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RESEARCH ARTICLE

COMPARISON OF GROUND LEVEL OZONE CONCENTRATION DURING SUMMER AND WINTER AT A RESIDENTIAL AREA, CHENNAI

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ABSTRACT

The Ozone concentration is influenced by the intensity of solar radiation and chemical reaction between oxides of nitrogen (NOx) and volatile organic compounds (VOC) in the presence of sunlight. This paper attempts to study the variation of ground level ozone for two seasons summer (Mar.' – May.'16) and winter (Jan.'-Feb.'16) at residential area, Chennai. The overall result shows that highest concentration of ground level ozone was observed in summer as compared to the winter season.

INTRODUCTION

A high concentration of ground level ozone has been recognized as a harmful pollutant for decades because it is the primary ingredient in photochemical smog and has detrimental effects on human health and the environment (Pires *et al*, 2009). It plays a vital role on the radioactive balance of the atmosphere (Londhe *et al*., 2008).Ozone does not have direct natural sources; It results from the photochemical reactions between oxides of nitrogen (NOx) and volatile organic compounds (VOCs) in the presence of sunlight (Dovile Laurinavicine, 2009).Ozone is strongly depend on meteorological parameters that controls, influences the speed and amount of photochemical production of Ozone. Typical summer weather conditions are responsible for an increase in ground level Ozone production (S.B. Debaje *et al*. 2003). This study intends to assess the variation in ground level Ozone concentration over two seasons (summer and winter) at Chennai.

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Experimental

Study Area

Ground level ozone measurements were carried out in the area of Ashok pillar (Fig. 1), Chennai for a period of five months from January 2016- May 2016 with the aim to assess the variation of ozone over the two seasons. This study area is of importance mainly because this region is now slowly developing into a well known area with new infra-structural developments introduced by the Government and Chennai Metro Railway station were started functioning here. It is located nearby Koyambedu, which houses Chennai's mofussil bus terminus.

METHODS

Ozone levels were continuously monitored every hour from January 2016 to May 2016 using the Aeroqual S 500 gas sensitive sensor (Fig. 2), which is based on the Gas Sensitive Semiconductor technology (GSS Technology). Gas sensitive semiconductor (GSS) technology is next up the ladder for accurate measurement of ozone at lower level.

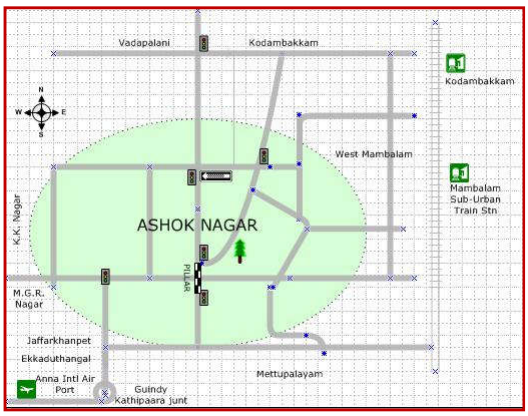

Fig.1 Study Area

Maintenance issues and the need for calibration are also eliminated with this technique. Sensing heads can be removed and new ones can be inserted in the field. GSS technology is a combination of smart measurement techniques and mixed metal oxide semiconductor sensors that exhibit an electrical resistance

Fig. 2. Aeroqual S500 Gas sensitive sensor

change in the presence of a target gas. The range of ozone measurement is 0.0-0.0150 ppm. The sensor can detect ozone values upto a lowest value of 0.001 ppm with a resolution of 0.001 ppm.The meteorological parameters were obtained from Indian Meteorological Department (IMD) and Tamilnadu Pollution Control Board (TNPCB), Chennai.

RESULTS AND DISCUSSION

Hourly average Variations

The general trend of Hourly Ozone variation at study area during monitoring period is represented in Figure 3. In the Season of Summer, the ozone Concentration was 34.19±2.16 and highest concentration (45.70) was recorded at 14:00 pm , and lowest was recorded at 01:00 am , where as in the season of Winter, the ozone Concentration was 26.41± 1.94 and highest concentration (39.83) was recorded at 14:00 pm and lowest was recorded at 02:00 am . The increase of ozone concentrations during daylight hours is attributed to the photolysis reactions of NO_2 and photo oxidation of VOC's, CO, hydrocarbons and other O3 precursors. It is also attributed to the downward transport of ozone by the vertical mixing, due to convective heating, which takes place during daytime hours (Lal *et al*, 2000; Tyson *et al*,1998).The low values at night were attributed to the destruction of ozone by a rapid reaction between ozone and nitric oxide (NO titration) and also there was no photolysis of O3 precursors taking place due to the absence of sunlight (Sillman, 1995).

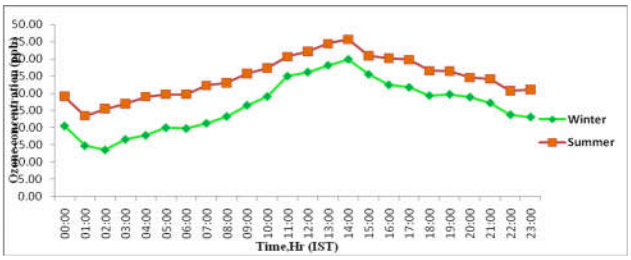

Fig 3. Hourly avg variation of ground level Ozone concentration

Seasonal Variations of Ozone

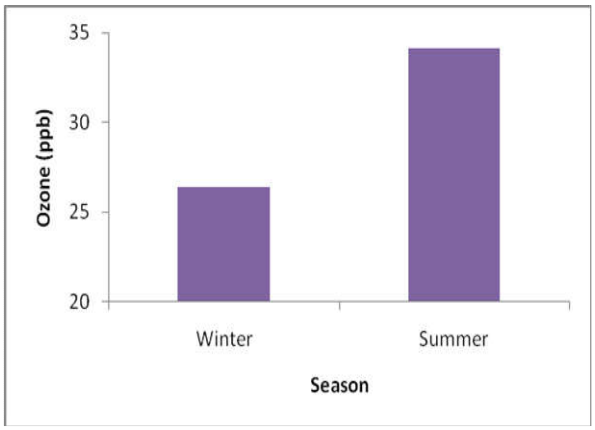

Fig.4. Seasonal Variations of ground level Ozone concentration

The variation in ozone concentration in two different seasons may be due to the variation in NOx, CO, CH4, hydrocarbon levels and changing meteorological conditions like temperature, cloud cover, wind velocity, wind direction, relative humidity and rainfall (Nishanth *et al*., 2011).The seasonal diurnal pattern has been determined by taking the overall average of the diurnal ozone values of various months. It is shown in Fig. 4. During summer, the diurnal pattern showed a peak as compared to winter. The shape and amplitude of ozone cycles are strongly influenced by meteorological conditions and prevailing levels of precursors (S. Singh *et al.,* 1997). Thus high temperatures, more intense solar radiation and longer day lengths enhance the photochemistry, resulting in high concentration of O_3 during summer (Pulikesi *et al*, 2005). As the study area experiences the lower ozone concentration levels seen in winter seasons can be attributed to the rainfall effect. Rainfall cleanses the atmosphere, which is clearly reflected by the reduction in ozone concentration during winter seasons.

Variation of Ozone with Meteorological parameters

The deviation in surface ozone concentration depends on not only on precursor emissions but also on meteorological conditions. Meteorological variables such as temperature and wind influence the ozone formation, deposition and transport process by affecting photochemical reactions and atmospheric dynamic conditions(D. Pudsainee *et al*, 2006).The influence of available meteorological variables on the surface ozone concentration at the observational site is discussed briefly in the following.

Correlation between temperature and surface ozone

The relation between ozone concentration and temperature is shown in Figure 5. The ozone concentration is at peak when temperature is the maximum which indicates ozone concentration levels are directly related to temperature. Ambient air temperatures differ with season of the year. During the study period, average maximum temperature about 32˚ C was observed in summer (May'16) and average low temperature of about 26˚C was observed in winter(Jan'16).

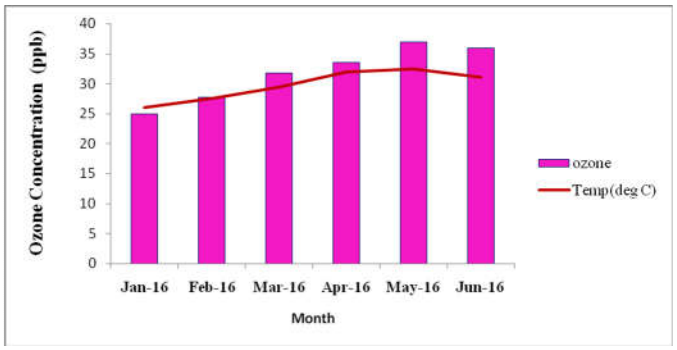

Fig. 5. Correlation between temperature and surface ozone

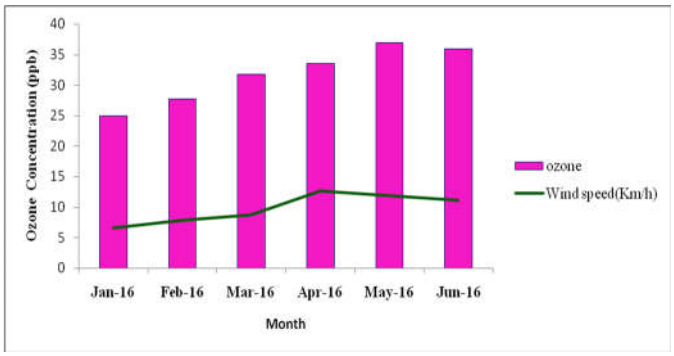

Fig. 6. Correlation between wind speed and surface ozone

Correlation between wind speed and surface ozone

The relation between ozone concentration and wind speed is shown in Figure 6. It can be examined that the peak tropospheric ozone concentration is obtained during the period from may to June when the wind speed value is at a slight minimum. This is because during this phase the temperature is high and cloud free conditions prevail. So, this period provides a favorable condition for the ozone production as this is the time with the higher amount of daylight, when solar radiation is most direct (the sun is at a small zenith angle) and air temperatures become quite high (most of the time greater than 28°C) and photochemical production of ozone occurs at peak rates (Decker *et al*., 1976).The average monthly ozone concentration was in slight positive correlation with the average wind speed during winter seasons and in slight negative correlation in summer.

Conclusion

Ground level ozone measurements were made at Ashok pillar, Chennai, a tropical urban site, in the southeastern coastal region of India for a period of five month from January 2016 to May 2016. During the entire study period, The diurnal pattern of surface ozone concentration clearly indicates its dependency on the photochemical production process rather than from on-site vertical or horizontal transport. In common the surface ozone concentration is observed to the maximum in summer and least in winter. From this study, it is found that there is an increasing trend in ozone concentration. This increasing trend is supported by the general pattern of variation and trend observed at south Indian continent. This is an indication of the increasing concentration of ozone precursor species. The investigation confirms that the ozone concentration was mostly positively correlated with temperature and slight positive correlation with the average wind speed during winter seasons and in slight negative correlation in summer.

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