CHARACTERIZATION OF RESUSPENDED AND RESPIRABLE URBAN AEROSOL

THESES OF THE PHD DISSERTATION

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INTRODUCTION AND AIMS

In most large cities of the world air pollution is a very complex issue which results from the presence of many natural and anthropogenic sources, and aggravated by unfavorable meteorological conditions. Among anthropogenic sources the traffic related particulate matter with other pollutants can increase the mass concentration of urban PM_{10}. Sometimes air pollution culminates in severe and dangerous episodes which require interventions by local authorities. Atmospheric particulate matter with aerodynamic diameter less than 10 μm (PM_{10}) is identified as one of the most dangerous pollutants on human health by the EU new directive on air quality (2008/50/EC), because particles in this size range may get into the lower airways, including the lung. These particles may cause respiratory symptoms and varying degrees of airway obstruction among those who are exposed to high concentrations for prolonged time periods.

Resuspended road dust may contribute up to 30% to urban PM_{10} (Ho *et al.*, 2003), because road dust can be easily resuspended by passing vehicles and wind. Resuspended road dust, like the urban aerosol, contains toxic, carcinogenic and mutagenic constituents, and microorganisms can proliferate. In addition deposited road dust can be an "archive" of previous air pollution.

In recent studies sampling of resuspended particulate matter has usually been performed by simply sweeping and sieving deposited road dust (Wei *et al.*, 2009), and the collected bulk samples were resuspended in the laboratory and the size-distribution of the particles was determined (Zhao *et al.*, 2006). These procedures and sample treatments were flawed by the loss of fine particles which are the most critical aerosol particles in terms of their health effects. A recent study has shown that aerosol particles can be quantitatively resuspended from road dust using a specific sampling device (Amato *et al.*, 2009).We have developed a mobile sampling unit for the on-line collection of the respirable fraction of resuspended particles.

The direct determination of phase composition of particulate matter has not generally been available in ambient aerosol studies due to limited sample size and the presence of a filter matrix. When constructing the specific sampling unit we deployed a cyclone separator which collects the $PM_{1\text{-}10}$ fraction in bulk form. Thus our sampling method facilitates the quantitative determination of mineral phase composition for the accurate identification of their major primary sources.

During my research, as a result of a tragic industrial accident in Kolontár, alkaline red mud sludge inundated settlements and agricultural areas. One of the major concerns regarding the

aftermaths of the catastrophe was of the high resuspension potential of dry red mud. With the sampling unit already developed, we were able to carry out a complete characterization of resuspended PM_{10} in the affected areas.

Aerosols from various sources contain toxic, carcinogenic, mutagenic and teratogenic constituents. Extensive studies established the link between air pollution and human health effects, with mass concentrations of $PM_{2.5}$/PM_{10} being the only measures of particulate pollution. During my research direct assessment of the overall ecotoxicity of various aerosol types was performed. The method is based on the *Vibrio fischeri* bioluminescence inhibition bioassay that has been standardized for solid samples. Adaptation of this method and the development of a sample preparation method (Kováts *et al.*, 2012) allowed the direct determination of ecotoxicity of various aerosol types for the first time in environmental sciences.

THESES

1. A mobile sampling unit was developed and constructed which collects the resuspended particulate matter (PM_{1-10} and PM_1) fractions directly from road surfaces simulating the effects of environmental factors leading to resuspension.

2. For the first time in atmospheric chemistry the mineral composition of resuspended particulate matter (PM_{1-10}) was determined quantitatively by X-ray powder diffraction. The results indicated that the resuspended road dust in cities mainly derives from soils and construction and/or demolition works with a combined contribution of more than 90%.

3. The sampling unit was deployed successfully on the site of the catastrophic red mud spillage near Ajka in October 2010, and the physical and chemical properties of the resuspended red mud dust were determined which are relevant in its health effects. The results implied that the mass concentration of resuspended red mud dust (PM_{10}) from an inundated paved surface exceeds 2000 mg m^{-3}, thus the large resuspension potential of dry red mud poses a serious health hazard to the local residents and to the people involved in the clean-up works.

4. Total ecotoxicity of various aerosol types was determined by a special method based on *Vibrio fischeri* bioluminescence inhibition bioassay for the first time in atmospheric science. Samples from biomass burning, cigarette smoking and the diesel exhaust proved to be the most ecotoxic aerosol types which EC_{50} values are less than 10 μg.

5. The ecotoxicity of winter urban PM_{10} strongly correlates with mixing height and the concentration of tracers of both biomass burning and traffic. The results confirm that primary emission sources contribute significantly to the overall ecotoxicity of urban particulate matter.

6. By establishing relationship between ecotoxicity and volatility of diesel emission samples of different emission standards it was shown that ecotoxicity is strongly linked to the presence of (semi-)volatile organic compounds.

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