Diurnal variability in optical characteristics of water-soluble brown carbon through online measurements over New Delhi

Neeraj Rastogi[1], Rangu Satish[1], Sachida Tripathi[2], Dilip Ganguly[3], J. G. Slowik[4], Andre Prevot[4]

[1]Geosciences Division, Physical Research Laboratory, Ahmedabad, India
[2]Department of Civil Engineering, Indian Institute of Technology, Kanpur, India
[3]Center for Atmospheric Sciences, Indian Institute of Technology, Delhi, India
[4]Laboratory of Atmospheric Chemistry, Paul Scherrer Institute, Villigen PSI, Switzerland

Keywords: Organic Aerosol, Absorption Coefficient, Mass Absorption Efficiency
Contact: nrastogi@prl.res.in

Introduction

Brown carbon (BrC) is light-absorbing component of organic carbon (OC) characterized by an absorption spectrum that smoothly increases from the visible to UV wavelengths. It can be of primary and/or secondary origin. Climatic significance of BrC through direct radiative forcing is an important issue. Further, a significant heating of clouds due to the presence of both BC and BrC could lead to cloud dissipation (Laskin et al., 2015). Despite their importance, the optical properties and composition of BrC are not well characterized, mainly due to lack of measurements. BrC studies are scarce in the Indian subcontinent. This study focuses on the temporal and diurnal characteristics of BrC over New Delhi during winter under the influence of various sources.

Methods

The study was carried out at a site located in the campus of Indian Institute of Technology, Delhi (28.4 °N, 77.1°E, 230 m above mean sea level) during 10-January to 28-February, 2018. New Delhi, a megacity, bears the intense pressure of urbanization, industrialization and dense population. The BrC absorption spectra (300-700 nm) and WSOC mass concentration in ambient $PM_{2.5}$ were measured semi-continuously (4 min integration time) using an assembled system (PILS-LWCC-TOC) that consists of a particle-into-liquid sampler (PILS) coupled to portable UV-vis spectrophotometer with a liquid waveguide capillary cell (LWCC) and total organic carbon (TOC) analyzer. In addition, black carbon (BC), carbon monoxide (CO), and nitrogen oxides were also measured. Light absorption coefficient (b_{abs}, Mm^{-1}) and mass absorption efficiency (MAE, $m^2\ g^{-1}$) were calculated as per Satish et al. (2017). Absorption coefficient at 365 nm (b_{abs_365}) was considered as a general measure of the absorption by BrC.

Conclusions

The WSOC varied from 1.0 to 62 µg m^{-3} (avg: 16 ± 9, 1σ), and b_{abs_365} ranged from 0.05 to 65 Mm^{-1} (avg: 18 ± 12) during the study period. This variability is attributable to various factors such as the dominance of specific sources (biomass and fossil fuel burning) and atmospheric processes. Further, BC, CO, and NO_X also exhibited large variability, broadly similar to those of WSOC and b_{abs_365}. Photochemical formation of secondary organic aerosol (SOA) was evident during morning hours (08:00 to 11:00 hours) whereas enhancement during late evening/night hours (19:00 to 23:00 hours) is attributed to both primary emission and secondary formation of WSOC. However, b_{abs_365} showed high concentrations throughout the night till morning hours (00:00 to 10:00). Further, the variability in b_{abs_365}/CO ratio (a measure of secondary BrC) suggest that secondary BrC fraction was significant. WSOC exhibited a strong correlation with b_{abs_365} with different ratio at different times of the day (Fig. 1), suggesting the presence of a significant but variable fraction of water-soluble chromophores. In January, BrC spectra showed a prominent peak at ~500 nm during night hours, suggesting the presence of secondarily formed nitroaromatics in the atmosphere. This peak disappeared during day hours, ascribable to photo-bleaching/volatilization of BrC.

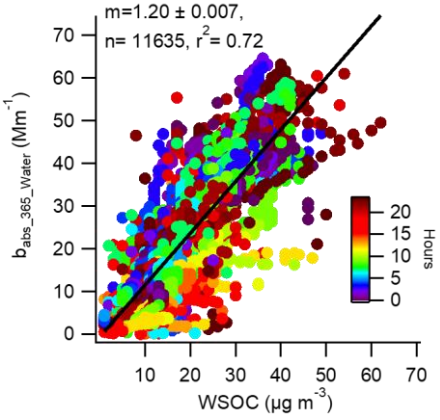

Figure 1. Scatter plot between WSOC and b_{abs_365}, and hours of the day as colored axis.

Laskin, A., Laskin, J., & Nizkorodov, S. A. (2015). Chemistry of Atmospheric Brown Carbon. *Chem. Rev.*, 115(10), 4335–4382.

Satish, R. V., Shamjad, P. M., Thamban, N. M., Tripathi, S. N., & Rastogi, N. (2017). Temporal Characteristics of Brown Carbon over the Central Indo-Gangetic Plain. *Environ. Sci. & Tech.*, 51, 6765-6772.