UNIVERSITEIT GENT

BIOMATH
Department of Applied Mathematics, Biometrics and Process Control

INTEGRATED MODELLING OF EUTROPHICATION AND ORGANIC CONTAMINANT FATE IN RIVERS

Tolessa Deksissa and Peter A. Vanrolleghem

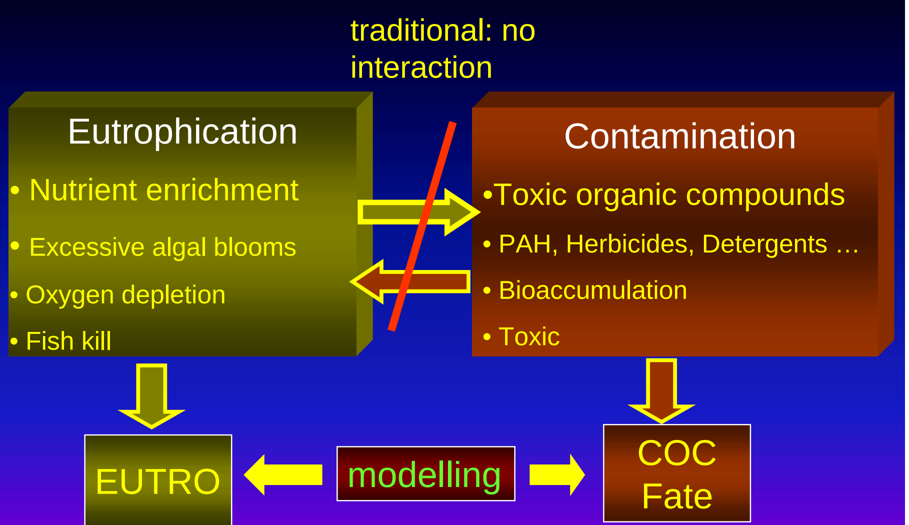
Ghent University, Coupure Links 653, B- 9000 Gent (Belgium)

tolessa@biomath.rug.ac.be

OUTLINE

- Introduction
- Problems & goals
- Modelling approach
  - Model structure
  - Calibration and validation
  - Implementation
- Results of the case study
- Scenario analysis
- Conclusions

Intro: water quality problems & interaction



Problems in modelling

- In single-issue model
  - The interaction is missed
- Temporal model resolution
  - Steady state and dynamic modelling
- Dynamic model: complex hydrodynamic model
  - The St. Venant Equations
  - Requires important data that are rarely available
  - Relatively complex for integrated water quality modelling
- Appropriate process description or state variables

Solutions/goals

- Integrated modelling
- Dynamic
- Simple and conceptual
  - Tank in series model
- Appropriate process description

Appropriative process description

Mass balance:

$$\frac{dM}{dt} = Load_{in} - Load_{out} \pm reaction$$

Biochemical conversion term

Eutrophication models

1. QUAL2E (Brown & Barnwell, 1987)
2. IWA River Water Quality Model No. 1 RWQM1 (Reichert et al., 2001)

Why River Water Quality Model No. 1 (RWQM1)

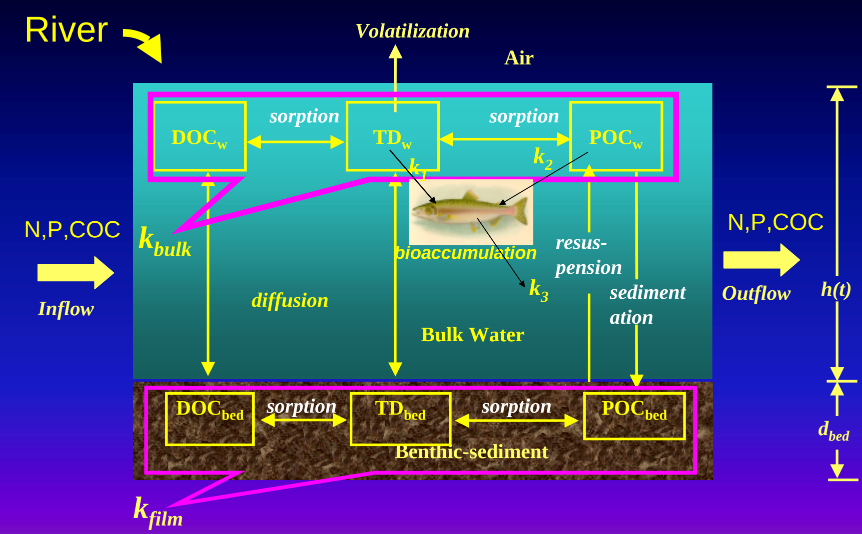
- State variables
  - Microbial biomass
  - Benthic sediment
- COD (not BOD like QUAL2E) as a measure of carbonaceous organic matter
- Consistency in mass balance
- Includes simple food chain, and has potential to include more

⇒ Suitable for integrated modelling

OUTLINE

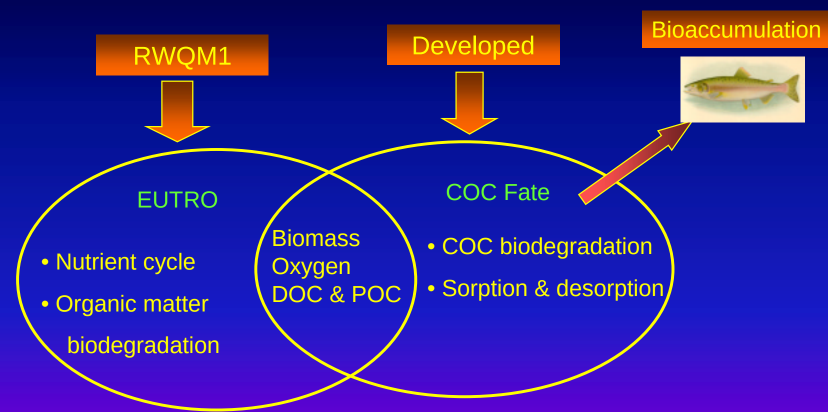
- Introduction
- Problems & goals
- Modelling approach
  - Model structure
  - Calibration and validation
  - Implementation
- Results of the case study
- Scenario analysis
- Conclusions

Model structure



Model structure

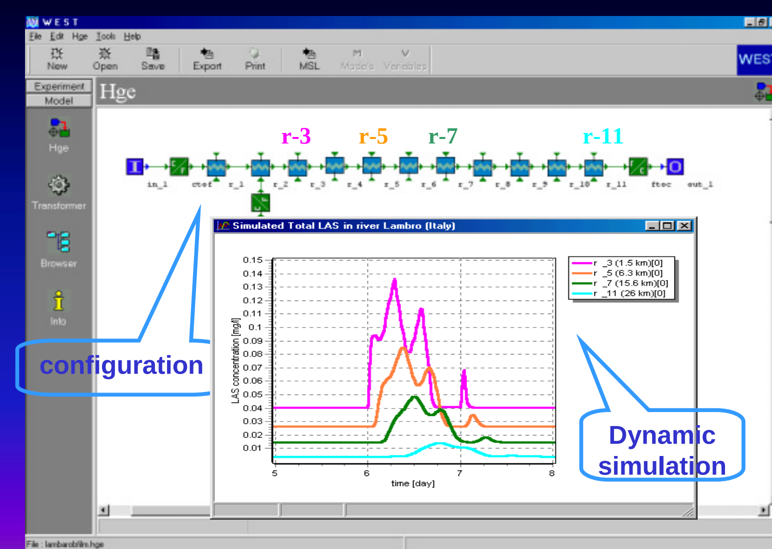
Coupling models: EUTRO + COC fate



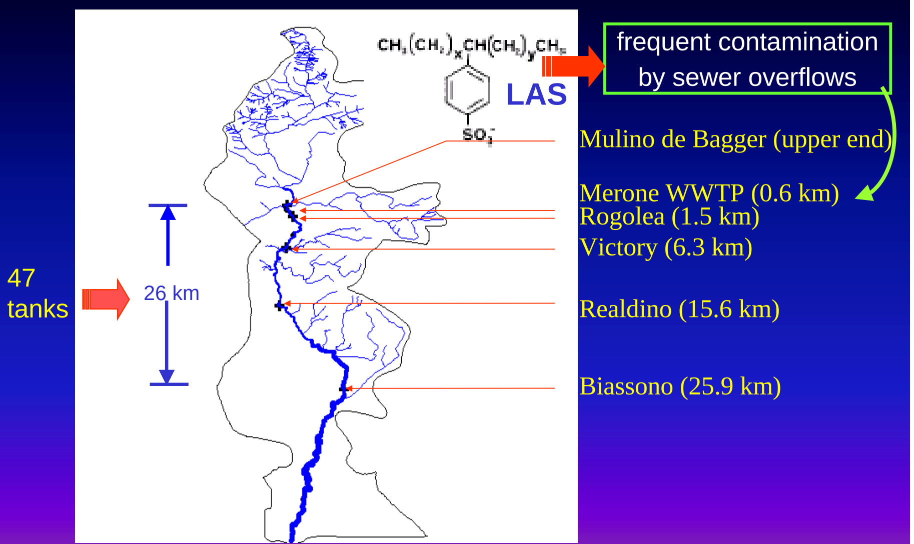
Model calibration & validation

- Calibration:
  - Using conservative substance (boron) as a tracer
  - Trial and error procedure
  - Tuning important parameters
  - Curve fits between measured and simulated data
- Validation:
  - No change of calibrated parameter values
  - Running the model with independent data
  - Compare simulated data sets with monitoring data sets

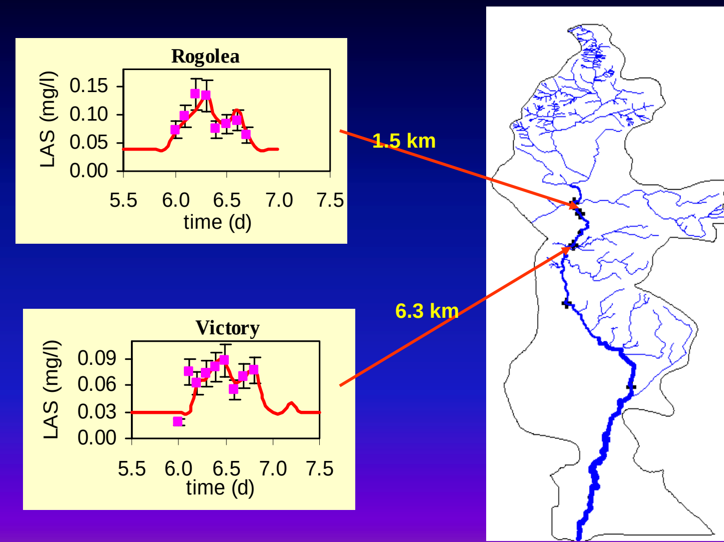
Model implementation in WEST® simulator



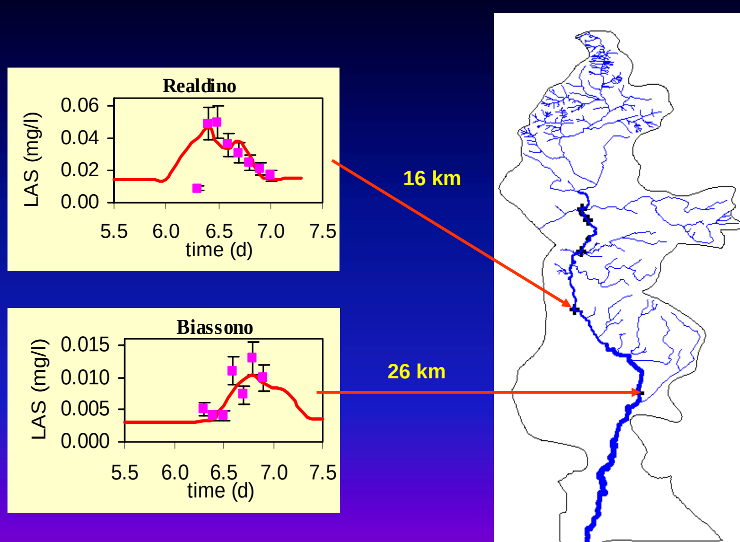
Case study : LAS in the Lambro river basin (Italy)



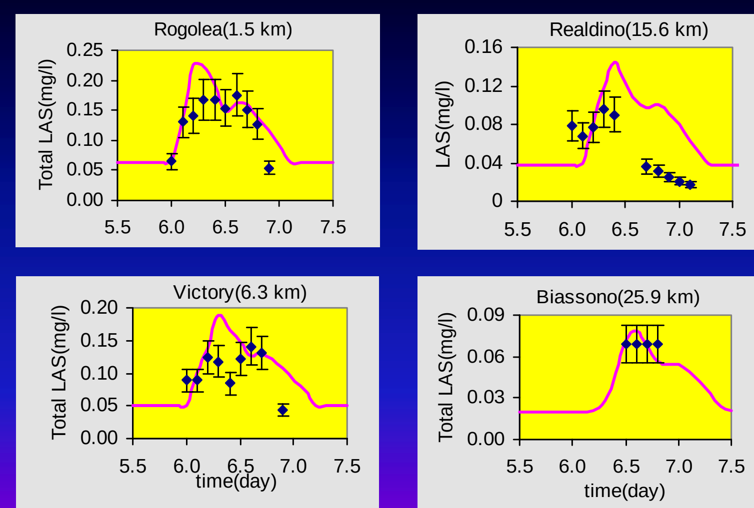
Results: Calibration (Feb. 1998)



Results: Calibration (Feb. 1998)



Results: Validation (May 1998)

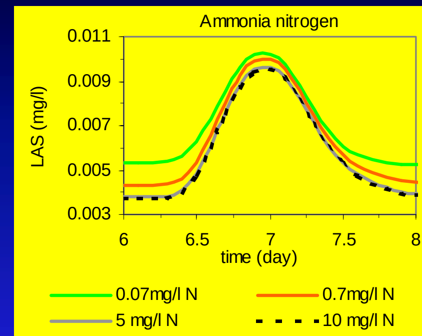


Scenario analysis

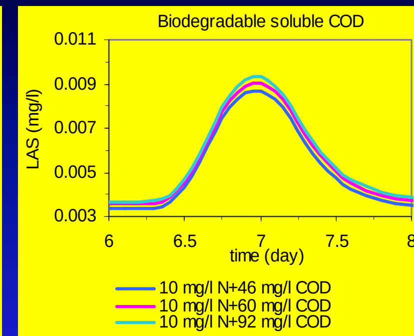
1. Effect of nutrient concentration on LAS removal
   - Ammonia nitrogen
   - Readily biodegradable soluble COD
2. Effects on bioaccumulation by
   - Nutrients (ammonia nitrogen) concentration
   - Total Suspended Solids (TSS)
   - Contamination frequency

Nutrient effect on LAS removal

Ammonia-N



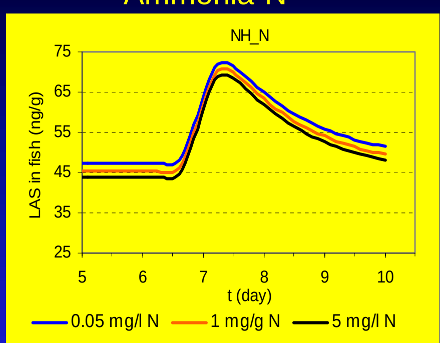
COD + N



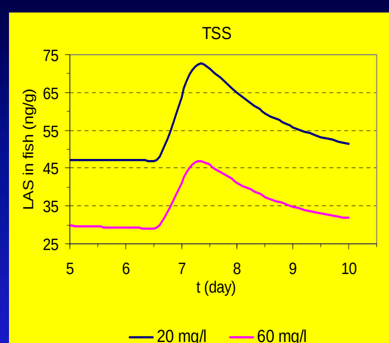
- Ammonia-N can enhance the LAS removal
- The effect of COD depends on the concentration of dissolved oxygen

Nutrient effect on Bioaccumulation

Ammonia-N



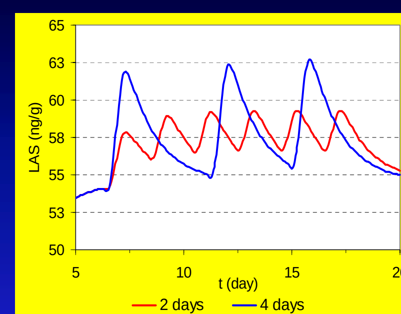
TSS

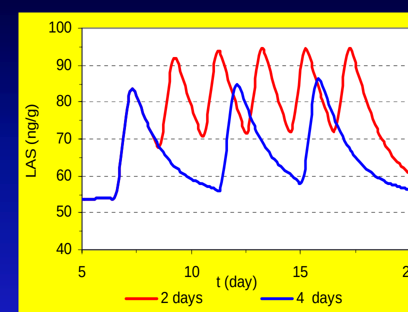


- Nutrients affect bioaccumulation
- TSS enhances COC removal: degradation, sorption-sedimentation

Scenario analysis

The effect of contamination frequency on bioaccumulation





Bioaccumulated concentration rises in more frequent sewer overflow contamination

Conclusions

- Dynamic integrated modelling
  - considers:
    - the frequency of occurrence, amplitude and duration of concentration
    - the interaction of nutrients and organic contaminants
  - Suitable for:
    - short term exposure assessment
    - highly variable emission management
- The case study and scenario analysis show the potential use of the proposed modelling approach

Acknowledgement

- Belgium Technical Co-operation (BTC-CTB)
- Members of GREAT-ER ECETOC task force, especially M.J. Gandolfi