



Original research article

Influence of ozone precursors and particulate matter on the variation of surface ozone at an urban site of Delhi, India



Ashima Sharma, Sudhir Kumar Sharma*, Rohtash, Tuhin Kumar Mandal

Radio and Atmospheric Sciences Division, CSIR-National Physical Laboratory, New Delhi 110012, India

ARTICLE INFO

Article history:

Received 4 June 2015

Received in revised form

31 August 2015

Accepted 17 October 2015

Available online 19 April 2016

Keywords:

Ozone

Ozone precursors

Seasonal variation

Particulates

ABSTRACT

Continuous measurements of surface O_3 and its precursors (NO , NO_2 , CO , CH_4 and NMHCs) at an urban site of Delhi, India during January 2012 to December 2013 are presented. In the present study, the annual average mixing ratios of surface O_3 , NO , NO_2 , CO , CH_4 and NMHC were 30 ± 6 ppb, 24 ± 6 ppb, 15 ± 4 ppb, 1.5 ± 0.4 ppm, 2.4 ± 0.4 ppm and 0.4 ± 0.1 ppm, respectively. The maximum average mixing ratios of surface O_3 , NO and NO_2 were observed during the summer, whereas, the minimum average mixing ratios of ambient NO and NO_2 were during monsoon seasons. The surface O_3 , NO and NO_2 have shown the prominent diurnal variations during all the seasons at the observational site of Delhi. The result reveals that the surface O_3 was negatively correlated with NO_x and CO during the study. The linear scatter plot analysis shows that the $PM_{2.5}$ and PM_{10} present in the ambient air of Delhi influence the production of surface O_3 at observational site.

© 2016 Chinese Institute of Environmental Engineering, Taiwan. Production and hosting by Elsevier B.V. This is an open access article under the CC BY-NC-ND license (<http://creativecommons.org/licenses/by-nc-nd/4.0/>).

1. Introduction

The emission of trace gases (O_3 , NO , NO_2 , CO , SO_2 , CH_4 and NMHCs etc.) in the lower troposphere has been increasing due to the industrialization and globalization during the past decades. The enhancement of mixing ratios of these trace gases modulates the Earth's climate because of their efficiency to modify the radiation and energy balance of the earth-atmosphere-system [1]. Surface O_3 is an important trace gas in the lower troposphere which plays a key role in enhancing the oxidizing capacity of the atmosphere and exerts adverse effects on human health as well as damages ecosystem and agricultural crops [2–5]. Ozone is a secondary air pollutant because its formation occurs in the presence of sunlight and its precursors, i.e., NO_x , CO and volatile organic compounds (VOCs), etc., which control the budget of tropospheric O_3 [3]. Apart from fueling the formation of tropospheric O_3 , a major tropospheric pollutant, the emissions and oxidative products of VOCs significantly influence the chemical composition of the atmosphere. The mixing ratio of O_3 may be directly affected by the changes in photolysis rate constant and indirectly by the NO_x and HO_x budget

modifications. As a consequence, the NO destroys O_3 , forming NO_2 through photolysis. Surface O_3 forms in the presence of sunlight from a chemical reaction between hydrocarbons (VOCs) and nitrogen oxides, both of which are emitted by human activities such as fossil fuel burning as well as by natural sources. The increase of industrial activities, vehicular traffic, and agricultural activities over the last century has resulted in a strong increase of emissions of CO , NO_x , CH_4 and VOCs and these species are involved in the chemical production of ozone in the troposphere [6–8].

The mixing ratios of O_3 precursors are increasing rapidly in Southeast Asia as a result of the fast growth of transportation and industrial sectors [9–12]. In tropical countries, biomass burning, especially from forest fires also contributes to ozone in the atmosphere [13,14]. The temporal variations of O_3 have been reported at many sites including rural, urban coastal and mountain sites of India [9–14]. Different groups [15–21] have conducted extensive studies over India and reported higher O_3 levels during late autumn and winter extending through May. Recently, the Indian Space Research Organization has initiated a network program in India to retrieve the Chemistry, Transport and Modeling of trace species at various locations in the Indian sub-continent and various groups have been involved in the long-term measurements of surface O_3 and precursors; these results are quite promising [22–28].

Particulate matter has complex effects on solar actinic flux photolysis rates in the troposphere and the surface O_3 . The

* Corresponding author.

E-mail address: sudhir@nplindia.org (S.K. Sharma).

Peer review under responsibility of Chinese Institute of Environmental Engineering.

reduction in surface O₃ production indicates the different impacts between absorbing and non-absorbing aerosols on photolysis frequencies. The ambient aerosol can reduce the photolysis frequencies of J [O₃ (¹D)] and J [NO₂] in the planetary boundary layer and it can reduce ground level O₃ concentration. This reduction could be due to the aggregate structure of aerosol particles, which provides a large specific surface area for heterogeneous interactions with reactive trace gases such as surface O₃ [5]. Many studies have focused on the efficiency of aerosols that can modify the photolysis rate of trace gases and revealed that absorbing aerosols can diminish UV actinic flux throughout the troposphere, leading to a reduction in near-surface ozone production [29–31]. Meteorology plays an important role in air pollutants formation, dispersion, transport and dilution. Therefore, the variations in local meteorological conditions, such as wind speed, wind direction, temperature and relative humidity (RH), can affect the temporal variation of surface O₃ and its precursors [5].

This paper studies the seasonal and diurnal variations of surface O₃ and its precursor gases (NO_x, CO, CH₄, etc.) and meteorological effects at an urban site of Delhi, India. The impact of particulate matter (PM_{2.5} and PM₁₀) in the reduction of surface O₃ at sampling location of Delhi is also studied.

2. Materials and methods

2.1. Description of site

The measurements of surface O₃, NO, NO₂ and CO have been carried out at sampling site (28°38' N, 77°10' E; 218 m mean sea level) of CSIR-National Physical Laboratory, New Delhi during January 2012 to December 2013, whereas NMHCs and CH₄ have been measured during May to October 2012. The sampling site represents a typical urban atmosphere, surrounded by huge roadside traffic and agricultural fields in the southwest direction (Fig. 1). This area is under the influence of air mass flow from the northeast to northwest in winter and from southeast to southwest in the summer. Roadside vehicles, industrial emission and biomass burning, etc. could be the major sources of carbonaceous aerosols and several other pollutants [32]. The combination of factors including industries, power plants, domestic combustion of coal and biomass, and transport is contributing to air pollution [21,32]. In Delhi, the increase in vehicles not only affects the total consumption of fuel but also increases the traffic congestion, vehicles idling time and delay events which ultimately results in more emission of NO_x, hydrocarbons, and CO [1]. The temperature of Delhi varies from minimum (monthly average: 12.9 °C) in winter (November to February) to maximum (monthly average: 34.8 °C) in summer (March to June). The average rainfall in Delhi during monsoon (July to October) is of the order of ~825 mm. Monthly variation of ambient temperature, RH, wind direction and wind speed at the observational site during study are given in Fig. 2. The subtropical atmosphere of Delhi and large scale emission of precursor gases cause significant increase in the surface O₃ concentration. Sufficient build up of tropospheric ozone has been reported with wide temporal and seasonal variation [15,19,21].

2.2. Experimental set up

A UV-based Ozone analyzer (Model: TECO-49C; M/s Thermo Environmental Instruments, Massachusetts, USA) was used for measurement of surface O₃. O₃-analyzer was calibrated periodically with primary standard of ozone with an accuracy of $< \pm 2\%$. NO and NO₂ were measured using NO_x-Analyzer (Model: CLD 88 p, M/s. ECO Physics AG, Switzerland) using a photocatalytic converter (Model: PLC 860 M/s. ECO Physics AG, Switzerland) with accuracy of ± 0.050 ppb. NO_x-analyzer was calibrated periodically using Zero

Air Generator (Model: PAG-003, M/s. ECO Physics AG, Switzerland, accuracy ± 0.01 ppb) and NIST certified NO span gas (500 ppb $\pm 5\%$). Carbon monoxide was measured using non-dispersive infrared gas filter correlation analyzer (Model: 48CTL; M/s Thermo Environmental Instruments, Massachusetts, USA). CO-analyzer was calibrated periodically using NIST traceable certified CO gas (8.1 ppm). The mixing ratio of NMHCs and CH₄ were measured using Methane-NMHC Analyzer (Model 55C, M/s. Thermo Scientific, USA) operating on FID method. These analyzers were operated continuously (15–20 d in each month) with uninterrupted power supply for the period of January 2012 to December 2013.

PM₁₀ and PM_{2.5} samples ($n = 60$ each) were collected simultaneously on Whatman quartz microfiber (QM-A) filters by using Fine Particle Sampler (APM 550, Make: M/s. Envirotech, India; one unit for PM₁₀ and another unit for PM_{2.5}). Ambient air was passed through a quartz filter (47 mm) at a flow rate of $1 \text{ m}^3 \text{ h}^{-1}$ (accuracy $\pm 2\%$) for 24 h during the sampling period. The amount of PM₁₀ and PM_{2.5} (in $\mu\text{g m}^{-3}$) calculated on the basis of the difference between final and initial weights of the quartz filters measured by a micro balance (M/s. Mettler-Toledo, resolution: $\pm 10 \mu\text{g}$) was determined by dividing the amount of total volume passed during the sampling.

In addition, the meteorological parameters (temperature, RH, wind speed, wind direction and pressure, etc) were measured by using sensors of a meteorological tower (4 stages tower of 30 m height), which is 100 m away from the observational site within the same campus. Meteorological tower measures the above mentioned parameters at four different heights (above ground level, i.e., agl). The various sensors are placed in the tower at different levels of 1.5, 10, 20 and 30 m agl height from the surface. We use the meteorological data available at 10 m height to correlate the surface O₃ and its precursors during the study period. Sampling inlets of all analyzers were stationed at ~10 m height agl. We have also analyzed the difference of the ambient temperature between different levels [(2 and 3: 10–20 m agl), (3 and 4: 20–30 m agl) and the height between them are 10 m] to estimate the atmospheric stability of the observational layer.

Fig. 3 shows the averaged diurnal difference in temperature ($^{\circ}\text{C m}^{-1}$) between different layers during winter, summer and monsoon seasons of the study period. During winter, at the observational site the average temperature at 10, 20 and 30 m agl were 11.90, 12.69 and 12.83 °C, respectively. The average difference of the ambient temperature between 10–20 and 20–30 m agl were 0.079 $^{\circ}\text{C m}^{-1}$ (range: -0.08 – $0.27 \text{ }^{\circ}\text{C m}^{-1}$) and 0.014 $^{\circ}\text{C m}^{-1}$ (range: -0.03 – $0.05 \text{ }^{\circ}\text{C m}^{-1}$), respectively during winter season. The average ambient temperature at 10, 20 and 30 m agl were 30.20, 31.30 and 31.53 °C, respectively during summer season whereas, the average difference of the ambient temperature between 10–20 and 20–30 m agl were 0.109 $^{\circ}\text{C m}^{-1}$ (range: -0.06 – $0.28 \text{ }^{\circ}\text{C m}^{-1}$) and 0.024 (range: -0.02 – $0.06 \text{ }^{\circ}\text{C m}^{-1}$), respectively. During monsoon, the average difference of the ambient temperature between 10–20 and 20–30 m agl ranged from -0.49 to 0.26 and 0.01 to 0.06 $^{\circ}\text{C m}^{-1}$, respectively with average value of -0.114 (at 10–20 m agl) and 0.036 $^{\circ}\text{C m}^{-1}$ (20–30 m agl). During the study period temperature variation between 10 and 20 m agl were higher than the 20–30 m agl. However, the analysis shows that the temperature variation were $< 0.3 \text{ }^{\circ}\text{C}$ between the levels upto 30 m agl and stable during the study period and not influence the sampling height of surface O₃ and its precursors gases.

3. Results and discussion

3.1. Mixing ratios of surface O₃ and its precursors

The average seasonal variation in mixing ratios of surface O₃, NO, NO₂, CO, CH₄ and NMHCs with an annual average values are

Download English Version:

<https://daneshyari.com/en/article/4435393>

Download Persian Version:

<https://daneshyari.com/article/4435393>

[Daneshyari.com](https://daneshyari.com)