

- **Title:** Sources of PM_{2.5} carbonaceous aerosol in Riyadh, Saudi Arabia
- **Abstract:**

Knowledge of the sources of carbonaceous aerosol affecting air quality in Riyadh, Saudi Arabia is limited, but needed for the development of pollution control strategies. We conducted sampling of PM_{2.5} from April to September, 2012 at various sites in the city, and used a thermo-optical semi-continuous method to quantify the organic carbon (OC) and elemental carbon (EC) concentrations. The average OC and EC concentrations were 4.7 ± 4.4 and $2.1 \pm 2.5 \mu\text{g m}^{-3}$, respectively, during this period. Both OC and EC concentrations had strong diurnal variations, with peaks at 6-8 am and 20-22 pm, attributed to the combined effect of increased vehicle emissions during rush hour and the shallow boundary layer in the early morning and at night. This finding suggested a significant influence of local vehicular emissions on OC and EC. The OC/EC ratio in primary emissions was estimated to be 1.01, close to documented values for diesel emissions. Estimated primary (POC) and secondary (SOC) organic carbon concentrations were comparable, with average concentrations of 2.0 ± 2.4 and $2.8 \pm 3.4 \mu\text{g m}^{-3}$, respectively.

We also collected 24 hour samples of PM₁₀ onto quartz microfiber filters and analyzed these for an array of metals by ICP-OES. Total OC was correlated with Ca (R^2 of 0.63), suggesting that OC precursors and Ca may have similar sources, and the possibility that they underwent similar atmospheric processing. In addition to a ubiquitous dust source, Ca is emitted during desalting processes in the numerous refineries in the region and from cement kilns, suggesting these sources may also contribute to observed OC concentrations in Riyadh. Concentration weighted trajectory (CWT) analysis showed that high OC and EC concentrations were associated with air masses arriving from the Persian Gulf and the region around Baghdad, locations with high densities of oil fields and refineries as well as a large Saudi Arabian cement plant. We further applied positive matrix factorization to the aligned data set of EC, OC and metal concentrations (Al, Ca, Cu, Fe, K, Mg, Mn, Na, Ni, Pb and V). Three factors were derived, and were proposed to be associated with oil combustion, industrial emissions (Pb-based), and a combined source from oil fields, cement production, and local vehicular emissions. The dominant OC and EC source was the combined source, contributing $3.9 \mu\text{g m}^{-3}$ (80%) to observed OC and $1.9 \mu\text{g m}^{-3}$ (92%) to observed EC.

- **Name of contact person:** Qijing Bian or Sonia M. Kreidenweis
- **Email for contact person:** bianqj@atmos.colostate.edu or sonia@atmos.colostate.edu
- **Format of data files:** TXT or CSV format
- **Location where data were collected:** Riyadh, Saudi Arabia.
 - West Bounding Coordinate: 46°27'E
 - East Bounding Coordinate: 46°57'E

- North Bounding Coordinate: 24°54'N
- South Bounding Coordinate: 24°27'N
- **Time period during which data were collected:** 2012-04 to 2012-09 (UTC+03:00)
- **File Information**
 ECOC_data_archive
 -ECOC_data_archive
 -raw_ECOC_data: raw data files and on-field processed data (747 .txt files)
 -Corrected_ECOC_data: re-processed data (597 .txt files)
 NOX_O3_metal_data_archive: include 3 files of PM₁₀ metal concentration, NO_x and O₃ concentration.
- **Definitions of acronyms, site abbreviations, or other project-specific designations used in the data file names or documentation files**
 EC: elemental carbon; OC: organic carbon
 -BlanksRes: the results of blank sample
 -LCRes: Results calculated based on the local condition
 -Res: Results calculated based on the standard condition
 -MinutesEC: measurement of EC (µg/m³) in every minute
- **Variable information:** the column headers include the names of chemical species or the measurement parameters (time, sample volume and etc.) and their units
- **Uncertainty, precision, and accuracy of measurements:** Uncertainty for each data point was recorded and the relevant column labeled as such
- **Environmental or experimental conditions:** ECOC, O₃ and NO_x were sampled continuously in the field, while PM₁₀ metal concentrations were analyzed in the laboratory post-study from filter samples. The field measurements were taken from a mobile laboratory which was positioned at various sites in Riyadh for indicated periods (stationary while sampling). The matrix of locations and map of sites are included in the referenced publication.
- **Method(s):** Hourly EC and OC concentrations were measured by an in-situ semi-continuous OC/EC analyzer (Sunset Laboratory Inc., Model-4). PM₁₀ aerosol samples were collected onto quartz microfiber filters over a 24 h period every three days and elemental analyses for Al, As, B, Ca, Cd, Co, Cr, Cu, Fe, K, Li, Mg, Mn, Mo, Na, Ni, Pb, Te, V, and Zn were performed in the laboratory by ICP-OES. NO and NO₂ (NO_x) were measured by chemiluminescence and O₃ was measured by UV photometer simultaneously, from the mobile laboratory, using a Signal Ambirak air quality monitoring system (Signal Ambitech Ltd, UK). The details of the sampling strategy and analyses are provided in our publication (Bian et al., accepted, 2018)

- **Standards or calibrations that were used:** These are described in the analytical methods section in the publication.
- **Quality assurance and quality control that have been applied:** We reprocessed the raw OC/EC data by applying a split point correction methodology developed after considering the influence of temperature on the laser signal due to the deposition of refractory materials in the dusty environment of Riyadh. The details are in related publication (Bian et al., accepted, 2018).
- **Software:** RTCalc629.exe, the Analysis Program provided by Sunset Laboratory Inc., was used to process raw data. Any text editor can open the files in the database.
- **Limitations to reuse:** Users should be aware of the corrections applied to the OC and EC data due to the presence of refractory material, which may include carbonates that could not be quantified with the methodologies used. Please refer to the referenced publication for further details.
- **Date dataset was last modified: 2014-12**
 - Are there multiple versions of the dataset? No.
- **Related materials: N/A**
- **Data source: N/A**
- **Related Files:** This dataset is used in the paper: *Bian, Q., Alharbi, B., Sharee, M. M., Husai, T., Pasha, M. J., Atwood, S. A., and Kreidenweis, S. M.: Sources of PM_{2.5} carbonaceous aerosol in Riyadh, Saudi Arabia, Atmos. Chem. Phys. Discuss., <https://doi.org/10.5194/acp-2017-829>, accepted, 2018*
- **Any other important information about your data: N/A**