

Predicting the Fate of Emerging Contaminants in Wastewater Treatment Plants

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Frédéric Cloutier, Ludiwine Clouzot and Peter A. Vanrolleghem



Canada Research Chair
on Water Quality Modelling



Overview

- Problem statement
- Objective
- Methodology
- Modeling
- Results
- Conclusion

Problem statement

- WWTPs not designed to remove ECs
- Ecological impacts
 - Endocrine disruptors
 - Feminization of male fishes
 - Reproductive disturbances
 - Chemicals (pesticides, insecticides)
 - Crossed beak in birds (Great Lakes)
 - Growth abnormalities in tadpoles (Canada)



**Joanne Parrott*



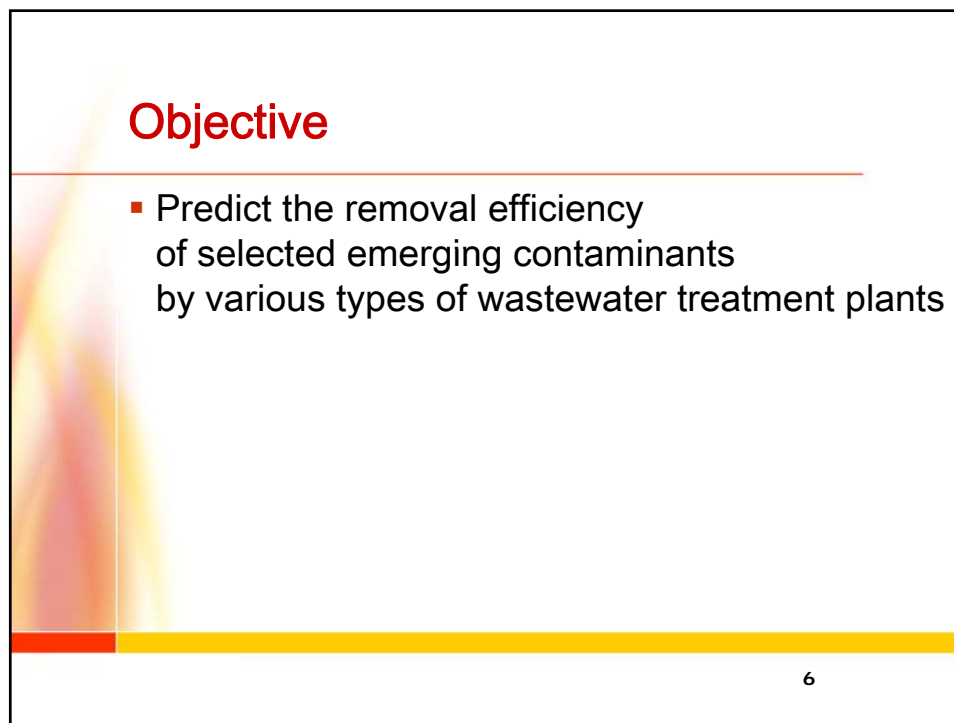
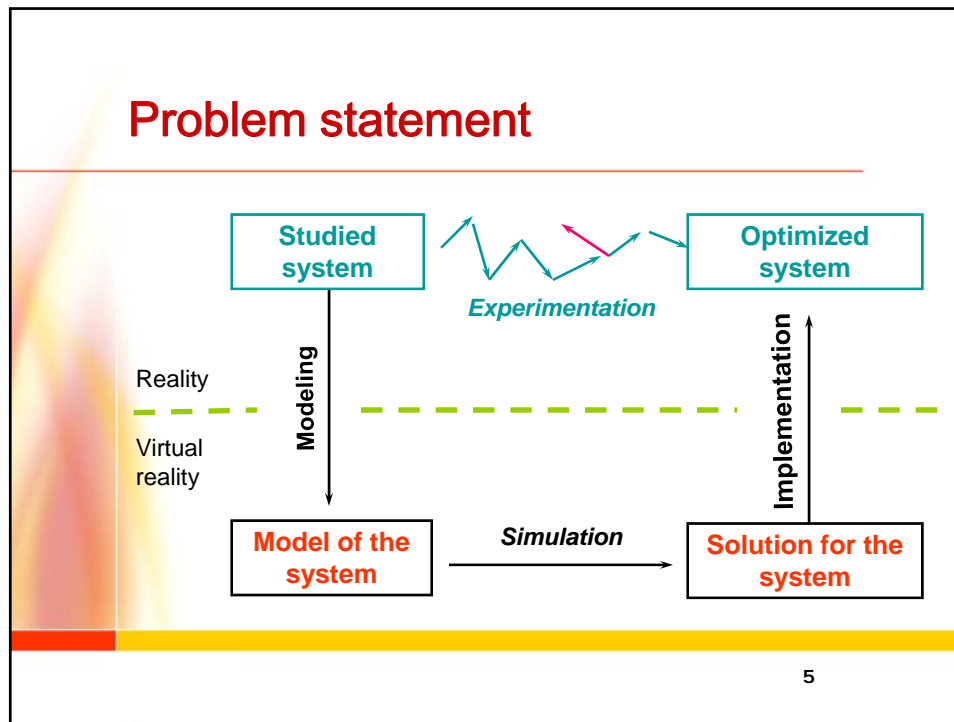
**US EPA*

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Problem statement

- How can we improve the situation?
 - Understanding the processes
 - Field studies can be inconclusive (limit of detection)
 - Modeling
 - Virtually modify the plant configuration/operation

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Methodology

- 6 different WWTP configurations
 - Conventional Activated Sludge (CAS)
 - Short sludge retention time, aerobic
 - Nitrifying Activated Sludge (NAS)
 - Long sludge retention time, aerobic
 - Biological Nutrient Removal (BNR)
 - Long sludge retention time, anaerobic-anoxic-aerobic
 - Enhanced primary clarification + Ozonation
 - Very short retention time, no biodegradation
 - CAS + Sand filtration (SF)
 - Aerated lagoons (LAG)
 - Long sludge retention time, aerobic and settling lagoons

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Methodology

- 3 emerging contaminants with different properties
 - Trichloroethylene (TCE)
 - Industrial solvent
 - 17 α -ethinylestradiol (EE2)
 - Active ingredient in birth control pills
 - Bis(2-ethylhexyl) phthalate (DEHP)
 - Plasticizer used in manufacturing of PVC articles

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Methodology

- Properties of the contaminants

Properties ↓	Volatilization	Sorption	Degradation
Henry's constant	✓		
Partition coefficient		✓	
Photolysis half-life			✓
Aerobic half-life			✓
Anoxic half-life			✓
Rate constant O ₃			✓
Rate constant OH [•]			✓

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Methodology

- Processes affecting each contaminant

Processes →	Volatilization	Sorption	Biodegradation	Photolysis
TCE	+++	-	-	-
EE2	-	++	+	+
DEHP	-	+++	++	-

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Modeling

- Wastewater treatment
 - Model based on ASM2d (Henze et al., 2000)
 - Organic substrate removal
 - Nitrification / denitrification
 - Biological phosphorus removal
 - Extension for micropollutants
 - Volatilization
 - Biodegradation
 - Sorption / desorption
 - Oxidation by ozone
 - Photolysis

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Modeling

Models → Processes ↓	Primary clarifier	Reactor	Secondary settler	Ozonator	Sandfilter	Lagoons
Sedimentation	+		+			+
Volatilization	+	+	+	+		+
Sorption- desorption	+	+	+	+		+
Biodegradation aerobic+anoxic	+	+	+	+		+
Photolysis						+
Oxidation with ozone				+		
Filtration					+	

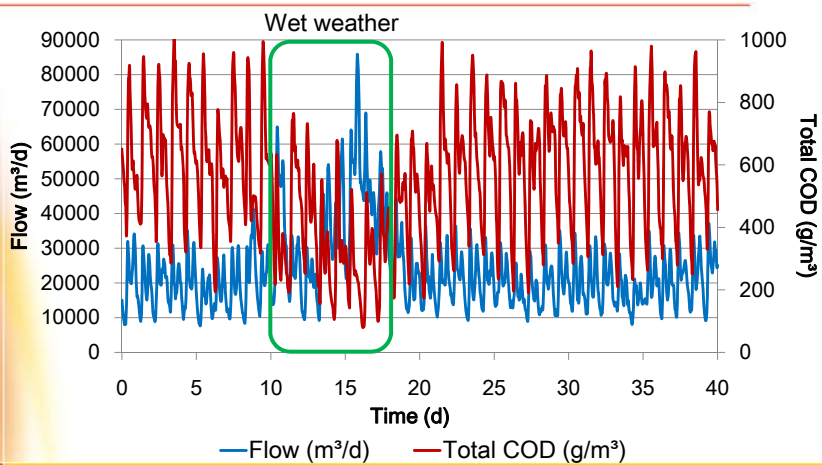
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Modeling

- Influent
 - Dynamic simulation
 - Realistic influent (flow and nutrients concentration)
 - Constant MP concentration (for ease of interpretation)
 - Different soluble/sorbed fraction for each MP

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Modeling



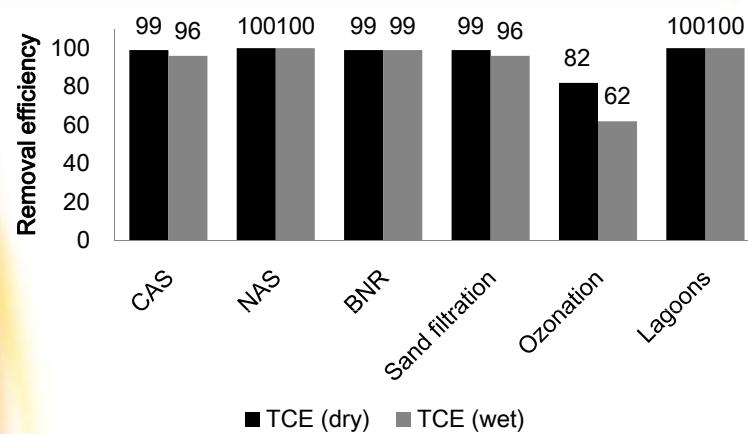
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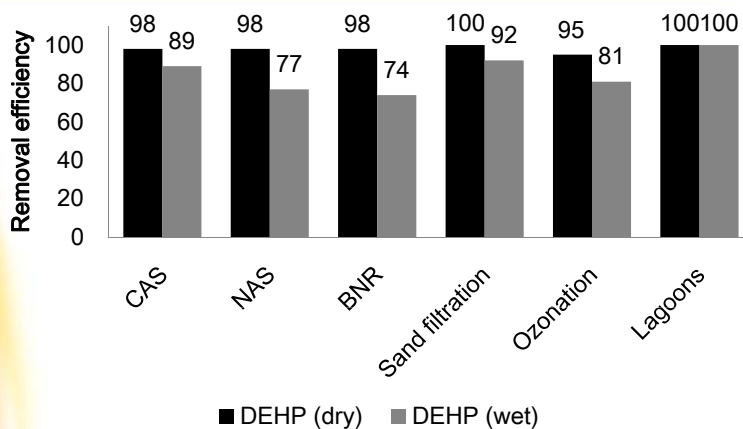
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Results –TCE



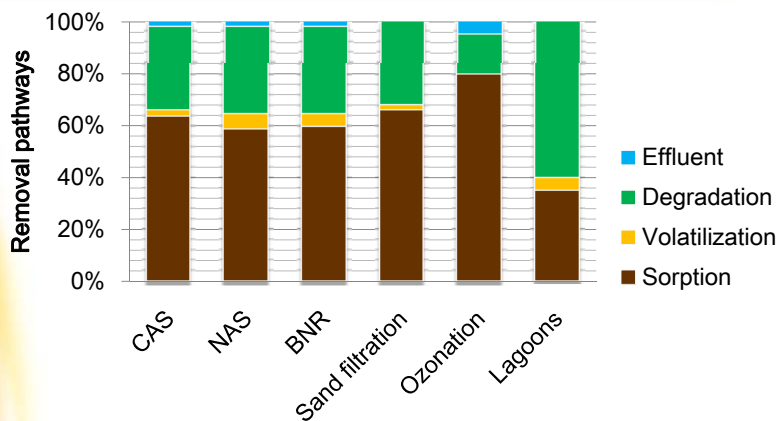
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Results – DEHP



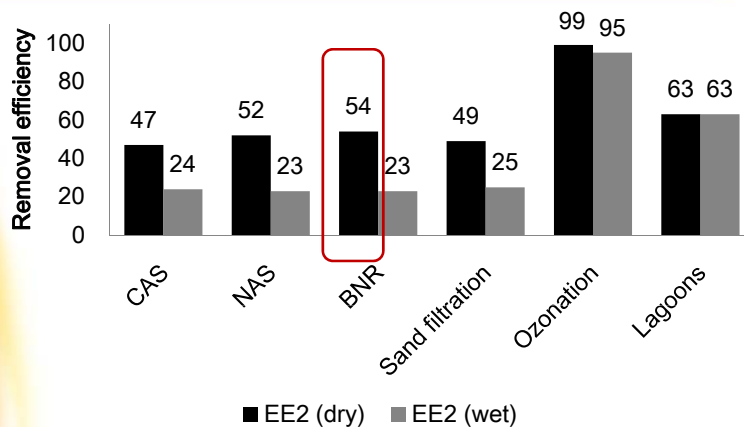
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Results – DEHP



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Results – EE2

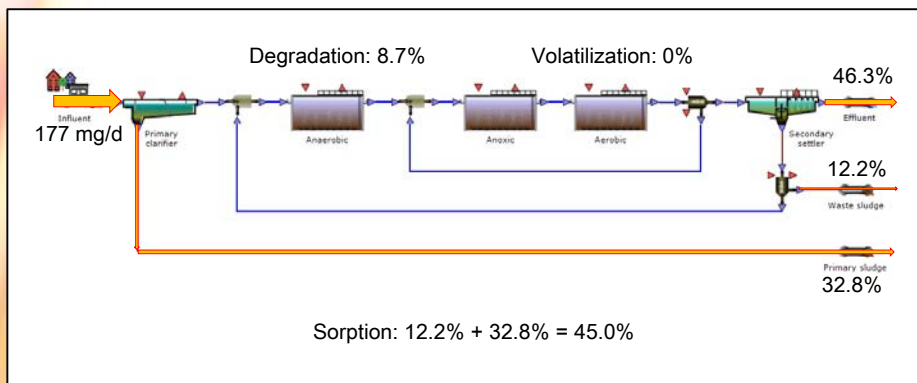


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Results – EE2



Substance flux analysis of EE2 in BNR



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Conclusion

- Water quality models allow:
 - Predicting the fate of traditional pollutants
- Micropollutant sub-models allow:
 - Predicting the fate of micropollutants
- Micropollutant fate models allow showing that
 - Different treatment plant configurations lead to different removal performances
 - Different micropollutants are removed with different efficiencies and along different mechanisms
- Models are excellent training tools

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Conclusion



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Conclusion

- Acknowledgments

- Ludiwine Clouzot
- Peter Vanrolleghem

