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Ambient Air Quality Status in an Industrial Area of Raipur City in the Year 2015

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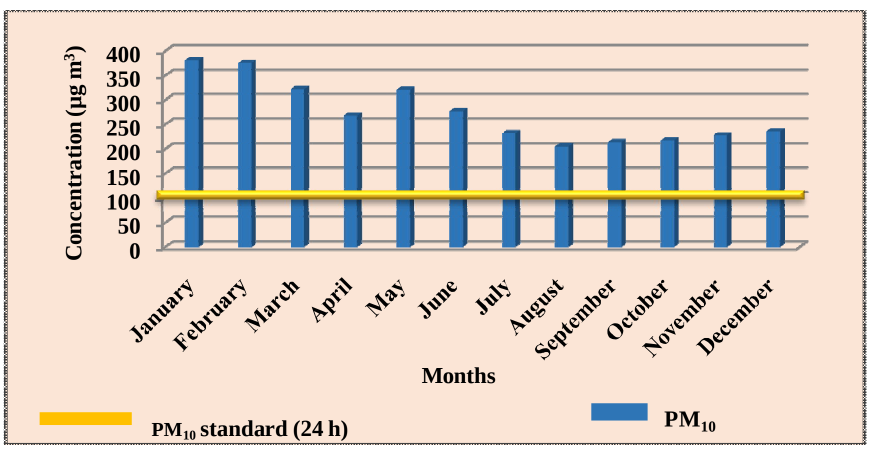
ABSTRACT

Urban air pollution and its impact on air quality is a world-wide problem. Due to rapid urbanization and industrialization, the air pollution has been recognized as a serious problem which has impacts both on environment as well as human health. The air pollutants like PM_{10}, SO_2 and NO_2 were studied for a period of one year i.e. from January 2015 to December 2015. On the basis of the study, it was found that the concentrations of the various air pollutants were higher in winter season due to slow dispersion of pollutants in winters and lower in monsoon season. The heavy transport, various industrial emissions, road dust, biomass burning, etc. used for cooking and other domestic purposes are the main causes of deterioration of the environment. The government should take necessary regulatory steps to reduce the ambient air pollution.

Graphical Abstract



Average Concentrations of PM_{10} with NAAQS standards.

Keywords: Particulate matter, Nitrogen dioxide, Sulphur dioxide, Health Impacts.

INTRODUCTION

Air is one of the most important constituent of nature which is necessary for the survival of all forms of life on earth. Due to presence of undesirable materials in the atmosphere, the ambient air quality has been progressively deteriorated and thus has become a major environmental concern for both the developed and developing countries. Urban air pollution and its impact on the air quality is a world-wide problem which manifests itself differently in different regions depending upon the political, economical and technological developments on climate and topography as well as on the nature of the available energy sources.

Due to rapid population growth, urbanization and industrialization in recent decades, the air pollution has globally been recognized as a serious problem with its short-term and long-term impacts on environment and human health [1]. The short-term impact has been studied extensively in mid 20th century, the London Fog and the subsequent series of the dramatic episodes in industrialized countries [2]. Few investigators have also attempted to illustrate the heterogeneity effect among the regions in terms of different levels, characteristics, potential confounders of air pollutants including temperature as well as humidity [3].

All the air pollutants are associated with a range of acute and chronic effects on human health [4]. In recent years, a large number of studies have also been done in the developing countries to find the public health implications on the emission of CO, SO_2, NO_X, O_3, toxicants and particulate matter. Particulate matter, PM_{10} and $PM_{2.5}$ which refers to as the particles suspended in the air with aerodynamic diameter less than or equal to 10 or 2.5 micrometers, respectively, is found as a major cause of all the respiratory problems [5]. Increased levels of atmospheric acidic pollutants like sulphur and nitrogen compounds in both gases and aerosol species causes adverse health effect like chronic bronchitis and also have potential to cause other environmental damage (e.g. acid rain). In some cases CO is also fatal in haemoglobin as it hampers oxygen supply to brain. These air pollutant compounds once released in the atmosphere either by man-made (anthropogenic) or natural sources can undergo several different processes like transformations, due to atmospheric reactions (e.g. gas to particle conversion), transport association with wind and lastly wet and dry deposition.

In 2013, PM from outdoor air pollution was classified as carcinogenic to humans by the International Agency for Research on Cancer. PM also causes visibility impairment and affects the earth's thermal radiation balance [6-7]. The national and international authorities had taken necessary regulatory steps to reduce the ambient air pollution but lack of national policy and unplanned growth across various developmental sectors (construction, transport, industry) hinders the effort.

To describe the air quality that how good or bad it is, one way is to report the concentrations of all the air pollutants with the acceptable levels (standards). Ambient air quality standards with air quality guidelines were established together by many countries around the world by World Health Organization (WHO) for the protection of local, regional and global atmosphere [1]. Routine wise air quality monitoring is very important in order to recognize long-term air quality trends, evaluate the effectiveness of air quality control regulations and refine the air quality management efforts [8]. The ministry of environment and forests revised the Indian National Ambient Air Quality Standards (NAAQS) for air pollutants in 2009. Since lack of public awareness on high air pollution concentration causes potential health risk, the information on the levels of air pollution should be presented in simple understandable format.

In the present study, the daily, monthly and seasonal variations of the pollutants i.e. PM_{10}, SO_2 and NO_2, affecting the ambient air quality of Urla-Sarora, an industrial area of Raipur city have been measured along with the meteorological parameters.

MATERIALS AND METHODS

Study Area: Raipur District (latitude: 21° 13′ N, longitude: 81° 37′ E, altitude: ~290 m above sea level) is situated in the fertile plains of Chhattisgarh Region. As per 2011 census, the Raipur urban agglomeration has a population of about one million. It has a tropical wet and dry climate, temperatures remain moderate throughout the year, except from March to June, which may be extremely hot. The highest temperatures were observed during the months of April-June (summer) whereas the lowest temperatures were during November-January (winter). About 1,300 mm of rain is received mostly in the monsoon season from late June to early October. Because of local industrial, human activities and regional transport, air quality of the city is a major concern.

Sampling Location: In the present study, the Urla-Sarora Industrial area (21º 17' 9.54" N, Latitude and 81º 36' 4.90" E, Longitude) (Figure 1) has been selected for the monitoring the air pollutants such as PM_{10}, SO_2 and NO_2. A continuous ambient air quality monitoring station has been installed by CECB in the premises of uniworth industries limited which is surrounded by various types of industries (mainly steel related) within Urla-Sarora industrial area.

Figure 1. Sampling Location.

Sample Monitoring and Measurements: Ambient air pollutants were monitored continuously for 24 h from January 2015 to December 2015. A respirable dust sampler (Envirotech Model APM 460 BL) figure 2 is used for monitoring PM_{10} while UV Fluorescence SO_2 analyzer (Thermo Fischer Scientific Model 43i) and Chemiluminescence NO_2 analyzer (Thermo Fischer Scientific Model 42i)

Figure 2. PM_{10} Sampler (Envirotech Model APM 460 BL).

are used for monitoring of SO_2 and NO_2 respectively (Figure 3, 4). The methods used for measurements along with the air pollutants with NAAQS values are summarized in table 1. The concentrations of the various air pollutants (PM_{10}, SO_2, NO_2) were expressed in microgram per cubic meter (µg m^3). The meteorological parameters like relative humidity (in %), air temperature (in ºC), wind speed (in m sec^{-1}), wind direction (in degree from the North) etc. were collected from Indira Gandhi Agriculture University, Raipur in order to identify the effect of local meteorology on pollution levels.

Figure 3. SO_2 analyzer (Thermo Fischer Scientific Model 43i).

Figure 4. NO_2 analyzer (Thermo Fischer Scientific Model 42i).

Table 1. Pollutants selected for study along with NAAQS 2009 and method of measurements [9].

S.No.	Pollutant	Time Weighted Average	Concentration in Ambient Air		Methods of Measurement
			Industrial, Residential, Rural and Other Area	Ecologically Sensitive Area (notified by Central Govt.)	
1.	Particulate Matter (size less than 10 µm) or PM_{10} µg m^{3-1}	Annual 24 h	60 100	60 100	**Gravimetric** TEOM Beta Attenuation
2.	Sulphur Dioxide (SO_2), µg m^{3-1}	Annual 24 h	50 80	20 80	Improved West and Geake Method **Ultraviolet Fluorescence**
3.	Nitrogen Dioxide (NO_2), µg m^{3-1}	Annual 24 h	40 80	30 80	Modified Jacob &Hochheiser (Na Arsenite) **Chemiluminescence**

RESULTS AND DISCUSSION

Monthly average concentrations of the various air pollutants from January to December 2015 have been illustrated in table 2. Maximum concentration of PM_{10} (380.79 µg m^3) was seen during the winter month in January while minimum concentration (204.31 µg m^3) was observed during monsoon in the month of August (Figure 5) which results that there occurs slow dispersion of pollutants during winters in more stable atmospheric conditions. These condition favours the built up of the atmospheric pollutants which gives rise to higher concentrations near to the source of pollution.

Table 2. Monthly average data of air pollutants.

Month	PM_{10} (µg m^{3-1})	SO_2 (µg m^{3-1})	NO_2 (µg m^{3-1})
January	380.79	18.66	49.10
February	374.75	18.58	47.91
March	321.66	16.39	44.65
April	267.00	14.41	38.05
May	320.41	14.73	38.26
June	276.68	13.80	35.64
July	231.76	13.60	37.03
August	204.31	12.71	34.67
September	213.68	13.46	36.00
October	217.18	13.85	37.35
November	227.50	14.41	37.81
December	235.50	15.00	39.00
Total	3271.22	179.6	475.47
Average	272.6	14.97	39.62

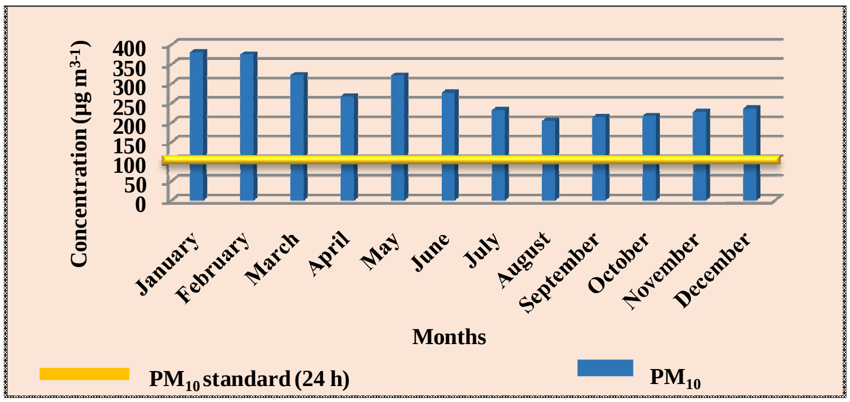


Figure 5. Average Concentrations of PM_{10} with NAAQS standards.

The maximum average concentration of SO_2 was obtained during January month (18.66 µg m^3), followed by February as 18.58 µg m^3 while lowest concentration was found during monsoon in August as 12.71 µg m^3 (Figure 6). High concentrations of SO_2 may be attributed to heavy congested traffic and biomass burning nearby residential areas and highways. An epidemiological study indicates that after exposure to SO_2, a proportion of population experiences changes in pulmonary function and other respiratory symptoms.

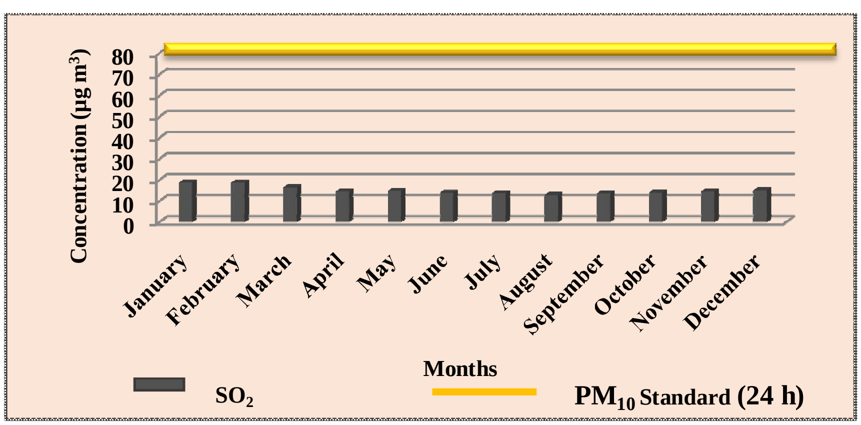


Figure 6. Average Monthly Concentrations of SO_2 with NAAQS standards.

The average concentration of NO_2 was found maximum during the winter months in January as 49.1 µg m^3 and minimum during monsoon in August month as 34.67µg m^3 (Figure 7).The primary sources of nitrogen oxides are power plants, motor vehicles as well as waste disposal systems. Epidemiological studies have shown that a bronchitic symptoms of asthamatic children increases in association with annual NO_2 concentration.

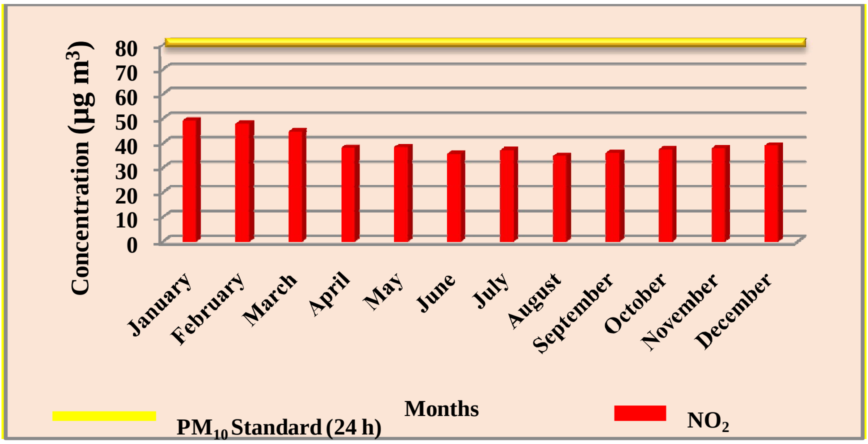


Figure 7. Average Monthly Concentrations of NO_2 with NAAQS standards,

CONCLUSIONS

The study concludes that the air pollutants are mostly above the permissible limits at the Urla-Sarora industrial area which may be due to heavy transport, various industrial emissions, road dust, biomass burning, use of cow dung, wood etc. used for cooking and other domestic purposes. High concentration of the pollutants in ambient air is found in winters as compared to the monsoon due to slow dispersion of pollutants. The national and international authorities should take necessary regulatory steps to reduce the ambient air pollution.

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