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Diurnal and Seasonal variability of Ozone with its Precursors Gases at Jabalpur

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ABSTRACT

Ozone is an allotrope generally found in the upper atmosphere in between the layer of troposphere and stratosphere; a layer ozonosphere. In the lower atmosphere, ozone has some precursor gases like CO, NO_2, CH_4 and TNMHC. These precursor gases fluctuates the concentration of O_3 diurnally as well as seasonally. Through the study in Jabalpur (2013 and 2014), the diurnal and seasonal variation of O_3 and its precursor gases had been observed. CO, CH_4 and NO_2 concentration was slightly upward in the year 2014 than 2013; whereas, concentration of O_3 and TNMHC was throughout high in the year 2013. The concentration of O_3 goes upwards the maximum with higher concentration of CO and NO_2, with a combination of moderate TNMHC and declined CH_4 concentration. The seasonal trend of 2013 was lower than 2014. The O_3 and NO_2 concentration increased during winter season whereas CO increased in summer.

KEY WORDS: Allotrope, CH_4, CO, Diurnal variation, NO_2, O_3, Ozonosphere, Seasonal variation, Stratosphere, TNMHC, Troposphere

CAPSULE ABSTRACT: Ozone and its precursor gases are interrelated with each other diurnally as well as seasonally. The year 2013 shows lower seasonal trend than 2014.

INTRODUCTION

Ozone is an allotrope which consists of three oxygen atoms that are bound together (triatomic oxygen) and forms the chemical formula 'O_3'. Generally, Ozone occurs in lower atmosphere with low concentration, but with significantly higher concentration in the upper atmosphere. Very high in the atmosphere in between tropospheric and stratospheric layer; a layer is present which is known as **Ozonosphere.** The ozonosphere extends between 13 km-40 km (9.3–22 mi; 49,000–110,000ft) in between troposphere and stratosphere where ozone creation takes place. In ozonosphere, concentration of O_3 varies from 2-8ppm which is slightly higher than lower atmosphere.

Production of O_3, in ozonosphere is a natural and continuous process where some oxygen (O_2) molecules absorb energy from the Sun's ultraviolet (UV) rays and split to form single oxygen atoms. These atoms combine with remaining oxygen to form ozone (O_3) molecules, which are very effective in absorbing UV rays.

Scientifically, ground level ozone is termed as secondary pollutant because it is formed when the primary pollutants nitrogen oxides (NOx) and volatile organic compounds (VOC) combine in the presence of sunlight. EPA states that chemical compounds, such as carbon monoxide (CO), methane (CH4), NMVOCs and nitrogen oxide (NOx) known as **ozone precursors**, react with other chemical compounds to form ozone in the troposphere. Concentration of ozone may vary with season as well as with topography. It has already been found that, ozone concentration increases with temperature and is generally minimum at night and maximum during mid day.

In between November 2009 to December 2011 an observational study of surface O_3, NOx, CH_4 and total NMHCs at Kannur, India was done by Nishanth et.al. (2014). It was found that the surface O_3 concentration was higher in afternoon and declined at night. NOx concentration exceeded during mid-night to early morning and was low during noon. The diurnal variations of mixing ratios for NOx and O_3 were anti-correlated. In December, the monthly average of CH_4 concentration was maximum (2.26 ± 0.44 ppmv) whereas in August it was minimum (0.43 ± 0.19 ppmv). The concentration of CH_4 and NO_X were similar in the early morning.

Analysis of Diurnal and Seasonal Behavior of Surface Ozone and Its Precursors (NOx) at a Semi-Arid Rural Site in Southern India was given by Reddy et.al. (2012). 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.

Lal et.al. (2000) has studied on the seasonal variation in surface ozone and its precursors over an urban site in India. 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. (2003) 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 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.

Seasonal distribution of ozone and its precursors over the tropical Indian region using regional chemistry-transport model (REMO-CTM) has studied by Roy et.al. (2009). 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.

SIGNIFICANCE OF THE STUDY

The study is significant to gain information about the ambient air quality of the city Jabalpur. The observation has continuously monitored by AAQMS (Ambient Air Quality Monitoring

System). In the upcoming years, AAQMS is going to enforce in each city to aware the population about its importance and necessity.

MATERIAL AND METHOD

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.

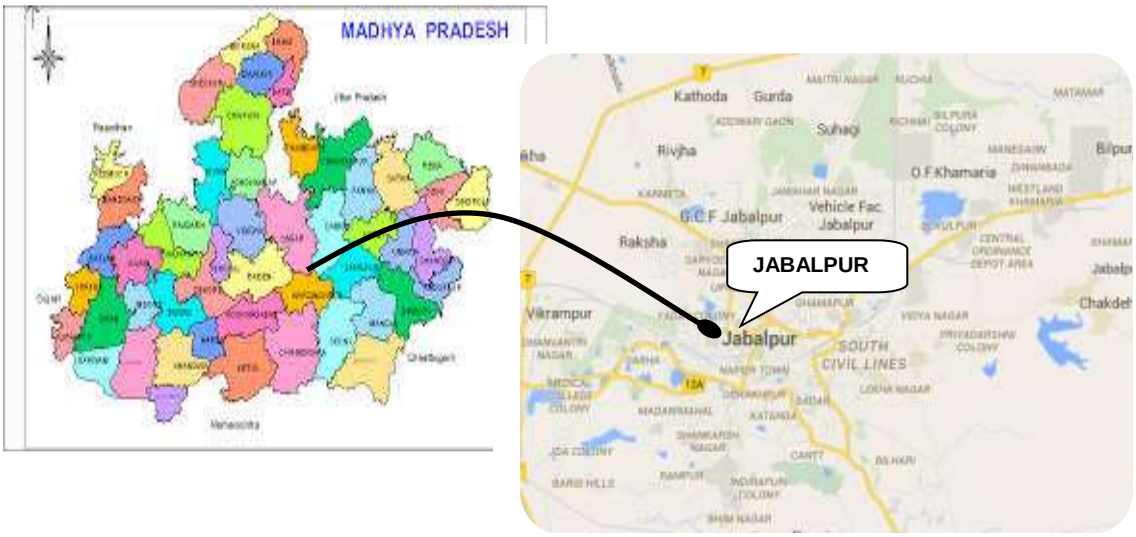

Fig. 1: Location of Jabalpur

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. These are EC9830 Carbon Monoxide Analyzer (CO), EC9810 Ozone Analyzer (O_3), EC9841 Nitrogen Oxides Analyzer (NO_X) and GC ALPHA 115 Methane/TNMHC.

Observation Table:

The study had done continuously (two years: 2013 and 2014) through the monitoring of ozone and its precursors gases i.e. CO, NO_2, CH_4 and TNMHC of Jabalpur. The observations are collectively based on the average diurnal and seasonal behavior of ozone with its precursor gases. The graphical representations here under, shows the diurnal average of 1hour interval at the day when concentration of O_3 and other gaseous pollutants were maximum in the year 2014. The diurnal fluctuation of CO, O_3, NO_X, CH_4 and TNMHC had taken from mid night to next mid day of the year 2013 and 2014:

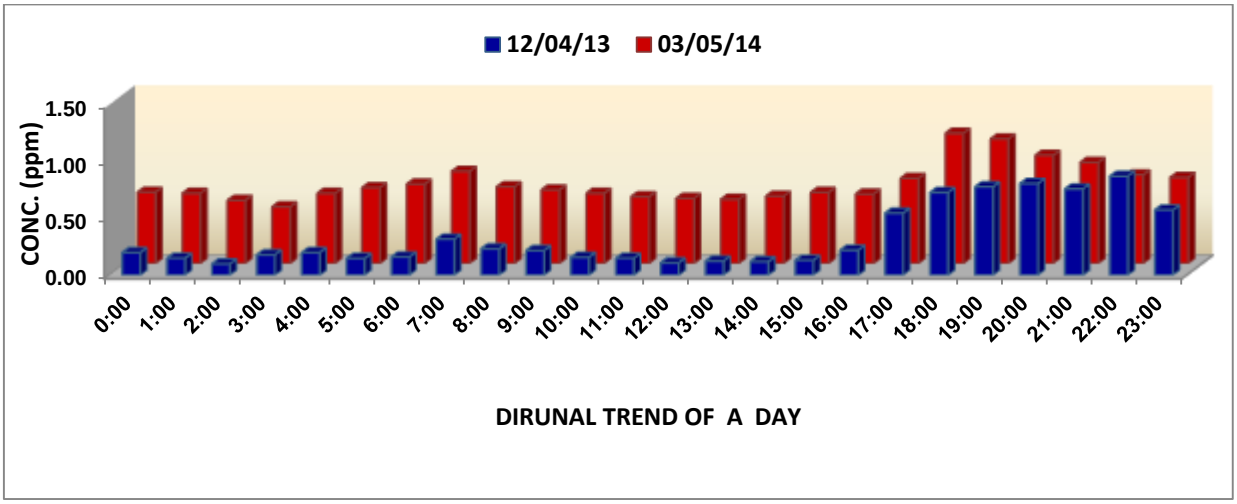

Fig. 2 (a): Diurnal fluctuation of the day when CO concentration was maximum during 2013 and 2014

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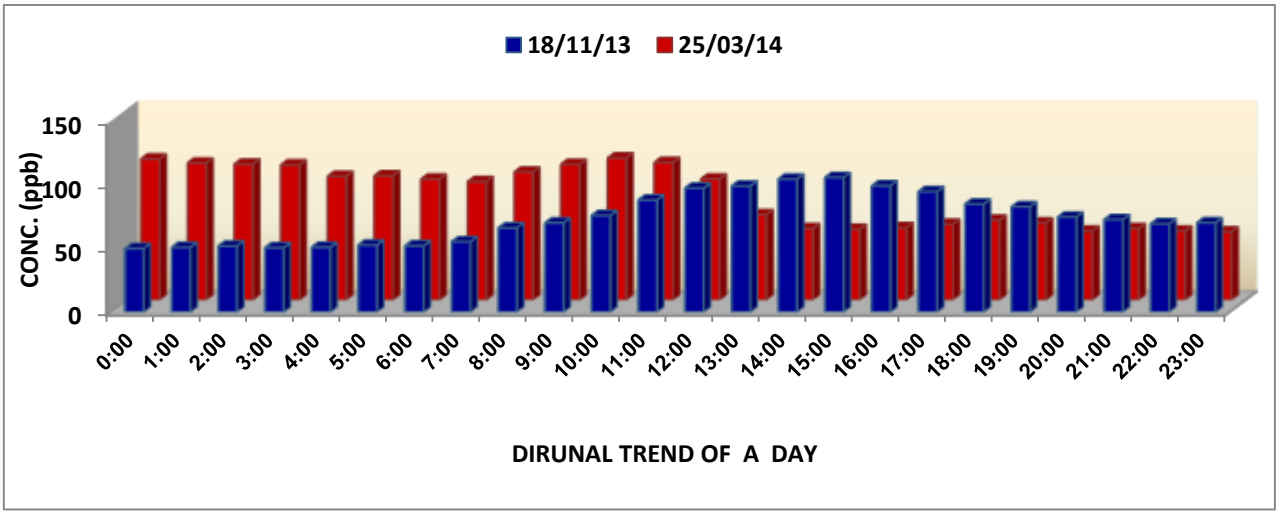

Fig. 2 (b): Diurnal fluctuation of the day when O_3 concentration was maximum during 2013 and 2014

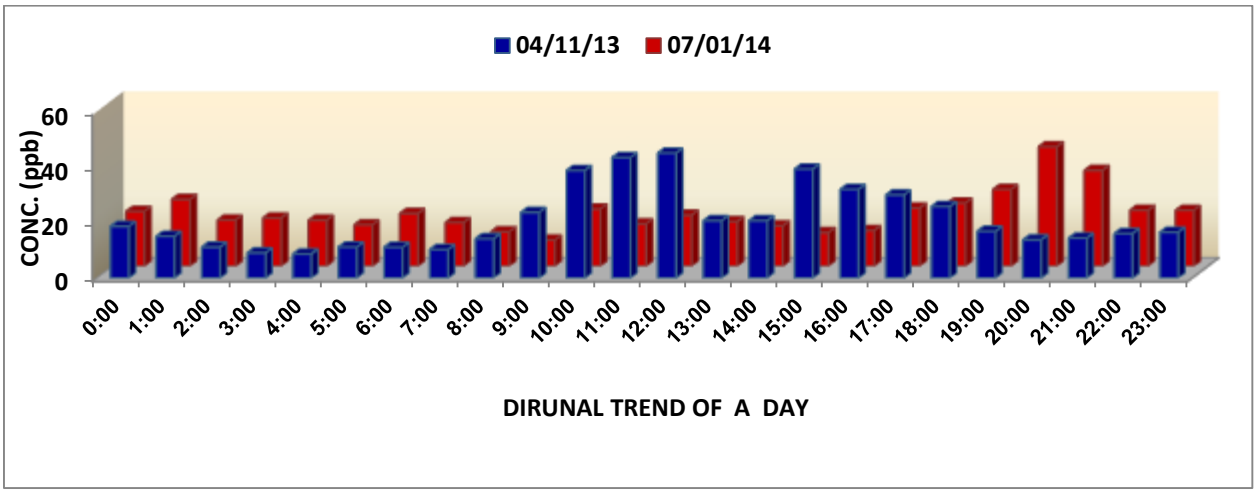

Fig. 3 (c): Diurnal fluctuation of the day when NO_2 concentration was maximum during 2013 and 2014

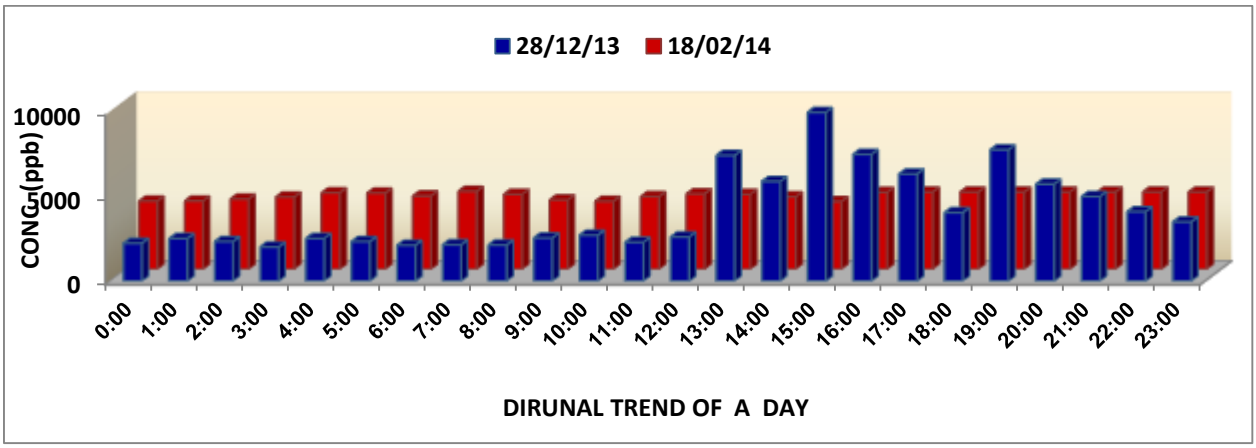

Fig. 2 (d): Diurnal fluctuation of the day when CH_4 concentration was maximum during 2013 and 2014

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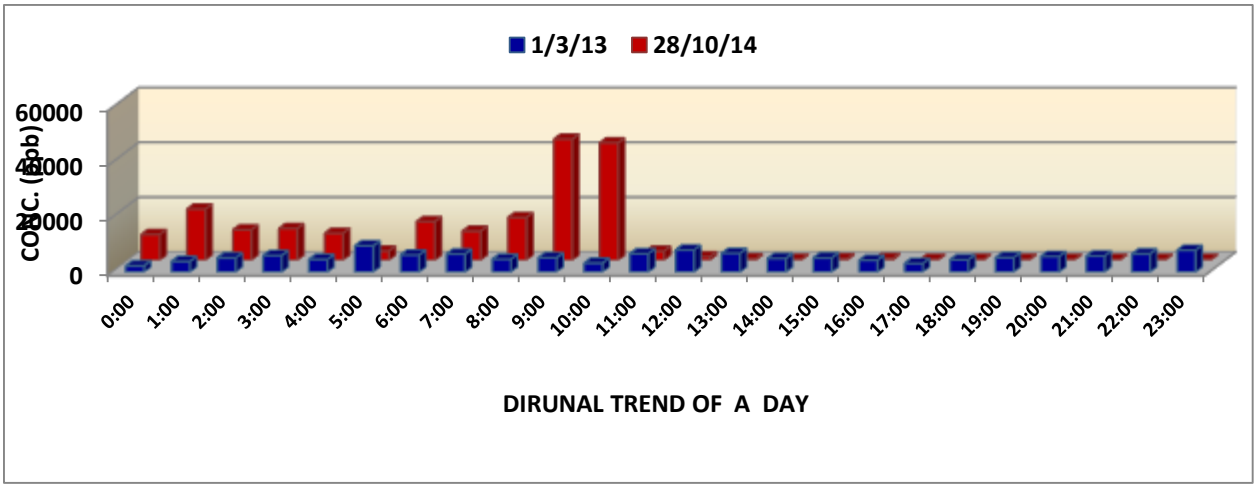

Fig. 2 (e): Diurnal average concentration of TNMHC of year 2013 and 2014

It has observed that, the concentration of O_3 rose after the midnight to early morning and then gradually decreased; this may be due to the effect of air pollution throughout the day [Fig. 2(b)] in the year 2014 whereas, in 2013 O_3 concentration has gradually increases after the evening. Concentration of CO and NO_2, progressively risen up in between evening and night [Fig. 2(a & c)]. It has observed that, concentration of CH_4 has increases in the afternoon when the temperature was maximum [Fig. 2(d)]. The concentration of TNMHC was stationary throughout the day in 2013 whereas it shown a major fluctuation in between 9-10am of the day in 2014 [Fig. 2(e)], this may be due to the effect of other meteorological factor.

The variation in the concentration of ozone and its precursor gases are simultaneously interrelated. That is why, the rise-fall in the concentration of precursor gases fluctuates the ozone concentration. Thus, the graph has shown the affected fluctuation when the O_3 interrelate with them:

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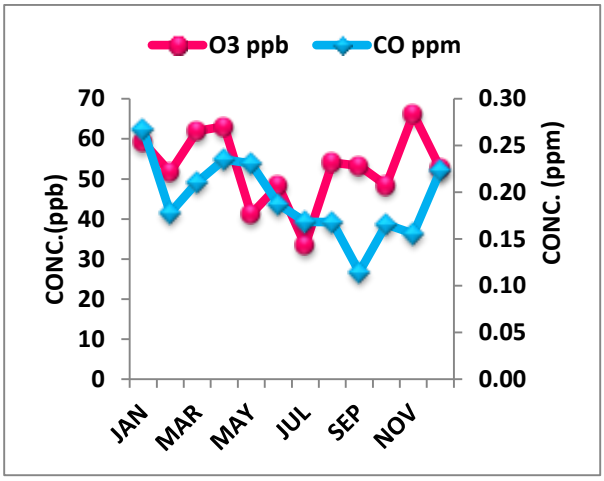

Fig. 3(a): Variation of O_3 with CO (2013)

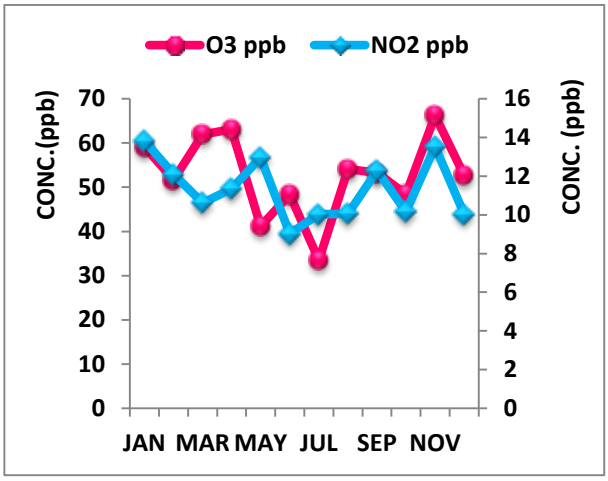

Fig. 3(b): Variation of O_3 with NO_2 (2013)

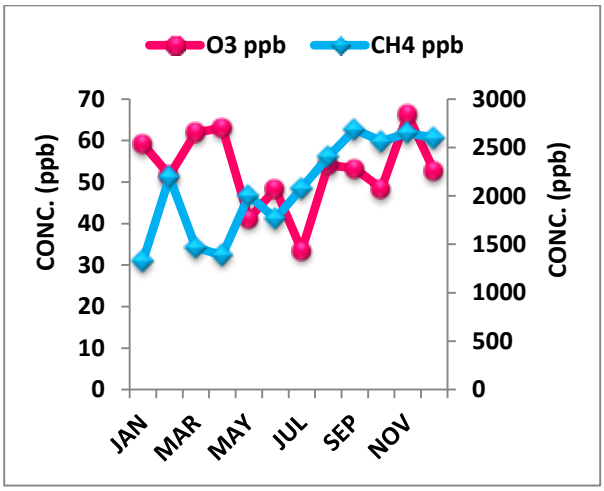

Fig. 3(c): Variation of O_3 with CH_4 (2013)

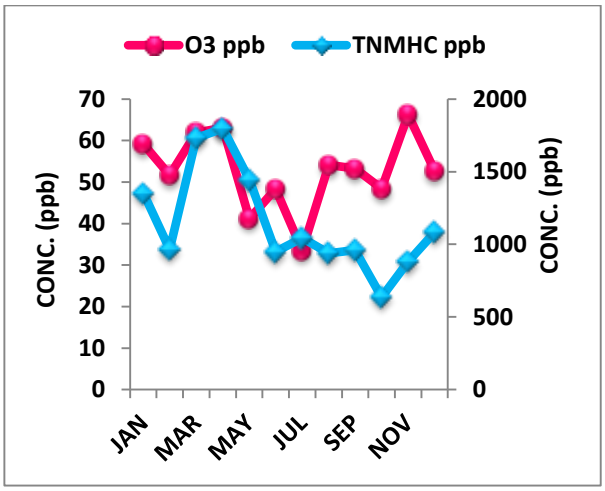

Fig. 3(d): Variation of O_3 with TNMHC (2013)

Above the graphs represents the comparison of O_3 with its precursor gases in the year 2013. The graphs 4 (a, b, c &d) were showing the monthly average with diurnal fluctuation in the year 2014, through which it has noticed that in the month of may rather than TNMHC, all other gaseous pollutants were showing moderate interrelation with O_3 :

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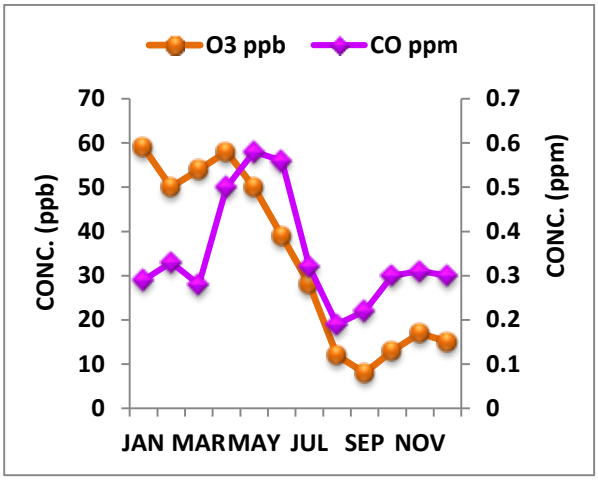

Fig. 4(a): Variation of O_3 with CO (2014)

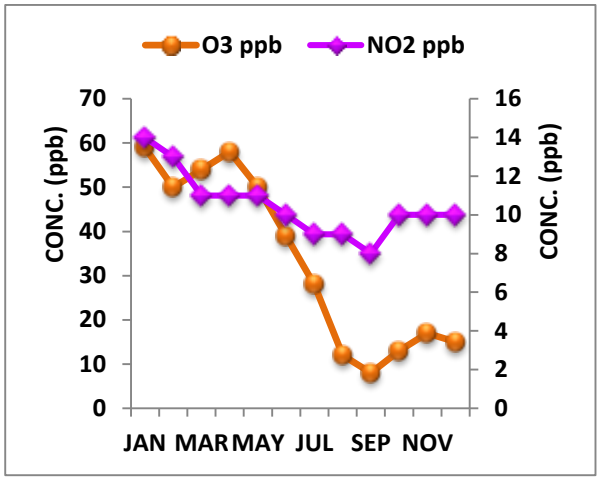

Fig. 4(b): Variation of O_3 with NO_2 (2014)

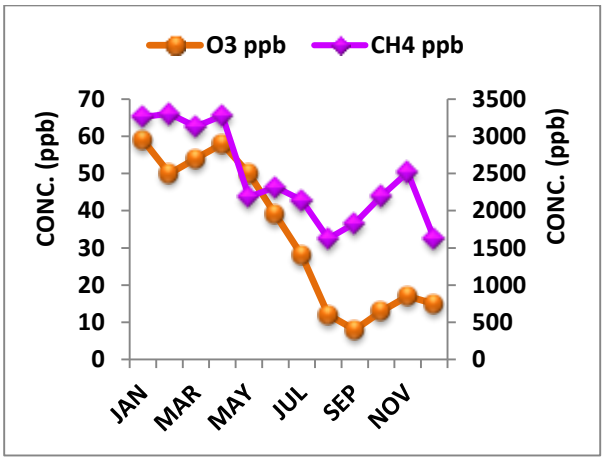

Fig. 4(c): Variation of O_3 with CH_4 (2014)

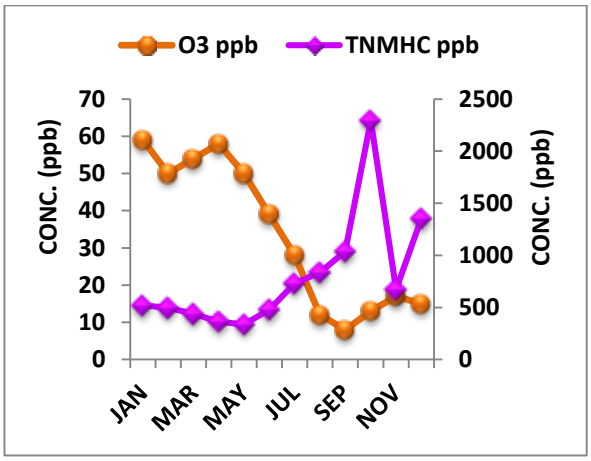

Fig. 4(d): Variation of O_3 with TNMHC (2014)

Basically, Indian region consists of four seasons in a year. These are: winter, summer or pre-monsoon, monsoon or rainy season and autumn or post-monsoon. The winter season belong the month of December to March end. After that summer has started in between April to June. Then Rainy season take place from July to mid September. At last, autumn started from October to last November. The graph has shown the seasonal variation or trend of O_3 and its precursor gases (CO, NO_2, CH_4 and TNMHC) in the year 2013 and 2014:

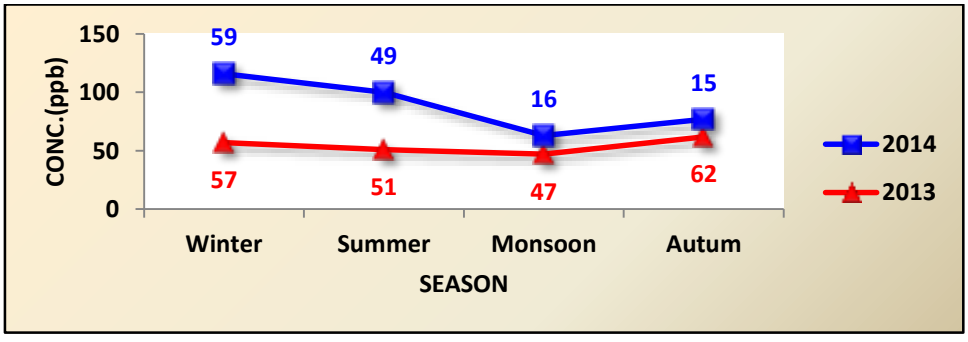

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Fig. 5(a): Average seasonal variation of O_3 in the year 2013 and 2014

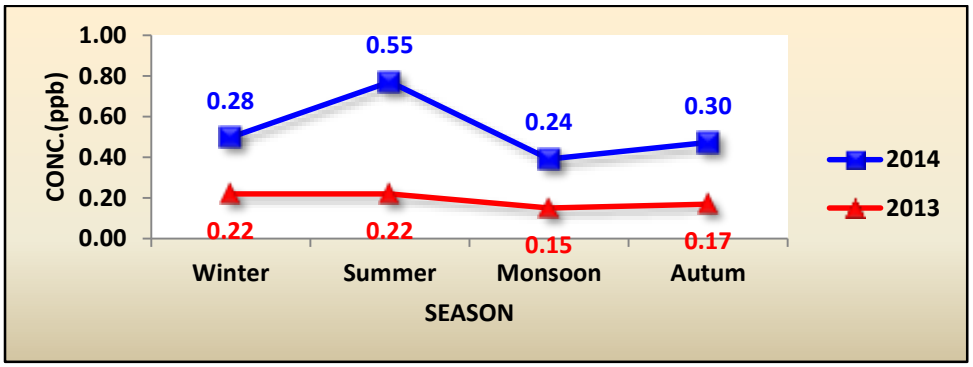

Fig. 5(b): Average seasonal variation of CO in the year 2013 and 2014

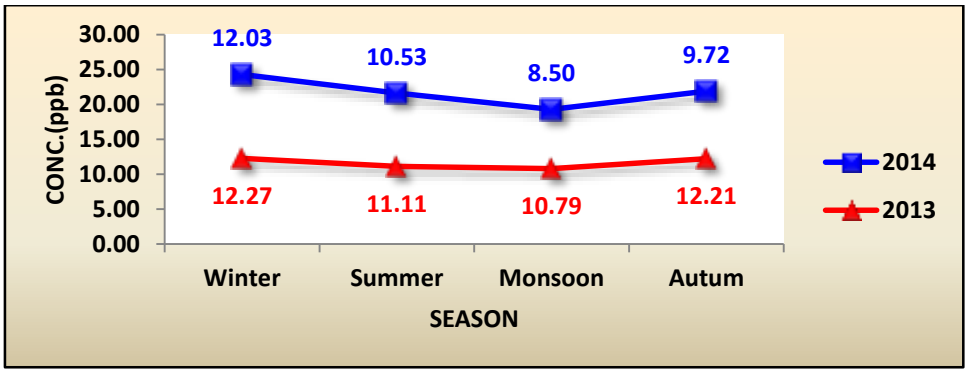

Fig. 5(c): Average seasonal variation of NO_2 in the year 2013 and 2014

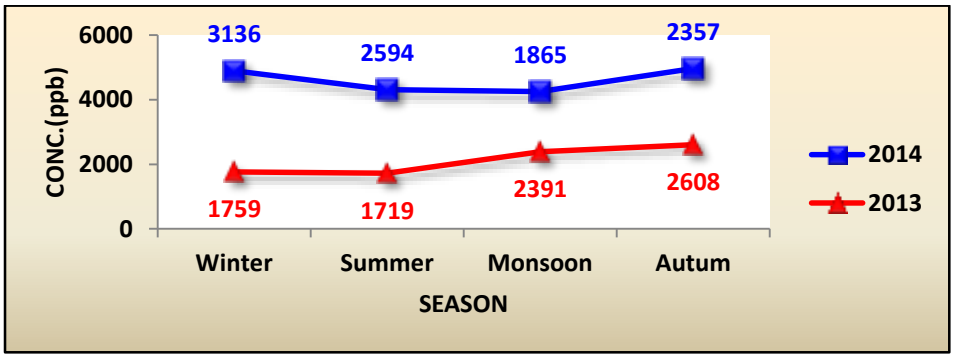

Fig. 5(d): Average seasonal variation of CH_4 in the year 2013 and 2014

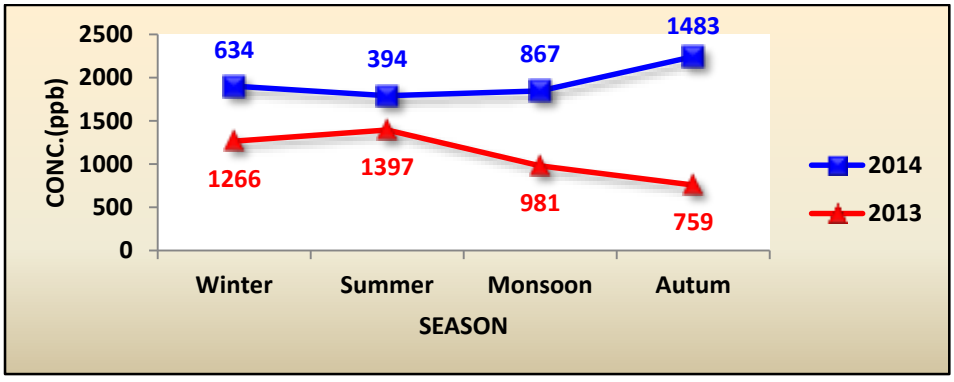

Fig. 5(e): Average seasonal variation of TNMHC in the year 2013 and 2014

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RESULT AND DISCUSSION

The graphs were showing that O_3 and its precursor gases are interrelated with each other. The resultant of diurnal variation of CO concentration was highest at Apr. 12 2013 and May. 03, 2014. Concentration of CO was gradually increases after the evening upto mid night with similar concentration level of NO_2 (Nov. 04, 2013 and Jan. 07, 2014) from Fig. 2 (a & c) whereas, O_3 concentration was totally opposite from the year 2013 to 2014. In the year 2013: O_3 concentration risen in the afternoon then gradually decreases whereas in 2014, the concentration of O_3 was increases during morning and then gradually declined (2013) from [Fig. 2(b)]. This difference is generally depends on the meteorological factors and climatic conditions.

While observing the monthly average of the year 2013, the concentration of O_3 was higher at January. Similarly like O_3 concentration, CO and NO_2 level goes higher in the month of January whereas, the level of TNMHC was moderate. The concentration of CH_4 was gradually decreases which has observed by Fig. 3 (a, b, c, d & e). Other than this in 2014, O_3 and CO concentration was higher in the month of May whereas CH_4 was highest than O_3. While O_3 concentration has shown increased trend with moderate NO_2 and low TNMHC concentration: Fig. 4 (a, b, c, d & e).

The seasonal trend of 2013 was lower than 2014. The O_3 concentration (59 ppb and 69 ppb: 2013 and 2014) and NO_2 concentration (12.03ppb and 12.23ppb: 2013 and 2014) was increased during winter season, whereas concentration of CO (0.55ppm and 0.22ppm: 2013 and 2014) has increases in summer. In addition to this, CH_4 concentration was more in autumn i.e. 2608ppb (2013) and winter i.e. 3136ppb (2014), whereas TNMHC has shown tremendous fluctuating trends in all the season and in both the years.

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.

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