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Chemistry of fine particulates during winter fog of 2017-18 at IGIA, Delhi

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PURPOSE:
Delhi region frequently receives fog of different intensity during winter (Dec-Feb) season. The peak months of dense and persistent fog occurrence over the Delhi region are December and January when temperature reaches to very low level and the frequency of Western Disturbance (WD), the only weather phenomenon causing rainfall over that region during the colder months, is increased. A polluted atmosphere with high aerosol concentration may be linked to the formation of fog in urban areas like Delhi.

METHODS:
Concentration of trace gases (NH3, HNO_3, HNO_2, HCl and SO_2) and inorganic chemical constituents (NO_3- , Cl-, SO42- , Na+, NH4+, K+, Mg2+ and Ca2+) of fine particulates (PM1 and PM2.5) was monitored simultaneously on hourly resolution using Monitor for AeRosols and Gases in ambient Air (MARGA) at Indira Gandhi International Airport (IGIA) Delhi, during a period from 01 December 2017 to 10 February 2018. The present work aims at investigating chemical composition of fine particles and their variability on different time scales during fog and non-fog episodes.

RESULTS:
Major ions constituting PM1 mass were chloride, nitrate, sulfate and ammonium. Their concentration during clear sky condition was 17.30 $\pm$ 16.84, 16.39 $\pm$ 8.04, 9.61 $\pm$ 5.24 and 17.03 $\pm$ 8.77 μgm-3 respectively which constituted 26.25%, 26.73%, 16.17% and 27.34% of the total PM1mass concentrations respectively. It was 25.81 $\pm$ 23.36, 18.88 $\pm$ 9.48, 12.58 $\pm$ 6.43 and 22.89 $\pm$ 11.99 μgm-3 respectively during moderate fog condition. During dense fog condition, concentration of all the above chemical species drastically decreased.

Chloride, nitrate, sulfate and ammonium dominated in PM2.5 mass also. Their mass concentration during clear sky condition was 29.81 $\pm$ 28.96, 25.57 $\pm$ 12.66, 15.48 $\pm$ 9.97 and 27.42 $\pm$ 14.54 μgm-3 respectively. It increased to 50.20 $\pm$ 38.84, 34.66 $\pm$ 12.91, 27.72 $\pm$ 15.66 and 43.84 $\pm$ 16.15 μgm-3 respectively during moderate fog episodes due to secondary aerosol formation.

On average, Sulphur Oxidation Ratio (SOR) during clear, moderate fog and dense fog days were 0.30 $\pm$ 0.20, 0.41 $\pm$ 0.24, 0.45 $\pm$ 0.26 respectively in case of PM1 and 0.35 $\pm$ 0.22, 0.54 $\pm$ 0.29, 0.67 $\pm$ 0.31 respectively in case of PM2.5. The increase in SOR values during fog episodes suggests higher oxidation of SO_2 during fog events.

NH4+appeared to be the main neutralizer during the whole observational period and mostly occurred as NH4Cl and $NH4NO_3$ and poorly as (NH4)2SO4 or NH4HSO4.

CONCLUSIONS:
The chemical composition of fine particulates during fog was dominated by nitrogen species (ammonium and nitrate), with important contributions from chloride and sulfate.This study shows how fog drastically modifies the atmospheric chemical properties of the polluted urban aerosol. It appears that secondary fine mode inorganic aerosol formation can occur rather rapidly under such conditions.