Size Dependant Metal Loads of Urban Stormwater Runoff Compared to the Loads of Total Suspended Solids

Comparaison des charges métalliques fonction de la taille et des charges totales de matières en suspension dans les eaux de ruissellement urbain

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RÉSUMÉ

Une campagne de contrôle des eaux pluviales d'une installation de traitement est menée afin d'étudier de façon plus approfondie la relation entre l'élimination des MES et la réduction de la charge polluante. Par conséquent, les caractéristiques des particules sont étudiées ainsi que 6 métaux associés au sein de différentes fractions granulométriques. La distribution des phases des métaux évalués montre qu'ils sont presque entièrement transportés dans la phase particulaire. En comparant les proportions de charge métallique aux proportions de MES à différentes granulométries, on peut observer que la grande partie provient de la fraction granuleuse la plus petite. Cependant, les particules les plus grossières contribuent également de manière significative à la charge totale de métal. Dans une prochaine étape, plus d'événements pluvieux et de métaux seront évalués et une comparaison avec une sélection de micropolluants organiques sera effectuée.

ABSTRACT

A stormwater monitoring campaign at a treatment facility is undertaken to further investigate the relationship of TSS removal and the reduction of the pollutant loads. Therefore the particle characteristics are investigated as well as 6 associated metals within different particle size fractions. The phase distribution of the evaluated metals show that they are almost completely transported in the particulate phase. Comparing the metal load proportions to the proportions of TSS within different size fractions it can be seen that the biggest part is contributed by the smallest particle fraction, however also the coarser particles contribute a significant amount to the total metal load. In a next step more rain events and metals will be evaluated and a comparison to a selection of organic micropollutants will be done.

KEYWORDS

Heavy Metals, Particle Size Distribution, Stormwater Quality, Total Suspended Solids

1 INTRODUCTION

Urban stormwater runoff can be highly contaminated. It is recognized to have significant negative impact on aquatic ecosystems worldwide. The pollution of urban runoff varies depending of the catchment area and the anthropogenic activities within that catchment. To design effective treatment measures a realistic estimation of urban stormwater pollutant loads is required. Very often models are used to support the process of planning and the implementation of urban drainage strategies. However, due to the fact that usually models are based upon empirical equations or simple regression functions to simulate the complex reality of nature, model outputs can be highly uncertain (Dotto et al. 2010). Therefore, in depth knowledge of physical and chemical particle characteristics such as particle size distribution (PSD), organic content, settling velocities or pollutant loading etc. is very important.

In this abstract the phase distribution, the respective total metal load within different size and the corresponding TSS load for so far 6 analysed rain events will be shown. The background of this ongoing study is to further investigate the hypothesis that with the removal of total suspended solids (TSS) a significant amount of particulate micropollutants can be removed as well. However, this hypothesis is strongly dependent on the characteristics of the particles in urban runoff and their associated pollutants, in this case metals. If, as literature suggests, the fine fraction is contaminated the most (Xanthopoulos and Hahn 1990), as well as the amount of fine particles in urban runoff is about 70-80 % of the total suspended solids (Fuchs et al. 2013), the hypothesis is doubtful. Due to the overall better removal efficiency of coarse particles, this less polluted fraction would be removed but the major part of pollutants would reaches the receiving waters with the fine fraction.

2 MATERIALS AND METHODS

2.1 Study area and monitored treatment facility

The catchment is located in the city of Freiburg in the south west of Germany. The area mainly consists of industrial and commercial buildings. It has a size of 110 ha with a degree of paving of 0.7. The complete catchment is served by a separate system. At the outlet of the area the stormwater sewer has a diameter of 2 m and is part of the treatment facility located there. It is an underground concrete build facility. Due to a movable weir it is possible to discharge a certain amount of treated water after an adjustable sedimentation period (currently 6 h) into the receiving water. The retained and after the sedimentation period highly polluted water is then discharged to the waste water sewer.

2.2 Sampling strategies and laboratory analyses

Large volume sampling tanks with a volume of about 1000 L are used. Two submersible pumps fill these containers volume proportional to each discharge (treated water and retained waste water). After a sedimentation time of about 3 to 5 days the solids are taken out of the containers and brought to the laboratory for further analysis. The analysis includes the PSD (< 63 µm, 63-125 µm, 125-250 µm and 250-2000 µm), the corresponding event mean concentrations (EMC) as well as the organic content of the particles in the respective size fractions. Furthermore the samples are analyzed for metals and numerous micropollutants. The sample taking, the preparation of the samples and the analytical steps are modified from (Fuchs et al. 2013; Dierschke and Welker 2015). A more detailed description of the study area, and the sampling and laboratory analyses can be found in (Baum and Dittmer 2017).

3 RESULTS AND DISCUSSION

The ongoing monitoring campaign is running since January 2017. Despite some technical problems of the operator and a very dry summer 2018, in total 24 rain events could be sampled so far. However due the rather big analytical program (besides standard parameter like COD, TOC, DOC, TSS etc. more than about 30 micropollutants and 20 metals are analysed) only 6 events have been analysed and evaluated for a small selection of 6 metals (Aluminium, Iron, Cupper, Cadmium, Lead) so far.

Fig. 3.1 shows the selected metals and their respective mean phase distribution for the considered 6 rain events. It can be seen that only cupper and cadmium show a small dissolved part. However also for those two elements the biggest part is transported in the particulate phase. The partitioning of metals in urban runoff is strongly influenced by the pH. The pH of the evaluated rain events was in the range of 6.6 to 7.7

Fig 3.2 shows the load proportion of the selected metals. It clearly can be seen that the smallest particles contribute the most to the total metal load (59%-69%). When comparing the load proportions in Fig. 3.2 with the respective particle size distribution of the respective rain events (Fig. 3.3) it can be seen that overall trend of the load distribution is the same. However 6% of TSS (63 – 125 µm) contribute 22 % - 28 % of the total metal load.

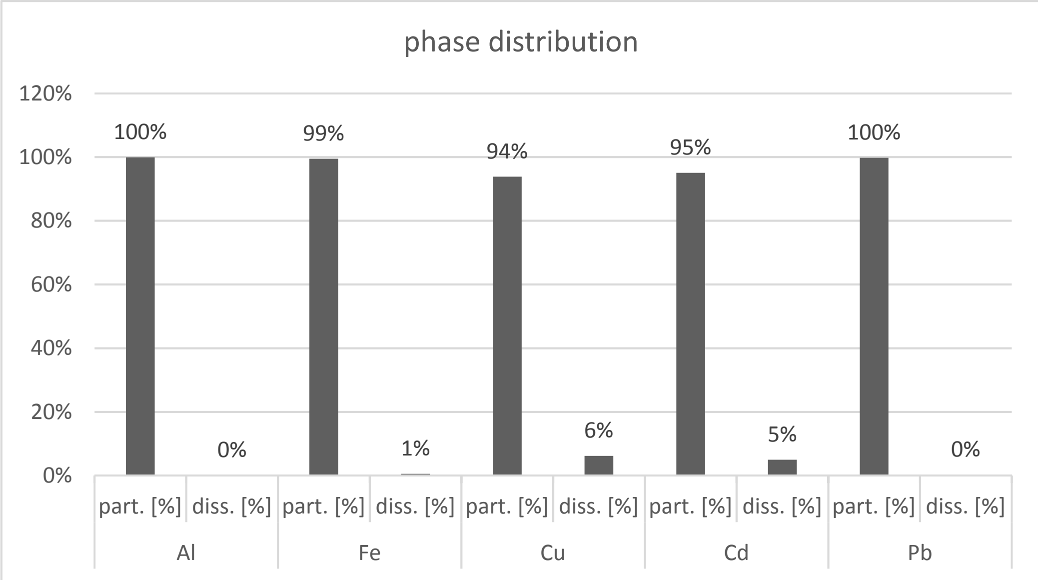

Fig. 3.1 : phase distribution of selected metals. 6 rain events

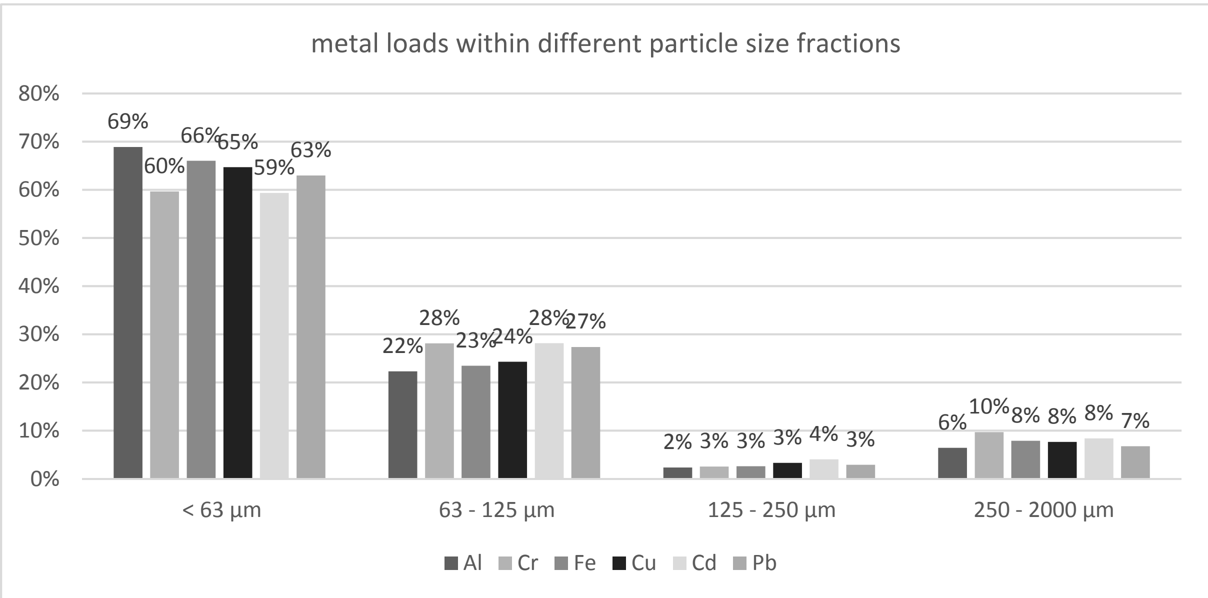

Fig. 3.2 : proportion of metal loads within different particle size fractions.

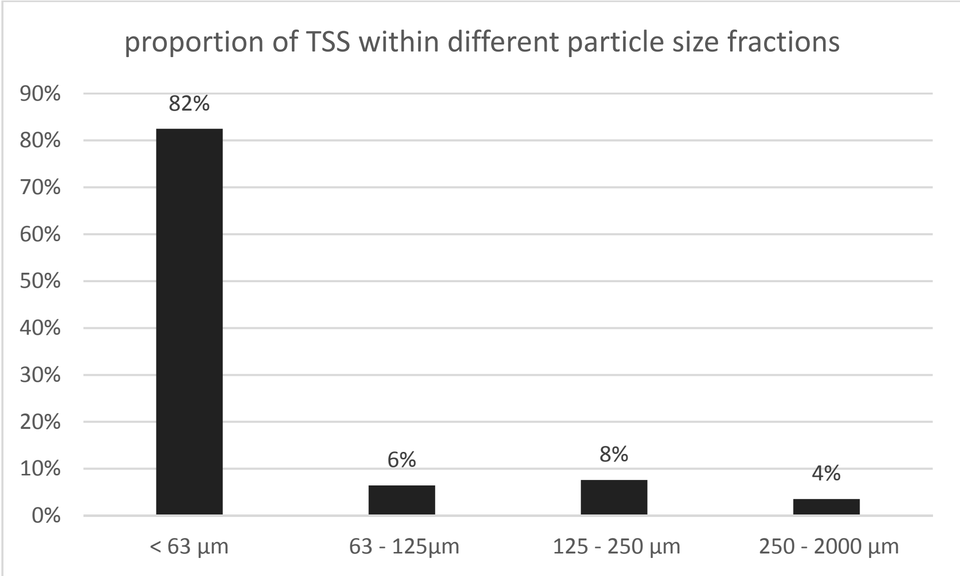

Fig. 3.3 : particle size distribution of the evaluated 6 rain events shown as particle size proportions of the total amount of suspended solids.

4 CONCLUSION AND OUTLOOK

Referring to the issue behind the investigations (further investigation of the hypothesis, that with the removal of total suspended solids (TSS), a significant amount of pollutants can be removed as well) the obtained results so far suggest, that by reducing the TSS load, the metal load can be reduced significantly as well. At least in terms of the 6 metals evaluated so far.

The evaluated data pool so far is rather small. However, the monitoring campaign is still ongoing, and in the upcoming months until the conference the total of 24 rain events will be analysed and evaluated for about 20 metals. The focus will also be on the variation between the different rain events and the pollutant loading of the different particle size fractions. The results for metals will be compared to a selection of organic micropollutants to further investigate if the overall pollution can be reduced by the removal of total suspended solids.

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