Incorporating model uncertainty into the evaluation of interventions to reduce microcontaminant loads in rivers

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10th MICROPOL & ECOHAZARD CONFERENCE 2017 – Vienna, Austria
- Presentation of the case study
- Development and calibration of Microcontaminant Fate and Transport Model
- Generation of scenarios of uncertainty and interventions
- Evaluation of scenarios
- Take-home messages
CASE STUDY LLOBREGAT

Llobregat river basin
56 WWTP
1,080,000 inhabitants connected

Model substance: anti-inflammatory drug
DICLOFENAC included in WFD “watch list”

Sampling campaign: September 2010
9 points in river
Influent and effluent 2 WWTP
MASS BALANCE (STEADY STATE)

\[ L_{\text{down, stretch1}} + L_{\text{eff, WWTP}} = L_{\text{up, stretch2}} \]
Estimation of WWTP influent loads

\[ L_{\text{inf}} = \text{Sales} \times \text{Influent loads factor} \times \text{Census population} \]

Degradation in WWTP (A. Joss et al, 2006) → Pseudo 1st order decay reaction

\[ L_{\text{effluent}} = L_{\text{inf}} \times \frac{1}{(1 + k_{\text{WWTP}} \times X_{ss} \times \theta_h)} \]

Degradation in river stretches → 1st order decay reaction (≈ GREAT-ER)

\[ L_{\text{downstream stretch}} = L_{\text{upstream stretch}} \times e^{-HRT \times k_{\text{river}}} \]

\[ HRT = \frac{L_{\text{stretch}}}{v} \]
RESULTS LLOBREGAT

$r^2 = 0.95$

- Sampling points
- WWTP Igualada
- WWTP Manresa

Model prediction (g·d⁻¹)

Measured loads (g·d⁻¹)
GENERATION OF SCENARIOS

12 WWTP interventions

36 scenarios

3 levels of uncertainty

36 distributions of diclofenac concentrations at every stretch

Evaluation at LLO7 (river mouth)

- Reference scenario (calibrated)
- 11 increases in WWTP removal efficiency ($k_{WWTP}$)

- Reference scenario (calibrated)
- Decrease uncertainty in $F$, $k_{WWTP}$ and $k_{river}$
- Increase uncertainty in $F$, $k_{WWTP}$ and $k_{river}$

20/09/2017
EVALUATION OF SCENARIOS

Upgrades in secondary treatment

Simulated concentrations of diclofenac (ng·l⁻¹) at LLO7

Increase in \( k_{\text{WWTP}} \) (%)

[WWTP removal efficiency (%) - median and 5 - 95 percentiles]

Increased unc
Calibrated pars
Decreased unc

tertiary treatments
Influence of Uncertainty on Selection of Interventions

**APPARENT REDUCTION**

- **Scenario 1**
  - No overlap → probability of achieving apparent reduction = 100%

**NO APPARENT REDUCTION**

- **Scenario 2**
  - Overlap → probability of achieving apparent reduction <<< 100%

Probability = (no. of values in Scenario < Percentile 5 of Reference values) / total no. of values in scenario

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EVALUATION OF SCENARIOS

Installation of tertiary treatments

Upgrades in secondary treatment

Probability of apparent reduction (%)

Increase in $k_{WWTP}$ (%) [WWTP removal efficiency (%) - median and 5 - 95 percentiles]

[40 (17-64)] [55 (28-77)] [87 (67-95)] [98 (95-99)]
- Model uncertainty influences the selection of WWTP upgrade interventions to reduce diclofenac loads in rivers.

- Installation of tertiary treatments results in apparent reductions in diclofenac concentrations, *regardless of uncertainty*

- Upgrades in secondary treatments result in apparent reductions in diclofenac concentration, *depending on uncertainty*

- Further research is needed to reduce uncertainties in human consumption and excretion of PhACs, in the removal of PhACs in sewers and in the WWTP and river degradation constants.
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