Wastewater treatment plants as a source of microplastic to the environment in New Zealand

Helena Ruffell

Helena Ruffell[a], Olga Pantos[b], Grant Northcott[c], Sally Gaw[a],*

[a]School of Physical and Chemical Sciences, University of Canterbury, 20 Kirkwood Avenue, Christchurch 8041, New Zealand
[b]Institute of Environmental Science and Research, 27 Creyke Road, Christchurch 8041, New Zealand
[c]Northcott Research Consultants Ltd, 20 River Oaks Place, Hamilton 3200, New Zealand

Introduction

Wastewater treatment plants (WWTPs) are thought to be a major source of microplastics, particularly microfibres sourced from washing machine effluent, into aquatic and terrestrial environments.[1]

WWTPs are not designed to remove microplastics from sewage, and microplastics are retained in sewage sludge or released with effluent.[2]

Previous studies have estimated removal efficiencies of greater than 99% of microplastics from influent to effluent (with microplastics retained in sewage sludge), however this still equates to figures in the millions of particles exiting WWTPs daily in effluent.[3, 4]

There is currently a lack of data in New Zealand on the amounts and types of microplastics entering and being discharged from WWTPs, and the risk they pose to the environment.

This study is the first of its kind to characterise the contribution of microplastics to coastal ecosystems from different WWTPs in Canterbury, New Zealand.

Aims and objectives

- Determine the relative abundance, morphotypes, and polymer types of microplastics present in wastewater influent and effluent from four WWTPs sampled on a weekday and weekend

- Determine the seasonal variability of microplastics present in effluent from three WWTPs

Method

- Four tertiary WWTPs in Canterbury, New Zealand were sampled (Figure 1)

- 10 L of influent and effluent each collected as a 24-hour composite sample

- Study 1 sampled influent and effluent from WWTPs 1 – 4 on a weekday and weekend of June 2018

- Study 2 sampled effluent from WWTPs 1 – 3 on a weekday of June, August, October, December 2018

- Influent and effluent wet sieved 1 mm and 300 µm

- Material on sieves digested using Fenton's reagent (1:1 0.05 Fe(II) solution and 30% H_2O_2)

- Vacuum filtered onto GFC filters (Whatman, 47 mm diameter, 1.2 µm pore)

- Filters analysed under stereomicroscope to identify potential microplastics and catergorised by morphotype

- µ-FTIR analysis of 100% of suspected microplastic particles

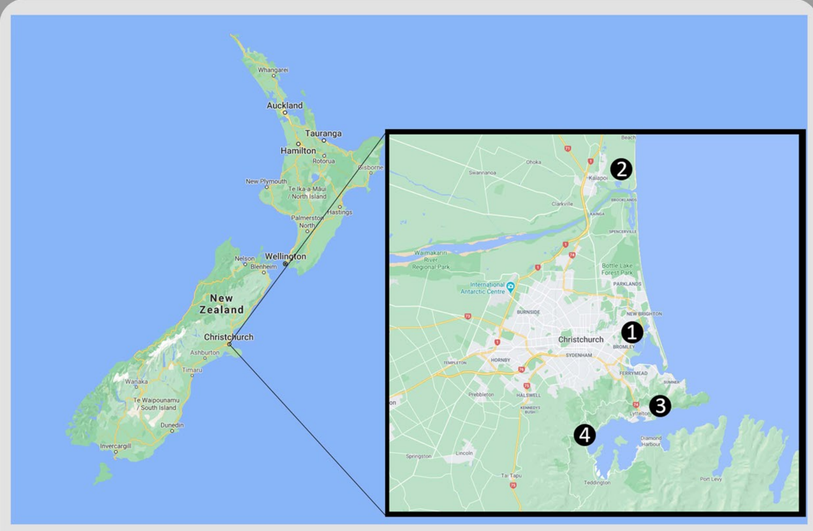


Figure 1. WWTP sampling locations in Canterbury, New Zealand. (1) Christchurch WWTP, (2) Kaiapoi WWTP, (3) Lyttelton WWTP, (4) Governors Bay WWTP.

Results

- Microplastics were detected at an average concentration of 2.4 and 1.2 particles/L in influent and effluent from Study 1 and 1.3 particles/L in temporal effluent from Study 2

- Microplastic concentrations decreased from influent to effluent

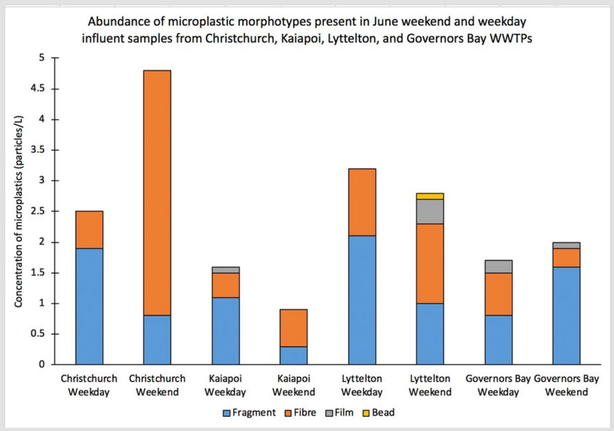
- Fragments the most abundant morphotype

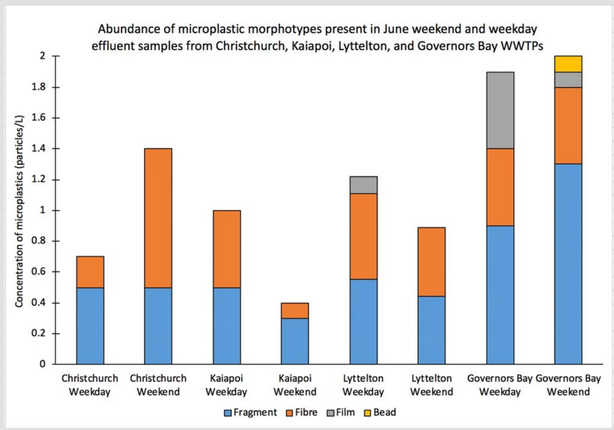
- Polyester the most abundant polymer type

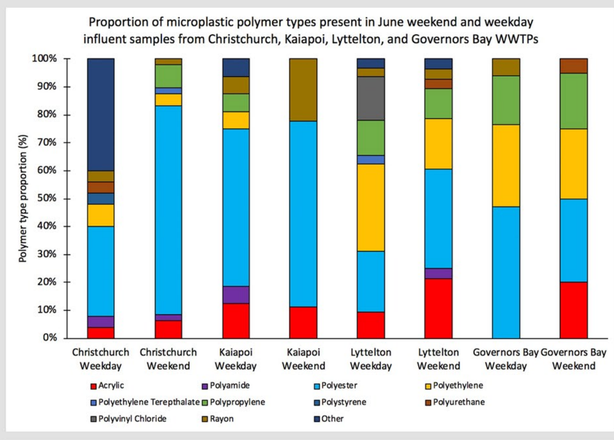
- Glitter and sponge fragments among microplastics found in influent and effluent

- Removal of microplastics from influent to effluent ranged from 0 – 72%

- 8.9 x 10^{10} microplastics estimated to enter the Canterbury coastline through discharge of effluent from the four WWTPs each year







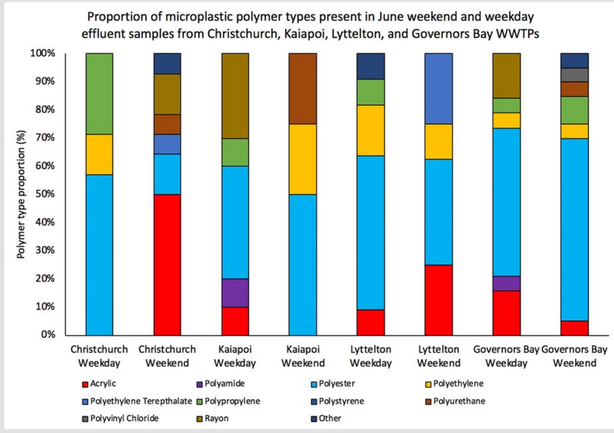
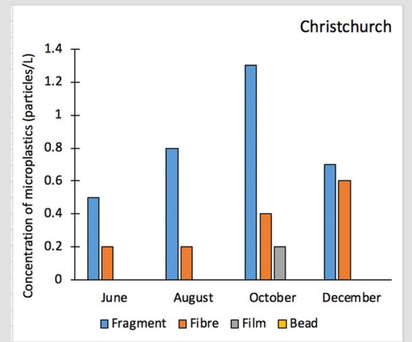
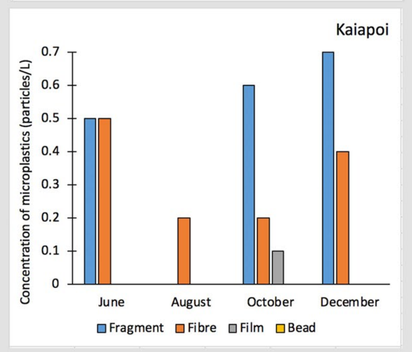


Figure 2. Study 1: Concentration of microplastic morphotypes and polymer type proportions in weekday and weekend influent and effluent from Christchurch, Kaiapoi, Lyttelton, and Governors Bay WWTPs.





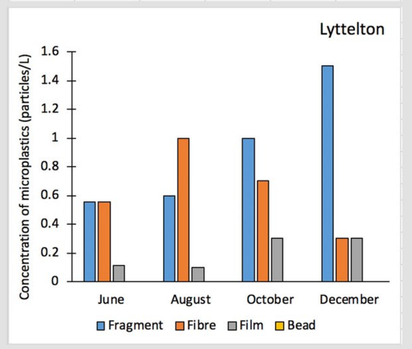


Figure 3. Study 2: Concentration of microplastic morphotypes in Christchurch, Kaiapoi, and Lyttelton effluents sampled in June, August, October and December

Conclusions

- No consistent trends in microplastic concentration, morphotype and polymer type were observed between weekday/weekend influent and effluent and temporal effluent samples, suggesting a common and continual source of microplastics into WWTPs.

- Wastewater influent and effluent is a complex matrix with many sources making comparison within and between studies difficult

- Glitter and sponge particles should be included as microplastic morphotypes

- Wastewater effluent is a significant source of microplastics to the coastal environment in Canterbury, New Zealand

Acknowledgements

We thank The Institute of Environmental Science and Research, The Brian Mason Scientific and Technical Trust, and The Evan's Fund for providing funding that supported this project.

We thank Bronwyn Humphries (Institute of Environmental Science and Research), Matt Polson, Wayne Mackay, Nick Oliver, Rob McGregor, Rob Stainthorpe, Kimberley Kovacs-Wilks, Amanda Inglis, Peter McGuigan (University of Canterbury), Mike Bourke, Lee Liaw, Paul Woods, Wayne Higgs, Grant Burgess (Christchurch City Council), Rob Frizzell (Waimakariri District Council), Kris Kaser and Shay Alford (City Care) for WWTP access and technical support.

References

1. Browne, M. A.; Crump, P.; Niven, S. J.; Teuten, E.; Tonkin, A.; Galloway, T.; Thompson, R. Accumulation of Microplastic on Shorelines Worldwide: Sources and Sinks. Environ. Sci. Technol. 2011, 45 (21), 9175-9179.
2. Talvitie, J.; Mikola, A.; Koistinen, A.; Setälä, O. Solutions to microplastic pollution–Removal of microplastics from wastewater effluent with advanced wastewater treatment technologies. Water Res. 2017, 123, 401-407.
3. Carr, S. A.; Liu, J.; Tesoro, A. G. Transport and fate of microplastic particles in wastewater treatment plants. Water Res. 2016, 91, 174-182.
4. Simon, M.; van Alst, N.; Vollertsen, J. Quantification of microplastic mass and removal rates at wastewater treatment plants applying Focal Plane Array (FPA)-based Fourier Transform Infrared (FT-IR) imaging. Water Res. 2018, 142, 1-9.