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Physical Model: Sand separation in a sediment trap of a WWTP using pressurized air

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Background

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To avoid the deposition of coarse sediment on screens before sand traps in waste water treatment plants (WWTP) an upstream sediment trap with a planar aeration (Fig. 1) is planned. Several pulses of controlled pressurized air ensure the remobilisation and thus, the separation of fine from coarse fractions. While the separated finer fractions are transported to the sand trap, the coarser fractions remain in the sediment trap for grabber removal, if necessary. The objective of this study is to optimize the operational parameters using a physical model experiment. (Fig. 2 and Fig. 3).

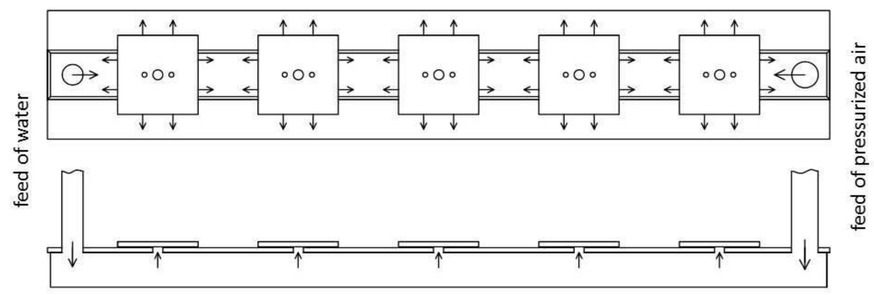

Fig. 1: Schematic sketch of a single aeration unit. Arrows show the inflow of pressurized air for the remobilsation of fine sediments and water to avoid clogging of the aeration units.

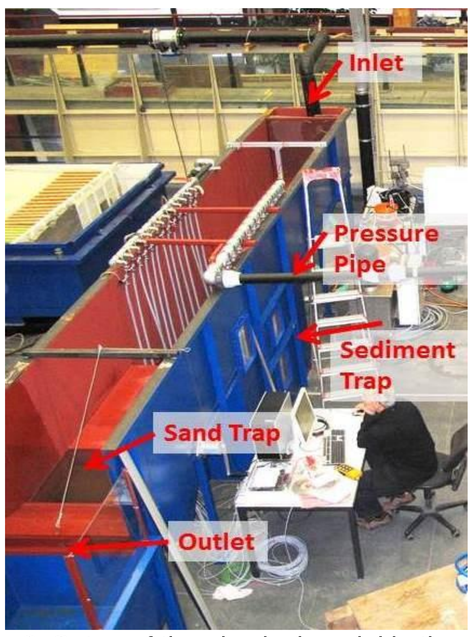

Fig. 2: Setup of the physical model in the hydraulic laboratory

Setup and Performance of the Experiment

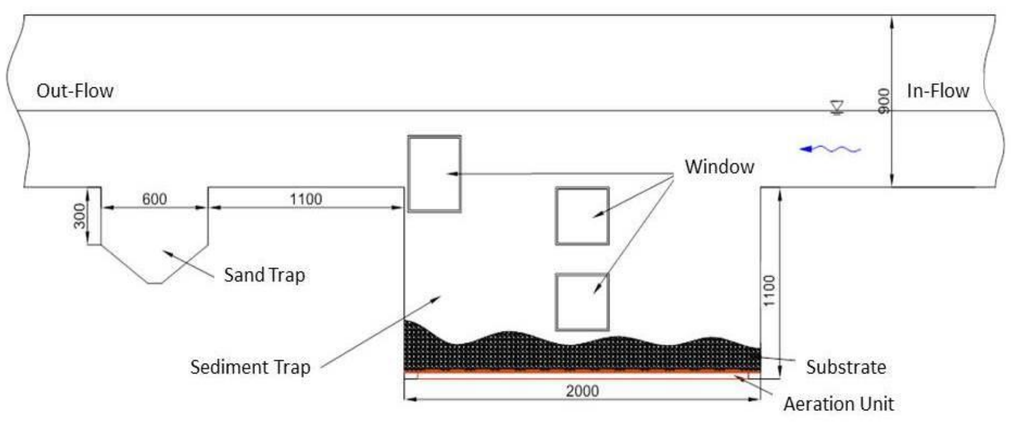

Fig. 3: Schematic sketch with dimensions [mm] of the model in the hydraulic laboratory.

Setup of the experiment

The setup of the experiment (Fig. 2 and Fig. 3) contains next to the sediment trap with aeration units an additional sand trap to quantify the amount of fines separated from the material in the sediment trap.

Performance of the experiment

For each run of the experiment, a coarse mixture of cobbles is introduced on top of the aeration units (Fig. 4). Afterwards a 5 cm thick mixture layer of coarse and fine material is spread. This mixture approximates the natural sediment condition (devoid of organic matter) in the inflow of the WWTP (Fig. 5).
The experiments encompass the investigations of the different influences of the most relevant operational variables on sediment separation. Therefore, the following parameters are varied: thickness of the sediment layer, volume of the pressurized air flow, longitudinal flow discharge and aeration interval.

Fig. 4: Introduced coarse cobble mixture on top of the aeration units (plan view)

Fig. 5: Introduced coarse cobble layer with 5 cm layer of coarse and fine material on top. (lateral view)

Results

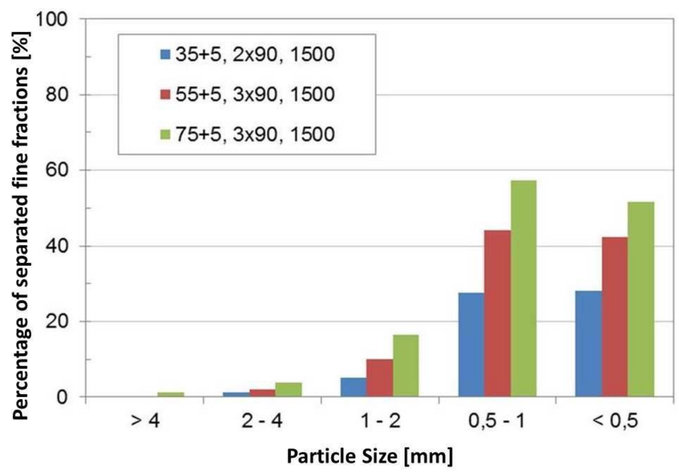

Fig. 6: Separated percentages for different particle size classes for a series of model runs with constant pressurized air flow (1500m³/h) and aeration time (90s) for different thicknesses of sediment layers (35cm coarse material + 5cm mixture of coarse and fine material, 55cm coarse material + 5cm mixture, 75cm coarse material + 5cm mixture).

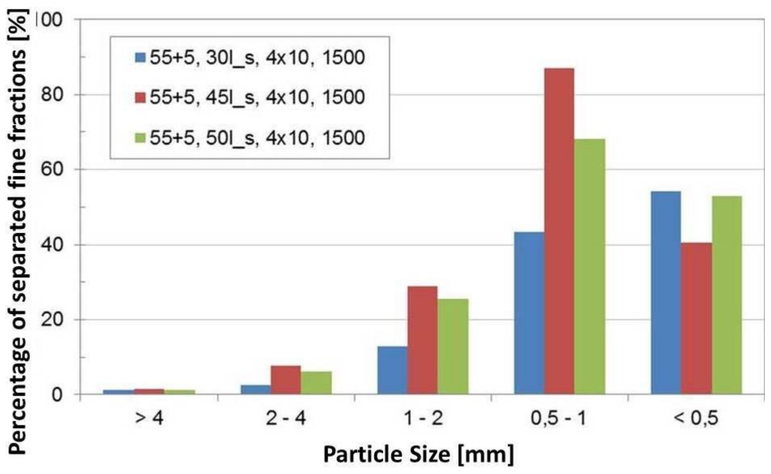

Fig. 7 Separated percentages for different particle size classes for a series of model runs with constant layer thickness (55cm coarse material + 5cm mixture), aeration time (10s), and pressurized air flow (1500m³/h) for variable longitudinal flow discharges (30l/s, 45l/s, 50l/s)

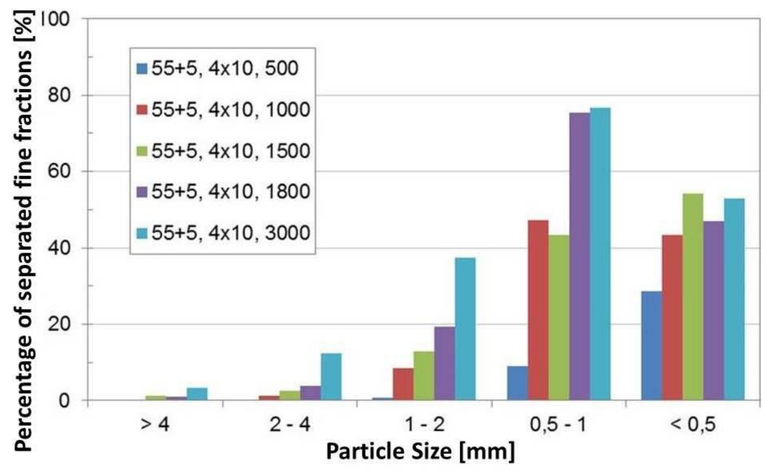

Fig. 8: Separated percentages for different particle size classes for a series of model runs with constant longitudinal flow discharge (30l/s), thickness of introduced material (55cm coarse material + 5cm mixture) and aeration time (10s) for variable pressurized air flow (500m³/h–3000m³/h)

Summary

The results show that an increase of the pressurized air flow, an increase of the sediment layer thickness and an increase of the longitudinal flow discharge is advantageous for the separation of fine from coarse fractions in the sediment trap. The increasing separation rates for increasing sediment layer thicknesses is caused by the reduction of the lifting distance (between sediment surface and longitudinal water flow). An air flow of 3000m³/h, a sediment layer of 80cm, a discharge of 50l/s and an intermittent aeration of 4 x 10s lead to highest separation rates of fine material (e.g. complete separation of particle sizes <1 mm).