

Anthropogenic input of pharmaceuticals and personal care products in swimming pools

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Background

- If present in pool water, pharmaceutical and personal care products (PPCPs) may pose a health risk to swimmers
- Urine can contain PPCPs which can be potentially harmful to human health⁽¹⁾
- Nearly one in five swimmers admit to urinating in a pool⁽²⁾
- Swimmers ingest on average 13.7 mL of pool water per hour when swimming (Fig. 1)⁽³⁾
- Some PPCPs take months to degrade and could potentially concentrate in pool water⁽¹⁾
- Conventional pool water treatment methods do not remove most PPCPs⁽¹⁾
- Risk factors associated with pool water contamination by PPCPs are unknown
- Knowledge of risk factors can guide recommendations for pool facility design

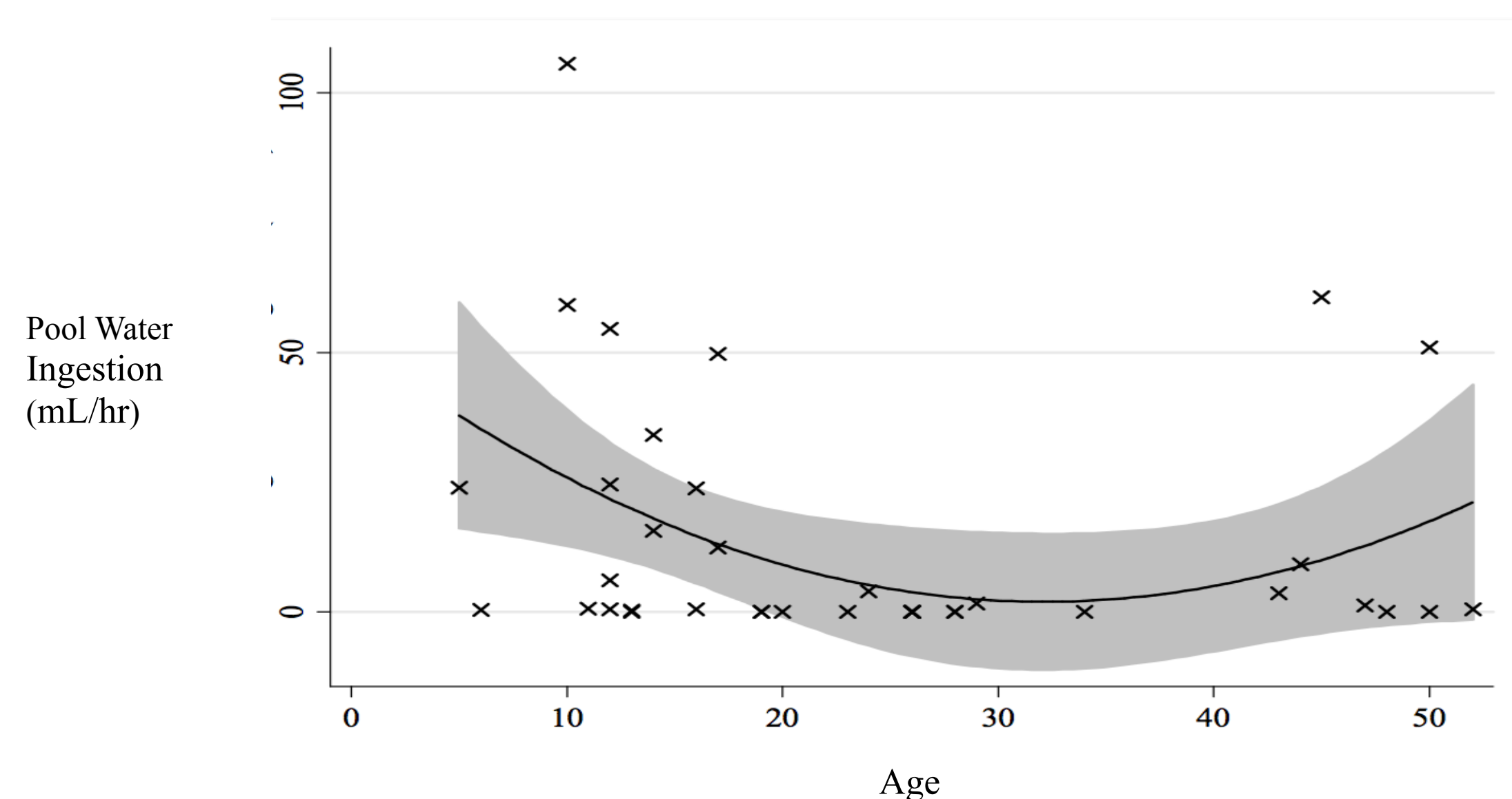


Fig. 1: Pool water ingestion per hour of swimming by age (avg ingestion all ages = 13.7 mL/hr)

Objectives

- Survey pool water for 32 PPCPs
 - Selection based on PPCPs found previously in tap and waste water, pharmaceuticals, lotions, detergents, and other products commonly used by the public, and the reactivity of PPCPs with chlorine
- Identify risk factors of contamination by assessing correlations between presence of PPCPs and pool operation and facility design
 - Ex. water exchange frequency, fill source, bather loads, toilet access, etc.

PPCP Purpose and Health Effect

- Health effects of PPCPs with highest likelihood of occurrence:
 - **Caffeine** (stimulant): insomnia, restlessness, irritability, tachycardia, nausea
 - **Ibuprofen** (analgesic/NSAID): nausea, vomiting, headache, diarrhea, constipation, dizziness
 - **DEET** (insect repellent): potential for impaired brain function, including muscle coordination, muscle weakness, walking, or even memory and cognition
 - **TCEP** (flame retardant): potential for kidney and thyroid tumors, infertility, hyperactivity

Methods

1. Pool recruitment (n = 30) in Eau Claire County, WI and Ramsey County, MN (Fig. 2)
 - Sites are a mix of indoor and outdoor pools used for recreation (hotels, apartments, water parks, workout facilities) and competition (schools and community pools)
2. Issue questionnaire to identify risk factors associated with pool water contamination by PPCPs (Fig. 3)

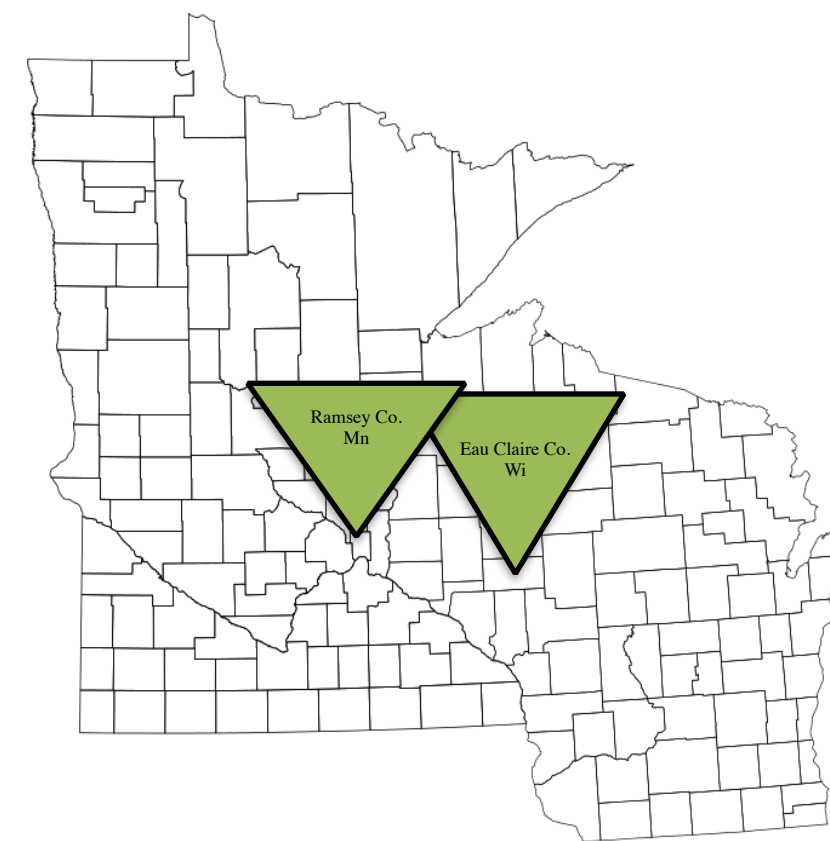


Fig. 2: Sampling site locations

Fig. 3: Risk factor questionnaire

3. Collect duplicate 1L fill and pool water samples per site (n = 60 water samples)
4. Preserve pool water with hydrochloric acid (pH 3) and process within 48 h
5. 1L samples processed with vacuum manifold using Solid Phase Extraction (SPE) to concentrate compounds of interest (Fig. 4)
6. Processing yields concentration factor of 2,000 times
 - SPE: Oasis HLB 6cc (Waters Corp.)
 - Apparatus flow rate: 10 mL/min
 - Elution: 5.0 mL methanol
 - Drying with 99.998% nitrogen gas
 - Reconstitution with 1.0 mL 95:5 formic acid methanol mix
7. Following reconstitution with formic acid methanol mix, samples are transferred to HPLC vials and stored frozen at -10°F
8. HPLC vials are packed on blue ice and shipped to Georgia Institute of Technology for analysis by mass spectrometry
9. Samples processed within 40 days of shipment



Fig. 4: PPCP extraction apparatus: pump, waste container, vacuum manifold, SPE cartridges, fritted glass filter with tubing

Preliminary Results

- Sample size to date, n=12
- Current samples have been collected at indoor swimming pools
- 7 Hotel pools, 2 school pools, 1 fitness pool, 1 therapy pool, and 1 water park pool have been sampled
- 11 pools are filled with tap (city water) and 1 pool with well water
- 11 pools utilize Chlorine disinfection, 1 pool utilizes Bromine and UV
- 25% of pools do not have toilets in pool area, with 0% reporting toilet breaks
- 58% of pools have shower facilities, with shower use ranging from 0% to 70%
- 67% of pools report that <10% of patrons use showers prior to swimming

Statistic	N	Mean	Standard Deviation	Minimum Value	Maximum Value
Bather Load/Day	11	74.68	118.61	3	358
Pool Volume (gallons)	11	50318.18	60660.23	500	184000
Flow Rate (GPM)	12	170.83	171.75	55	580
Dump/Refill Frequency (Calculated per year)	12	3.81	10.16	1 time every 6 years	36 times per year

- 25/32 PPCPs have been found in both pool and fill water samples
- DEET (insecticide) and TCEP (flame retardant) appear to be present in higher concentrations in pool water compared to fill water (no statistical tests have been performed) (Figs. 5 and 6)
- Ibuprofen, DEET, TCEP and BPA are the most concentrated chemicals on average in pool water, respectively

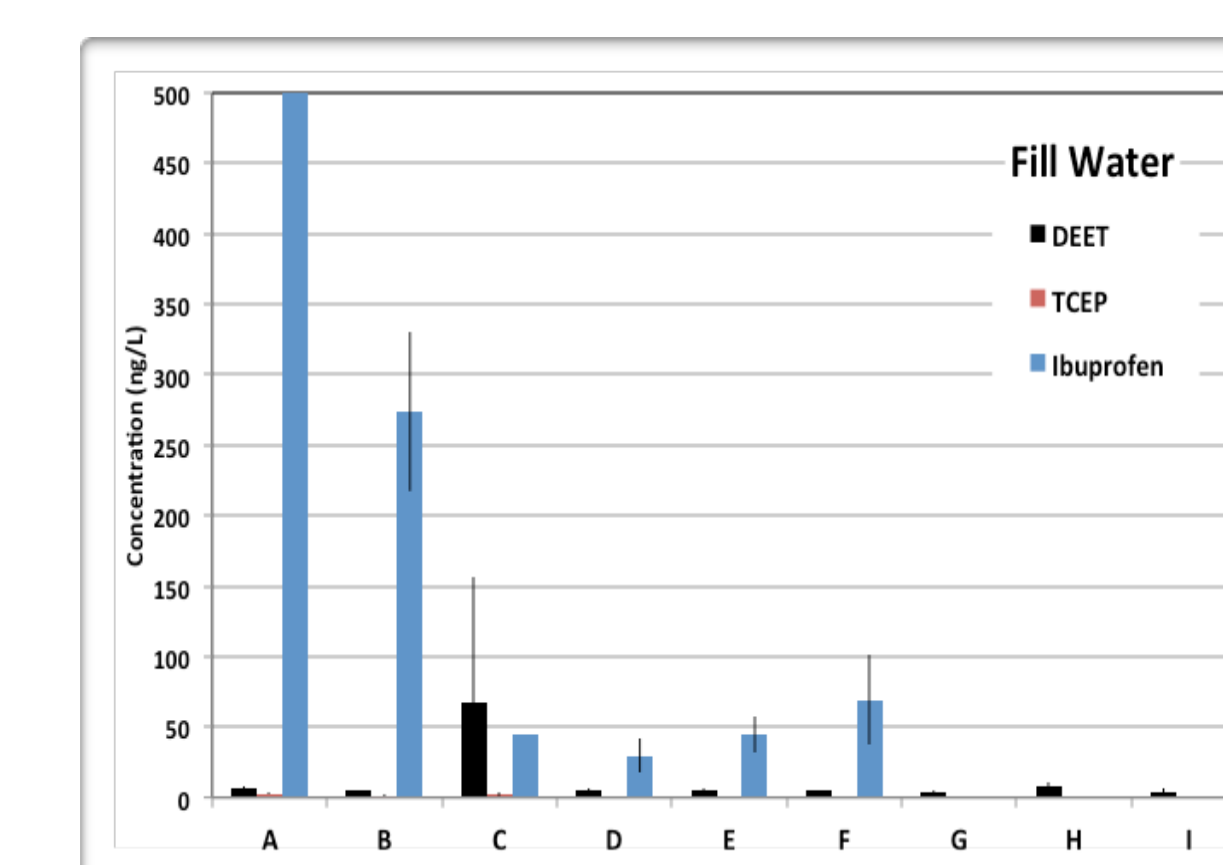


Fig. 8: PPCP concentration in fill water

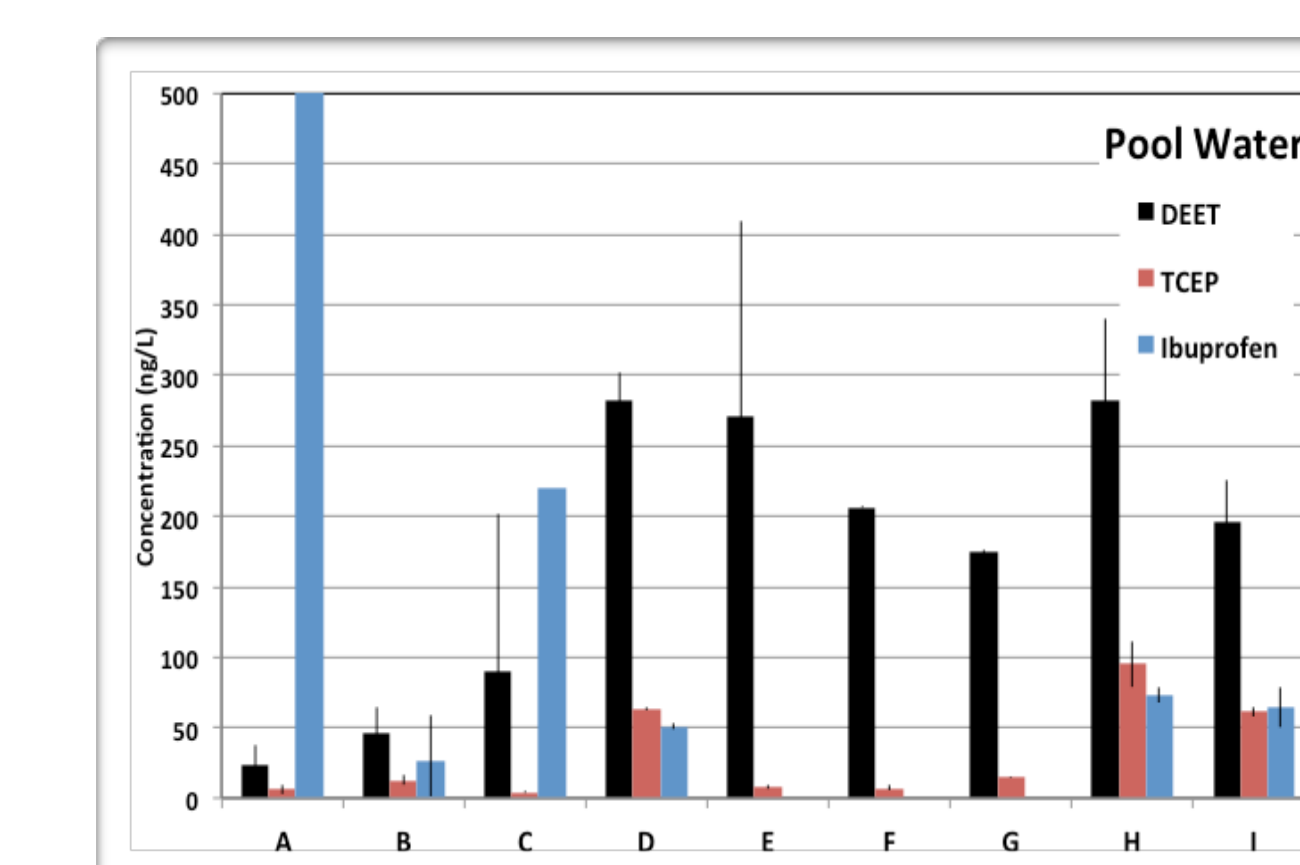


Fig. 9: PPCP concentration in pool water

Future Work

- Analytical method optimization is being finalized
- Sample collection expected to be complete fall, 2015

References

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