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Full Length Research Paper

Diurnal and Seasonal behavior of $PM_{2.5}$ over surface ozone concentration at Jabalpur

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Abstract

Air pollution is a major concern of now days. It is caused by many gaseous as well as particulate pollutants. The ground level O_3 and SPM ($PM_{2.5}$) are the two essential sources which can fluctuates the quality of ambient air in the atmosphere. The diurnal average of O_3 and $PM_{2.5}$ of the year 2014 reflected the annual and seasonal variations throughout the year. The correlation between O_3 and $PM_{2.5}$ shows maximum fluctuating concentration in the month of December with positive correlation (r=0.1886). The seasonal correlation also shows positive correlation in all the seasons with the interrelation of O_3 and $PM_{2.5}$.

Keywords: *Gaseous pollutants, Suspended Particulate Matter, Diurnal average, Positive correlation.*

INTRODUCTION

Our atmosphere is made up of many components; which are chemical, physical, gaseous as well as biological. All the components are inter-dependent. As such, the gaseous pollutant O_3 (Ozone) is a major constituent which act as a secondary pollutant in the lower atmosphere. Chemically, when primary pollutants NO_X and VOCs chemically react with the external substance like dust, smog, smoke and suspended particulate matters of nature in the presence of sunlight the resultant is O_3.

Scientifically, O_3 shows tremendous fluctuation with other pollutants of ground level. One of them is suspended particulate matter which plays a vital role for the formation surface O_3 in ground level. Suspended particulate matters (SPM) are the one of the major pollutants in the developing countries. The SPM are mainly divided into two parts: $PM_{2.5}$ and PM_{10}. SPM which is less than or upto 2.5 μ/m^3 in size comes under $PM_{2.5}$. This $PM_{2.5}$ has an adversely impact on human respiratory system. Thus, it is a part which causes air pollution.

The concentration of O_3, $PM_{2.5}$ and PM_{10} were fluctuated during all the seasons because their concentration depends on the regional topography and climatic behavior. According to IMD (Indian Meteorological Department); India is 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 *(Kour et al., 2015)*.

During the study at Jabalpur, various gaseous pollutants (O_3, CO, CH_4 and NO_2) came forward which has shown fluctuation throughout the years. Result found that, when O_3 concentration was higher (in the studied year) concentration of CO and CH_4 was gradually increases whereas NO_2 decline its concentration *(Sarkar, 2015).*

In winter season, the ozone concentration is higher *(David, 2011)* due to elevated amount of precursor gases and low solar radiation. Thus, O_3 concentration has shown inverse correlation with its precursor gases while whole diurnal interval.

Spatial and temporal variations of PM_1, $PM_{2.5}$, PM_{10} and particle number concentration during the (AUPHEP—Austrian Project on Health Effects of Particulates)—project" was done by Gomisceka *et al.* (2004). For this project, they selected four sites in

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Austria 3 urban sites and 1 in rural for the monitoring data of PM mass fractions - PM_1, $PM_{2.5}$, PM_{10} and TSP as well as the particle number concentrations over a 1 year period. The ratios between the different fractions were concerned usually the daily and seasonal pattern. Annual means of mass concentrations for PM_1, $PM_{2.5}$, PM_{10} were in urban sites, a little bit lower at the rural site.

At the city Kannur, surface ozone has been continuously monitored throughout the study which shown its diurnal variation and correlation with various meteorological parameters *(Nishanth et al., 2011)*. During winter season, mixing ratios of surface ozone has maximum at the rural areas (44.01±3.1ppbv) and urban areas (36.3±5.4ppbv). It has also noticed that during winter, production of ozone was much higher in the afternoon *(Selvaraj et al., 2013).*

At Bhubaneswar the study of surface ozone variation and its correlation with various parameters has performed. It found that, seasonal variation of O_3 concentration was maximum in January (~85ppbv), gradually it has increases in the month of June (~38 ppbv) and minima in the month of August (~20ppbv). Affected by topography and climatic conditions in contrary, ozone raised during pre-monsoon and monsoon. *(Mahapatra et al., 2012)*

Bahauddin and Uddin (2010) studied status of particulate matter and its impact on roadside population of Dhaka city, Bangladesh. This paper investigated the level of particulate matter and to determine adverse impact of this on health of roadside population of Dhaka city. It was a desk research which has involved the collection of previous research reports, newspapers, journal content and also collection and synthesis of existing project reports regarding to air pollution of Bangladesh. In the year 2002-07, the maximum concentration of PM2.5 and PM10 in Dhaka city and average of particulate matter levels were 2 times higher than the Bangladeshi standard and the residential areas.

Zhao et al. (2013) investigated “characteristics of visibility and particulate matter (PM) in an urban area of Northeast China”. They studied visibility data from 2010 to 2012 obtained at Shenyang in Northeast China and the relations between visibility, PM mass concentration and meteorological variables were statistically analyzed. These results demonstrate that the monthly–averaged visibility over Shenyang was higher in March and September with low visibility over Shenyang occurred in January.

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. figure 1

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, BAM1020 provides all the observation of $PM_{2.5}$. The BAM1020 is determined the concentration in units 18 of milligrams or micrograms of particulate per cubic 19 meter of air. A small 14C (carbon 14) element emits a 20 constant source of high-energy electrons known as beta 21 particles

A statistical analysis Pearson correlation coefficient has done to estimate the correlation of O_3 concentration with $PM_{2.5}$.

Observation Table

The site for the study is quite dense related to residential area but the place of Jabalpur is also very near to green belt. While on monitoring the ambient air by AAQMS (Ambient Air Quality Monitoring System) of the city, some gaseous pollutants are like ozone (O_3) and $PM_{2.5}$.The observation of gaseous pollutants and SPM has been observed of the year 2014. Here, the graphical representation showing the annual average comparison of O_3 and $PM_{2.5}$ figure 2.

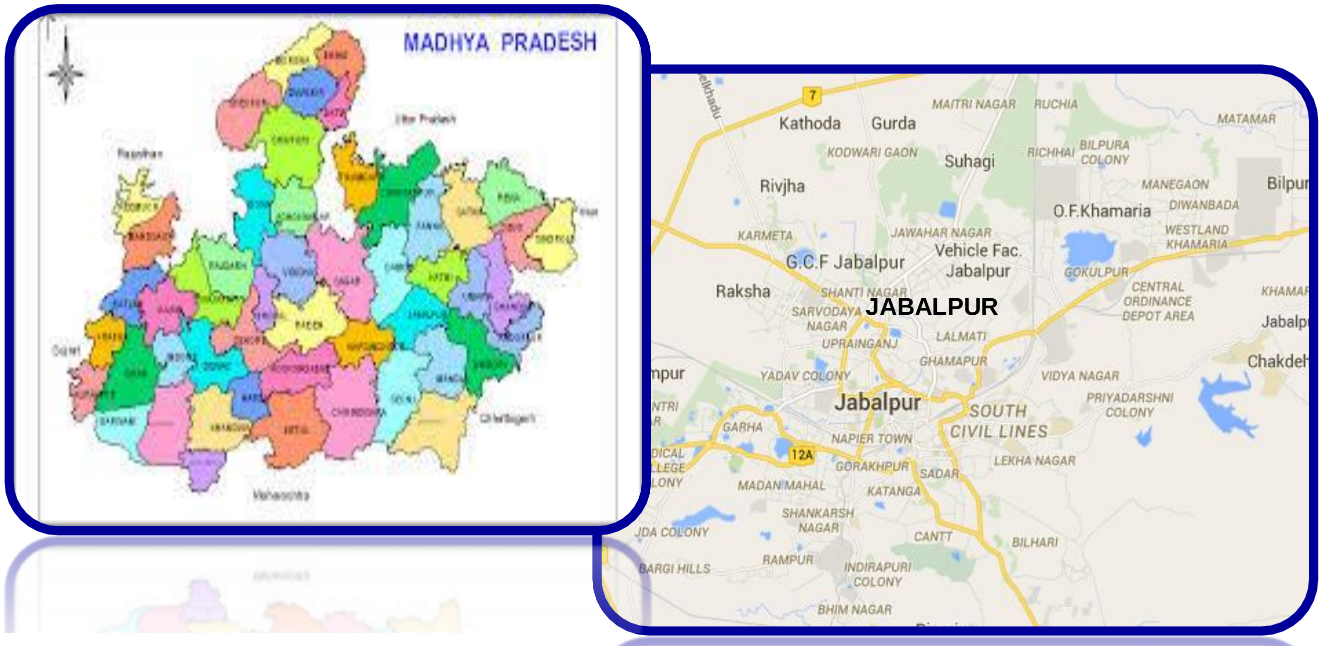


Figure1. Location of Jabalpur

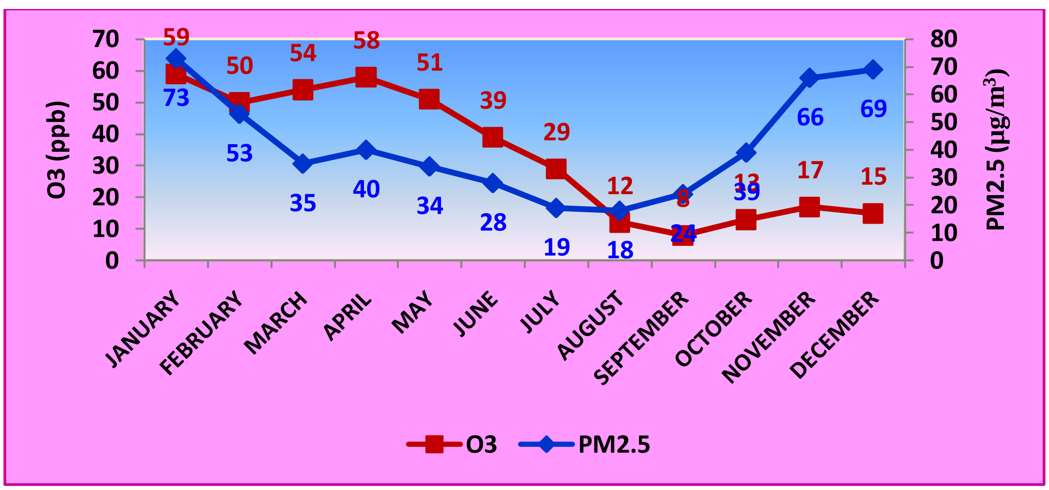


Figure 2. Monthly comparison of O_3 and $PM_{2.5}$ concentration of 2014

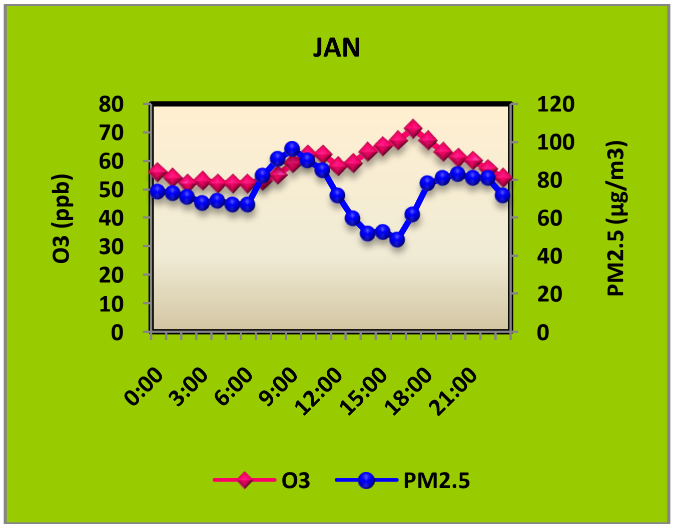
The comparing trend of O_3 was almost similar with $PM_{2.5}$ concentration in the initial month (Jan-Feb). Later on it gradually increased and decreased but at the month of August both the concentration goes down and again rose in December.

The diurnal monthly average value of O_3 and $PM_{2.5}$ shows the fluctuation of 24 hours time interval of each month.

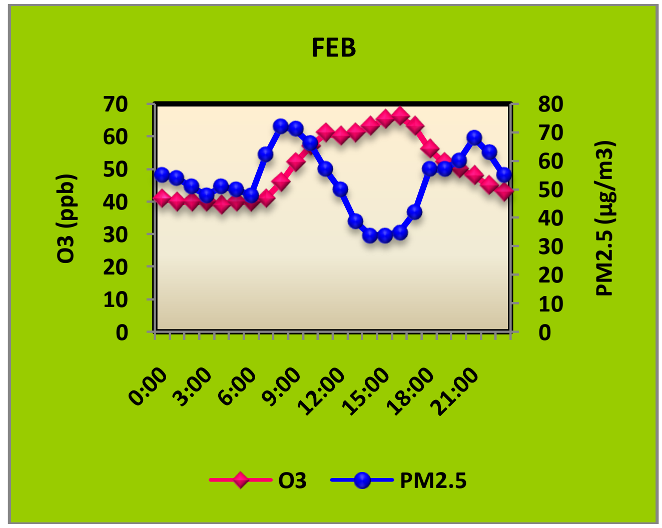
The graphical representation below (Figure 3) of each month shows the variation in the concentration of O_3 and $PM_{2.5}$. The time interval of 1hrs within the 24hrs in each day of each month performs the diurnal average.

The seasonal monitoring of O_3 with respect to $PM_{2.5}$ shows a trend line fluctuation in all the weathers. This may be affected with other meteorological parameters present in the atmosphere. It observed that, O_3 concentration was highly affected during the autumn season due to high humidity. In other hand, $PM_{2.5}$ was very low in monsoon from Table 1.

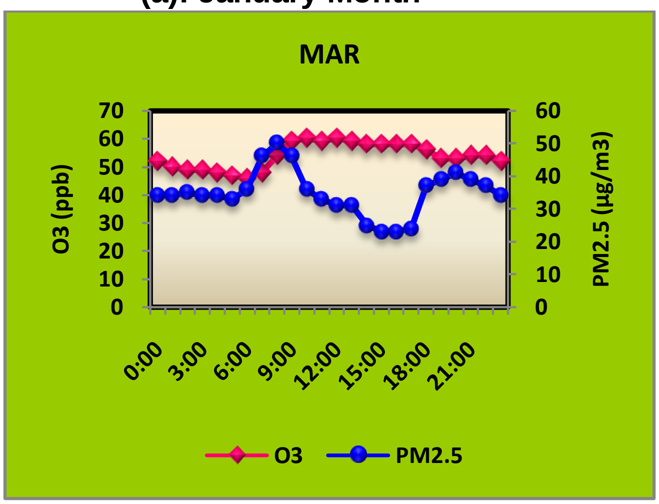
The seasonal correlation of O_3 and $PM_{2.5}$ were almost simultaneously gone but it has highly fluctuated during autumn. The graph (figure 4) shown that both the pollutants were declined in the monsoon season thus, it related to humidity factor.



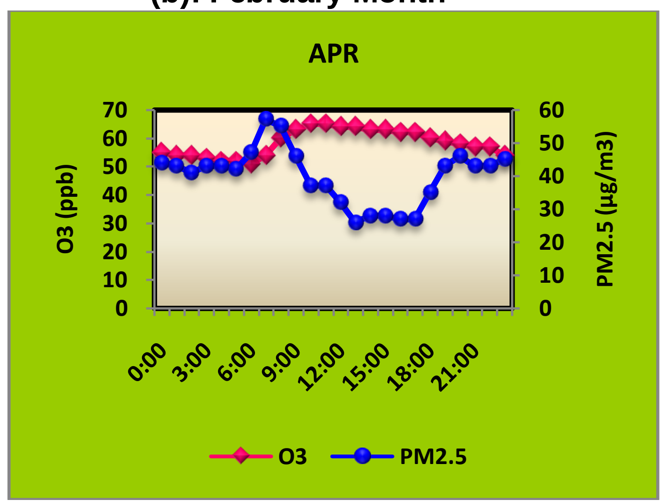
(a): January Month



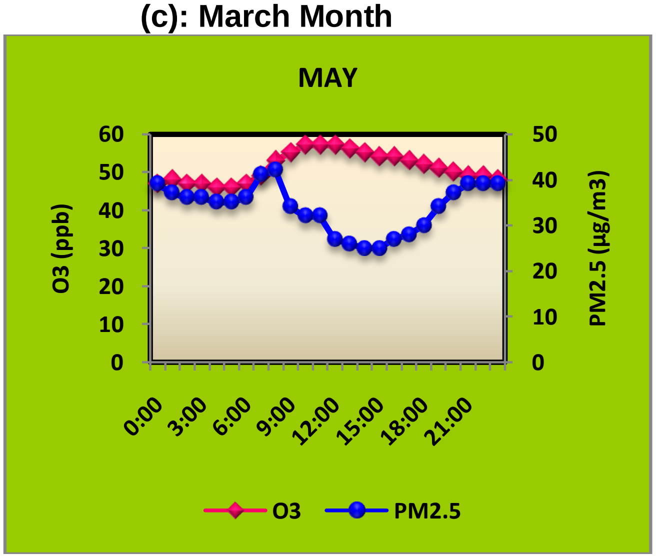
(b): February Month



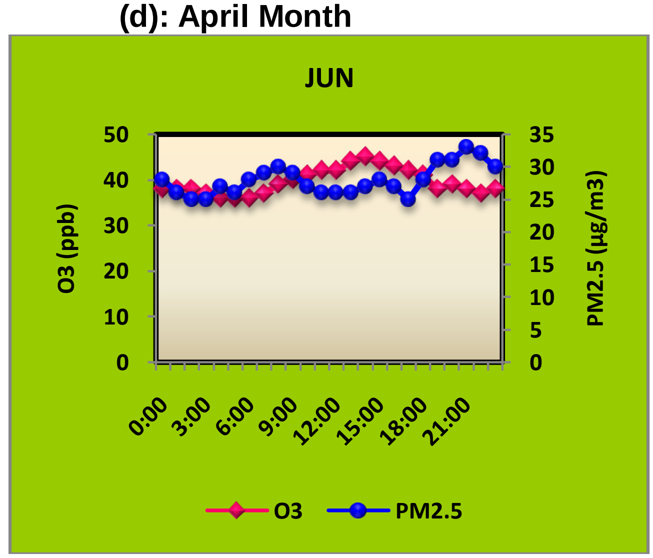
(c): March Month



(d): April Month

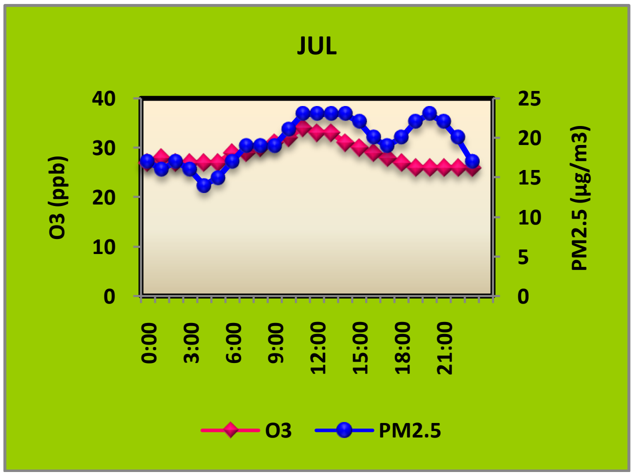


(e): May Month

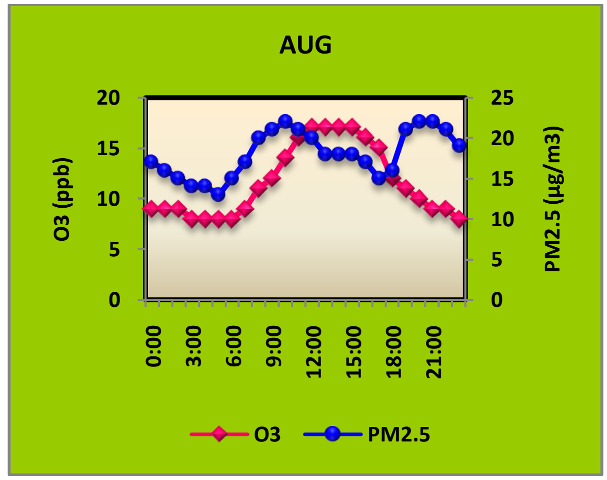


(f): June Month

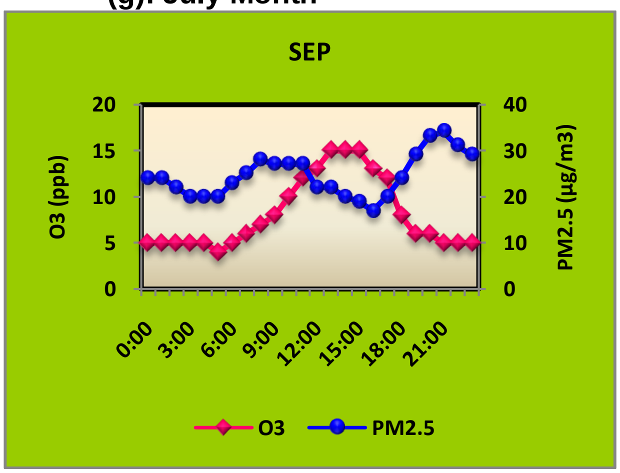
Figure3. Diurnal average comparison of O_3 and $PM_{2.5}$ concentration of 2014



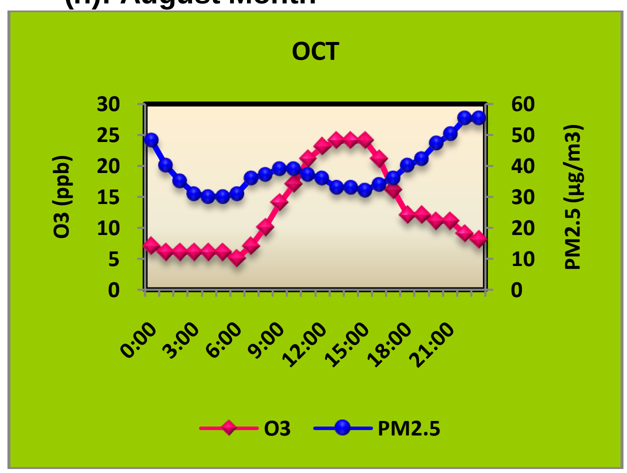
(g): July Month



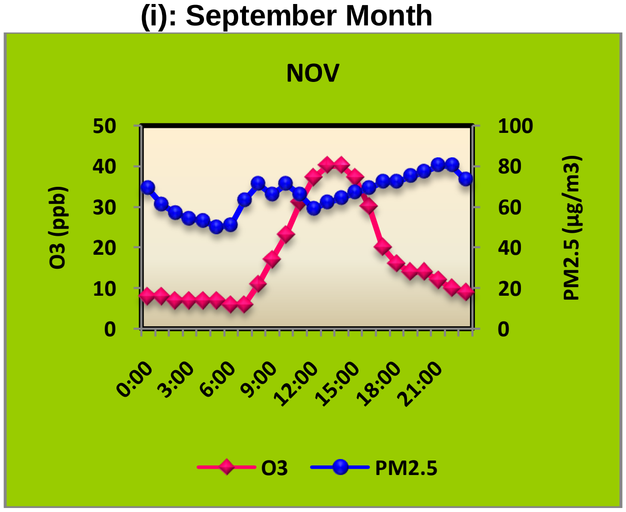
(h): August Month



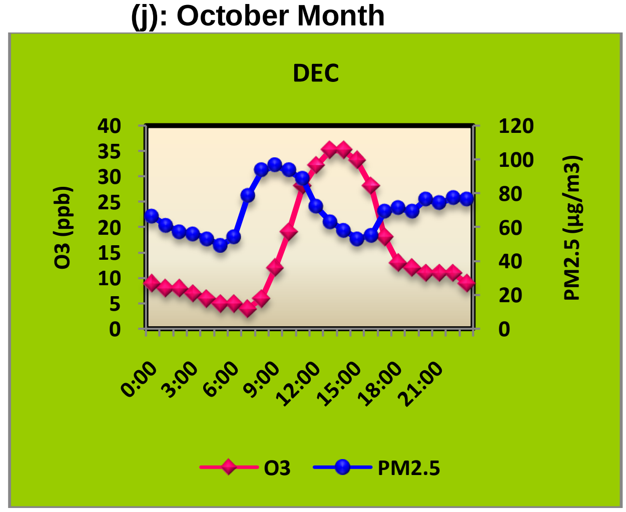
(i): September Month



(j): October Month



(k): November Month



(l): December Month

Figure 3. Continuation

Table 1. Observation of Ozone and $PM_{2.5}$ 2014

YEAR	2014			
SEASON	**Winter**	**Summer**	**Rainy**	**Autumn**
O_3 (ppb)	59	49	16	15
$PM_{2.5}$ (µg/m^3)	54	34	20	58

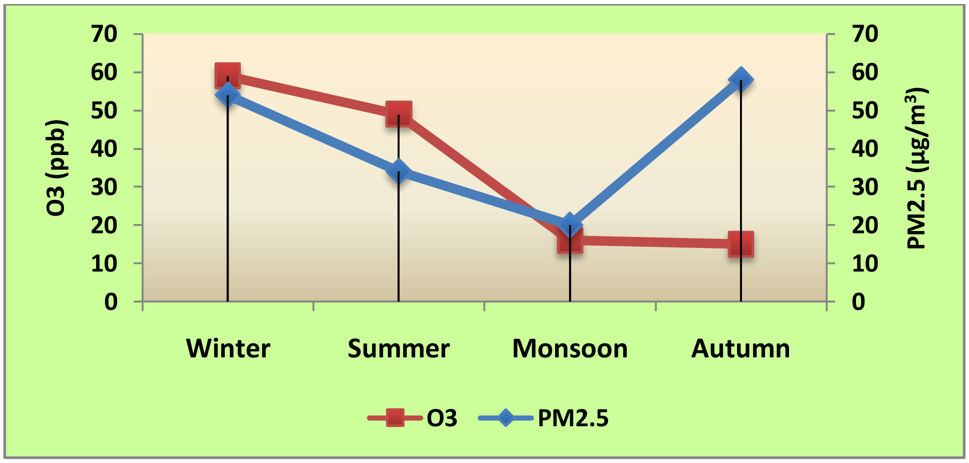


Figure 4. Seasonal Correlation of O_3 and $PM_{2.5}$ concentration of 2014

Table 2. Result of average diurnal comparison of O_3 and $PM_{2.5}$ concentration of 2014

DIURNAL CORRELATION			
O_3 and $PM_{2.5}$	r= 0.1886	r^2= 0.356	Positive Correlation

Where, r= coefficient of correlation
r^2= coefficient of determination

Table 3. Result of Seasonal Correlation of O_3 and $PM_{2.5}$ concentration of 2014

CORRELATION				
	WINTER	SUMMER	MONSOON	AUTUMN
r	0.2831	0.5595	0.005	0.1439
r^2	0.0801	0.313	0	0.0207
CORRELTION	Positive	Positive	Positive	Positive

RESULT AND DISSCUSSION

The ambient air quality at the city Jabalpur has compared the diurnal average (24hrs) and seasonal monitoring of the pollutants O_3 and $PM_{2.5}$. The diurnal comparison of O_3 and $PM_{2.5}$ has shown major fluctuation in the month of November and December. Somehow, it can easy to understand that their interrelationship going opposite during the winter. Thus, the diurnal correlation of O_3 and $PM_{2.5}$ shows positive correlation (Table 2) because they are almost interrelated with each other.

In the addition to this, seasonal concentration shows a highly fluctuating trend in the month of December ($O_{3=}$ 15 ppb and $PM_{2.5}$= 58µg/m^3). Other than this, all the month shows nearly similar concentration and very minute fluctuation (Table 3). The seasonal correlation in between O_3 and $PM_{2.5}$ shows positive correlation in all the season and their value of "r" is given here under:

Thus, through the study the variation of O_3 and $PM_{2.5}$ easily correlated and provide the necessary details which help the study for better results.

CONCLUSION

A developing city like Jabalpur needs very small initiation to tackle the big need to fight, with the slowly increasing pollution. For this, the best way to secure the atmosphere is to make people aware of the exact condition for the pollution level of the city.

ACKNOWLEDGEMENT

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