Removal of Selected Pharmaceuticals and Personal Care Products in a Sewage Lagoon

M. Ehsanul Hoque[1], Carlo Arcieri[1], Mark McInnes[1], Craig Murray[1], Frederic Cloutier[2], Peter Vanrolleghem[2] and Chris D. Metcalfe[1]

[1]Water Quality Centre, Trent University, Peterborough, Ontario, Canada

[2]Department of Civil Engineering and Water Engineering, Laval University, Quebec City, Quebec, Canada

ehsanulhoque@trentu.ca

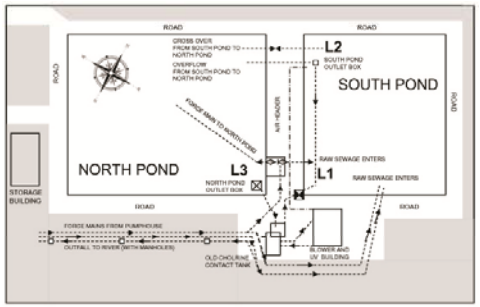
Objective

- To determine removals of selected **pharmaceuticals and personal care products** (**PPCPs**) in a sewage lagoon
- To access seasonal variations in **removal efficiency** during three different seasons, summer, fall and winter
- To evaluate **fate** of PPCPs (contaminants of emerging concern)
- To predict concentration of PPCPs using **lagoon modelling**

Introduction

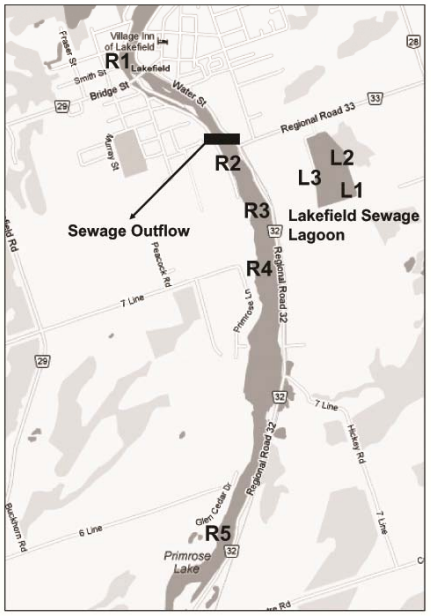
- Sewage lagoons are widely used in North America for treatment of municipal wastewater in small communities
- Lagoon-based wastewater treatment systems are pond-like water bodies or basins that receive, hold and treat the wastewater by allowing the solids to settle to the bottom of the pond and allowing naturally-occurring microorganisms to digest the organic matter
- Treatment processes are a combination of physical, chemical and biological processes: sedimentation, bioflocculation, precipitation, biochemical oxidation, photolysis, volatilization, fermentation and disinfection
- Sewage lagoon system is relatively inexpensive to construct, operate and maintain, and may be set up to function without electricity or mechanical equipments
- It requires a large area and usually is located away from populated areas

Lakefield Sewage Lagoon



Schematic of Lakefield sewage lagoon in Ontario, Canada. L1, L2 and L3 sites at raw sewage inflow (influent), aerated sewage and treated sewage outflow pipe (final effluent), respectively

Sampling Sites



Lakefield sewage lagoon and Otonabee River in Ontario, Canada (From Google map). L1, L2 and L3 sites at raw sewage inflow (influent), aerated sewage and treated sewage outflow pipe (final effluent), respectively. R1 at Otonabee River reference site upstream of the sewage outflow grate. R2, R3, R4 and R5 sampling sites at increasing distances downstream of outflow gate

Sampling Periods

- Summer: (i) July 5 to July 19, 2010 (14 days in Lakefield Sewage Lagoon) and (ii) July 5 to August 04, 2010 (30 days in Otonabee River)
- Fall: (i) October 28 to November 11, 2010 (14 days in Lakefield Sewage Lagoon) and (ii) October 28 to November 27, 2010 (30 days in Otonabee River)
- Winter: (i) March 23 to April 6, 2011 (14 days in Lakefield Sewage Lagoon)

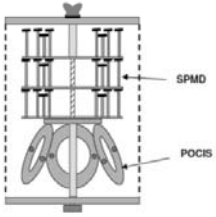
List of PPCPs

- Monitored only "indicator compounds" to minimize analytical effort and cost
  - (i) Polar and recalcitrant: ***Carbamazepine***
  - (ii) Moderately polar and moderately recalcitrant: ***Trimethoprim and Gemfibrozil***
  - (iii) Polar and susceptible to photodegradation: ***Sulfamethoxazole***
  - (iv) Polar and susceptible to microbial degradation: ***Ibuprofen***
  - (v) Non-polar and susceptible to partitioning to sediments: ***Triclosan***
  - (vi) Non-polar and susceptible to volatilization: ***HHCB and AHTN Musks***

Passive Sampling Device

POCIS (Polar Organic Chemical Integrated Sampler): Polar compounds (carbamazepine, trimethoprim, sulfamethoxazole, ibuprofen and gemfibrozil)

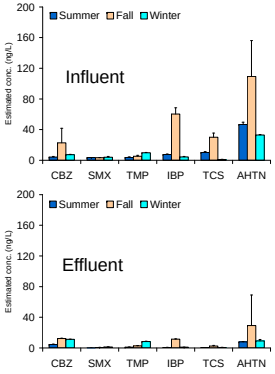
SPMD (Semipermeable Membrane Device): Non-polar compounds (TCS, AHTN and HHCB)



Analysis

LC-MS/MS (PPCPs)
GC-MS (HHCB, AHTN)

PPCPs in Lakefield Sewage Lagoon



Measured conc. of selected PPCPs compared with the model predicted values (for details, please visit a poster by Frederic Cloutier *et al.*)

Removal Efficiency

Compounds	Summer	Fall	Winter
	% Removal	% Removal	% Removal
Carbamazepine	- 9.28	45.8*	- 54.1*
Sulfamethoxazole	98.9*	78.1*	69.5*
Trimethoprim	70.8*	48.5	14.0
Gemfibrozil	- 23.9	- 45.7	- 99.8
Ibuprofen	91.5*	81.1*	78.3*
Triclosan	97.2*	91.4*	42.5
HHCB	96.0*	87.5*	40.8*
AHTN	83.0*	73.4*	72.1*

*Removals that show statistically significant differences between raw influent and final effluent

Mass Loading

Compounds	Summer	Fall	Winter
	Mass Loading (mg/1000 inhabitant/day)	Mass Loading (mg/1000 inhabitant/day)	Mass Loading (mg/1000 inhabitant/day)
Carbamazepine	2293	4258	7508
Sulfamethoxazole	20	245	767
Trimethoprim	541	897	5530
Gemfibrozil	39	48	25
Ibuprofen	322	3800	630
Triclosan	147	800	317
HHCB	2.2E+04	7.0E+04	1.9E+05
AHTN	4023	9717	6080

Daily average effluent discharge volume into the Otonabee River: 1314000 L for July 2010, 867000 L for October 2010 and 1720000 L for March 2011. Population of Lakefield Village: 2600. Mass Loading = (concentration in final effluent x daily average effluent discharge volume)/(served population)x1000

- Daily mass loading is dependent on resident population, consumption patterns and effluent discharge rate
- Mass loading is found to be higher in compare to the literature values

Conclusion

- Sewage lagoon removes contaminants of emerging concern
- The patterns of removal in the lagoon for specific compounds are consistent with data from WWTPs
- Seasonal variations were observed, and better removals occurred during summer
- The model was able to adequately predict the concentrations of carbamazepine, sulfamethoxazole, triclosan and HHCB in Lakefield sewage lagoon in summer and winter (for details, please visit a poster by Frederic Cloutier *et al.*)

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