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Abstract

A model for simulation of substance flows in urban sewer systems has been developed in the computer programme package MATLAB/Simulink. The model is called SEWSYS and it handles fluxes of substances within an urban catchment. SEWSYS keeps track of each substance; where it originates and where it finally ends up. Some of the substances included are water, phosphorus, nitrogen, heavy metals and PAH. SEWSYS consists of a stormwater module, sanitary wastewater module and a wastewater treatment plant with nitrogen reduction. Verifications have been carried out both for each component separately and for the model as a whole. The results show that the modelling approach is valid, but further enhancements should be made.

Keywords

Computer modelling, substance flows, materials flow, urban sewer systems, stormwater, MATLAB/Simulink, Urban drainage, source control

Introduction and background

A large number of models are available for simulation of quantity and quality aspects in urban drainage. The models can be used as design tools, decision support tools or even both. A review of urban stormwater models has been made by Zoppou (2001). The reviewed models are different in terms of complexity and also require different kinds and amounts of input data. More detailed models like SWMM, Mouse and STORM describe the physical processes to a high degree and require extensive measurements for calibration. They are very suitable as design tools but they also require a skilled and experienced engineer to interpret the results. This tendency of complexity makes it more difficult to use sewer quality models in an operative way. According to Ahyerre *et al.* (1998) further research is needed to be able to improve the modelling approach and basic knowledge. Further Ahyerre *et al.* (1998) suggest that a clear distinction should be made between management tools and research models.

A decision support tool must be designed so that trained professionals can use it in practice. The context, simplicity and user-friendliness of the tool are more important than the degree of sophistication. However, attempts should be made so that the modelled processes are described as accurately as possible, but still within the context of the tool. A planning-level tool for quantification of pollutant transport and design of stormwater treatment facilities was developed by Larm (2000). The stormwater model in this tool (StormTac), uses land use specific input data, such as runoff coefficients, areas per land use and standard pollutant concentrations. The model works with relatively simple equations for quantification of pollutant transport. Under the prerequisite that the objective is not to study the dynamic properties in the stormwater system, Larm considers the equations to be accurate enough for planning-level analyses. The approach with standard pollutant concentrations for different land uses is useful because it makes the model easier to work with since it requires less input data.

However, to be able to achieve true source control, i.e. reducing the pollutants at the source, it is necessary to have a larger resolution in the pollutant transport model. The sources for pollutants from different activities in the urban area must be separated in their respective origin; material corrosion, brake wear, tyre wear etc. The pollutants in stormwater, especially the heavy metals, contribute to a large extent to the total pollutant mass flow in the sewer system (Boller 1997). The appropriate long-term strategy would be to avoid, replace or reduce the sources for stormwater pollution. This would raise a need for co-operation between sanitary engineers, city planners, architects and car manufactures, etc. The incentive for such co-operations can only come from politicians and other decision makers.

We have identified a need for a decision making tool where true source control can be analysed. In concordance with the general perception of the term sustainable development, the most sustainable solutions for future stormwater management must contain components for achieving the required goal now, but should not neglect the needs of the future (Butler and Parkinson 1997).

The authors of this paper are involved in a Swedish research programme called “Sustainable Urban Water Management” which started in 1999 and runs until 2005 (Malmqvist 1999). The concept of the inter-disciplinary programme is to develop a holistic approach to the entire urban water system within a sustainable society. Research is carried out in different projects in the range of economic studies to microbial risk assessment. Five different kinds of model cities have been selected, typical for Swedish conditions. The essential part of the Urban Water programme is the development of a toolbox, which planners of future urban water systems in Swedish cities can use to decide on “the most sustainable” solutions for urban water management.

In this research project we are focusing on keeping stormwater pollution apart from the biological cycle. The objective of the project is to characterise the substance flows and develop different strategies towards a sustainable management of stormwater systems. In order to achieve sustainability it is necessary to understand the function of the whole sewer system and its interaction with stormwater (Butler and Parkinson 1997). The chosen approach is to develop a flux model and use it in the different model cities for simulations of the present sewer system and alternative ones. The simulations will be evaluated on the basis of different sustainability criteria. The substance flow model will be our contribution to the Urban Water toolbox. This paper describes the development of the flux model.

Model layout and description

A model for simulation of urban sewer systems has been developed in the computer programme package MATLAB/Simulink. The model is called SEWSYS and handles sources and fluxes of substances within the urban sewer system. SEWSYS is originally derived from two Master’s Thesis projects (Ahlman 2000; Engvall 1999) and has then been developed further within the above-mentioned research project. SEWSYS consists of a stormwater module, sanitary wastewater module and a wastewater treatment plant (WWTP) with nitrogen removal. Simulation of stormwater treatment in wet ponds is possible. Both duplicate and combined sewer systems can be simulated. It is also possible to simulate stormwater and sanitary wastewater separately.

The platform MATLAB/Simulink has been chosen because it is widely spread both in the academic and private sector. Another important factor is that the source code is open, which will facilitate future development. There is also a possibility to create graphical user environments and consequently make the model user-friendlier.

The SEWSYS vector

The substance fluxes are combined into a row vector with 21 columns, one for each substance (See Table 1). The SEWSYS vector works as an interface throughout the model and hence makes it easier to add new sub-models. There is also a possibility to add additional substances, e.g. pathogens, when it is required in future developments.

The included substances have been chosen because of their relevance regarding environmental impact. The most important constituents in stormwater pollution are heavy metals (Cu, Zn, Pb, Cd), PAH and to some extent nutrients (P and N). The platinum group elements (PGE) metals have been included because PGE concentrations in the environment have increased since the introduction of automobile catalysts (Rauch 2001). PGE concentrations are still relatively low but it is useful to include them in the model at this stage rather than later. The remaining substances derive either from sanitary wastewater or from processes in the WWTP.

Table 1. The SEWSYS vector

No	Substance	Unit	Comments
1	H_2O	m^3/s	Water
2	Tot-P	g/s	Total Phosphorus
3	Tot-N	g/s	Total Nitrogen
4	NH_3/NH_4^+ -N	g/s	Nitrogen in ammoniac and ammonium
5	NO_3 –N	g/s	Nitrogen in nitrate
6	N_2O –N	g/s	Nitrogen in nitrous oxide
7	SS	g/s	Suspended Solids
8	BOD_7	g/s	Biochemical Oxygen Demand (7 days)
9	COD	g/s	Chemical Oxygen Demand
10	Tot-C	g/s	Total Carbon
11	Phase Index	-	Part VS (Volatile Solids) of SS
12	Cu	g/s	Copper
13	Zn	g/s	Zinc
14	Pb	g/s	Lead
15	Cd	g/s	Cadmium
16	Hg	g/s	Mercury
17	Cr	g/s	Chromium
18	Pt	g/s	Platinum
19	Pd	g/s	Palladium
20	Rh	g/s	Rhodium
21	PAH	g/s	Polycyclic Aromatic Hydrocarbons

Main window

SEWSYS consists of a main window, different input files and the Simulink model. The main window is the panel from where the user controls the model (See Figure 1). This is where the user enters specific parameters about the studied catchment. When all the parameters have been entered and the runoff process has been calibrated the model is ready for simulations; the Simulink model opens and runs with the specified parameters. Then the output can be viewed in different plot windows or be further processed in MATLAB.

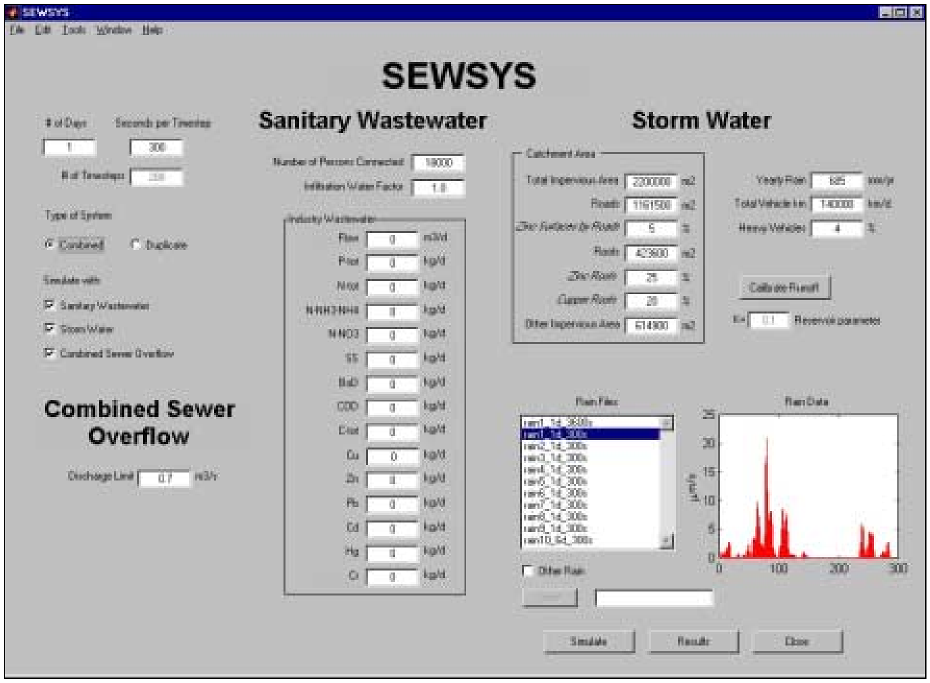

Figure 1. SEWSYS main window

SEWSYS is a time discrete model with a fixed time step that can be chosen between 60 and 3,600 seconds.

The main window also controls which type of sewer system is to be used in the simulation. There are two options: combined and duplicate. For each system sanitary wastewater and stormwater can be simulated together or separately. If the model is to run with a combined sewer overflow, the discharge level must be specified.

The parameters for sanitary wastewater consist of the number of people living in the catchment and the infiltration water factor. Background values for sanitary wastewater pollution are given in per capita values, hence the requirement for number of people. The infiltration water factor will decide how much infiltration water is brought to the system. A factor of 1.0 means the same amount of infiltration water as sanitary wastewater.

Additional wastewater, e.g. from industrial activities, can be added if there are any known figures for it. This seldom is the case but for a smaller catchment it is more likely to occur. The figures will be incorporated with sanitary wastewater and consequently have the same daily variation.

Parameters for stormwater include total impervious area, annual precipitation, traffic load and the percentage of heavy vehicles. The distribution between road, roof and other areas is also required for the impervious area. Here it is also entered how much of the roof area that is zinc (galvanised) and copper surfaces. For zinc, corrosion rates are given for an unpainted surface. A study in the US, referred to by Persson and Kucera (1996), shows that the corrosion rate from painted plates is 1/10 of that from unpainted plates. In the study the paint contained about 5 percent by weight of zinc oxide. Therefore the painted zinc area must be reduced with 1/10 before it is added to the total zinc area.

The input that drives the stormwater simulation is a time series of rainfall data. This is loaded into the model with a rain file, which has to be specified from the SEWSYS main window.

Calibration of runoff

Before the simulation can be started, calibration of the runoff process is needed. It is important that the runoff hydrograph is given a correct appearance since this will decide the amount of water diverted from the combined sewer or emergency overflows. Calibration here means adjusting a parameter K for a certain impervious area and rain intensity, so that the runoff is given a reasonable concentration time, i.e. the time it takes for the whole area to contribute to the discharge at the endpoint.

Simulink model

These are in fact two different Simulink models, one for combined systems and one for duplicate systems, since the fluxes take different paths in the two systems. In Figure 2 the top level for the duplicate system is shown. In the Appendix more sublevels for the stormwater module are presented.

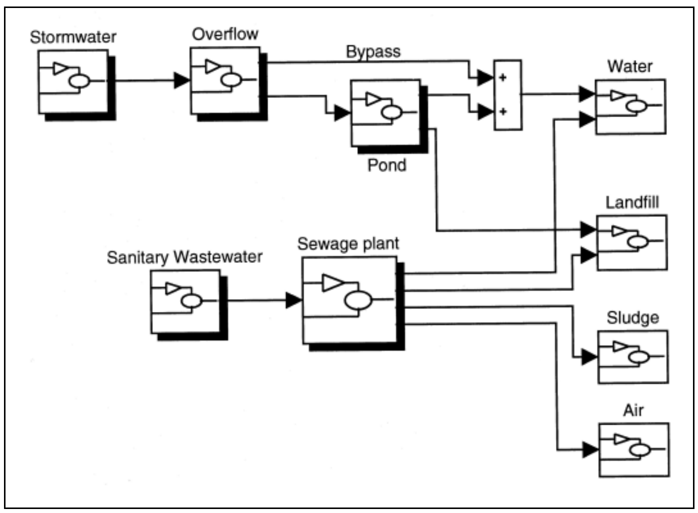

Figure 2. Top level for the duplicate system in Simulink

The Simulink model contains modules for pollutant sources, treatment modules and different recipients. There are four recipients: water, sewage sludge, landfill and air.

The model takes input from both the SEWSYS main window and from certain input files. These files contain general pollution figures, e.g. corrosion rates and emissions from different kinds of material. Data for the pollutant sources in the stormwater and sanitary wastewater modules were obtained from literature studies and other existing Swedish models (Dalemo 1999; Stockholm Vatten 1999; VBB Viak 1997).

Sanitary wastewater

The sources for sanitary wastewater pollution are divided into grey water, urine and faeces. The water consumption per capita is set to 150 l/d for grey water and 50 l/d for toilet use. In Table 2 some of the key figures for sanitary wastewater substances are listed. These values originate from a Swedish study where the content in domestic wastewater was investigated (Sundberg 1995), except for the values in italics that originate from Dalemo (1999).

Table 2. Some pollutants from sanitary wastewater

Source	P-tot	N-tot	BOD	COD	Cu	Zn	Unit
Grey water	0.3	1	28	52	0.006	0.05	g/person, day
Urine	1 .0	11	*3*	*3.5*	0.0001	0.000045	g/person, day
Faeces	0.5	1.5	17	*43*	0.0011	0.0108	g/person, day

Stormwater

Stormwater runoff is calculated with the precipitation that falls as rain; snowmelt is not considered in the model. The precipitation is reduced with initial loss and a reduction factor. Initial loss is the amount of water that must fall before any runoff is noticed, i.e. the build-up of wet film and water in puddles. This amount is estimated to 0.6 mm. The reduction factor takes into account the fact that not all of the rainwater becomes stormwater. A small fraction will evaporate and another part is lost on the way to gutters and manholes. SEWSYS calculates with a reduction factor of 0.8.

The net and yearly precipitation, together with general pollution values for wet deposition, give the amount of pollutants that come with the rain. Table 3 shows the values used for wet and dry deposition (Areskoug 1993; Malmqvist 1983; Notter 1993; Stockholm Vatten 1999).

Table 3. Pollutants from wet and dry deposition (values in μg/m^2/year)

Substance	Wet deposition	Dry deposition
Phosphorus	7,500	8,000
Nitrogen	1,000,000	66,667
Copper	1,500	2,500
Zinc	8,000	7,000
Lead	1,500	8,500
Cadmium	50	100
PAH	1,200	0

In SEWSYS the impervious area is divided into three parts: roads, roofs and other areas. Dry deposition is calculated separately for each of the areas with the values from Table 3. The other sources for pollutants from road areas consist of tyre and road wear, brake wear, exhaust, oil spillage, catalysts and zinc corrosion. It is assumed that 70% of the yielded pollution will end up in the stormwater. The tyre and road wear differs between cars and heavy vehicles. The pollutant content and wear from car tyres are shown in Table 4 (Ahlbom and Duus 1994; Stockholm Vatten 1999; VBB Viak 1997). The pollutant load for heavy vehicles is 4.5 times higher, assuming that heavy vehicles wear one third of the total tyre material and account for 10 % of the total traffic load. Brake linings are made of copper or brass and plastic. The brake wear contains mainly copper and zinc, with load values of 1,500 and 650 μg/km, respectively (Landner and Lindeström 1999; Malmqvist 1983). Zinc corrosion products derive from the galvanised surfaces in the vicinity of the road, e.g. railings and lampposts.

Table 4. Pollutant content and load from car tyres

Substance	Concentration in material (PPM)	Amount released per kilometre travelled (μg)
Copper	250	25
Zinc	15,000	1,500
Cadmium	5	0.5
PAH	140	14

The pollutions from roofs originate mainly from corrosion processes that occur when the metallic surface is exposed to air and water. Copper and zinc corrosion are modelled separately, with corrosion rates constant over time. It is assumed that 50% of the corrosion products are available for stormwater uptake. The corrosion rates used in the model for copper and unpainted zinc surfaces are shown in Table 5 (Odnevall Wallinder and Leygraf 1997; Odnevall Wallinder *et al.* 2001; Persson and Kucera 1996).

Table 5. Corrosion rates for copper and zinc surfaces

Substance	Copper surface (mg/m^2/year)	Unpainted zinc surface (mg/m^2/year)
Copper	2,600	-
Zinc	-	4,000
Lead	-	1.5
Cadmium	-	0.09

Pollutants from sources like dry deposition, traffic and construction materials are generated during dry weather and accumulated until they are washed out at rainfall. The fastest rate of accumulation is found during a few days after a rainfall (Overton and Meadows 1976). After that the accumulation rate slows down due to the fact that surface material is removed by winds and after a few weeks of a dry period a rather stable amount of pollutants is reached. The accumulation process is modelled as a function of pollutant generation and removal. Generation is assumed to be constant over time while removal is thought to be dependent on the accumulated amount which can be expressed as

$$\frac{dL}{dt} = C - k_a \cdot L \tag{1}$$

where L is the accumulated load (µg), C is the deposition rate (µg/s) and k_a the rate constant of pollutant removal (s^{-1}).

The accumulated pollutants are washed out during rainfall. The pollutant removal is assumed to be proportional to the accumulated amount and to the rain intensity (Overton and Meadows 1976) and given as

$$\frac{dP}{dt} = -k_w \cdot r \cdot P \tag{2}$$

where P is the accumulated amount of pollutants on the surface (µg), k_w is the washout rate constant (mm^{-1}) and r is the rainfall intensity (mm/s).

In further transport the pollutant level would be expected to vary due to particle settling in pipes and other structures. These transport processes have not been incorporated in the model. Pollutants are modelled to move entirely and instantly from the catchment to the outlet or overflow.

Fast surface runoff is modelled with the theory for a non-linear reservoir, i.e. using a kinematic wave. Input to the runoff module is the inflow for that specific time step. Inflow is calculated as net precipitation multiplied with total impermeable area.

The change of water level in the reservoir can be expressed as

$$\frac{dh}{dt} \cdot A = Q_{in} - Q_t \qquad (3) \qquad Q_t = A \cdot K \cdot h_t^{5/3} \qquad (4) \qquad K = \frac{M \cdot \sqrt{S}}{L} \quad (5)$$

where A is the total impervious area (m^2), Q_t is the outflow from the reservoir (m^3/s), h_t is the level in the reservoir at time t (m) and the reservoir parameter K, which works as a damping coefficient. The parameter K depends on Manning's number ($m^{1/3}s^{-1}$), slope (m/m) and runoff length (m). Since the reservoir parameter includes three physically based parameters, the runoff calibration procedure is simplified.

Wastewater treatment plant
The WWTP is a modified version taken from ORWARE, a Swedish model for management of municipal organic waste (Dalemo 1999). The original model has been modified to suit the SEWSYS vector. The module describes a conventional three-step WWTP with mechanical, biological and chemical treatment. The mechanical treatment consists of a screen, sandpit and pre-sedimentation. Nitrogen treatment with de-nitrification and nitrification is also included. The original model has been developed to operate with yearly average values, i.e. kg/year, and is therefore not ideal for dynamic simulations. However, over long simulation periods the WWTP module can still provide reasonable results.

Stormwater treatment pond
The removal of pollutants in the stormwater treatment pond is modelled according to a US EPA-method, with a dynamic phase during wet weather conditions and a quiescent phase during dry weather (EPA 1986). The particulate bound pollutants are removed through sedimentation which is assumed to be the predominant part in pollutant reduction. The sedimentation process depends on factors such as size of the pond, the water flow, size and density of the suspended particles.

The dynamic phase is calculated with the following equation

$$R_d = 1.0 - \left[1.0 + \frac{1}{n} \cdot \frac{v_s}{Q / A_{pond}} \right]^{-n} \qquad (6)$$

where R_d is the removal rate of particles, v_s is the settling velocity (m/s), Q is the inflow (m^3/s), A_{pond} is the pond area (m^2) and n is a turbulence constant. An n-value of 1 specifies poor pond performance which is the case under variable inflow and consequently used in this module.

The quiescent phase uses the equation

$$R_q = 1.0 - e^{-v_s \cdot t / d} \qquad (7)$$

where R_q is the removal rate of particles, t is the inter-event dry period (s) and d is the pond depth (m).

In Pettersson (1999) investigations have been made of pollution reduction in stormwater ponds. Two different ponds have been studied and the pollutant removal efficiency for total suspended solids (TSS) was found to be in the range of 70-85%. Zinc, copper and lead had removal efficiencies of 30-50% whereas cadmium had 11%. From these investigations the part of each substance that is particulate bound has been calculated.

The average settling velocity has been calculated with Stoke's law

$$v_s = \frac{g}{18}(\rho_p - \rho_w)\frac{{d_p}^2}{\eta} \tag{8}$$

where ρ_p is the particle density (kg/m^3), ρ_w is the water density (1,000 kg/m^3), d_p is the particle size (m) and η is the dynamic viscosity (0.00131 kg/ms). Using a particle density of 1,400 kg/m^3 and a particle size of 30 μm in Stoke's law gives an average settling velocity of 0.54 m/h, which has been used in the stormwater pond module. The only required user-defined parameters are pond area (m^2) and average pond depth (m). A finding in Pettersson (1999), which could be useful here, states that there is an optimal pond size, compared to the impervious area, of about 250 m^2/ha.

Results from the model

In SEWSYS the user can keep track of each substance; where it originates and where it finally ends up. The Simulink model stores output data from the simulation in a set of matrices, which are stored in the MATLAB Workspace. These can be used for graphical display in MATLAB or be exported to other programs. The matrices basically have 21 columns, one for each substance, and the same number of rows as the number of time steps used in the simulation. The elements of the matrices have mass flow units (g/s), except for water (m^3/s). The model also has the capacity to display event mean concentrations (EMCs). For sanitary wastewater, the pollution load can be derived either from urine, faeces or grey water whereas stormwater pollution can be identified from the sources wet deposition, road, roof and other areas. All this assembled facilitates the evaluation process when different measures have been simulated and a comparison is wanted.

Verifications

Verifications have been carried out separately for each component in SEWSYS, i.e. pollutant generators, runoff module, WWTP and stormwater pond.

Sanitary wastewater pollutants generators

Data from Ölmanäs WWTP has been used to verify the key figures used in the sanitary wastewater module. Ölmanäs is a small WWTP, receiving domestic wastewater from approximately 6,000 people. The sewer system is of duplicate type and no industrial activity is connected. The result from the verification is shown in Table 6. An infiltration factor of 1.2 has been used to adjust the water flow.

Table 6. Verification result for sanitary wastewater

	Ölmanäs	SEWSYS
Flow (m^3/d)	2,665	2,640
Phosphorus (kg/d)	11	11
Nitrogen (kg/d)	60	81
SS (kg/d)	386	361
BOD (kg/d)	265	288
COD (kg/d)	720	589

The comparison between measured and modelled values shows acceptable concordance, since there are some uncertainties concerning the amount of infiltration water.

Stormwater pollutants generators

The stormwater pollution generator has been validated with measurements taken from an urban catchment in Göteborg called Järnbrott. The district consists of residential as well as industrial areas and is intersected by an urban highway. The size of the district is about 480 ha with an impervious area of 161 ha. Verifications have been made in Engvall (1999) and Svensson, Malmqvist et al. (2000) with measurements taken from Pettersson (1999). The verification result from Svensson, Malmqvist et al. (2000) is shown in Figure 3.

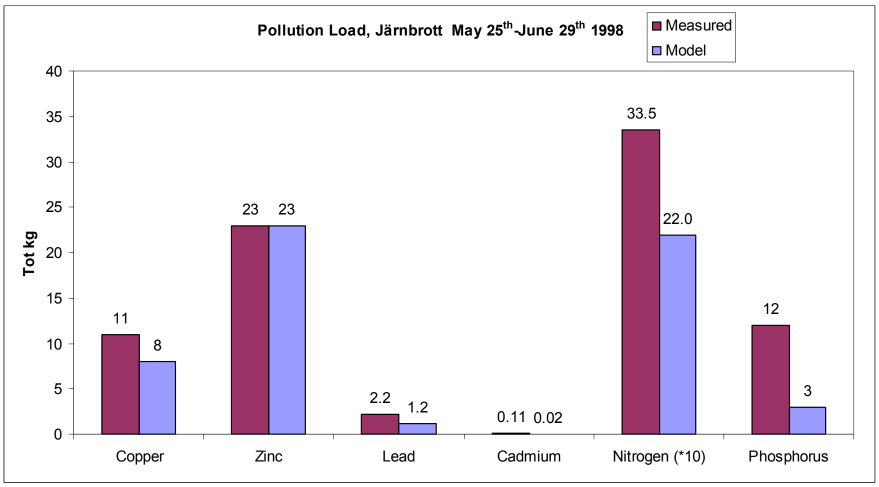

Figure 3. Verification of stormwater pollution

The agreement is satisfactory for copper and zinc but rather unsatisfactory for the remaining substances where the simulated loads are smaller than in the observed data. The reason for the fairly high differences could be that too low values have been chosen for the emissions or that there are sources missing.

Runoff module

Verifications of the runoff module have been performed for two different areas, the above-mentioned district Järnbrott and a parking lot next to Chalmers University of Technology in Göteborg (Ahlman 2000). The verifications show that the modelled runoff hydrographs agree fairly well with the observed ones. Figure 4 shows the measured and modelled hydrographs for one rain event in the Järnbrott district.

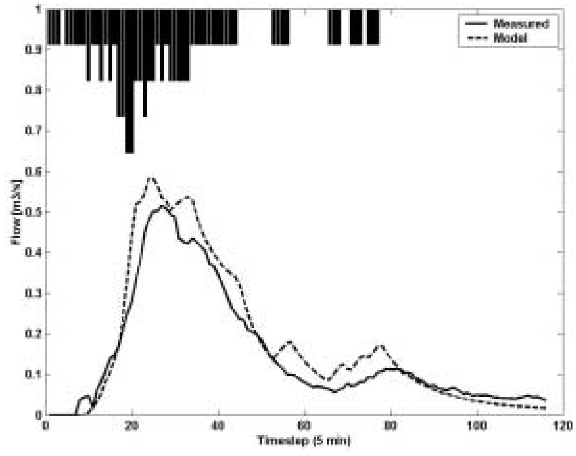

Figure 4. Verification of runoff module for the Järnbrott district

The damping effect seems all right whereas the delay is less noticeable. But since the damping effect is the most important factor for a correct inflow to the combined sewer overflow and stormwater pond module the modelled approach is believed to be valid.

Wastewater treatment plant

The wastewater treatment plant module has been verified with measurements taken from Skene WWTP, which is located in the municipality of Mark, southeast of Göteborg. The sewer system is of duplicate type where infiltration water is directed to the sanitary wastewater pipe system. There are 17,300 people connected and the BOD load is 18,000 pe. The treatment processes in the Skene WWTP agree in general with the ones in SEWSYS, with the exception that Skene has a bio-bed for nitrification. The result from the verification is presented in Table 7. The annual mean daily inflow of sewage is 14,160 m^3/d.

Table 7. Verification of the wastewater treatment plant (annual mean daily values)

	Inflow (kg/d)	Outflow (kg/d)	
		Skene WWTP	SEWSYS
BOD	1,240	40	37
COD	4,866	357	335
Tot-P	52	2.6	1.3
Tot-N	300	108	74
Copper	0.8	0.08	0.07
Zinc	1.3	0.47	0.32
Lead	0.1	0.05	0.02
Cadmium	0.005	0.002	0.002

From the WWTP verifications it can be said that the overall agreement is good. The tendency for somewhat lower values from the model has not been explained. One explanation for lower nitrogen values could be that nitrogen treatment is a difficult process to model conceptually since many different parameters are involved.

Stormwater pond

The stormwater pond module has been verified in Svensson, Malmqvist et al. (2000) and is believed to function properly. There are however some uncertainties regarding the input to the module, especially for particle size and density. The solids that settle vary in size and density from 5-40 µm and from 1,050-2,000 kg/m^3, respectively. Assigning an average value for all solids is thus a rough simplification, but still gives a reasonable settling velocity (0.54 m/h).

Conclusions and future work

- The chosen modelling approach for SEWSYS is believed to be valid since the verifications show acceptable results for every component.
- It is possible to quantify the pollutant load from an urban catchment through the study of different diffuse sources of pollution present in the area.
- The model is considered useful for understanding the processes of generation and spreading of the included substances.

Some processes are missing, e.g. the sedimentation in pipe systems, which is believed to influence the total material transport with first-flush effects, especially for long distances. Furthermore, the processes of accumulation and wash off in the stormwater module are modelled thoroughly taking into account factors like rain duration and intensity as well as dry periods. This is not in concordance with the modelled WWTP, which in fact is quite static with no time aspect at all. From this point of view the WWTP could be improved in further developments.

One important factor for a model's accuracy is without a doubt the correctness of input data. The background data and key figures used as input for SEWSYS are by no means supreme and they can be revised by new research or be adjusted to fit other geographical areas. The open source code and the approach with input files will facilitate future development. One way to improve the accuracy in SEWSYS is to perform an uncertainty and sensitivity analysis of input data using e.g. Monte Carlo sampling in combination with regression analysis.

SEWSYS has thus far been used in a study where different strategies for management of pollutant stormwater from an urban highway in Göteborg – Sweden were simulated and compared (Svensson *et al.* 2000). This was the first project where SEWSYS was used and the model showed promising potential. The different abatement strategies could be simulated and the results evaluated including identification of pollution sources.

Future work will include validation of the model for different kinds of sewer systems within the model cities included in the research programme.

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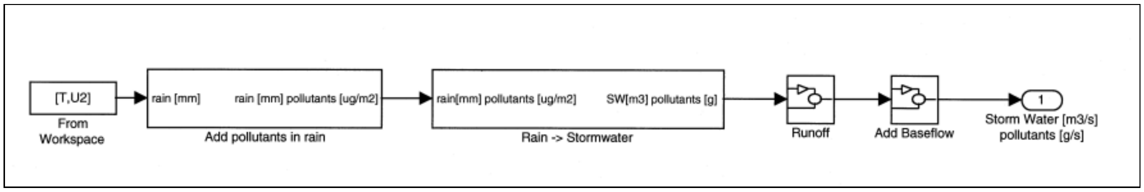
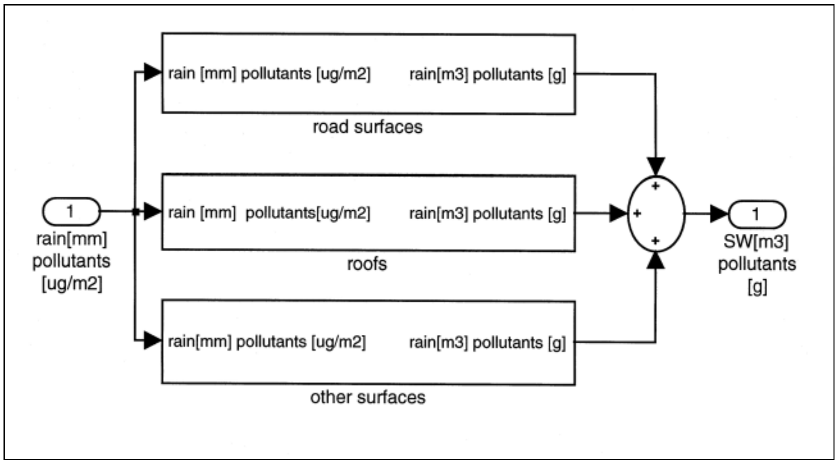
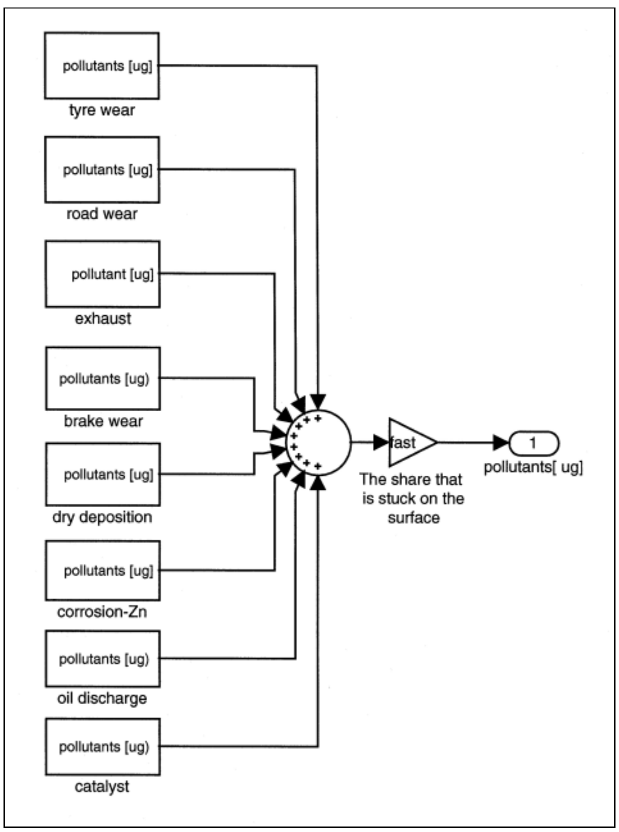
Appendix. Figure Gallery



/Stormwater



/Stormwater/Rain →Stormwater



/Stormwater/Rain→Stormwater/road surfaces/pollutants on roads