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AIR POLLUTION IN JHANSI: AIR QUALITY INDEXING AND STATISTICAL DATA ANALYSIS

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Abstract: The population increasing in developing country and gluttony patterns of consumption and mass- scale production in industrialized countries has upset the balance between people and resource leading to deterioration of the environment. In developing countries, P3 syndrome (Population, Poverty and Pollution) is the key factor leading to environmental degradation. Air pollution is a serious issue in modern India with major source being crop residue burning in agricultural field, vehicle emission due to traffic congestion stone crushers and small industries. Increasing of air pollution level causes adverse environment impacts on human health and socio-economic problems. This paper present over view on the status of air quality index (AQI) of Jhansi city by using multivariate statistical techniques. This base line data can help governmental and non-governmental organization for the management of air pollution.
Keywords: Air Quality Index, Health risk, Jhansi city, Multivariate statistical techniques.
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INTRODUCTION

In developing countries, the increased levels of pollution are a major environmental problem. Pollution has become a great topic of debate at all levels in India, especially the air pollution because of the enhanced anthropogenic activities. Among the harmful chemical compounds entering into the atmosphere as a result of fossils fuels burning are carbon monoxide (CO), sulfur dioxide (SO_2) nitrogen oxide (NOx), and tiny solid particles including lead from gasoline additive. The studies on air pollution in large cities of India showed that ambient air pollution concentrations are at such levels where serious health effects are possible. Continuous rise of population due to urban activities along with the lack of suitable measures for air pollution control means that there is a great potential that conditions may worsen in future in Indian cities. In urban areas, the air quality is affected adversely due to emission and accumulation of SPM, RSPM, SO_2, and NOx. All these pollutants may pose harmful effect on human health, as exposure of these are associated with cardiovascular and respiratory disease, neurological impairments, increased risk of preterm birth and even mortality and morbidity (Devendra and Vijayant, 2014). The single most important factor responsible for the deterioration of air quality in the cities is the exponential increase in the number of vehicles. At least 500,000 premature deaths and four to five million new cases of bronchitis are reported each year (WHO, 1992). Further 4% to 8% of premature deaths on a global scale are due to exposure to high levels of particulate matter in ambient air (WHO, 2000). To monitor the quality of air in different cities of India, a network of air quality monitoring stations has been established by National Environmental Engineering Research Institute (NEERI), Nagpur in cities where its zonal lab is present. However, there is no air monitoring station of NEERI in Jhansi (Chauhan *et al.,* 2013). Therefore, in the present study, ambient air quality was monitored at residential and commercial area of Jhansi city to assess the prevailing concentration of the SPM, RSPM, SOx and NOx.

EXPERIMENTAL

Study Area: Jhansi is one of the important districts out of the five districts of Bundelkhand massif of Uttar Pradesh occupies almost 70,000 square kilometers of the central plains in India. The Bundelkhand massif covers about 26000 sq. Km of the total area of the southern Uttar Pradesh and north-eastern Madhya-Pradesh in central India and forms the northern fringes of the Peninsular Indian shield. The district Jhansi lies in southwest portion of Jhansi division of Uttar Pradesh state of India between 25˚ 30' N and 25˚ 57' N latitudes and 78º 40' E and 79º 25' E longitudes. The present study area of the district according to survey of India is covering 5,024 square kilometers. Jhansi falls under a semi arid climate, with two main seasons specially Monsoon and Dry. Mining and rock crushing are the major essential activities that provide the raw material for society. Also, Jhansi is known one of the important granite mining centers in the Bundelkhand region.

Figure 1. Map of the study area presenting the Sampling location points

Methodology for Estimation of Air Pollutants: Respirable Dust Sampler (RDS) APM 460 was used for collecting air samples from different localities of city. The Respirable Dust Sampler is popular and frequently used equipment for the determination of Suspended Particulate Matter (SPM) and Respirable Suspended Particulate Matter (RSPM), SOx and NOx gaseous pollutants.

Table 1. Methodology for Air Quality Monitoring by Respirable Dust Sampler (RDS) APM 460

Particulars	RSPM	SPM	SOx	NOx
Sampling equipment	Respirable Dust Sampler (RDS) APM 460	Respirable Dust Sampler (RDS) APM 460	RDS with gaseous sampling attachment	RDS with gaseous sampling attachment
Collection Media	Glass fibre filter paper	Dust cup	TCM (Tetrachloromercurate)	NaOH plus sodium arsenite
Flow Rate	1.0-1.3 m^3 / min	1.0-1.3 m^3/min	0.5 L/min	0.5 L/min
Analytical Method	Gravimetric method	Gravimetric method	Spectrophotometry method (West and Gaeke method)	Spectrophotometery method (Jacobs-Hochheiser)
Time Frequency	8 Hourly	8 Hourly	4 Hourly	4 Hourly
Sampling Duration	continuously for 24 Hours	continuously for 24 Hours	Continuously for 24 Hours	Continuously for 24 Hours

Air Quality Index (AQI): AQI is developed to provide the information about air quality. From a series of observation, an index (a ratio or number) is derived which is an indicator or measure of condition or property the concentration of the major pollutants based on monitored and subsequent converted into the AQI (Table 2) using standard formula (Tiwari and Ali, 1987).The categorization of ambient air quality on the basis of AQI is presented in Table 2.

Table 2. Shows the Air Quality Categories Based on AQI

Category	AQI of Ambient air	Description of Ambient air quality
I	< 10	Very clean

II	10-25	clean
III	25-50	Fairly clean
IV	50-75	Moderately polluted
V	75-100	polluted
VI	100-125	Heavily Polluted
VII	> 125	Severely Polluted

The air quality index (AQI) was calculated using the method suggested by Tiwari and Ali (1987). First of all, the air quality rating of each pollutant was calculated by the following formula:

$$Q = \frac{V \times 100}{Vs}$$

Where Q= Quality rating,
V= the absorbed value of the pollutants,
Vs= Standard value recommended for that pollutants.
The Vs value used as the recommended national ambient air quality standard (Table 1) for different areas.

Table 3. Shows the National Ambient Air Quality Standards (NAAQS) for 24 hours time average

Pollutants	Concentration in Ambient air (µg/m³)	
	Residential area	Industrial area
SO_2	80	80
NO_2	80	80
SPM	200	500
RSPM	100	100

Source: Central Pollution Control Board (CPCB), 2009 New Delhi India.

If total n indicate the number of pollutants considered for air quality monitoring. Then, geometric mean of these n number shows the quality rating as calculated in the following way:

$$G = \text{Anti log} \frac{(\log_a + \log_b + \log_c + \text{-------} \log_x)}{n}$$

Where G= geometric mean, while a, b, c and x represent different values of quality rating and "n" is the number of values quality rating.

Statistical Analysis

Pearson Correlation: Pearson correlation coefficient is commonly used to measure and establish the strength of a linear relationship between two variables or two sets of data. It is a simplified statistical tool to show the degree of dependency of one variable to the other (Belkhiri *et al.,* 2010). The Pearson correlation coefficient (r_{xy}) is computed by using the formula as given (Patil and Patil, 2010; Jothivenkatachalam *et. al.,* 2010; Kumar and Singh, 2010). The correlation co-efficient 'r' was calculated using the equation-

$$r_{xy} = \frac{n\sum (x_i\, y_i) - (\sum x_i).(\sum y_i)}{\sqrt{[n\sum x_i^2 - (\sum x_i)^2]\,[n\sum y_i^2 - (\sum y_i)^2]}}$$

Where Xi and Yi represents two different parameters
n = Number of total observations.
The correlation coefficient is always between -1 and +1. A correlation closer to +/- 1 implies that the association is closer to a perfect linear relation. Interpretation of the Pearson correlation coefficients, adopted in the present study are: r = -1 to -0.7 (strong negative association); r = +0.7 to +1.0 (strong positive association); r = -0.7 to -0.3 (weak negative association); r = +0.3 to +0.7 (weak positive association); r = -0.3 to +0.3 (negligible or no association). Thus, for the eleven water quality parameters, the possible correlations between every pair were computed using SPSS (Version 17.0) and are arranged into a correlation matrix. Precisely, a correlation matrix is a table of all possible correlation coefficients between a set of variables.

Linear Regressions: In this study, we have applied the linear regression approach to develop a relationship between several independent/predictor variables and a dependent/predict and variables. This method is successfully used by different authors to establish statistical model (Shreya and Nag, 2015).

RESULTS AND DISCUSSION

Ambient air quality of residential and commercial area of Jhansi City has been monitored since January 2014 to December 2014.

Gaseous Pollutants

Sulphur dioxide can cause irritation of visibility and respiratory diseases. Healthy person are mostly affected by experience broncho-construction at 4540 µg/m^3 of SO_2 for a few minutes exposure. Throat irritation occurs at 33800 µg/m^3 level. At 56400 µg/m^3 SO_2 concentrations may cause immediate cough and eye irritation. Exposure ranges from 400 to 500 ppm of sulphur dioxide even for a few minutes is highly dangerous to human life

(Chauhan *et al.,* 2013). The concentration of the SO_2 recorded in the study areas have been ranged between 5.7 to 10.47μg/m^3. Residential area has lower values of SO_2 (8.19 μg/m^3) compared to commercial area value of SO_2 (10.47μg/m^3). The SOx show positive correlation with NOx, SPM and RSPM in both commercial and residential area of Jhansi city. Nitric oxide (NO) and nitrogen dioxide (NO_2) are also of great to the concern to human health. NO is not irritating and it will not cause any adverse health effects at atmospheric concentrations. But when NO undergoes oxidation to NO_2, it poses health hazards as oxidant. Hemoglobin has 300000 times more affinity for absorbing NO_2 than O_2, which reduce oxygen carrying capacity of the blood. Nitrogen dioxide at high-level exposures in the range of 150 ppm (285 mg/m^3) and above may be fatal to humans (Chauhan *et al.,* 2013). The concentration of the NO_2 recorded in the study areas have been ranged between 16.71 to 27.93 μg/m^3 (Table 3). Sensitive area has lower values of NO_2 (22.87 μg/m^3) compared to commercial and residential area value of NO_2 (27.93μg/m^3). The value of NO_2 in the commercial, residential and sensitive areas was within the prescribed value (80μg/m^3) by the National ambient air quality standards.

SPM and RSPM

When particulate matter of different particles sizes is inhaled by human beings, it gets deposited in various parts of the respiratory system, with reference to mining and rock crushing areas. If particle size is greater than 10 μm, they are retained by the cilia of the nose whereas if the size of the particles is less than 10 μm they may enter into the upper respiratory tract. The upper respiratory tract consists of nasal cavity, nasal pharynx, larynx and trachea. The size of the particles ranges from 2 to 10 microns may enter specially into the trachea but the movement of cilia sweep mucus upward, carrying particles from windpipe to mouth, where they can be swallowed. The lower respiratory tract consists of bronchi, bronchioles, alveolar ducts, alveolar sacs and alveoli of the lungs. Particles size less than 2 microns are deposited mostly in bronchioles but few of them may reach the alveolar ducts. A particle size ranges from 0.25 to 1 μm enter mainly into the alveoli of lungs and gets deposited. Its reduces the volume of the alveoli thereby causing damage to the lungs by minimizing the oxygen exchange from air to blood. The concentration of the RSPM monitored in the study areas were ranged within 78 to 138 μg/m^3 and SPM is recorded between 131 to 301 μg/m^3. Both show positive correlation with SOx.

Table 4. Quantitative chemical analysis result of air quality of Jhansi city during January 2014 to December 2014

Study Area	Veerangana Nagar (Residential Area)					Manick Chowk (Commercial Area)				
Parameters/ Months	SOx	NOx	RSPM	SPM	AQI	Sox	Nox	RSPM	SPM	AQI
January	5.98±0.18	16.71±0.51	106.17±2.1	224.87±3.5	26.33	7.16±0.16	18.60±0.91	138.03±1.5	277.10±6.7	32.81
February	6.52±0.11	15.72±0.54	67.63±1.4	131.63±3.9		7.20±0.15	23.44±1.1	111.88±3.2	222.46±6.3	
March	5.75± 0.12	17.70±0.57	87.57±1.8	174.80±4.1		7.01±0.17	19.91±0.78	93.40±2.8	197.87±5.9	
April	7.02± 0.14	18.67±0.63	95.57±1.7	202.47±3.7		8.41±0.19	21.25±1.1	128.63±2.2	270.40±5.2	
May	8.19±0.16	25.41±0.65	114.67±2.4	242.93±4.6		10.18±0.21	27.93±1.3	132.03±2.6	276.27±5.8	
June	7.11±0.19	19.48±0.45	19.48±2.6	197.77±4.4		9.07±0.23	20.61±0.96	136.97±2.9	280.70±6.2	
July	6.33± 0.16	17.25±0.42	84.33±2.2	179.20±5.1		7.35±0.24	20.00±0.83	117.93±2.1	253.30±4.7	
August	5.63±0.18	18.41± .47	78.43±1.9	170.13±5.5		7.14±0.28	19.91±0.72	101.80±1.9	211.93±6.2	
September	6.44±0.20	21.43±0.49	100.07±1.7	210.20±4.9		7.76±0.17	21.81±0.71	127.17±1.7	262.87±5.4	
October	8.02±0.15	20.38±0.39	128.80±1.8	260.30±4.3		10.47±0.19	23.30±0.54	151.83±2.5	301.80±5.2	
November	8.32±0.18	22.87±0.61	106.53±2.3	224.43±4.9		9.40±0.20	27.88±0.62	144.63±2.3	295.03±4.7	
December	5.88±0.17	18.36±0.62	80.67±1.5	169.77±5.5		8.14±0.21	20.50±0.72	99.93±2.9	208.83±4.9	

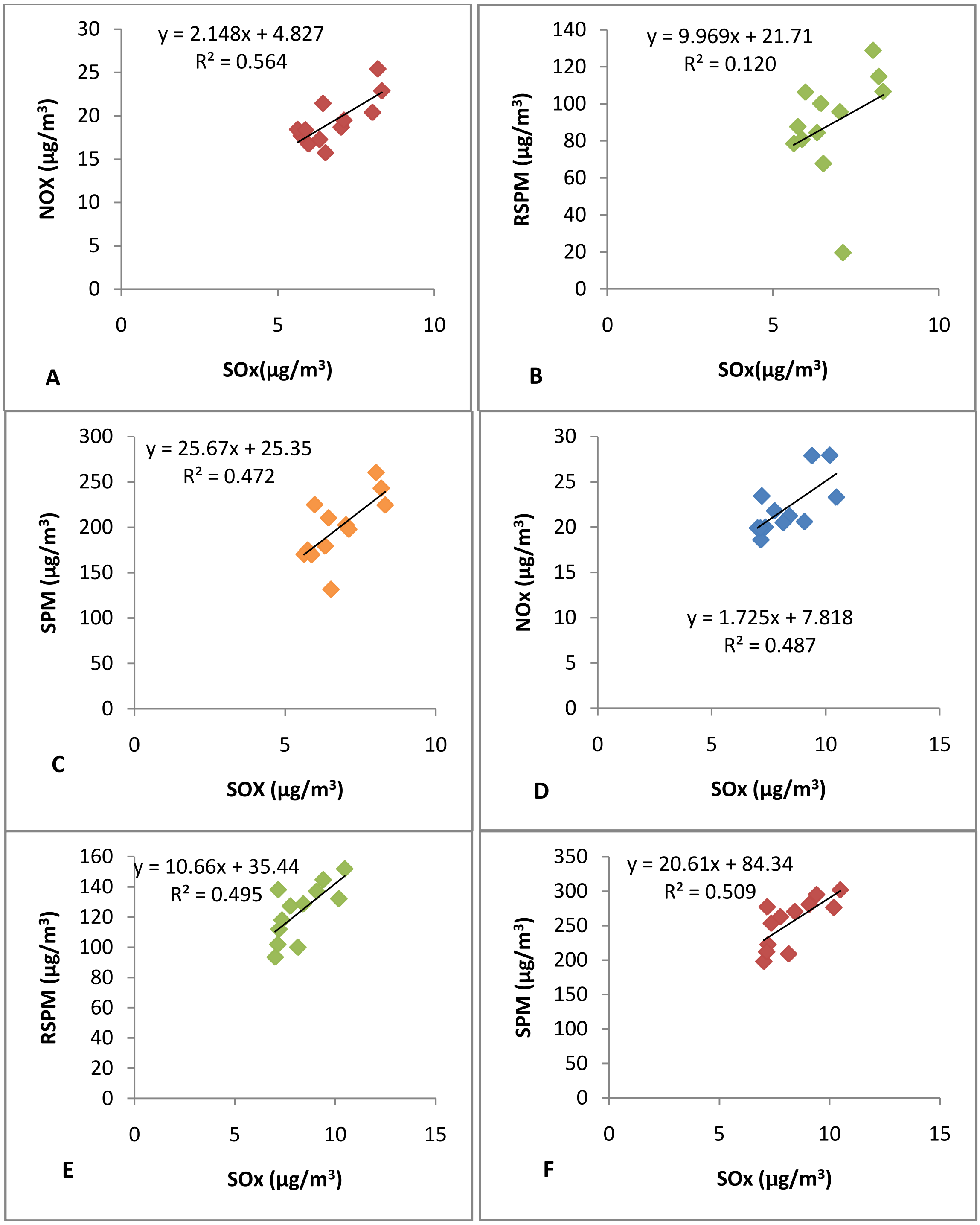

Figure 2. Correlation analysis graphs presenting correlation trends of SOx with the other parameters of air quality in both (a,b,c) Residential area and (d,e,f) for Commercial area

Correlation Analysis

The correlation analysis study involving statistical calculation was devised by Pearson (1896). Based on the value, correlation coefficient 'r' indicates the correlation between two variable parameters plotted on a XY scatter diagram can be termed as positive or negative. Correlation analysis is a common and useful statistical tool for air quality studies indicating which pollutant control the atmospheric chemistry. It is simply a measure to exhibit how well one variable predicts the other (Kurumbein and Graybill, 1965). In the present study, correlation of SOx has been worked out with rest of the analyzed air quality parameters and the following observations have been made from the trend analysis graphs (Figure 2 and Table 5). SOx is observed to shows a positive correlation with NOx (r = 0.75 and 0.69) at both residential and commercial areas respectively. RSPM shows weak positive correlation at residential area (r =0.34) and strong correlation at commercial area (0.70), SPM shows strong positive correlation at both sites residential and commercial (0.68 and 0.71) respectively. Same trend was also recorded by (Ganesh *et al.,* 2012; Arya *et al.,* 2016 ; Saurabh *et al.,* 2013 and Chauhan *et al.,* 2013).

Table 5. Correlation coefficient matrix for air quality of Jhansi city

Parameters	Veerangana Nagar (R)				Manick Chowk (C)			
	SOx	**NOx**	**RSPM**	**SPM**	**SOx**	**NOx**	**RSPM**	**SPM**
SOx	1	0.75	0.34	0.68	1	0.69	0.70	0.71
NOx	0.75	1	0.39	0.68	0.69	1	0.44	0.44
RSPM	0.34	0.39	1	0.61	0.70	0.44	1	0.98
SPM	0.68	0.68	0.61	1	0.71	0.44	0.98	1

R= Residential, C= Commercial

CONCLUSION

In Bundelkhand, especially Jhansi region and its adjoining area are highly affected by the particulate matters and have reached alarmingly at high levels of SOx and NOx air pollutant due to mining and rock crushing activities over past two decades. Around the mining sites lie within 5 Km radius, a number of private government hospital, schools and University are situated which comes under the highly dust pollution zone. Analysis of the ambient air quality data monitored over one year in the year 2014 reveals that some of the pollutants, especially particulate matter exceeds the National Ambient Air Quality standards (NAAQS) set by the central pollution control board (CPCB) New Delhi. The respirable suspended particulate matter and suspended particulate matter (RSPM and SPM) concentration of 260 to 360 μg/m^3 recorded respectively during investigation. As Indian have short life span, the total impact on life year lost due to air pollution is greater than in developed countries. It is necessary to use a rating system, such as air quality index (AQI) which will provide information about the air quality of concerned area. It is noted that the low the AQI rating scale value, 26.33 for residential area and 32.41 for commercial area is good for health. This AQI data will be used to enable the public to take appropriate precautions to safeguard themselves and their families and also communities against exposure to air pollution levels in the granite geo- mining terrains in Jhansi region. For the reduction of air pollution levels, one has to take enforce regulatory measure for local impact.

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