A new approach of measuring TSS settling velocity based on turbidity measurements

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INTRODUCTION & OBJECTIVES

Total Suspended Solids (TSS) are a major source of pollution in storm- and wastewater as they transport at least 50% of organic matter, nitrogen & phosphorus, pathogens, heavy metals & micropollutants and inorganics (sand) (Vanrolleghem *et al.*, 2018). To understand their fate in sewers multiple characteristics have been suggested: size, density, settling velocity. The latter is of interest to this work as a Particulate Settling Velocity Distribution (PSVD) provides key information on the settleability of particles, as they exist in raw wastewater and stormwater, and provides insight in particles transport mechanisms.

The main objective of this work is to provide a more practical procedure for determining the PSVD using an automated equipment based on turbidity meters rather than on manual TSS measurements as with the original ViCAs protocol (French acronym of "wastewater settling velocity") (Chebbo and Gromaire,2009).

METHODOLOGY

In this work, two experimental set-ups are used. The first set-up is the standard ViCAs column used to measure the cumulative mass $M(t)$ of solids having settled at the bottom of the column (Figure 1, left). The second set-up is a closed settling column equipped with two turbidity meters at two different heights (Figure 1, right) developed as part of a research initiation project at INSA Lyon (France). Generally, no pre-treatment of wastewater sample is required. The homogenous sample fills the settling columns quickly thanks to a vacuum pump and particles are then subject to settling.

In the standard ViCAs protocol, the mass of TSS which settles at the bottom of the settling column is collected by the operator in aluminium cups at predefined times and then measured. By cumulating these masses over time, one obtains the experimental $M(t)$ curve. The $M(t)$ curve is then transformed into the final PSVD curve by means of a model based on the following assumptions: i) the settling column is virtually divided into layers; ii) the particles are distributed in classes, each class being characterised by its settling velocity; iii) particles settle from upper layers to lower layers according to their settling velocities; iv) a mass balance is calculated over time for each class of particles in each layer, starting with an initially homogeneous distribution of particles in the entire column at $t = 0$, and v) the accumulated particles reaching the lowest layer at the bottom of the column are compared with what has accumulated in the aluminium cups. The standard ViCAs protocol requires i) several manual operations by a trained operator with risks of errors (although training is swift as shown by many student trainees able to perform repeatable ViCAs experiments after a few tests), and ii) many hours to measure the TSS. Thus, a more automated protocol is desirable.

The proposed new protocol derives the PSVD curve from the settling experiment where the turbidity is continuously measured at two different heights. The developed parametric model, which in addition to the previous assumptions requires a correlation between turbidity and TSS concentrations for changing fractions of classes of particles at the two measuring points, determines the PSVD curve from a *prior* approximation which is then transformed into a final *posterior* PSVD curve by using the two measured turbidity time series. The standard ViCAs protocol is used as a reference to validate the new protocol.

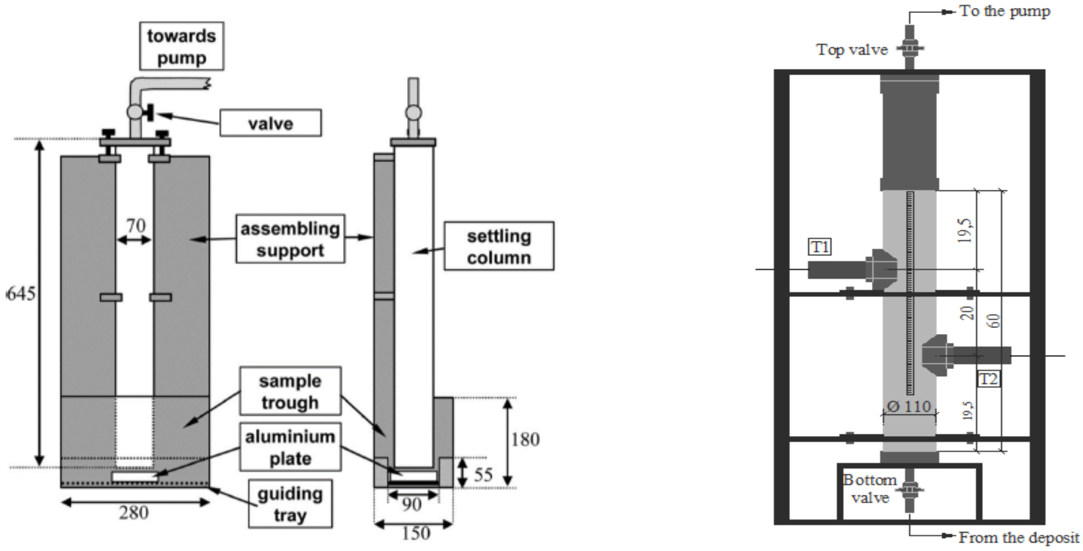

Figure 1 Left: Scheme of standard ViCAs equipment; Right: Settling column with two turbidity meters

RESULTS

Initial results suggest that there is a great opportunity to substitute the manual procedure with an automated protocol to acquire the evolution of particulate concentrations in the settling column (Figure 2). Further experiments and parameter estimation exercises are scheduled to improve the fit between measured and modelled turbidity curves in order to obtain more accurate PSVD curves.
A combination of the two tests: using turbidity measurements and the accumulated mass at the bottom of the settling column can also be looked at for improved parameter estimation and a better fit between modelled and experimental curves.

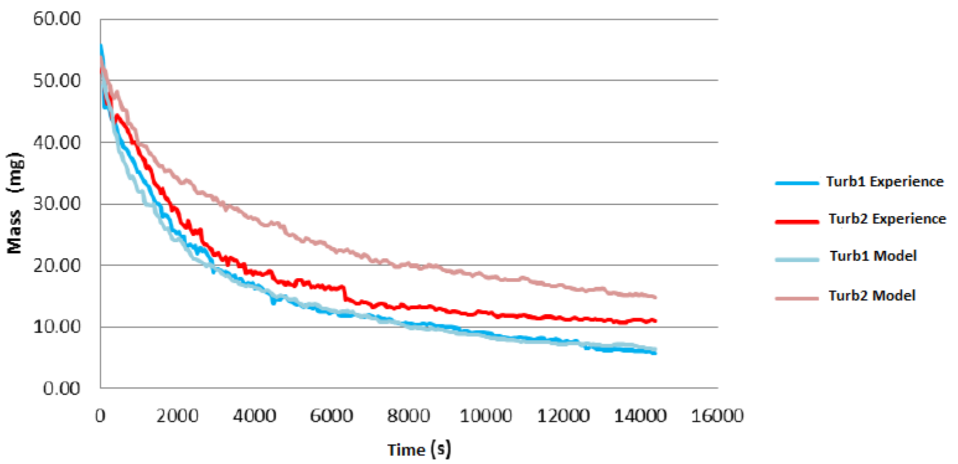

Figure 2 Preliminary comparison of turbidity settling measurements with pre-calibrated models.

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