# Persistent, mobile, and toxic plastic additives in Canada – identification and prioritization strategies

Eric Fries[1], Tanjot Grewal[1], Roxana Sühring[1*]

[1] Department of Chemistry and biology, Toronto Metropolitan University, 350 Victoria Street, Toronto M5B 2K3, ON, Canada

## 1 Introduction

Plastics are a global pollution problem. Their global annual emission into rivers, lakes, and the ocean range from 9 to 23 million metric tons (Borrelle et al., 2020). A major side-effect of this output is growing environmental pollution, including plastic-associated contaminants. Plastic-associated contaminants (microplastics and [organic] chemical plastic additives) pose risks to the environment and to human health, with effects that include endocrine disruption, carcinogenicity, and developmental effects (Rochman et al., 2019).

A challenge for the environmental chemical risk analysis of plastic-associated contaminants is the focus of current regulatory frameworks on persistence, bioaccumulation potential, and toxicity (PBT) as assessment criteria (Government of Canada). While these criteria are useful for identifying legacy persistent organic pollutants (POPs), they fail to address the environmental risk from microplastics and their water-soluble additives that are not bioaccumulative but persistent, mobile in water, and toxic (PMT) (Reemtsma et al., 2016). PMT substances are toxic polar organic compounds that are persistent in water and can therefore pose a long-term risk to the aquatic environment. Due to their polarity, generally low volatility, and low potential to sorb to organic matter or particles, emitted PMT substances remain in water or can penetrate groundwater aquifers and threaten the quality of drinking water sources (Reemtsma et al., 2016). Moreover, the high environmental stability of PMT substances can enable them to undergo long-range water-based transport into remote environments such as the Arctic Ocean (Sühring et al., 2021).

Recent screening studies for potential PMTs in Europe reported that a considerable amount of the commercially used PMTs are plastic additives such as plasticizers, dyes, flame retardants, and surface treatment agent (Wiesinger et al., 2021). Many of these plastic additives are known to be hazardous for the environment as well as human health (Rochman et al., 2016). Yet, while PMTs have been recognized as a potential threat to human and environmental health, there are significant analytical and regulatory challenges associated with their identification, quantification, and management (Reemtsma et al., 2016).

In the presented study, we used the PMT criteria defined by the German Environmental Protection Agency (UBA) to identify PMT plastic additives used in Canada and developed a prioritization framework based on their physical-chemical property space and expected retention in wastewater treatment plants.

## 2 Materials and Methods

A comprehensive list of PMT plastic additives registered for use in Canada was developed based on the PMT criteria and PMT suspect list published by UBA (Neumann et al., 2019). This "UBA PMT list" (available on the Norman Network, https://www.norman-network.net) was combined and compared to the Canadian Domestic Substances List (DSL) using CAS numbers to create a list of PMT substances registered for use in Canada. This list was then compared to the PlasticMAP database published by Wiesinger et al. (2021) that contains over 10,000 plastic monomers, additives, and processing aids to create a list of PMT plastic additives registered for use in Canada. Physical-chemical property data for PMT substances was collected from Arp et al. (2017) as well as the CompTox Chemistry Dashboard by the US Environmental Protection Agency.

The open access wastewater treatment model SimpleTreat was used to model the removal efficiencies of the PMT plastic additives from wastewater effluent to assess their potential for human and environmental exposure. Once the removal efficiencies were acquired the PMT substances were ranked based on their estimated emissions via effluent and classed based on their physical chemical properties (partitioning coeffifients).

## 3 Results

One hundred and twenty-four (124) PMT plastic additives registered for use in Canada were identified based on the criteria developed by UBA, with median modelled emissions through effluent of > 75% (Figure 1). Among these, 50% contained nitrogen, 33% were halogenated, 13% contained sulfur, 4% contained phosphorus, and 3% contained silicon. Of the compounds with the highest predicted emissions (> 80%) may were ionizable (42%) and most contained nitrogen (68%).

Typical applications of PMT plastic additives were found to be as 'processing aids' (60%), 'colorants' (53%), and 'intermediates' (47%).

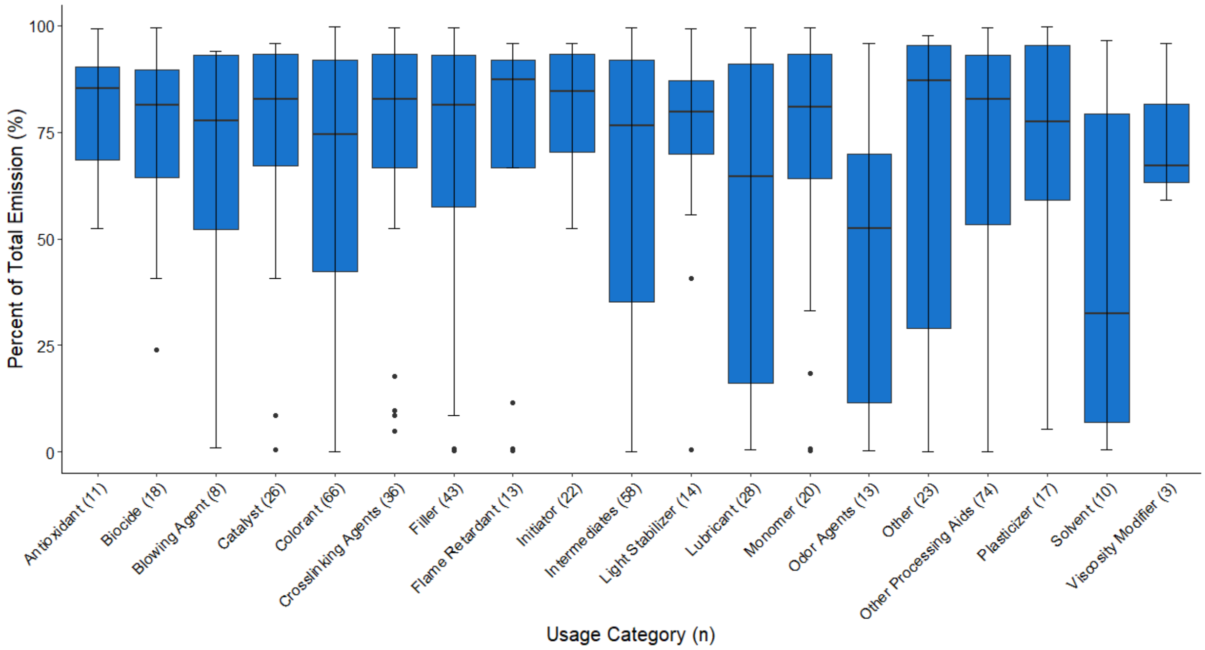


Figure 1: The distribution of effluent emission (as a percentage of total emission) of 124 PMT plastic additives, based on their use category.

## 4 Discussion

In an assessment of over 10,000 plastic additives, monomers, and processing aids used on the global market, Wiesinger et al. (2021) showed that only 57 were considered either PBT or very persistent and very bioaccumulative (vPvB). Conversely, we identified 124 plastic additives registered for use in Canada that meet or potentially meet the criteria for PMT. Considering that PMT substances can pose a risk to drinking water security and that PMT substances can be considered an equivalent level of concern to substances of very high concern (SVHCs) under REACH (Hale et al., 2020) the use of PMT substances in Canada clearly merits further investigation. This is particularly important for the 66 PMT plastic additives with predicted emissions through wastewater effluent of > 80%. These poorly retained that are persistent and toxic could pose a poorly reversible risk to drinking water security and the quality of receiving aquatic environments.

Considering the number of identified PMT plastic additives and range of uses, prioritization is key to address potential risks for human health and the environment from compounds that are most susceptible to pass through WWTPs and into surface and drinking waters.

PMT plastic additives share common physicochemical properties (log Kow/Dow/Koc/Doc, log Kaw, and vapor pressure) that could be used to identify them. The property ranges identified in this study can be used in the future for the initial screening of PMT substances entering WWTPs. Specifically, PMTs with a log Koc between -3.3 and 3.2, and a log Kaw between -16 and -2.4 at a 90th percentile were predicted to be emitted in the effluent at > 80%.

Moreover, there was a clear difference between common structural components in high emission PMT plastic additives compared to the overall PMT plastic additives. 68% of the high emission PMT plastic additives (>80% emission) contained nitrogen compared to only 23% of halogenated PMT plastic additives. This is important to consider for future screening for contaminants of potential concern, because historically, halogenated substances have typically been flagged as more concerning than nitrogen-based compounds.

An important limitation of the current study was the lack of available monitoring data for PMT plastic additives in wastewater treatment plants as well as a lack of experimental physical-chemical property data. The current shortness of experimental and monitoring data is due to a lack of previous regulatory and scientific focus on PMT substances as a group as well as substantial analytical challenges with regards to the detection and quantification of PMT substances (Reemtsma et al., 2016). Sensitive and robust analytical methods play a key role in the future of researching and monitoring PMT substances and additional research and analytical techniques, as well as standards are needed to enable the investigation of PMT substances as potential environmental contaminants.

## 5 Conclusions

The current study resulted in a ranked list of PMT plastic additives registered for use in Canada that are expected to have little to no retention in WWTPs. However, lack of monitoring data, experimental physical-chemical property data, as well as information on tonnages are substantial barriers to an effective fate and risk analysis of PMT plastic additives and PMT substances in general. There is a clear need for greater emphasis on the monitoring, development of experiments, models, and regulations for PMT plastic additives given their abundance and lack of current regulatory mechanisms. This is true in Canada as well as globally as persistent and mobile chemicals pose transboundary environmental and health risks that can only be addressed through integrated regulatory approaches and information exchange (Jin et al., 2020).

## 6 Acknowledgments

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## 7 References


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