

Stormwater quality calibration by SWMM: A case study in Northern Spain

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Abstract

This article presents an application of the Storm Water Management Model (SWMM) in order to predict the pollution in rainy weather in a combined sewer system catchment in Santander, Spain. Suspended solids (SS), chemical oxygen demand (COD) and total Kjeldahl nitrogen (TKN) were measured at the exit of the catchment and these parameters were used for the calibration and validation of the model. The process of hydraulic and quality calibration is described and the values of the adjusted parameters are presented, comparing them with those obtained from other studies. The calibrated model simulated accurately the hydrograph's shape and the time of presentation of the peak flows. The accuracy of adjustment of the volume was 96%. As for the quality validation, the accuracy of adjustment among the total simulated loads of SS, COD and TKN, and those measured at the end of the rainfall events were 93, 95 and 78% respectively, confirming the accurate confirming the relative accuracy of the model in the prediction mode. The phenomenon of the first flush was analysed, and it was determined that 65, 57 and 54% of the polluting loads of COD, SS and TKN respectively, were swept along by the first 30% of the volume in the rainfall events used for the calibration of the model.

Keywords: calibration, SWMM, sewage, first flush, stormwater runoff, event mean concentration, urban areas

Introduction

Urban runoff is one of the factors which has the most influence on the water quality of water bodies (Characklis and Wiesner, 1997; Tsihrintzis and Hamid, 1998). The determination of the even mean concentration (EMC) is an approximation method, which is used to study its effects (Huber, 1992; Novotny and Olem, 1994; Charbeneau and Barrett, 1998).

$$EMC = \frac{M}{V} = \frac{\int_0^t C(t)Q(t)dt}{\int_0^t Q(t)dt}$$

where:

- EMC = event mean concentration ($M \cdot L^{-3}$)
- M = total mass of the pollutant over the total duration of the event (M)
- V = total volume of the flow generated by the event (L^3)
- T = time (T)
- C(t) = concentration of the pollutant in the time instant t ($M \cdot L^{-3}$)
- Q(t) = flow in the time instant t ($L^3 \cdot T$)

An approximation of this type has the advantage of simplicity. However, in some cases, it is necessary to resort to all the information obtained in the hydrographs and pluviographs generated by one rainfall event. On these occasions the existence of a hydraulic model as well as the calibration and validation of the catchment area of the study, signifies great help for the design

of the regulation structures of the combined sewer system (Temprano and Tejero, 2002).

On the other hand, several authors (Gupta and Saul, 1996; Deletic, 1998) suggest that the most polluted part and therefore, the most adverse for the receiving water, is the one generated at the start of a rainfall event. Therefore the study of the initial flow of precipitation acquires great importance, especially when studying the combined sewer overflows generated in the storage structures located downstream of the combined sewer system (Diaz-Fierros et al., 2002). Nevertheless, there are authors (Cristina and Sansalone, 2003) who suggest that the approximation of the first flush is not enough, since at least with respect to the separation of particles, it would be necessary to retain the ones generated by the precipitation as a whole and not only those which would correspond to the first flush.

The above discussion reveals the need for knowing in advance the quantity and quality of the mixed waters in rainy weather in combined sewer systems, in order to estimate their effects at the very moment when the overflows take place, and for the design and the proper performance of the combined sewer system, in terms of the quality criteria of the receiving waters. Several mathematical simulation models have been developed for this purpose; the most well-known are: SWMM (Huber and Dickinson, 1988), STORM (Hydrologic Engineering Center, 1977), DR3M-QUAL (Alley and Smith, 1982), MOUSE (Danish Hydraulic Institute, 1990). As discussed by Zoppou (2001) there is a great variety of models for this type of simulation.

The Storm Water Management Model (SWMM version 4.4 h) was used here (Huber and Dickinson, 1988), as it is one of the most complete and widely used throughout the world. The SWMM allows the simulation of flows and polluting loads of urban runoff as well as their carriage through the combined sewer system. This is not only for a single rainfall event, but

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Received 10 May 2005; accepted in revised form 20 September 2005.