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GESTION INTÉGRÉE DES EAUX USÉES URBAINES: CARACTÉRISATION ET MODÉLISATION DU COMPORTEMENT DES POLLUANTS DANS UN BASSIN DE RÉTENTION EN RÉSEAU UNITAIRE

Thèse présentée
à la Faculté des études supérieures et postdoctorales de l'Université Laval
dans le cadre du programme de doctorat en génie des eaux
pour l'obtention du grade de Philosophiæ Doctor (Ph.D.)

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UNIVERSITÉ LAVAL
QUÉBEC

2012

Abstract

Combined Sewer Overflows (CSOs) are known to contribute considerably to the environmental impact of the urban wastewater system. However, the efficient implementation of retention tanks (RT) to mitigate such pollution remains a challenge. Indeed, a growing number of studies tend to prove that RT emptying has a negative impact on the wastewater treatment plant (WWTP) performance, and hence on the environment. Studying this question uniquely by way of *in situ* measurements can be difficult due to its multidisciplinary nature, and the large spatial and time scales of the issue. In this context, the integration of several models describing the urban wastewater system offers a powerful tool. Scenario simulations can lead to a better understanding and prediction of the effects of wastewater management options, under both dry and wet weather conditions. Thus, economical and ecological costs due either to the development of new infrastructure or to decision-making about system management can be optimized. The need is therefore identified to produce efficient models that are able to describe water quality all along the course of wastewater in the urban wastewater system.

Little data exist on the pollutant behaviour in RTs and the wastewater returned to the WWTP is poorly studied. As a consequence, the RT-behaviour is often more assumed than observed. An important part of this PhD study has thus focused on performing a sampling campaign to characterize these phenomena. This field work was a difficult exercise since the occurrence of storm events is hardly predictable. The goals of the sampling campaign were to harvest data at the inlet and the outlet of the RT, mainly for Total Suspended Solids (TSS), Chemical Oxygen Demand (COD) and settling velocity (Vs) distributions, the latter using the ViCAs batch settling test. The results have shown typical dynamics during emptying revealing a "U" shape of pollutant concentrations. This shape underlines three phases called : initial, middle and final, where each phase is characterized by a specific range of TSS and COD concentrations and a specific settling velocity distribution. In general, it was observed that higher concentrations correspond with a so-called heavy settling velocity distribution, i.e. with a higher mass fraction with higher settling velocities. These data coupled with measurements carried out for a collector and for a Primary Clarifier allowed a better understanding of the involved phenomena and the interactions between the subsystems of the urban wastewater system, and building a solid model framework.

The scientific literature contains a large number of wastewater quality modelling studies concerning treatment processes. However, it is not as rich regarding the description of the evolution of the quality of the wastewater stored in sewers or in RTs. Only few RT models exist describing quite simply the settling and resuspension of particles, which are the dominant processes of the system. Moreover, these models are rarely validated against field data since the involved phenomena are difficult to observe and quantify.

The PhD project aimed at developing an RT model describing TSS and COD behaviour at the RT's outlet (the wastewater sent to the WWTP). The model also had to be compatible with the activated sludge models (ASMs) of the International Water Association (IWA). The description of the settling and resuspension phenomena is based on a fractionation of solids in different particle classes which are characterized by specific settling velocities. This fractionation is the result of in situ measurement of the variation of the settling velocity distribution. Since the RT studied is emptied by pumping, the resulting effects on settling and resuspension also had to be described. Two observed events were used for model calibration and another was used for validation. This validation had never been done for an RT model.

The final objective of the PhD study was to integrate the model in a more global model of the system (sewer - WWTP - river). RT emptying strategies were set to highlight interactions between sub-systems in terms of TSS and particle class distribution. Indeed, studying the fate of particle settling velocity distribution along the water course can be useful to anticipate problems in secondary treatment processes. For example, a higher fraction of particles with higher settling velocity (typically larger particles) leaving a primary clarifier can lead to : 1) an increase in the necessary time for hydrolysis in activated sludge systems ; or 2) a higher risk of biofilter fouling. A better understanding of these interactions can result in proposals for improved management and control rules that aim at decreasing the impact of wastewater treatment on the environment.