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ANALYSIS OF AEROSOL NUMBER CONCENTRATION SPECTRUM DURING FOG OVER DELHI

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Abstract

Urban areas are facing increasing fog frequencies that may result due to increased air pollution emanating from variety of sources. The increased pollution levels may lead to the atmospheric reactions resulting into the formation of secondary pollutants that may also lead to increased aerosol number concentrations (ANC) in the atmosphere. This could cause enhanced water aerosols in the presence of favourable meteorological conditions and high relative humidity. This study analyses the levels of air pollutants, aerosol spectrum and meteorological conditions during one week of the year 2006 in order to have an improved understanding of their role in fog formation in mega-city Delhi. Measurements included episodes of dense, thick and moderate fogs. The measurements cover most of the accumulation mode and greater size spectrum of aerosols. Thus, the analysis is performed for the entire period, specifically, before the fog sets up, during and afterwards. In general, the relatively small variations in number concentration show larger variations in visibility prior and post dense fog formation than during dense fog episodes. Sulfur-dioxide and Nitrogen dioxide were found to have inverse relationship with visibility during fog which may be due to formation of secondary pollutants such as sulfate and to a lesser extent nitrates.

Introduction

One of the most troublesome weather phenomena in an urban area is fog. The limited visibility associated with fog is responsible for a loss of time and money in all forms of transportation (Finlayson-Pitts and Pitts, 2000). Collier (1970) also mentioned that fog occur more frequently in the city in comparison to airport due to urban air pollution. An increased frequency of fog in urban areas has often been mentioned as a result of air pollutant emissions. Landsberg (1964) indicated that urban areas may experience 100% more winter fog than adjacent rural areas. There are now enough evidences that these atmospheric aerosols can be responsible for accelerating and intensifying the fog formation in the urban areas (Mircea et al., 2002). Toon (2000) stated that polluted cloud being capable of having eight times as many droplets of half the size, twice the surface area, twice the optical depth, and causing higher obscurity than natural cloud. Small droplets have larger surface area than the large droplets for the same volume. So it reflects more light and enhances fog formation. The rate of growth of small droplets will be faster than the rate of growth of larger droplets by Langmuir's equation, as long as there is an excess of water vapor for condensation (Reist, 1993). Physical properties of aerosols such as mass concentration ($\mu g\ m^{-3}$) have been in focus for already some decades in India but very little research efforts have been given for the number concentration of particles (Mohan and Nigam, 2003; Mohan and Payra, 2004). Delhi has been chosen because it is a rapidly growing mega city in Asia and very few fog related studies have

been undertaken in addition to the fact that increased anthropogenic emission has also resulted in increased aerosols here with secondary pollutants such as sulfates and nitrates as well. The characteristics of aerosols (number concentration, size distribution, chemical composition) have a large impact on when and where a fog layer will form. Therefore, the present study covers an in-depth analysis of ANC spectrum during winter fog over Delhi

Sampling Site and Techniques

New Delhi is located 160 km south of the Himalayas at latitude $28^0 53'$ and longitude $76^0 20'$ with an altitude of 216m above sea level. The measurements for aerosol spectrum were performed for a week from 6th January to 13th January, 2006 with continuous observations using 15 minute averaging time. The sampling site site was located in IIT, Delhi, which is a residential area in the South West part of the city. The GRIMM Aerosol Monitor (Model 1.108) - a 15 channel aerosol spectrometer was used to measure the total number concentration of particles. Visibility is also measured near the study area.. Pollution levels (air) were collected from Central Pollution Control Board (CPCB) for the ITO site in Delhi.

Analysis of observations and result

Figure 1 shows time series of hourly averaged values of ANC and visibility for a week- long campaign in January (6-12), 2006 at IIT Delhi. The minimum and maximum values of hourly mean number concentration of aerosols are 3.47×10^5 particle/liter (8th January, 4 pm) and 4.9×10^6 particle/liter (12th January, 8 am) respectively. The corresponding visibilities are more than 3000m and 400m respectively.

Figure 2 shows lognormal function fitted to number concentration with particle diameter for the period around thick fog episode of the year 2006 which covers pre-fog, fog and post fog conditions of the episode. Figure 2 shows that till about 1 μm, the curves for pre-fog, fog and post-fog conditions show practically similar variations. The ANC variation with size is similar between pre-fog and fog conditions till about 5 μm size which subsequently shows higher values of ANC during fog which may be due to coalescence or growth of some activated particles in the fog. The increase ANC beyond 5 μm in this figure perhaps could be due to formation of fog droplets during fog resulting into more ANC in comparison to pre or non-fog condition.

The trend of NO_2 and SO_2 is not always in phase (Figure 3). So the contribution to increase/decrease of ANC is not very straight forward in this experiment. It also strengthens the result of increase NO_2 in Delhi due to the CNG transportation source where SO_2 has some different sources. Given the range of RH values present during the fog episodes it appears likely that increased ANC may enhance the formation of small water droplets first (which may grow in size later perhaps) that may lead to reduced visibility (preference is for the formation of small droplets over the large droplets as explained by Langmuir's equation, Reist, 1983).

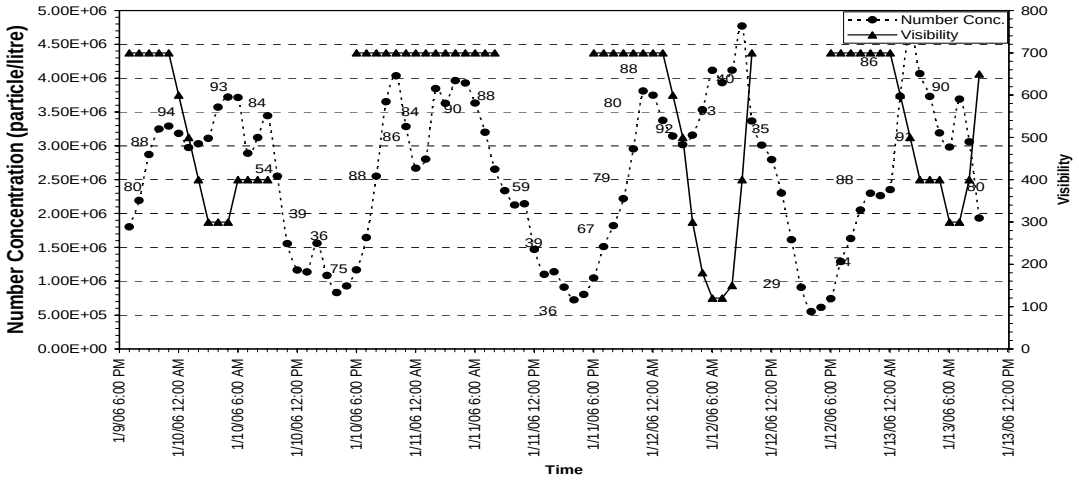

Fig :1 Time series of Visibility (m), Aerosol Number Concentration and Relative Humidity during dense fog for a period of 10^{h} to 13th January, 2006.(The numerical value of RH (%) is denoted on the ANC curve)

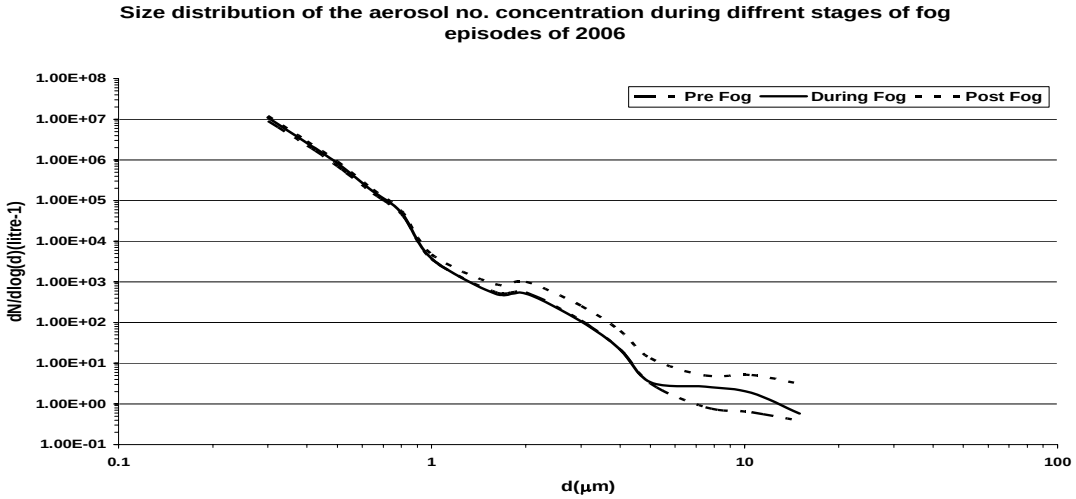

Fig 2:- Size distribution of aerosol number concentration during different stages of fog episodes of 2006

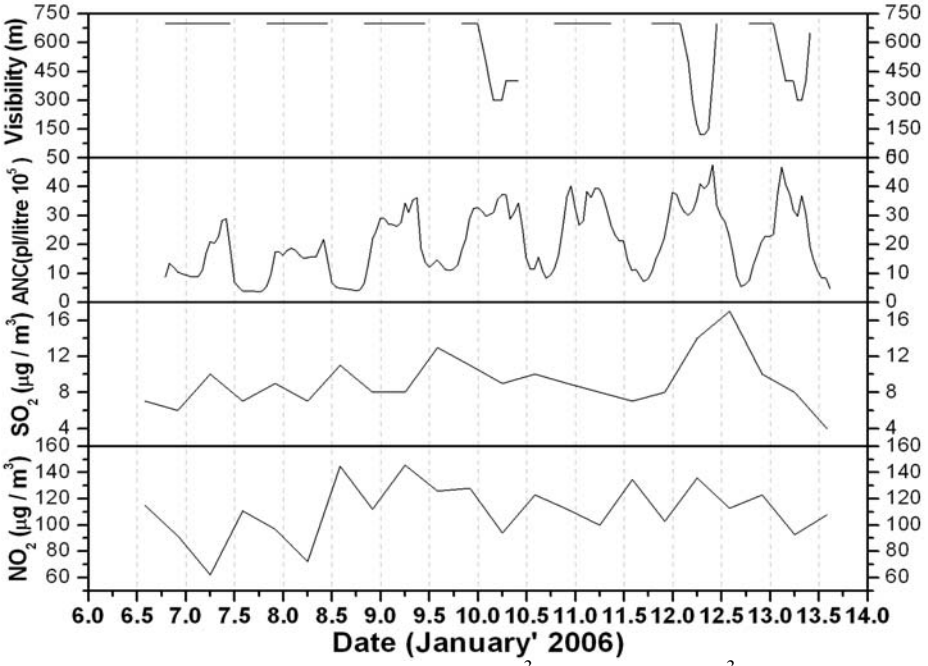

Figure 3: Time series of NO_2 ($\mu g/m^3$), SO_2 ($\mu g/m^3$), Aerosol Number Conc. (particle/liter) and Visibility (m) for a period of 6th to 13th January, 2006. Exact date denotes midnight and half decimal shows 12 noon.

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