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RESEARCH ARTICLE

ASSESSMENT OF OZONE VARIATIONS AND METEOROLOGICAL EFFECTS IN AN URBAN AREA IN THE JABALPUR REGION

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ABSTRACT

Ozone concentrations are valuable indicators of possible health and environmental impacts. However, they are also used to monitor changes and trends in the sources of ozone. For this purpose, the influence of meteorological variables is a confusing factor. This study presents an analysis of a year of ozone concentrations measured in a Jabalpur city. Firstly, the aim of this study was to perceive the daily, monthly and seasonal variation patterns of ozone concentrations. Diurnal cycles are presented by season and the fit of the data to a normal distribution is tested. In order to assess ozone behavior under temperate weather conditions, local meteorological variables (wind direction and speed, temperature, relative humidity, pressure and rainfall) were monitored together with ozone concentrations. The main relationships we could observe in these analyses were then used to obtain a regression equation linking diurnal ozone concentrations in summer with meteorological parameters. Results of this study have revealed that the annual mean of daily average surface ozone concentration varies from 16 ppb to 49 ppb. The highest average seasonal concentration was observed in summer and lowest in winter season.

INTRODUCTION

Tropospheric ozone concentrations are currently a matter of large concern. Since the beginning of this century, it is obvious that background ozone concentrations have more than doubled. The assessment of ozone levels is extremely important since ozone is a key element to control the chemical composition of the troposphere and climate as it is also a greenhouse gas. The production of ozone in the Troposphere is accomplished through a complex series of reactions referred to as the 'photochemical smog mechanism'. Urban air pollution in many cities is currently an issue of great concern to the general public maintaining a high profile on the political agenda. The reality of numerous situations in which the near-surface ozone concentration exceeds the adopted threshold values, has attracted considerable public attention due to the well-known harmful impact on biosphere, human health, animal populations, agriculture productivity and forestry. 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. In addition, favorable meteorological conditions have a great influence on ozone concentrations. Urban ozone formation is a complex phenomenon since this pollutant is not emitted into the atmosphere directly but it is produced thanks to the interaction of meteorology, NO*x* and VOCs (Finlayson-Pitts and Pitts, 1986; Saunders *et al*., 1991). Therefore, several surveys have tried to assess the impact of meteorological factors taking into consideration ozone levels in order to detect changes in ozone precursor emissions. The work reported in this paper is an investigation into the importance of meteorology in determining surface ozone concentrations, the study focuses on the impact of meteorological parameters on ozone variability at urban area in the Jabalpur region. Ozone concentrations are strongly linked to meteorological conditions. In addition, favorable meteorological conditions (*Temperature, Sun shine, Rainfall, Relative humidity, Wind speed and Pressure)*. 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. Biomass of the African savannas is known to produce large

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amounts of photo chemically active aerosols and trace gases that are necessary precursors of tropospheric ozone (Selvaraj et al., 2013) leads to a decrease in average concentrations of ozone. The main objectives of this study were to determine the concentrations of ozone in the lower atmosphere, and to relate the concentrations to changing meteorological conditions. The study was conducted which is considered a 'clean' environment since it is far from mines, industrial areas and human settlements which 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 tropical 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.

I. Significance of the study:- 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.

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, Central India. It is a District of Madhya Pradesh State. District Head quarter of Jabalpur is in Jabalpur city. 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.

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.

Table & Graph

Figure. (1, 2, 3, 4, 5, 6) shows 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 (16 °C) and an average maximum of May (49°C). During the measurement period the average highest relative humidity was found during August (81) and lowest during May (29). Wind speed records its maximum value during August (8 m/s) and minimum during November (2 m/s). It is evident from the observational site is strongly influenced by the south west monsoon rainfall.

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.

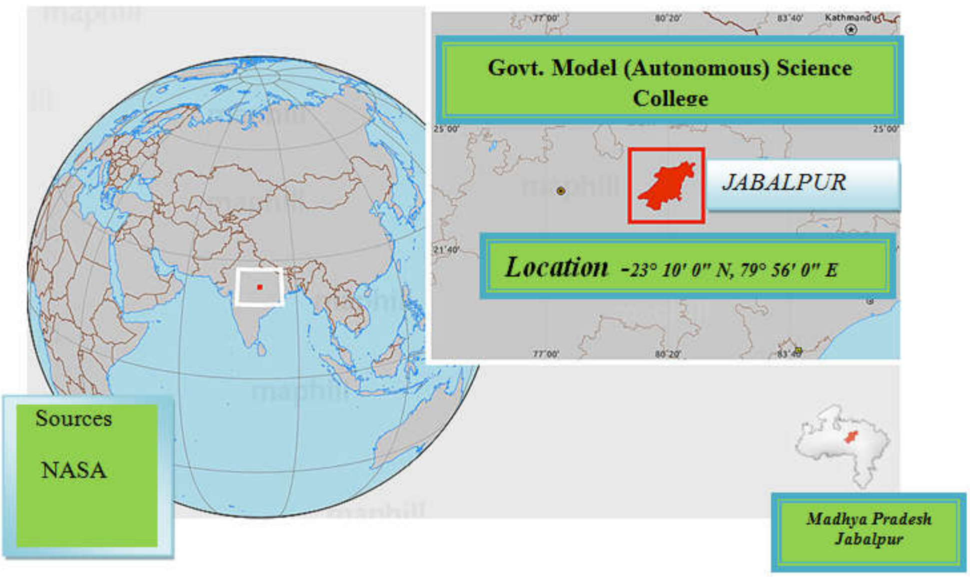

Fig.1. Location of the observation site

Month	*O_3* ppb	*Temp. (Max. Min.)* (ºC)	*S.S* (ºC)	*R. Fall* (mm)	*R.H* (%)	*W.S* (m/s)	*Pressure* (m/s)
January	16	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	49	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

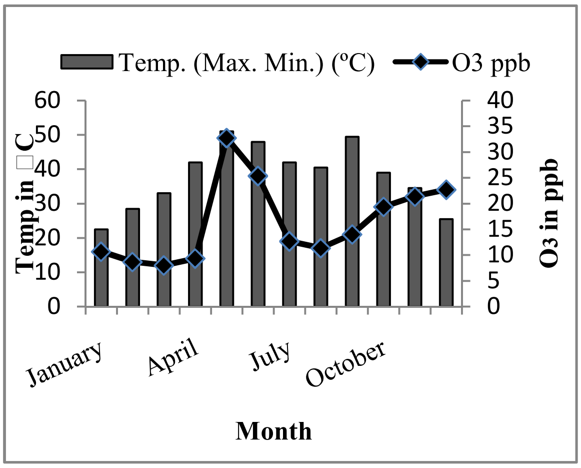

Fig.1.

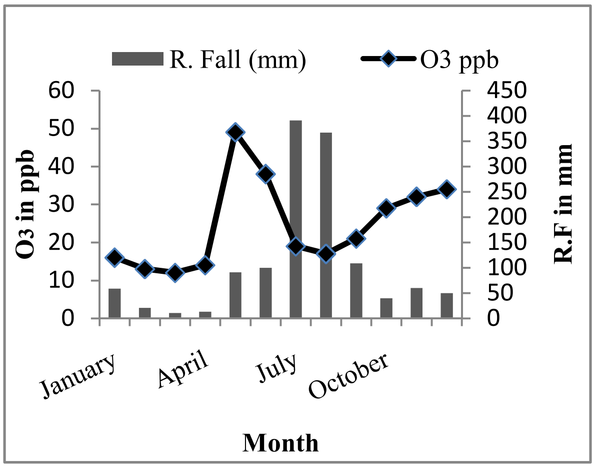

Fig.2.

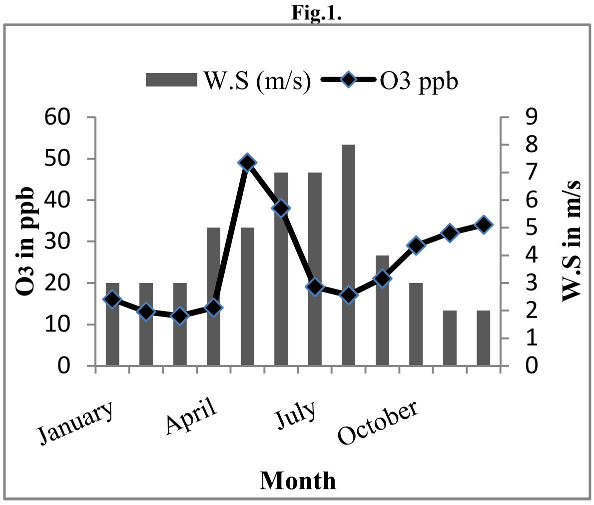

Fig.3.

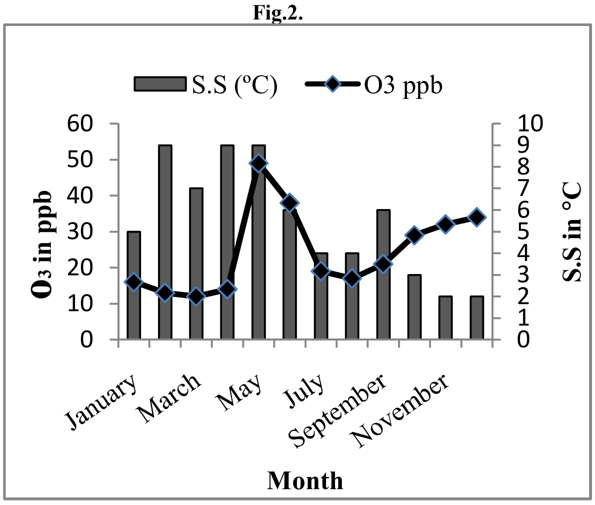

Fig.4.

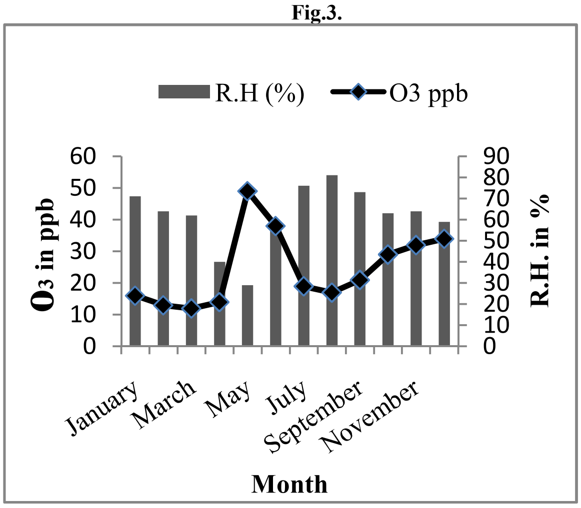

Fig.5.

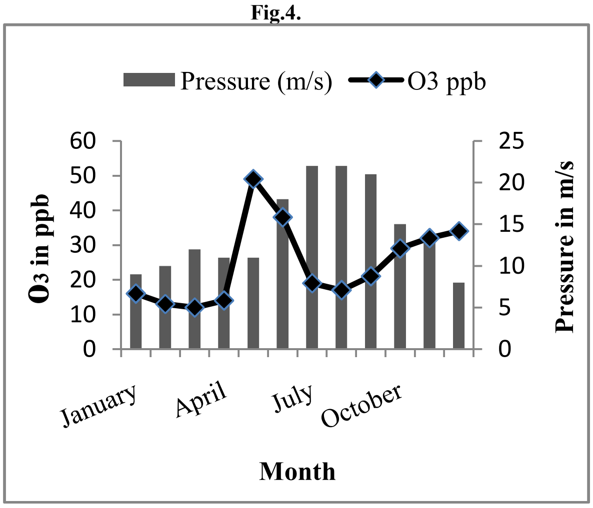

Fig.6.

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 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

(AAQMS)

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.

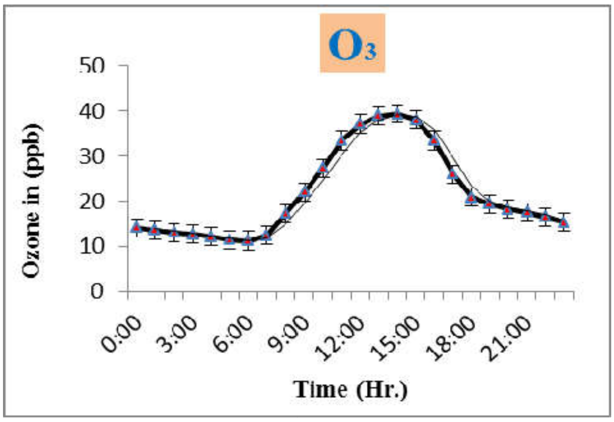

Fig. 7. Diurnal variation of ozone concentration

During the entire period of study the troposphere ozone concentration varied from the minimum of 16 ppb to a maximum of 49 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 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.

RESULTS AND DISCUSSION

The measured O_3 data is analyzed on the basis of diurnal 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.

- 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.

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