Evaluation of Dibutyltin and Monobutyltin Leaching from PVC pipe: A Bench and Pilot Scale Approach

by

Patrick Michael Henry Tyrrell

A thesis submitted in conformity with the requirements
for the degree of Master of Applied Science

Graduate Department Civil Engineering
University of Toronto

Evaluation of Dibutyltin and Monobutyltin Leaching from PVC pipe: A Bench and Pilot Scale Approach

Patrick Michael Henry Tyrrell

Master of Applied Science

Graduate Department Civil Engineering
University of Toronto

2024

Abstract

Bench scale pipe-section reactors (PSRs) along with pilot scale pipe-loops were used to examine the leaching of toxic dibutyltin (DBT) and monobutyltin (MBT) heat stabilizers which are commonly used in drinking water distribution systems across North America from C900 and C909 PVC pipe. PSR trials were conducted using artificial freshwater containing up to 4 mg/L free chlorine, as typically employed for drinking water distribution. Pipe-loops located onsite at a water treatment facility continuously received chloraminated water. MBT was observed above the detection limit only during the first 24 hours of the PSR trial, with the presence of chlorine showing a positive impact on leaching. Pipe-loop and PSR results did not show DBT above the detection limits during the trials. These findings suggest that DBT leaching from C909 and C900 PVC pipes within a typical drinking water distribution system should not pose a concern to consumers.

Acknowledgements

This work was funded by the Natural Sciences and Engineering Research Council of Canada (NSERC) Chair in Drinking Water Research at the University of Toronto.

I would like to thank my supervisor Dr. R. C. Andrews for your guidance, support, and insight. To Dr. H Almuhtaram thank you for your guidance and assistance in my research. And to Juan Li for your assistance and input into this project.

I would like to thank Jim Wang and Alan McClenaghan for your help and guidance in the lab at UofT. To the City of Toronto staff, Patrick Onyia for coordinating with the City, Aman Bal for coordinating plant staff, and to David Collins for fabricating the necessary headworks for our pilot and your continued assistance with the pilot system.

Finally, I would like to thank Iain Cameron for your friendship and electrical assistance, my Grandfather Tom Smyth for supplying me with most of my tools, and special thanks to my Father John Tyrrell, the engineer who I aspire to be, who I can always count on for support.

TABLE OF CONTENTS

LIST OF TABLES

LIST OF FIGURES

LIST OF APPENDICES

NOMENCLATURE

"	Inch
%	Percent
>	Greater than
<	Less than
≥	Greater than or equal to
±	Plus/minus
A	Area
AFW	Artificial Freshwater
ASTM	American Society for Testing and Materials
AWWA	American Water Works Association
C	Degrees Celsius
˚C/min	Degrees Celsius per min
cm	Centimetre
CPVC	Chlorinated Polyvinyl Chloride
DBT	Dibutyltin
DI	De-ionized
DMT	Dimethyltin
DO	Dissolved Oxygen
DOT	Dioctyltin
EI	Electron Ionization
EPA	Environmental Protection Agency
eV	Electron Volt
g	Gram
GCMS	Gas Chromatography - Mass Spectrometry
h	Hour
HRT	Hydraulic Retention Time
L	Litre
m	Metre
M	Molarity
m(t)	Organotin leaching rate at time t
m/s	Metre per second
m/z	Mass to charge ratio
m^2	Metre squared
m^2/m^3	Metre squared per metre cubed
m^3	Metre cubed