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RESEARCH ARTICLE

A STUDY OF DIURNAL AND SEASONAL VARIATION OF PARTICULATE POLLUTANTS (PM_{10} AND $PM_{2.5}$) AND AIR QUALITY INDEX IN JABALPUR

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ABSTRACT

Particulate pollutant gives harmful effects to our environment as well as human beings and became one of the main causes of the cultural heritage deterioration. The research is focuses on the particulates at the Jabalpur city. The BAM (Beta Attenuation Monitoring) instrument is used for analyzing sample coarse and fine particulate matter (PM_{10} & $PM_{2.5}$). Jabalpur it is a fast growing city and in one of five biggest city of Madhya Pradesh air quality parameter as PM_{10} and $PM_{2.5}$ was analyzed at sampling station at Jabalpur results shows increased values of parameters at severed sampling station.

INTRODUCTION

Particulate pollution, also known as particulate matter (PM), is a mixture of tiny particles and liquid droplets that, when inhaled, can cause damage to the lungs. Particle pollution is typically made up of components like nitrates, sulphates, organic chemicals, metals, and soil or dust particles. Particulates pollutants, in recent years, a huge number of studies of suspended particulate air pollution have been undertaken in developing countries. As the EPA puts it, particulate pollution is really "a mixture of mixtures". The World Health Organization (WHO) declared air pollution the world's single largest environmental health risk and attributed million deaths globally to air pollution. A recent study by Liu et al. (2015) on Seasonal and diurnal variation in particulate matter (PM_{10} and $PM_{2.5}$) at an urban site of Beijing: analyses from a 9-year study and another study by Zhang (2015) on fine particulate matter ($PM_{2.5}$) in China at a city level. Their study presents one of the first long term datasets including a statistical summary of $PM_{2.5}$ concentrations obtained from one-year monitoring in 190 cities in China.

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Objectives

- Monitoring of particulate pollutant like- PM_{10} & $PM_{2.5}$ in Jabalpur by the help of AQMS (Air Quality Monitoring Station).
- Diurnal and Seasonal variation of PM_{10} & $PM_{2.5}$.
- Correlation of PM_{10} & $PM_{2.5}$ with meteorological parameter like-Temperature.
- Determination of AQI (Air Quality Index).

Importance of the study

This monitoring network study is generating huge amount of data, which need to be properly collected, evaluated, interpreted and compiled in the form of reports. The data will provide seasonal and diurnal information on the success of the abatement measures, air quality trend, and impact of policies etc. Good public information and awareness system is needed for particulate pollution in severely polluted in these countries.

Materials methods or experiment

Sampling site- Jabalpur is located in central part of India. It is situated at 23°9′38″N 79°56′19″E. Atmosphere of Jabalpur is affected by emissions from vehicle exhaust, factory,

particulate matter and moderate concentrations of surface ozone that predominantly arise during the summers have been shown to be detrimental to human health and destructive to vegetation (NRC, 1991). In this study, the status of ambient air quality due to the presence of different pollutants in the environment of Jabalpur is monitored specially PM_{10} and $PM_{2.5}$.

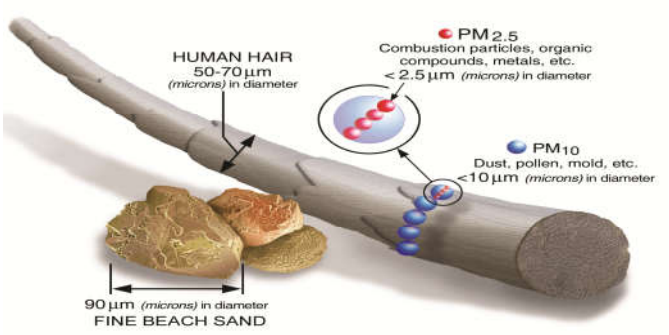


Fig. 1. Particulate Matter (PM_{10} & $PM_{2.5}$)

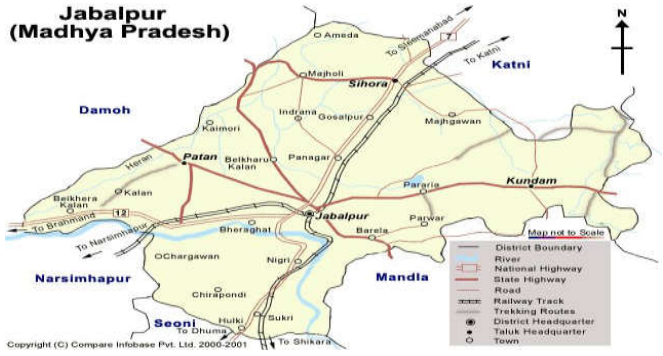


Fig. 2. Location of Jabalpur

AAQMS Instrument: The data is collected with the help of AQMS (air quality monitoring system) through WINAQMS Software and that show every five minute data and meteorological data through AWS (Automatic Weather Station) installed in the Laboratory.

Particulate Matter Measurement Used Beta Attenuation Monitor Analyser (BAM): The Met One instruments model BAM-1020 automatically measures and records airborne particulate concentration levels using the principal of beta ray attenuation. This method provides a simple determination of concentration in units of milligrams or micrograms of particulate per cubic meter of air.

Model BAM-1020 PM_{10} USEPA Equivalent Method

The Met One Instruments, Inc. Model BAM-1020 is designated as an equivalent method for PM10 monitoring by the United States Environmental Protection Agency on August 3, 1998.

Designation Number: EQPM-0798-122

The BAM-1020 is operated to obtain a daily average of the hourly measurements, with a filter change frequency of one hour.

- The inlet must be equipped with the standard BX-802 EPA PM_{10} inlet head.
- The unit must be used with standard glass fiber filter tape.
- Internal calibration device.
- The SAMPLE TIME parameter must be set for 50 minutes.

Model BAM-1020 $PM_{2.5}$ USEPA Equivalent Method

The Met One Instruments, Inc. Model BAM-1020 Beta Attenuation Mass Monitor – $PM_{2.5}$ FEM Configuration, is designated as an equivalent method for PM2.5 monitoring in accordance with 40 CFR Part 53 by the United States Environmental Protection Agency as of March 12, 2008.

Designation Number: EQPM-0308-170

Air Quality Index (AQI): To calculate the AQI by using respective pollutant concentration data, the following equation and table is required:

$$I_p = \frac{I_{Hi} - I_{Lo}}{BP_{Hi} - BP_{Lo}}\left(C_p - BP_{Lo}\right) + I_{Lo}$$

Where,

I_P = The index for pollutant p
C_P = The rounded concentration of pollutant p
BP_{Hi} = The breakpoint that is greater than or equal to C_P
BP_{Lo} = The breakpoint that is less than or equal to C_P
I_{Hi} = The AQI value corresponding to BP_{Hi}
I_{Lo} = The AQI value corresponding to BP_{Low}

Table 1. Breakpoints of PM_{10} and $PM_{2.5}$ for the AQI

PM_{10} (µg/m^3) 24-hours	$PM_{2.5}$ (µg/m^3) 24-hours	Equal to AQI	Category
0 - 50	0 - 30	0 - 50	Good
51 - 100	31 - 60	51 - 100	Satisfactory
101 - 250	61 - 90	101 - 200	Moderate
251 - 350	91 - 120	201 - 300	Poor
351 - 430	121 - 250	301 - 400	Very Poor
430+	250+	401 - 500	Severe

Source: Central Pollution Control Board

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.

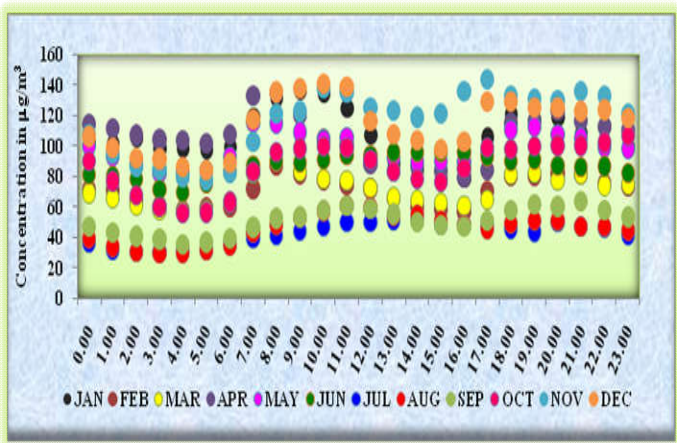
An Automatic weather station (AWS) is an automated type of traditional weather station, either to enable measurements from remote areas or to save human labour. The system may report in several different ways. It may be in real -time via a local link to a computer system or via telecommunications or satellite systems. Most automatic weather stations have Thermometer for measuring temperature, Anemometer for measuring wind speed, Hygrometer for measuring humidity, Barometer for measuring pressure. Some of them even have rain gauge for measuring rainfall, ceilometers for measuring cloud height, present weather sensor or visibility sensor.

OBSERVATIONS, FINDING, RESULT AND DISCUSSION

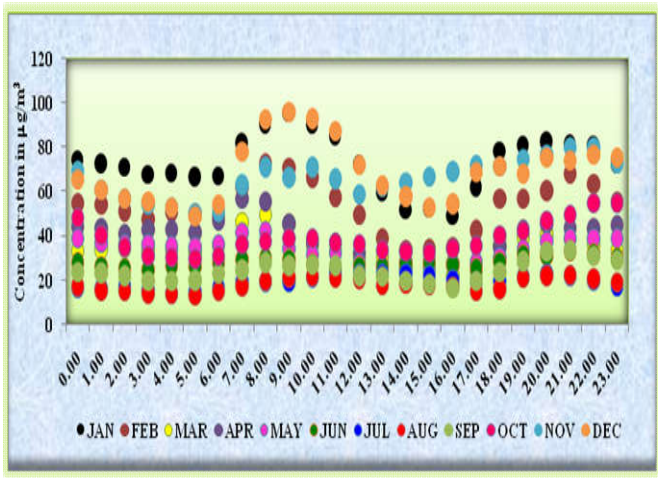
In Jabalpur, the study of PM_{10} and $PM_{2.5}$ was performed using an AAQMS by BAM sampler. Concentration of PM_{10}, $PM_{2.5}$ and Temp. in geographical locations at Jabalpur. This study obtained annual, diurnal, seasonal and AQI data. The data reported in this study in the result of two year study in Jabalpur.

Diurnal variation of PM_{10} and $PM_{2.5}$ in two years study: Variation of PM_{10} and $PM_{2.5}$ during two year study period, it shows highest concentration occurred during morning and evening time and shows highest peak because of morning buildup of local anthropogenic activities associated with the higher traffic density during the rush hour combined with a lower atmospheric height and lower ambient temperature are responsible for their peaks.

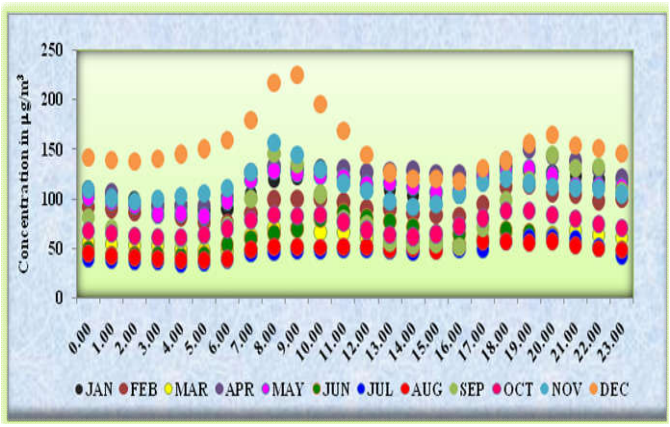
Low concentration in mid afternoon hours between 12 to 3 pm local time and nocturnal peak have also attributed with the atmospheric boundary layer (ABL) dynamics. Correlation with PM_{10} and $PM_{2.5}$ shows similar fluctuation with each other when, we will see both graphs and both pollutant cross the standard limits given by CPCB. PM_{10} and $PM_{2.5}$ show the strong positive correlation.



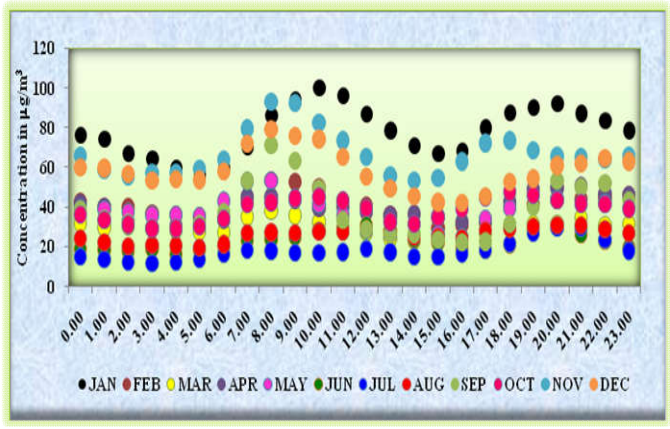
Graph 1. Diurnal variation of PM_{10} concentration during 2014



Graph 2. Diurnal variation of $PM_{2.5}$ concentration during 2014

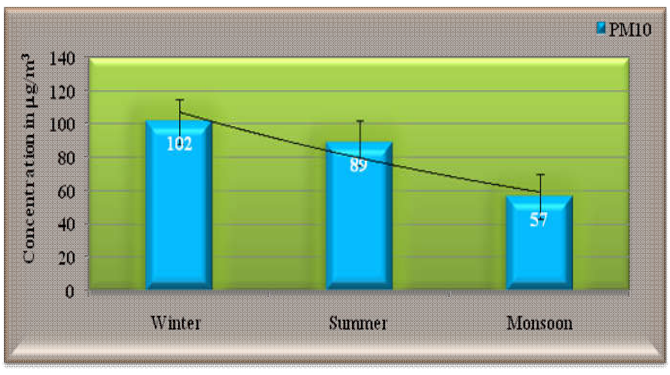


Graph 3. Diurnal variation of PM_{10} concentration during 2015

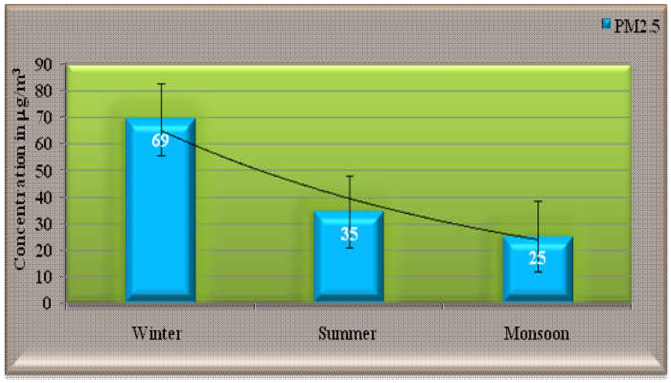


Graph 4. Diurnal variation of $PM_{2.5}$ concentration during 2015

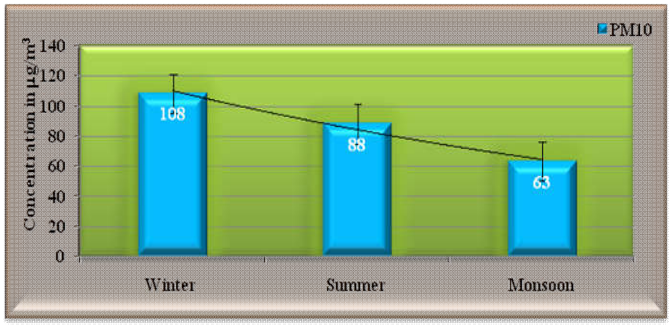
Seasonal variation of PM_{10} and $PM_{2.5}$ and correlation with Temperature in two years study: To understand the general trend of the measured mass concentration and the seasonal variations of PM_{10} and $PM_{2.5}$, there were graphically investigated. To understand the changes of seasonal PM variation mean concentration were calculated during two year study. The mean mass concentration of PM_{10} and $PM_{2.5}$ during the summer and winter season shows higher values and the monsoon season shows lower value. Winter season shows minimum temperature and creates lower atmospheric boundary layer so that, PM concentration was maximum at that time. Summer season shows highest temperature and highest PM concentration because of vehicular emission and wind storm. Monsoon season shows minimum PM concentration because of rainfall wash the dust particles.



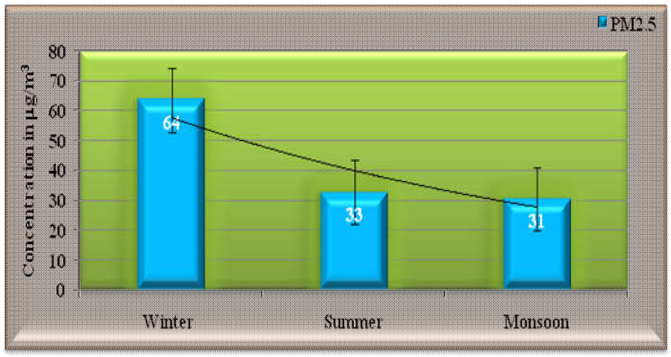
Graph 3. Seasonal average concentration variation of PM_{10} in 2014



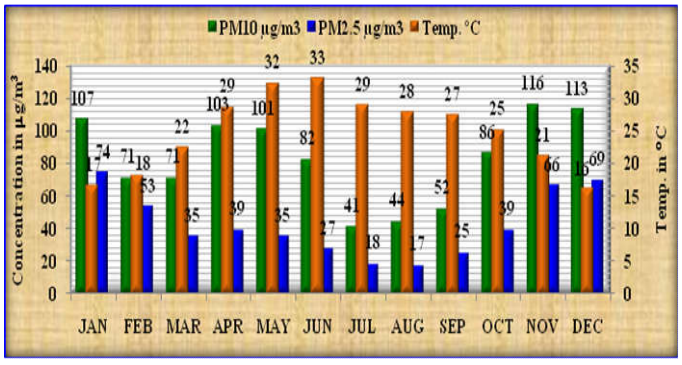
Graph 4. Seasonal average concentration variation of $PM_{2.5}$ in 2014



Graph 5. Seasonal average concentration variation of PM_{10} in 2015



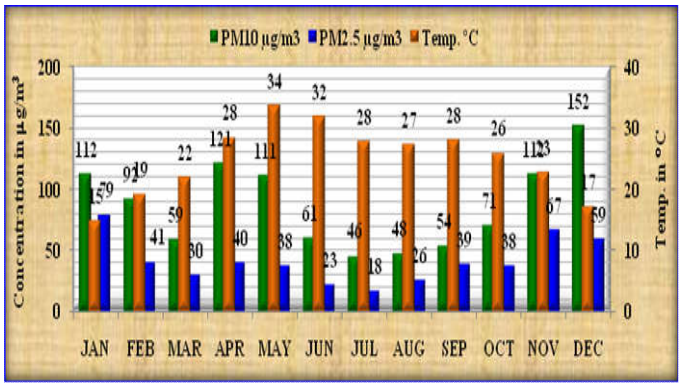
Graph 8. Seasonal average concentration variation of $PM_{2.5}$ in 2015



Graph 9. Annual average correlation between PM_{10}, $PM_{2.5}$ and Temp. in 2014

Annual variation of PM_{10} and $PM_{2.5}$ and correlation with Temperature in two years study

Particulate matter creates more pollution in the atmosphere. For this, during the two year study the correlation between PM_{10}, $PM_{2.5}$ and Temperature was observed found that the annual variation of PM_{10} and $PM_{2.5}$ increases when temperature increases in Jabalpur area.

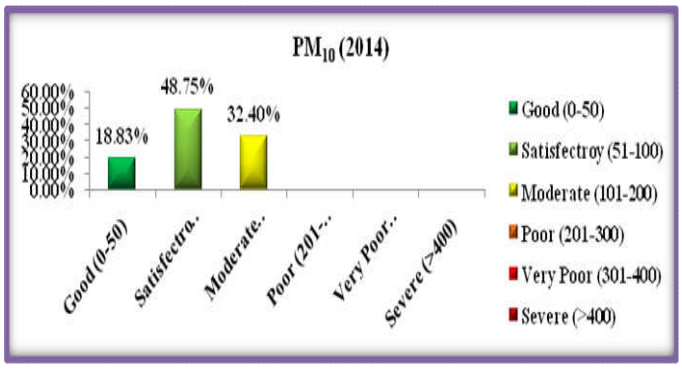


Graph 10. Annual average correlation between PM_{10}, $PM_{2.5}$ and Temp. in 2015

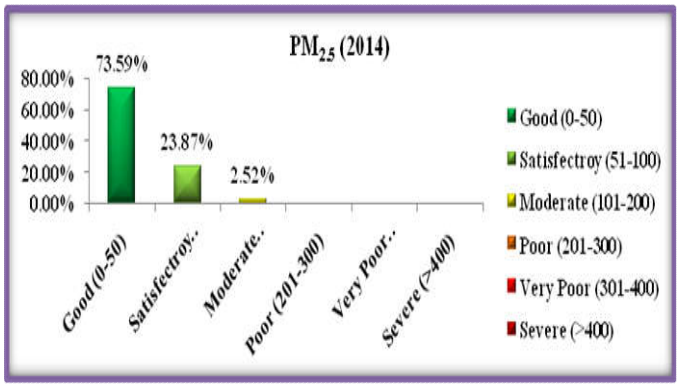
AQI compiling results of PM_{10} and $PM_{2.5}$ during two years study:

The overall AQI can give clear view about ambient air and the critical pollutant are mainly responsible for the quality of air (particulate matter), which can be easier for a common man to understand. The AQIs were calculated to assess the ambient air quality at Jabalpur area.

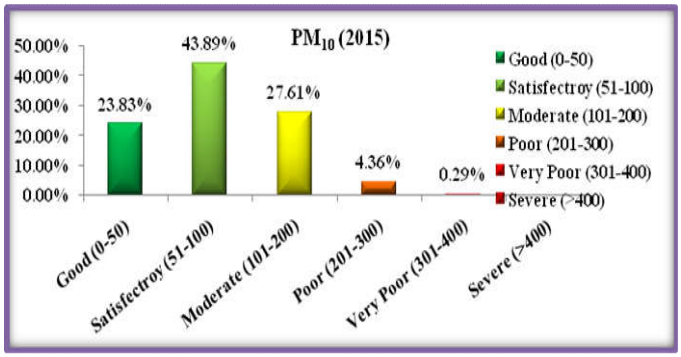
The national air quality index was proposed by CPCB of PM_{10} and $PM_{2.5}$. Different competitive index values are 0-50 (Good), 51-100 (Moderate), 101-200 (Satisfactory), 201-300 (Poor), 301-400 (Very Poor) and 401-500 (Severe). The result shows moderate AQI in respective all the two year study.



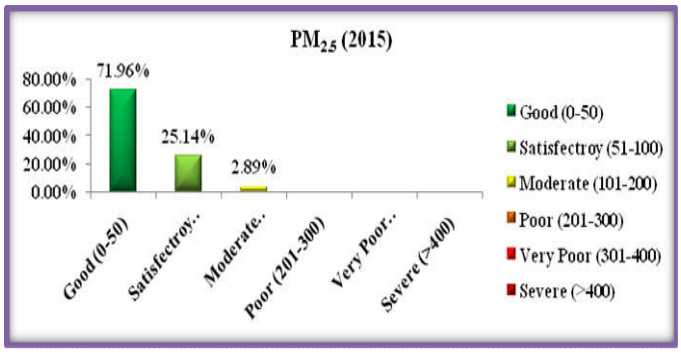
Graph 11. AQI of PM_{10} in 2014



Graph 12. AQI of $PM_{2.5}$ in 2014



Graph 13. AQI of PM_{10} in 2015



Graph 14. AQI of $PM_{2.5}$ in 2015

Conclusion

The diurnal, seasonal and annual mass concentration of PM_{10} and $PM_{2.5}$ in Jabalpur area had high average values in comparison to CPCB Standard occurred.

- During the study period, diurnal variation shows higher values in the morning and evening and lower in afternoon.
- Seasonal particulate variability patterns shows highest values were observed in winter and summer and lower in monsoon season.
- The correlation between PM_{10} and $PM_{2.5}$ always shows positive correlation.
- Temperature correlation with particulate matter of two size particles showed negative (major) as well as positive correlation (minor).
- The compiled AQI result show moderate category in all the two year of the study.

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