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北京典型道路交通环境机动车黑碳排放与浓度特征研究

Emission characteristics and concentrations of vehicular black carbon in a typical freeway traffic environment of Beijing

关键词：黑碳 交通流 机动车 排放因子 AERMOD模型

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作 者	单位
严 晗	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
张少君	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
宋少洁	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. 麻省理工学院地球大气与行星科学系，马塞诸塞州，美国
傅立新	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
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：本研究对2009年北京市典型道路（北四环中路西段）进行实际交通流监测和调研，分析了总车流量、车型构成和平均速度的日变化规律.应用北京机动车排放因子模型（EMBEV模型）和颗粒物黑碳排放的研究数据，计算该路段的黑碳平均排放因子和排放强度.根据同期观测的气象数据，应用AERMOD模型对道路黑碳排放进行了扩散模拟，并根据城市背景站点和道路边站点的监测数据对模拟结果进行了验证.研究表明，该路段黑碳平均排放因子与重型柴油车在总车流中所占比例呈现出极强的相关性，由于北京市实行货车区域限行制度，日间时段总车流的平均黑碳排放因子为（9.3±1.2）mg・km^{-1}・veh^{-1}，而夜间时段上升至（29.5±11.1）mg・km^{-1}・veh^{-1}.全天时均黑碳排放强度为17.9~115.3 g・km^{-1}・h^{-1}，其中早（7：00—9：00）晚（17：00—19：00）高峰时段的黑碳排放强度分别为（106.1±13.0）g・km^{-1}・h^{-1}和（102.6±6.2）g・km^{-1}・h^{-1}.基于同期监测数据验证，AERMOD模型的模拟效果较好.模拟时段的道路黑碳排放对道路边监测点的平均浓度贡献为（2.8±3.5）μg・m^{-3}.由于局地气象条件差异，日间和夜间的机动车排放对道路边黑碳的模拟浓度存在显著差异.日间时段，小型客车排放对道路边站点的黑碳浓度贡献最高，达（1.07±1.57）μg・m^{-3}；其次为公交车，达（0.58±0.85）μg・m^{-3}.夜间时段货车比例明显上升，其黑碳排放占主导地位，贡献浓度（2.44±2.31）μg・m^{-3}.

Abstract：Traffic flow data, including hourly profiles for total traffic volume, fleet composition by vehicle category and average speed, were investigated on a typical freeway (the North Fourth Ring Road) in Beijing during 2009. By applying the Emission Factor Model for Beijing Vehicle Fleet (EMBEV) in combination with previous studies on vehicle emissions of black carbon (BC), we estimated BC emission factors and emission intensity from on-road vehicles. In combination with simultaneously measured meteorological data in Beijing, dispersion of road traffic BC emissions was simulated with the AERMOD model in a roadside environment and further validated with concurrently observed BC concentration data. Our results showed that the hourly average BC emission factor was very strongly correlated with the proportion of the traffic volume of heavy-duty diesel vehicles (e.g., diesel-powered passenger buses and freight trucks). Due to the traffic restrictions on truck use in the urban area of Beijing during the day time (6 a.m. to 11 p.m.), the average BC emission factor was (9.3±1.2) mg・km^{-1}・veh^{-1} during the day but increased to (29.5±11.1) mg・km^{-1}・veh^{-1} during night time. On the other hand, BC hourly emission intensity ranged from 17.9 g・km^{-1}・h^{-1} to 115.3 g・km^{-1}・h^{-1} for this road segment. Two peaks of BC emission intensity were observed synchronized with traffic volume peaks, (106.1±13.0) g・km^{-1}・h^{-1} during the morning rush period (7:00—9:00) and (102.6±6.2) g・km^{-1}・h^{-1} during the evening rush period (17:00—19:00). The AERMOD was able to provide satisfactory simulation results of BC concentration at the road side due to traffic emissions as validated by observed concentration data. Road traffic emissions were estimated to contribute (2.8±3.5 μg・m^{-3}) BC on average at the road side with the AERMOD model. In particular, due to the great differences of local meteorological conditions, substantial seasonal and diurnal variations were observed from the simulated BC concentrations. During the day, light-duty passenger cars were the largest contributor (1.07±1.57 μg・m^{-3}) among all vehicle categories, followed by the public bus fleet (0.58±0.85 μg・m^{-3}). During night time, trucks became the dominant contributor (2.44±2.31 μg・m^{-3}) to BC concentration at the road site.

Key words：black carbon traffic flow vehicle emission factor AERMOD