Urban stormwater management: Calibration and validation of an off-line retention tank dynamic model for water quality

T. Maruejouls, P. A. Vanrolleghem and P. Lessard

Département de génie civil et de génie des eaux, Université Laval. Pavillon Adrien Pouliot, 1065 Av. De la médecine, Québec, Qc, G1V 06A, CANADA.
Thibaud.Maruejouls.1@ulaval.ca; Peter.Vanrolleghem@gci.ulaval.ca; Paul.Lessard@gci.ulaval.ca

ABSTRACT

As the integrated management of urban wastewater systems becomes more and more popular, the development of wastewater management subsystem models appears essential to improve the understanding of the pollutant dynamics and their interactions. In such a context, a review of the literature reveals a lack of efficient models describing the dynamics of the water quality stored in off-line retention tanks. A model has thus been proposed based on the fractionation into three classes of the particle settling velocity distribution measured in the field using the ViCAs settling test. In this paper, full-scale field data sets from three different events are used for 1) calibrating this new dynamic retention tank model (two data sets) ; and 2) validating that model on the last data set. The results show a good fit between observed and simulated data both for the total suspended solids (TSS) and the total chemical oxygen demand (CODt).

KEYWORDS

Combined sewer overflow, settling velocity, urban wastewater modelling, water quality

1 INTRODUCTION

To improve operation of combined sewer overflow retention tanks (RT), important infrastructures for urban stormwater management, it is necessary to consider the system as a whole (Rauch *et al.*, 2002), following the fate of water from catchment runoff down to the receiving body. The scale of such a system is so big that it becomes rather difficult to assess the interactions between the different subsystems with in situ measurements. In such a context, modelling appears a very usefull tool as the phenomena occurring in RTs are increasingly understood (Maruejouls *et al.*, 2011; 2012). Modelling the dynamics of the water quality that is stored in sewers and specifically in RTs, can help improve the accuracy of the predictions of wastewater treatment plant (WwTP) influent quality. One of the important elements that stands in the way of integrated modelling improvements is the compatibility between the submodels in terms of state variables and parameters (Fronteau *et al.*, 1997; Rauch *et al.*, 2002). When developing new models, it thus appears necessary to consider the parameters and variables of the models to which they will be linked. Also, the new models need to be tested with full-scale data, be compatible with one another and require only a short calculation time.

The first approach for RT modelling is the computational fluid dynamic (CFD), e.g. Vazquez *et al.*, 2008. The long-time requirement for simulations does not allow their use in an integrated system context. A different approach was used in this study, which is more phenomenological in nature and requiring shorter time for simulating. Most of such RT models available today are quite simple as they are linear reservoirs merely representing the hydraulics and not paying a lot of attention to the water quality dynamics. However, several modelling studies taking into account water quality have already been carried out. They describe the settling processes in a more or less complex way. Some use a single removal rate value in a set of ordinary differential equations (Lessard and Beck, 1991; Wong and Geiger, 1997) and/or an average settling velocity (Vs) parameter (Kutzner *et al.*, 2007; Frehmann *et al.*, 2005) and/or surface load as predominant factor (Vaes *et al.*, 1999; Luyckx *et al.*, 2002) while some add different operational modes distinguishing pollutant behaviour for filling, overflow, storage or emptying phases (Lessard and Beck, 1991). Nevertheless, none of these models has ever been successfully validated with full-scale field data (Kutzner *et al.*, 2007).

Particles Vs studies on such infrastructures are quite rare, but many authors agree on the relevance of studying such a variable (Michelbach, 1995; Boxal *et al.*, 2007; Maruejouls *et al.*, 2012). Even if a Vs can be easily understood from a physical point of view, determining an average one describing the whole settling processes is a difficult task as particle Vs found in combined sewers are known to vary a lot (Michelbach, 1995; Maruejouls *et al.*, 2011). Vallet (2011) already proved the potential and interest of using classes of particles with different Vs for settling modelling in stormwater basins.

The current work presents the calibration method of a new off-line RT dynamic model based on the Lessard and Beck (1991) model. It describes sedimentation, resuspension and hydrolysis processes using three different particle classes associated with three different Vs. The first part of this paper describes the methodology used for the calibration. The second part shows simulation results obtained during the calibration and validation.

2 MATERIALS AND METHODS

2.1 The data

The data used for the calibration and the validation presented in this study come from two sampling campaigns performed during the summers of 2009 and 2010 on a 7,580 m^3 off-line RT located on a combined sewer in the area of Quebec City, Canada. The whole sampling and analysis methodology is more detailed in Maruejouls *et al.* (2011).

2.2 The retention tank model

The developed model represents the mechanisms driving pollutant behaviour occurring in the system by using ordinary differential equations. It is a 1-D dynamic off-line RT model adapted from Lessard and Beck (1991). The main improvements are adding a pumping well (PW) and changing the settling model using three particle classes associated to three Vs. The whole concept of the model is detailed in Maruejouls *et al.* (2012). The ultimate goal of such a model is to be further integrated in a "combined sewer – WwTP" model. The pollutant behaviours (TSS and CODt) are mainly reproduced through two processes, the settling and the resuspension of particles. The description of the sedimentation is based on ViCAs tests (Chebbo and Gromaire, 2009) giving a particle Vs distribution which is split in three particle classes representing: 1) a fraction with a very low Vs where the largest part will never settle during storage; 2) a fraction settling more slowly for which it takes many hours to be completely removed; and 3) a particle fraction that settles quickly when entering the tank. The model includes a fractionation step for both TSS and CODt variables as shown in Figure 1. Such a fractionation makes the model capable of direct connections to activated sludge models using ASM1 (Henze *et al.*, 1987) variables.

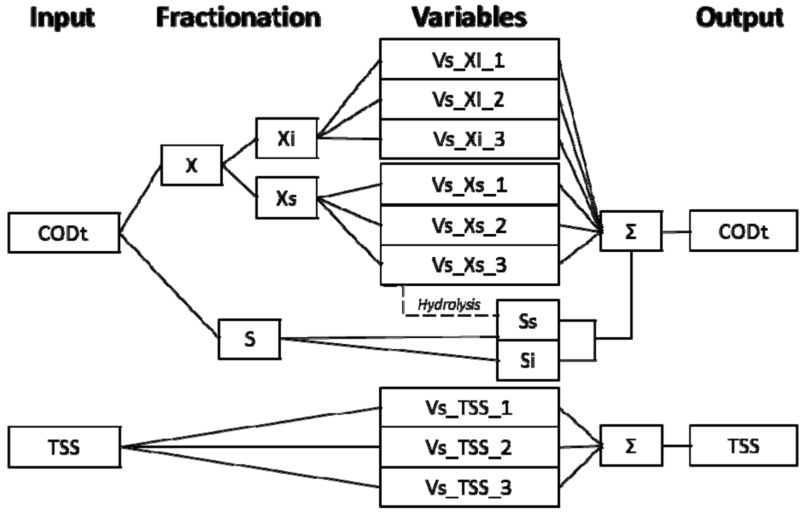

Figure 1. Fractionation concept of the collected data (*input*) to the model variables. Variables named "*Vs_XXX_1,2,3*" are subject to sedimentation/resuspension. Hydrolysis reactions occur between "*Vs_Xs_1,2,3*" and "*Ss*" variables.

Some slight improvements were made to the model proposed in Maruejouls *et al.* (2012). Figure 2 presents the concept of the proposed model improved in three ways:

- A fourth accumulation layer was added in the pumping well in order to trap a particle fraction which won't be resuspended and will remain in that layer until a manual extraction.
- The description of the output quality/quantity is solely described by the $J_{Down,j}$ flux which is coming out from the "*Down*" layer and has the same quality.
- A hydrolysis process was added allowing the transformation of particulate biodegradable matter (*Xs*) in soluble biodegradable matter (*Ss*). Since it was shown that the organic matter biodegradability is heterogeneously distributed with respect to the particle Vs (Hvitved-Jacobsen *et al.*, 1998), three different rates are available depending on the Vs class.

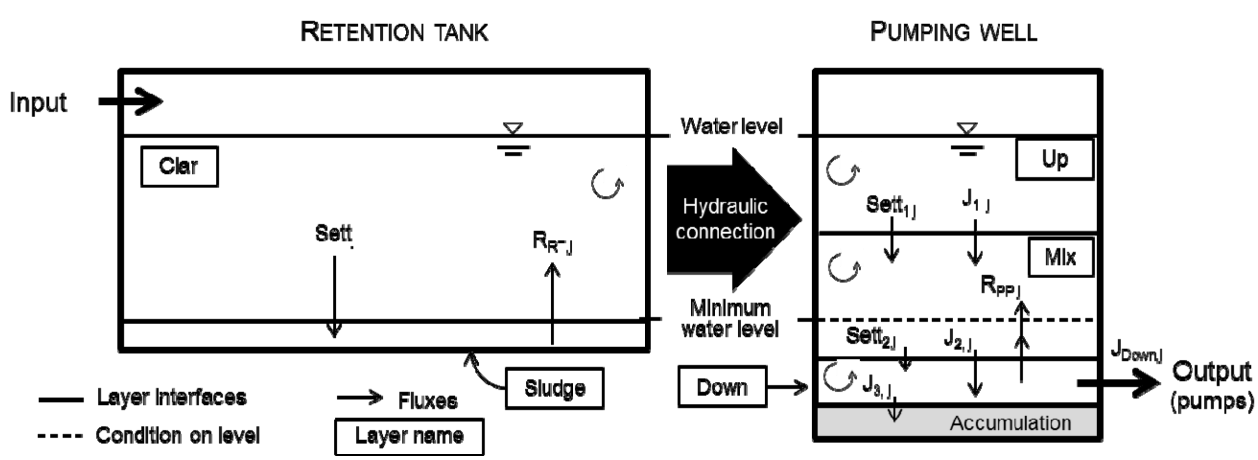

Figure 2. RT/PW model conceptual diagram from Maruejouls *et al.* (2012) improved by three ways.

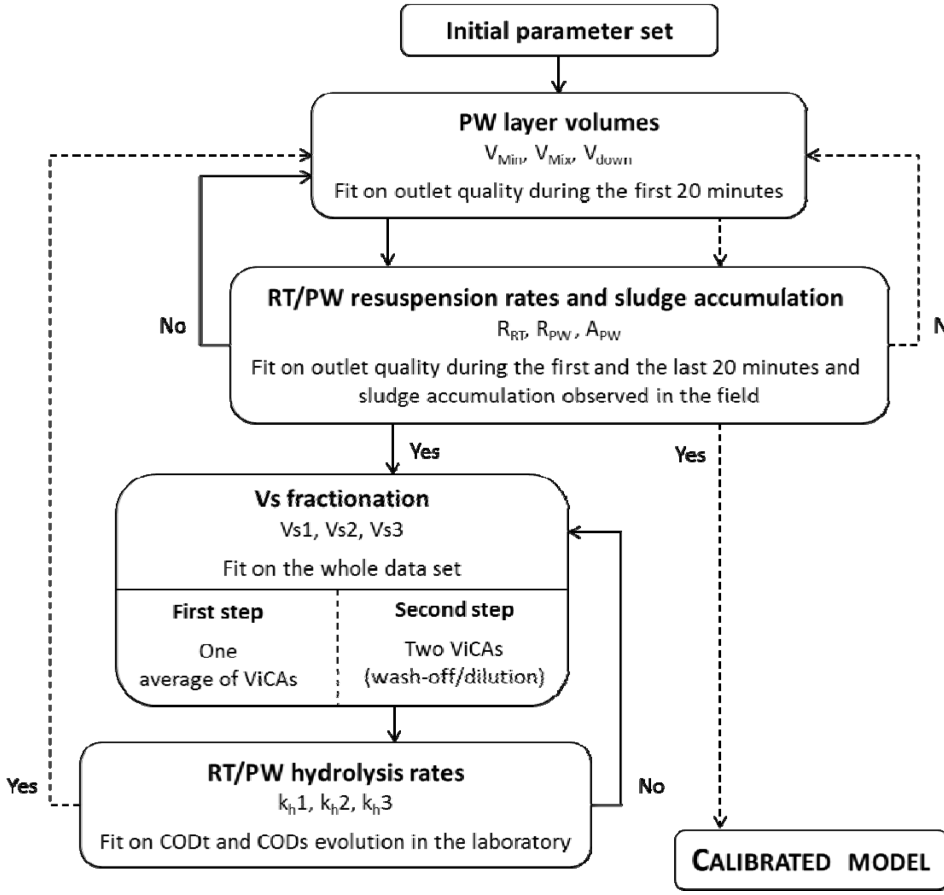

Figure 3. Model parameter calibration steps.

2.3 The calibration method

The calibration of the thirteen parameters is roughly made up of three main steps as presented in Figure 3. On Figure 3, the first stage is represented by the continuous line until the hydrolysis process calibration is completed. Then, the second stage is illustrated by the dotted line. The Vs fractionation steps are found to be the most tedious task and will be further detailed.

2.3.1 PW layer volumes (V_{Min}, V_{Mix} and V_{Down} in m^3), resuspension rates (R_{RT} and R_{PW} in h^{-1}) and the sludge accumulation (A_{PW} in %)

Their calibration is subject to an iteration aiming at an optimization before going through the next step. The volumes are fitted according to the effluent quality during the first 20 minutes of emptying. Indeed, the essential purpose of those three volumes is the distribution of the resuspended particles in the bulk due to the pumps activation. This phenomenon is visible on the emptying pollutograph within those first minutes. After that, all resuspended particles are extracted. Thus, the shape of the first peak highly depends on those volumes. For example, if the "*Down*" volume is too small, the particles would be extracted too fast. Resuspension rate in the PW (R_{PW}), is calibrated by fitting on the same data and is also important, i.e. when that rate is too slow, the particles are not resuspended enough and thus are extracted too fast. R_{RT} is calibrated with regards to the pollutant concentration observed within the last ten minutes of emptying. Indeed, that increasing load at the end of emptying is due to the resuspension of pollutants accumulated at the bottom of the retention tank. Finally, A_{PW} is calibrated by fitting the mass of particles that has accumulated at the bottom of the PW as observed in the field.

2.3.2 Vs fractionation

Based on an approach proposed by Vallet (2011), the Vs fractionation starts from measurements carried out with the ViCAs protocol (Chebbo and Gromaire, 2009). The concept of this calibration approach was published in Maruejouls *et al.* (2012). Nevertheless, the different Vs combinations tested are detailed here in Table 1.

First step (one ViCAs): to illustrate calibration step, particle Vs distributions from the influent samples are presented in Figure 4. The dashed curve (Figure 4(a)) is an average made over all ViCAs results collected at the studied RT (ten data sets). The first step of the calibration is performed by moving the class limits (dotted lines) over that average curve until the resulting TSS and CODt concentration simulation results fit the measured the concentration in the outlet during emptying (see Figures 6 and 7). Then, the Vs assigned to that class are found by calculating the geometric average on the abscissa between the boundaries. For example, the limits drawn on Figure 4 correspond to the combination 1 presented in Table 1: class 1 = 10% of the total particle mass with a *Vs1* = 0.014 m/h; class 2 = 10% with a *Vs2* = 0.16 m/h; and class 3 = 80% with a *Vs3* = 1.5 m/h. Once the class limits are defined, the ViCAs curve defines the TSS fractions belonging to each of the three classes. Therefore those are not considered model parameters to be fitted.

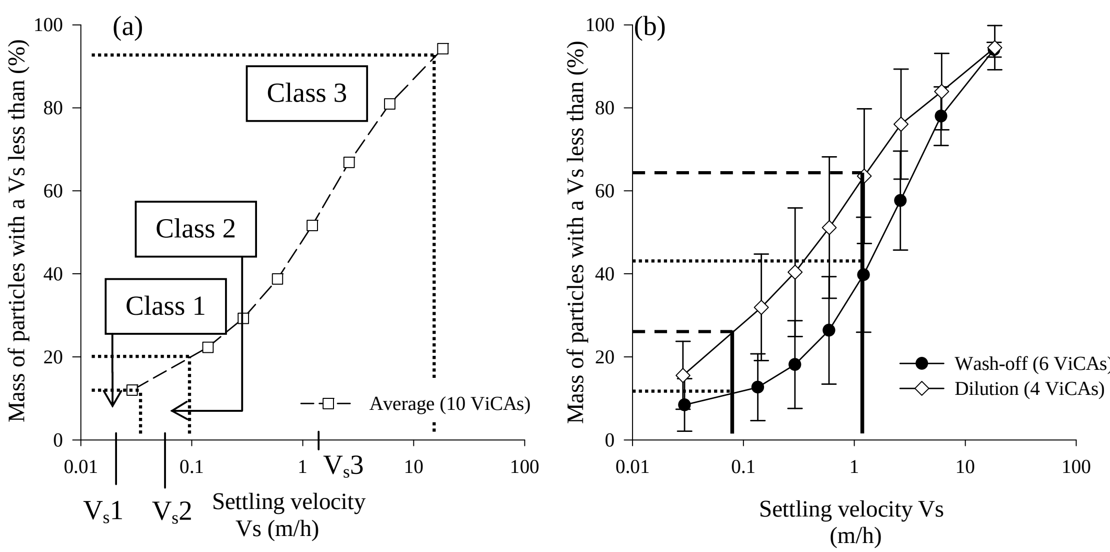

Figure 4. Vs fractionation description for the three classes' definition. a) Calibration on one ViCAs average; and b) Vs distributions used for calibration on two ViCAs averages ("*Wash-off*" and "*Dilution*" periods).

Second step (two ViCAs): on Figure 4(b), two periods are distinguished since Maruejouls *et al.* (2011) highlighted a possible correlation between concentration and Vs distribution. The "*Wash-off*" curve is an average of ViCAs results obtained over six samples collected during the first flush (Deletic, 1998; Bertrand-Krajewski *et al.*, 1998). Typically, that period corresponds to high pollutant concentrations. The "*Dilution*" curve is an average of ViCAs results from four samples collected during the period which comes after the "*Wash-off*". The second step of the Vs fractionation calibration is performed using those two curves. The optimal Vs classes found using one ViCAs average (combination 8 of the left column of Table 1) are then used as a basis to find the limits of the classes within both the "*Wash-off*" and "*Dilution*" period. On Figure 4(b) the two different ViCAs are shown with their peculiar TSS fractionation, i.e. three classes for the "*Wash-off*" period and three others for the "*Dilution*" period. The TSS concentration value separating the two periods is a new parameter to set. As in Maruejouls *et al.* (2012), it was set to 100 g/m^3. Again, this calibration method makes that the TSS fractions are directly defined by settling on the Vs class limits, i.e. a unique fraction corresponds to a unique Vs for each ViCAs.

2.3.3 The hydrolysis rates (k_h1, k_h2 and k_h3 in h^{-1})

This process allows transforming a fraction of the *Xs1*, *Xs2* and *Xs3* into soluble COD, *Ss*. The parameters are calibrated by fitting laboratory experimental results. The experiment to be conducted consists in measuring the evolution of the total and soluble COD in a water sample from the tank. This sample is inserted in a beaker and left settling for 24 hours in order to reproduce the storage conditions occurring in the tank. The measurements are collected in the middle of the beaker with a piston-driven air displacement pipette.

Once the calibration of the Vs fractionation and the hydrolysis rate are finalised, iteration is carried out to optimise the PW volumes, the resuspension and the sludge accumulation rates again before the model is considered completely calibrated.

3 RESULTS AND DISCUSSION

In the next paragraph, the chosen parameter values and the pollutographs resulting from the calibration and validation steps are presented and discussed. Two different events were used for the calibration while one was kept for the final validation step.

3.1 Calibration

3.1.1 Hydrolysis rates

Results of the hydrolysis rates calibration (k_h1, k_h2, k_h3) using the values from Table 2 are reported in Figure 5. The laboratory experiments reveal a quite constant CODt and a slightly increasing soluble COD, around $1 g/m^3/h$. That means a fraction of the particulate COD is transformed in soluble COD. In the current study, the hydrolysis rate is important enough to be noticeable in laboratory tests. Nevertheless, the data are quite insensitive to it in the current simulations. The calibration was performed using the CODt and soluble COD results of a laboratory experiment.

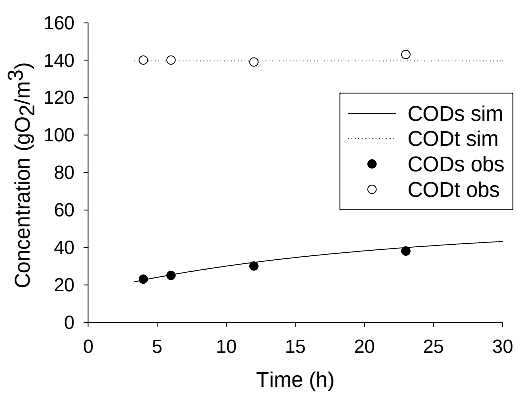

Figure 5. Calibration results of the hydrolysis rate.

3.1.2 Vs fractionation calibration steps

Eight combinations were tested for the Vs fractionation (Table 1). For example, the percentage values on the left columns of Table 1 represent the three fractions of the particle mass assigned to the three Vs. The first six combinations were chosen to cover the most extreme range of possibilities in terms of fractions. An extreme is represented by the classes made up of one big fraction (80% of the total particle mass) and two small ones (10%). Then, the seventh is an equal distribution of the mass between the three classes and the eighth one is the optimal combination found fitting the measured concentrations at the pump outlet.

Table 1. Vs fractionation combination tested: a) on the left, using solely one ViCAs average over all the whole event, the different Vs will be first defined; and b) on the right, using the Vs previously defined, the TSS fractions obtained using two different ViCAs averages.

	One ViCAs average		"*Wash-off*" period	"*Dilution*" period
Combination number	**TSS fractions (%)**	**Vs (m/h)** *Vs1-Vs2-Vs3*	**TSS fractions (%)** f_w1-f_w2-f_w3	**TSS fractions (%)** f_d1-f_d2-f_d3
1	10-10-80	0.014-0.016-1.5	8-7-85	15-15-70
2	20-20-60	0.035-0.31-3.9	15-20-65	30-25-45
3	10-80-10	0.014-0.5-15	8-82-10	15-75-10
4	20-60-20	0.035-0.85-10.7	15-62-23	30-55-15
5	80-10-10	0.25-8.5-15	77-13-10	85-5-10
6	60-20-20	0.14-3.5-10.7	52-25-23	70-15-15
7	33-34-33	0.075-1.33-7.8	25-40-35	50-25-25
8	**15-40-45**	**0.024-0.33-5.85**	**9-13-78**	**23-47-30**

Table 2. Parameter values resulting from the calibration. Grey zones indicate parameters that are obtained from lab experiments.

Parameters		Calibrated values	Parameters		Calibrated values
PW layer volumes	V_{Min} (m^3)	*13*	*Hydrolysis rates*	k_h1 (h^{-1})	*2*
	V_{Mix} (m^3)	*40*		k_h2 (h^{-1})	*1.5*
	V_{Down} (m^3)	*11*		k_h3 (h^{-1})	*0.5*
Resuspension rates	R_{PW} (h^{-1})	*200*	***Fraction wash-off***	**f_w1 (%)**	***9***
	R_{RT} (h^{-1})	*1000*		**f_w2 (%)**	***13***
Accumulation	A_{PW} (%)	*83*		**f_w3 (%)**	***78***
Settling velocities	Vs1 (m/h)	*0.024*	***Fraction dilution***	**f_d1 (%)**	***23***
	Vs2 (m/h)	*0.33*		**f_d2 (%)**	***47***
	Vs3 (m/h)	*5.85*		**f_d3 (%)**	***30***
Wash-off/Dilution TSS limit	Lim (g/m3)	*100*			

3.1.3 Parameter set up

The calibrated parameter values were used for the further simulations. As explained earlier, Table 2 includes the thirteen parameters being calibrated plus the six fractions which are directly dependent on the Vs choice (in bold). Parameters in grey zones are fixed from lab experiment. Their value is thus automatically set when the Vs class limits are set. The grey zone means that those parameters are defined by the calibration of the Vs and are not to be calibrated further. The volume V_{Min} is close to what is expected based on field observation, i.e. around 13 m^3 of stored water remaining in the PW after emptying.

3.1.4 Results of the calibrated model

The calibration of the other parameters was carried out using two different events, of July 27th 2009 (Figure 6) and September 27th 2009 (Figure 7). The figures show the effluent concentrations comparing the collected data against the simulated data. The two variables observed for this calibration are the TSS (on the left) and the CODt (on the right) concentrations. The flow at the effluent is represented by the dashed line.

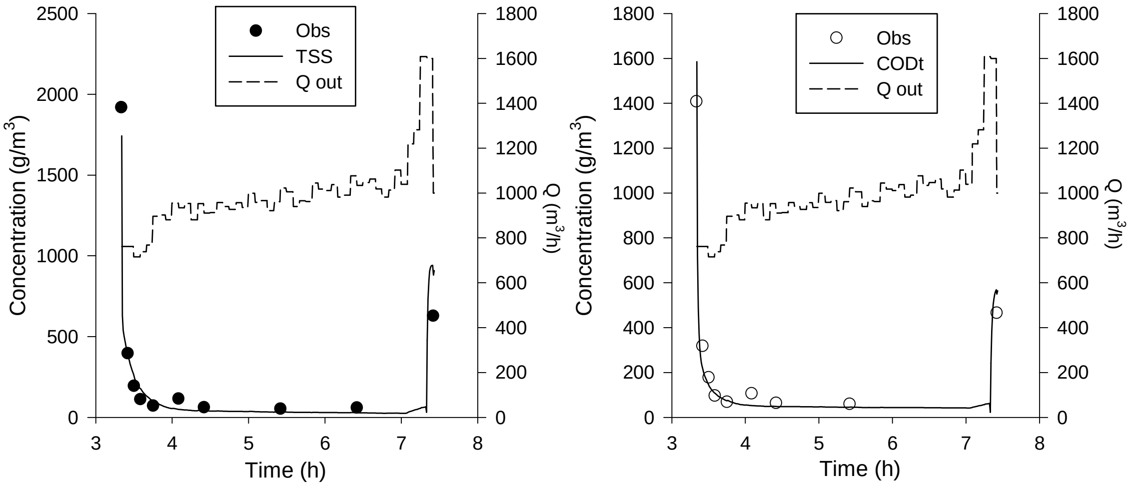

Figure 6. Calibration results for the July 27th 2009 event. a) On the left, the effluent TSS concentration; and b) on the right, the effluent CODt concentration.

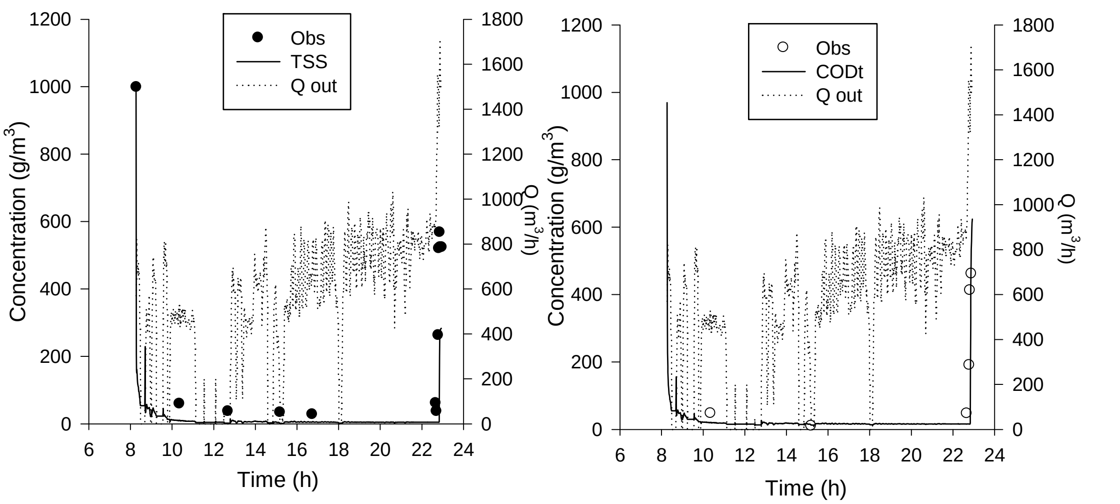

Figure 7. Calibration results for the September 27th 2009 event. a) On the left, the effluent TSS concentration; and b) on the right, the effluent CODt concentration.

Concerning the July 27th 2009 event, the emptying lasts around four hours without any interruption. It started about three hours and twenty minutes after water entered the tank. The outflow rate remained quite constant until the last fifteen minutes where it almost doubles. The first peak, resulting from the initial conditions, is well simulated. Indeed, that initial peak corresponds to the extraction of particles remaining in the PW from the previous event. To represent that initial mass, the model needs to set initial conditions. It is obvious that the Vs distribution is not equi-proportional for each class. Thus, a first warm-up simulation is run to set the particle distribution remaining in the PW as initial conditions for the real simulation (see Maruejouls *et al.*, 2012 for more details). Both for the TSS and CODt concentrations, most of the time, values are a little bit underestimated whereas for the last peak, the model also fits quite well.

The emptying of the September 27th 2009 event lasts more than fourteen hours and starts around eight hours after filling has begun. That long emptying period is explained by many interruptions of the pumps due to several problems occurring in the field. In general, the TSS concentration is slightly underestimated (for the lowest values, around 15 g/m^3 for the measurements and around 5 g/m^3 for the simulation). However, the CODt is quite well simulated even at low concentrations.

One can observe the good fit of the model with the data collected for both of the events both for TSS and for CODt. Nevertheless, it can be noticed that the CODt concentrations are more properly simulated as the middle periods of the emptying and the final peaks are well reproduced.

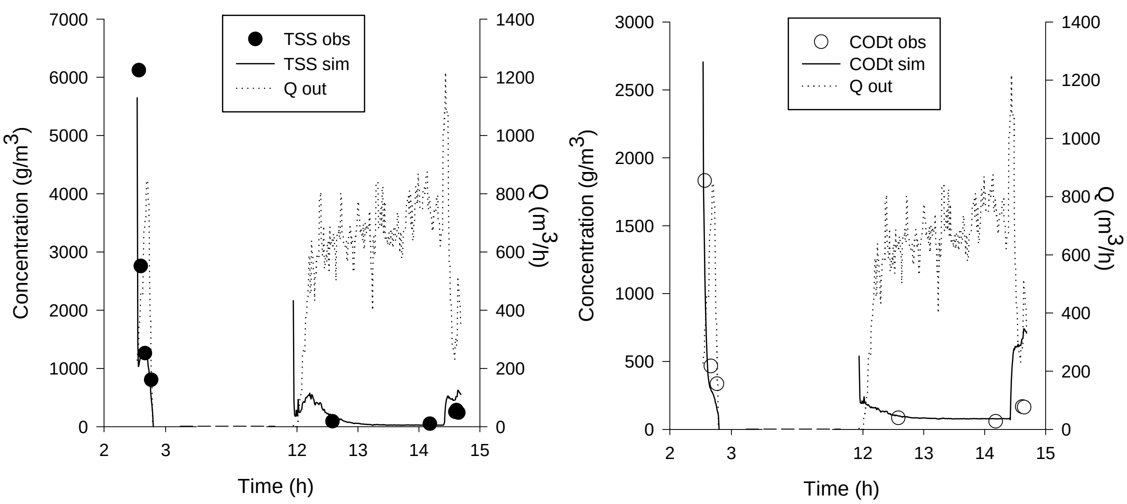

Figure 8. Validation results for the July 13th 2010 event. a) On the left, TSS effluent concentrations; and b) on the right, CODt concentrations.

3.2 Validation

The results of the validation using the parameters of Table 2 are presented in Figure 8. The emptying starts rather soon after the end of filling and lasts around nine hours. Actually, the total stored volume is emptied in two periods. The first pump activation lasts only for around 15 minutes and results in the "*initial*" peak (from 2.54 hours to 2.8 hours). A big part of the matter remaining in the PW from the previous event is released. Nevertheless, the last fraction of that remaining matter plus the particles that settled during the ten hours of storage are extracted within the second emptying period, that starts at around 12h00. This second concentration peak (at 12h00), which is actually a second "*initial*" phase, could not be validated by observations since none were collected. Between those two periods, no concentrations were calculated since no flow water is released. One can notice that for CODt, the final phase is overestimated by the model (around 800 g/m^3). It must be stated that the values observed in the field (TSS = 238 g/m^3 and CODt = 168 g/m^3) are lower than the usually observed ones (around 500 g/m^3).

4 CONCLUSION

The performance assessment of a new model describing pollutant behaviour in an off-line combined sewer retention tank has been carried out using full-scale field data. It is a 1-D phenomenological model requiring only a short simulation time. The pollutant evolution mechanisms are reproduced through three main processes: the sedimentation and resuspension of the particles, and hydrolysis of the biodegradable particulate COD. As far as the authors know, this is the first paper 1) proposing a method for the calibration of a retention tank model; and 2) showing the results of its validation. Retention tank emptying impacts both on the receiving body and the WwTP are an important issue of the integrated wastewater management and this study illustrates the potential of such a model to properly describe the water quality in combined sewers and the influent quality of a WwTP. This model has been developed to allow its integration in a "sewer – WwTP" system model. Different scenarios of emptying rules can now be tested to estimate the impact on the WwTP efficiency, i.e. scheduling the emptying of the different tanks in a sewer system in order to dilute the highest loads, or bypassing the less loaded volumes to minimize the load shocks at the WwTP.

This study provides a useful tool for integrated urban wastewater management, the performance of which has been assessed using full-scale field data. In the frame of a global approach, modelling establishes itself as essential for the understanding of wastewater engineering issues.

5 ACKNOWLEDGEMENT

The authors want to acknowledge the ret*EAU* project team for their precious help and the city of Quebec for its technical support. Funding for this work comes from the Fonds québécois de la recherche sur la nature et les technologies (FQRNT). Peter Vanrolleghem holds the Canada Research Chair on Water Quality Modelling.

6 REFERENCES

6.1.1 Journal references

Bertrand-Krajewski, J.L., Chebbo, G. and Saget, A. (1998) Distribution of pollution mass vs volume in stormwater discharges and the first flush phenomenon. *Wat. Res.*, 32(**8**), 2341-2356.

Chebbo, G. and Gromaire, M.C. (2009) ViCAs—An operating protocol to measure the distributions of suspended solid settling velocities within urban drainage samples. *J. Environ. Eng.,* **135**, 768-775.

Deletic, A. (1998) The first flush load of urban surface runoff. *Wat. Res.*, 32(**8**), 2462-2470.

Hvitved-Jacobsen, T., Vollertsen, J. and Tanaka, N. (1998) Wastewater quality changes during transport in sewers – An integrated aerobic and anaerobic model concept for carbon and sulfur microbial transformation. *Wat. Sci. & Tech.*, 38(**10**), 257-264.

Kutzner, R., Brombach, H. and Geiger, W.F. (2007) Sewer solids separation by sedimentation – the problem of modeling, validation and transferability. *Wat. Sci. & Tech.*, 55(**4**), 113-123.

Frehmann, T., Flores, C., Luekewille, F., Mietzel, T., Spengler, B. and Geiger, W.F. (2005) Modelling of sedimentation and remobilization in in-line storage sewers for stormwater treatment. *Wat. Sci. & Tech.*, 52(**5**), 151-158.

Fronteau, C., Bauwens, W. and Vanrolleghem, P.A., (1997) Integrated modelling: Comparison of state variables, processes and parameters in sewer and wastewater treatment plant models. *Wat. Sci. & Tech.*, 36(**5**), 373 - 380.

Henze, M., Grady, C.P.L., Gujer, W., Marais, G.v.R. and Matsuo, T. (1987) Activated sludge model No. 1. IAWPRC Scientific and Technical report No. 1, London.

Lessard, P. and Beck, M.B. (1991) Dynamic simulation of storm tanks. *Wat. Res.*, 25(**4**), 375-391.

Luyckx, G., Vaes, G. and Berlamont, J. (2002) Surface load as predominant factor for CSO efficiency. *In Proceedings, 9th International Conference on Urban Drainage*, Portland, USA.

Maruejouls, T., Vanrolleghem, P.A., Pelletier, G., and Lessard, P. (2012) A phenomenological retention tank model using settling velocity distributions. *Wat. Res.* XXX. *(status: in press* ; available online; accessed March 20th 2012) http://www.sciencedirect.com/science/article/pii/S0043135411007597)

Maruejouls, T., Lessard, P., Wipliez, B., Pelletier, G. and Vanrolleghem, P.A. (2011) Characterization of the potential impact of retention tank emptying on wastewater primary treatment: a new element for CSO management. *Wat. Sci. & Tech.* 64(**9**), 1898-1905.

Michelbach, S. (1995) Origin, resuspension and settling characteristics of solids transported in combined sewage. *Wat. Sci. & Tech.*, 31(**7**), 61-69.

Rauch, W., Bertrand-Krajewski, J.-L., Krebs, P., Mark, O., Schilling, W., Schütze, M. and Vanrolleghem, P.A. (2002) Deterministic modelling of integrated urban drainage systems *Wat. Res.*, 45(**3**), 81-94.

Wong, T.H.F. and Geiger, W.F. (1997) Adaptation of wastewater surface flow wetland formulae for application in constructed stormwater wetlands. *Ecol. Eng.*, 9, 187–202.

6.1.2 Book references

APHA, AWWA, WEC (2005) *Standard Methods for Examination of Water and Wastewater*. 21st edition. Centennial Edition. American Public Health Association, Washington, DC, USA.

Boxall, J., Saul, A. and Shepherd, W. (2007) *Performance of Storm Tanks and Potential for Improvements in Overall Storm Management – Phase 2*. Wastewater Treatment and Sewerage: Collection Systems WW/22. Yorkshire Water Services Ltd. (UK Water Industry Research), Gordon Rogers.

Vallet, B. (2011) *Stormtank modelling in view of improving the river water quality by real-time control*. PhD thesis in civil engineerng at Université Laval, Québec, Qc, Canada. 358p. (*partially in French*)

6.1.3 References in languages other than English

Brombach, H. and Weiß, G. (1997) Hydrodynamic separators (FluidSep): Notes on planning and dimensioning. Handbuch Wasser 4, Landesanstalt für Umweltschutz Baden-Württemberg (ed.), Karlsruhe, Germany. (*in German*)

Vazquez, J., Dufresne, M., Terfous, A., Ghenaim, A. and Poulet, J.-B. (2008) Forecasting storm tank efficiency using 3D modeling: from the experiment tank to the full-scale structure. *La Houille Blanche*, Octobre 5, 92-98 (*in French*).

7 QUESTIONARY

1. Name of the author that will present the paper: **Peter Vanrolleghem**

(please note that one author can have only one oral and one poster presentation at the Conference)

2. Is the first author an young researcher (according to IWA, under the age of 35): **Yes**

3. Have you submitted the extended abstract yet: **Yes**

If **Yes**, give the file name of extended abstract: URBAN STORMWATER MANAGEMENT: CALIBRATION AND VALIDATION OF AN OFF-LINE RETENTION TANK DYNAMIC MODEL FOR WATER QUALITY

4. Have you previously published this paper at another conference or Journal: **No**

5. Do you want to have the full paper offered for the Journal:

Water Science and Technology: **No**

Journal of Hydraulic Research: **No**

Other Journal: **Urban Water Journal**

6. Have you checked your paper for style, formatting and English language: **Yes**