Characterisation and Treatment of Nano-sized Particles, Colloids and Associated Polycyclic Aromatic Hydrocarbons in Stormwater - DTU Orbit (16/11/2019)

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Stormwater from urban areas contains a vast array of different pollutants, including particulate matter and organic and inorganic compounds as well as microbial pollution. These compounds can be found associated with particulate matter, colloids and nano-sized particles in stormwater. The associated pollutants will, if not removed in stormwater treatment facilities, be discharged into receiving surface waters, due to enhanced transportation exerted by the colloids and nano-sized particles. More stormwater than previously is separated from wastewater and drained to stormwater treatment facilities in Denmark. This is a consequence of climate changes, with increasing precipitation in Europe. The increased precipitation causes problems with hydraulic overloading of sewer systems and therefore stormwater is directed into stormwater drainage systems and to stormwater treatment facilities. Since little is known about the colloids and nano-sized particle-enhanced transportation of pollutants in stormwater, it has been difficult to determine their quantitative role in the total release of pollutants into receiving waters. Therefore the main purpose of this thesis has been to document the presence and size distribution of colloids and nano-sized particles in stormwater, as well as quantify the particle-enhanced transportation of polycyclic aromatic hydrocarbons (PAHs) in stormwater. Stormwater from five sites in Europe was collected to characterise the particulate matter, colloids and nano-sized particles in the stormwater, in terms of particle size distribution (PSD) and zeta potential. In combination with the characterisation of the particles, concentrations of organic and inorganic compounds were quantified in the stormwater, with a focus on PAHs, together with physical and chemical parameters such as pH, Total Suspended Solid (TSS), turbidity, and electrical conductivity. The five sites where stormwater was sampled from used two different methods of stormwater treatment: settling and filtration, and four different treatment techniques: detention ponds, stormwater pond, disc filter and combined sedimentation tanks. From all sites, inlet and outlet stormwater were collected, and pollutant concentrations were quantified as well as the removal efficiencies calculated. The colloidal and nano-sized particle-enhanced transportation of pollutants was also scrutinised in the stormwater. The μm-range PSD measured in the stormwater showed that the majority of the particles were < 10 μm in diameter (both inlet and outlet samples). The nm-range PSD on the colloids and nano-sized particles was found in the size range of 50–200 nm in diameter. The zeta potentials were negative for all of the stormwater (-13 – -50 mV), indicating a negative surface charge. This indicates that the particles in the stormwater were of clay and silt and also humic and fulvic acids. For all five stormwater treatment facilities, the measurements showed a reduction of particulate matter, quantified as TSS and turbidity, as well as organic and inorganic pollutant content from the inlet to the outlet samples. The PSD was found to be identical for inlet and outlet samples, despite a reduction in pollutant components. Sorption experiments using stormwater and a passive dosing technique revealed that the stormwater particulate fractions were able to sorb PAHs, thereby enhancing the transportation in stormwater. In the stormwater collected from the four of the five different sites was PAHs found associated with the particulate fraction containing the large particles (>0.7 μm). The PAHs were also found sorbed to the colloids (4.2-56%) and occurred in the dissolved fraction (0.9-25%). From one of the sites, 82% of the PAHs were found in the particulate fraction in the inlet sample and 18% in the colloidal fraction (< 0.7 μm). The PAHs occurred also in both fractions in the outlet samples, but in lower concentrations. Overall, it was found that 30–40% of the PAHs were associated with colloids (< 0.7 μm), and that the PAHs of 4–5 aromatic rings were more often in association with the colloids and nano-sized particles than with particles > 10 μm. The particulate matter, colloids and nano-sized particles are able to sorb PAHs and thereby enhance the transportation of PAHs in stormwater systems. To gain a better understanding of the colloids and nano-sized particles in stormwater, techniques to separate nano-sized particles and colloids should be further investigated. Thereby a more quantitative measurement of the PSD could be achieved.

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