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Original Research Article

An observation of seasonal and diurnal behavior of O_3–NO*x* relationships and local/regional oxidant (OX = $O_3 + NO_2$) levels at a semi-arid urban site of western India

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ABSTRACT

The present study summarizes the continuous measurements of ozone (O_3) and oxides of nitrogen (NO*x* = NO + NO_2) along with meteorological conditions in the ambient atmosphere of semi-arid urban site of western India during the year 2012–13. Seasonal and diurnal variations of gaseous pollutants were investigated and compared using the results of time series analysis. The marked seasonal difference was observed for O_3 as highest/(lowest) during pre-monsoon/(monsoon), respectively. In contrast, NO and NO_2 exhibit the highest and lowest levels during post-monsoon and monsoon, respectively. The diurnal cycle of O_3 and NO*x* exhibited inverse relationship where surface O_3 showed mid-day peak and lower night-time concentrations. The dataset was used to examine the association of O_3 with the ambient levels of NO, NO_2 and NO*x* during day-time and night-time, separately. The variation of an oxidant OX ($O_3 + NO_2$) with the levels of NO*x* was examined to infer the atmospheric sources of OX as sum of NO*x*-independent regional and NO*x*-dependent local contributions. Significantly strong positive correlations were observed of O_3 with temperature and solar radiation with strong negative correlation with relative humidity during the studied seasons. Inconsiderable difference ($< 10\ \mu g\ m^{-3}$) was observed between weekends and weekdays for the levels of O_3 during entire observation period.

1. Introduction

Ozone (O_3), a type of photochemical oxidant, is formed in the troposphere with complex non-linear processes among interaction of nitrogen oxides (NO*x*), volatile organic compounds (VOCs), temperature and intensity of solar radiation [1,2]. Tropospheric O_3 has a significant role in contributing global warming and climate change phenomenon as Short-Lived Climate Forcer/pollutant [3]. It influences the chemical properties of the atmosphere and considered as the third most important anthropogenic greenhouse gases after CO_2 and CH_4 [4,5]. It is the essential precursor of hydroxyl radical which controls the oxidizing capacity of the atmosphere and influences the primary air pollutants [6]. The concentrations of O_3 are mainly influenced by its precursor emissions and various processes such as photochemistry, physico-chemical removal and transport of the pollutants [7,8].

Tropospheric O_3 formation is initiated by photochemical destruction of nitrogen dioxide (NO_2) resulting in the formation of nitric oxide (NO) and mono-atomic oxygen (O). Afterwards, released oxygen atom together with molecular oxygen forms O_3 molecule while NO quickly reacts with O_3 in regenerating NO_2 in the absence of VOCs. On the other hand, the levels of O_3 increase after conversion of NO to NO_2 with the release of hydroperoxy (HO_2) and peroxy (RO_2) radicals [9]. The O_3 formation increases with increasing concentrations of VOCs while rising levels of NO*x* leads to increase/decrease O_3 depending on the prevailing ratio between VOCs and NO*x* [10,11]. O_3 is greatly influenced by prevailing meteorological conditions (temperature, wind, relative humidity and solar flux). Many observations have shown that O_3

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concentration increases with increase in temperature and solar flux [12]. Furthermore, the observed concentration of O_3 variation is higher in clear days as compared to cloudy days. Transport of O_3 precursors over long distances in the presence of favorable meteorological conditions results in O_3 formation far from the emission sources [13].

Apart from climatic impacts, continuous exposure of O_3 and NO_2 can have adverse impacts of public health (short-term mortality and respiratory illness), animal population, agricultural productivity and vegetation [14,15]. Also keeping the NO_2 concentration at lower levels provides significant benefits for human health [16]. Due to toxic effects, WHO has recommended the guideline values for O_3 (100 $\mu g\ m^{-3}$ for 8-h mean) and also set an interim target (160 $\mu g\ m^{-3}$ for 8-h mean) and a high levels value (240 $\mu g\ m^{-3}$ for 8-h mean) for significant health effects [17]. In case of NO_2, the standard limits were established at 40 $\mu g\ m^{-3}$ annually and 200 $\mu g\ m^{-3}$ hourly as a value not exceeding more 18 times in a year [18].

Studies pertaining to chemistry of O_3 and NO_x have been widely performed at many locations across the world including Indian region [19–25]. However, very limited studies regarding O_3 and its precursors have been reported in the western part of the Indian region. The present study aims to evaluate the tropospheric levels of O_3 and NO_x for the entire year during December 2012 to November 2013 in the ambient atmosphere of Jodhpur, Rajasthan, India. The main objectives of the work are (a) To monitor the seasonal and diurnal variability of O_3 and NO_x; (b) To estimate the relationship between O_3 and NO_x ($NO + NO_2$) during day-time and night-time; (c) To examine variation of an oxidant OX ($O_3 + NO_2$) with NO_x to know the atmospheric sources of OX in the area; (d) To observe the extent of association of O_3 with NO_x and meteorological parameters; and (e) To investigate the weekend effect of O_3 in the studied area.

2. Materials and methodology

2.1. Study area

The continuous real time ambient air quality monitoring of gaseous pollutants and meteorological parameters was carried out at the center of the Jodhpur District, State Rajasthan, India (Fig. 1). Jodhpur (also known as Sun City), a metropolitan city situated in western India extends between 26°18′ N latitude and 73°04′ longitude. The city is located at an altitude of 250–300 m from mean sea level. It is spread over an area of 290 km^2 having population approximately 1,033,800; of which male and female are 52

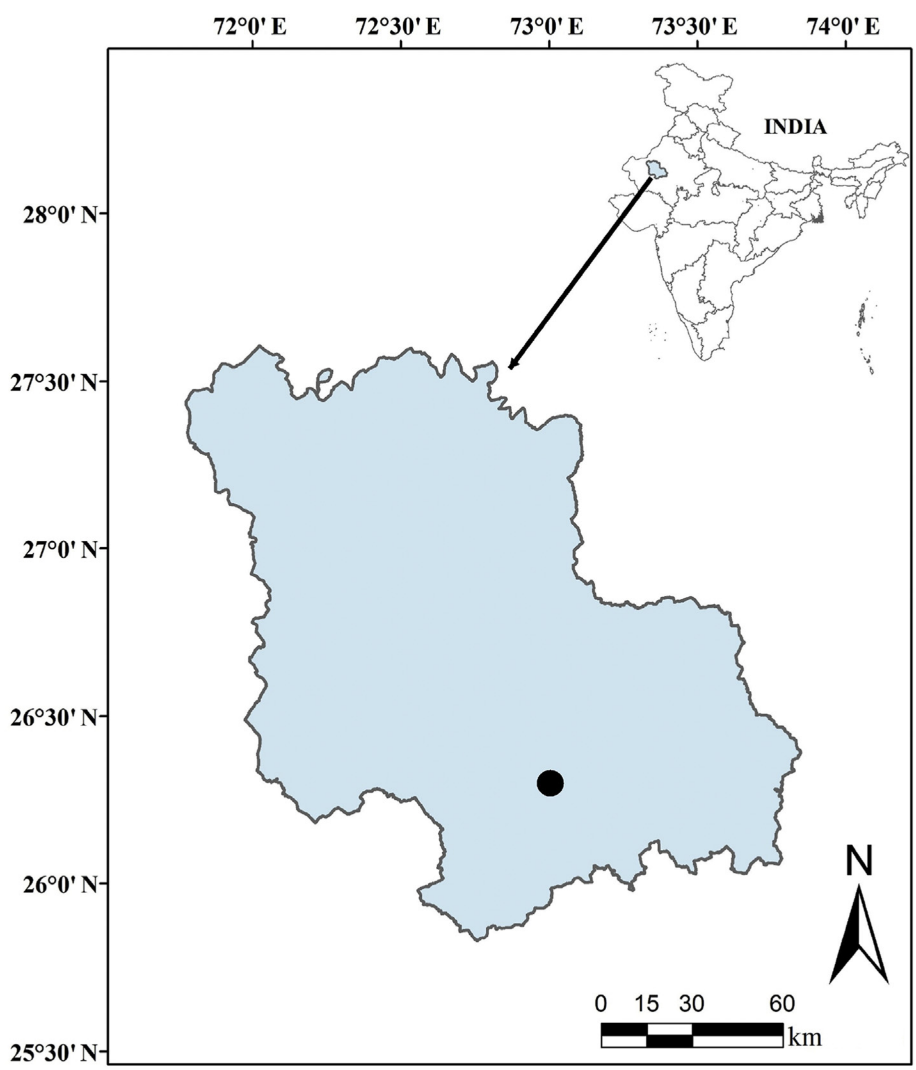

Fig. 1. Map showing the study area (Jodhpur), India (Black circle presents sampling point).

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