Smart monitoring and modelling to enhance treatment and reuse of highway stormwater

Favarin, M.; Nielsen, K.; Sambo, F.; Biondi, S.; Capuzzo, F.; Gambaro, A.; Bertuzzo , E.; Vezzaro, Luca

Publication date:
2021

Document Version
Publisher's PDF, also known as Version of record

5th IWA Specialized International Conference 'Ecotechnologies for Wastewater Treatment (EcoSTP) 2021' - June 21-25, 2021 - Milan, Italy

Smart monitoring and modelling to enhance treatment and reuse of highway stormwater

M. Favarin[1], K. Nielsen[1,2], F. Sambo[3], S. Biondi[3], F. Capuzzo[4], A. Gambaro[1], E. Bertuzzo[1], L. Vezzaro[1,2*]

[1] Department of Environmental Sciences, Informatics and Statistics, Ca' Foscari University of Venice, 30172 Venezia-Mestre, Italy
[2] Pipe Center, Energy and Climate Division, Danish Technological Institute, 2630 Taastrup, Denmark
[3] Department of Environmental Engineering, Technical University of Denmark, 2800 Kgs. Lyngby, Denmark
[4] SWI Group S.r.l., 30176 Marghera Venezia, Italy
[5] CAV S.p.a Concessioni Autostradali Venete, 30175 Marghera Venezia, Italy
[*] corresponding author: luve@env.dtu.dk

Summary: Reuse of highway runoff is strongly limited by its high pollution. An effective treatment of this water flux requires monitoring approaches that are suited for the high dynamic variability of stormwater quality. In this study we present the preliminary results of a project testing a combination of monitoring approaches (online sensors, passive chemical sampler, and dynamic mathematical models) to support an improved operation of highway runoff treatment solutions.

Keywords: passive samplers; highway stormwater runoff, dynamic models.

INTRODUCTION

During the last decades, growing urbanization and increased anthropogenic activities have turned stormwater into a pollution source for natural waters. The complex mixture of contaminants transported by runoff has negative impacts on chemical status, biological functions, and ecological health of receiving waters. On the other hand, stormwater can represent an important water source if properly monitored and treated, supporting water reuse and "water fit for purpose" applications.

Stormwater runoff carries a complex matrix of contaminants from different sources which include e.g. atmospheric deposition, leaching from building material and traffic emissions. The latter has been recognized as a major contribution to emissions of heavy metals (antimony, cadmium, chromium, copper, lead, nickel, and zinc) and PAHs [1,2], seriously limiting the potential for reuse of runoff from roads and highways due to the toxicity and persistence of these pollutants [3].

Current practices for treating stormwater rely on static approaches, based on fixed rules and regulations that do not consider the highly inherent variability of stormwater pollutant release and transport processes. To enable an effective reuse of the water fluxes from traffic areas it is necessary to apply monitoring approaches which can provide high-time resolution data on pollutant profiles. This information can be provided by online sensors, typically measuring basic water quality parameter such as turbidity, pH, conductivity, temperature. However, these sensors are not capable of measuring critical pollutants such as heavy metals and PAHs.

This study presents the first outcomes of a project aiming at improving the monitoring of contaminants in highway runoff by combining different solutions such as online sensor, passive chemical samples, and mathematical models [4]. The improved information provided by the tested approach will improve the efficiency of

existing stormwater treatment solutions and thereby increase the potential for reuse of highway runoff.

MATERIALS AND METHODS

The model-based approach described in [4] will be tested at D9 treatment plant, place the along the Passante di Mestre highway (Italy) during winter and spring 2020-2021. This approach includes the use of data from online sensors (turbidity, flow, temperature, conductivity) and passive chemical sensors measuring PAH and heavy metals concentrations (Sorbisense, https://www.eurofins.dk/). Measurements from the online sensors and passive samplers will then be used to calibrate a dynamic stormwater quality model.

Figure 1 show the monitoring setup: stormwater enters a storage tank, where the water is treated by adsorption filters. The tank is then emptied by a pump operated based on simple rules, which do not consider the dynamics in the stormwater pollution levels. Passive samplers are installed at the inlet and outlet of the adsorption filters and are removed after major rain events. The first monitoring campaign will focus on heavy metals, which have been identified as the major source of concern. This installation allows to estimate the average concentration of pollutants during different storm events, and to assess the removal performance of the existing treatment solution.

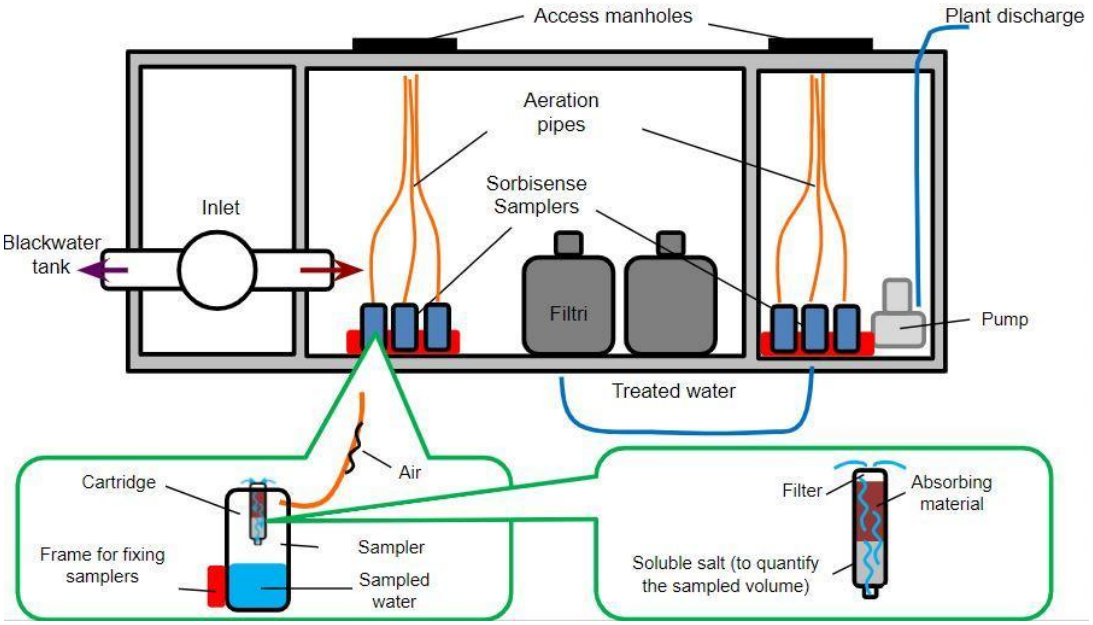

Figure 1: Illustration of the treatment plant system

The dynamic stormwater quality model (Figure 2) estimates both water quantity and quality by using rainfall data as input and a conceptual representation of the rainfall-runoff generation and pollutant accumulation-washoff processes. Data from the monitoring campaign will allow the estimation of the model parameters. The calibrated model will enable (a) the quantification of the pollutant loads and concentration in the highway runoff, (b) the evaluation of the long-term performance of the adsorption filters, and (c) the assessment of different operational scenarios aiming at enhancing the water treatment processes (e.g. operation of the pumping system to maximize the treatment of the most polluted fraction of highway runoff).

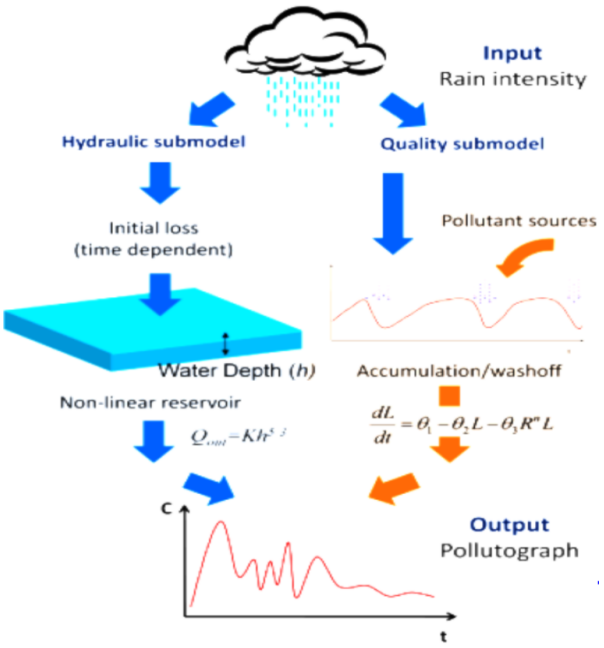

Figure 2: Scheme of rainfall/runoff model and accumulation/release model

RESULTS

The study is supported by SIMIIAA, a research project involving Stormwater Italia, a company managing and operating a network of over 180 stormwater treatment plants, spread along highways in the Veneto Region (Italy). Each plant is equipped with the automatic monitoring setup as in the D9 test site. Results from this study could therefore be straightforwardly transferred to other locations.

The application of the proposed smart monitoring and modelling approach is thus expected to improve the knowledge on highway runoff pollutions, to enhance its treatment efficiency. This will reduce the impacts from highway runoff and transform this water flux into a new water source.

ACKNOWLEDGMENTS

This study was financed by the SIMIIA project, EU Regional Development Fund managed by Regione Veneto (n. 2120-0005-1463-2019). Thanks also to StormWater Italy group and CAV (Concessioni Autostradali Venete) for their technical support.

REFERENCES

[1] Bakr, A. R., Fu, G. Y. & Hedeen, D. 2020 Water quality impacts of bridge stormwater runoff from scupper drains on receiving waters: A review, *Science of The Total Environment,* **726**, 0048-9697.

[2] Huber, M., Welker, A. & Helmreich, B., 2016 Critical review of heavy metal pollution of traffic area runoff: Occurrence, influencing factors, and partitioning, *Science of the Total Environment* **541**, 895-919.

[3] Huber, M. & Helmreich, B. 2016 Stormwater Management: Calculation of Traffic Area Runoff Loads and Traffic Related Emissions, Water 2016, 8(7), 294;

[4] Birch, H., Vezzaro, L. & Mikkelsen, P. S. 2013 Model-based monitoring of stormwater runoff quality, *Water Science & Technology,* **68.5**, 1063-1071