Enhanced Secondary Organic Aerosol during foggy episodes

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Introduction

Frequent and extended fog episodes over the Indo-Gangetic Plain (IGP) during winter make it an ideal site to study the impacts of fog on visibility, health and climate. One phenomenon of interest is the interaction between fogs and carbonaceous aerosols. These aerosols can be formed via gas to particle partitioning of various low volatility products of photo-oxidation reactions; particulate organic matter produced by this processes is referred to as secondary organic aerosol (SOA).

Formation mechanisms have been suggested both in wet aerosols and in fogs and clouds (Blando et al., 2000). Mechanisms of SOA production remains poorly understood partly due to the complex nature of multiphase processes likely involved in SOA production. This study has examined the aqueous phase production of SOA.

Method and Site Description

PM_1 samples were collected from January 16, 2010 to February 20, 2010 in Kanpur city (26.5° N, 80.3° E, 142 m msl) which is located in the most polluted and densely populated (~ 2.6 million) Indo-gangetic plain of the India (Fig 1). Micro-Pulse Lidar Network (MPLNET), a part of National Aeronautic Space Administration (NASA), was used for identification of fog duration. Organic Carbon (OC), Elemental Carbon (EC) and water soluble organic carbon (WSOC) measurements were carried out by EC-OC analyzer and TOC analyzer, respectively. Trace gases (O_3,CO,SO_2) and solar flux measurement were carried out by gas analyzer and pyranometer (a part of NASA), respectively to identify the photo-chemical activity. Meteorological data were measured by atmospheric weather station. EC tracer method (Turpin et al., 1991) was used to estimate the SOA. All the filters were also analyzed for biomass tracer, K^+ by ion chromatograph to examine biomass burning. More details of the findings are included elsewhere (Kaul et al., 2011)

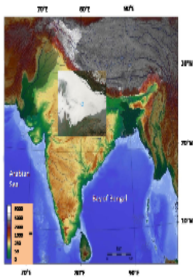

Figure 1: Sample site, Kanpur (shown by circle). Fog shows the spatial scale to which the area can affected by the event (figure to the scale)

Trace Gas and Atmospheric Conditions

- Foggy day is characterized by relatively small photo-chemical reactions (Fig 2 A & B)
- SO_2 is scavenged and removed from the atmosphere (Fig 2 A)

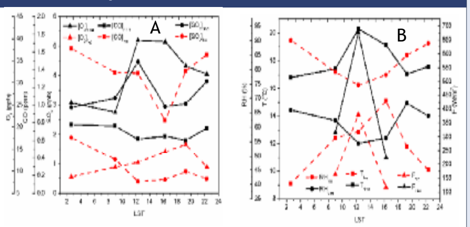

Figure 2: (A) Study average diurnal variation of trace gas (O_3,CO,SO_2) during clear and foggy day (B) Study average diurnal variation of relative humidity (RH), solar flux (F) and temperature (T) during clear and foggy day. LST is local standard time (Kaul et al., 2011)

Primary Organic Carbon

- Slope of ordinary linear regression is primary OC/EC ratio (Fig 3-A)
- Frequency of minimum OC/EC ratio shows that most of the data point considered for estimation of primary OC/EC ratio are during evening through morning which is period of low photo-oxidation reaction (Fig 3-B)

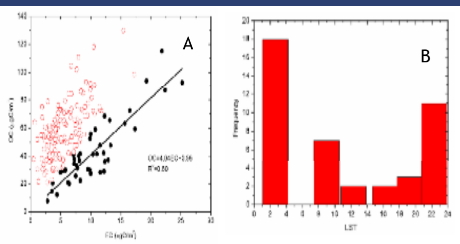

Figure 3: (A) An ordinary linear regression between organic carbon (OC) and elemental carbon (EC) (filled circles) (B) Frequency distribution of minimum OC/EC ratio data points. LST is local standard time (Kaul et al., 2011)

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Secondary Organic Aerosol

- Increase of OC/EC ratio as fog evaporates, higher concentrations of OC/EC ratio and SOA and insignificant contribution of biomass during foggy days indicates SOA formation through aqueous mechanism (Table 1, Fig 4 A & B)
- WSOC may originate from the secondary production and biomass burning
- Smaller concentration of biomass tracer, K^+ ensured its insignificant contribution to WSOC during foggy day.

Table 1: Behavior of organic carbon (OC) to elemental carbon (EC) ratio as fog is evaporating. LST stands for local standard time (Kaul et al., 2011)

DATE (YYYY-MM-DD)	LST (hours)		
	2.625	9	12.3
2010-01-16	---	12.80	15.15
2010-01-18	13.87	14.45	34.43
2010-01-19	15.41	17.63	15.41
2010-01-20	10.90	9.67	13.68
2010-01-21	6.19	13.24	13.31
2010-01-22	6.22	10.40	13.89
2010-01-23	9.09	10.86	10.76
2010-01-25	7.98	15.14	14.28
2010-01-26	---	8.80	10.86
2010-01-28	3.88	4.98	---
2010-02-13	2.77	75.10	26.70

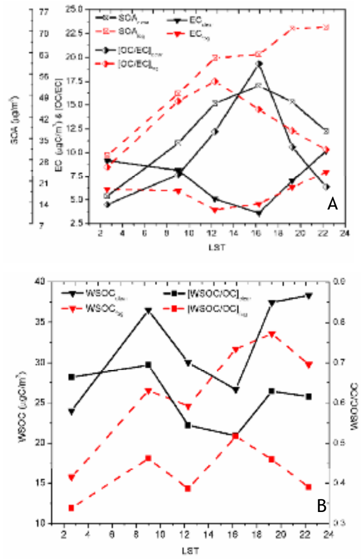

Figure 4: (A) Study average diurnal variation of organic carbon (OC) to elemental carbon (EC) ratio, EC and secondary organic aerosol (SOA) during clear and foggy day (B) Study average diurnal variation water soluble organic carbon (WSOC) and WSOC/OC ratio during clear and foggy day (Kaul et al., 2011)

Effect of Temperature and Relative humidity

- Insignificant effect of temperature and relative humidity on SOA formation was found (Fig 5-A & B)

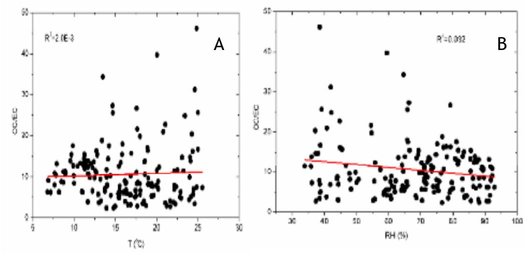

Figure 5: (A) Ordinary linear regression between temperature (T) and OC/EC ratio (B) Ordinary linear regression between relative humidity (RH) and OC/EC ratio. OC and EC are organic and elemental carbon (Kaul et al., 2011)

Summary and Conclusion

Aqueous phase production of secondary organic aerosols (SOA) through fog was studied. The enhanced production of SOA was observed during foggy day. Insignificant contribution of biomass to SOA was found during foggy day. The temperature and relative humidity has negligible influence on SOA formation.

References

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