A Study of the Organic Composition of Haboob Particulate Matter

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Introduction

Each July marks the beginning of the summer monsoon season in the southwestern United States. Storms originating south of Phoenix create cold fronts that travel northwest towards Phoenix. The presence of loose soil along the storm's path, as well as its downward trajectory into the valley, causes a wall of sand and dust to be suspended into the air and commingle with urban particulate matter (PM). This type of storm is commonly known as a haboob.

The composition of haboob dust is not well known and it remains unclear whether the composition of haboob dust significantly impacts background urban PM.

This project aims to characterize the carbonaceous fraction of haboob dust so that we may begin to learn how air quality in Phoenix is affected by the occurrence of haboob events.

Experimental Setup

Sample Collection

Haboob PM and background urban PM samples were collected during the July – September monsoon seasons of 2013 and 2014 at the ASU campus in Tempe, Arizona using high-volume aerosol samplers.

Instrumental Analysis

The $PM_{2.5}$ fractions (PM with aerodynamic diameters less than 2.5 micrometers) were analyzed by thermal optical transmittance to determine atmospheric concentrations of organic and elemental carbon in background urban PM and haboob PM. The samples were then analyzed by GC/MS to identify *n*-alkanes, polycyclic aromatic hydrocarbons (PAH), and oxy-polycyclic aromatic hydrocarbons (oPAH).

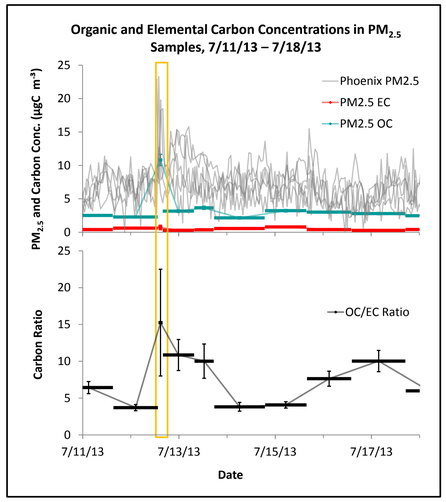
Weather Data

Weather and air quality data were obtained from NOAA and the US EPA Air Quality System at two locations close to the ASU Tempe campus (see map below):

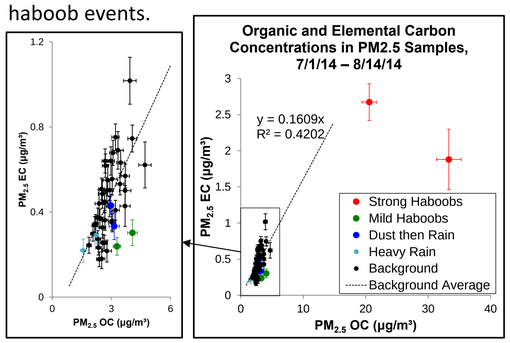
ASU Sampling Site
Roof of ASU Life Sciences Bldg.

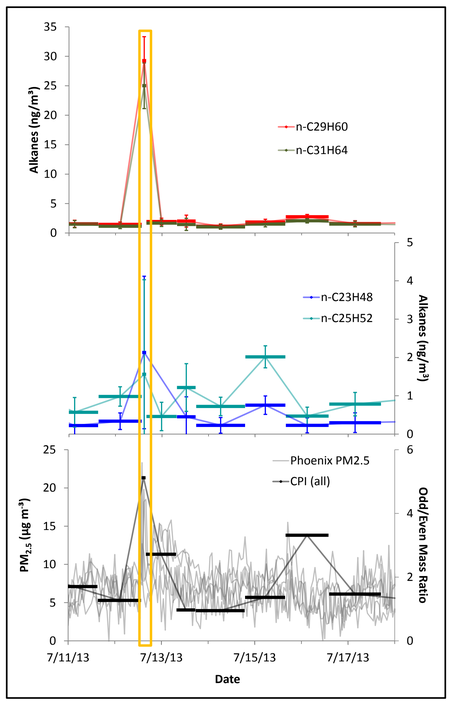
Maricopa County
Air Monitoring Site
AQS (Air Quality System, US EPA)

Results



Haboob events are accompanied by a brief abrupt increase in $PM_{2.5}$ as measured by the US EPA AQS. During these events, our samples indicate increases in OC and EC concentrations in $PM_{2.5}$. The OC/EC ratio increases slightly during mild haboobs and blowing dust events but significantly increases during strong haboob events.





n-alkanes in $PM_{2.5}$ collected July 11-17, 2013 were quantified. A brief increase in the concentration of odd-chain length *n*-alkanes was observed during the July 12, 2013 haboob event. This increase was more pronounced for long-chain *n*-alkanes.

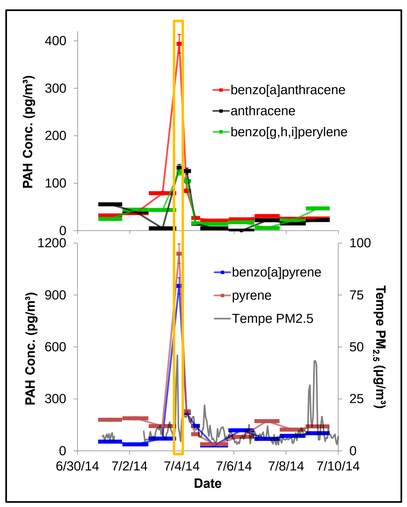
The carbon preference index (CPI) for *n*-alkanes was calculated:

$$\mathrm{CPI} = \frac{\sum[C_{odd}]}{\sum[C_{even}]}$$

A CPI close to one is characteristic of a dominance of anthropogenic emission sources. A CPI greater than five is indicative of a contribution of biogenic components to aerosol. An increase in the CPI was observed during this haboob event.

The haboob events observed in 2013 and 2014 were accompanied by an increase in the measured concentration of PAH characteristic of anthropogenic emissions.

The charts to the right show the changes of PAHs in a haboob event. The largest increases were pyrene and benzo[*a*]pyrene which reached 1 ng/m³. Anthracene and benzo[*g*,*h*,*i*]perylene didn't increase to as high of levels (0.1 ng/m³) but remained elevated longer.



Discussion

Haboob events are characterized by short spikes in $PM_{2.5}$ concentrations (25 - 50µg/m³). The levels were moderate; the US EPA 24-hour $PM_{2.5}$ air standard is 35 µg/m³. Following the event, concentrations go down to typical summer urban levels rather quickly.

An increase in $PM_{2.5}$ measured by the US EPA AQS corresponds with measured increases of organic and elemental carbon mass in $PM_{2.5}$ at our sampling site.

During strong haboobs, we observed a significant increase in the ratio of organic carbon to elemental carbon. A smaller OC/EC ratio increase is observed for mild haboobs, and the OC/EC ratio measured during blowing dust events is closer to that of background urban PM. This is indicative of an increase in the influx of biogenic material with increasing haboob strength. A distinction between a haboob and blowing dust may also be made.

The CPI of long-chain *n*-alkanes increases during a haboob, corroborating an influx of biogenic material.

The combined PAHs analyzed reached 4.8ng/m³ during a strong haboob. That level is 10^5 times lower than OSHA and NIOSH workplace eight-hour limits for total PAHs. Benzo[*a*]pyrene, which is classified as a probable human carcinogen, reached 1ng/m³. That is 600x lower than the EPA one-year average level for health concern.

The brief increases in elemental carbon concentrations and PAH concentrations during haboobs may suggest a resuspension of anthropogenic material.

Conclusions

Total $PM_{2.5}$ mass increases significantly during haboob events. Increases in OC concentrations in $PM_{2.5}$ and the CPI of long-chain *n*-alkanes suggest an influx of biogenic material during haboob events.

Resuspension of anthropogenic matter during haboobs is indicated by increases in EC and PAH concentrations. The elevated levels of PAHs were lower than long-term standards for health concern.

Further Experimental Work

Additional sample analyses are currently ongoing and chemical composition data will be available for more time periods.

The chemical analysis will be extended to other organic molecules that are used as tracers for specific carbonaceous aerosol sources, including biogenic (plant and bacterial materials), anthropogenic (vehicle emissions), and mixed (biomass burning) molecular markers.

Additional data analysis will be performed by combining organic and inorganic/metal aerosol data (see companion poster, A. Marcotte *et al.*).

Acknowledgments