Quality characteristics of urban stormwater runoff at the outlet of a separate sewer network

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INTRODUCTION

Rainfall related point discharges from urban systems are a major source of pollution of surface water bodies. Most pollutants are associated to particulate matter. In order to estimate the pollution potential from these discharges it is essential to get more information about quality and quantity of discharged solids.

SAMPLING

A submerged pump (fig. 1) was installed at the inlet of a storm water sedimentation tank and pumped samples in a 1000 liter sampling tank (fig. 2). Composite samples were obtained based upon the effluent flow of the stormwater sedimentation tank, i.e. the higher the (effluent) flow the higher the frequency at which the samples were taken. Samples were taken over a period of one month, so that several storm events could be analyzed and time depended effects could be estimated.

After settling took place in the sampling tank, solids were removed and divided in the following fractions via wet sieving:

- clay & silt (< 0,063 mm)
- sand (0,063 - < 2 mm)
- gravel (≥ 2 mm)

The fractionated samples were analysed for dry weight and organic content (loss on ignition – LOI).

Figure 1 Submerged pump in the inlet of a stormwater sedimentation tank

Figure 2 Sampling tank (1000 Liters)

RESULTS

The following results are related to an urban catchment with a drainage area of 75 ha.

About 78 % of the dried sediment consists of the clay & silt fraction (< 63 µm) (fig. 3). The larger the particle size the higher and more variable is the content of organic matter (expressed as loss on ignition - LOI) (fig. 4). Because of the high amount and constant values, the fine fraction (< 63 µm) was chosen for further investigation.

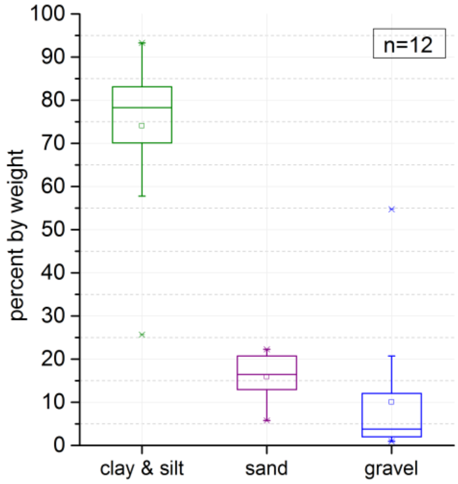

Figure 3 Percent by weight of the separated fractions

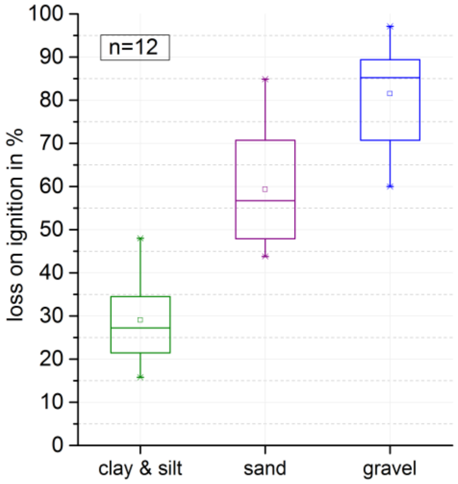

Figure 4 Loss on ignition in the separated fractions

We determined that the organic content decreases with increasing maximum rainfall intensity and with increasing load of fine suspended solids. The organic content increases with increasing dry weather days (not shown here).

A good correlation (after Pearson) between the clay & silt load and rainfall related characteristics was observed (fig. 5 and fig. 6).

The relationship between rainfall and solid characteristics like antecedent dry weather days and organic content or load of clay & silt show that the load of particulate matter decreases the longer the dry period is (fig. 5). Furthermore increases the load of clay & silt the higher the rainfall intensity is (fig. 6).

To calculate the suspended solids load two kind of models – one after Gupta and Saul, 1996 (power function) and one linear regression model - were compared.

Gupta and Saul determined the following power function based formula:

$$load_{TSS} = \alpha * D^{\beta} * I_{max}^{\gamma} * ADWP^{\delta} \qquad (1)$$

With	α, β, γ, δ:	empirical numerical coefficients
	D:	Storm duration in hours
	I_{max}:	maximum storm intensity in mm per min
	ADWP:	ancient dry weather period in days

For the given values no significant correlation was found for load and storm duration (Pearson R = 0,38, sig. = 0,45). Therefore this term was not considered in the estimation of the empirical coefficients for this area.

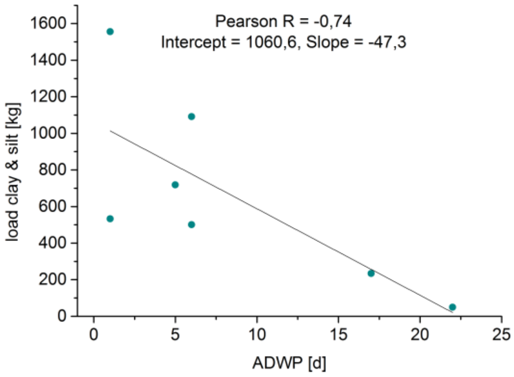

Figure 5 Correlation between dry weather days and load of clay & silt

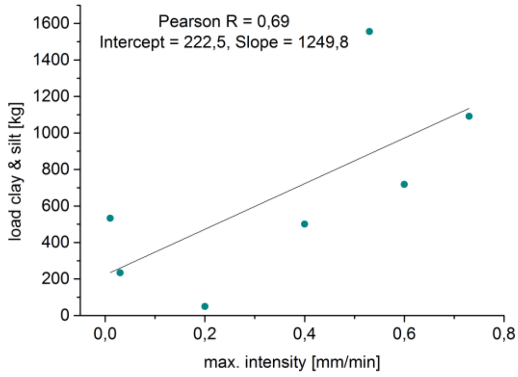

Figure 6 Correlation between maximum rain intensity and load of clay & silt

For the considered site, the following formula was determined:

$$load_{TSS} = 1952{,}55 * I_{max}^{0{,}31} * ADWP^{-0{,}46} \quad (2)$$

Figure 7 shows the estimated loads with the modified power function by Gupta and Saul, the measured loads and loads, which are calculated with a linear regression function:

$$load_{TSS} = 660 + 846{,}7 * I_{max} - 35{,}4 * ADWP \quad (3)$$

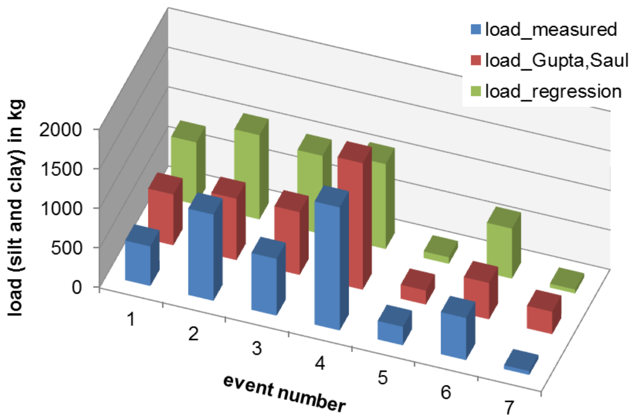

Figure 7 Comparison of measured and predicted loads

DISCUSSION

The correlation by Gupta and Saul was derived from first-flush data. The data for this paper are related to a sequence of several storm events (one to five) with different durations and intensities. It seems that storm duration is no dependent variable for time dependent effects.

The calculation of loads is based on measured data at the outflow of a stormwater sewer. Gupta and Saul, 1996 used dates from combined sewer flows. Both estimations identified the maximum intensity and antecedent dry weather period as important factors. This shows that stormwater characteristics dominate the suspended solids load.

CONCLUSION AND OUTLOOK

The results presented above allow a first estimation of relationships between organic matter and amount of clay & silt solids as well as a first prediction of clay and silt loads in storm water runoff in relation to rainfall characteristics.

Since high-resolution precipitation data for the other regarded urban catchments are not available, a comparison between these catchments was not possible. Site specific empiric parameters have to be determined by further investigation. It has to be examined if the predicted load can be confirmed by data from single storm events.

ACKNOWLEDGEMENT

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REFERENCES

Gupta and Saul, 1996: Specific relationships for the first flush load in combined sewer flows. *Wat. Res*., 30(5), p. 1244–1252