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研究论文

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北京市典型道路交通环境细颗粒物元素组成及分布特征

Characteristics of elements in size-resolved fine particles in a typical road traffic environment in Beijing

关键词：交通环境 北京奥运会 细颗粒物 元素 富集因子 因子分析

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摘要：对北京市典型道路交通环境中不同粒径段(0.2~0.5 μm、0.5~1.0 μm和1.0~2.5 μm)的细颗粒物进行了采样分析,在2008—2009年期间5个阶段内共采集了198个细颗粒物样品.通过XRF分析得到细颗粒物中Al、Na、Mg、K、Ca、Si、S、Cl、Fe、Mn、Ti、Cu、Zn、As、Br和Pb 16种元素的质量浓度.含量较高的元素有S、K、Fe、Cl、Si、Ca和Zn,占测试元素总浓度的90%以上.应用富集因子法将元素分为地壳元素、双重元素和污染元素三类.应用因子分析法分离出两个主要因子,因子1主要与地壳元素和双重元素相关,可归于扬尘源的贡献;因子2主要与污染元素相关,可能来自机动车、燃煤、生物质燃烧和工业等排放源.人为源对小粒径(0.2~0.5 μm)颗粒物的贡献较大,而地壳源的贡献更集中于大粒径段(1.0~2.5 μm).多数地壳元素和双重元素在夏季和冬季均随粒径的增大而富集,且冬季浓度较高,而多数污染元素的分布形态存在季节差异.Br、As和Pb夏季在0.5~1.0 μm出现峰值,而冬季在0.2~0.5 μm出现峰值.冬季因采暖增加的煤和生物质的燃烧造成部分元素浓度在0.2~0.5 μm有显著增加.云层内部的硫酸盐生成过程可能是夏季S元素在0.5~1.0 μm出现峰值的原因.通过奥运时期与非奥运时期元素浓度和分布的比较,发现奥运时期交通源临时控制措施对机动车排放和道路扬尘均有显著的削减作用,削减率分别为53%和63%,且随粒径增大而增加.

Abstract: Fine particles in three size ranges (0.2~0.5 μm, 0.5~1.0 μm and 1.0~2.5 μm) were sampled at a typical roadside site in Beijing. There were 198 samples collected during five sampling periods in 2008—2009. The mass concentrations of Al, Na, Mg, K, Ca, Si, S, Cl, Fe, Mn, Cu, Zn, As, Br and Pb in these samples were measured using XRF method. Elements with the highest concentrations are S, K, Fe, Cl, Si, Ca and Zn, accounting for more than 90% of the total mass concentrations. Using enrichment factor analysis, we found that these elements can be classified into three clusters: crustal elements, mixed elements, and pollution elements. Two main factors were identified using factor analysis. One factor was mainly associated with crustal elements and mixed elements. We attributed this factor to dust sources. The other factor was mainly correlated with pollution elements and was due to anthropogenic activities including motor vehicles, coal combustion, biomass burning and industries. Anthropogenic sources contributed most to the particles in the size range of 0.2~0.5 μm, whereas the crustal sources contributed most to those in the size range of 1.0~2.5 μm. Most crustal elements and mixed elements showed similar distribution patterns in both summer and winter, with higher enrichment in larger particle sizes. Higher concentrations were found in winter. However, the distributions of most pollution elements showed seasonal differences. Br, As and Pb peaked at 0.5~1.0 μm and 0.2~0.5 μm in summer and winter, respectively. The concentration increases of some elements in 0.2~0.5 μm particles in winter were most likely due to the increased coal combustion and biomass burning for heating. The peak of S at 0.2~0.5 μm in summer was possibly related to the in-cloud formation of sulfate. The effects of the temporary traffic control measures were evaluated by comparing the data before, during, and after the Olympics. The reduction rate of 53% was found for the elements originated from the vehicle emission. Moreover, the reduction rate became larger with increasing particle sizes.

Key words: traffic environment Beijing Olympics $PM_{2.5}$ elements enrichment factors factor analysis