Absorptive Removal of Selected Heavy Metals from Urban Stormwater Runoff

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Abstract

Urban stormwater runoff carries various kinds of contaminants from the impervious surfaces (e.g. roads, freeways, sidewalks, roofed structures, parking lots, airports, and industrial sites) into the sewer systems and receiving waters. Amongst the most commonly found contaminants in urban runoff are heavy metals. These can be very toxic to aquatic life and can have acute or chronic adverse effects on human health. Therefore, attention should be directed to develop technologies for efficient and cost-effective removal of heavy metals from the stormwater runoff.

Currently there are several treatment methods available for removal of heavy metals from urban stormwater runoff. Chemical precipitation, coagulation-flocculation, ion exchange, and membrane filtration produce large volumes of sludge and waste that need to be disposed of and can consequently cause a lot of problems to the environment due to the high content of toxic and hazardous content. Technologies such as ultra filtration, nanofiltration, and reverse osmosis are also associated with high capital and operational costs. One of the technologies that can overcome the aforementioned disadvantages is adsorptive removal of contaminants.

Adsorption technology has many advantages over other treatment methods: simple design, low investment cost, limited waste production, etc. (Viraraghven and Dronamraju, 1993). Recently, many researches revealed that effective removal of heavy metals such as arsenic, cadmium, chromium, copper and lead can be achieved by using iron oxide based adsorbents e.g. Iron Oxide Coated Sand (IOCS) (Petrusevski, 2000). The majority of previous research work on heavy metal removal by adsorptive filtration was conducted by using model water with a single heavy metal. Only few studies have been carried out with model water mirroring real stormwater composition (Genç-Fuhrman, et al., 2007).

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In presented study, IOCS was used to investigate competitive adsorptive removal of selected heavy metals, namely chromium, lead, cadmium and copper. A series of batch adsorption experiments were conducted to first remove single metals (Cd, Cu, Cr(III), Cr(VI), and Pb), *Adsorptive Removal of Selected Heavy Metals from Urban Stormwater Runoff* followed by experiments in which model water contained combination of different metals with Cr(III) and Cr(VI). Simultaneously, blank experiments were conducted with model water without adsorbent, to determine the stability of metals in model water.

To assess the effectiveness of selected heavy metals removal, two types of model water were used in batch adsorption experiments:

(i) Model water without HCO3- with an initial pH≈6, and
(ii) Model water with 100 mg/L HCO3- and pH adjusted to 6.

The model water was prepared in laboratory using demineralised water and taking into account concentrations of these metals in urban-run-off of developed countries (adopted from: Göbel et. al., 2007):

- chromium - 50 µg/L,
- cadmium - 13 µg/L,
- copper - 140 µg/L and
- lead - 525 µg/L.

The contact time was 24 hours with fixed amount of 0.2 g/L IOCS. IOCS used is a by-product from Brucht water treatment plant, which treats groundwater with high iron content. PHREEQC software was used to predict equilibrium conditions of selected metals under studied conditions. Results obtained demonstrated that under conditioned applied all metals included in this study, with an exception of Cr(VI), can be efficiently removed from model water containing either single or combination of two metals (Fig. 1).

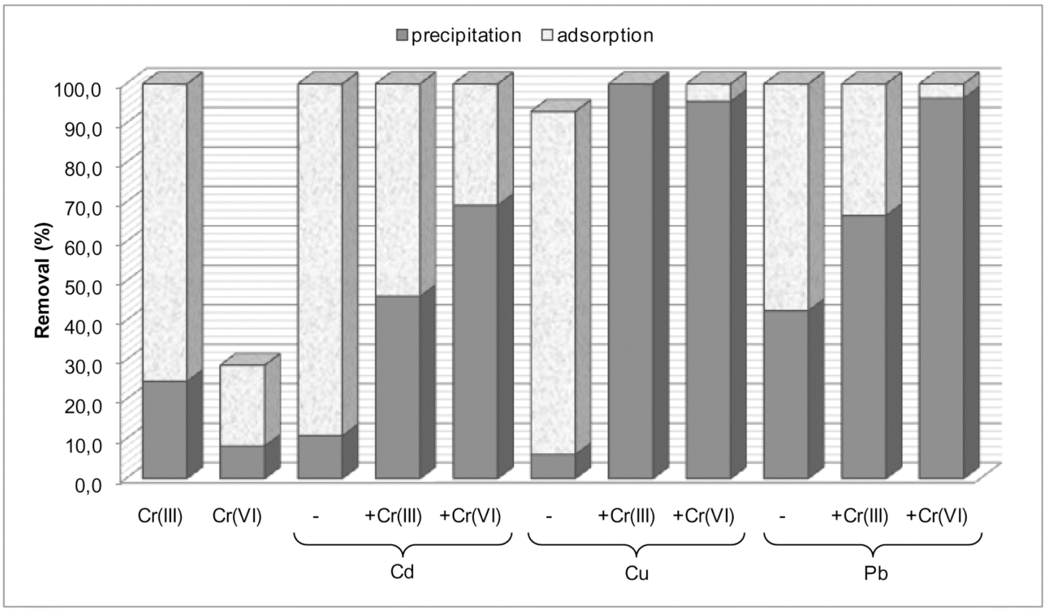

Figure 1 Removal of heavy metals from model water after 24 hrs of contact time. Model water containing 100 mg/L of HCO3- and pH adjusted to 6.

Complete removal of most metals studies was achieved within 15 min of contact time. Two removal mechanisms, namely precipitation and adsorption, were found to be responsible for removal of studied metals. For model water with a single metal adsorption on IOCS was found to be the predominant removal mechanism. Results obtained also showed that presence of multiple metals in model water resulted in a shift of removal mechanisms from adsorption to precipitation. Presence of HCO3- increased precipitation of all metals studied. The effect was most pronounced in the case of copper. Specific contribution of precipitation and adsorption to overall removal is a function of a metal type and water quality (e.g. pH and HCO3- concentration). In agreement with the experimental results PHREEQC predicted precipitation of Cr(III) in both model water with and without HCO3-. Calculations with the PHREEQC model showed that co-occurrence of metals, under conditions applied, could enhance the precipitation of some metals.

Full paper will further provide detailed results of conducted batch adsorption experiments and will extrapolate on possible use of treatment based on combination of adsorption on IOCS and precipitation in practice.

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