International Research Journal of Engineering and Technology (IRJET) e-ISSN: 2395 -0056
Volume: 04 Issue: 05 | May -2017 www.irjet.net p-ISSN: 2395-0072

Assessment of Ambient Air Quality of Lucknow City, Uttar Pradesh: A Review

Neha Mumtaz[1], Anshika Yadav[2], Tabish Izhar[3]

[1]Assistant Professor, Department Of Civil Engineering, Integral University, Lucknow -226026, U.P., India
[2]Student, M.Tech Environmental Engineering, Department Of Civil Engineering, Integral University, Lucknow -226026, U.P., India
[3]Assistant Professor, Department Of Civil Engineering, Integral University, Lucknow -226026, U.P., India

---

Abstract - *Air pollution is one of the foremost and grave public health and environmental anxiety in most of evolving countries. Due to increase in immense number of vehicles, industries and manufacturing units has resulted in excess assembly of pollutants in air making air pollution as a state of national emergency across various cities around the country. Lucknow is a fast growing city. During the last many years, researchers from the city have studied various aspects of air pollution and identified particulate matter is one of the main air pollutants in the city. The objective of this review article is to analyze the ambient air pollution status of city, associated with the environmental and health impacts and possible control measure presented in the studies on Lucknow from the available literature. Particulate matter; $PM_{2.5}$, PM_{10} and SPM were observed to be exceed the National ambient air Quality Standards (NAAQS) limits in most of the studies but oxides of sulphur and nitrogen (SO_2 and NOx) were within the limit of National ambient air Quality Standards (NAAQS). Particulates and associated toxic chemicals (metals and PAHs) and gaseous pollutants have found to be toxic to human and plants in Lucknow. The exposure of these pollutants is associated with cardiovascular and respiratory diseases, neurological impairments; increased risk of preterm birth and even mortality and morbidity. Air pollution level at control site (village or low traffic density area) was lower than the other urban sites of the city.*

Key Words: Air pollution, Concentration of the pollutants, Health effect, Control measures.

1. INTRODUCTION

Ambient air pollution has become a matter of severe concern, particularly in mega cities and urban areas. Rapid industrial and commercial developments coupled with emission from transport sector are recognized as the prime sources. In the urban areas, the situation is alarming and gradually becoming more severe (T. Banerjee et.al. 2011).

The consequences of air pollution have led to poor urban air quality in many Indian cities. The air pollution and the resultant air quality can be attributed to emissions from transportation, industrial and domestic activities.

The air quality has been therefore, an issue of social concern in the backdrop of various developmental activities. Though the measurement of air quality is complicated, there are a few pollutants which regulators keep a watchful eye on though regular monitoring. The most watched pollutants include particulate matter (PM), Nitrogen di oxide (NO_2) and sulphur dioxide (SO_2). The World Health Organization estimates that air pollution contributes to approximately 800000 deaths and 4.6 million lost life years' annually (Sharma et.al. 2015).

Air pollutants emitted from vehicles and industries are responsible for rise in irritation, discomfort and increase in airborne diseases and deterioration of heritage building of cultural importance in urban area. Many researchers carried out short term studies in Lucknow city with respect to PM_{10}, $PM_{2.5}$, SPM, SO_2, NOx and metals etc. in ambient air. Since the air quality standards in India have been categorized in industrial, residential/ commercial and sensitive area category, most of the early studies reported from Lucknow, India covered areas.

2. STUDY AREA

Lucknow is popularly known as the City of Nawabs. It is also known as the Golden City of East. Lucknow, which has a population of 3.3 million (Municipal corporation and cantonment), area of 310 km^2 and its graphical position is $26^0$52'N latitude to $80^0$56'E longitude; 128m above the sea level. City has a number of small industries located in different parts of city.

It is rapidly emerging as a manufacturing, commercial, and retailing hub and this unique activity of the city is responsible for the depreciated ambient air quality. Industrial operations, construction activities, poor traffic control, uneven roads and extensive automobiles exhausts are additionally helping in its quality drop. It is need of the hour for the awareness of common people especially in the urban area regarding vehicular pollution, industrial pollution etc and human health and its consequence in the

short and the long term. Climate data recorded at Lucknow Airport by Metrological Department of India is as in Table- 1

Table -1: Climate data for Lucknow

Month	Temperature ^{0}C			Rain-fall mm	Avg. Rainy day
	Avg. high	Daily mean	Avg. low		
January	19.0	11.3	3.5	21.0	1.5
February	23.3	14.8	6.3	26.0	1.5
March	31.1	21.8	12.5	16.0	1.0
April	36.8	27.9	19.0	15.0	0.6
May	40.0	32.0	24.0	23.4	1.6
June	38.4	32.6	26.7	122.9	5.4
July	33.9	29.8	26.0	276.2	12.0
August	33.2	29.0	25.6	278.9	11.6
September	33.1	28.6	24.1	175.9	8.6
October	31.0	23.4	17.7	24.7	1.7
November	27.7	18.8	10.0	7.4	0.5
December	20.5	12.2	4.7	12.6	0.8
Yearly	30.7	23.7	16.7	1000	46.8

3. AIR POLLUTION STATUS AND ITS IMPACT

The ambient air quality studies of Lucknow reported in literature since the last many years have been summarized in this section. The researchers have studied ambient air pollution status and correlated it with environmental, human and plants health impacts. Survey at seven locations in residential, commercial and industrial areas of Lucknow during 1999-2000, showed that particulate concentration and their metallic content tend to fluctuate with the change in meteorological conditions. In this study levels of PM_{10} was 230.9, 216.5, 261.5, 241.1µg/m^3 during winter, summer, pre and post monsoon respectively and the corresponding values for SPM were 565.4, 522.3, 918.4 and 551.9 µg/m^3 respectively. All the value were higher than the prescribed NAAQS. Particulate fraction PM_{10} assessed for heavy metals showed the presence of Cd, Cr, Cu, Fe, Mn, Ni, Pb and Zn in all the seasons. The results of the study indicate marked variations in the metal contents from different locations and differ significantly in different seasons. As per the authors opinion the higher particulates can be attributed to the greater density of small diesel driven vehicles plying through routes nearby sampling locations (A.Pradhan et.al. 2004).

Air pollution status at twelve sites (close to road crossings) in Trans-Gomti area (approximately half on one side of river dividing the city) of Lucknow was studied in moderate traffic hours (11.00 AM-1.00 PM) during 2000-01, which is high traffic density areas. The observed average PM10in this study 499.4µg/m^3 was more than the NAAQS permissible limit (100µg/m^3). The highest PM_{10} level (995µg/m^3) was recorded at the busiest crossing with maximum traffic density (6723vehicle/h) and least (150 µg/m^3) at low traffic density crossing with minimum traffic load (52vehicle/h). Gaseous pollutant (SO_2 and NO_2) levels were also recorded maximum (41.92 and 38.24 µg/m^3) and minimum (SO_2-ND, NO_2-4.29 µg/m^3) at the respective locations. The levels of all automobile pollutants showed a trend of positive correlation with the traffic density. The Air Quality Index (9.89) at low traffic density site which is also under thick forest cover is of very clean category and that of busiest crossing (68.42) near to the value of polluted category (75-100). This investigation revealed that environment of the Trans-Gomti area is mainly contaminated with PM_{10} and suggested to ban diesel driven vehicles in the city areas to bring down the PM_{10} level within the permissible limit (A.Verma et.al.2003).

A study in Low/High Traffic Density (LTD/HTD) sites in urban Lucknow in 2001- 02, during summer revealed PM_{10} levels at LTD site as 73.0 and at two HTD sites as 100.4 and 96.4 µg/m^3 and the corresponding values of SPM to be 137.5 (at LTD), 159.6 and 153.4 µg/m^3 (at HTD). However, in winter season observed PM_{10} levels were 165.2, 288.7 and 264.3 µg/m^3 at one LTD and two HTD sites respectively. Similarly SPM levels were 222.6, 361.9 and 332.8 µg/m3 at respective sites. Particulates exceeded NAAQS limits in winter only, while SO_2 and NOx were within the limits in both the seasons. The authors also studied PAHs attached to particulates, revealing the presence of all the examined types (both auto exhaust/ biomass emission specific PAHs) in the sampled air. The mean values of sum PAHs at HTD sites and LTD sites were (24.76 ng/m^3) and (9.44 ng/m^3) during summer and (106.08 ng/m^3) and (26.64 ng/m^3) during winter respectively. The mean values at both the sites were much greater than the guide value of 1 ng/m^3 set for PAH by the World Health Organization (WHO). The mean PAHs value was approximately three to fou times higher in winter than summer and almost similar trend was observed between HTD and LTD. The author further emphasized that a substantially higher percentage of population is exposed to PAHs and faces the risk of short-term clinical symptoms related to cardiovascular, respiratory, ear and eye systems that are attributable to PAH exposure. As per study the estimated cost of health damage in the PAH exposed population (1.64million) on an average is Rs.900 million per annum for Lucknow (S.K. Bhargava et.al. 2003).

During post monsoon (October, 2001) the average SPM in residential, commercial and industrial areas; 342.0, 547.5,

541.7 µg/m3 was higher than the NAAQS limits, while SO2 (23.06-36.5 µg/m3) and NOx (26.54-43.0 µg/m3) was less than the standards. The study has identified vehicular traffic as the root cause of air pollution with contributions from industries and other scattered burning activities (G.C.Kisku et. al. 2003).

The average concentration of PM10 during winters of 2002, 2003 and 2004 was 196.5, 266.8 and 166.3 µg/m^3 in residential, 258.2, 321.7, 211.2 µg/m^3 in commercial and 205.0, 231.5, 198.5 µg/m^3 in industrial area respectively, were above their respective NAAQS of 100 µg/m^3 for residential/ commercial, rural and other areas and 150 µg/m^3 for industrial areas. The Pb concentration in this study ranged 0.07-0.89 µg/m^3. Introduction of CNG buses for public transport in place of diesel-operated threewheelers on the trunk route resulted in lower PM_{10} levels in 2004 (S. Pradhan et.al. 2013).

The Study based on emissions from 2-Wheelers, 3-Wheelers, 4-Wheelers, Light Commercial Vehicles (LCVs) and Heavy Vehicles (HVs) at Lucknow City, India for three consecutive months; February 1, 2014 to April 30, 2014 revealed the concentration of SO_2, PM, CO and NO_2 of selected location was 0.21 µg/m^3, 6.27 µg/m^3, 74.28 µg/m^3 and 40.64 µg/m^3 at Hazaratganj Road where as for Kalidas road it was 0.11 µg/m^3, 2.87 µg/m^3, 35.78 µg/m^3 and 18.77 µg/m^3, respectively. (Tiwari et. al 2014)

The concentration of PM_{10} at 10 locations in city was recorded in the range of 107.6-237.8 µg/m^3 in summer (May, 2005) in Lucknow. It was 146.9 and 178.4 µg/m^3 in residential and commercial areas where as 107.6 µg/m^3 in one industrial area. The relative difference (%) of PM_{10} with NAAQS i.e. the expedience factor ranged from 0.7 in industrial to 2.4 in commercial area. Author also reported that the mean concentration of Fe (1242.10 ng/m^3) was maximum and Cd (6.36 ng/m^3) minimum in the city. The concentration of PM_{10} in air was found higher almost double than NAAQS. For high concentration of PM_{10} in air trace metals Fe, Mn and Mg were found responsible. The adverse health effects of PM10 related to Fe, Mn and Mg may be the reason for frequent hospital visitors. Author commented that the considerable abatement at root levels in the sources of these metals may reduce the concentration of PM_{10} and thus the air quality as well as the health of the city dwellers will certainly improve (K.Sharma et.al. 2006).

In a study at ten locations during May, 2006 in urban area of Lucknow city and one nearby village (control), the values of PM_{10} and SPM were found to be 168.2 and 374.5, 180.2 and 399.5, 141.4 and 327.8, 73.1 and 196.3 µg/m^3 in residential, commercial, industrial and control village respectively. The concentration of SO2 and NOx in this study ranged from 11.7- 32.4 and 14.7-46.0 µg/m^3. The mean concentration of air pollutants (RSPM, SPM, SO_2 and NOx) found in the increasing order of village area (control) <industrial area <residential area <commercial area. In the same study maximum and minimum mean metal concentration was found for Fe (1029.95 ng/m^3) and Cr (6.92 ng/m^3) respectively. Metals like Pb, Cu and Cr showed a significant association with SPM, RSPM, SO_2 and NOx suggesting their inter-dependence (S.C.Barman et.al. 2010).

The PM_{10} concentration (µg/ m^3) in Lucknow city at 4 locations (in residential, commercial and industrial areas) in three different seasons was 187.2 during summer (March-June, 2007), 155.7 during monsoon (July-October, 2007) and 269.0 during winter (November, 2007-February, 2008). While, $PM_{2.5}$ level was 45.6, 39.8 and 212.4 µg/ m^3 during respective seasons. The mass fraction ratio of $PM_{2.5}$ ranged between 0.22-0.92 (avg. 0.42 ± 0.26) and was significantly high during winter season. The results found in this study show that 24 hour mean respirable particulate ($PM_{2.5}$ and PM_{10}) were higher than the respective NAAQS 24 hourly standards of 60 and 100 µg/m^3 respectively and may lead to the substantial burden of disease and premature death in the population. During monsoon and summer $PM_{2.5}$ is about one fourth of PM_{10}, while in winter the ratio increases to 75%. Stronger relationship between $PM_{2.5}$ and PM_{10} is an indication of direct emissions, most likely transport and burning of bio-fuels (P. Pandey et.al. 2012).

In a study conducted at four locations of the city during 2007–09, the average value of PM_{10} and $PM_{2.5}$ was 168.1 (1.7 times) and 87.3 (1.5 times) µg/m^3 higher than their respective NAAQS limits of 100 and 60 µg/m^3. Amongst the metals associated with PM10, maximum Fe and minimum Cd was observed. Concentration of Pb, 40.6 was less than 1000 ng/m^3, while Ni, 35.1 exceeded 20 ng/m^3 limits prescribed by NAAQS-2009. The maximum values of metals were observed during winter. The average level of benzo(a)pyrene (51.96 ng/m^3) was about 50 times higher than the standard value of 1 ng/m^3 (NAAQS-2009, India: annual average). Author suggested that the higher prevalence of diseases viz.; asthma, tuberculosis, pneumoconiosis, chronic bronchitis and lung cancer among Lucknow population can be linked to the high concentration of fine particulates, toxic metals and PAHs found in urban atmosphere (D. Patel et. al. 2013).

In this study conducted at eight locations of the Lucknow city and Sitapur city, in which six locations selected monitoring location of Lucknow and two location of Sitapur city. The value of Reparable Suspended Particulate Matter was in the range of 145.15 to 85.23µg/m^3 in Lucknow city and 98.40 to 89.70µg/m^3 in Sitapur city. The concentration of SO_2 was in the range of 17.61 to 11.23µg/m^3 in Lucknow city and 18.60 to 18.21µg/m^3 in Sitapur city. The concentration of NOx was in the range of 25.11 to 15.11µg/m^3 in Lucknow city and 24.80 to 24.17µg/m^3 in Sitapur city. The concentration of the Reparable Suspended Particulate Matter was above the NAAQS limits in Lucknow city and Sitapur and the concentration of the SO_2 and NOx was within the NAAQS limits in Lucknow city and Sitapur (G.S. Gupta et.al. 2014).

4. DISCUSSION

In Indian cities is air pollution is an increasing rapidly. In the above studies, particulate matter levels in particular were higher than NAAQS and gaseous pollutants were within the limits. As referred to above studies PM_{10} and SPM in the city were observed in the range of 100.4 – 499.4 μg/m^3 and 200.6 – 1088.8 μg/m^3 ; higher than their respective limits (100 μg/m3 NAAQS-2009 and 200μg/m^3 NAAQS-1994), except in a few studies. In some comparative studies in urban area of Lucknow and control (near by village), low levels of PM_{10} and SPM (73.1and 196.3 μg/m^3), which is observed within the NAAQS limits. A few studies referred in this manuscript recorded $PM_{2.5}$ in the range of 76.0- 212.4 μg/m^3, which is observed above the NAAQS limit of 60μg/m^3.

Air pollution level is closely related with metrological conditions. Lucknow city does not have a uniform weather throughout the year and the seasonal variations like summer, winter and Monsoon (Rainy season). In winter season, fog is quite common from late December to late January and In the summer season, which is very hot with dry wind. The concentrations of gaseous compounds were highly dynamic with significant seasonal variation characterized by high winter and low monsoon levels in Lucknow.

The concentration of all the pollutants in city was in general more during winter followed by summer and least during the rainy season. This may be due to low wind speed, less than 5 km/h and high humidity during the winter season in comparison to other seasons. The stable atmospheric conditions hamper the vertical and horizontal turbulence for proper mixing of pollutants with upper air makes the air mass more stagnant. As a result, minimum atmospheric dispersion throughout the planetary boundary layer is observed in the study area. Fog formation during early winter early winter morning dampens the air and increases in density, which results in accumulation of pollutants near the ground breathing zone concentration.

The lack of precipitation during winter months reduces the potential for wet deposition and associated cleansing mechanisms. Conversely, during monsoons, low pollutant concentrations can be ascribed to precipitation driven washout (especially for SO_2 and NO_2). Monsoon rains have the most dramatic effect in lowering the gaseous pollutant levels in the atmosphere. Despite low solubility of oxides of nitrogen in water, rains in the monsoon season effectively reduce their concentrations in the air.

5. CONCLUSION

Lucknow has witnessed significant growth during the last one and half decades and recorded similar trends of air pollution to other cities located in northern Indo Gangetic plains of India. Lucknow has a complex mix of air pollution like any other urban centers. The present review, based on the studies conducted in Lucknow, identified particulate matter as the main air pollutant in the city. Most of the time particulate fractions ($PM_{2.5}$, PM_{10}, SPM) exceeded the NAAQS limits. Gaseous pollutants sulphur dioxide and nitrogen dioxide although remained within the NAAQS limits, but were high enough to cause substantial damage to human and plant health.

The pollution levels in the city have increased in time and space. High traffic densities and abnormal meteorological factors adversely influenced the ambient air quality of Lucknow. Degraded air quality has adverse effects on building, materials, human health and plants. Air pollutants exposure may lead to the substantial burden of disease and premature death. Number and mass concentration, shape, size, composition of particulates and presence of co-pollutants determines their detrimental effects.

The estimated high values of excess cancer risk for metals associated with PM_{10} and $PM_{2.5}$ in a study suggest the potential risk to cancer. Fine particulates less than 2.5 micron are the carriers of metals and are loaded with reactive species including PAHs which can pierce the alveoli and diffuse into the blood system, transported to other organs and may cause systemic poisoning. Lucknow reported high air pollution in high traffic density zones than the control sites with low traffic density. Plants in general are exposed to ambient air pollution but roadside plants are exposed to extreme level of air pollutants.

6. RECOMMENDATIONS

India needs to generate regular information on the ambient concentration levels of repairable particulates and take urgent steps to control their emissions. There is an urgent need to adopt suitable strategies for air quality control to improve urban air quality. Exposure to air pollutants is largely beyond the control of individuals and requires action by public authorities at the national, regional and local levels. City's proposed master plans of 2021 and 2031 have envisaged expansion of the city up to proposed new ring road of about a length of 150 km. The estimated population of city would be about 45 lakh by 2021.

These are some recommendation for improvement of the ambient air quality:

- Public mass transport must be strengthened to minimize use of personal vehicle.
- Improvement in the traffic management.
- Encroachment should be removed for smooth flow of traffic.
- Check on fuel adulteration.
- Regular sweeping of roads to avoid re- suspension of soil dust.
- Increase use of alternative fuel e.g. CNG.

ACKNOWLEDGEMENT

The authors are thankful to the anonymous reviewers for their valuable suggestion which helped a lot in enhancing the quality of this review paper.

REFERENCES

[1] Barman S.C., Kumar N., Singh R., Kisku G.C., Khan A.H.,Kidwai M.M., Murthy R.C., Negi M.P.S., Pandey P.,Verma A.K.,Jain G. and Bhargava S.K., Assesment of urban air pollution and it's probable health impact, *J. Environ. Biol.*, 31(6), 913-920, (2010).

[2] Bhargava S. K., Kumar S., Mathur N. And Srivastava A.K., A study of environmental exposure to PAHs in economically underprivileged population of urban/rural areas of Uttar Pradesh, *Reconciling Environment and Economics : Executive Summaries of EERC Projects by :Environmental Economics Research Committee,* 274-282, (2003).

[3] G.S.Gupta, M.K. Gupta, "Ambient Air Quality status in Lucknow city and sitapur city (U.P.)". (2014) vol-IV Toxicol., 77, 419-426,(2006).

[4] Kisku G. C., Salve P. R., Kidwai M.M. Barman S.C., Khan A. H., Singh R., Misra D., Sharma S. and Bhargava S. K., A random survey of ambient air quality in Lucknow city and it's possible impact on environmental health, *Ind. J. Air Poll. Cont.,* 3(1), 45-58, (2003).

[5] Pandey P., Khan A. H., Verma A. K., Singh K. A., Mathur N., Kisku G. C. And Barman S.C., Seasonal treands of PM2. and PM10 in ambient air and their correlation in ambient air of Lucknow city, India, *Bull. Environ. Contam.Toxicol.*, 88(2), 264-270, (2012).

[6] Patel D. K., Pandey P., Khan A. H., Barman S. C., Murthy R. C. and Kisku G. C., Temporal distribution of fine particulates (PM2.5, PM10), potentially toxic metals, PAHs and metal-bound carcinogenic risk in the population of Lucknow city, India, *J. Environ. Sci. Heal.*, Part A, 48(7), 730-745, (2013).

[7] Pradhan A., Waseem M., Dogra S., Khanna A. K. and Kaw J. L., Trends of metals in the respirable particulates: a comparative seasonal study in Lucknow city, Poll. Res., 23(3), 445-450, (2004).

[8] Pradhan S., Kisku G.C., Khan A.H. and Bhargava S.K., Pollution in Lucknow city and its health implication on exposed vendors, drivers and traffic policemen, *Air Qual. Atmosp. Heal.*, 6(2), 509-515, (2013).

[9] Sharma K., Singh R., Barman S.C., Mishra D., Kumar R., Negi M.P.S., Mandal S.K., Kisku G.C., Khan A.H., Kidwai M.M. and Bhargava S.K., Comparison of trace metals concentrations in PM10 of different locations of Lucknow city, *Bull. Environ. Contam. Toxicol.*, 77(3), 419-426, (2006).

[10] Sharma, G. D., Verma, A.K., Saxena, A., Khan, Md.B.., "Air pollution problems in Lucknow city, India: A Review". '(2015), vol.9 (4).

[11] T. Banerjee, S. C. Barman, R.K. Srivastava, Application of air pollution dispersion modelling for source-contribution assessment and model performance evolution at integrated industrial estate-Pantnagar865-875,(2011).

[12] Tiwari M., Shukla SP, Shukla NK, Singh RB, Mumtaz N, Gupta VK and Kumar V . Emission profile of pollutants due to traffic in Lucknow City, India International Research Journal of Public and Environmental Health Vol.1 (7),pp. 150-157, 2014.

[13] Verma A., Singh S.N. and Shukla M.K., Air quality of transgomti area of Lucknow city, India, *Bull. Environ. Contam. Toxicol*., 70(1), 166-173, (2003).