a place of mind
THE UNIVERSITY OF BRITISH COLUMBIA

Okanagan Estrogens Project

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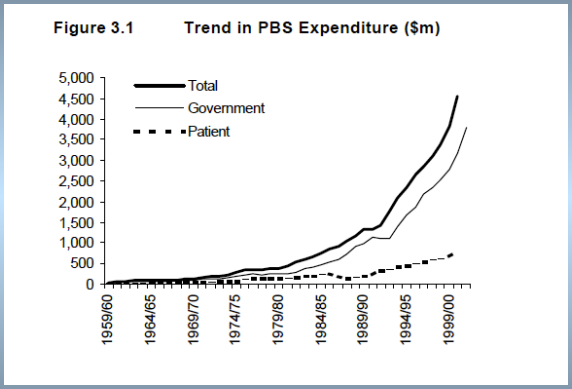
Endocrine Disruption (Hormones, PCPs)

Special Risks from Endocrine and Metabolic Disruptors?

- Human population growth
- Exposure of surface water to human wastes
- Explosion in use of metabolic regulators (drugs)



Explosive Use of Drugs

- Decadal rate of increase 25% per year ($)
- e.g. in two week interval ~60% of people will use pharmaceuticals
- Avg ~$30-40 per prescription

Drugs into Water

- Metrics are poor, variable activity, mass dosage, cost
- 0.04 Prescriptions/m^3, globally averaged at developed world levels. (25 m^3/ subscription)
- Non-uniformly distributed!!!

Population/Water Supply

- Worst case is large population w/small water supply (Okanagan?)
- Following the Pattern recognition - regulation

Outline

- Study Background
- Study Objectives
- Results
- Potential concerns
- Application to other areas

Background

- Estrogens are Emerging Contaminants
- Okanagan has among Canada's lowest per capita water supply -- lowest dilution for wastewater

Estrogens

- Estradiol -17β-estradiol (E2) - the most potent naturally occurring estrogen
- Estrone (E1) - a metabolite of E2
- Estriol (E3) – mainly produced during pregnancy
- Ethinylestradiol (EE2) – synthetic estrogen, the most commonly used medication.
  - One of most potent estrogenic compounds (Thorpe et al, 2003)
  - These three estrogens are generally considered to be the principle EDCs of concern in wastewater effluents (Gomes et al., 2003; Hanselman 2003; deMes et al., 2005; Falconer et al., 2006).

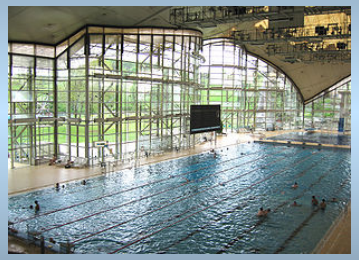
Study Objectives

- Measure estrogens in effluent and receiving waters
- Calculate degradation rates in receiving waters

Environmentally Relevant Concentrations

- Concentration of 5ng L^{-1} *(Estradiol)* caused total collapse of fish population (Kidd, 2007) - fish should not live in wastewater
- British Columbia Ministry of Environment guideline for 17 α-ethinylestradiol
  - *"30-d average concentration should not exceed 0.5 ng L^{-1} with no single value to exceed 0.75 ng L^{-1}"*

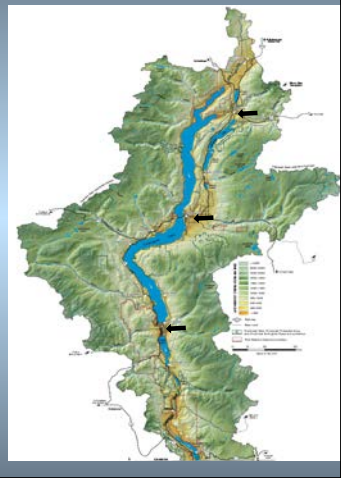
What is a ng/L?



One part per trillion (1 ppt) is a proportion equivalent to one-twentieth of a drop of water diluted into an Olympic-size swimming pool

Study Sites

- 3 large centers with similar WWTP, but different discharge Methods
- Very low per capita water supply and low precipitation
- Long residence time of Lakes



Sample Site Information

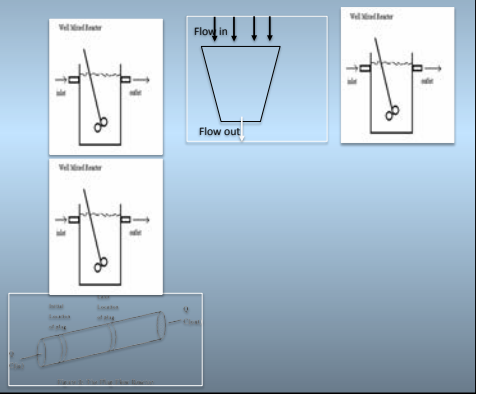
- All Biological Nutrient Removal Plants (BNR)
  - Designed for Nutrient and Pathogen removal
- Vernon Sample Sites
  - Plant effluent= 11500 m^3 /day (2104.5 USGPM)
- Kelowna Sample Sites
  - Plant effluent = 35000 m^3 /day (6405 USGPM)
- Penticton Sample Sites
  - Plant effluent = 10000 m^3 /day (1830 USGPM)

Receiving water sample sites – very different

- MacKay reservoir in Vernon
- Okanagan Lake in Kelowna
- Okanagan River in Penticton

Receiving water scavenging mechanisms

- Vernon
- Kelowna
- Penticton



Methods

- Grab samples
  - Monthly from treated wastewater effluent
  - Monthly from receiving waters (2y, 2009-10)
- Solid Phase Extraction (SPE) clean up
  - Needed to figure out how to treat the diverse sample matrices
- Liquid Chromatography (LC) and tandem Mass Spectrometry (MS)
  - This is the most common method used for direct quantitation

Total estrogens in wastewater treatment effluents

DL = approximately 0.07 ng/L

Site	Total Estrogens (ng/L)
Vernon Water Reclamation Centre	0.5-27.9
Kelowna Wastewater Treatment Facility	3.0 – 148.4
Penticton Wastewater Treatment Plant	<0.07 – 35.0

Total EDCs in receiving waters

DL = approximately 0.07 ng/L

Site	Total EDC (ng/L)
MacKay Reservoir	0.3-1.3
Vernon Tailwaters	Non Detect
Okanagan Lake	Non Detect
Okanagan River	<0.07-0.4

MacKay Reservoir - Vernon Effluent

- Approximate scavenging rate calculated from reservoir concentration, treatment plant loading and reservoir water balance

- $k = 0.007 day^{-1}$
- Half life = 200 d

MacKay Reservoir - Vernon Effluent

Season	Half life, d
Spring	35
Summer	60
Fall	150
Winter	650

Estrogens in Tailwater - Vernon Effluent (irrigation returns)

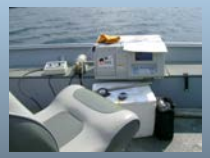
Kalamalka/Okanagan Lakes

Non-detectable

Okanagan Lake - Kelowna Effluent

•Extensive sampling eventually detected a very dilute 'plume' (conductance, and fluorimetry)

•Levels of estrogens throughout the lake were undetectable



Okanagan River - Penticton Effluent

- Travel time avg. 5h (3-9 h)
- No measured degradation.
- Values are close to dilution

Some Conclusions

- Wastewater treatment plants are releasing estrogens
- There are environmental mechanisms that can reduce estrogens in receiving waters (microbial degradation)
- In a reservoir environment it takes about 100 days for these compounds to degrade by 50% and further polishing occurs through groundwater infiltration and then dilution

Applications to other systems

- The decay rate can be used to calculate what might be expected in other systems
- Multiple levels of "treatment" are optimal to cleanup estrogens (ie. Vernon)
- Rivers provide less dilution volume and lower residence time for polishing of estrogens in wastewater. Treatment plan options? (average residence time of surface water on continents is <100d

What is in the drinking water?

- So far the numbers indicate concentrations in receiving waters would appear to be negligible for human consumption but very little research on chronic low dose exposure outcomes

Ecosystem concern

- **Exposure of aquatic organisms is chronic (like air pollution to humans).**
- **Hermaphroditic fish, alligators etc.**

Effects of chronic exposure to wastewater effluent on gene expression in goldfish -- assays of estrogenic chemicals

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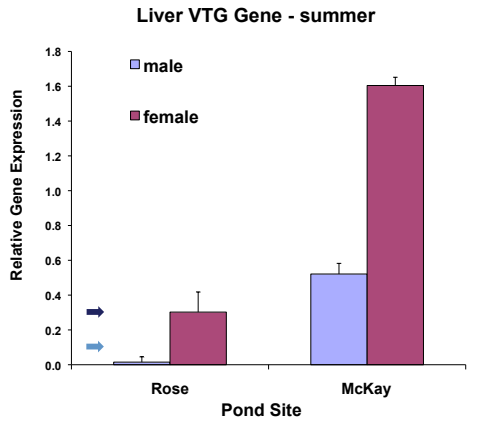
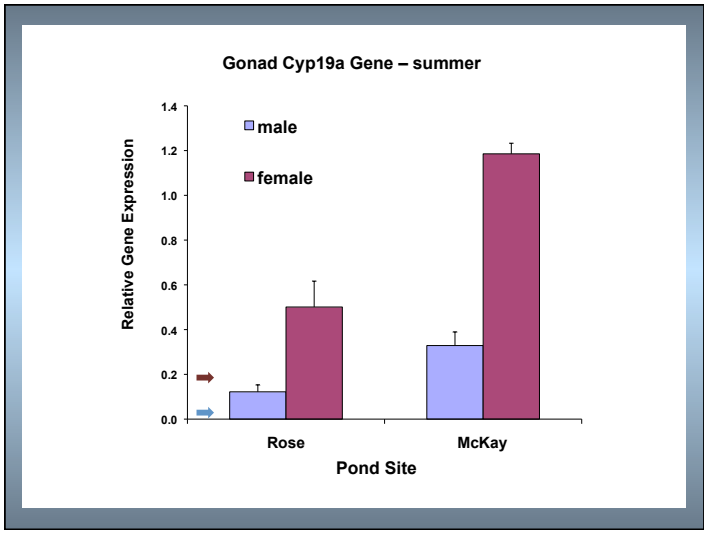
UBC Okanagan Campus
September 2, 2011





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