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The MEDUWA project

Modelling pharmaceuticals and resistant bacteria in the trans-border catchment Vechte

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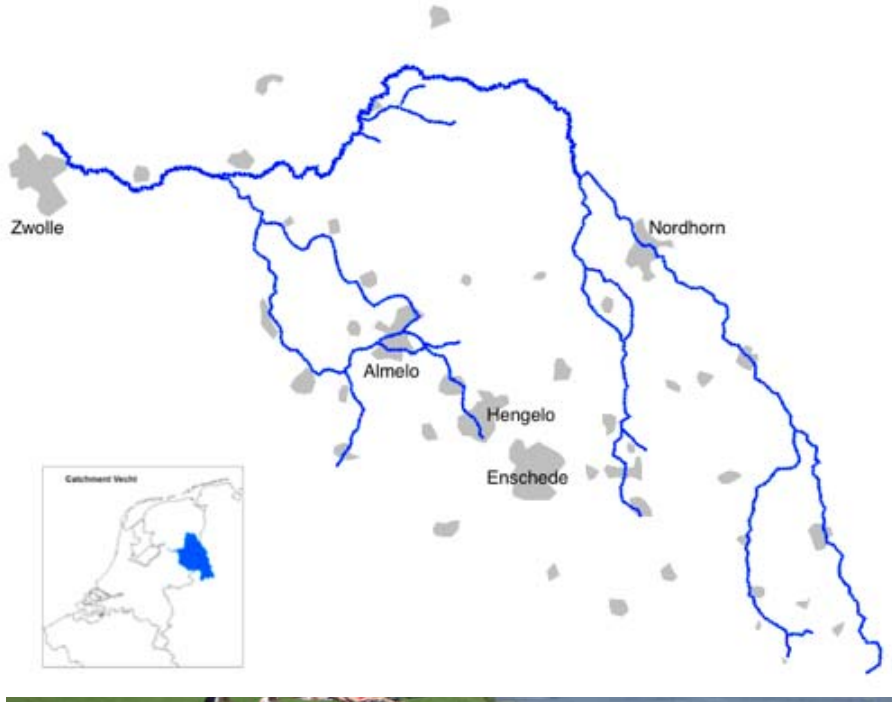
The MEDUWA Project

MEDUWA (*MED*icines *U*nwanted in *WA*ter) is an EU-INTERREG project that aims at reducing use and emissions of human and veterinary medicines and minimize the occurrence of antibiotic resistant micro-organisms in the environmental cycle.

Partners are situated in the trans-border catchment of the Vecht and work together in six work packages on the development of a set of socially responsible, complementary measures to achieve the project goal.

The MEDUWA-Vecht(e) project



NL/DE cross border coalition
12 innovative products
developed by 21 partners:
8 scientific institutions, 10 SME's
1 hospital and 2 consultancies

Background of our work

- Pharmaceuticals including antibiotics are widely detected in the aquatic environment
- Sewage treatment plants (STP) have already been identified as major exposure route for pharmaceuticals
- Resistant bacteria may also enter surface water via domestic or hospital wastewater
- Exposure assessment is performed by a combination of monitoring (WETSUS) and model simulations (IUSF)

Objectives of Work Package

- Prediction of spatially explicit concentrations of pharmaceuticals in the Vecht catchment with the GREAT-ER model
- Application of the model to bacteria concentrations
- Use management scenarios for a priori evaluation of the effectiveness of reduction measures

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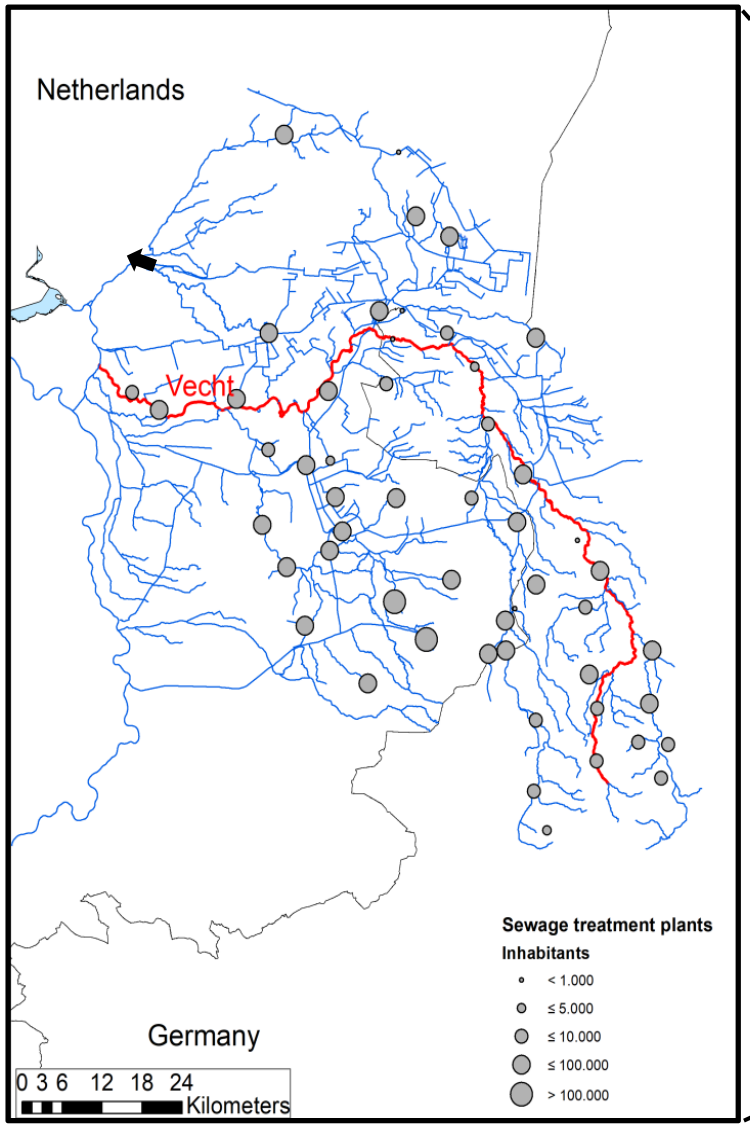
The Model GREAT-ER

- **G**eography-referenced **R**egional **E**xposure **A**ssessment **T**ool for **E**uropean **R**ivers
- GIS application originally developed for ‘down-the-drain-chemicals‘
- Steady state, mass balance model
- Successfully applied for pharmaceuticals, e.g. β-blocker in Glatt valley (Switzerland) and Diclofenac in Ruhr river basin

Vecht catchment



Cross-border (GER - NL) catchment (6,224 km^2)

Mean discharge at outlet: 44 m^3/s

53 sewage treatment plants serving 1.2 million inhabitants

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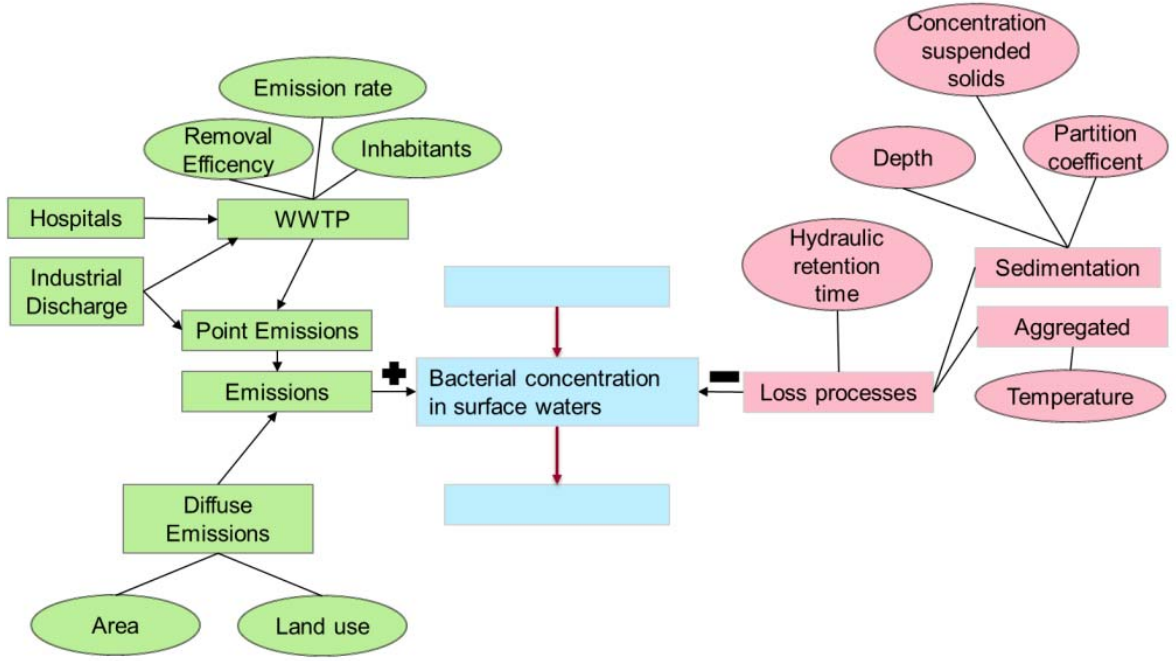
Model Simulations

- Emission of pharmaceuticals is estimated from
  - national per capita (for hospitals: per patient) consumption
  - average human excretion rate and
  - sewage treatment plant removal efficiencies
- Loss by photolysis and sedimentation is considered
- Parameter variability (discharge) and uncertainty (emission) is taken into account by probabilistic Monte Carlo simulations
- Calibration for diclofenac, carbamazepine and metformin has been successfully completed

Simulating Bacteria

- Simulation routine for bacteria was subjoined into GREAT-ER
- Bacterial STP emissions were back-calculated from effluent data
- Diffuse runoff emissions were considered as annual average



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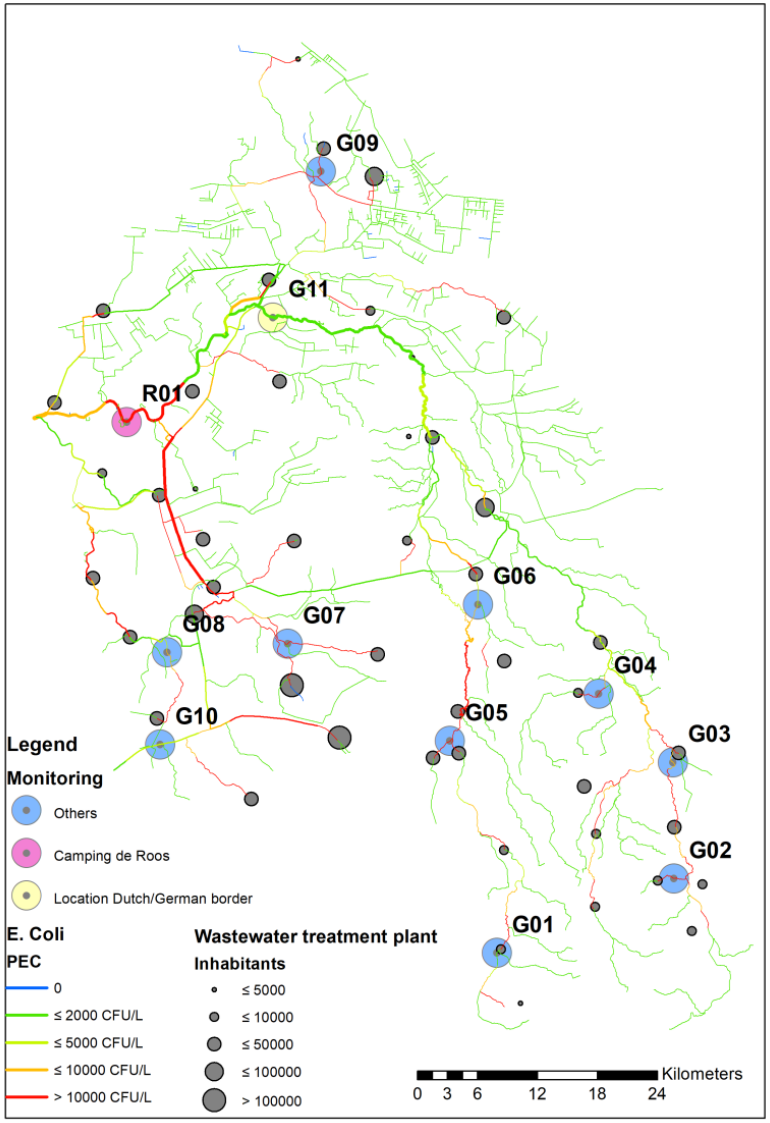
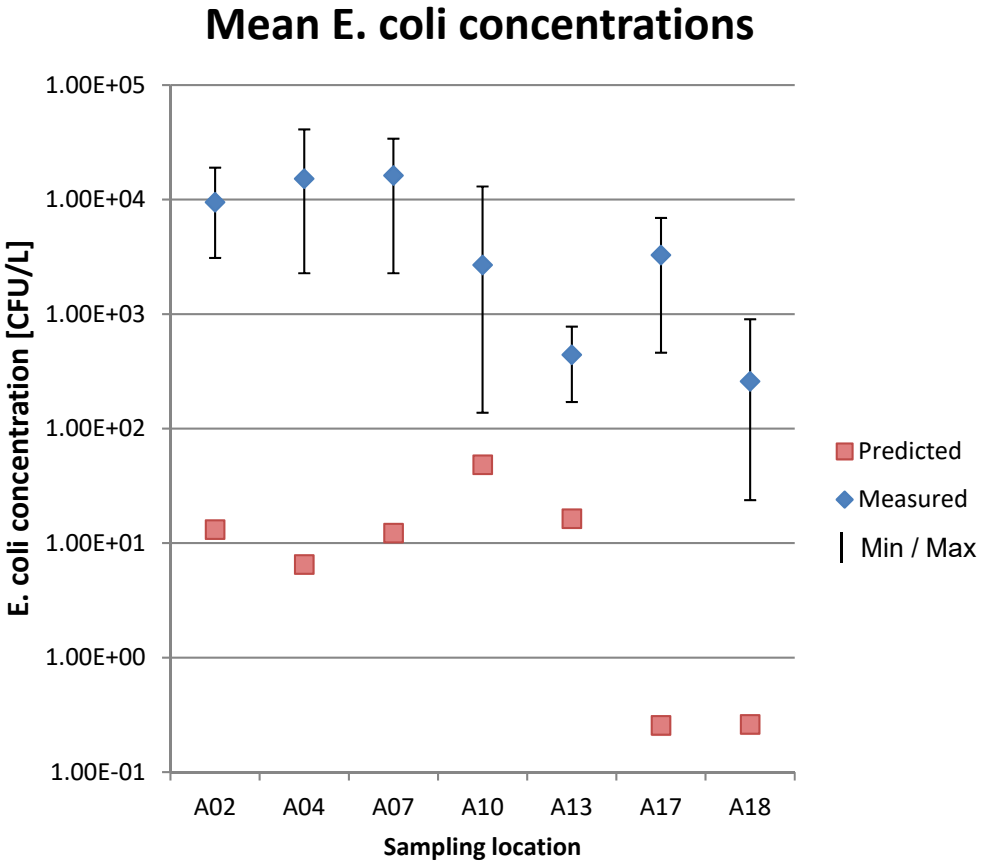
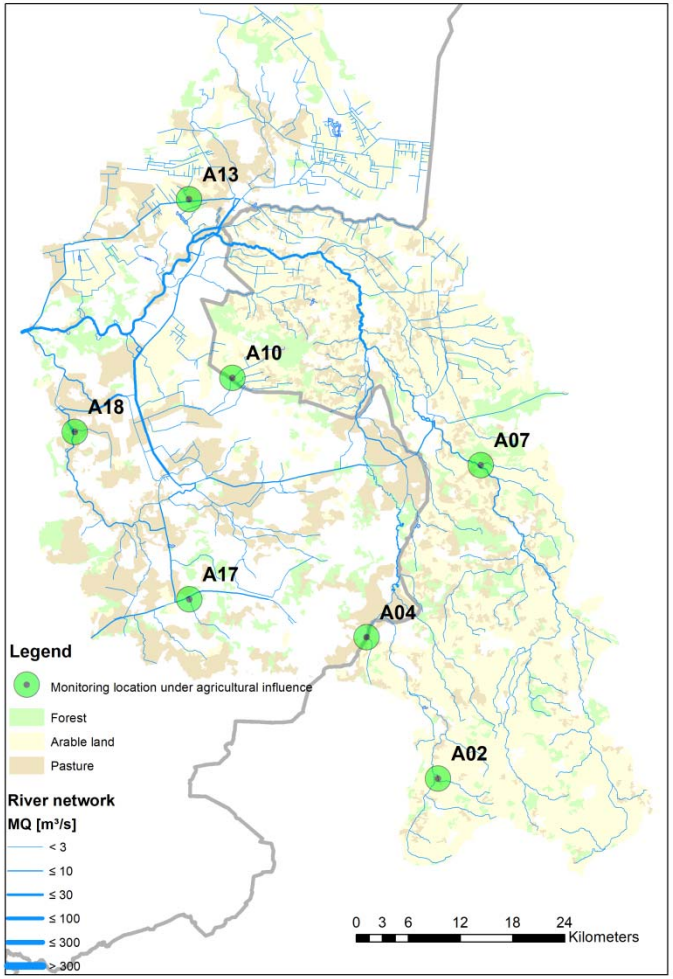
Orienting simulation in Vecht basin



- Low background emissions extracted from literature
- Highest concentrations are predicted downstream of wastewater treatment plants
- Parameter for canal waterways in the Netherlands (e.g. travel times) need to be reviewed

Background sites in agricultural areas





Large underestimation of measured E. coli concentrations by the model at background sites

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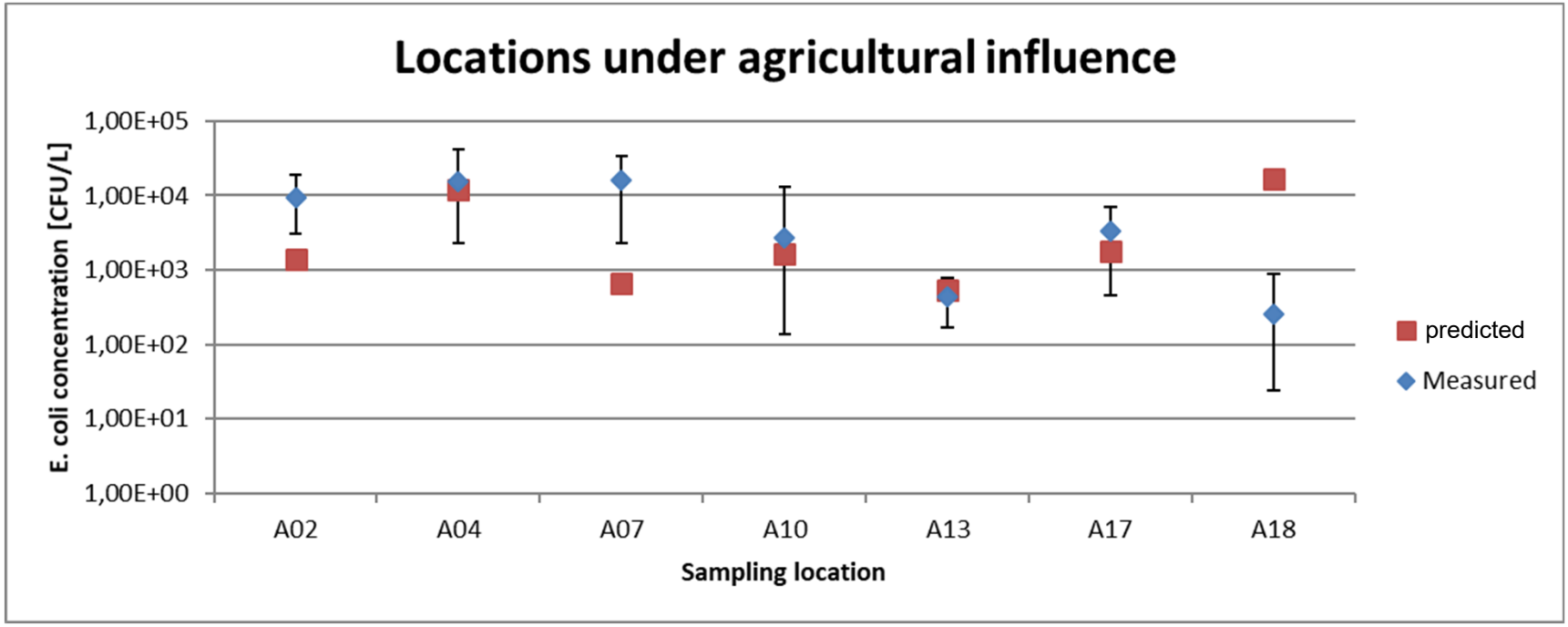
Model calibration for E. coli

- Surface runoff rates had been extracted from literature and were adjusted in the calibration step
- Much better agreement between measured and predicted data



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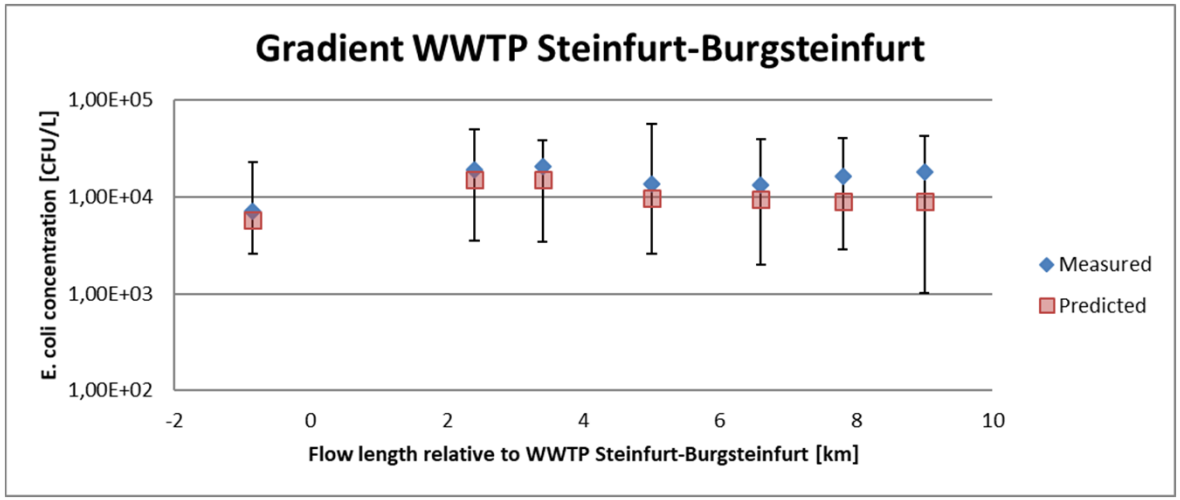
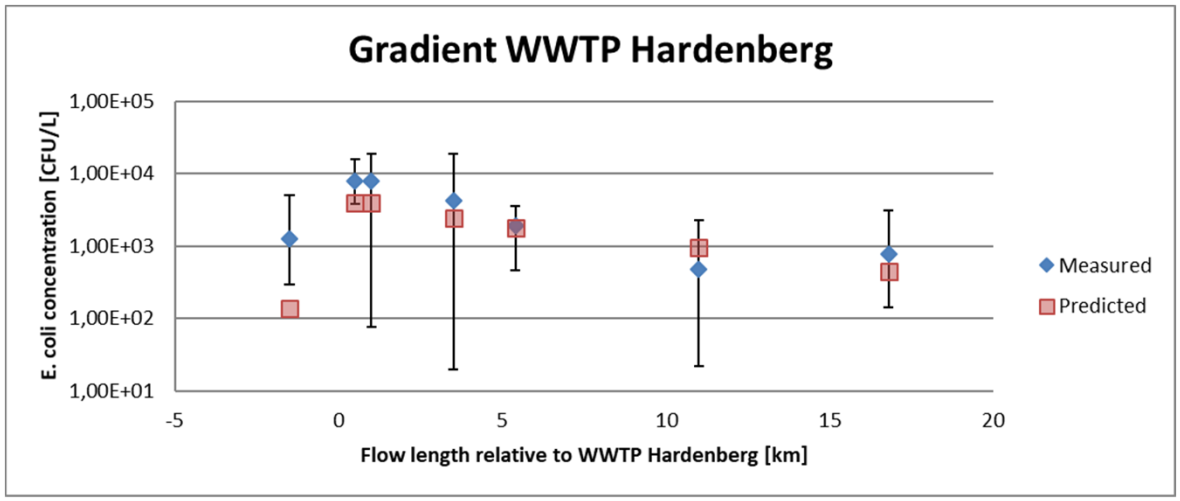
Evaluation downstream of sewage treatment plants





Per capita emission estimated from effluent data and extrapolated.

Loss (dying and sedimentation) considered with half-life of approx. five hours.

↓

Good agreement between predictions and measured data downstream of 2 STPs

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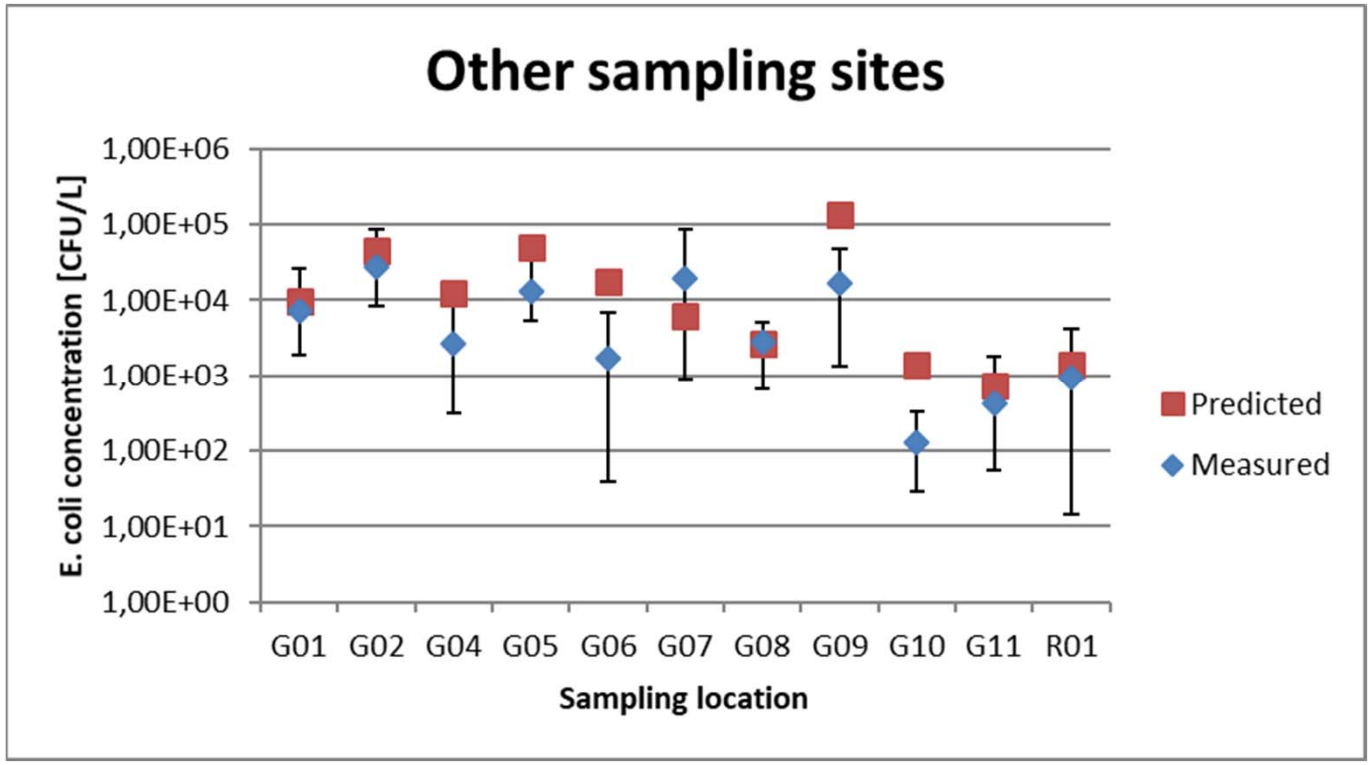
Verification at other sites

Good agreement between measurements and simulation results at other sites affected by agriculture and WWP effluents



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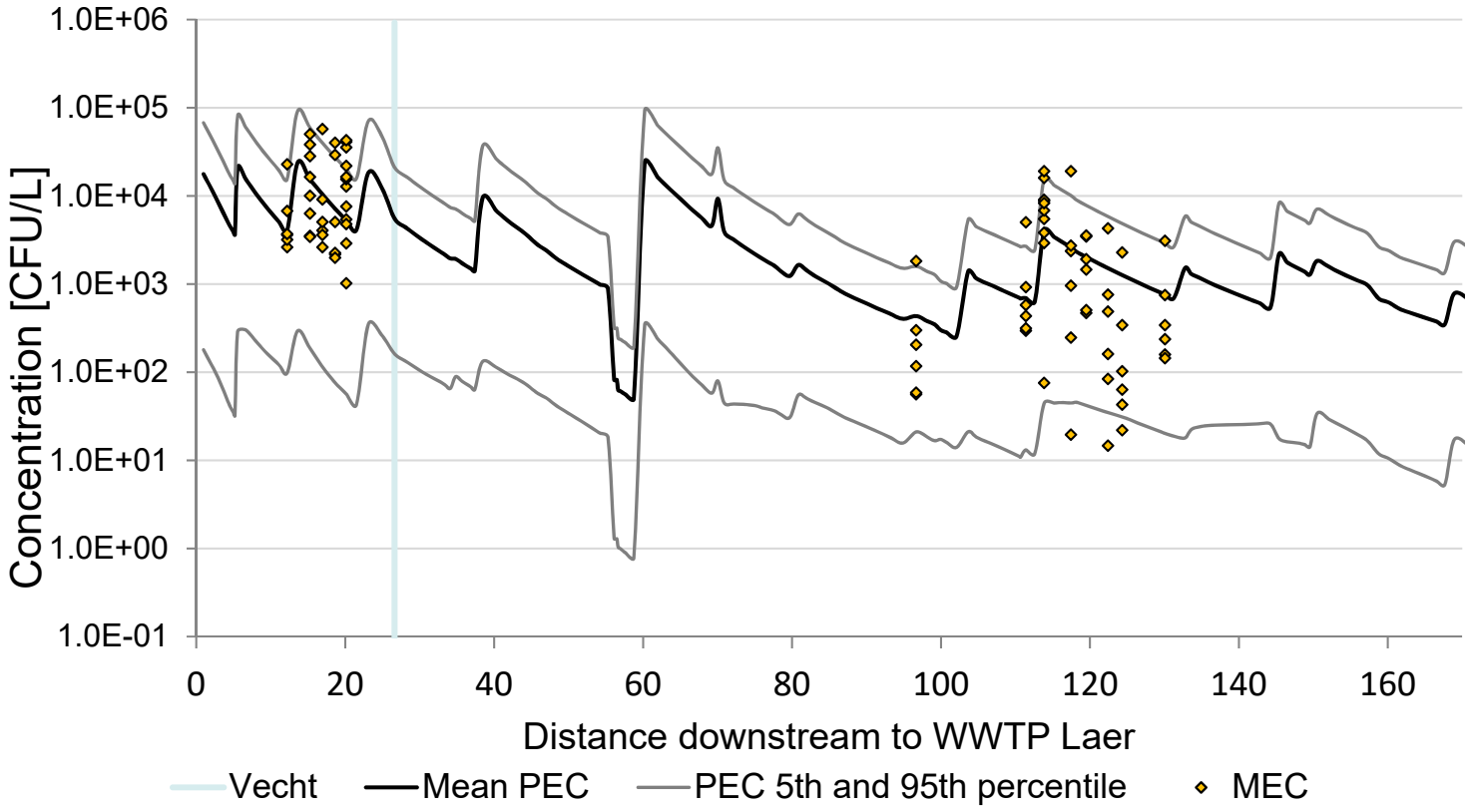
Probabilistic Simulation for E. coli

Measured concentrations are mostly in the range spanned by the 5th and 95th percentile of the simulation



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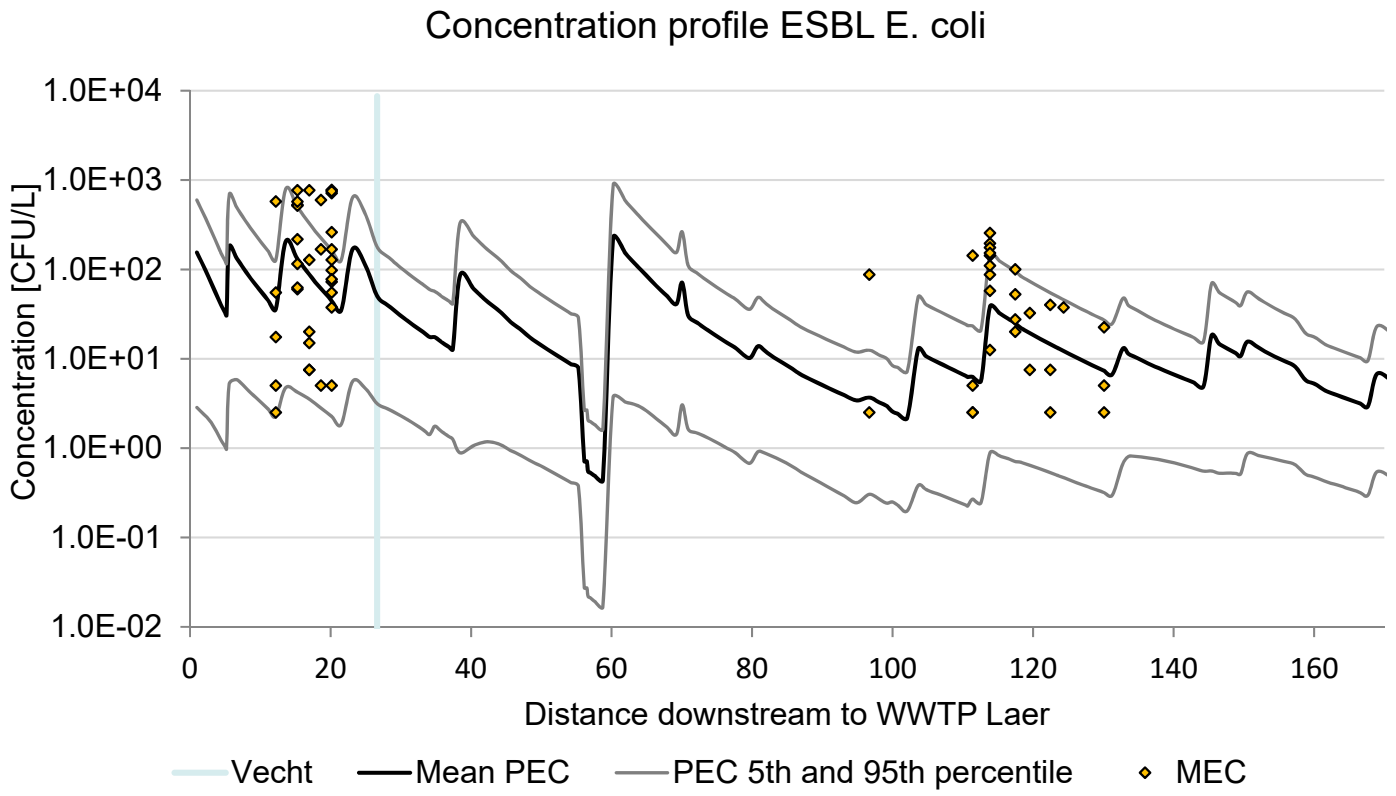
Probabilistic Simulation for ESBL E. coli

Measured concentrations are also mainly between the 5th and 95th percentile of the probabilistic simulation result.



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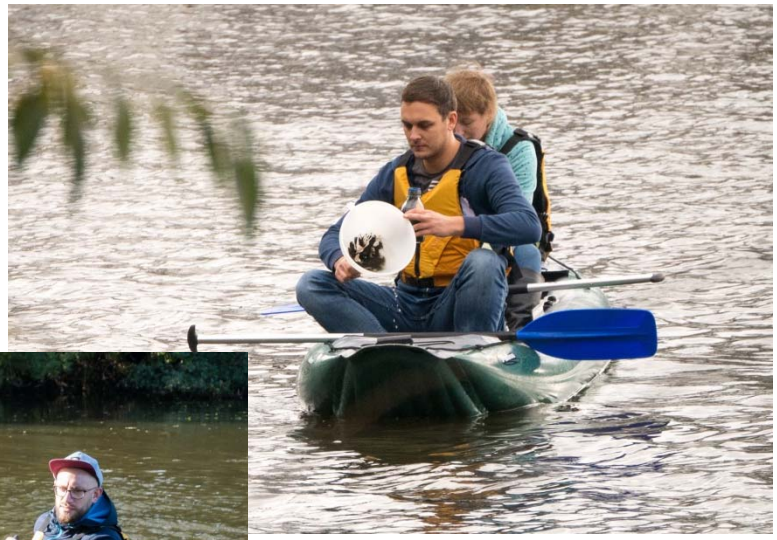
Summary

- GREAT-ER was parameterized for georeferenced simulations in the Vecht catchment.
- Simulation routine for bacteria has been successfully subjoined.
- Calibration against measured data revealed high uncertainty of input parameters for E. coli extrapolated from literature (e.g. surface runoff rates, environmental fate).
- After a series of calibration steps good agreement between measurements and predictions was achieved.
- The calibrated model performed well for ESBL E. coli.

Outlook – Calibration for Lake Vechte

Joint sampling of water and sediment samples in Lake Vechte (16th October) by WETSUS and IUSF for further verification



Next step:
Inclusion of carbapenemase forming E. coli