Available Online at http://www.recentscientific.com

ISSN: 0976-3031

International Journal of Recent Scientific Research
Vol. 6, Issue, 1, pp.2513-2518, January, 2015

International Journal of Recent Scientific Research

RESEARCH ARTICLE

CONTRIBUTION AND VARIATION OF AIR POLLUTANTS IN INDUSTRIAL AREA OF NAGPUR, INDIA

[1]*Amruta Anjikar, [2]Vishal Soni, [3]Pravin Meshram and [4]Animesh Kumar Garg

[1*,3,4]Rashtrasant Tukdoji Maharaj, Nagpur University, Nagpur, India
[2]University of Rajasthan, Jaipur, India

ARTICLE INFO

Article History:

Received 5th, December, 2014
Received in revised form 12th, December, 2014
Accepted 6th, January, 2015
Published online 28th, January, 2015

Key words:

Air Quality, Air Pollutants (SO_2, NO_X, H_2S, NH_3, SPM, RPM)

ABSTRACT

Large-scale industrialization, population inflow, and rapid urbanization coupled with unfavorable meteorological conditions often induce significant degradation of urban environment. In order to assess the extent of environmental impacts due to establishment of the industries in Nagpur City, ambient air was monitored from September 2010 to February 2011. Collected baseline information was normalized and interpreted with respect to air. Among the pre identified air pollutants, suspended particulate matter was found to be the principal culprit to deteriorate ambient air quality, with a maximum annual concentration of 270μg/m^3. Monthly average concentrations of respirable particulate matter (aerodynamic diameter < 10 μm) also persist at a critical level with an annual maximum of 150 μg/m^3. Monthly variation of air pollution parameters which indicates a mild control over few pollutants throughout the study period with rising in quality of analytical sampling and analysis. The result had been found to be effectively below the Central Pollution Control Board (CPCB) standards.

INTRODUCTION

Phenomenal growths in population, use of energy, economic transformation, rapid urbanization and industrialization have made enormous complications upon the habitability on earth. To assess the extent of environmental impacts in any locality or regions, researchers have developed various environmental tools. Nagpur is a city, located at the heart place of India, hosting various ancient, historical as well as beautiful places and spots that greatly enjoyed by the tourists. Nagpur is now a fast growing centre for business & industries.

Continuous technological advancement leads to generation of huge amount of baseline data related to ambient air and water quality, but these may not provide a clear picture of the surrounding environment (Sharma *et al*, 2003). In fact, decision makers and the general public need information in a simple and understandable format regarding the levels and potential health risks associated with pollution. Moreover, inefficiency of the raw data to provide sufficient information often results in lowering of public interests regarding environmental friendly practices. Furthermore, the success of commitment of a nation to improve environmental quality depends exclusively on the obligation of the citizens who should be well informed about the current status of the environment. Therefore the prime importance should be to provide adequate information in a simple format.

The CPCB, Delhi has introduced several air quality standards and guidelines in order to regulate environmental quality. Therefore, current approaches for evaluating environmental quality are based on the comparison of monitored values with the respective standards. However, it often becomes difficult to incorporate these standards into a reference scale (Ghosh, S. K *et al*, 1982). Moreover, by providing an upper threshold concentration value in the form of standards, environmental quality tends to get categorized either as good or bad, depending on whether the standards have been exceeded or not (Sahoo, B. N *et al*, 1981). Even the frequency with which concentrations of pollutants exceed the national standards is not found sufficient by the citizens to assess the actual environmental quality. It is suggested that use of standards is only imperative in administrating or to enforce any desired policy, not to appraise environmental quality (Sharma, P. K *et al*, 1990).

Therefore, in this experiment, an attempt has been made to evaluate the status of ambient air with the impacts of air pollutants in industrial and rapid urbanization on the adjacent environment of Nagpur, Maharashtra, India.

Study Area

Hingna Industrial Area established in 1962, it is located 7 Km. from Nagpur city. In this Industrial area, several engineering Industries, Electrical based Industries, food based industries were located. The Nagpur industries have played a major role in providing economic stability to the city of Nagpur. As a matter of fact, the government had decided to put a huge sum of money estimated to be around 5000 crores into the

Corresponding author:* **Amruta Anjikar
Rashtrasant Tukdoji Maharaj, Nagpur University, Nagpur, India

development and growth of the industrial infrastructure of Nagpur. To make this Industrial Estate a Model one, the Maharashtra Industrial Development Corporation (MIDC) has also identified Residential and Commercial Zones, with their attendant facilities within the Industrial Area, to take care of the Workers and the Executives' housing needs, as transit accommodations, dormitories and residential quarters have already been constructed by MIDC for use of the industry. Additionally the City and Industrial Development Corporation of Maharashtra (CIDCO) too has started its housing scheme in the area.

Fig. 1 Industrial Area (Study Area) at Nagpur

Behavior of Air Pollutants in Nagpur

Air pollutants show short term, seasonal and long term variations. Atmospheric conditions determine the fate of the air pollutants after their release into the atmosphere. The mean transport wind velocity, turbulence and mass diffusion are the three important and dominant mechanisms in the air pollutant dispersal. Meteorology plays a major role in study of air pollution. The wind speed and direction play a major role in dispersion of air pollutants. The wind direction is the measurement of direction from which the wind is blowing, measured in points of compass viz. North, South, East, and West or in Azimuth degrees (0-360). Wind direction has an important role in distributing and dispersing pollutants from stationary and mobile sources in horizontally long downwind areas. The effect of wind speed on air pollution is two-fold. It determines the travel time from a source to a given receptor while on the other causes dilution of pollutants in downwind direction. The frequency distribution of wind speed and direction varies considerably during the study period as compared to other seasons and atmospheric dispersion is typically at a minimum and therefore the pollutants will not be as widely dispersed.

During the summer months, the average mixing height is typically at its greatest resulting in increased mixing through a greater volume of the troposphere, and hence lower pollutant concentrations. The monsoons results in large amount of precipitation, high wind velocities and changes in general wind direction. The large amounts of precipitation reduce atmospheric pollution via associated wet deposition processes. Further higher wind velocities allow for pollutant transport away from sources, increase mixing processes and the winds coming from the environment have less background concentrations than that of continental air masses.

Seasonal Variation in Suspended Particulate Matter

Suspended particulate matter is represented based on their size range. The suspended particulate in general (0-100 micron diameter) are termed as SPM/TSPM, those in size range (0-10 micron diameter) are termed as PM_{10} or respirable suspended particulate matter (RSPM) or simply respirable particulate matter (RPM), and those in size range (0-2.5 micron diameter) are termed as $PM_{2.5}$ or fine particulate matter (FPM).

Major manmade sources of Particulate Matter are

- Emission from coal based power station
- Emission from oil fired furnace/boiler
- Emission from stone crusher, hot mix plants, lime kilns, foundry
- Hospital waste incinerator
- Emission from stationery DG sets/portable DG sets
- Emission from diesel vehicles (bus, trucks, locomotives)
- Emission from 2- stroke vehicles (2T oil used)
- Re suspension of road dust
- Burning of biomass/ tire, tube
- Emission from waste oil reprocessing industries

The winter months are relatively much calm than other months. The prevailing calm conditions facilitate more stability to atmosphere and consequently slow dispersion of pollutants generated and helps in build-up of pollutants in vicinity of the pollutant sources. Lower average mixing height in winter season results in less volume of troposphere available for mixing and hence higher SPM and RSPM concentrations.

During the summer months, though the average mixing height is typically at its greatest resulting in increased mixing through a greater volume of the troposphere, the dust raising winds, however cause increased levels of SPM and RSPM. The strong and medium winds during summer months create turbulent conditions and local disturbances in the environment which cause frequent dust storm and hazy conditions. These dust storms and hazy conditions build up high particulate matter levels in the ambient air, mostly constituting soil borne particles. The monsoon, the atmosphere particulate gets washed out with rains resulting in low concentrations of SPM/RSPM.

Role of Meteorology in Air Pollution

Meteorology is the science of weather. It is essentially an inter-disciplinary science because the atmosphere, land and ocean constitute an integrated system. The three basic aspects of meteorology are observation, understanding and prediction of weather (M. Aldrin *et al* 2005). There are many kinds of routine meteorological observations. Some of them are made with simple instruments like the thermometer for measuring temperature or the anemometer for recording wind speed.

Meteorology is studied through several measurable parameters like, wind velocity, air temperature, relative humidity, solar radiation, cloud cover. These parameters are sometimes used to derive secondary parameters that help in classifying the atmospheric conditions. Some of the derived parameters are mixing height, friction velocity, Bowen ratio etc. The extent of wind velocity determines the rate at which pollutants are driven off from near the source of pollutant. However, the cleaning or ventilation of atmosphere is also a function of height of atmosphere within which the pollutants are trapped. The height within which pollutants may get trapped after being released from the source is determined by mixing height. During day time, the mixing height gains a large value owing to vertical convection current (convective boundary layer). However during night time, the vertical convection dominates the downward radiation and the temperature of atmosphere increases as we move up in the atmosphere near the earth surface. This condition is called inversion condition.

Modeling in Industrial Area

Air quality models are valuable air quality management tools. Models are mathematical descriptions of pollution transport, dispersion, and related processes in the atmosphere. Air quality models estimate the air pollutant concentration at many locations, which are referred to as receptors. The number of receptors in a model far exceeds the number of monitors one could typically afford to deploy in a monitoring study. Therefore, models provide a cost effective way to analyze impacts over a wide spatial area where factors such as meteorology, topography, and emissions from nearby sources could be important.

Air pollution source information such as the rate of emissions from stacks and openings, stack heights, stack gas temperatures and velocity and the influence of surrounding buildings is examined during a modeling analysis. The source data is evaluated in conjunction with meteorological information such as wind speed, direction, atmospheric stability, air temperature, and inversion heights in the air quality model. The model examines all of these components together to characterize the state of the atmosphere and predict how pollution is transported from the sources and estimates the concentration of these pollutants in the atmosphere.

METHODS AND MATERIALS

The study was carried out during 2010 and 2011 on the gaseous pollutants and particulate pollutants concentration in the ambient air of Nagpur City, Maharashtra State, India. Ambient air monitoring for the analysis of PM_{10} and associated gaseous pollutants and particulate pollutants was carried out at Hingna Industrial Area in the Nagpur City (Fig. 1).

The sampling station is situated within 10 km area around the centre of Nagpur City i.e. Zero milestone near Reserve Bank of India Square. Using high volume air sampler (Envirotech's APM 415, Envirotech instruments, Upkaran Pvt. Ltd., New Delhi), (Gadgil, A. S. *et al*, 2004) samples for 24 h were collected from sampling station. The sampling details and average flow rate were recorded and carefully maintained constant throughout the study. All the collected samples were packed in polyethylene covers and transported immediately to the laboratory and analysed for PM_{10} and heavy metals in PM_{10} using standard laboratory procedures (USEPA 1999b). SO_2 NO_X, NH_3 and H_2S were collected by bubbling the sample in a specific absorbing (sodium tetracholoromercurate for SO_2, sodium hydroxide for NO_X, Nesseler method for NH_3) solution at an average flow rate of 0.2-0.5 min1.The impinger samples were put in ice boxes immediately after sampling and transferred to a refrigerator until analyzed. The concentration of NO_X was measured with standard method of Modified Jacobs - Hochheiser method. SO_2 was measured by Modified West and Geake method, $PM_{2.5}$ and PM_{10} using filter paper methods.

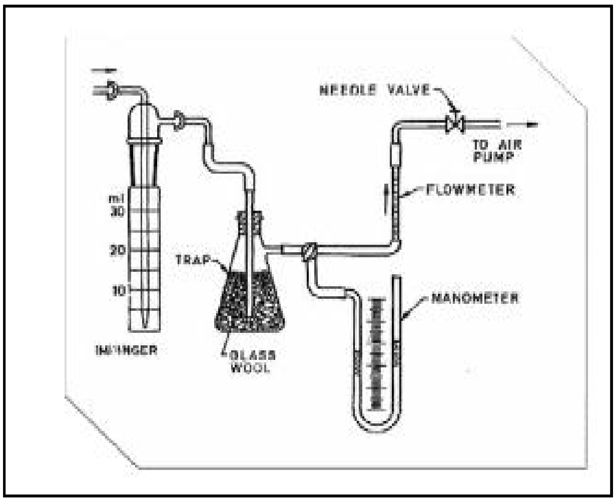


Fig. 2 Trapping of gaseous sampling

The apparatus was kept at a height of 2 meters from the surface of the ground. However air pollutants data for site was collected from Andhra Pradesh Pollution Control Board, Hyderabad. The street level concentration of nitrogen dioxide and suspended particulate matter observed in Hong- Kong (C. Cowherd Jr *et al* 1980). A respirable dust sampler (RDS APM 460BL, Envirotech, New Delhi, India) was used to monitor SO_2, NO_2, suspended particulate matter (SPM), and respirable particulate matter (RPM; aerodynamic diameter < 10 μm).

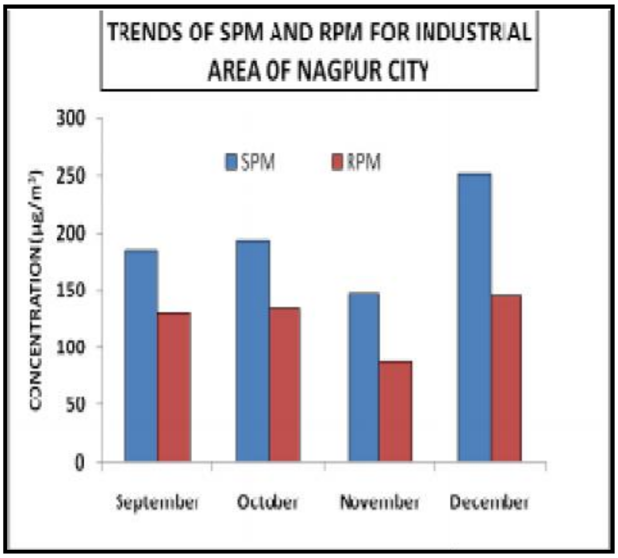
The RPM was measured by using Glass fibre filter paper (Whatman) of 8 × 10'' in size, while the non-RPM (nRPM, >10 μm) was measured by collecting the heavier particles in hopper attached at an outlet of cyclone. The concentration of the SPM was computed by aggregating the concentration of the RPM with the nRPM (Sharma, P. K. *et al*, 1990). The filter paper was conditioned in a desicator for 24 h and weighed on a balance with the sensitivity of 0.001 g, both before and after air quality monitoring. The conditioned and weighed filter paper was placed in desiccator's and taken for monitoring to avoid any possibilities of contamination and moisture absorption.

The PM monitoring was performed at an average flow rate of 1 m^3/min. In order to maintain the specific flow rate, the manometer reading was taken 3 or 4 times in a day so that the flow rate variations were within 1–1.3 m^3/min. The average flow rate was finally considered for computing the total amount of air sampled. Air quality monitoring was done twice in a week continuously for 24 h. Adequate preventive measures were taken to avoid any sort of moisture absorption to the filter paper, and concentrations of the PM were calculated gravimetrically.

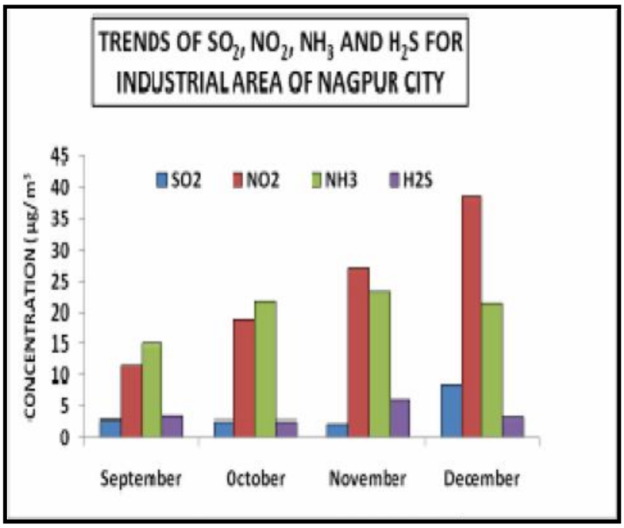
The Gaseous Sampler attached with a RDS was used to monitor the gaseous pollutants. For both SO_2 and NO_2, the monitoring was done at a constant flow rate of 1 liter per minute (lpm) by bubbling ambient air through the liquid absorbing medium. The improved West and Geake method with potassium- tetracholoromercurate as the absorbing medium was used to determine the ambient SO_2 concentrations. However, for determination of NO_2, the modified Jacob and Hocheiser method with a solution of sodium hydroxide and sodium arsenite was used. Gaseous pollutants present in the ambient air were absorbed in the respective absorbing medium and analyzed spectrophotometrically at 560, 540 425 and 650 nm for SO_2, NO_2, NH_3 and H_2S respectively.

RESULTS AND DISCUSSION

The level of SPM and RPM increased in the month of December and slightly decreased in November (Graph 1). The concentration of NO_2 increases from September to December similarly the concentration of NH_3 also increases from September to December (Graph 2) but not exceeded the CPCB limits.



Graph 1 Variation of SPM and RPM with respect to conc. of Industrial area of Nagpur



Graph 2 Variation of SO_2, NO_2, NH_3 and H_2S with respect to conc. of Industrial area of Nagpur

Extreme Temperature

The mean maximum temperature of Nagpur in the year 2010 was 45.2° C. (www.imdnagpur.gov.in_listofclimaticf2ngp) and the minimum temperature was 19.0 ° C in the year 2011. The lowest minimum and highest maximum temperature in degree Celsius with date during the study period are indicated in the following table:-

Year	2010	2011
Lowest minimum temp in °C	21.3	19.0
Recorded Date	05	02
Highest Maximum temp in 0C	45.2	41.2
Recorded Date	17	28

The variation of wind speed as well as wind direction was shown with respect to month. Wind roses at 08.30 and 17.30 hrs according to Indian Standard Time for the month of September have been depicted in (Figure 2). In this month, north westerly wind speed up to 4.5 mps which was more predominant in the morning and evening hours.

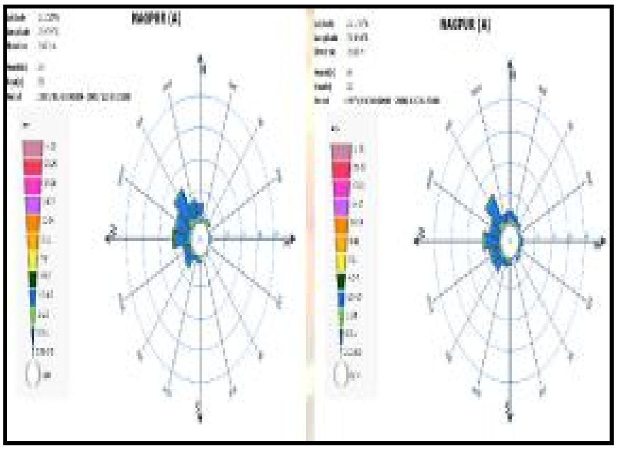


Figure 2 Wind rose at 08.30 hours and 17.30 hours I. S. T. for September

Mainly north-westerly to north easterly wind blow (up to 4.5 mps) during morning hrs along with north westerly and northly wind more predominant and blowing from all direction during evening hrs in the month of October (Figure 3). However, North easterly and easterly was more predominant during evening hrs of October. Calm wind during morning hrs are high (26%) compared to evening (22%).

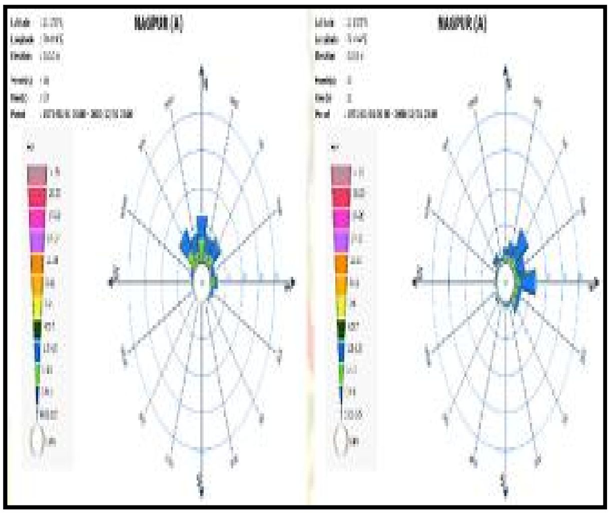


Figure 3 Wind rose at 08.30 hours and 17.30 hours I. S. T. for October

Mainly northerly wind blow (upto4.5mps) during morning hours along with north northeasterly to easterly wind and mainly north easterly to easterly wind blow (upto4.5mps) in the evening hours in the month of November. Calm winds during evening hours are high (27%) compared to morning (23%) (Figure 4).

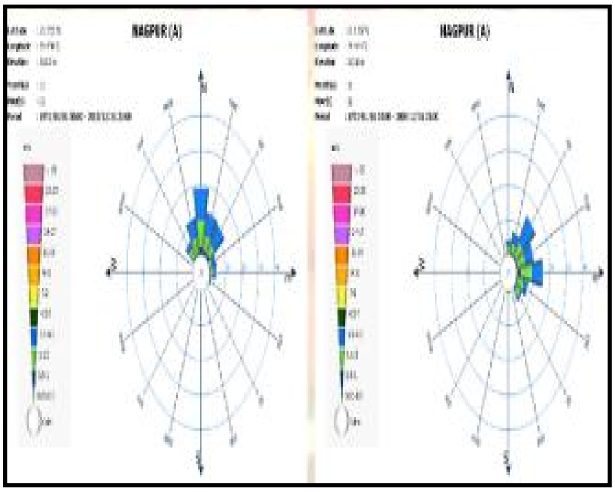


Figure 4 Wind rose at 08.30 hours and 17.30 hours I. S. T. for November

Monthly average of wind speed in December, January and February was 5.0, 5.5, 6.6 mps respectively. Wind roses at 08.30 and 17.30 hrs for December, January and February are shown in (Figure 5, 6 and 7) respectively. Mainly northerly wind with speed up to 4.5 mps prevailed in December & January and north to north-easterly during morning. Calm winds are also more frequent during morning compared to evening. Calm winds during morning of December, January and February are 31%, 32% & 21% respectively.

Easterlies are more predominant during the evening of December. Easterly to south easterlies are also more predominant during the evening of January. However, wind blows from all the direction during the evening of February and north easterlies to easterlies are more frequent. Calm winds during the evening of December, January & February are 29%, 22% and 11% respectively

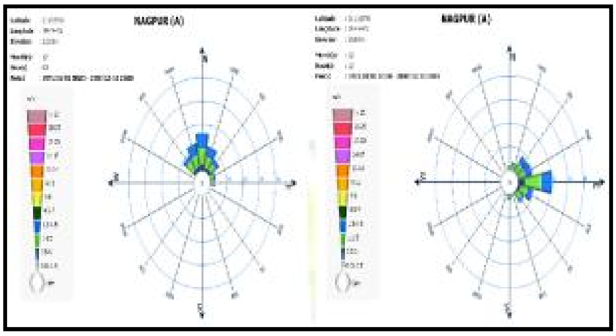


Figure 5 Wind rose at 08.30 hours and 17.30 hours I. S. T. for December

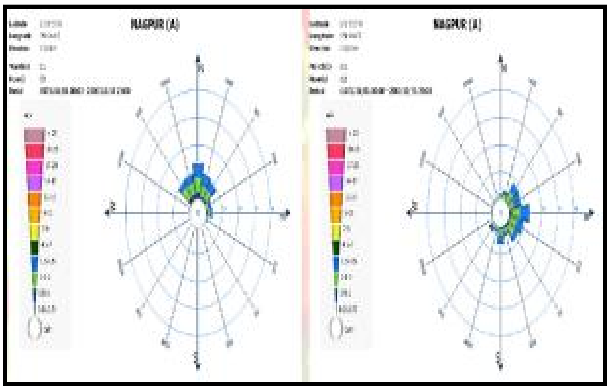


Figure 6 Wind rose at 08.30 hours and 17.30 hours I. S. T. for January

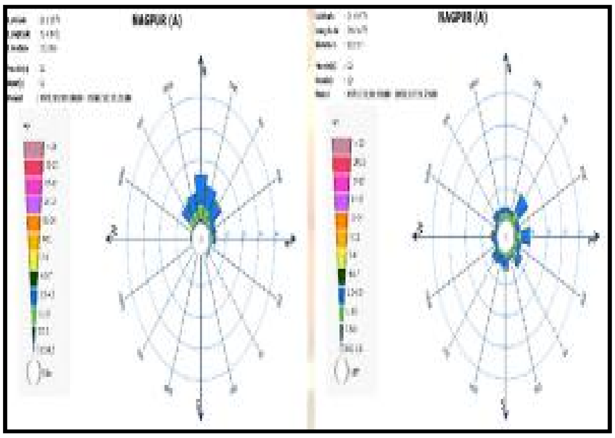


Figure 7 Wind rose at 08.30 hours and 17.30 hours I. S. T. for February

CONCLUSION AND RECOMMENDATIONS

The critical air pollutant will not necessarily be SPM; hence, information on other pollutants is also required for proper presentation of air quality through the AQI. The green Nagpur may not stay as green if the polluting sources are not controlled. Since the maximum ground level concentration of NO_2 from the Industrial sources is found much closer to the Central Pollution Control Board (CPCB) standard limits.

Various measures are suggested to control air pollution from industries in Nagpur:

- Shifting of Industries from non- conforming zones.
- Switching over to clean technologies.
- Using clean fuels.
- Installation of Pollution control Devices.
- Development of green belt around the industries.
- Suggestions:
- Implementation of the emission norms as well as fuel quality in Accordance with the road map proposed by the Auto Fuel Policy.
- Switching over to clean alternate fuels like CNG, LPG & Bio-fuels. Augmentation in Public Transport system.
- Better traffic management Implementation of fiscal measures, etc.

References

1. C. Cowherd Jr., Ed., in The Technical Basis for a Size Specific Particulate Standard, Proceedings, Parts I & II, APCA Specialty Conference, Air Pollution Control Assoc, Pittsburgh, PA (1980).
2. Gadgil, A. S., & Jadhav, R. S. (2004). (Dept Environ Sci, Univ Pune, Pune 411 007). Street-level concentrations of suspended particulate matter (SPM), nitrogen dioxide (NO2) and sulphur dioxide (SO2) in Pune city. *Journal of Environmental Science & Engineering*,46(2), 143–150.
3. Ghosh, S. K., Sinha, J. K. and Banerjee, S. P.: 1982, 'Air Pollution in Dhanbad and its Impact on Human Health', in Proceeding of the Seminar on Minerals and Ecology, Session 5, Indian School of Mines, Dhanbad, 6–7 March:1–5.
4. H.S. Chahal, D.J. Romano, "High Volume Sampling: Evaluation of an Inverted Sampler for Ambient TSP Measurements," fAPCA 26:895 (1976).

5. Indian Standard (IS): 5182 (Part 2) (2001). Methods for measurement of air pollution. New Delhi, India: Bureau of Indian Standard.
6. J.W. Coffer, C. Mcjilton, RJ. Charlson, "SO_2 Oxidation to Sulfate Due to Particulate Matter on a High Volume Air Sampler Filter," Document # ANAL 102, presented at the Division of Analytical Chemistry, 167th National Meeting, Los Angeles, CA (1974).
7. Jeba Rajasekhar, R. V., Bhaskar, B. V., Kulandaisamy, I.,& Muthusubramanian, P. (2001). SPM concentration ambient air of Madurai city. *Journal of Environmental Sciences,* 5(1), 56–61.
8. L. Bruckman, R.A. Rubino, "High Volume Sampling: Errors Incurred during passive deposition exposure periods," fAPCA 26:881 (1976).
9. M. Aldrin, I.H. Haff, “Generalized additive modeling of air pollution, traffic volume and meteorology”, Atmos Environ, Vol 39, pp 2145-2155, 2005.
10. Sahoo, B. N.: 1981, ‘Environmental Pollution of Mine Atmosphere with Special Reference to Particulate Pollution’, Ph.D. Thesis, Dhanbad, Indian School of Mines.
11. Sharma, M., Pandey, R., Maheshwari, M., Sengupta, B., Shukla, B. P., Gupta, N. K., *et al*. (2003). Interpreta- tion of air quality data using an air quality index for the city of Kanpur, India. *Journal of Environmental Engineering and Science*, 2, 453–462.
12. Sharma, P. K. and Singh G.: 1990, ‘Assessment of air quality in Tilaboni, Nakrakonda and Jhanjra block of Raniganj coal field’, Indian J. Env. Protect. 10(2): 105–112.
13. Srinivas J, Purushotham A.V., Determination of Air Quality Index Status in Industrial areas of Visakhapatnam, India
14. USEPA (1996). Air quality criteria for particulate matter. United States Environmental Protection Agency, Research triangle, NC, Environmental Criteria and Assessment office, Rep. EPA/600/P-95/001aF.
15. USEPA (1999a). National Air Toxics Program. The Integrated Urban Strategy, United States Environmental Protection Agency’s, Federal Reg. 64 (137).
16. USEPA (1999b). Method for the determination of inorganic compounds in ambient air. United States EPA, office of research and development, Washington, DC,EPA/625/R-96/010a.
17. W.R. Pierson, W.W. Brachaczek, T.J. Korniski, T.J. Truex, J.W. Butler, "Artifact Formation of Sulfate, Nitrate, and Hydrogen Ion on Backup Filters: Allegheny Mountain Experiment," fAPCA 30:30-34 (1980).
18. (www.imdnagpur.gov.in_listofclimaticf2ngp)

****