Optical properties of light-absorbing carbonaceous aerosols from on-road vehicles

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Introduction: Light-absorbing carbonaceous aerosols, black carbon (BC), and brown carbon (BrC) can absorb light in the atmosphere that leads to climatic imbalance. There is a dearth in vehicular specific optical properties (such as aerosol light absorption ($b_{abs,\ \lambda}$), Absorption Angstrom exponent (AAE), and Mass absorption efficiency (MAE)) in the real-world driving conditions. The objective of the study is to find the optical properties ($b_{abs,\ \lambda,}$ and AAE) of light-absorbing carbonaceous aerosols specific to the vehicular emissions from the kerb-side and road-tunnel measurements having different traffic characteristics. And also investigated the contribution of light-absorbing particulate organic carbon (BrC) to total vehicular light-absorbing carbonaceous aerosols.

Methodology: Gravimetric $PM_{2.5}$ was collected on the Teflon filters (47mm, Whatman) by using a low volume $PM_{2.5}$ sampler (MiniVol, Airmetrics, USA) at the kerb-side (KS) of an arterial road (JVLR), and entry and exit of the road-tunnels (Freeway (FT) and Kamshet (KT) tunnel) in Mumbai, India. Light absorption by the $PM_{2.5}$ was measured with a SootScan Model OT21 optical transmissometer (Magee Scientific, USA) at wavelengths of 370 nm and 880 nm.

Results&Discussion: The light absorption (370 and 880nm) at KT was ~1.5 and ~5.3 folds higher than the kerbside and EFT, respectively due to the prevalence of more HDVs (~20%) at KT than at the kerbside (~8% HDVs) and EFT (~2% HDVs), which emit relatively more light-absorbing carbonaceous aerosols than other vehicle types. At kerbside, the average (±SD) contribution of particulate BrC absorption was 28 (±9)% at 370 nm whilst it is negligible at FT and KT. AT KS, BrC contribution to total absorbing carbon is 29% more in afternoon hours than during the morning hours, likely due to enhancement in the formation of secondary organic aerosols which are more absorbing. At KS the measured AAE was 1.40, which suggests that, other than vehicle emissions, BrC contribution is from other nearby sources such as residential cooking and also through the secondary formation. The measured AAE at the exit of KT (AAE=0.52) and EFT (AAE=0.54) was 9.5% and 33% higher, respectively as compared to the entry, suggesting the enrichment in the absorption of aerosols as the vehicle moves from entry to exit of the tunnel and indicating the contribution of vehicular emissions inside the tunnel. At KT, the AAE is 6% higher in the afternoon hours compared to morning whereas at FT, it is quite similar suggesting low to negligible secondary organic PM transformation inside the tunnels.

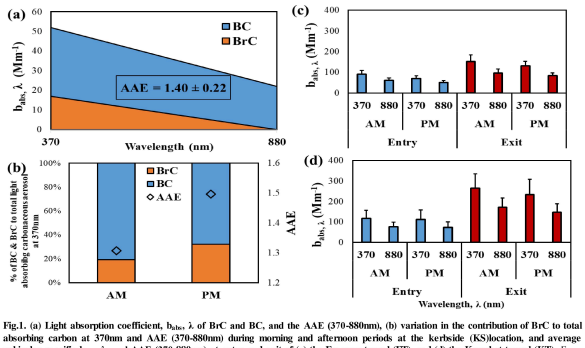

Fig.1. (a) Light absorption coefficient, b_{abs}, λ of BrC and BC, and the AAE (370-880nm), (b) variation in the contribution of BrC to total absorbing carbon at 370nm and AAE (370-880nm) during morning and afternoon periods at the kerbside (KS)location, and average vehicular specific b_{abs}, λ, and AAE (370-880nm) at entry and exit of (c) the Freeway tunnel (FT), and (d) the Kamshet tunnel (KT). *Error bar represents the standard deviation.*