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BIOMATH
Department Applied Mathematics, Biometrics and Process Control

Manejo integrado de cuencas hidrograficas

Peter Vanrolleghem
May 22nd 2001

ESPOL, Guayaquil, Ecuador

RUG-Biomath, Coupure 653, 9000 Gent, Belgium (e-mail Peter.Vanrolleghem@rug.ac.be)

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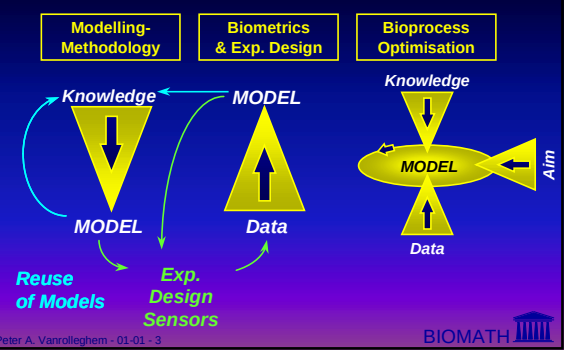
BIOMATH research

Peter Vanrolleghem
May 22nd 2001

Status report May 1st 2001

RUG-Biomath, Coupure 653, 9000 Gent, Belgium (e-mail Peter.Vanrolleghem@rug.ac.be)

BIOMATH Structure



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Definitions

- System
  Part of reality that is separated from its environment on the basis of a purpose defined by the researcher
- Model
  An approximate description of a part of reality considering only those aspects of interest
- Simulation
  = Virtual Experimentation: Manipulation of a model to gain insight in the "behaviour" of the real system

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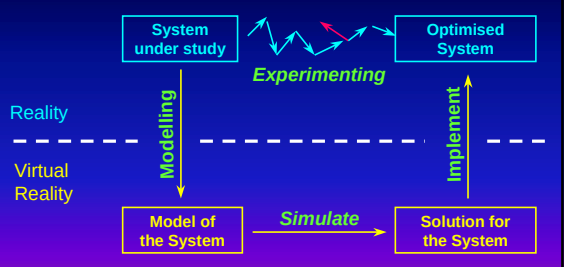
Why Modelling ?

Solving Problems for complex systems



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BIOMATH Department

- Personnel:
  - 4 professors — 2 math, 1 elec. eng., 1 bio-eng.
  - 3 post-doc: — 2 chem. eng., 1 soft.
  - 14 PhD.: — 8 (bio-)eng., 2 soft., 2 math, 2 stat
  - 8 project eng.: — 6 (bio-)eng., 1 soft., 1 stat
  - 1 Lab technician, 4 secretariat
  - 4 MSc. students (engineering, Erasmus)

Multicultural (Canada, Ecuador, Ethiopia, Romania, Turkey)

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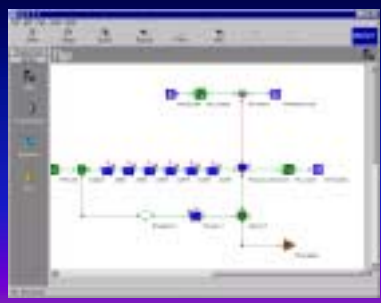
WEST: Wastewater treatment Engine for Simulation and Training



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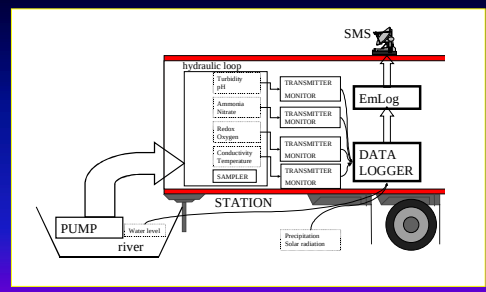
Automatic River Measuring Stations



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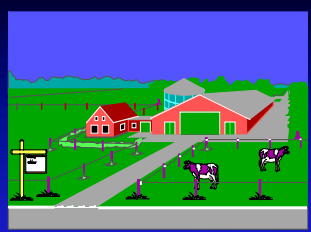
Models in Agriculture

Model of a dairy farm



Submodels:

- Milk production
- Fodder intake
- Growth of young cattle
- Growth of grass under mowing or grazing

Question: optimal eco(l/n)o(g/m)ical management?

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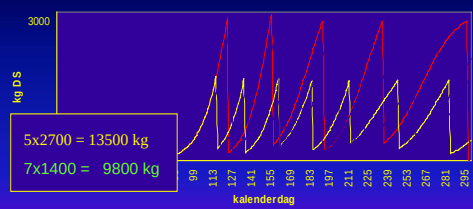
Growth of grass when mowing



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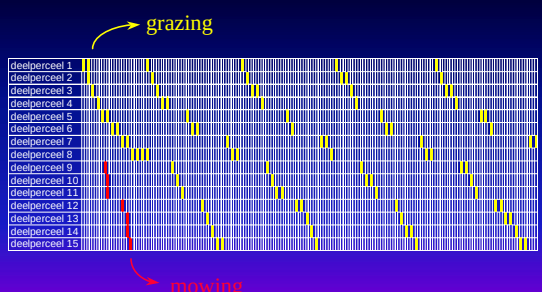
Optimised parcel management



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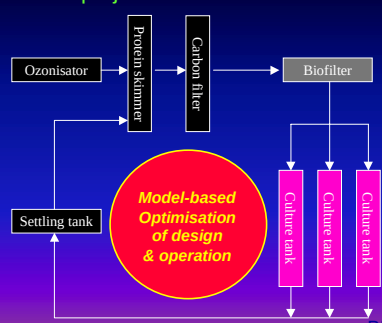
Models in Aquaculture

New project: Water reuse in hatcheries



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Peter Vanrolleghem
May 22nd 2001

RUG-Biomath, Coupure 653, 9000 Gent, Belgium (e-mail Peter.Vanrolleghem@rug.ac.be)

Two main approaches for Integrated Water(shed) Management

- Environmental Quality Objectives / Environmental Quality Standards (EQO/EQS)
  - Objectives: bathing, drinking water, fishing, navigation, ...
  - Looked at from the environment's perspective (river)
  - Immission
- Uniform emission standards (UES)
  - Looked at from polluter's perspective (translation of EQO)
  - Sewer, Wastewater Treatment Plant, Agriculture
  - Emission

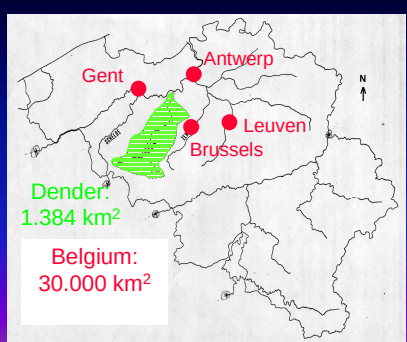
Two approaches: Europe vs. USA

- Europe: current legislation
  - Uniform Emission Standards
  - Norms attached to all point source emissions
- Europe: future legislation (°2000, imposed by 2018)
  - River quality objectives
    e.g. ecological integrity, morphology, …
- USA
  - Uniform Emission Standards
  - TMDL (Total Maximum Daily Load) concept
  - Waste allocation to different pollutant sources
  - Also non-point sources (e.g. agriculture !)

Problems in future immission based integrated water management

- Ecological integrity
  - what indicators (biotic indices - macroinvertibrates) ?
  - relation physico-chemistry (pH, N, P, ...) - ecology
  - long term effects (no longer in days…)
  - cause-effect relationships (needed for management !)
- Diffuse pollution: how to quantify ?
- Data sets are enormous and geo-referenced (GIS)

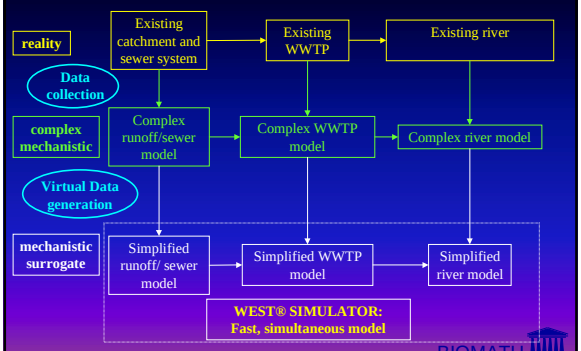
Typical data sets needed: Dender (B)



Typical data sets: Infrastructure

- Sewerage connection degree : 84%
- Wastewater treatment
  - 4 plants
  - Inhabitants connected to WWTP: 40000
  - Degree of treatment: 12%
- Point sources: 958 (309 industrial emissions)
- Master plan:
  - 14 new WWTP's
  - Degree of treatment: 97 %

BIOMATH integrated modelling approach



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Case study: site description

Speibeek

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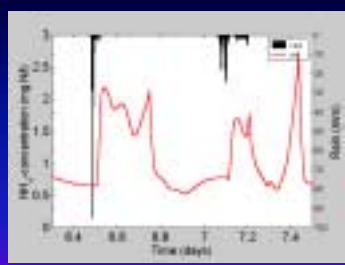
Immission based control: Results



Base case

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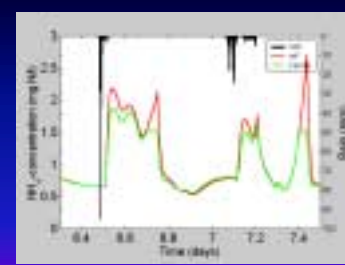
Immission based control: Results



Control of pump at off-line storage tank

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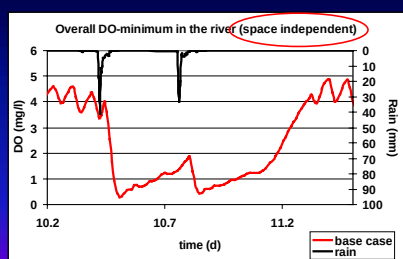
Immission based control: Results

Secondary objective evaluation



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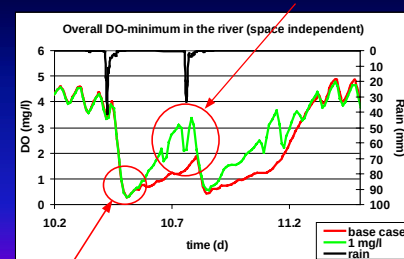
Immission based control: Results

Quicker recovery



Absolute minimum does not improve

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GREAT-ER

Geography-referenced Regional Exposure Assessment Tool for European Rivers

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RUG-Biomath, Coupure 653, 9000 Gent, Belgium (e-mail Peter.Vanrolleghem@rug.ac.be)

GREAT-ER project

Geography-referenced Regional Exposure Assessment Tool for European Rivers

- prediction of the fate of specific **"down-the-drain" chemicals** in **surface water**
- using **Geographical Information Systems** (GIS)
- for use within **Environmental Risk Assessment**

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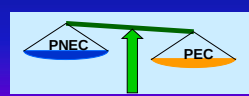
Environmental Risk Assessment

- Aim = **assess** the probability and severeness of negative **effects** on ecosystems after exposure to **chemicals**
- steps:
  - **exposure**: Predicted Environmental Concentration **(PEC)**
  - **effects**: Predicted No Effects Concentration **(PNEC)**
  - **risk ratio**: $\frac{PEC}{PNEC} < 1$?



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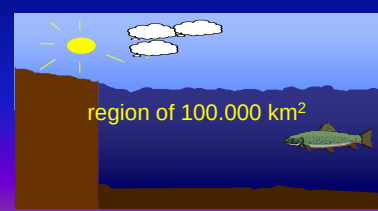
Environmental exposure assessment

- **Current methods** (advised in EU legislation):
  - **multimedia fate models**



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Environmental exposure assessment

- **Current methods**:
  - **multimedia fate models**
  - no spatial nor temporal variability considered → limited accuracy **FACTOR > 100-1000 !**
- **GREAT-ER: refine PEC calculations**
  - 'real' **geo-referenced** data
  - **variability**
  - geo-referenced → **validation** is possible

AIM = FACTOR < 3-5

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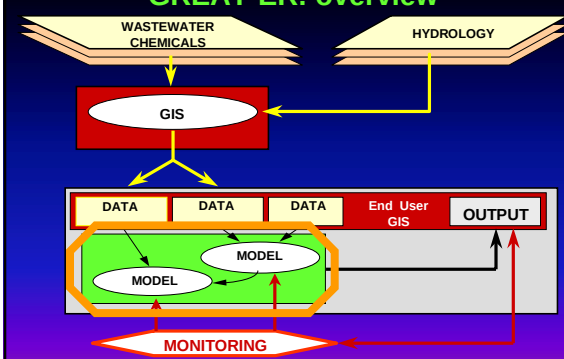
GREAT-ER: overview



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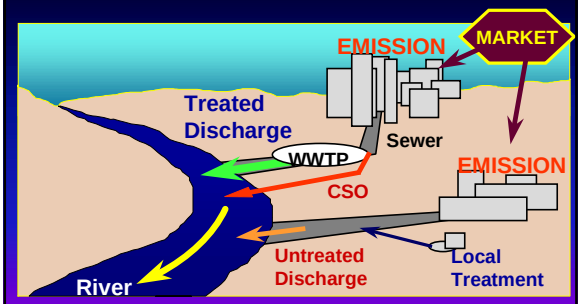
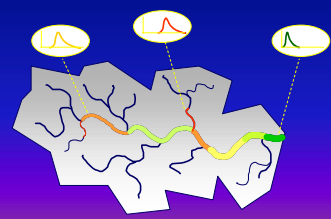
Deterministic Model



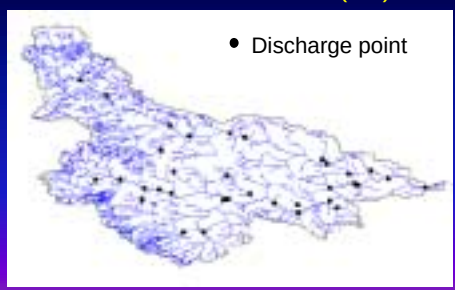
Analysis

- direct GREAT-ER **simulation results**
  geo-referenced predicted concentrations



GREAT-ER Validation

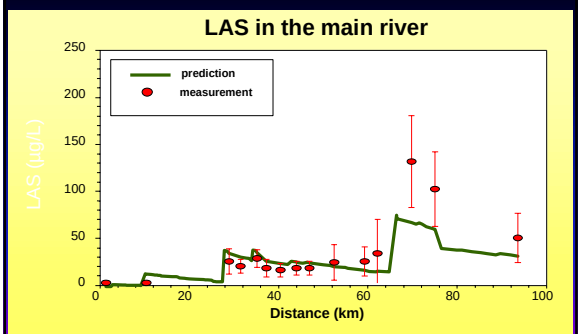
Catchment in Yorkshire (UK)



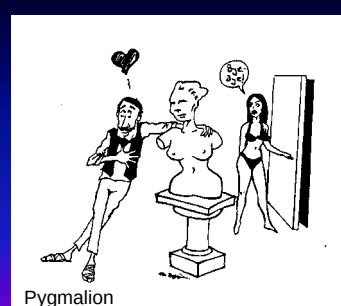
GREAT-ER Validation

LAS concentrations in the river stretches

Validation of GREAT-ER



"Do not fall in love with your model"



Pygmalion