https://dx.doi.org/10.22161/ijeab.45.39 *ISSN: 2456-1878*

Tropospheric Ozone Monitoring in Pune City

E. Ravendiran[1*], V. M. Motghare[2], Ajay R. Ojha[3], Prasad R. Pawar[3], Mohamad Nadeem Shaikh[3]

[1]Member Secretary, Maharashtra Pollution Control Board, Mumbai, India
[2]J.D. APC, Maharashtra Pollution Control Board, Mumbai, India
[3]Technogreen Environmental Solutions, Pune, India

Abstract**—** *Certain levels of stratospheric ozone are essential for existence of life. On the other hand, it has been proven that even very low levels of tropospheric or photochemical ozone damages plants and materials such as rubber and have harmful effects on the human respiratory system. With increasing industrialization and the tendency of majority of industries to congregate in areas which are already heavily industrialized, the problem of air pollution has begun to be felt in India. Short-term studies conducted by National Environmental Engineering Research Institute, Nagpur have confirmed that cities like Calcutta, Mumbai, Delhi and Pune are facing the impact of air pollution on a steadily increasing level. The present study deals with ground level ozone concentration at different sites in Pune. The sites have been categorized as residential cum commercial (Nalstop), commercial (Swargate), industrial (Bhosari), mixed land use (Karve Road), and area outside Pune (PimpriChinchwad Municipal Corporation). The average concentration of ozone in Pune as measured during the study period ranges from 0.39 ppmv to 3.36 ppmv. Bhosari has recorded maximum average concentration of ozone whereas Karve road shows the minimum average concentration of ozone.*

Keywords**— Stratospheric ozone, photochemical, air pollution, urban air, major Indian cities.**

I. INTRODUCTION

Ozone is one of the secondary air pollutants whose high concentration is harmful to humans and plants [3]. Ozone is known to be a toxic agent to humans and phytotoxic to vegetation [2]. Stratospheric input and photochemical ozone formation in the troposphere are the two main sources determining the ozone levels in the surface layer of the atmosphere. Because of the importance of ozone in controlling the atmospheric chemistry and its decisive role in the heat balance of atmosphere, leading to climate change, the examination of its formation and destruction are of great interest [4]. Several studies have been made concerning ozone behavior in the natural troposphere. However, the importance of studies on tropospheric ozone being realized, particularly in rapidly developing countries located in the tropics and subtropics, which are also regions of very limited measurements of ozone and its precursor gases(particularly Asia) [8]. Many studies measuring ozone concentrations have tended to focus on traffic intersections such as the ITO junction in Delhi [10[. Since ozone precursors and ozone travel large distances, it is important to measure ozone away from traffic corridors. Ozone concentrations may very well be much higher in non-traffic areas.

However, information on ozone levels in tropical areas, especially in Asian countries, which are at the threshold of rapid industrial development, is scanty. The Honorable Supreme Court of India has declared Pune as one amongst the 16 most polluted cities in India. With regards to these, various studies have been conducted in Pune since 2002 [7]. However, these studies have been restricted to aerodynamic diameter of 10 microns (PM_{10}). Like any other city, Pune is also witnessing a spurt in the number of vehicles. There are approximately 33,00,000 vehicles in Pune city. This year the growth rate of vehicles has doubled. The trips of the vehicles have also increased thereby making the growth rate of traffic 25% [7]. In the contextof the same, it was anticipated that surface ozone in Pune might be a critical parameter and indicator of air quality thereby scoping our studies to O_3 monitoring in Pune as an urban area.

II. MATERIALS AND METHODS

2.1. Study Area

Pune (18°32'N, 73°51'E) is situated on the Deccan Plateau, on the lee side of the Western Ghats (range of hills) and is about 100 km inland from the west coast of India. It is situated at a height of 560 meters above the mean sea level, near the confluence of Mula andMutha Rivers. Over the

https://dx.doi.org/10.22161/ijeab.45.39 *ISSN: 2456-1878*

years the number of vehicles in Pune has increased. Around 10,000 vehicles are added to the Pune roads every month. This not only adds to congestion but also deteriorates the air quality of the city. It is estimated that about 60% of the Pune Municipal Corporation (PMC) roads in the heart of the city are congested whereas remaining 40% of the roads in the fringe area have relatively lower traffic volumes. Based on the criteria shown in TABLE 1,O_3 monitoring sites have been selected. The locations of the monitoring sites are represented in the map of the Pune city as shown in Fig. 1.

Fig.1. Map showing monitoring locations in Pune.

2.2. Meteorology

During monitoring period (January) prevailing wind direction was from the east with an average speed between 1.9 – 7.5 km/hr. The temperature averaged between 20-24˚C with a relative humidity ranging from 35 - 40%.

2.3. Frequency of Sampling

Monitoring was carried out at locations as described earlier for a period of one month. Samples were collected twice a week from Nalstop, Swargate and Bhosari as per the National Ambient Air Quality Monitoring Program (NAAQMP) protocol. Total samples collected from these three sites were twenty-four, eight samples from each site. At Karve road and Pimpri Chinchwad Municipal Corporation (P.C.M.C.) monitoring was carried out daily making in all 62 samples.

2.4. Analytical Protocol

High Volume Sampler (HVS) (Envirotech APM 460DX) was used for sampling. The O_3 concentrations were estimated by Neutral Buffered Potassium Iodide (NBKI) (pH=6.870.2) method, by bubbling a known volume of ambient air (1 l/min for 8 hrs). The absorbing reagent consists of 1 % potassium iodide in a neutral buffer composed of potassium dihydrogen phosphate annhydrous disodium hydrogen phosphate. The absorbing reagent was stored in the amber colored bottle and kept at room temperature for one day before using. The absorbing reagent was stored in the amber colored bottle in the refrigerator for several weeks [1]. The iodine liberated in the absorbing reagent is determined spectrophotometric ally by measuring the absorption of a tri-iodide ion at 352 nm. The range of this method extends from 0.01 ppm to 10 ppm. The reaction can be given as follows:

$O_3 + 3\ KI + H_2O \rightarrow KI_2 + 2\ KOH + O_2$

III. RESULTS AND DISCUSSIONS

Variations in the ground level ozone concentration observed at different sites, in Pune have been represented and discussed in the following sections.

3.1. Ozone Concentration at Karve Road

Results of ozone concentration at Karve Road are shown in Fig. 2; ozone shows marked temporal variation at Karve Road. The average concentration of ozone at this site was found to be 0.54 ppmv with a standard deviation of 0.06. At this site concentration of ozone varies from 0.398 ppmv – 0.65 ppmv. This sampling site is close to the center of the city, therefore, it primarily reflects the vehicular sources that are contributing to the ozone-forming precursors [6].

https://dx.doi.org/10.22161/ijeab.45.39 *ISSN: 2456-1878*

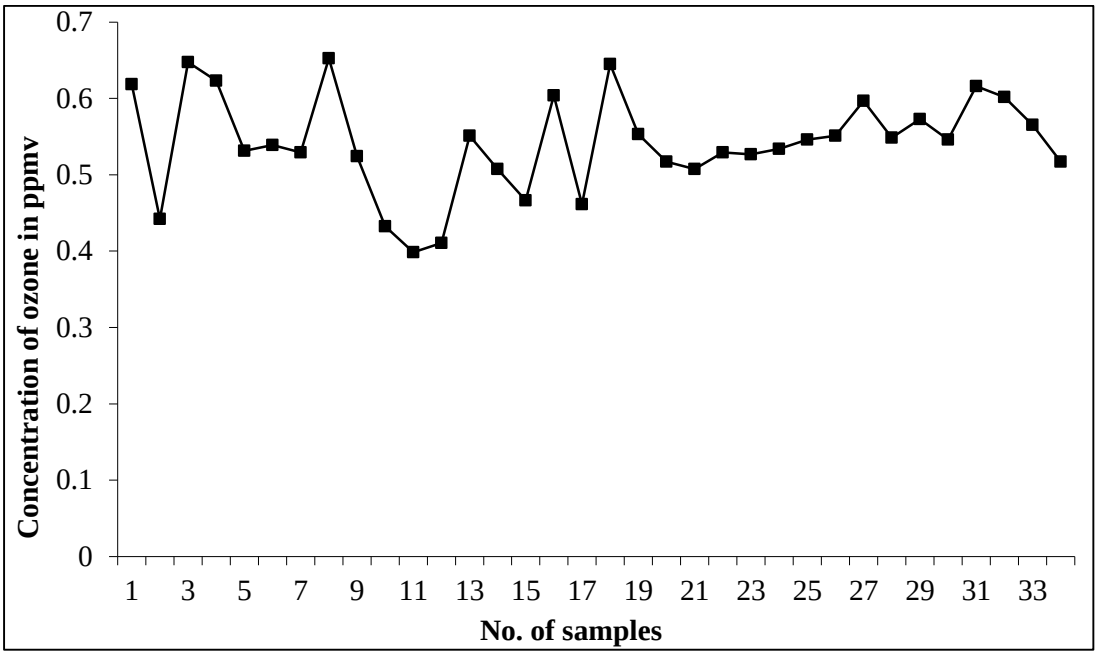

Fig.2. Concentration of ozone at Karve road.

3.2. Ozone Concentration at P.C.M.C.

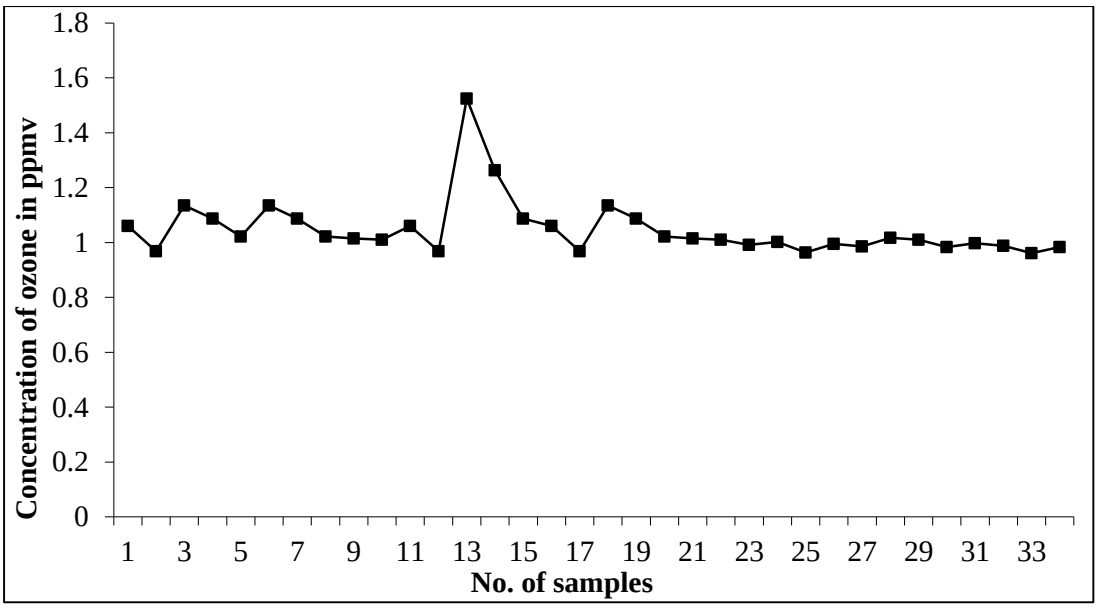

Fig.3. Concentration of ozone at Pimpri Chinchwad Municipal Corporation.

Fig. 3 shows comparatively higher temporal variation in ozone at P.C.M.C. than Karve Road. This site was selected to make a comparison between sites in Pune and site outside the Pune. The average concentration of ozone at this site was found to be 1.04 ppmv with standard deviation 0.1. At this site concentration of ozone varies from 0.96 ppmv to 1.52 ppmv. Ozone concentration observed at this site was higher than that of Karve Road. This area is of mixed land use; therefore there might be many different types of sources of ozone precursors.

https://dx.doi.org/10.22161/ijeab.45.39 *ISSN: 2456-1878*

3. 3. Comparative Account of Ozone Concentration across Three Different Areas

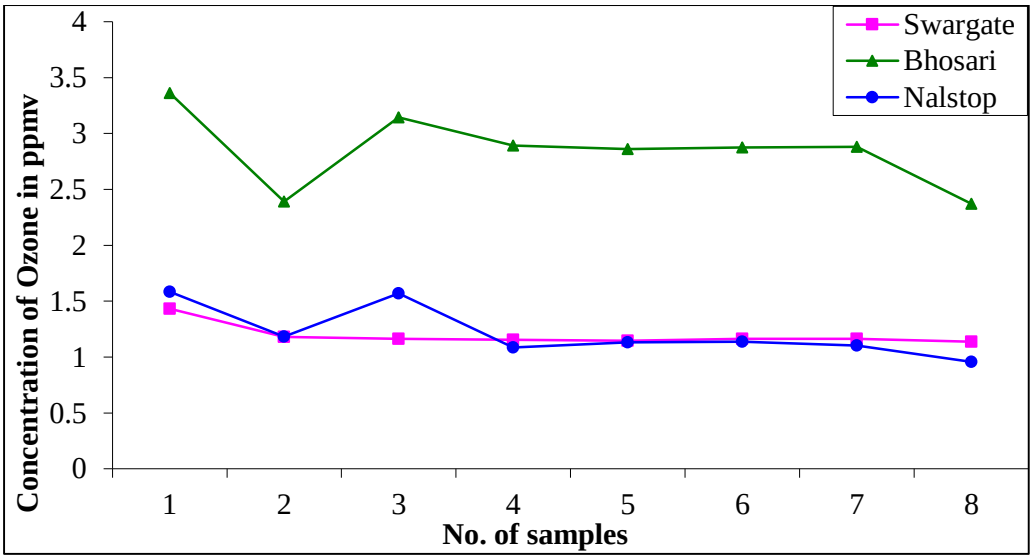

Fig.4. Concentration of ozone at three different areas.

Nalstop, Swargate and Bhosari sites are not regularly monitored. There is a marked similarity between the trends in ozone concentration at Swargate and Nalstop (Fig. 4).Swargate is a commercial area and it also represents the traffic intersection, with high vehicular density. Nalstop on the other hand is a residential cum commercial site. At these two sites, one of the major sources of ozone precursors seems to be traffic. Whereas the industrial site Bhosari shows a different pattern of ozone concentration revealing that there might be a number of different sources contributing to ozone precursors in this area.

3.4. Comparative Account of Ozone Concentration across Two Different Areas

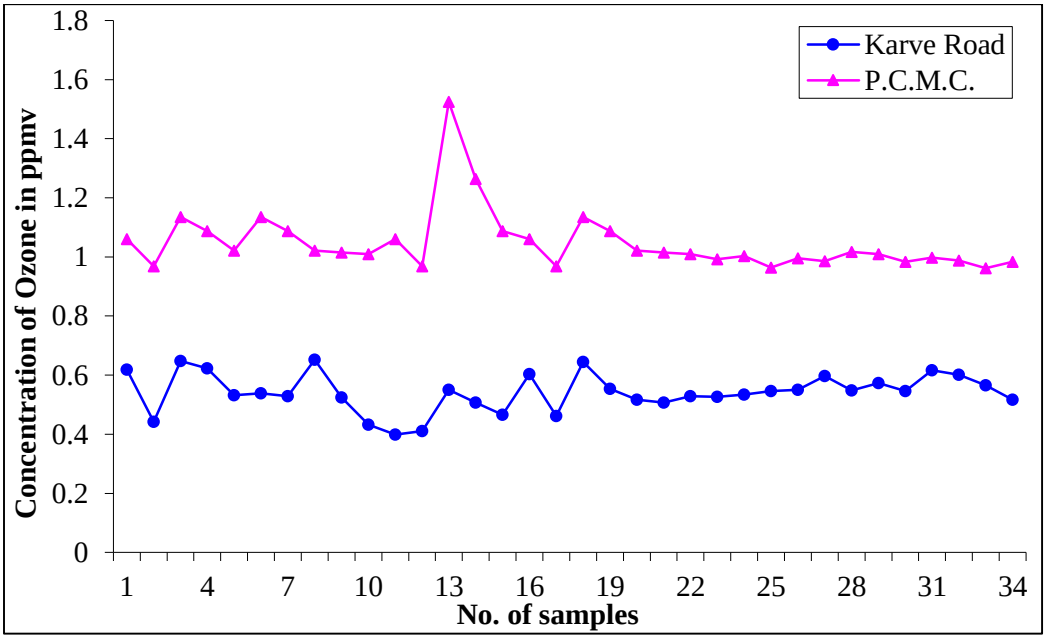

Fig.5. Concentration of ozone at two different areas.

https://dx.doi.org/10.22161/ijeab.45.39 *ISSN: 2456-1878*

Karve road and P.C.M.C. sites were monitored daily for a period of one month. The concentration of ozone at P.C.M.C. was found to be much higher than the concentration at Karve road and is represented in Fig. 5.There might be various reasons of increased ozone concentration at P.C.M.C. such as it being near to the industrial zone, Bombay-Pune highway and in addition to that there was a road construction activity that resulted in the traffic congestion. On the other hand, at Karve Road only one source that is traffic, which might be contributing to a source of ozone precursor [5].

3.5. Spatial Variation of Ozone

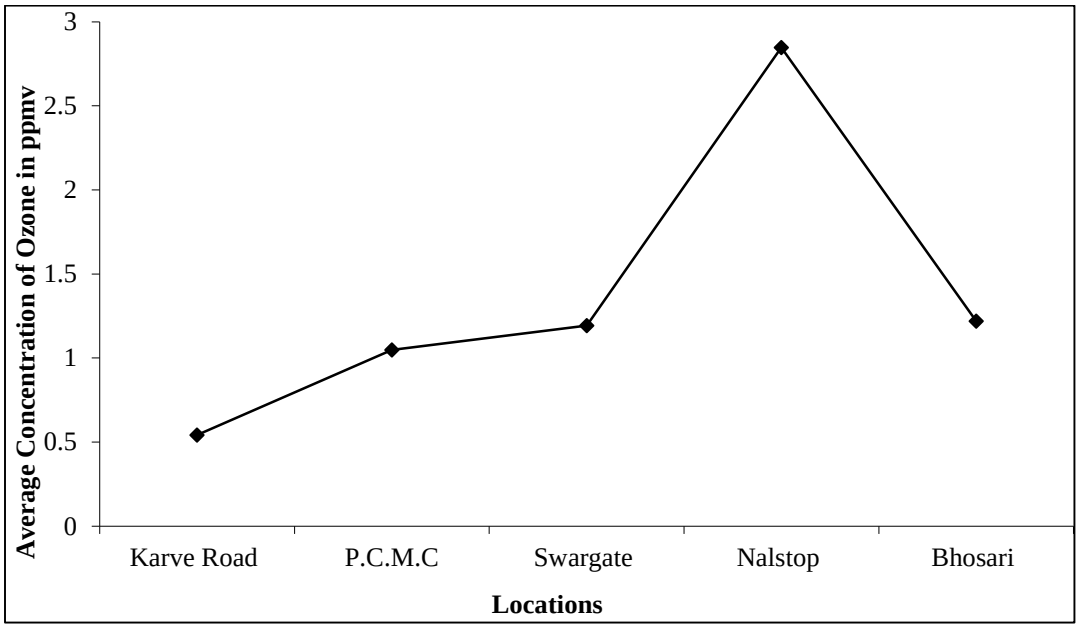

Fig.6. Spatial variation of ozone.

As shown in Fig. 6**,** Bhosari has recorded maximum average concentration of ozone. Bhosari being an industrial zone comprising mainly of petrochemical, chemicals, and other air polluting industries, it is quite expected to have high amounts NOx and VOC that indeed leads to increase in the concentration of ozone. Karve road shows the minimum average concentration of ozone. This is because there might be very low concentrations of the precursors required for ozone formation.

https://dx.doi.org/10.22161/ijeab.45.39 *ISSN: 2456-1878*

3.6. Comparison with the NOx data

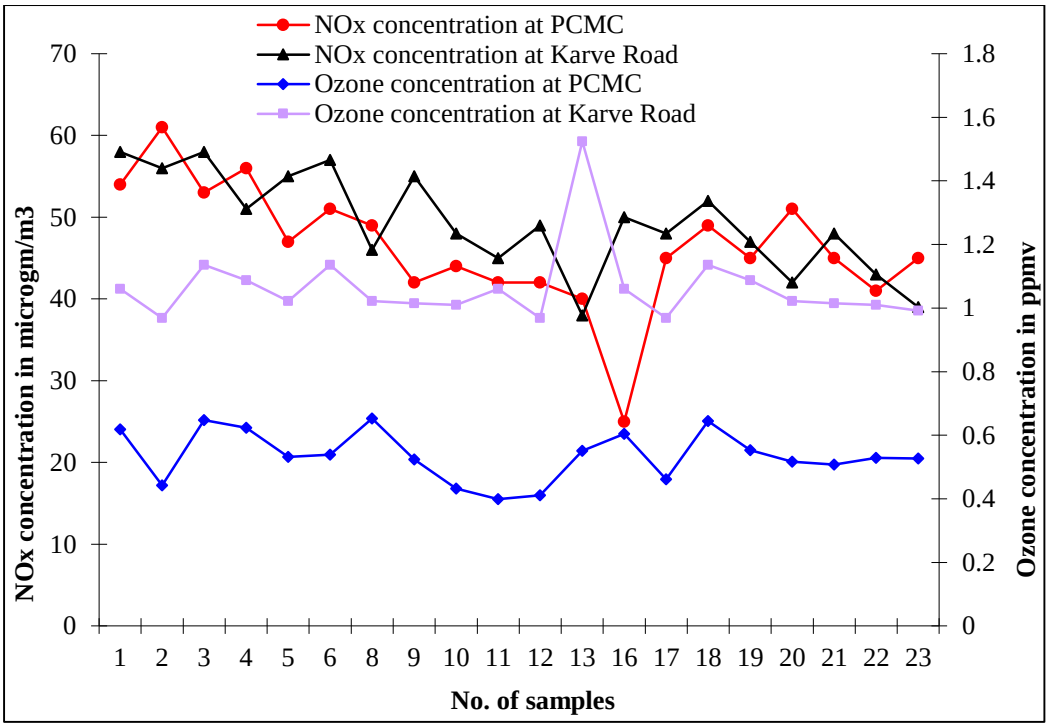

Fig.7. Comparison with the NOx data.

Maharashtra Pollution Control Board (MPCB) has carried out a sampling of NOx at different sites in Pune, under National Air Monitoring Program. High concentration of NOx encourages ozone production [5]. In order to sustain high levels of ozone, large amounts of precursors like NOx are needed. This leads to very low levels of these precursors, as they are used up for ozone production. As observed in Fig. 7, NOx and ozone concentrations show almost similar trend because the rate of emission of NOx is equivalent to the rate of ozone formation.

IV. CONCLUSION

Measurement of tropospheric ozone concentration in Pune shows the signature of the polluted site in tropics. The ambient air standard of 0.12 ppm adopted by the Environment Protection Agency (EPA) for ozone is violated on many occasions [9]. Differences in the ozone concentrations at various sites may be due to differences in the concentration of the precursors, secondary chemical reactions and more of the atmospheric chemistry related to ozone formation. Bhosari shows high variation in ozone concentration, which may be due to the significant increase of the precursor load from the industrial area. Most of the study sites are concentrated in the central part of the Pune city; hence ozone concentrations have been expected to primarily reflect the impact of vehicular sources. There is still a direct need for more thorough study investigation on the diurnal variations as well as measurement of precursors for a better understanding of the ozone behavior in fast developing cities of India.

V. ACKNOWLEDGEMENT

We received generous support from Mr. R. B. Sorte (Scientific Officer – MPCB) during sampling. We would like to thank field assistants of MPCB who have aided us during sampling.

REFERENCES

[1] American Public Health Association (APHA), 1989. Water Environment Federation (1995) Standard methods for the examination of water and wastewater.

[2] Chameides, W.L., Xingsheng, L., Xiaoyan, T., Xiuji, Z., Luo, C., Kiang, C.S., St John, J., Saylor, R.D., Liu, S.C., Lam, K.S. and Wang, T. (1999). Is ozone pollution affecting crop yields in China?*Geophysical Research Letters*, (ISSN: 1944-8007), 826(7), 867-870.10.1029/1999GL900068

[3] Finnan, J.M., Burke, J.I. and Jones, M.B. (1997). An evaluation of indices that describe the impact of ozone on the yield of spring wheat (*Triticumaestivum L.*). *Atmospheric*

Environment, (ISSN: 1352-2310), 31(17), 2685-2693.10.1016/S1352-2310(97)00105-2

[4] Khemani, L.T., Momin, G.A., Rao, P.S.P., Vijayakumar, R. and Safai, P.D. (1995). Study of surface ozone behaviour at urban and forested sites in India. *Atmospheric Environment*, (ISSN: 1352-2310), 29(16), 2021-2024.10.1016/1352-2310(94)00293-T

[5] Latha, K.M. and Badarinath, K.V.S. (2004). Correlation between black carbon aerosols, carbon monoxide and tropospheric ozone over a tropical urban site. *Atmospheric Environment*, (ISSN: 1352-2310), 71(4), 265-274.10.1016/j.atmosres.2004.06.004

[6] Latha, K.M. and Badarinath, K.V.S. (2003). Diurnal and seasonal variations of NOx over urban environment- a case study from Hyderabad, India. *Indian Journal of Environmental Sciences*, (ISSN: 0971-8958), 7(1), 63-73.

[7] Urban Air Quality Management in India, 2002. MoU between USEAP, GoIandMoEF.

[8] Naja, M., Lal, S. and Chand, D., 2003. Diurnal and seasonal variabilities in surface ozone at a high altitude site Mt Abu (24.6 N, 72.7 E, 1680 m asl) in India. *Atmospheric Environment*, (ISSN: 1352-2310), 37(30), 4205-4215.10.1016/S1352-2310(03)00565-X

[9] Sharma, B.K. "Environmental Chemistry", 11th edition, Meerut, India:S. K. Rastogi for Krishna Prakashan Media (P) Ltd., 2004.

[10] Tata Energy Research Institute (TERI), 2001. Review of past and on-going work on urban air quality in India. New Delhi: Tata Energy Research Institute. 101 pp.[TERI Project Report No. 2001EE41].