for implementing new technologies that can eliminate CECs including pharmaceuticals during treatment. Currently several technologies have been shown to significantly remove pharmaceuticals from wastewater. The most widely used process is activated carbon treatment as it is able to remove both organic and inorganic pollutants. However, the process requires adequate monitoring strategies since adsorption competition can reduce a compound's removal and large bed volumes are required to have enough available adsorption sites.

Advanced oxidation processes are also promising technologies. They are able to remove a wide range of CECs. However they can be expensive to operate due to the need to prepare and recover the photocatalyst. Constructed wetlands are a new green technology that mainly involves the use of vegetation, soil, and microoganisms to improve the water quality. They can remove large percentages of CECs but do not seem to achieve total removal and may suffer from sediment accumulation and microbe release. Currently no single technology is ideal is all circumstances.

The increase in pharmaceuticals is wastewater is directly linked to the increase in the use of pharmaceuticals worldwide for global health. However, the outcomes of such compounds being released into the environment has highlighted the importance of knowing the risks associated with exposure to these compounds. The solution relies on the development of adaptive and holistic environmenta1 monitoring strategies, implementation of wastewater regulations based on CEC management protocols, and research into new technologies to remove the compounds during wastewater treatment. WC

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