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北京道路交通环境亚微米颗粒物元素组成特征及来源分析

Characteristics and source apportionment of elements in submicron particulate matter near an urban freeway in Beijing

关键词：亚微米颗粒物 交通环境 元素特征 因子分析

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作　者	单位
李佳琦	清华大学环境学院, 环境模拟与污染控制国家联合重点实验室, 北京 100084
吴　烨	1. 清华大学环境学院, 环境模拟与污染控制国家联合重点实验室, 北京 100084;2. 国家环境保护大气复合污染来源与控制重点实验室, 北京 100084
宋少洁	麻省理工学院地球大气与行星科学系, 马萨诸塞州, 美国
郑　轩	清华大学环境学院, 环境模拟与污染控制国家联合重点实验室, 北京 100084
王　悦	清华大学环境学院, 环境模拟与污染控制国家联合重点实验室, 北京 100084
郝吉明	1. 清华大学环境学院, 环境模拟与污染控制国家联合重点实验室, 北京 100084;2. 国家环境保护大气复合污染来源与控制重点实验室, 北京 100084

摘要：于2011年12月和2012年8月对北京北四环道路交通环境中亚微米颗粒物(PM_1)进行了采样,并对PM_1的质量浓度、元素组成及主要来源进行了分析.夏季非灰霾时段PM_1日平均浓度为(52.5±29.9) μg·m^{-3},灰霾时段PM_1浓度增加到(154.2±36.3) μg·m^{-3};冬季非灰霾时段PM_1日均浓度为(59.6±32.5) μg·m^{-3}.采用X射线荧光光谱法(XRF)对颗粒物中元素进行分析,共得到Na、Mg、Al、Si、P、S、Cl、K、Ca、Ti、V、Cr、Mn、Fe、Ni、Cu、Zn、As、Cd、Ba和Pb等21种元素的质量浓度.其中S、Cl、K、Na、Si、Zn、Fe和Ca等8种元素含量较高,占测试元素质量浓度90%以上.污染元素浓度呈现显著的季节差异,夏季S元素浓度较高,冬季As、Cl、K、Pb、Mn、V、Cd和P等元素浓度较高.应用富集因子法发现,PM_1相对$PM_{2.5}$能够更好地反映人为源的元素污染特征.应用因子分析法分析出PM_1的3个元素浓度贡献主成分因子:因子1反映燃煤、交通源排放和生物质燃烧,因子2反映道路及建筑扬尘贡献,因子3反映机动车排放和工业排放.因子1和因子3之和的夏季和冬季贡献比例分别高达46.8%和68.3%,表明来自机动车、燃煤、生物质燃烧等重要人为源对道路交通环境PM_1浓度的贡献显著高于其他来源.灰霾期间S、As、Pb等污染元素浓度明显高于非灰霾期间,地壳元素在灰霾期间无明显浓度变化.

Abstract：A sampling campaign was performed to characterize the elemental composition of submicron particulate matter (i.e., PM_1) near the North 4th Ring Road, a typical urban freeway in Beijing. This field study was carried out during December 2011 and August 2012. Results showed that average PM_1 concentrations on normal days were (52.5±29.9) μg·m^{-3} in the summer and (59.6±32.5) μg·m^{-3} in the winter, but increased to (154.2±36.3) μg·m^{-3} on hazy days in the summer. Twenty one elements including Na, Mg, Al, Si, P, S, Cl, K, Ca, Ti, V, Cr, Mn, Fe, Ni, Cu, Zn, As, Cd, Ba and Pb were analyzed by XRF. Elements with the highest concentrations were S, Cl, K, Na, Si, Zn, Fe and Ca, altogether accounting for more than 90% of the total measured element mass concentrations. Concentration of the elements varied seasonally: S was higher in summer, while As, Cl, K, Pb, Mn, V, Cd and P were higher in winter. Using enrichment factor analysis we found that those pollution elements were enriched in PM_1 more than in $PM_{2.5}$. Three factors were identified using factor analysis: factor 1 was mainly associated with vehicle emissions, coal combustion and biomass burning; factor 2 was attributed by dust sources; and factor 3 was related to vehicle and possibly industrial emissions. The sum of factors 1 and 3 contributed as high as 46.8% in summer and 68.3% in winter, respectively, which indicated that these major anthropogenic sources (e.g., vehicles, coal burning, and biomass burning) played the leading role to PM_1 elemental concentrations near the road. During hazy days, concentrations of S, As and Pb were much higher than for non-hazy days while crustal elements showed no significant difference between these two periods.

Key words：submicron particulate matter traffic environment elements factor analysis

主办单位：中国科学院生态环境研究中心
单位地址：北京市海淀区双清路18号 邮编：100085
服务热线：010-62941073 传真：010-62941073 Email：hjkxxb@rcees.ac.cn