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COMPARATIVE STUDY OF AMBIENT AIR QUALITY STATUS OF LUCKNOW AND JHANSI CITY IN UTTAR PRADESH, INDIA

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Abstract: Air pollution is a serious issue in 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. The present study was under taken to assess the comparative study of ambient air quality status of Lucknow and Jhansi city in Uttar Pradesh, India by using cluster statistical techniques. The samples were collected for Suspended Particulate Matter (SPM), Respirable Suspended Particulate Matter (PM$_{10}$), oxide of sulfur (SOx) and oxide of nitrogen (NOx) during january-2014 to June-2014 from commercial, residential Industrial and sensitive area of both cities. It was noticed in this study that the SPM and RSPM levels at all selected sites exceeds the prescribed limits of the NAAQS as stipulated by central pollution control board (CPCB) New Delhi. The average ambient air concentration of SOx and NOx were found below the permissible limits of NAAQS of CPCB at all the sites of both cities.
Keywords: Air pollution; Cluster statistical techniques; Jhansi; Lucknow.

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INTRODUCTION

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 and79º 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 (Ganesh *et al.,* 2012). Lucknow is the largest city of the state of Uttar Pradesh, India a major metropolitan city of India, Lucknow is the administrative headquarters of the eponymous District and Division and the capital of the state of Uttar Pradesh. It is a fast growing city. In 1951, area of Lucknow was 48 sq Km which has now increased to 310 sq.km in 2011. As per 2011 census, the city has a population of 28.15 Lakh (Municipal Corporation + Cantonment). The city witnessed development of new areas like Mahanagar, Indira Nagar, Aliganj, Gomti Nagar towards the end of the 20th century. During the last 20 years, rapid development has taken place in the city and practically

most of the open space available has been occupied for the construction of residential, commercial and office buildings. Population density of city is increasing. Pressure on management of services, facilities and amenities is also increasing.

Source of air pollution in Lucknow city

Vehicular traffic is the main source of particulate air pollution in Lucknow city. The number of different categories of vehicles registered with RTO (Regional Transport Office) Lucknow is 18,64,556 as on 31.03.2016 which is 9.06% higher over the last year. Uttar Pradesh State Road Transport Corporation (UPSRTC) introduced bus services under the banner "*Lucknow City Transport Services Limited*" on different routes of Lucknow city. The details of bus routes and number of buses plying as on 31.03.2016 are given in Table 2. In Lucknow city there are 125 filling stations for petrol, diesel and CNG operated by different oil and gas companies, IITR report (2016).

Source of air pollution in Jhansi city

Mining and rock crushing are the major essential activities that provides the raw material for society and the Jhansi is known one of the important granite mining centers in the Bundelkhand. Due to lack of proper adequate preventive measures adoption for the activities of granite mining it has caused serious negative impacts on the environment and also on human health in and around existing mining areas. In Jhansi, granite mining is done mainly through the open cast mining by manual and some extent to mechanized methods because of the following reasons: (i) it requires less mining investment (ii) mechanization is likely to prove inefficient (iii) availability of cheap labor and (iv) large

scale unsystematic way of underground dynamite blasting large scale activities (Chauhan *et al.,* 2013).

EXPERIMENTAL

Location of Sampling stations in Lucknow

Five air quality monitoring locations representing different activities/areas *i.e.* two in residential, two in commercial cum traffic and one industrial area were selected for the study as summarized in Table. 1.

Table 1. Monitoring Locations of Lucknow City

S.No.	Locations	Activities
1.	Vikas Nagar	Residential
2.	Aliganj	Residential
3.	Charbagh	Commercial cum traffic
4.	Chowk	Commercial cum traffic
5.	Amausi	Industrial

Location of sampling stations in Jhansi

Five location select for air quality monitoring in Jhansi city which cover to whole city. Location is divided into different categories as follows:

Table 2. Monitoring Locations of Jhansi City

S.No.	Locations	Activities
1.	Shivaji Nagar	Residential
2.	Manikchowk	Commercial cum traffic
3.	Bus stand	Commercial cum traffic
4.	Sipri	Commercial cum traffic
5.	Medical College	Sensitive area

Methodology

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 3. 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 fiber 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

Statistical Analysis

Cluster Analysis: Cluster analysis (CA) is one of a large family of statistical techniques whose main purpose is to categorize entities *e.g.* sampling sites into distinct groups or clusters according to some criteria, such that the within-group similarity is maximized and among-group similarity is minimized. Hierarchical agglomerative clustering is the most common approach, which provides intuitive similarity relationships between any one sample and the entire data set (McKenna, 2003). The Euclidean distance is a commonly used distance coefficient, which usually gives the similarity between two samples and a distance that can be represented by the difference between analytical values from both the samples (Otto, 1998). The result of hierarchical clustering is typically illustrated by a dendrogram (a tree-like plot), which provides a visual summary of the agglomeration processes, depicting a picture of the clusters and their similarity, with a dramatic reduction in dimensionality of the original data set (Shrestha *et al.,* 2007). It is done by using SPSS software version 20.

RESULTS AND DISCUSSION

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

Air Quality Status of Lucknow City

The concentration of the SO_2 recorded in the study areas have been ranged between 15.2 to 12.6 µg/m³. Industrial area (Amusi) has lower values of SO_2 *i.e.* 12.6 µg/m³ compared to commercial area (Charbag) value of SO_2 (15.2 µg/m³). The concentration of the NO_2 recorded in the study areas have been ranged between 45 to 32µg/m³ (Table 3). Residential area (Vikas Nagar) has lower values of NO_2 32 µg/m³ compared to commercial area (Charbag) value of NO_2 (45 µg/m³). The value of NO_2 in the commercial, residential and industrial areas was within the prescribed value (80µg/m³) by the National ambient air quality standards. The concentration of the RSPM monitored in the study areas were ranged within 222 to 191 µg/m³ and SPM is recorded between 498 to 407 µg/m³.

Air Quality Status of Jhansi City

The concentration of the SO_2 recorded in the study areas have been ranged between 12.9 to 9.1 µg/m³. Sensitive area (Medical college) has lower values of SO_2 (9.1µg/m³) compared to commercial area (Manik Chowk) value of SO_2 (12.9 µg/m³). The concentration of the NO_2 recorded in the study areas have been ranged between 34 to 24 µg/m³ (Table 4). Residential area (Shivaji Nagar) has lower values of NO_2 (24 µg/m³) compared to commercial area (Bus Stand) value of NO_2 (34 µg/m³). The value of NO_2 in the commercial, residential and sensitive areas was within the prescribed value 80µg/m³ by the National Ambient Air Quality Standards. The concentration of the RSPM monitored in the study areas were ranged within 141 to 201 µg/m³ and SPM is recorded between 295 to 430µg/m³.

Table 4. Chemical analysis of Air quality of Jhansi city during January 2014 to June 2014

S.No.	Parameters/Sites	SPM µg/m³	RSPM µg/m³	Sox (µg/m³)	NOx (µg/m³)
1.	Vikas Nagar (L-R)	407±23	198± 7	13.2±0.7	32±1.2
2.	Aliganj (L-R)	498±25	191±9	13.1±0.6	33±1.5
3.	Charbagh (L-C)	435±18	222±12	15.2±0.4	45±1.9
4.	Chowk (L-C)	472±20	220±8	13.3±0.8	35±1.0
5.	Amausi (L-I)	425±15	198±5	12.6±0.3	40±1.3
6.	Shivaji Nagar (J-R)	295±14	141±6	10.7±0.5	24±1.4
7.	Manikchowk (J-C)	396±10	183±3	12.9±0.6	24±1.2
8.	Bus stand (J-C)	320±17	175±8	12.4±0.7	34±1.3
9.	Sipri (J-C)	430±24	201±5	12.3±0.4	32±1.0

| 10. | Medical College (J-S) | 360±29 | 165±2 | 9.1±0.8 | 27±1.6 |

Legends: L-R (Lucknow-Residential), L-C (Lucknow-Commercial), L-I (lucknow- Industrial), J-R (Jhansi-Residential), J-C (Jhansi-Commercial)), J- I (Jhansi-Industrial) and J-S ((Jhansi-Sensitive)

Cluster analysis

Cluster analysis (CA) was employed to identify groups of similar monitoring sites and explore spatial heterogeneity of air quality. It generated a dendrogram, grouping the 10 sites into two distinct clusters (Figure 1). Sites 8,10,6 situated in Jhansi city are classified in group1, which are alike (Figure 1). Group 2 contained sites 2 and 4 located in Lucknow city both are alike. Sites 5, 9 and 3 are included in group 3, located in Lucknow and Jhansi city, they are similar. Sites 1 and 7 located in Lucknow and Jhansi city are categorized into group 4.
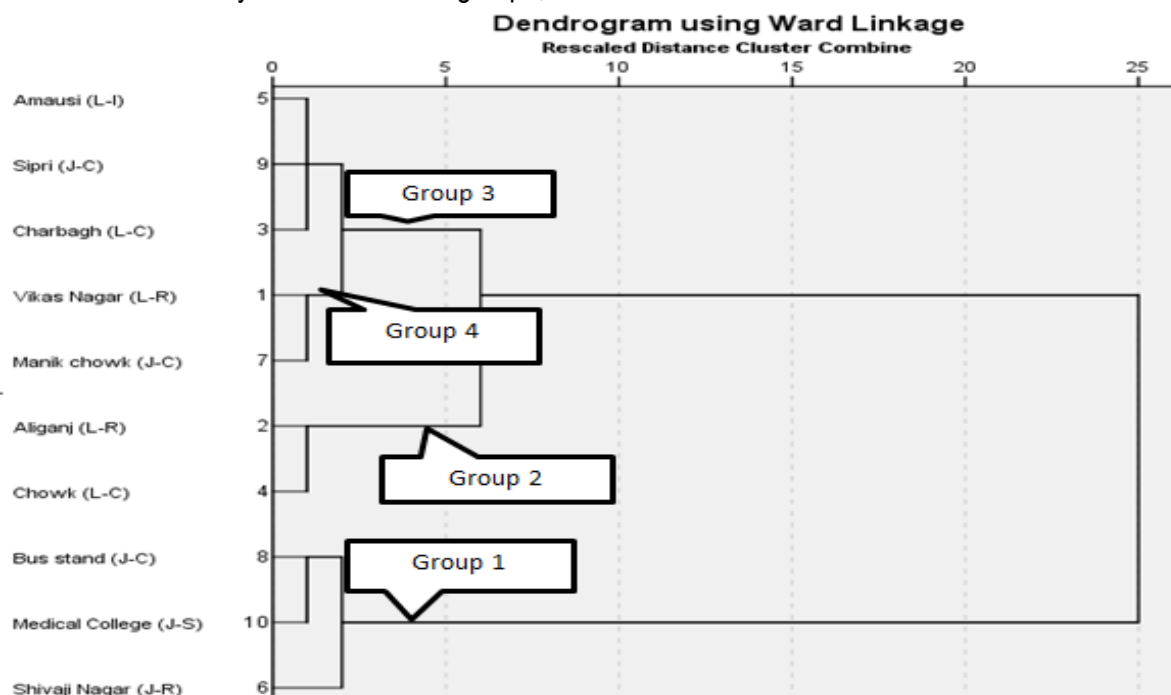

Figure 1. Dendrogram showing spatial clustering of monitoring sites

CONCLUSION

It has been concluded from the present study of Lucknow city that the SO_2 and NO_2 concentrations were well below the National Ambient Air Quality Standards, while RSPM concentration had shown high at all sampling and the SPM concentrations had shown the increasing trend at sampling station Residential to commercial. The present study of Jhansi city showed that the SO_2 and NO_2 concentrations were well below the National Standards, while the SPM concentrations in residential area were found to be slightly more than the NAAQS 2009. It can be concluded from present and previous study of ambient air quality status of Lucknow and Jhansi city respectively that there has been a rapid growth of population leads to increase automobile transportation in both the cities, contributing various air pollution problems. There has been also a rapid growth of crusher industries and small industries in cities especially in Jhansi, contributing to air pollution. Due to various environmental problems, new methods should be innovated to pose a high risk to the health of citizens and appropriate measures need to be taken, in terms of planning future urban growth.

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