Hospital Emitted Pharmaceuticals in Urban Wastewater and WWTP Removal Efficiency

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Introduction

Pharmaceuticals (pharma) are extensively used and introduced into our wastewater where inadequate removal leads to release into surface waters. The possibility of separately treating hospital wastewater (a major pharma point-source) is currently being discussed by water quality regulators and environmental protection bodies in the UK. However, more research is needed to characterise pharma introduction and behaviour in hospital wastewater and wastewater treatment plants (WWTPs). In response, this pilot-scale project investigated water quality and the wastewater treatment cycle in relation to Caithness General Hospital (CGH) in Wick, UK. The results will be used to inform future decision-making at CGH, and to highlight pharma pollution which may adversely affect receiving environments in rural communities.

Research Objectives:

(1) Monitor pharma in Caithness General Hospital wastewater, Wick WWTP influent and final effluent

(2) Calculate pharma removal efficiency in WWTP

(3) Perform risk assessment

Methods

- Sampling (n = 20) performed every day (Feb, 2018) at Caithness General Hospital and Wick WWTP
- 1.5 L wastewater samples collected
- Filtration (0.7 µm GF) + Solid Phase Extraction (Oasis Prime HLB)
- Quantification with Triple Quadrupole HPLC-MS/MS (**Fig 1**)

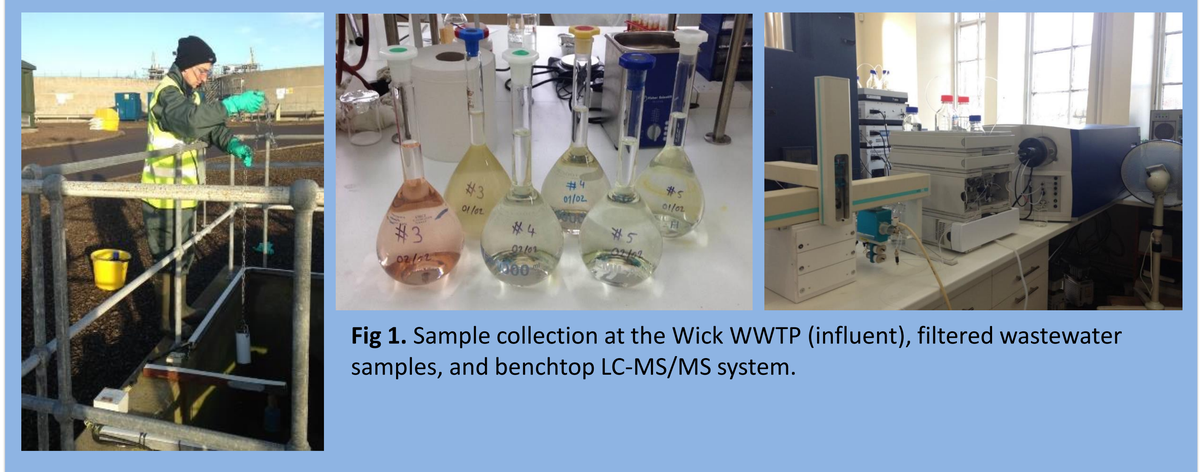


Fig 1. Sample collection at the Wick WWTP (influent), filtered wastewater samples, and benchtop LC-MS/MS system.

Target Pharma:

- Analgesics: Paracetamol (PAR), Ibuprofen (IBU), Diclofenac (DCF)
- Antibiotics: Clarithromycin (CLAR), Trimethoprim (TRI)
- Psychiatric drugs: Carbamazepine (CBZ), Fluoxetine (FLX)
- Estrogen contraceptive: 17α-Ethynylestradiol (EE2)

Results

- Pharma detected in all wastewater samples, >75 % detection PAR, IBU, DCF, TRI, CBZ, CLAR, FLX in hospital samples.
- Observed concentrations ranged 0.95 ng/L (EE2, hospital) to 10600 ng/L (PAR, influent) (**Fig 2**).
- High variability (% RSD > 40 %), expected when performing grab sampling with complex wastewater media.
- Variable removal during WWT, ranging -58 % (CLAR) – 88 % (PAR) (**Fig 3**)**.** Most pharma had no appreciable difference, <25 % removal.

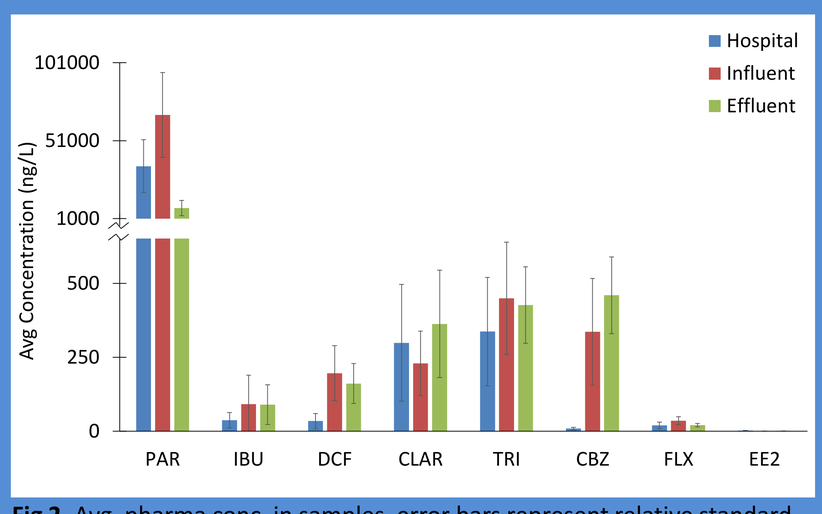


Fig 2. Avg. pharma conc. in samples, error bars represent relative standard deviation (% RSD). EE2: 2.0 ng/L ± 57 % (hospital), <LOQ (influent), 1.1 ± 4 % (effluent).

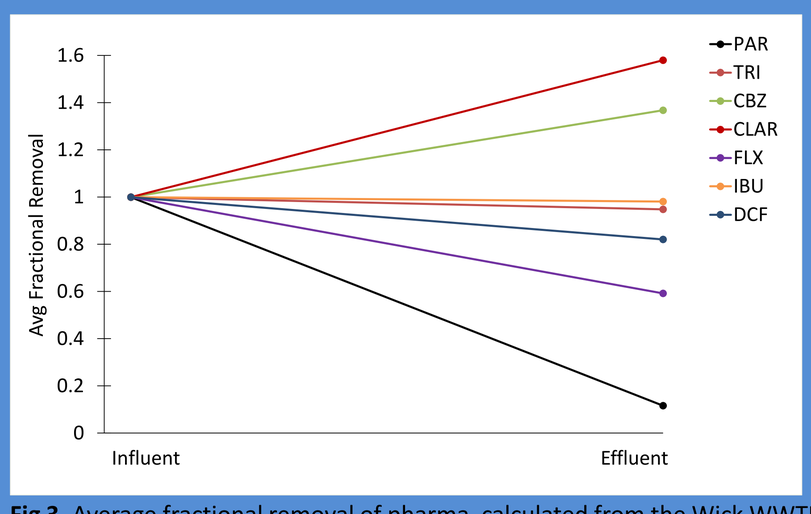


Fig 3. Average fractional removal of pharma, calculated from the Wick WWTP influent and effluent concentrations.

Risk Assessment: 10 ng/L (EE2) and 100 ng/L (DCF, CLAR) are max. allowable levels in surface water (EU *Water Framework Directive*). Additionally, DCF, CLAR and CBZ are prioritized in UK water pollution Watchlists. Several pharma exceeded max. values in Wick effluent, indicating potential risk in water.

Conclusions & Future

- The hospital influenced EE2, CLAR, PAR and DCF concentrations in municipal wastewater, based on detection frequency and avg. conc.
- Wick WWTP is ineffective for pharma removal. Increased CLAR concentration after treatment not previously reported, but CBZ behaviour expected.
- DCF, EE2 PAR, CBZ, and CLAR have high risk associated with observed effluent concentrations, based on risk quotient calculation (not presented here). However, dilution in receiving water may reduce this.
- **Further investigation** of pharma behaviour and degradation in conventional, rural WWTPs should be considered; particularly identification of potentially harmful transformation products.

LC Chromatograms

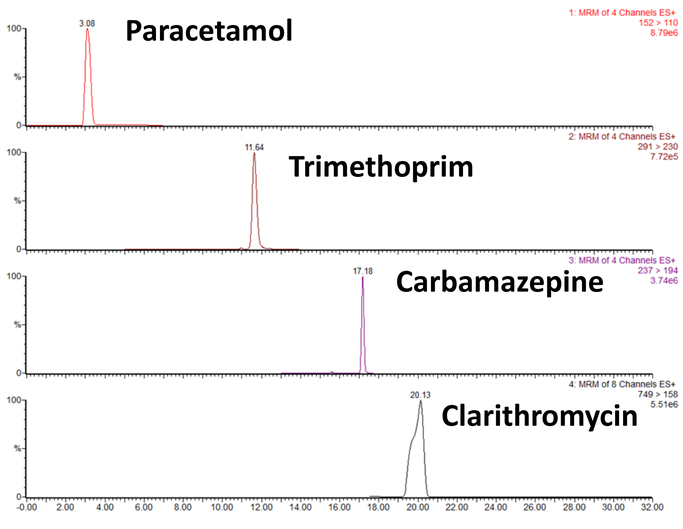
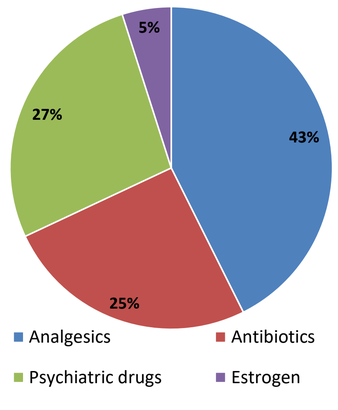


Fig 4. HPLC separation of pharma detected in a hospital wastewater sample (above). Pharma 'make-up' of hospital wastewater, total pharma detection frequency (right).



Acknowledgements: This project was in collaboration with Highlands and Islands Enterprise and NHS Highland, we are thankful for their funding. We thank the Hydro Nation Scholars Programme and CREW for their support of the PhD research.

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