



HAL
open science

A new model to evaluate the impact of SUDS on water quality

Evi Vinck, Birgit De Bock, Tom Wambecq, Rosalia Delgado

► **To cite this version:**

Evi Vinck, Birgit De Bock, Tom Wambecq, Rosalia Delgado. A new model to evaluate the impact of SUDS on water quality. Novatech 2023, Jul 2023, Lyon, France. hal-04184255

HAL Id: hal-04184255

<https://hal.science/hal-04184255>

Submitted on 22 Aug 2023

HAL is a multi-disciplinary open access archive for the deposit and dissemination of scientific research documents, whether they are published or not. The documents may come from teaching and research institutions in France or abroad, or from public or private research centers.

L'archive ouverte pluridisciplinaire **HAL**, est destinée au dépôt et à la diffusion de documents scientifiques de niveau recherche, publiés ou non, émanant des établissements d'enseignement et de recherche français ou étrangers, des laboratoires publics ou privés.

A new model to evaluate the impact of SUDS on water quality

Un nouvel outil d'aide à la décision pour évaluer l'impact des systèmes de gestion des eaux pluviales sur la pollution par ruissellement urbain

E. Vinck*, B. De Bock**, T. Wambecq***, R. Delgado****

* Aquafin NV Dijkstraat 8 B-2630 Belgium, Evi.Vinck@aquafin.be

** Aquafin NV Dijkstraat 8 B-2630 Belgium, Birgit.debock@aquafin.be

*** Aquafin NV Dijkstraat 8 B-2630 Belgium, Tom.Wambecq@aquafin.be

**** Aquafin NV Dijkstraat 8 B-2630 Belgium, Rosalia.Delgado@aquafin.be

RÉSUMÉ

Les systèmes de drainage urbain durable (SUDS) apparaissent comme une stratégie prometteuse pour réduire les impacts négatifs du changement climatique, tels que les inondations urbaines et la pollution des eaux réceptrices. Pour mettre en œuvre efficacement ces systèmes, des outils sont nécessaires pour modéliser leur impact. Dans ce travail, un nouvel outil est présenté qui peut être utilisé pour modéliser la concentration des polluants les plus fréquents dans le ruissellement urbain, à savoir Zn, Cu, Pb, PAH(1)6, TN et TP, en se basant non seulement sur le type de surface mais aussi sur d'autres entrées telles que le volume de trafic ou les types de bâtiments. L'outil comprend également un modèle simple pour évaluer l'impact de différents types de SUDS. Le modèle de qualité de l'eau a été évalué par des campagnes de mesure dans des réseaux d'égouts séparés de quelques petits bassins versants en Flandre. Le modèle a pu reproduire de manière satisfaisante la dispersion observée des concentrations.

ABSTRACT

Sustainable urban drainage systems (SUDS) are emerging as a promising strategy to reduce the negative impacts of climate change, such as urban flooding and pollution of the receiving waters. To effectively implement these systems, tools are needed to model their impact. In this work, a new tool is presented which can be used to model the concentration of the most frequent pollutants in urban runoff, *i.e.* Zn, Cu, Pb, PAHs, TN and TP, based not only on the surface type but also on other inputs such as the amount of traffic or the building types. The tool also includes a sedimentation model to evaluate the impact of different SUDS types. The water quality model was evaluated by measurement campaigns in separate sewer systems of a few small catchments in Flanders. The model was able to reproduce the observed spread in concentrations in a satisfactory manner.

KEYWORDS

aquaSens, climate change, decision-support-tool, sustainable urban drainage, water quality.

1 INTRODUCTION

Stormwater runoff is often discharged untreated to receiving waters, which is widely recognized as a threat for their water quality. Urban runoff pollution is expected to worsen by climate change and increasing population. The European Union has already begun to adopt more stringent stormwater quality standards. Sustainable urban drainage systems (SUDS) are emerging as a promising strategy to reduce this pollution and other impacts of climate change such as flooding and drought. To effectively implement these systems, tools are needed to model their performance.

Urban runoff quality can be assessed by the current catchment modelling tools (e.g. SWMM, ICM, MIKE URBAN), which have also incorporated most SUDS types as standard modules. Next to the standard software, several other tools have been developed to model SUDS, e.g. MUSIC, P8-UCM, WinSLAMM, GIFMOD (Zhou 2014, Jayasooriya 2014). In many tools such as SWMM, MIKE URBAN or GIFMOD, urban runoff quality can be modelled by a deterministic approach, assuming pollutant buildup during dry weather and pollutant wash-off during storm events for different categories of landuses. However, the parameters of the buildup and wash-off curves have to be defined by the user. Many studies have tried to estimate the build-up and wash-off dynamics for different types of surfaces, at both small and larger catchment scales, with varying level of success (Bonhomme, 2017). Unfortunately, the ranges of the model parameters are very wide depending on the experimental study. For small scale studies, the wash-off is well predicted and mainly dependent on the rainfall characteristics. Although build-up is commonly understood to depend on the number of antecedent dry days, many researchers have noticed that the build-up rates and loads are site specific and dependent on factors such as road surface condition and traffic volume. Nevertheless, in many studies, the build-up parameters are determined by drainage surface type (e.g. roof, highway, road, residential), without taking into account these other factors. Also other sources that have been reported to contribute to the pollution, such as atmospheric deposition or anthropogenic activities (e.g. pets and wildlife, gardening) are ignored in these studies. Other tools, such as WinSLAMM or P8-UCM use a statistical approach to assess urban runoff quality. Here an average pollutant concentration is assumed for different types of surfaces (roofs, streets) based on a large number of studies.

In this contribution, we present a simple and easy-to-use tool, aquaSens, in which the pollutant build-up for small catchments is calculated by taking into account different sources of pollution and catchment specific data such as the type of buildings, the road type and the traffic volume. The tool includes a simple sedimentation model to evaluate the impact of SUDS. Different SUDS can be selected and modelled in one run, so that their impact (both hydrological and water quality) can easily be compared. Also different dimensions or configurations of the SUDS can be modelled and compared in one run.

The tool can be used by decision makers, for instance to prioritize which surfaces need to be treated before discharge to surface waters and to select treatment strategies. The tool is designed to model small catchments. However, the water quality model is basically a build-up/wash-off model, so can also be implemented in standard hydrological tools to model larger catchments. This was beyond the scope of the present study but can be studied in the future.

2 DESCRIPTION OF THE TOOL

2.1 Runoff calculation

Precipitation (5 min) and evaporation (daily) data are provided by the Belgian Meteorological Institute (Willems, 2000). The runoff is calculated by taking into account depression storage and a fixed runoff coefficient. No routing is included, so the tool can only be used for smaller catchments.

2.2 Waterquality

The pollutants and pollutant sources that are included in the aquaSens tool are show in Figure 1. The pollution load from these sources is calculated by the Water Emission Inventory Support System (Van Esch, 2009). Details of the methodology can be found on the website.

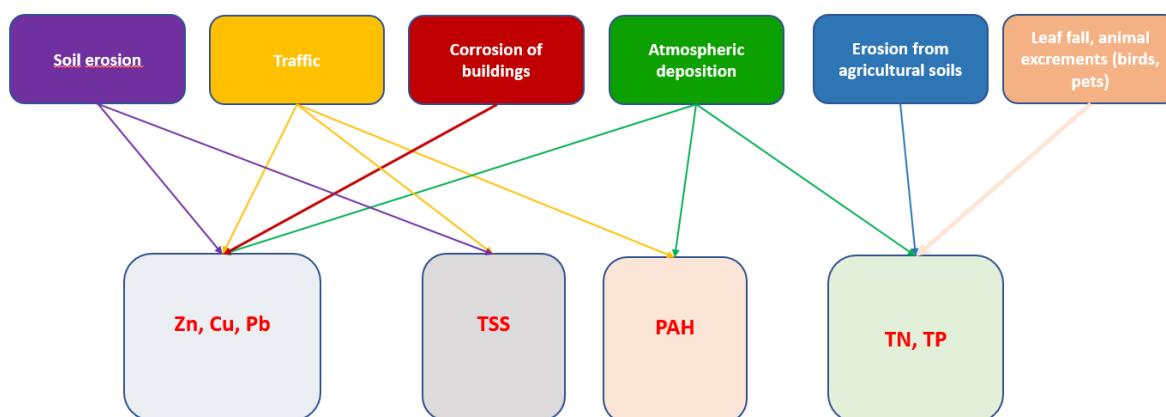


Figure 1. Pollutant sources included in the aquaSens tool.

The method returns a total annual load in g/year. It is assumed that the pollutants build up linearly during dry weather conditions. For Zn, Cu and Pb, a maximum build-up is assumed, as described in Wicke (2012).

During storm events, the pollutants are washed off. The wash-off equation from Wicke (2012) for concrete surfaces was used. The same wash-off curve was used for all surface types. This didn't have much impact on the results.

2.3 Impact of SUDS

The tool also includes a sedimentation model to evaluate the impact of different SUDS on the water quality. The following extended set of treatments is included: green roofs, rainwater harvesting tanks, storage tank, infiltration well, infiltration basin, bioswale, infiltration trench, vertical and horizontal infiltration pipes, soakaway crates, infiltration street gully, permeable paving, street trees, reduction of impervious surface, bluebloqs system for rainwater purification. A set of discrete, default values for the dimensions of the SUDS are assumed, based on local regulations and standards of manufacturers. These values can also be adjusted by the user. This allows for a primary dimensioning of the SUDS.

3 EVALUTATION OF THE TOOL

The waterquality model was evaluated by measurement campaigns in separate sewer systems of a few small catchments in Flanders. The model was able to reproduce the observed spread in concentrations in a satisfactory manner.

Test site	Street surface (m ²)	Roof surface (m ²)	Street length (m)	Traffic (/u)*
Walem	3780	7880	630	30
Wilsele	27000	26000	850	105
Wolvenberg	5600	0	800	270
Mechelen	29210	61980	5848	79

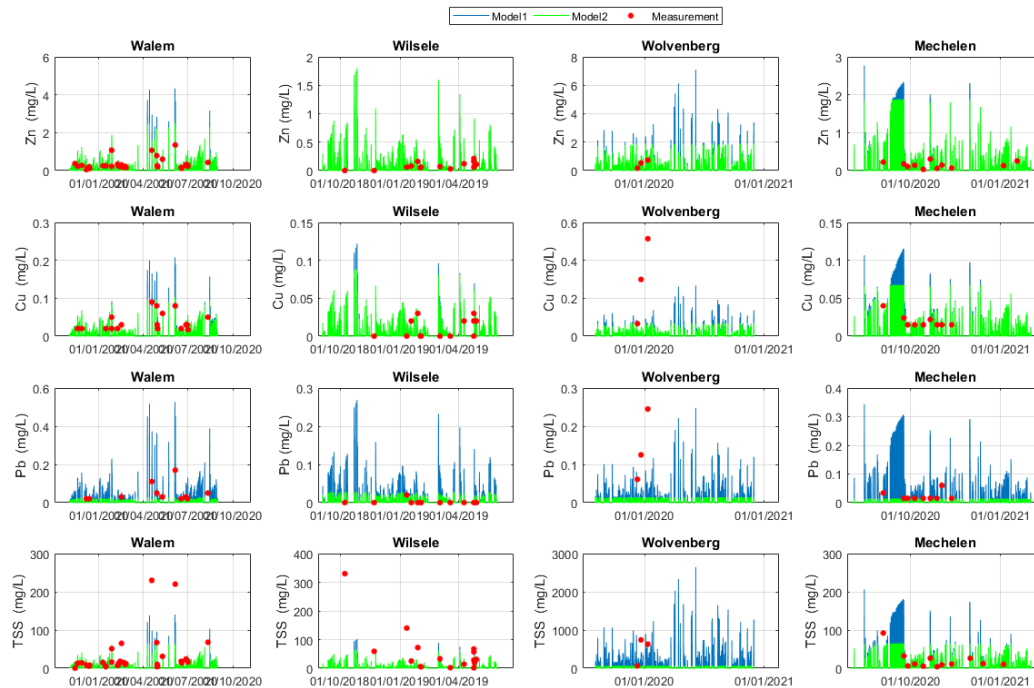


Figure 2. Modelled and measured heavy metals and TSS concentrations in different catchments. Model1 are the concentrations derived by the WEISS method, without assuming a maximum build-up, whereas in Model2 a maximum build-up is incorporated.

LIST OF REFERENCES

- Bonhomme C., Petrucci G. 2017. Should we trust build-up/wash-off water quality models at the scale of urban catchments ? *Water Research* 108: 422-431.
- Jayasooriya V.M., Ng A.W.M. 2014. Tools for Modeling of Stormwater Management and Economics of Green Infrastructure Practices : a Review. *Water Air Soil Pollut* 225, 2055
- Van Esch, L.; Vos, G.; Janssen, L.; Engelen, G. The Emission Inventory Water: A Planning Support System for Reducing Pollution Emissions in the Surface Waters of Flanders. In *Planning Support Systems Best Practice and New Methods*, Geertman, S.; Stillwell, J., Eds.; 2009; Volume 95, 490pp.
- [WEISS Geoloket \(vito.be\)](http://vito.be)
- Wicke D., Cochrane T.A., O'Sullivan O. 2012. Build-up dynamics of heavy metals deposited on impermeable urban surfaces. *Journal of Environmental Management* 113. 347-354.
- Willems P. 2000 Compound IDF-relationships of extreme precipitation for two seasons and two storm types. *Journal of Hydrology*. 233, 189-205.
- Zhou, Q. 2014 A review of sustainable urban drainage systems considering the climate change and urbanization impacts. *Water*. 6, 976-992.