HEAVY METALS IN THE FINEST SIZE FRACTIONS OF ROAD DUST

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Introduction

The dust deposited on the street is a multi-component material composed of mineral constituents, natural biogenic materials and anthropogenic inorganic/organic matters. In paved road urban environments sources of road dust are to a large extent wear products from tires, brakes and the road surface. In sub-arctic regions of the world the use of sanding for traction control contributes to the amount of road dust (Kupiainen, 2007). The composition of urban road dust is an indicator for environmental pollution. For this reason, many studies have been carried out to determine heavy metals contents in road dust using different sampling procedures. The usual method for dust collection is a clean shovel and a small brush. Alternatively, vacuum cleaners are used. The contamination level of heavy metals in road dust is dependent upon the traffic volume, vehicle speeds and the surrounding environment. The highest concentrations of heavy metals are found in samples from highways while in downtown areas the concentrations are considerably lower (Duong and Lee, 2011). Heavy metal concentration data measured in several studies were summarized by Faiz et al. (2009). The various heavy metals originate from different sources. The major sources of Cu were determined to be brake abrasion, while the concentration of Zn was influenced by tire wear. (Duong and Lee, 2011). In several studies (Pagotto et al. 2001; Zhu et al. 2009; Fujiwara et al. 2011; Abdel-Latif and Saleh, 2012) the collected road dust was separated into various size fractions by sieving. These studies showed that the chemical composition of road dust varies with the grain size. However, separation by dry sieving is typically limited to a cut size of approximately 30-100 µm. The size dependence of the heavy metal concentrations is quite important because road dust can become re-suspended by passing vehicle induced turbulence and shear stress of the tires or wind (Nicholson and Branson, 1990). This re-suspension is strongly influenced by the size of the particles. Exposure to the inhalable size fractions of dust (PM2.5 and PM10) is associated with increased risk to human health and respiratory illnesses. Therefore, the size dependence of the heavy metal concentrations in road dust is of special interest for the finest fractions which cannot be separated by sieving. In this paper the first results of a study are presented, where the distribution of heavy metals in the smallest size fractions of road dust is investigated. For the separation of road dust air classification was applied.

Methods

The study is performed in Wels, a mid-size town in Austria with approximately 60,000 inhabitants. The road dust samples were collected at the unloading area of the road sweeping vehicles. Before unloading, the vehicle was in operation for approximately four hours cleaning main roads as well as side roads. The speed of the vehicle when cleaning is 5 km/h. Thus, the unloaded dust was collected from roughly 20 km of road. Twenty samples of the material unloaded were each taken with a shovel at various points of the heap. In total 10 kg of material was collected. The material was dried at 105°C for twenty-four hours. In a first stage the dry material was sieved with a 2 mm sieve and in a second stage with a 200 µm sieve. The passage from the second sieving was air classified into six size fractions. Because of erosion of Cr and Ni in the classifier these heavy metals cannot be investigated (Lanzerstorfer, 2015). The particle size distribution of these fractions was measured using a Sympatec HELOS/RODOS laser diffraction instrument with dry sample dispersion. For the heavy metals analysis the dust samples were dissolved by aqua regia digestion. The concentrations were measured by inductively-coupled plasma optical emission spectroscopy (Horiba Jobin Yvon Ultima 2).

Results

The size distributions of the particle classes produced by air classification are shown on the left in Figure 1. Particle class 1 corresponds approximately to PM2.5 and the sum of particle classes 1 and 2 would correspond to PM10. The mass fractions of particle classes 1 to 6 in the road dust < 200 were µm 3.5%, 10.7%, 13.7%, 13.9%, 19.8% and 38.4%. On the right in Figure 1 the concentrations of some heavy metals in the various size fractions are shown. The concentrations are increased in the finer particle classes. In comparison to the total dust < 200 µm the concentrations of Zn, Pb and Cu in the finest particle class (corresponding to PM2.5) are increased by a factor of 6.3, 6.0 and 4.0, respectively. The concentration of Sr was nearly constant in all particle classes.

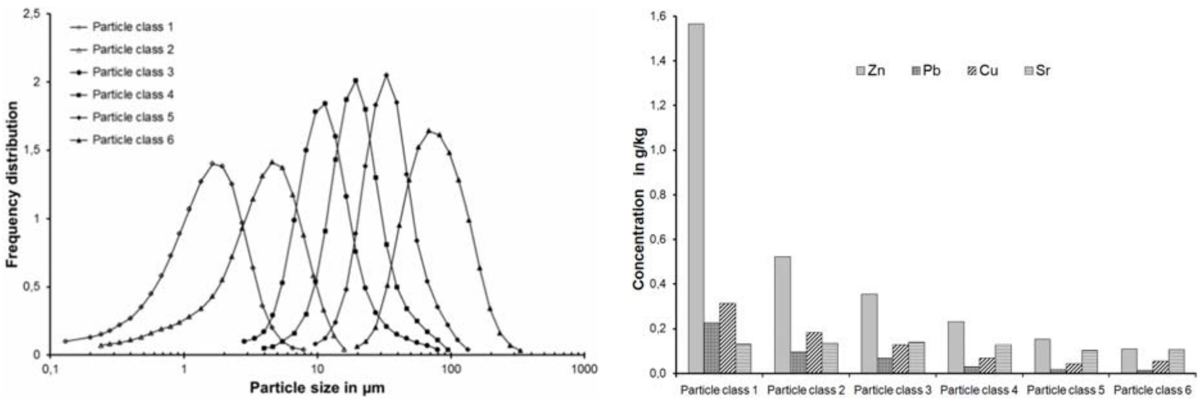

Figure 1. Particle size distribution (left side) and heavy metal content (right side) of the various particle classes

Conclusion

First results of the study showed substantially higher concentrations of Zn, Pb and Cu in the finest fraction of the road dust compared to the concentration in the dust < 200 µm. Further measurements are planned to investigate the enrichment of heavy metals in the finest fractions of road dust in detail.

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