International Research Journal of Environment Sciences ISSN 2319–1414
Vol. **4(7),** 81-85, July **(2015)** *Int. Res. J. Environment Sci.*

Seasonal Monitoring of Ozone Concentration and its Correlation with Temperature and Relative Humidity

Shampa Sarkar
Environmental Research Laboratory, P.G. Department of Environmental Science, Govt. Model Science College (Autonomous), Jabalpur 482001, MP, INDIA

Available online at: www.isca.in, www.isca.me
Received 30th May 2015, revised 14th June 2015, accepted 10th July 2015

Abstract

The triatomic oxygen, high in the atmosphere reconstructs itself and converts it into ozone (O_3). In lower atmosphere O_3 act as a secondary pollutant, which depends on regional topography and climate. The Indian Meteorological Department (IMD) designated India into four seasons: winter, summer, monsoon and autumn. The seasonal study of Jabalpur shows higher O_3 concentration in autumn (62ppb) and winter (59ppb) of the year 2013 and 2014 respectively. The concentration of O_3 correlates with meteorological parameters like temperature and relative humidity (RH). In the year 2013, O_3 shown negative correlation with both temperature and RH (r= -0.5163 and -0.1729) respectively. Similarly in the year 2014, O_3 shown negative correlation with temperature and RH (r= -0.3597 and -0.3880) respectively, though their fluctuation may vary with each other.

Keywords: Meteorological parameters, negative correlation, relative humidity, secondary pollutant, topography.

Introduction

Ozone is an allotrope which consisting of three oxygen atoms that are bound together (triatomic oxygen) and forms the chemical formula 'O_3'. At very high in the atmosphere in between tropospheric and stratospheric layer; a layer is present which known as ozonosphere where O_3 occurred. In ozonosphere, concentration of O_3 varies from 2-8 ppm which is slightly higher than lower atmosphere.

Mainly O_3 is an important part in stratosphere and also troposphere. Scientifically, ground level ozone is termed as secondary pollutants because it is formed when the primary pollutants nitrogen oxides (NO_X) and volatile organic compounds (VOC) combine in the presence of sunlight. O_3 concentration is shows variation due to topography and season of the region.

According to IMD (Indian Meteorological Department); India has designated into four seasons: winter, summer, monsoon and autumn. Winter occurred from December to March. Summer or pre-monsoon lasting from April to June and May is the hottest month of the year. Monsoon or rainy season enduring from July to September and contains lots of humidity. Post-monsoon or autumn season lasting from October to November, after that again winter is started.

In addition to this, the meteorological parameters; temperature and relative humidity fluctuates the concentration of O_3 rapidly. They are inter-correlated with each other and provide accuracy throughout its assessment. Distribution of ozone and its precursors over Bay of Bengal during winter 2009: role of meteorology[1] has studied by *David et.al*. Ozone mixing ratio was observed at the head and southeast of BoB, with a mean value of 61±7 ppb and 53±6 ppb respectively. Diurnal patterns decreased ozone mixing ratio during noon/afternoon which has increase in nighttime and high in morning.

Lal et.al. has studied on the seasonal variation in surface ozone and its precursors over an urban site in India[2]. They have selected the site Physical Research Laboratory (PRL), Ahmedabad for the measurement of ozone and its precursor's gases (NOx, CO, and CH_4). They found NOx and CO is higher in the morning due to the fluctuation in higher level of anthropogenic activities, boundary layer processes and meteorological parameters. In winter season, the ozone concentration is higher due to elevated amount of precursor gases and low solar radiation. Dissimilar to the seasonal variation, precursor gases show anti-correlation with ozone in the diurnal variation.

Naja et.al. published a paper on Diurnal and seasonal variabilities in surface ozone at a high altitude site Mt Abu (24.6ºN, 72.7ºE, 1680m asl) in India[3] by measuring surface ozone, CO and oxides of nitrogen in 1993-2000. Result said that, throughout the year oxygen mixing ratio was declined. Some metorological parameters are responsible for the seasonal and diurnal variations. During the continuous monitoring of ozone, 90 ppbv of average ozone mixing ratio was found.

Analysis of Diurnal and Seasonal Behavior of Surface Ozone and Its Precursors (NOx) at a Semi-Arid Rural Site in Southern India[4] was given by *Reddy et.al.* In the selected site of Anantapur- surface O_3, NO, NO_2 and NOx. The O_3

concentration was highest monthly mean in April (56.1±9.9ppbv) and lowest in August (28.5±7.4ppbv). Seasonal variation in ozone concentration was highest in summer (70.2±6.9ppbv) whereas lowest in season (20.0±4.7ppbv). Other than this, higher NOx shows in winter (12.8±0.8ppbv) while lower in the monsoon season (3.7±0.5ppbv). The concentration of ozone shows positive correlation with temperature, and a negative correlation with both wind speed and relative humidity. In contrast, NOx shows positive correlation with humidity and wind speed, in addition, negative correlation with temperature.

Seasonal distribution of ozone and its precursors over the tropical Indian region using regional chemistry-transport model[5] (REMO-CTM) has studied by *Roy et.al.* The observation correlates with different meteorological parameters like precipitation and wind. The seasonal distribution of ozone and its precursors over the Indian region indicates a differential pattern driven by the local emission of climatic conditions. The continental tropical convergence zone (CTCZ) and long-range/regional transport of ozone, CO and NO_x concentrations was higher than other parts of India.

Ozone Layer Depletion and Its Effects: A Review[6] has given by *T. Sivasakthivel and K.K. Siva Kumar Reddy*. The paper reviewed on the origin, causes, mechanism and bio-effects of ozone layer depletion and vanishing of their protective measures. In the future, the ozone behavior will be changes due to the changes in methane, nitrous oxide, water vapors, sulphate aerosol and changing climate.

Diurnal variation of Surface Ozone with Meteorological parameters at Kannur, India[7] has acknowledged by *Nishanth, T. and Satheesh Kumar, M.K*. Result shows that surface ozone was higher in Kannur University campus than at Kannur Town. During winter, mixing ratios of surface ozone has maximum at the rural (44.01±3.1ppbv) and urban (36.3±5.4ppbv) sites. Similarly, production of ozone was higher in the afternoon of winter months.

Nair et.al. studied on the ozone in the marine boundary layer of Bay of Bengal during post-winter period: Spatial pattern and role of meteorology[8]. During the post-monsoon (March-April) the maximum ozone mixing ratio in head BoB was observed with a mean value 27-3 ppb and minimum in the mid BoB was 12-3 ppb. Chemical box model simulated the diurnal patterns.

Jeelani studied on the Diurnal and Seasonal Variations of Surface Ozone and Its Precursors in the Atmosphere of Yanbu, Saudi Arabia[9]. The annual average concentrations of O_3, NO, NO_2, NOx, SO_2, CO, CH_4, TNMHCs and THC were 22.51 ppb, 15.58 ppb, 17.25 ppb, 23.84 ppb, 6.66 ppb, 165.13 ppb, 3.44 ppm, 0.56 ppm and 3.88 ppm, respectively. Ozone concentration during diurnal cycle was highest in daytime whereas lowest in nighttime. The O_3 and NO have higher concentrations in autumn and winter than summer and spring seasons.

Diurnal and seasonal characteristics of ozone and NOx over a high altitude Western Ghats location in Southern India[10] has been observed by *Udayasoorian et.al*. As a result, it has found that ozone and NOx concentrations were higher during warmer months. The seasonal variation in ozone was maximum (62 ppb in March) in summer with values sometime exceeding 90 ppb and a minimum in the monsoon and post monsoon season (17 ppb in August). On the contrary, lower ozone mixing ratio was observed during the daytime. A monthly maximum NOx value was observed during summer month of April (1.85ppb), whereas minimum value was observed during monsoon (0.19 ppb in August).

Surface ozone variation at Bhubaneswar and intra-corelationship study with various parameters[11] has been acknowledged by *Mahapatra et.al*. The ozone seasonal variation has maximum in January (~85ppbv), a bit increased in June (~38 ppbv) and minimum in August (~20ppbv). Affected by various distance and climatic conditions in contrary, ozone raised during pre-monsoon and monsoon and in winter anti-weekend ozone effect (~5ppbv) has observed.

Jayamurugan et.al. has studied the influence of temperature, relative humidity and seasonal variability on Ambient Air Quality in a Coastal Urban Area[12] with respect to meteorological parameters. At North Chennai, during monsoon, post-monsoon, summer and pre-monsoon seasons (2010-11) SO_2 and NOx were shown negative correlation in summer while positive correlation during post-monsoon season with temperature. The influence of temperature on gaseous pollutants (SO_2 and NOx) was effective in summer than other seasons negative correlations were found with humidity.

Reddy et.al. has analyzed the Diurnal and Seasonal Behavior of Surface Ozone and Its Precursors (NOx) at a Semi-Arid Rural Site in Southern India[13]. The O_3 concentration was highest monthly mean in April (56.1 ± 9.9ppbv) and lowest in August (28.5 ± 7.4), with an annual mean of 40.7 ± 8.7ppbv. Seasonal variation in ozone concentration was highest in summer (70.2 ± 6.9ppbv) whereas lowest in season (20.0 ± 4.7 ppbv), with an annual mean of 40.7 ± 8.7ppbv. Other than this, higher NOx shows in winter (12.8 ± 0.8 ppbv) while lower in the monsoon season (3.7 ± 0.5 ppbv). The O_3 concentration shows positive correlation with temperature, and a negative correlation with both wind speed and relative humidity. In contrast, NOx shows positive correlation with humidity and wind speed, in addition to negative correlation with temperature.

OZONE: Layer Identification in the presence of Cyclic Dependencies[14] has acknowledged by *Laval et.al.* This paper exist three approaches which predicted by the softwares: i. provides a strategy supporting the automated detection of cyclic dependencies, ii. Proposes heuristics to break cyclic dependencies and iii. computes an organization of software entities in multiple layers even in presence of cyclic dependencies.

Li et.al. has studied on the process analysis of regional ozone formation over the Yangtze River Delta, China[15] using the Community Multi-scale Air Quality modeling system. At the height of 300–1500m ozone occurs by gas-phase chemistry which causes strong vertical ozone transport from upper levels to the surface layer. Process of cloud formation increases ozone a bit. In the rural area after sunset, O_3 concentrations starts decreases in the cities, due to NO emissions, but it was controlled in rural areas where the NO emissions are very small.

Material and Methods

The Study Area: Madhya Pradesh is generally known as the heart of India. The site Jabalpur is one of the major centers of Madhya Pradesh in India and is famous for its green belt. Geographically, it is located at *23.17°N 79.95°E*. It has an average elevation of 411 meters (1348 ft). Topographically Jabalpur is rich with forests, hills and mountains which contain lots of minerals in it. On the other hand, quality of air is getting deteriorated slowly by increasing industrialization and due to tremendous increase in number of vehicles plying on the roads.

Sampling and Investigative method: The instrument *Ambient Air Quality Monitoring System (AAQMS)* was manufactured by *Ecotech* Australia. It is systematic, assessment of long term pollutants in the surroundings. *Ecotech* established the instrument for environmental monitoring that is WinAQMS (Air Quality Monitoring Station). This WinAQMS has two parts: the client as client and the server. The monitoring system consists of the assembly of many transducers and analyzers employing various instrumentation techniques. The instrument has provided all the yearly observation of the O_3 concentration by EC9810 Ozone Analyzer (O_3).

In addition to this, a statistical analysis Pearson correlation coefficient has done to estimate the correlation of O_3 concentration with temperature and relative humidity (RH).

Observation Table: The study has been done continuously (two years: 2013 and 2014) through the monitoring of ozone concentration. The seasonal observation has obtained from the average value categorized into seasons. These are: Winter (December-March), Summer (April-June), Monsoon (July-September) and Autumn (October-November). The seasons are the main parameters which fluctuates the concentration of O_3 naturally. Other than this, meteorological parameters like temperature and relative humidity are also responsible for O_3 variation throughout the season.

The table-1 represents the seasonal average of O_3 concentration, temperature and relative humidity of the year 2013 and 2014. According to that, the variation between the two years was clearly clarified. O_3 concentration was gradually decreased after the end of winter in both the years (2013-2014). Temperature and relative humidity has similarly shown the up-down fluctuation in the seasons i.e. in winter and in monsoon, when both the meteorological parameters were risen up.

The graph easily estimated the average fluctuation of O_3 concentration in between winter, summer, rainy and autumn. From bottom to top, it has observed that the concentration of O_3 was greater in the winter season. In addition to this, seasonal correlation of O_3 with temperature and relative humidity brings the accuracy towards its study by using Pearson's coefficient correlation:

Table-1
Seasonal observation of Ozone, Temperature and Relative Humidity of 2013 and 2014

YEAR	2013				2014			
SEASON	Winter	Summer	Monsoon	Autumn	Winter	Summer	Monsoon	Autumn
OZONE (ppb)	57	51	47	62	59	49	16	15
TEMP (°C)	18.6	30.3	26.7	22.2	18.5	31.3	28	23.1
RH (%)	62.1	44.3	84.1	69.1	66.4	38.6	74.8	61.3

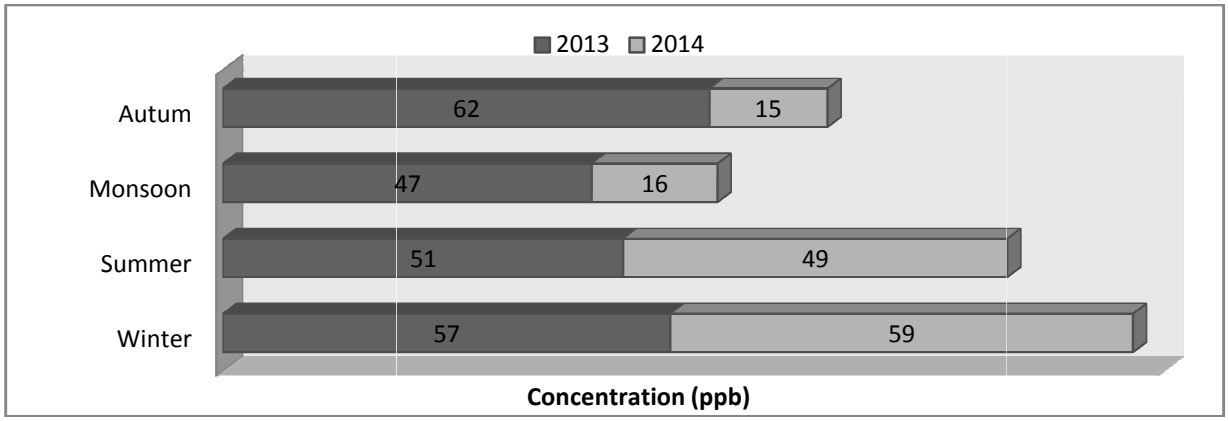
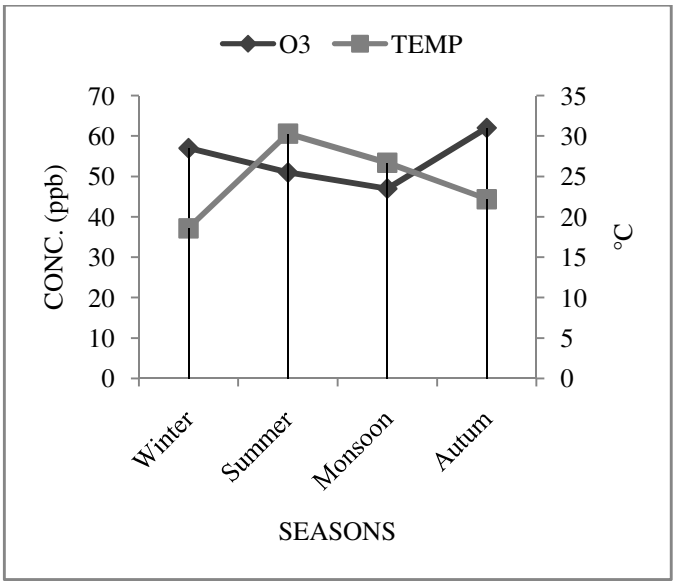
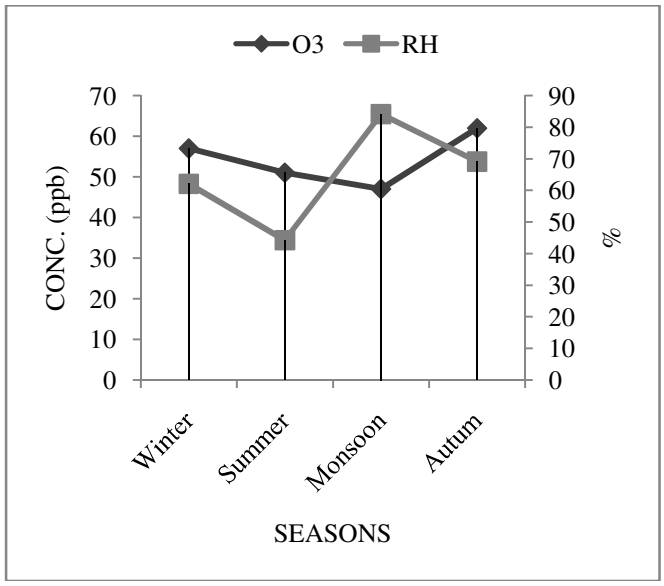


Figure-1
Seasonal average concentration of Ozone of the year 2013 and 2014

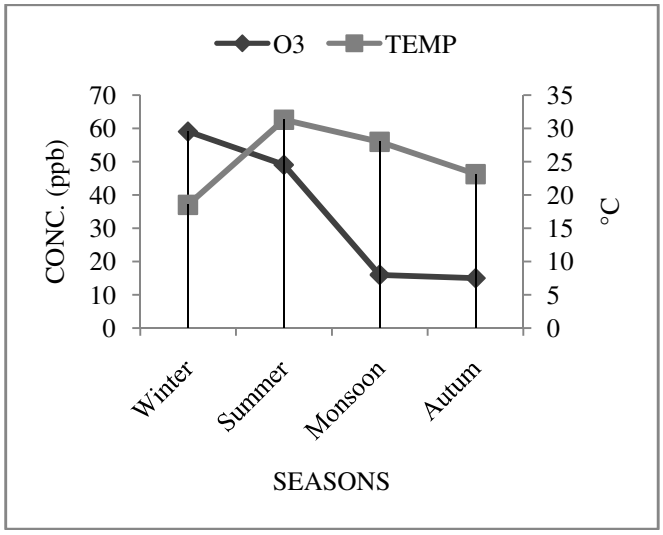


(a) r = -0.5163 (-ve correlation)

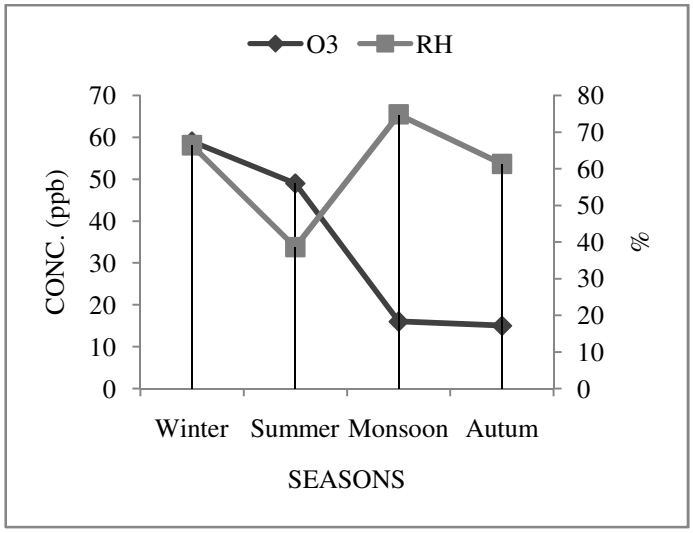


(b) r = -0.1729 (-ve correlation)

Figure-2 (a and b)
Seasonal Correlation of O_3 with temperature and relative humidity (2013)



(a) r = -0.3597 (-ve correlation)



(b) r = -0.3880 (-ve correlation)

Figure-3
(a and b) Seasonal Correlation of O_3 with temperature and relative humidity (2014)

Results and Discussion

The study of seasonal average O_3 concentration of the year 2013 and 2014 found that in after winter season O3 concentration ass gradually decreased and in autumn it is on peak (57ppb<51ppb<47ppb>62ppb) in the year 2013 whereas, in the year 2014 O_3 concentration was higher in winter and gradually declined at the autumn (59ppb>49ppb>16ppb>15ppb) from figure-1. Thus, it clarified that concentration of O_3 are equally depends on the meteorological parameters like temperature and relative humidity.

The seasonal average temperature was maximum in the summer and shows negative correlation with O_3 (r= -0.5163 and -0.3597) in the year 2013 and 2014 respectively figure-2 (a and b). In the other hand, seasonal average relative humidity was maximum during monsoon and winter. Similarly like temperature; relative humidity also shows negative correlation with O_3 (r= -0.1729 and -0.3880) in the year 2013 and 2014 respectively figure-3 (a and b). The observations found that temperature and relative humidity were shown opposite relation to each other rather than this; they are very important meteorological parameters for interrelationship with O_3 concentration.

Acknowledgement

The author expresses our regards to Indian Institute of Tropical Meteorology (IITM), Pune to install the Ambient Air Quality Monitoring System (AAQMS) in Environmental Research Laboratory of Government Model Science College (Autonomous) Jabalpur.

Conclusion

A developing city like Jabalpur needs small initiation to undertake the big need to fight, with the gradually increasing pollution. For the above mentioned purpose the monitoring of ambient air quality in every season is the best way to make people aware of the exact condition for the pollution level of the city.

References

1. David L.M., Girach I.A. and Nair P.R., Distribution of ozone and its precursors over Bay of Bengal during winter 2009: role of meteorology, *Annales Geophysicae,* **29**, 1613–1627, **(2011)**

2. Lal S., Naja M. and Subbaraya B.H., Seasonal variation in surface ozone and its precursors over an urban site in India, *Atmospheric Environment*., **34**, 2713-2724, **(2000)**

3. Naja M., Lal S. and Chand D., Diurnal and seasonal variabilities in surface ozone at a high altitude site Mt Abu (24.6ºN, 72.7ºE, 1680m asl) in India., *Atmospheric Environment,* **37**, 4205-4215, **(2003)**

4. Reddy B.S.K., Kumar K.R., Balakrishnaiah G., Gopal K.R., Reddy R.R., Sivakumar V., Lingaswamy A.P., Arafath S. Md., Umadevi K., Kumari S.P., Ahammed Y.N. and Lal S., Analysis of Diurnal and Seasonal Behavior of Surface Ozone and Its Precursors (NOx) at a Semi-Arid Rural Site in Southern India, *Aerosol and Air Quality Research*., **12**, 1081–1094, **(2012)**

5. Roy S., Beig G. and Jacob D., Seasonal distribution of ozone and its precursors over the tropical Indian region using regional chemistry-transport model, *Journal of Geophysical Research*, **113**, **(2009)**

6. Sivasakthivel T and Reddy K.K. and Siva Kumar, Ozone Layer Depletion and Its Effects: A Review, *International Journal of Environmental Science and Development,* **2(1)**, **(2011)**

7. Nishanth T. and Satheesh Kumar M.K., Diurnal variation of Surface Ozone with Meteorological parameters at Kannur, India, *Advances in Applied Science Research,* **2 (3)**, 407-417, **(2011)**

8. Nair P.R., David L.M., Girach I.A. and George K.S., Ozone in the marine boundary layer of Bay of Bengal during post-winter period: Spatial pattern and role of meteorology, *Atmospheric Environment,* **45**, 4671-4681, **(2011)**

9. Jeelani A.H., Diurnal and Seasonal Variations of Surface Ozone and Its Precursors in the Atmosphere of Yanbu, Saudi Arabia, *Journal of Environmental Protection*, **5**, 408-422, **(2014)**

10. Udayasoorian C., Jayabalakrishnan R.M., Suguna A.R., Venkataramani S. and Lal S., Diurnal and seasonal characteristics of ozone and NOx over a high altitude Western Ghats location in Southern India, *Applied Science Research,* **4(5)**, 309-320, **(2013)**

11. Mahapatra P.S., Jena J., Moharana S., Srichandan H., Das T., Roy Chaudhury G. and Das S.N., Surface ozone variation at Bhubaneswar and intra-corelationship study with various parameters, *Journal of Earth System and Science,* **121(5)**, 1163-1175, **(2012)**

12. Jayamurugan R., Kumaravel B., Palanivelraja S. and Chockalingam M.P., Influence of Temperature, Relative Humidity and Seasonal Variability on Ambient Air Quality in a Coastal Urban Area, *International Journal of Atmospheric Sciences,* Article ID 264046, 7 **(2013)**

13. Reddy B.S.K., Kumar K.R., Balakrishnaiah G., Gopal K.R., Reddy R.R., Sivakumar V., Lingaswamy A.P., Arafath S.Md., Umadevi K., Kumari S.P., Ahammed Y.N. and Lal S., Analysis of Diurnal and Seasonal Behavior of Surface Ozone and Its Precursors (NOx) at a Semi-Arid Rural Site in Southern India, *Aerosol and Air Quality Research*, **12**, 1081–1094, **(2012)**

14. Laval J., Anquetil N., Bhatti U. and Ducasse S., OZONE: Layer Identification in the presence of Cyclic Dependencies, *Science of Computer Programming,* hal-00732655, version- 1, **(2012)**

15. Li, L., Chen C.H., Huang C., Huang H.Y., Zhang G.F., Wang Y.J., Wang Y.L., Lou S.R., Qiao L.P., hou M., Chen M.H., Chen Y.R., Streets, D.G., Fu, J.S. and Jang C.J., Process analysis of regional ozone formation over the Yangtze River Delta, China using the Community Multi-scale Air Quality modeling system. *Atmospheric Chemistry and Physics,* **12**, 10971–10987, **(2012)**