

# Study of Air Quality Index for Particulate Matter in Ambient Air of West Nagpur Zone, India

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**Abstract**— In this project an attempt to find the quality of the ambient air in the West Nagpur Zone is carried out. Mainly the two criteria of pollutants viz. Respirable suspended particulate matter, Suspended particulate matter are taken into account for carrying out the present research work. The sampling was done at nine monitoring sites covering three sites for each residential, commercial and industrial zone across the West Nagpur area in two seasons i.e. winter season (December and January) and summer season (March and April). Sampling duration was for twenty-four hours at each monitoring site. Analytical results show average RSPM concentration in residential, commercial and industrial areas for winter and summer season does not exceed the NAAQS standards. Again considering the average concentrations of RSPM for all three locations it was found that the Air quality index (AQI) for winter and summer season, the residential area comes under good category i.e. varying between 0-50  $\mu\text{g}/\text{m}^3$ , the commercial area comes under moderate category i.e. varying between 51-100  $\mu\text{g}/\text{m}^3$  during winter and under good category during summer while the industrial area comes under moderate category in both winter and summer season.. However the concentration of particulate matter during the summer season is less as compared to the winter season due to high wind speed conditions resulting in dilution of pollutants in the air.

**Key words:** RSPM, SPM, National Ambient Air Quality, Air Quality Index

## I. INTRODUCTION

Particulate pollution is one of the major causes of environmental health problems which cause approximately two-three million deaths every year in the world (WHO, 2001). Particulate matter (PM) is actually a mixture of several substances which may differ in various sizes. The particulate matter mainly consists of suspended and the respirable particulate matter. Again the respirable particulate matter consists of two sizes i.e. PM10 whose size is less than 10 $\mu\text{m}$  and PM2.5 whose sizes are less than 2.5 $\mu\text{m}$ . Air pollutants show different variations i.e. short term, long term and seasonal variations. Atmospheric conditions which are prevailing determine the fate of pollutants and the gases after they are being released into the atmosphere. The three important criteria in the air pollutant dispersal are - mean transport wind velocity, turbulence and mass diffusion. Meteorology plays a major role in study of air pollution. The direction and the speed of wind play a crucial role in the dispersion of the various air pollutants. The wind direction is the measurement from which the wind blows, measured in points of compass viz. North, South, East and West. Wind direction plays an important role in distributing and dispersing pollutants from stationary and mobile sources to the downwind areas. The wind speed can be defined as the

measure of horizontal motion or direction of wind relative to the surface of earth in per unit time. It determines the time of travel from a source to a receptor while in the other causes it shows the dilution of particulate pollutants in the downwind direction. The dissipation and dilution of pollutants emitted will be more if the wind is stronger. The wind speed frequency and direction varies considerably from month to month.

Today, the ambient air in most Indian cities is severely polluted and this pollution has a tremendous impact not only on the health of the population but also in the ecosystem. Industrialisation and the growth in the number of vehicles in urban areas have lead to pollution of ambient air quality by emitting various kinds of air pollutants. Urban air pollution has grown in cities like Kolkata, Mumbai and Delhi across the Indian subcontinent in the last decade in an alarming condition (Agarwal et al., 1999). The World Health Organization ranked Delhi as one of the most polluted metro city of the world (UNEP/WHO, 1992). However, in Indian subcontinent, it is not just Delhi but even small and medium towns are deteriorating air quality rapidly (CPCB, 1995). Out of the 23 mega cities, Delhi is declared as the most polluted which is followed by other cities such as Mumbai, Calcutta, Bangalore, Chennai, Kanpur, Ahmedabad and Nagpur. They have severe air pollution problems mainly with the levels of particulate matter which is much higher than the standards prescribed by CPCB. Large cities in India appear to have high concentrations of fine particles (World Bank, 2004). In India, Central Pollution Control Board (CPCB) monitors the ambient air quality in various cities on a regular basis. According to CPCB report in 2008 Chennai had shown all three criteria pollutants viz. RSPM, SO<sub>2</sub> and NO<sub>2</sub> within the national standards. Other three mega cities such as Mumbai, Kolkata and Delhi had shown that the annual concentration of SO<sub>2</sub> and NO<sub>2</sub> are well within the limits suggested by National Ambient Air Quality Standards (NAAQS) while RSPM indicated increasing trend in all five consecutive years. In India due to increasing traffic, industrial development, energy consumption, alarming levels and poor quality of roads, large number of particulate matter are been reported to be deposited in the atmosphere in recent years by various researchers and environmentalists. Among the particulate matters, the RSPM is a major source as it contains the heavy metals which are easily deposited in the respiratory tract. Due to the deposition of metals in human body various harmful diseases such as asthma, Chronic Obstructive Pulmonary Disease (COPD), cystic Fibrosis etc. are caused. Various standards and guidelines are put forward to regulate the environmental air quality by the CPCB, New Delhi. Therefore for evaluation of the air quality for the current on-going projects, the monitored values are compared with the respective standards values. It is the

responsibility of the Government to implement strict laws and regulations who is indulging in the pollution in the air. Nagpur located at the heart place of India is considered as one of the green and clean city in the country having many beautiful places that are greatly enjoyed by the tourists. Nagpur is fast growing as a centre of attraction for business & industries but now it is listed in the polluted cities in India according to the latest report on ambient air pollution by WHO. Vidarbha Environment Action Group (VEAG) have already warned that air pollution is increasing in the city due to large number of emission from vehicles, open burning of the garbage waste and also due to the power plants in the city. Therefore, in this experiment, an evaluation of the quality of ambient air in residential, commercial and industrial areas on the adjacent environment of West Nagpur Zone, Maharashtra, India is carried out.

## II. MATERIALS AND METHODS

The monitoring was done during winter season and summer season. For carrying out the project work, the West Nagpur Zone has been considered as the study area. The monitoring areas included- Residential Areas i.e. G.H.Raisoni Boy's Hostel (R1), Friend's colony (R2) and Dutta Wadi (R3); Commercial Areas i.e. Wadi Naka (C1), Dharampeth (C2), Shankar Nagar (C3) and Industrial Areas i.e. MIDC (I1, I2, I3). Samples for 24 hours were collected at all sampling stations. SPM and RSPM were monitored by using Respirable Dust Sampler. Whatman Glass micro fiber filter paper, popularly known as GF/A filter paper of size 8x10 ins was used for determination of RSPM and the flow rate was kept at 1-1.5 m<sup>3</sup>/min. The model NPM – HVS/R is used which has a cyclone separator which separates the particulate matter larger than 10µm from air stream (drawn into the sampler) in the cup before filtering on GF/A filter paper.



Fig.1: Location of ambient air sampling stations in West Nagpur Zone

NAAQS or other standards like WHO standards are built up in order to determine the critical threshold of air pollution or to provide a safe dose of pollution. The standards or guidelines specify pollutants of interest along with their concentrations and averaging time. These guidelines also help governments in setting standards suitable to local conditions as well as take risk management decisions in making framework of air quality management. The latest National ambient air quality standard (NAAQS) is represented in Table.1. The air quality is usually determined AQI. AQI is basically an indicator which reports the daily quantity of air at a particular location. The EPA measures the AQI of five major air pollutants regulated by the Clean Air Act namely ground-level ozone, particulate matter

pollution, carbon monoxide, sulphur dioxide and nitrogen dioxide. EPA has already established national air quality standards for each of these pollutants to protect public health. Ground-level ozone and airborne particulate matter pollution are the two pollutants that pose the greatest threat to human health in this country. The quality of air is found out by comparing the RSPM values obtained during sampling with the Air Quality Index table which is suggested by the Central Pollution Control Board, New Delhi. The AQI is mainly categorised into six zones, each zone giving description of the quality of the ambient air. The greater AQI value indicates the higher level of air pollution and the greater concern for the health hazards. If an AQI value is 50 it represents good air quality with little potential effect on public health, whereas if an AQI value is over 300 than it represents hazardous air quality with great concern on public health. AQI values which are below 100 are generally considered as satisfactory. If the AQI values are above 100 than the air quality is considered as unhealthy for children and aged people and then it gets unhealthy for everyone as AQI values get higher. EPA has assigned a specific colour to each AQI category to make it easier for everyone to understand quickly if the air pollution is reaching unhealthy levels in their communities or not. Various health related impacts associated with each zone are also suggested by the CPCB. A specific colour is nominated to each AQI category so as to make it easier for everyone to understand quickly if the air pollution is reaching unhealthy levels in their locality or not as shown in fig 1.

## III. RESULTS AND DISCUSSION

The estimated RSPM and SPM concentrations in the atmospheric environment of the West Nagpur Zone over the residential, commercial and industrial areas for winter season are shown in fig. 3, 4 and 5 whereas for summer season are shown in fig. 7, 8 and 9. The variation of wind speed and wind direction of Nagpur City for the winter season is shown in wind-rose diagram in fig.6 and for summer season in fig.10.

Pollutant	Time weighted average	Conc. in Industrial, Residential, Rural and other areas	Conc. in Ecologically Sensitive area
Particulate Matter (size less than 10 µm) or PM <sub>10</sub> µg/m <sup>3</sup>	24 hrs	100	100
Particulate Matter (size less than 2.5 µm) or PM <sub>2.5</sub> µg/m <sup>3</sup>	24 hrs	60	60

Table 1: National Ambient Air Quality Standards

AQI Value	Air Quality	Color Code
0-50	Good	Green
51-100	Moderate	Yellow
101-150	Unhealthy for sensitive groups	Orange
151-200	Unhealthy	Red
201-300	Very unhealthy	Purple
301-500	Hazardous	Maroon

Fig. 2: Air Quality Index Table

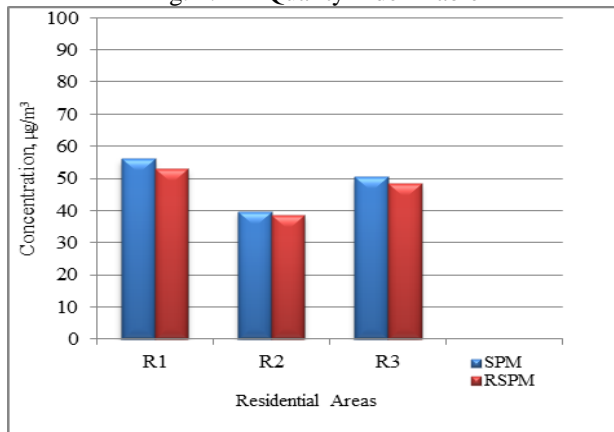


Fig. 3: Trends of SPM and RSPM in Winter for Residential Area

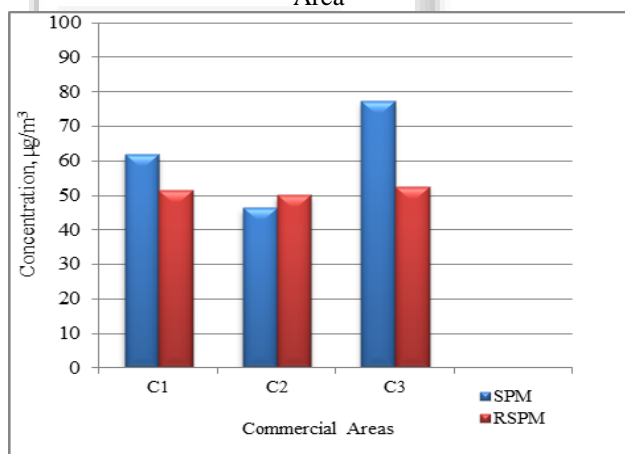


Fig. 4: Trends of SPM and RSPM in Winter for Commercial Area

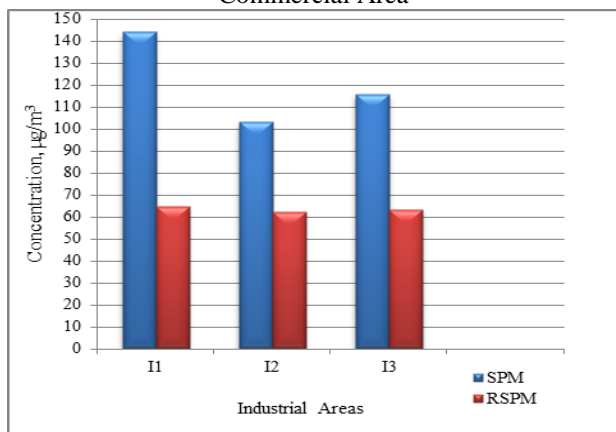


Fig. 5: Trends of SPM and RSPM in Winter for Industrial Area

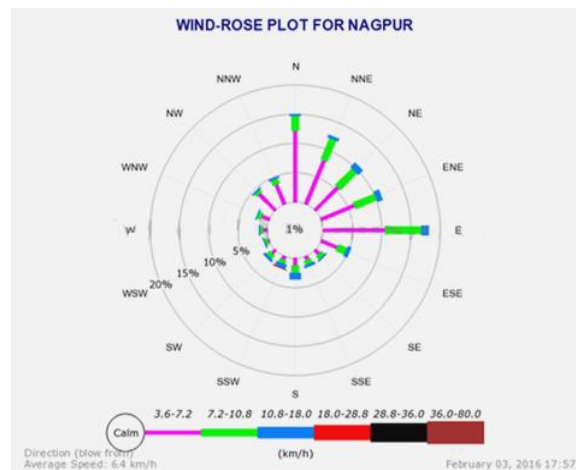


Fig. 6: Wind Rose Diagram of Nagpur City for Winter

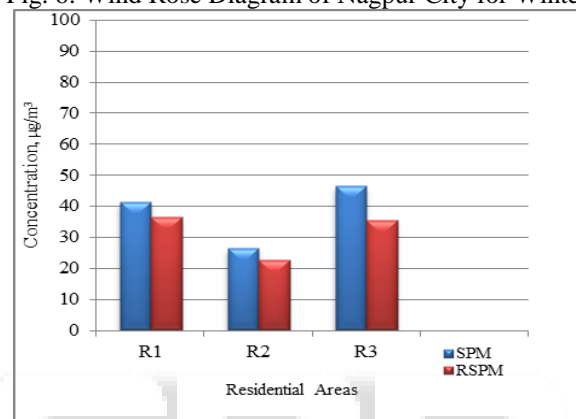


Fig. 7: Trends of SPM and RSPM in Summer for Residential Area

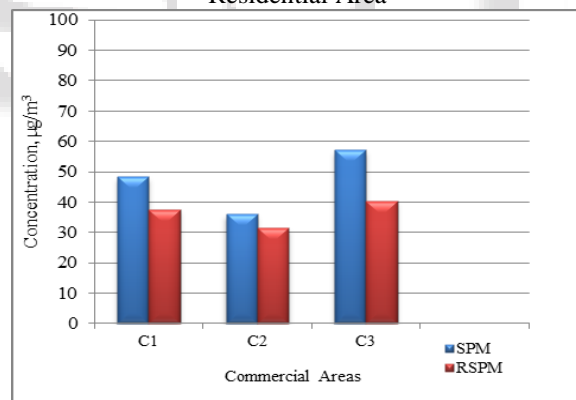


Fig. 8: Trends of SPM and RSPM in Summer for Commercial Area

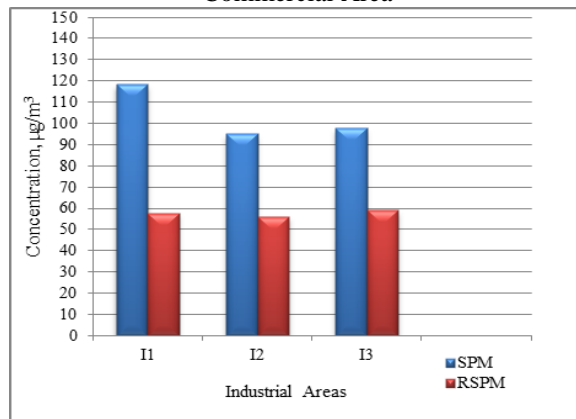


Fig. 9: Trends of SPM and RSPM in Summer for Industrial Area

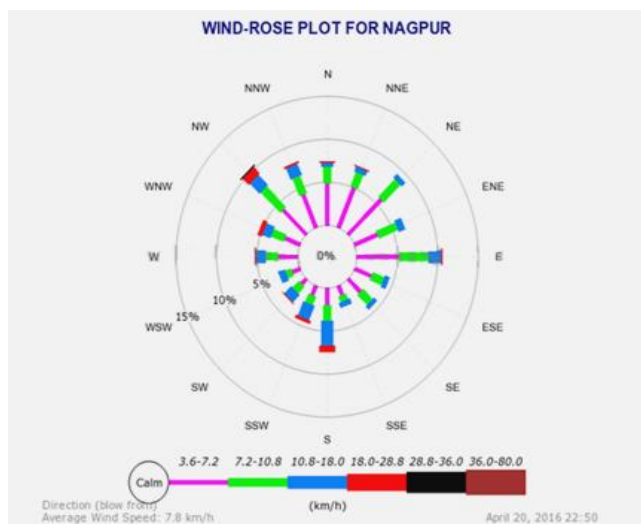


Fig. 6: Wind Rose Diagram of Nagpur City for Winter

It was observed that the concentration of RSPM at location R1 in winter was  $52.98\mu\text{g}/\text{m}^3$  which comes under category II i.e. moderate air quality whereas at location R2 and R3 the concentration was  $38.58\mu\text{g}/\text{m}^3$  and  $48.35\mu\text{g}/\text{m}^3$  which comes under category I i.e. good air quality. Again at location C1 and C3 the concentration of RSPM for winter was  $51.44\mu\text{g}/\text{m}^3$  and  $52.47\mu\text{g}/\text{m}^3$  which comes under category II whereas C2 comes under category I having concentration  $49.89\mu\text{g}/\text{m}^3$ . The RSPM concentration for winter at location I1, I2 and I3 were  $64.81\mu\text{g}/\text{m}^3$ ,  $62.24\mu\text{g}/\text{m}^3$  and  $63.27\mu\text{g}/\text{m}^3$  all comes under category II. It was also noted that the SPM values are quite higher in industrial area than in commercial and residential areas. Now the results in summer are lesser than the winter results. The results suggest that the concentrations of RSPM during summer at R1, R2 and R3 are  $36.52\mu\text{g}/\text{m}^3$ ,  $22.63\mu\text{g}/\text{m}^3$  and  $35.49\mu\text{g}/\text{m}^3$  which come under category I i.e. good air quality. Similarly concentration at C1, C2 and C3 are  $37.55\mu\text{g}/\text{m}^3$ ,  $31.38\mu\text{g}/\text{m}^3$  and  $40.123\mu\text{g}/\text{m}^3$  all coming in category I. However the RSPM concentration at location I1, I2 and I3 are  $57.61\mu\text{g}/\text{m}^3$ ,  $56.17\mu\text{g}/\text{m}^3$  and  $59.16\mu\text{g}/\text{m}^3$  all coming under category II. Here too the SPM concentration of industrial area is very much higher as compared to residential and commercial area. The result shows that lower concentration of RSPM in residential area is due to the presence of good vegetation cover while in the commercial and industrial area, due to less vegetation cover as well as increase in traffic, industrial activity and poor quality of roads, the results showed higher values of RSPM. It is also found out that the PM10 at all the sampling sites were within the permissible limits put forwarded by the Central Pollution Control Board, India.

#### IV. CONCLUSION

In this research work it is found out that the RSPM values at all the locations in both the seasons are within prescribed limit. The quality of air at the residential site during both winter and summer season is good. However the quality of air at commercial area is satisfactory during winter season and good during summer season. This variation is due the dilution of pollutants in the air during summer season. Again the air quality is satisfactory in industrial area on both winter and summer season. The concentration of SPM and RSPM is different in both the seasons. The results are higher

during winter than in summer. Wind-rose diagram clearly shows that the wind speed and its direction changes during the summer season resulting in dispersion and dilution of pollutants in the atmosphere. Many researchers have also researched in this field to find the amount of concentration of gaseous and particulate matter which is present in the ambient air. According to the literature survey, it shows that in many existing results the concentrations have already crossed the new standards or regulations of NAAQS. Therefore it is very much important that the continuous monitoring of ambient air is done in order to prevent various health hazards.

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