DIURNAL AND SEASONAL VARIATIONS IN TROPOSPHERE OZONE LEVEL AT SUB-TROPICAL STATION, JABALPUR, INDIA, AND RELATIONSHIP WITH METEOROLOGICAL CONDITION

Dr. R.K Srivastava, Pavan Gautam & Dr. Gufran Beig[1]
Environmental Research Laboratory, PG Deptt. of Botany & Environmental Science
Govt. Model Science College (Autonomous)
NAAC Reaccredited 'A' Grade, College with Potential for Excellence (UGC)
Centre of Excellence for Science Education (Govt. of M.P.)
Jabalpur, 482001 M.P. India
[1]Program Director & Senior Scientist-F (Indian Institute of Tropical Meteorology) Dr.HomiBhabha Road, Pashan, Pune 411008, Maharashtra, India.

ABSTRACT: *Troposphere ozone measurements at Central India sub tropical site Jabalpur (located at 23°10'N 79°57'E / 23.17°N 79.95°E) India has been studied for the period from January 2015 to December 2015.Tropospheric ozone is both a greenhouse gas and harmful air pollutant, it is important to understand how anthropogenic activities may influence its abundance and distribution through the 21st century. Ambient Air Quality Monitoring System (AAQMS) is sensor based ozone monitor which in used for measurement. Temperature shows a good positive correlation whereas relative humidity shows a negative correlation with ozone. Results of this study have revealed that the annual mean of daily average surface ozone concentration varies from 11 ppb to 38 ppb. The highest average seasonal concentration was observed in summer and lowest in winter season.*

KEYWORDS: Troposphere ozone, Meteorological parameters, Seasonal Variation, Air Pollution

INTRODUCTION

Air pollutants are substances that adversely affect the environment by interfering with climate, physiology of plants, animal species, entire ecosystems, as well as with human property in the form of agricultural crops or man-made structures.Ozone is present in the atmosphere that surrounds us. It is formed when hydrocarbons (HCs) and nitrogen oxides (NOx) from forests, industries, and automobile exhaust react with heat and sunlight. This tropospheric ozone is often called "bad" ozone because it damages living tissue. Some tropospheric ozone is natural. Lightning and static discharges are one natural source of tropospheric ozone. Ozone gives off the acrid smell after a lightning discharge. Some ozone is also produced when natural hydrocarbons formed by trees and other vegetation react with nitrogen oxides in the atmosphere and sunlight. This activity is based on the high oxidation capacity of ozone, which causes rubber and plastic products to breakdown after relatively short exposure. *Elampari et al. (2011)* reported that by observing how rubber bands deteriorate and develop cracks or pits, the relative ozone levels can be determined for

ISSN 2056-7537(print), ISSN 2056-7545(online)

different locations. Surface ozone is not emitted directly into the atmosphere. It results from photochemical reactions between oxides of nitrogen (NOx) and volatile organic compounds (VOCs) in the presence of sunlight. Photochemical production, Chemical destruction, Atmospheric transport, Surface dry deposition on vegetation, water and other materials and Stratospheric-Tropospheric exchanges are the five main factors which control the tropospheric ozone levels. At the surface level, photochemical ozone formation depends on a number of natural and anthropogenic factors. High surface ozone concentrations are not only confined to urban environment but are also spreading to the relatively cleaner areas in remote locations. The reduction of surface ozone is an important objective of air quality policy for many governments. At present, ozone is measured in very few cities in India. Significant amount of research, including monitoring of surface ozone pollution, is required to draft policies for its control.*)*.To track and predict ozone, one must create an understanding of not only ozone itself but also the conditions that contribute to its formation. It is necessary to apply models that describe and understand the complex relationships between ozone concentrations and the many variables that cause or hinder ozone production. Some other factors, such as regional transport of ozone and its precursors, can affect ozone levels. Ozone concentrations are strongly linked to meteorological conditions. Relative humidity has an effect on the concentrations of air pollutants. A study by *Udayasoorian et al (2013)* reported that an increase in relative humidity. *Selvaraj et al (2013)* the main objective of the study was to determine the concentrations of ozone in the lower atmosphere, and to relate the concentrations to changing meteorological conditions. The study was conducted in a place which is considered as 'clean' environment as it is far from mines, industrial areas and high traffic density is considered as relatively "polluted" environment because it is situated close to mines and industrial areas.

Objective of the Study

In this study an attempt has been made to address briefly some of the important issues, relevant to the changing climate scenario, with special emphasis on temporal (diurnal and seasonal) variations in troposphere ozone over a subtropical site. Study related with the inter relation of ozone and available meteorological parameters ***(Temperature, Sun shine, Rainfall, Relative humidity, Wind speed and Pressure)*** is also carried out and discussed.

Significance of the Study:

An air quality monitoring network is established at the Govt. Model Science College Jabalpur by IITM Pune is collaboration with Ministry of Earth Science, New Delhi. This monitoring network study is generating huge amount of data, which need to be properly collected, collated, evaluated, interpreted and compiled in the form of reports. The data will provide information on the success of the abatement measures, air quality trend, and impact of policies etc. Good public information system is needed for air pollution in severely polluted countries.

ISSN 2056-7537(print), ISSN 2056-7545(online)

Meteorology of the Study Area

Jabalpur (23°10′N 79°57′E / 23.17°N 79.95°E) is one of the biggest city of Madhya Pradesh State in Central India. It lies in Mahakoshal region of Madhya Pradesh. District Head quarter of Madhya Pradesh. It is considered one of the fastest growing cities of Central India. Despite of the pace of growth, it is believed to have maintained its natural beauty and resources. It is on the bank of holy Narmada River.

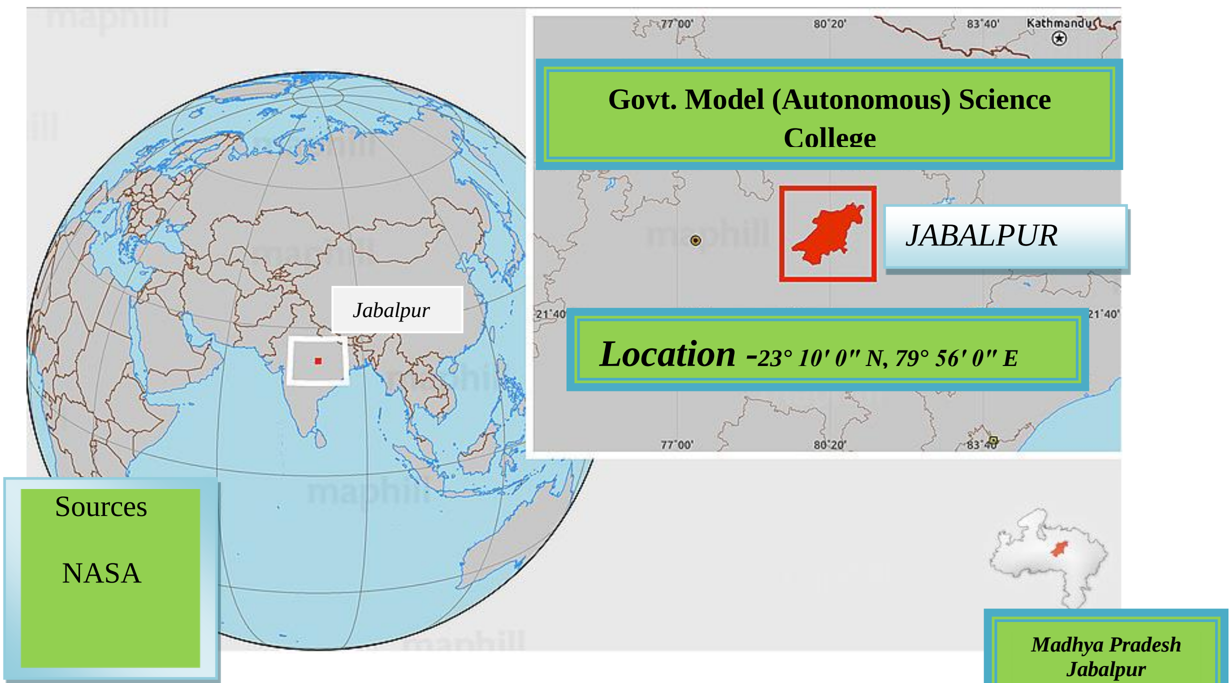

Fig.1.Location of the observation site

MATERIALS AND METHODS

Ambient Air Quality Station

Ambient Air Quality Monitoring Systems (AQMS) monitored the level of pollutants – Ozone, NOx, CO, CH_4, Particulate Matter (PM_{10}& $PM_{2.5}$), etc. in the ambient atmosphere. From a single analyzer to complete systems provides a wide range of solutions to meet much of the Ambient Air Quality Monitoring demands.

Ecotech established an instrument for environmental monitoring that is Win AQMS (Air Quality Monitoring Station). Win AQMS has been designed as a client/server program. This means that Win AQMS has two parts: the client and the server. The server handles all the communication between the logger and the analysers, recording of data and starting/stopping of calibrations. The client is concerned with giving the users access to settings and data. On its own the server has no user interface and there is no way you can interact with it using the mouse or keyboard. The client is the visual interface of Win AQMS and communicates with

ISSN 2056-7537(print), ISSN 2056-7545(online)

International Journal of Environment and Pollution Research
Vol.4, No.4, pp.34-45, September 2016
Published by European Centre for Research Training and Development UK (www.eajournals.org)
the server by requesting information or receiving information that it has asked for at a prior time. This arrangement means that the Win AQMS server must always be turned on before the Win AQMS client program can connect to it.

Ambient Air Quality Station

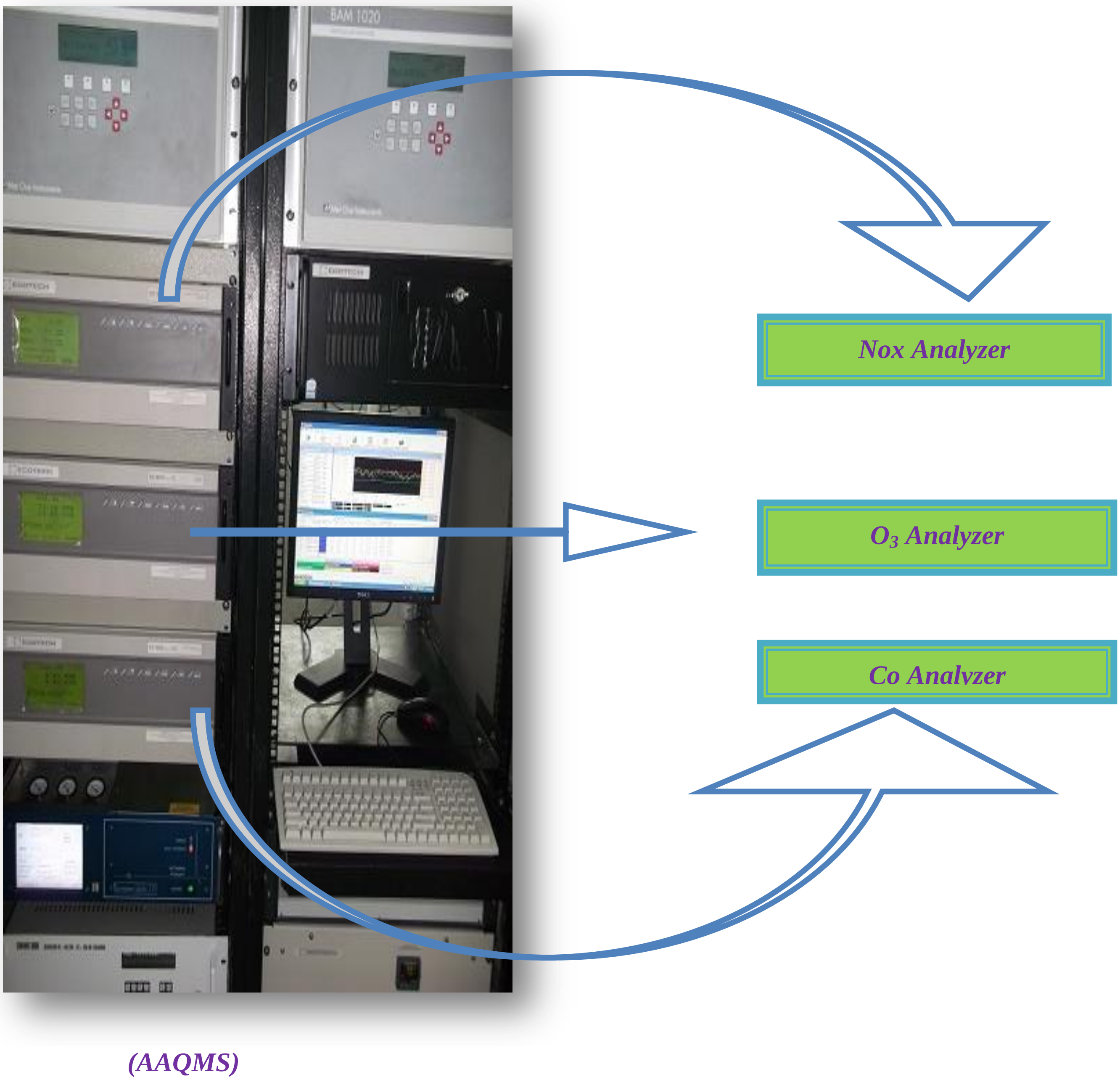

Fig. 2.

ISSN 2056-7537(print), ISSN 2056-7545(online)

Ozone (O_3) Analyser:-

The EC 9810 ozone (O_3) analyser is a non dispersive ultraviolet (UV) photometer which alternately switches a selective ozone scrubber in and out of the measuring stream and computes the ratio of transmitted light giving an accurate and reliable measure of ozone concentration in the presence of common atmospheric compounds. A mercury vapor lamp is used as the light source. Its 254 nm line is close to the center of the ozone absorption band. The selective scrubber uses manganese dioxide (MnO_2) to selectively destroy ozone and pass other common absorbers such as $SO_2$and aromatics. Since absorbances add, the resulting difference in beam intensity between the scrubbed and non-scrubbed cycle is a function of ozone concentration. The system is under the control of the EC9800 series microprocessor module. Software algorithms handle all internal adjustments,

continuously perform diagnostics, indicate errors, display status and make calculations of ozone concentration. The only operator functions are to perform routine maintenance on the pneumatics and periodically verify calibration of the unit. The microprocessor continuously monitors the source and many other parameters, making adjustment as necessary to ensure stable and accurate operation. In addition to temperature and pressure compensation, the EC9810 analyser can readjust its span ratio based on a known concentration of gas used to span the analyser. Thus feature is not automatically implemented and must be selected by the operator. Data collection and recording is available for either a data acquisition system (such as data logger) or a strip chart recorder. A DB50 connector is also included for digital input control and digital output status. The EC9810 also features internal data storage capabilities. The instrument includes an over-range feature that, when enabled, automatically switches the analog output to a preselected higher range if the reading exceeds 90% of the nominal range. When the reading returns to 80% of the nominal range, the analyser automatically returns to that range.

PLATES:

AWS (Automatic Weather Station):- This instrument provides metrological data e.g. wind speed, pressure, humidity, temperature, wind direction and rain fall with the help of intercept-software. It gives every 10 minutes data. A atmospheric weather station is a facility, either on land or sea, with instruments and equipment for measuring atmospheric conditions to provide information for weather forecasts and to study the weather and climate. The measurements taken include temperature, sunshine, rainfall, humidity, wind speed and pressure. Wind measurements are taken with as few as other obstructions as possible, while temperature and humidity measurements are kept free from direct solar radiation, or isolation.

ISSN 2056-7537(print), ISSN 2056-7545(online)

Figure 3: AWS (Automatic Weather Station)

OBSERVATION, RESULT AND DISCUSSION

Variation of ozone with meteorological parameters:-

Variation in surface ozone concentration depends not only on precursor emissions but also on meteorological conditions**.** Meteorological variables such as solar radiation, near surface wind, temperature and precipitation influence ozone formation, deposition and transport process by affecting photochemical reactions and atmospheric dynamic conditions. Clear sky, warm temperature, solar radiation and soft winds are believed to have a great influence on surface ozone concentration. The influence of available meteorological variables on the surface ozone concentration at the observational site is discussed briefly in the following sections.

ISSN 2056-7537(print), ISSN 2056-7545(online)

Table & Graph:-

Month ***2015***	***O_3***	***Temp. (Max. Min.)***	***S.S***	***R. Fall***	***R.H***	***W.S***	***Pressure***
	ppb	**(ºC)**	**(ºC)**	**(mm)**	**(%)**	**(m/s)**	**(m/s)**
January	**11**	**15**	**5**	**59**	**71**	**3**	**9**
February	**13**	**19**	**9**	**21**	**64**	**3**	**10**
March	**12**	**22**	**7**	**11**	**62**	**3**	**12**
April	**14**	**28**	**9**	**13**	**40**	**5**	**11**
May	**19**	**34**	**9**	**91**	**29**	**5**	**11**
June	**38**	**32**	**6**	**100**	**55**	**7**	**18**
July	**19**	**28**	**4**	**391**	**76**	**7**	**22**
August	**17**	**27**	**4**	**367**	**81**	**8**	**22**
September	**21**	**33**	**6**	**109**	**73**	**4**	**21**
October	**29**	**26**	**3**	**40**	**63**	**3**	**15**
November	**32**	**23**	**2**	**60**	**64**	**2**	**13**
December	**34**	**17**	**2**	**50**	**59**	**2**	**8**

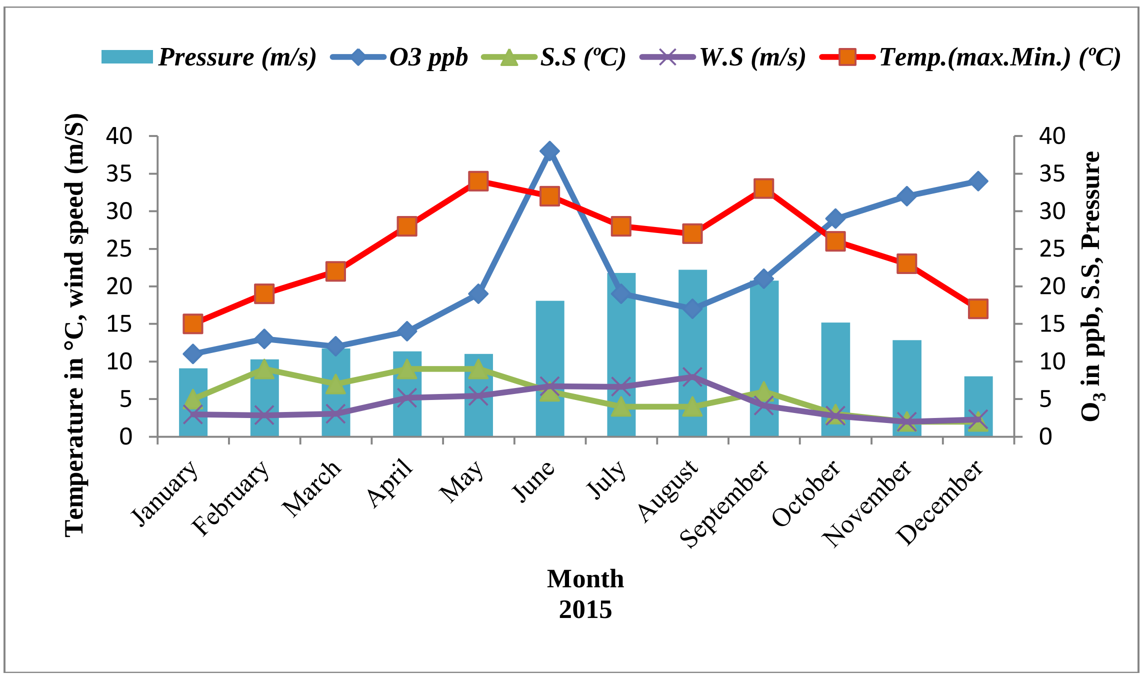

Fig .4.

ISSN 2056-7537(print), ISSN 2056-7545(online)

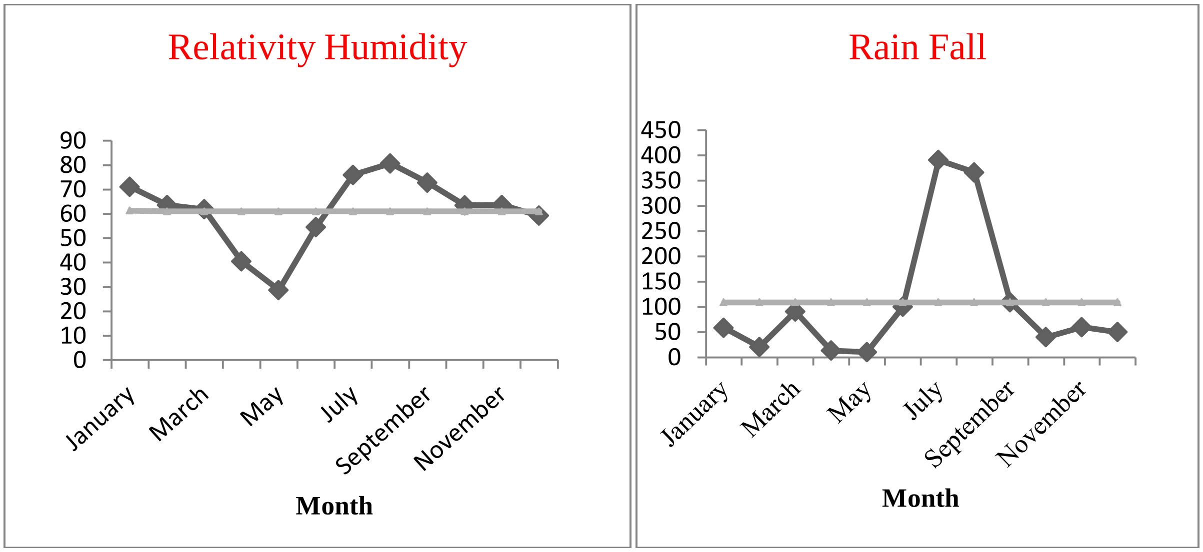

Fig. 5. Average monthly variations of Meteorological variables.

Figure. (4, 5) show the average monthly variations in minimum and maximum temperature, relative humidity, wind speed, and rainfall during the observational period. The site records an average minimum temperature of January& February (15 °C) and an average maximum of May (34°C). During the measurement period the average highest relative humidity was found during July (391) and lowest during March (11). Wind speed records its maximum value during August (8 m/s) and minimum during November (2 m/s). It is evident from the Figure (4) the observational site is strongly influenced by the south west monsoon.

Diurnal Variations:-

The diurnal variation of surface ozone is helpful to understand the different processes responsible for ozone formation and destruction at this particular location. Chemical and atmospheric dynamic processes regulate the diurnal ozone concentration. A typical diurnal ozone variation coincides with the intensity of solar radiation where as the maximum ozone is shifted towards afternoon.

ISSN 2056-7537(print), ISSN 2056-7545(online)

2015	
Month	O3 ppb
January	**11**
February	**13**
March	**12**
April	**14**
May	**19**
June	**38**
July	**19**
August	**17**
September	**21**
October	**29**
November	**32**
December	**34**

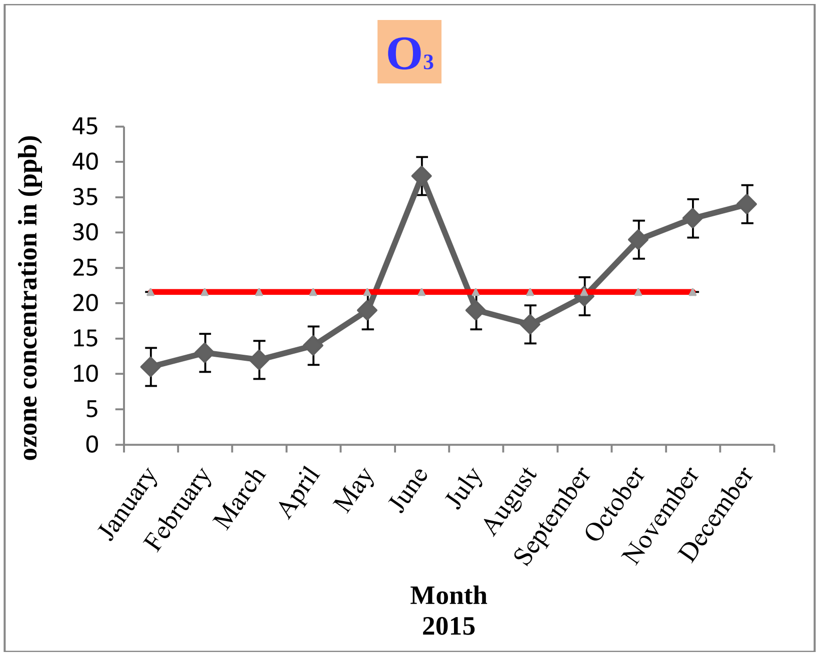

Fig. 6.

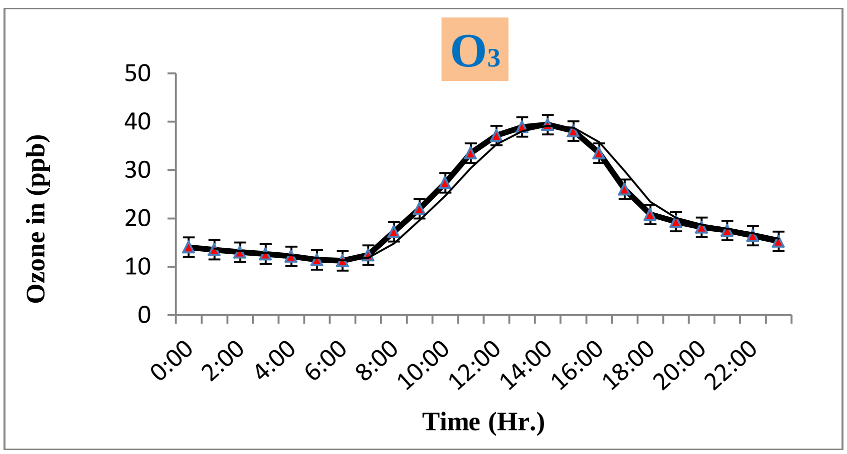

Fig.7.

During the entire period of study, the troposphere ozone concentration varied from the minimum of 11 ppb to a maximum of 39 ppb. The diurnal cycle of ozone was characterized by the maximum ozone concentration in the afternoon (14:30 hr) and minimum ozone concentration in the early hours of the morning (06:00 hr). A gradual decrease was observed in the evening hours (17:30 hr). After sunset, the concentration declining further and reached the lowest level between (02:30) hr and (05:30 hr.) The cycles showed that the relationship between the buildup of ozone precursor gases in the morning hours and the photochemical

ISSN 2056-7537(print), ISSN 2056-7545(online)

formation of ozone around the afternoon time. 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 O_3 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. In the evening, ozone concentration decreases steadily because the night inversion layer is formed and once it is formed, no great changes occur. 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 O_3 precursors taking place due to the absence of sunlight. *Baxla et al (2009).* The rate of increase in the morning was faster whereas the rate of decrease in the evening was quite slower. This means that, in situations with significant ozone formation, destruction of O_3 is small compared to the rate of O_3 production. The diurnal behavior of surface ozone at this place could be explained on the basis of the basic atmospheric processes. The rate of photolysis of NO_2 increases due to intense solar radiation produces atomic oxygen in an energetically exited state which is followed by a reaction to produce two OH radicals. This OH radical plays an important role in atmospheric oxidation processes of many organic compounds and there by supports the photochemical ozone production.

Seasonal Variation:-

The diurnal variation of average ozone concentration which includes four different seasons for the study period 2015 is shown in Fig. **8.**

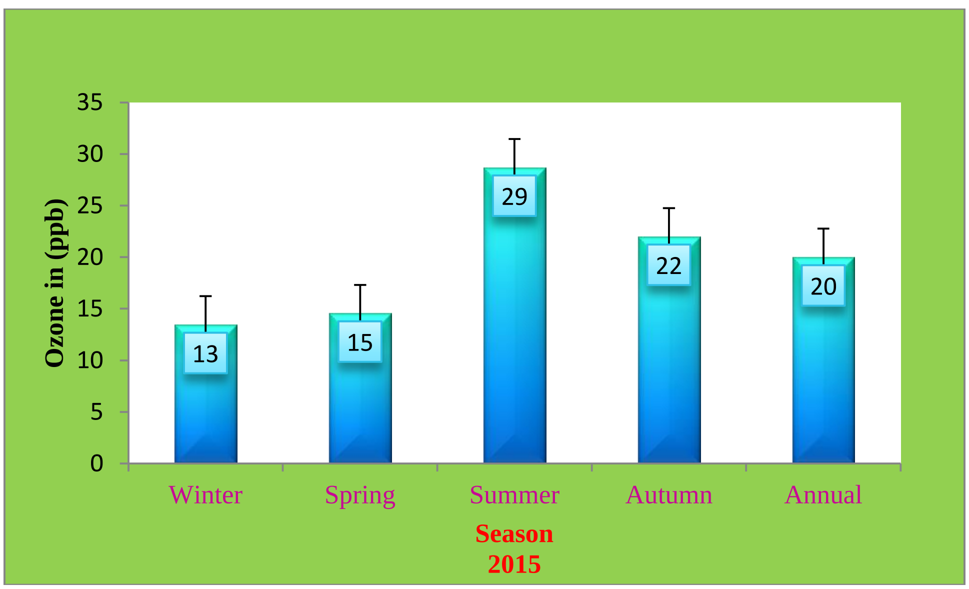

***Fig. 8.* Seasonal variation of surface ozone**

High levels of average O_3 concentrations were reached in summer followed by south west monsoon and low values at winter. From the Figure 9, it can be seen that in summer the maximum ozone concentration is 29 ppb and the lowest is about 13 ppb. The variation in

ISSN 2056-7537(print), ISSN 2056-7545(online)

ozone concentration in different seasons may be due to the variation in NOx, CO, CH4, hydro carbon levels and changing meteorological conditions like solar radiation, temperature, cloud coverage, wind velocity, wind direction, relative humidity and rainfall. Low ozone concentrations observed in attributed to the non-availability of adequate solar radiation due to the cloudy skies that reflected back the solar radiation from reaching the surface, and also the reduction in precursor species from the atmosphere by rain which took place during this season.

CONCLUSION

The measured O_3 data is analyzed on the basis of diurnal, seasonal and annual variations. All hourly values were used to analyze diurnal variability and daily averaged values were used to analyze the day-to-day variability. Monthly means are calculated from the daily values, to study the seasonal cycle. As a result of the field study conducted at sub-tropical station, Jabalpur, India, a data pool of surface ozone concentration was obtained with AAQMS data points.

- The diurnal pattern of surface ozone concentration clearly indicates its dependency on the photochemical production process. In general the surface ozone concentration is observed to the highest in summer, and lowest 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 Jabalpur (M.P). This is an indication of the increasing concentration in ozone precursor species.
- Concentrated study on the surface ozone concentration at the sub-tropical station, Jabalpur brings forth the first hand information on the lower atmosphere. The characteristic properties were well-understood. It illustrates the healthy atmospheric conditions. Although surface ozone concentrations are below the national standard at present, it has the potential to be a problem in the future with increased anthropogenic activities.

Acknowledgement:-
The authors are thankful to Indian Institute of Tropical Meteorology (IITM), Pune and Ministry of Earth Science. Govt. of India for providing financial assistance in the form of Major Research Project. Authors are the thankful to the Principal, Govt Model Science College, Jabalpur for providing necessary facilities.

REFERENCES

Ayantunji B. G and Okeke P. N., (2011) "Diurnal and Seasonal Variation of Surface refractivity Over Nigeria" Progress In Electromagnetic Research B, Vol. 30, pp. 201- 222

Baxla S.P. and A.A. et al. (2009) " Analysis of Diurnal and Seasonal Variation of Submicron Outdoor Aerosol Mass and Size Distribution in a Northern Indian City and Its Correlation to Black Carbon Aerosol and Air Quality Research, vol. 9: pp. 458-469,

ISSN 2056-7537(print), ISSN 2056-7545(online)

Dawson G. B. and Fisher R. G. (2011) "Diurnal and seasonal ground temperature variations at Wairakei, New Zealand Journal of Geology and Geophysics, vol. 7:1, pp 144-154

Ganguly Nandita D. and Joel, (2010) "Vincent Long Term Trend, Diurnal and Seasonal Variations of Atmospheric Ozone at Indian Antarctic Station Maitri" Earth Science India, Vol. 3 (III), July, 2010, pp. 174-180

Ganguly Nandita D and Ranjan R R et al, (2006) "Diurnal and seasonal variation of columnar ozone at Rajkot, Indian Journal of Radio & Space Physics Vol. 35, pp. 181-186

Jeelani Hesham, (2014). " Diurnal and Seasonal Variations of Surface Ozone and Its Precursors in the Atmosphere of Yanbu, Saudi Arabia"

Journal of Environmental Protection, 2014, vol. 5, 408-422

Lal Shyam and Naja Manish et al, (2000) " Seasonal variations in surface ozone and its precursors over an urban site in India" Atmospheric Environment vol. 34, pp 2713-2724

Selvaraj R. Samuel and Padma K. et al, (2013) "Seasonal variation of surface ozone and its association with meteorological parameters, UV-radiation, rainfall and cloud cover over Chennai, India" Current Science, Vol. 105, No 5,

Udayasoorian C. and Jayabalakrishnan R. M. et al, (2013) "Diurnal and seasonal characteristics of ozone and NOx over a high altitude Western Ghats location in Southern India" Advances in Applied Science Research, vol. 45 pp-309-320