Spatial variation of pharmaceutical concentrations in the River Almond
EU noPILLS project

• Funded by Interreg IV B
• 6 partners in 5 countries
• Aim: To reduce pharmaceutical pollution in the environment
  ➢ Technical solutions: wastewater treatment
  ➢ Societal solutions: reducing input of pharmaceutical residues via behaviour change
  ➢ Increase understanding of sources and pathways
Selection of study catchment

• UKWIR-CIP results for some of the STW:
  – Low environmental dilution
  – High effluent concentrations

• Catchment characteristics:
  – Highly urbanised
  – Sewer system overstretched with multiple CSOs
River Almond
River Almond Catchment

Schematic representation showing wastewater treatment works and sampling points in River Campaign
Specific objectives

• To build up a general understanding of concentrations in the catchment
• To investigate long range (10km) transport of pharmaceutical pollutants
• To investigate the effect of dilution by a tributary
• To investigate the effect of a large WWTP
Sampling and analysis

• Sampling
  – 4 consecutive days in June 2014
  – Characterised by dry weather and low flows
  – Daily grab samples & flow measurements
  – Flow estimation via relative catchment size

• Analysis
  – LC-MS/MS (Thermo Fisher Scientific Q Exactive Quadrupole Orbitrap mass spectrometer)
  – Deuterated internal standards used where available
Overview of results (mean values)
### ‘Sense check’

<table>
<thead>
<tr>
<th></th>
<th>Expected daily load (mg/day)</th>
<th>Measured daily load (mg/day)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Atenolol</td>
<td>4404</td>
<td>3802</td>
</tr>
<tr>
<td>Bezafibrate</td>
<td>285</td>
<td>133</td>
</tr>
<tr>
<td>Carbamazepine</td>
<td>195</td>
<td>462</td>
</tr>
<tr>
<td>Clarithromycin</td>
<td>916</td>
<td>503</td>
</tr>
<tr>
<td>Lidocaine</td>
<td>-</td>
<td>216</td>
</tr>
</tbody>
</table>

- All values within a factor 3 of prediction
- Prediction based on national average prescriptions (2012-13 NHS data), excretion data and removal data from literature
- Measured data are concentrations in daily grab samples x measured flow at Loc2
Environmental risk

\[ RQ = \frac{PEC}{PNEC} \]

PEC = Measured environmental concentration
PNEC = Predicted no-effect concentration

High risk: \( RQ > 1 \)
Moderate risk: \( 1 > RQ > 0.1 \)
Low risk: \( RQ < 0.1 \)
Spatial and Temporal Variation
(4 days, 7 locations)

Atenolol (PNEC = 30µg/l)

Bezafibrate (PNEC = 0.46µg/l)
Spatial and Temporal Variation

**Carbamazepine** (PNEC 0.42 µg/l)

**Clarithromycin** (PNEC 0.07 µg/l)

**River Almond**

**Breich Water**

**Clarithromycin** (PNEC 0.07 µg/l)
Spatial and Temporal Variation

Lidocaine
River Almond Catchment

WWTP (Capacity in PE)

- 0-200 PE
- 200-10,000 PE
- 10,000-50,000 PE
- > 50,000 PE

Sampling point

[Diagram showing the River Almond Catchment with various WWTPs and sampling points]
Upstream and downstream from large STW (PE=60,000)

Mean concentrations increase by a factor 1.5 to 6
Concentrations Breich Water

Atenolol
Bezafibrate
Carbamazepine
Clarithromycin
Lidocaine

10km

(µg/l) (µg/l) (µg/l)
0.0
0.2
0.4
0.6
0.8
1.0

0.0
0.2
0.4
0.6
0.8
1.0

0.0
0.2
0.4
0.6
0.8
1.0
Calculated Loads Breich Water

Loc1: Upstream from STW (flow based on measurement at Loc2)

Loc2: 0.4km downstream from STW
      Based on measured flow

Loc3: 10km downstream from STW
      Based on flow estimated from relative catchment size

mg/day  mg/day  mg/day
Controlled Activity Regulations (CAR) Authorisations
Summary

• Many of the compounds are present at (chronic) toxic levels (RQ>0.1)
• Significant rise in concentration after addition of WWTP discharge
• Suspected additional inputs from non-point sources
Future work

• Confirm results (sampling campaign planned for June ‘15)
• Investigate possible diffuse sources or minor point sources
• Repeat in wet weather (influence of CSO)
Thank you for your attention

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## Toxicity and Persistency

<table>
<thead>
<tr>
<th>Compound</th>
<th>PNEC (µg/l)</th>
<th>Reference</th>
<th>Removal in WWTP (Verlicchi et al., 2012)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Atenolol</td>
<td>30</td>
<td>Boillot (2008), in: Verlicchi et al., 2012</td>
<td>38</td>
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<tr>
<td>Bezafibrate</td>
<td>0.46</td>
<td>Isidori et al., 2007</td>
<td>61</td>
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<td>Carbamazepine</td>
<td>0.42</td>
<td>Ferrari et al., 2003</td>
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<tr>
<td>Clarithromycin</td>
<td>0.07</td>
<td>Boillot (2008), in: Verlicchi et al., 2012</td>
<td>40</td>
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<tr>
<td>Lidocaine</td>
<td>nd</td>
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</table>
## Defined Daily Doses of the investigated drugs

<table>
<thead>
<tr>
<th>Drug</th>
<th>DDD</th>
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<tbody>
<tr>
<td>Atenolol</td>
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<td>Bezafibrate</td>
<td>600mg</td>
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<tr>
<td>Carbamazepine</td>
<td>1000mg</td>
</tr>
<tr>
<td>Clarithromycin</td>
<td>500mg</td>
</tr>
<tr>
<td>Lidocaine</td>
<td>n/a</td>
</tr>
</tbody>
</table>
References