Understanding the ecological impacts of treated and untreated sewage inputs in waterways

Healthy Waterways Strategy 2018-2028
Port Phillip & Westernport, Victoria

Melbourne Water

RMIT UNIVERSITY A3P

Strategic alignment

Regional Performance Objectives

RPO 23: The potential impacts of emerging contaminants of concern such as microplastics, pesticides and pharmaceuticals, and toxic chemicals are better understood and mechanisms to respond collaboratively developed.

RPO 24: Risk-based programs are in place to mitigate sources of urban pollution (licensed and unlicensed discharges) to protect bays and waterways.

SCPOs: Protect water quality for Port Phillip Bay and waterways by maintaining the current quality of discharges from sewage treatment plants (and reducing where possible) ensuring they are released in a manner that ensures environmental values are supported in the waterway.

Key Research Areas

Water quality: Understanding the environmental impacts of pollutants, including contaminants of concern, to inform risk-based management of waterways across the region.

Summary

Wastewater is generated from a variety of sources, including domestic sewage, trade waste and stormwater runoff. It contains high concentrations of faecal material and urinary metabolites and is typically composed of 98% water. Trade waste may contain various contaminants and specified industrial chemicals at concentrations higher than would be expected in domestic sewage. Urban stormwater is surface runoff from storm events that washes off hard surfaces into waterways. In Victoria, sewage is designed to overflow to stormwater drains and waterways when water volumes exceed capacity, such as during heavy rainfall events. Recycled water is wastewater that has been sufficiently treated to meet standards set by EPA Victoria and the Department of Health and Human Services. Recycled water quality varies widely and is dependent on the composition of the source water and any activities in the sewerage catchment that might contribute contaminants (e.g., trade waste), as well as the level of treatment the sewage undergoes at the treatment plant.

In Victoria, water is managed regionally by different water corporations. In the metropolitan area, Melbourne Water is the wholesale provider of water and sewerage services, and Greater Western Water (City West Water and Western Water), Yarra Valley Water and South East Water are the retail providers. Approximately 90% of all Melbourne sewage is processed by the Western Treatment Plant (WTP) and the Eastern Treatment Plant (ETP), with the remaining 10% being processed by smaller treatment plants run by retail providers.

Untreated sewage inputs, in the form of dry weather (e.g. sewer and septic leaks) and wet weather (Emergency Relief Structure (ERS)) spills have the potential to impact water quality in waterways. However, the extent to which such spills cause ecological and human health impacts is less certain. This research is helping our understanding of the significance of certain types of sewage contamination (e.g. septic vs ERS spills) in particular catchments, with the intention to be used by managers to detect and trace major sources of sewage contamination for pollution mitigation. An evidence-based understanding of sewage discharge characteristics and how these impact ecological and social values will enable a more structured and strategic process for prioritising the investigation and management of sewage inputs.

This project has identified micropollutants present in waterways receiving sewage inputs, some of which may be useful as chemical indicators of sewage pollution.

This information will now be used to design and carry out ecotoxicological experiments to determine toxic thresholds for high-risk sewage contaminants, and in doing so, enable an understanding of the relative ecological impacts from various sewage sources.

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Recommendations

- Continue to understand the sources and waterway impacts of sewage to inform strategic prioritisation of sewage management efforts (i.e., septic tanks, untreated ERS spills and treated discharges from wastewater treatment plants) across the region.
- Update guidance and recommendations for monitoring of treated and untreated sewage during wet and dry conditions using sewage source indicators identified by this research project.
- Employ passive sampling monitoring approaches to test the suitability of recycled water for reuse.

What did we do?

Literature Review

Wastewater management and regulation in Victoria

To help identify opportunities to reduce the risk of treated and untreated sewage inputs to waterway across the region, this review focused on relevant aspects of the management of untreated and treated sewage discharges in Victoria, including sections on recycled water discharges and septic system management, compliance and upgrade/replacement programs that are currently underway. It describes sewage regulation in Victoria and includes information about the amendment of the Environment Protection Act 2017 that incorporates general environmental duty (GED).

Sewage spill characteristics and chemical indicators of sewage pollution

Several years of water quality monitoring data for domestic sewage, septic discharges and trade waste from Melbourne Water and retail water companies was collated to identify the most frequently observed compounds in the different waste streams and to establish expected concentration ranges for microbial indicators and compounds including metals, surfactants, PAHs and phenols, pesticides, pharmaceuticals and personal care products.

A summary of the chemical concentrations that have been measured in surface waters, sediments and passive samplers by A3P over the past 3 years has also been produced.

Further more, data from the Melbourne Water Sewage Transfer Monitoring Plan (Water Quality Monitoring) has been collated for the period 2000 to 2019. This dataset includes more than 7300 records for chemicals measured in sewage.

Field sampling

Sampling for this project occurred from November 2019 to December 2022, which included surface water sampling and deployment of three passive sampler types for one month at 52 sites around Greater Melbourne. Additional sampling commissioned by Yarra Valley Water and South East Water expanded the number of sewage (treated) sites by 6, and the sewage (untreated) sites by 24 (Hassell et al. 2020; Hassell et al. 2021; Hassell et al. 2023; Hassell and Pettigrove, 2021). Sewage (treated) sites are ones that are downstream of wastewater treatment plant discharges and sewage (untreated) sites include ones downstream of Emergency Relief Structures and those in areas of known or suspected sewage and septic tank leaks.

Through the research collaboration with National Measurement Institute, we were able to screen for a total of 215 different chemicals in passive samplers, including pesticides, pharmaceuticals and personal care products (PPCP).

What did we find?

Literature Review

Wastewater management and regulation in Victoria

In Victoria, the management of treated sewage (domestic and industrial wastewater), including discharge to surface waters as well as reuse and recycling is governed by the Environmental Reference Standard (formerly State Environmental Protection Policy (Waters)) and the Victorian Guideline for Water Recycling. Several guidance documents are available that provide information relevant to treated sewage discharges to waterways. Sewage management in Victoria is regulated by several broad pieces of legislation that apply to the entire collection, treatment and discharge process. Legislation and guidelines relevant to sewage aim to protect beneficial uses of aquatic environments, which are described as current or future environmental values or uses of surface waters that communities want to protect. There are multiple regulatory bodies involved in sewage management in Victoria, including Department of Energy, Environment and Climate Action (DEECA), Environmental Protection Authority Victoria (EPA), Department of Health and Human Services (DHHS), Department of Treasury and Finance (DTF) and the Essential Services Commission (ESC).

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The Environmental Reference Standard (ERS) was introduced in July 2021 under the new Environment Protection Act 2017 that replaces the Environment Protection Act 1970 and the State Environmental Protection Policy (Waters). The ERS is an environmental benchmark that describes different environmental values and the relevant indicators and objectives that need to be maintained to ensure environmental and human health outcomes are achieved. The new Environment Protection Act 2017, along with Environment Protection Regulations 2021 and the ERS establishes a new framework for environmental protection that focuses on pollution prevention rather than management of pollution impacts and introduces the general environmental duty (GED). The GED is a central component of the new Environment Protection Act 2017 and ERS, which requires all Victorians to manage their activities in such a way as to reduce and minimise the risks of harm from pollution or waste on environmental and human health, as much as reasonably practical. For managing sewage inputs into waterways this means that the Environmental Reference Standard can be used to identify relevant environmental values that may be at risk and identify which indicators and objectives could be used to assess and minimise risk. It may also be important to consider other potential risks that may not have specific indicators or objectives, which in the case of sewage inputs, might include compounds such as emerging contaminants.

Sewage spill characteristics and chemical indicators of sewage pollution

Sewage can end up in waterways from a variety of sources, including licensed discharges (as wastewater effluents), and unlicensed discharges such as leaks from septics, sewer spills and sewer/ stormwater cross connections. The volume and composition of sewage from unlicensed discharges is dependent on both its source and whether it is a dry weather or wet weather spill.
During wet weather events, stormwater can enter the sewerage system through broken pipes and illegal stormwater-sewer cross connections. Therefore, sewerage infrastructure needs to be large enough to collect and transfer large volumes of stormwater/wastewater. To prevent the risk of sewage backflowing into households, similar to other cities in Australia, the Melbourne sewerage system includes emergency relief structures (ERS), which allow controlled discharge of sewage into receiving environments. They are designed to function only during wet weather events and are subject to 1 in 5 year Average Recurrence Interval (ARI) or 18.1% Annual Exceedance Probability (AEP) containment standards, as set by EPA Victoria (typically equivalent to 25 mm of rain occurring in 1 hour). Dry weather spills into waterways occur when sewerage infrastructure is damaged (i.e., broken

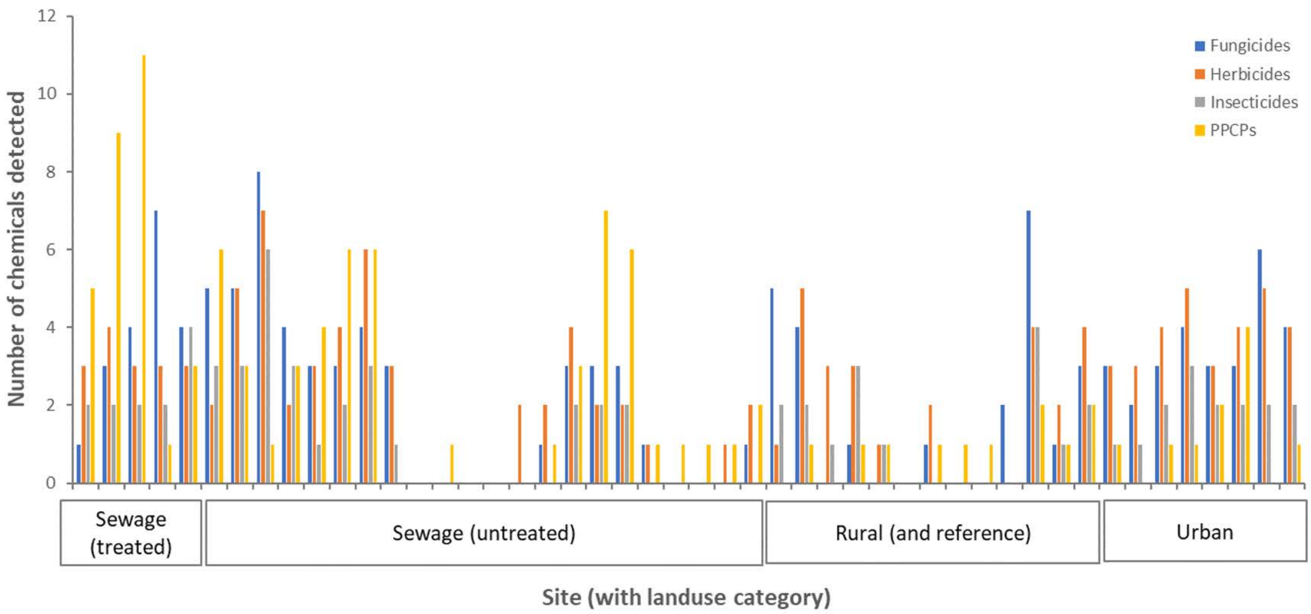

Figure 1. Number of compounds detected in POCIS passive samplers, deployed at 52 sites around Greater Melbourne between November 2020-January 2021.

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pipes) or where on-site systems, such as septic tanks perform poorly and fail to contain sewage within the property boundaries. Since there may be little or no dilution of the sewage once it enters a waterway, dry weather spills may pose greater human and environmental health risks.

The most frequently detected chemicals from the Melbourne Water Sewage Transfer Monitoring Plan (Water Quality Monitoring) included metals such as Zn, Cu, Cr, Ni, Pb, Ca, volatile organic compounds such as formaldehyde and BTEX (benzene, toluene, xylene, ethylbenzene), phenols, surfactants, hydrocarbons and several pesticides. Median concentrations were generally in the low range for most chemicals, with occasional spikes at much higher concentrations for some. Data provided from South East Water on trace organic chemicals measured in sewage from 2016-2019 showed several pharmaceuticals and personal care products, plasticisers, industrial chemicals and endocrine disrupting chemicals (EDCs) detected in all samples. See Field sampling below for a summary of the chemical concentrations that have been measured is surface waters, sediments and passive samplers by A3P over the past 3 years.

Field sampling

Surface water showed the presence of ammonia, nutrients, metals, pesticides and PPCPs at some sites, and sediments showed TPH, metals and some pesticides. Sediment concentrations of bifenthrin at some sites were above levels at which ecological impacts are likely. The sewage (untreated) group of sites tended to have the highest values for ammonia, total nitrogen and metals, although detections above guideline values were observed across all landuse categories, including reference sites for some parameters.

A total of 71 different chemicals were detected, and there were differences in the total numbers of chemicals detected at sites categorised into different landuse types (Figure 1) (Hassell and Pettigrove, 2021). Some chemicals were only detected in one sample, and they were excluded from subsequent categorisations. For the remaining 46 chemicals (detected at least twice), their presence was associated with the different land use types, including knowledge of treated and untreated sewage inputs (Figure 2).

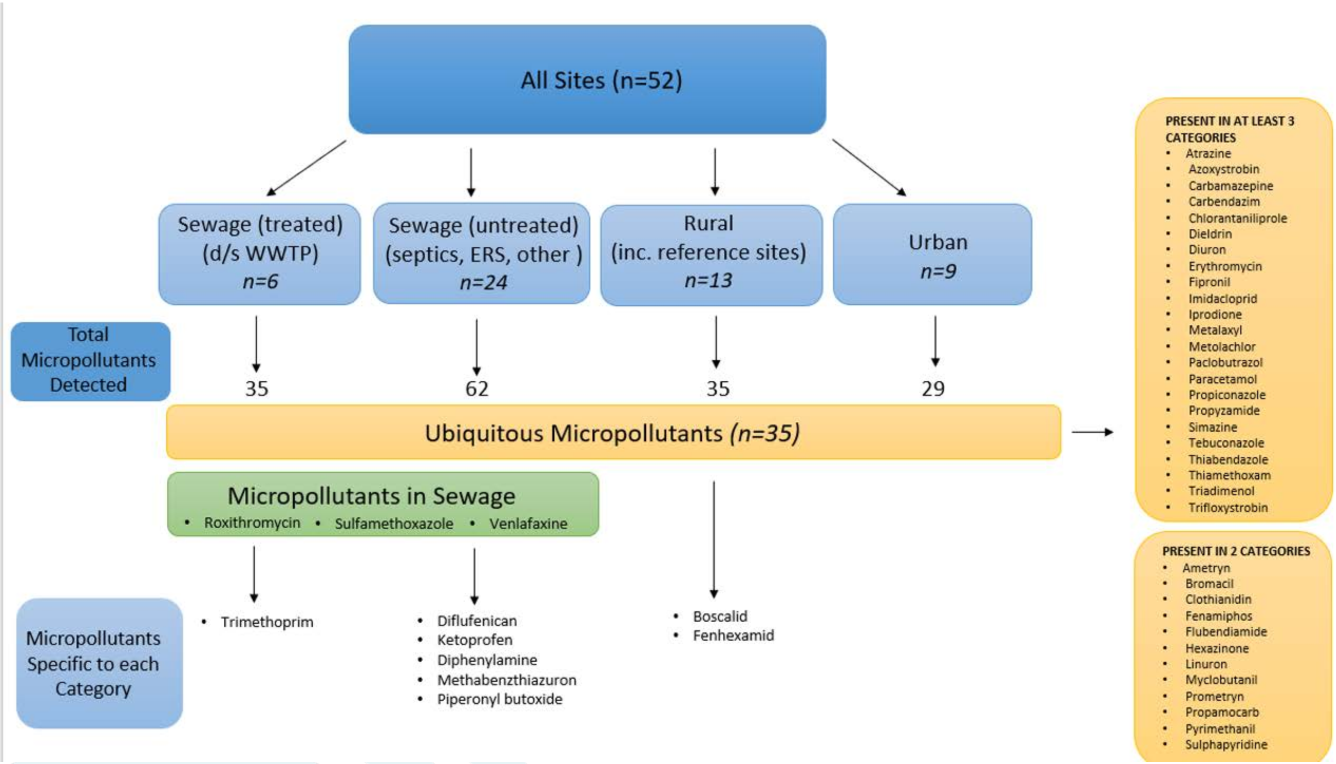

Figure 2. Summary of chemical indicators present in different landuse categories. Several chemicals are deemed ubiquitous for occurring in multiple categories, and would not be suitable indicators, whilst others were specific to sewage-related sites and may be suitable chemical indicators of sewage pollution.

This process distilled a list of several chemicals which were only detected in sewage associated sites, and these constitute a list of potential chemical indicators of sewage pollution (Figure 2). In the sewage untreated category, a total of 5 distinct chemicals were identified (Diflufenican, Ketoprofen, Diphenylamine, Methabenziazuron and Piperonyl Butoxide), and in the treated sewage category, 1 chemical was identified specific to that group (Trimethoprim), as well as another 3 that were common to both untreated and treated sewage sites (Roxithromycin, Sulfamethoxazole, Venlafaxine). All of these chemicals were detected in at least 2 separate sites.

Several chemicals (n=35) were detected in multiple landuse categories and are thus not considered suitable indicators of sewage pollution. The most frequently detected chemicals within that list would be worthwhile investigating further due to widespread presence in waterways around Melbourne, but not for the purpose of identifying sewage pollution. Two chemicals were also identified as specific to rural land uses, which again may be useful information for general pollution monitoring, but not specifically for understanding sewage pollution.

Future direction and knowledge gaps

Field sampling

Targeted field sampling should be continued at a subset of existing field sites identified as likely to be impacted by sewage pollution to determine the presence of priority chemicals identified in the literature review and to validate their use as chemical indicators of sewage pollution. Event sampling to determine any inputs from wet weather spills (i.e. downstream of ERSs) will be included, to help separate micropollutant signatures between wet weather and dry weather spills. The list of priority chemicals may include ones that have been sampled in previous sampling rounds, as well as new ones that are added to the NMI chemical screens. Sediment, surface waters and passive samplers should be utilised.

Recycled water reuse is very topical within the water industry at present, and as part of a separate project (funded by Water Research Australia) we have been trialling the use of passive samplers in recycled water streams, to determine the presence of any micropollutants. The types of passive samplers and chemical screening methods will be the same as we have used to monitor surface waters.

Passive sampling methods should be refined by moving away from semi-quantitative (presence/absence) to quantitative assessments (to report data as a concentration). This is necessary to adequately quantify risks associated with these chemicals entering surface waters. Calibration studies to determine uptake and saturation rates, as well as optimising deployment times to maximise uptake of chemicals, but to prevent fouling are needed, as well as trialling other types of passive samplers that target different chemical groups.

Ecotoxicological testing of identified priority chemicals to establish threshold levels are needed, to calculate the relative risk of each chemical and impact assessments using fish, invertebrates or other biota in identified priority areas to contribute to understanding the risks of sewage pollution in waterways.

Continue to work with retail companies collaboratively to prioritise sewage strategies, with particular focus on management options for different wastewater sources (i.e. septic tanks, untreated ERS spills and treated discharges from wastewater treatment plants). The information presented is expected to be useful for informing and refining performance objectives in future Healthy Waterways strategies related to wastewater discharges to waterways.

References/ Reports

Hassell, K., Boyle, R., Kellar, C., Tewman, M. and Pettigrove, V. (2022) Understanding the ecological impacts of untreated sewage inputs in waterways, Part A: Wastewater management and regulation in Victoria, Technical Report :13. Aquatic Environmental Stress Research Group, RMIT University, Victoria, Australia.

Hassell, K. (2020) Aquatic Pollution Prevention Partnership Project B1.2B: Untreated Sewage Spills. Summary Report - Round One Sampling, Technical Report: 36. Aquatic Environmental Stress Research Group, RMIT University, Victoria, Australia.

Hassell, K., Tewman, M. and Pettigrove, V. (2021) Aquatic Pollution Prevention Partnership Project B1.2: Understanding the ecological impacts of treated and untreated sewage inputs in waterways - Identification of potential chemical indicators of sewage pollution (Round Two Sampling, Nov 2020 – Jan 2021). Technical Report: 57. Report for Melbourne Water. Aquatic Environmental Stress Research Group, RMIT University, Victoria, Australia

Hassell, K., Boyle, R., Kellar, C., Tewman, M. and Pettigrove, V. (2020) Sewage management, spill characteristics and ecological impacts in waterways Sewage spill characteristics and chemical indicators of sewage pollution. Technical Report :64. Aquatic Environmental Stress Research Group, RMIT University, Victoria, Australia.

Odell, E., Tewman, M., Hassell, K., Myers, J. and V. Pettigrove (2023) Sewage management, spill characteristics and ecological impacts in waterways: Risk assessment screening of suitable chemical indicators of sewage pollution to Healthy Waterways Strategy environmental values, Technical Report: 65. Aquatic Environmental Stress Research Group, RMIT University, Victoria, Australia.

Hassell, K., MacMahon, D. and Pettigrove, V. (2023) Aquatic Pollution Prevention Partnership Project B1.2: Understanding the ecological impacts of treated and untreated sewage inputs in waterways - Round Three Sampling (Oct-Dec 2022), Technical Report No. 91. Report for Melbourne Water. Aquatic Environmental Stress Research Group, RMIT University, Victoria, Australia.

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