Integrated urban catchment modelling for a sewer-treatment plant-river system in Luxembourg

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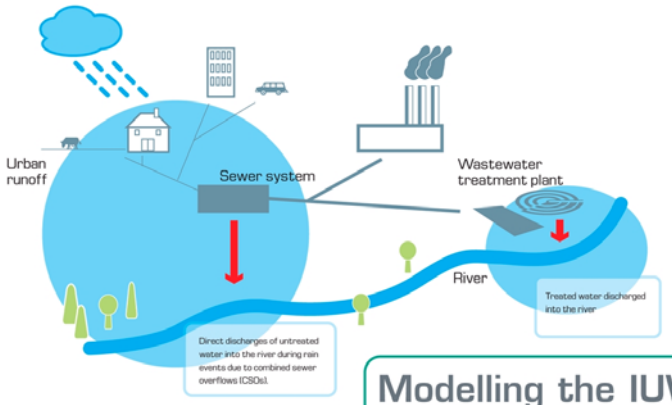
The integrated urban wastewater system (IUWS)



The EU Water Framework Directive WFD (2000)

The main objective of the WFD is to achieve a 'good' chemical and ecological status of water quality for both surface and ground waters within given time periods. This demands a holistic approach and leads towards an integrated management of the urban water system.

Aim: Optimisation of the operation of sewer and WWTP

In the sewer system all storage may not be used and the treatment capacity of a WWTP may not be fully exploited; and individual optimisation of the sewer or the WWTP does not guarantee for best river water quality. Sometimes it can therefore be useful to overload the treatment plant or even, rather than overloading the WWTP immediately during a rain event, let the river assimilate some untreated water upstream until a certain setpoint of ammonia is reached. All these are operation strategies that can be tested in view of optimising the river water quality in a cost-effective way.

This requires the construction of a model of the integrated system. From there, scenarios (virtual experiments) can be run and tested in order to identify the best control strategie(s) fulfilling the objectives. However the modelling the IUWC is confronted to difficulties not alone due to its complexity in itself. These include linkage difficulties at the subsystem boundaries, and data transfer problems during simulations due to distinct softwares for the submodels.

Modelling the IUWS: Problems - Solutions

Simplification through model reduction

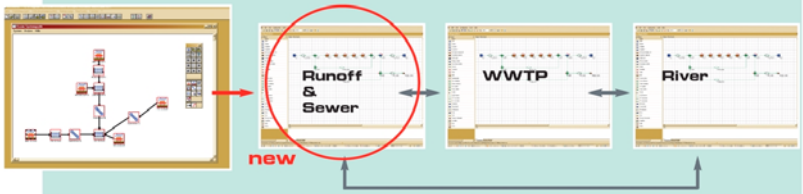
Complex partial differential equations for the hydraulics in the sewer system and the river, as well as the complexity of the whole system give long **calculation times**

Compatibility between the submodels: Different processes of interest and importance bring about different variables and parameters in the submodels

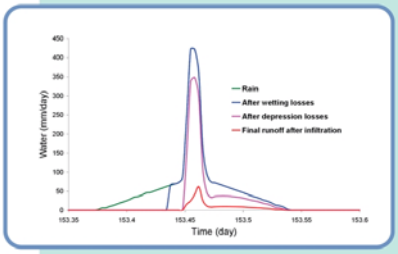
Harmonisation

One software: WEST®

Different **softwares** for sewer, WWTP, river



Having only one software avoids data transfer problems during integrated simulations. WEST® (Hemmis N.V., Kortrijk, Belgium) is an open platform, which allows the user to add models to the existing model base. For surface runoff and sewer transport, the KOSIM (ITWH GmbH, Hannover, Germany) hydrological model was implemented into the WEST® modelbase. This was done by transforming time discrete recursive expressions into ordinary differential equations, that can be treated by the solvers inside WEST®.



The elements of KOSIM-WEST are the catchment, collectors (pipes) and structures like retention basins. The catchment model takes into account evaporation, wetting losses, depression losses and infiltration for pervious surfaces. Figure 1 gives a quantitative idea of these processes for a pervious surface. The collectors are modelled as a cascade of linear reservoirs. Figure 2 shows the results of a comparison of simulations in both softwares.

Figure 1: KOSIM-WEST: From rain to surface runoff

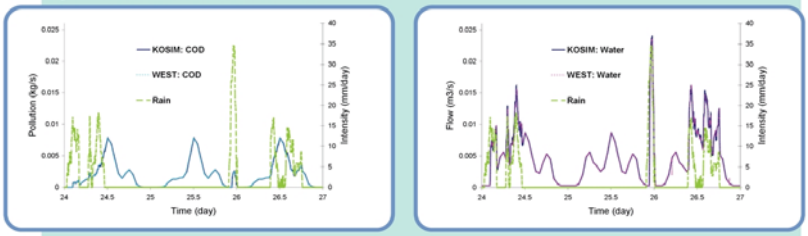


Figure 2: Simulation comparisons for flow and pollution (chemical oxygen demand) in KOSIM and KOSIM-WEST for a hypothetical catchment.

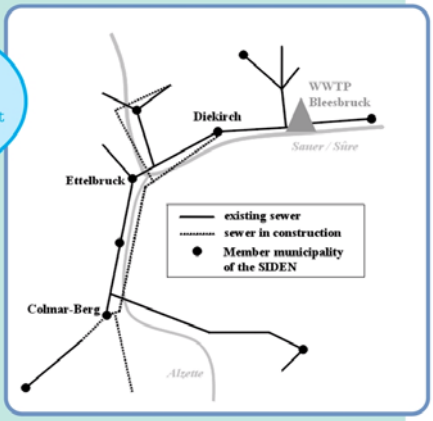
Although the concepts behind both modelling tools are identical, their fields of applicability diverge.

KOSIM-WEST	KOSIM
Interception of information for all variables (cf. Figure 1)	Information only on pollutant charges and flows
Possibility for the user to add models for his needs	Computational speed of KOSIM is higher by an order of 10^2
Contained in the same software than the models for the WWTP and the river	

Applicability: How to approach an integrated study? What models to choose? What level of complexity?

Field study in Luxembourg

Sûre river basin; catchment feeding the WWTP of Ieesbr c



The operating syndicate, participating at this project, is the **SIDEN** (Syndicat Intercommunal des Eaux Résiduaires du Nord)

Catchment	Sewer catchment area: ~ 10 km^2 Domestic and industrial discharges: ~ 52000 PE (population equivalent)
Sewer Network	60 km (+12 km of parallel main collector in construction + replacement of CSOs by retention basins)
WWTP 'Bleesbruck'	Hydraulic capacity: 100.000 PE Pre-treatment (screen, grit removal and grease separation), 2 activated sludge units in series, phosphate precipitation, on-line sensor equipment for nutrients
River 'Sauer'	Flow: 10 – 20 m^3/s depending on season Problems: High ammonium and phosphate concentrations

OUTLOOK

System Analysis : Collection and analysis of data for the 3 subsystems and identification of problems related to chemical concentrations in the receiving waters.

Construction of the Model : Due to data scarcity from the sewer network especially for pollutants and backwater effects, a hydraulic model in Infoworks™ CS (Wallingford Software, UK) will be used to calibrate the hydrological model in WEST®.

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