Characterizing Sources of Particulate Matter and Ultrafine Particles in Manhattan Using Traffic and Air Quality Measurements

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Aerosol pollution poses significant risks to human health, especially in urban areas where emission sources, including traffic, are higher. Yet, the contribution of individual sources to ambient particulate matter (PM) and ultrafine particle (UFP) concentrations in high-traffic urban areas is largely unknown. Using an AI-powered traffic sensor (Telraam S2 Outdoor) alongside optical and condensation particle counters (QuantAQ MODULAIR-PM and MODULAIR-UFP), we measured traffic volume and PM_1, $PM_{2.5}$, PM_{10}, and UFP concentrations on 2nd Avenue in Manhattan, NY, from June 4th to August 2nd, 2026, and compared these to regional background $PM_{2.5}$ from a nearby NYC Department of Health and Mental Hygiene monitoring station (NYC DOHMH, 2026). Traffic volume peaked between 7 and 11am and was lowest around 4am, with no significant difference between weekdays and weekends. All four aerosols correlated significantly with traffic volume, most strongly UFP (R^2=0.574, $p<0.001$).

Using a 4-factor solution, non-negative matrix factorization of hourly PM size distributions and UFP concentrations suggested that the local UFP source is dominated by motor vehicle traffic, as we found a strong correlation between the UFP factor intensity and traffic volume (R^2=0.50, $p<0.0001$). Factors 2 and 3, both dominated by PM_1 and $PM_{2.5}$, correlated with regional background $PM_{2.5}$ (factor 2: r=0.25, factor 3: r=0.63); only Factor 3 intensified during a regional wildfire smoke event (July 15th to 20th, 2026), distinguishing regional background aerosol (Factor 3, 0.35-1.0 μm) from local non-vehicle exhaust (Factor 2, 1.0-2.5 μm). Factor 4, representing coarse PM (2.5-10 μm), showed significantly lower intensity on weekends, consistent with confirmed nearby construction activity. These results suggest that vehicle traffic is the dominant local source of UFP on 2nd ave., while fine and coarse PM source from regional urban background, local non-traffic related activity, and construction, demonstrating that NMF-based source apportionment can separate urban UFP and PM sources to inform future air quality improvement projects.