Emission Profile of Heavy Metal Pollutants in Ambient Air of Lucknow City (U.P.)

Neha Mumtaz[1], Anshika Yadav[2], Tabish Izhar[3]
[1,3] Assistant Professor, Department of Civil Engineering
Integral University, Lucknow, India
[1] nehamumtaz@iul.ac.in
[3] tizhar@iul.ac.in
[2]M.Tech Environmental Engineering
Department of Civil Engineering, Integral University, Lucknow, India
[2] anshika1910yadav@gmail.com

***Abstract*— The objectives of this study is (1) To assess the ambient air quality with respect to Particulate Matter ($PM_{2.5}$ & PM_{10}) and heavy metal lead (Pb), nickel (Ni). (2) To the preliminary information of the study area and principal source of pollution. (3) To study trends of pollutants over a period of time, to create a database for future use and space. In the last few decades, the human behaviours have changed the global atmospheric condition, the present study deals with the quantitative effect of vehicular emission on ambient air quality during Dec2016- Feb 2017 in three locations viz. Aliganj (Residential area), Gomtinagar (Commercial cum traffic area), Talkatora (Industrial area) of Lucknow city. The air quality was based on measuring four air pollutants namely Particulate Matter ($PM_{2.5}$ & PM_{10}), and Heavy Metal Lead (Pb) & nickel (Ni). The $PM_{2.5}$ level at all the locations were higher than the NAAQS limits .The PM_{10} levels at all the monitoring locations were higher than the NAAQS limits. The concentrations of the Heavy Metal Lead (Pb) and Nickel (Ni) higher at all locations than the NAAQS limit. Heavy vehicular density and construction activity at road side, unpaved road is the causes of increase particulate matter in atmosphere.**

Keyword - Air quality, Air pollutants, Particulate Matter ($PM_{2.5}$ & PM_{10}), Lead (Pb), Nickel (Ni)

I. INTRODUCTION

In the present scenario, Environmental pollution is a common problem in both developing countries and developed countries[1]. Ambient air pollution has become a matter of grave concern, particularly in megacities and urban areas and rapid industrial development coupled with emission from transport sector are recognized as the prime source [2]. The contaminants or pollutants may generate from the natural sources as well as human activities. Population growth, urbanization, economic development, transportation needs and rapid increase in energy consumption are major driving force of air pollution in large cities, especially in megacities.

The urban population is mainly exposed to high levels of air pollution including metals as well as fine and ultra fine particles from the vehicular emission [3]. Every city has its own characteristics which becomes the pull factor for its growth and development and developmental progress, if not checked poses risks to environment and health of people [1].

Air pollution is defined as the presence in the external atmosphere of one or several substances introduced by man to such as extent as to affect health and welfare of human system and the life in atmosphere [4]. Air pollution is caused due to both gaseous pollutants (Oxide of nitrogen, Oxide of sulphur, Oxide of carbon) & particulate pollutants (Organic and Inorganic). Heavy metals are particulate inorganic pollutants released in the atmosphere through natural and man-made processes. Heavy metals are relatively dense and toxic at low concentration [5]. Heavy metals can be transported from one place to another air through wind blow dust [6]. Several pollutant may be directly emitted by human activities where as the others may be formed in the air with the effect of sunlight, as in photochemical smog. The particles may range from carbonaceous sooty to heavy metal complex organic compound as well as nuclear fallout. They may have a periodicity which is especially manifested in the biological pollutants, including the airborne spores [7].

Air pollution can cause several adverse effects health and building. Pollutants may cause several diseases such as respiratory diseases, including asthma, bronchitis, eye-irritation etc, to human being living in the surroundings of the industries. Thus we can see that both air and water pollution emerging from industries is very seriously concern to the human health and environment [4].

Particulate Matter ($PM_{2.5}$) - The increases in particulate matter have been shown to cause small, reversible decrement in lung function in normal asymptomatic children, and in both adults and children who have some form of pre-existing respiratory condition, particularly asthma. These changes were often accompanied, especially in adults, by increases in symptoms such as chronic bronchitis or cough.

Particulate Matter (PM_{10}) - This is associated with aesthetic and environmental impacts such as soiling of materials or smothering of vegetation. it may pose the greatest threat to human health because, for the same mass, they absorb more toxic and carcinogenic compounds than larger particles and penetrate more easily deep into the lungs.

The respirable particles are responsible for the cardiovascular as well as respiratory diseases of human being because these particles can penetrate deep into the respiratory system, and studies indicates that the smaller the particle, more severe the health impacts [8].

Lead (Pb) – Prolonged exposure can cause damage to the nervous system, digestive problems, and in some cases cause cancer. It is especially hazardous to small children.

Nickel (Ni) – Nickel is one of many carcinogenic metals known to be an environmental pollutant. Chronic exposure has been connected with increased risk of lung cancer, cardiovascular disease, neurological deficits, and developmental deficits in childhood and high blood pressure.

There are several reports that high level of Pb can induce severe neurological and haematological effects on the exposed population especially children, where as Ni are known for inducing carcinogenic effects in humans through inhalation [9].

Lucknow is popularly known as the City of Nawabs. It is also known as the Golden City of East and 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. In view of above facts, it needs to monitor the ambient air quality of Lucknow city. The percentage contribution from various sources is as shown in Table I.

Table I. The percentage contribution of various air pollutants from various sources

Sources	Percentage (%)
Roadside dust	14-29
Vehicles	9-20
Industries	6-9
Construction	23
Domestic	3-9
DG sets	7-12

The level of Particulate Matter ($PM_{2.5}$ & PM_{10}) and Heavy metal Lead (Pb) and Nickle (Ni) was measured to check the ambient air quality at three different activity areas of the Lucknow city.

II. LITERATURE REVIEW

M. Tiwari et. al. [10] studied about the emission of the pollutant SO_2, NO_2, CO and Particulate matter from the 2-Wheelers, 3-Wheelers, 4-Wheelers, Light commercial vehicles (LCVs) and Heavy vehicles (HVs) at Lucknow city for three consecutive months Feb to April. The contribution of emission of SO_2 or PM was less and the contribution of emission of CO or NO_2 was high. The concentrations of above pollutants were more at Hazartganj Road as compare to Kalidas Road. The emission profile of SO_2, PM, CO and NO_2 were within in national ambient air quality standard.

G. S. Gupta et. al. [4] studied about the ambient air quality status Lucknow city and Sitapur and presents the concentration of RSPM, SOx and NOx at eight different location of Lucknow city and Sitapur. The concentration of suspended solid pollutants was found above the permissible limit in most of the sites while the concentration of gaseous pollutants was found within the permissible limit as per the standards given by Central Pollution Control Board (CPCB).

P. Pandey et. al. [11] in this study was to assess the magnitude of air pollution risks to public health by determining four crucial parameter– inhalable particulates, metals in particulates and PAHs which are associated with PM10 in the air environment of Lucknow. The average values of PM_{10}, $PM_{2.5}$, Ni, and Benzo(a)pyrene are higher than the safe limits prescribed by NAAQS, indicating the critical pollution levels in the city. The higher prevalence of diseases among the population may be due to high concentration of particulate coated with toxic metals and PAHs present in air environment.

S.C. Barman et. al. [9] in this study deals with the effect of fireworks on ambient air quality during Diwali festival in Lucknow city. In this, PM_{10}, SO_2, NOx and trace metals associated with PM_{10} were estimated at four location during day and night times for pre diwali and diwali day. When compared with the respective concentration of pre diwali and normal day. On the diwali day, 24 H values for PM_{10}, SO_2 and NOx were found

to be higher than prescribe limit of National Ambient Air Quality Standards (NAAQS) and expontionally high for PM_{10}. The 24H mean concentration of metal associated with PM $_{10}$ was found to be in the order of Ca>Fe>Zn>Cu>Pb>Mn>Co>Cr>Ni>Cd in ng/m3 and all these values were found to be higher than the pre diwali and normal day.

G.D. Sharma et. al. [12] in this study is to analyze the air pollution status of Lucknow city, associated environmental and health impacts and possible control measures presented in studies on Lucknow. Particulate fractions viz: $PM_{2.5}$, PM_{10},& SPM were reported to exceed the Nation Ambient Air quality Standard (NAAQS) limit but oxide of sulphur & nitrogen (SOx & NOx) were within the limit of 80μg/m^3. Lack of dispersion of pollutants in winter season was reported to be the main reason for highest air pollution during this season & minimum in monsoon due to washout by rains. The rapid growth of Lucknow city in term of area, population & number of registered vehicles, planning & implementation of suitable air pollution control measures are necessary to protect the health of its citizens.

Saroj kumar Sahu et. al. [13] studied on the system of Air quality Forecasting and Research (SAFAR) project developed for air quality forecasting during the Commonwealth Games (CWG)-2010, a high resolution Emission Inventory (EI) of PM_{10} & $PM_{2.5}$ has been developed for the metropolitan city Delhi for the year 2010. It has been found that the total emission of PM_{10} & $PM_{2.5}$ is 236 Gg yr^{-1} & 94 Gg yr^{-1} respectively over NCRD. The transport sector which has direct contribution through fossil fuel combustion and indirect related to road condition provide the key to air quality.

Ateeque Ahmad et. al. [1] studied about the ambient air quality status in Firozabad city, which assessed based on measuring four air pollutant namely suspended particulate matter (SPM), Respirable Suspended Particulate Matter (RSPM), Oxides of nitrogen(NOx) and Sulphur dioxide (SO_2). It has been found that the average concentration of SPM and RSPM at all the locations in each year has exceeded the prescribe limit by NAAQS. Apart from this SO_2 and NO_2 levels remain under prescribed limit with minor fluctuations.

S.K.Bhargava et. al. [8] in this study deals with the quantative effect of vehicular emission on ambient air quality in urban area of Lucknow city. In this study SPM, RSPM, SO_2, NOx & 7 trace metals (Fe, Zn, Cu, Pb, Mn, Ni, Cr) associated with RSPM were estimate at 10 representatives in urban area & one village areas for control. In this ambient air quality in the urban area is affected adversely due to emission and accumulation of SPM, RSPM, SO_2, NOx and trace Metals. These pollutant may pose detrimental effect on human health, as exposure of these are associated with cardiovascular & respiratory diseases, neurological impairments increased risk of preterm birth & even mortality & morbidity.

Srimanta Gupta et. al. [14] studied about the concentration of Particulate Matter (PM_{10}), oxide of sulphur, oxide of nitrogen, & ozone (O_3) have been monitored from Feb 2013 to May 2013 over Gopalpur village in Durapur. The temporal variations of the concentrations of PM10, SOx, NOx & O_3 have been explored & their relationships with different metrological parameters have been identified, which is shows that ozone has positive correlation with temperature & high negative correlation with humidity. Atmospheric concentration of selected heavy metals including lead (Pb), Copper (Cu), Manganese (Mn), & Cadmium (Cd) were also measured followed by the analysis of their probable sources. Industrial emission, vehicular exhaust, open biomass burning, mining etc. have been identified as the probable sources of the pollutants in the ambient atmosphere of Gopalpur**.**

C. Vijayanand et. al. [15] studied about the estimate the concentration of various heavy metals in Suspended Particulate Matter (SPM)of ambient air in coimbatore city identified a part of urban area with high level of SPM. And also it was found to have low concentration of heavy metals.The level of SPM found to be either at permissible or non-permissible limit depending upon the category of the sampling station. Concentration of Zn were found to be maximum than other heavy metal. The order of average concentration of heavy metals in comibatore atmospheric air was Zn>Fe>Cu>Pb>Cr>Ni>Cd. For the higher concentration of the heavy metal Zn by the protective coating on iron, steel etc. & other industries in comibatore city.

Ashish Dhamaniya et. al. [16] studied about the air pollution level in Agra city, as the Taj Trapezium zone being declared as a sensitive region by MoEF, GoI. Data on the SPM, RSPM, SO_2,NO_2 for all the days of the year and conclude that the GIS technology to have a clear vision on the pollution level during summer and winter season and it is seen that pollution level is more in winter season rather than the summer.

III.METHODOLOGY

A- Study area

Lucknow city (Fig 1) is the capital of Uttar Pradesh, one of the fast growing metropolises in India has been suffering from air pollution for the last two decades. In the last two decades the rapid urbanization and industrialization has been catalyzing this problem. Lucknow, which has a population of 3.3 million (Municipal corporation and cantonment), area of 310 km2 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. Vehicular traffic is main source of particulate air pollution in Lucknow city.

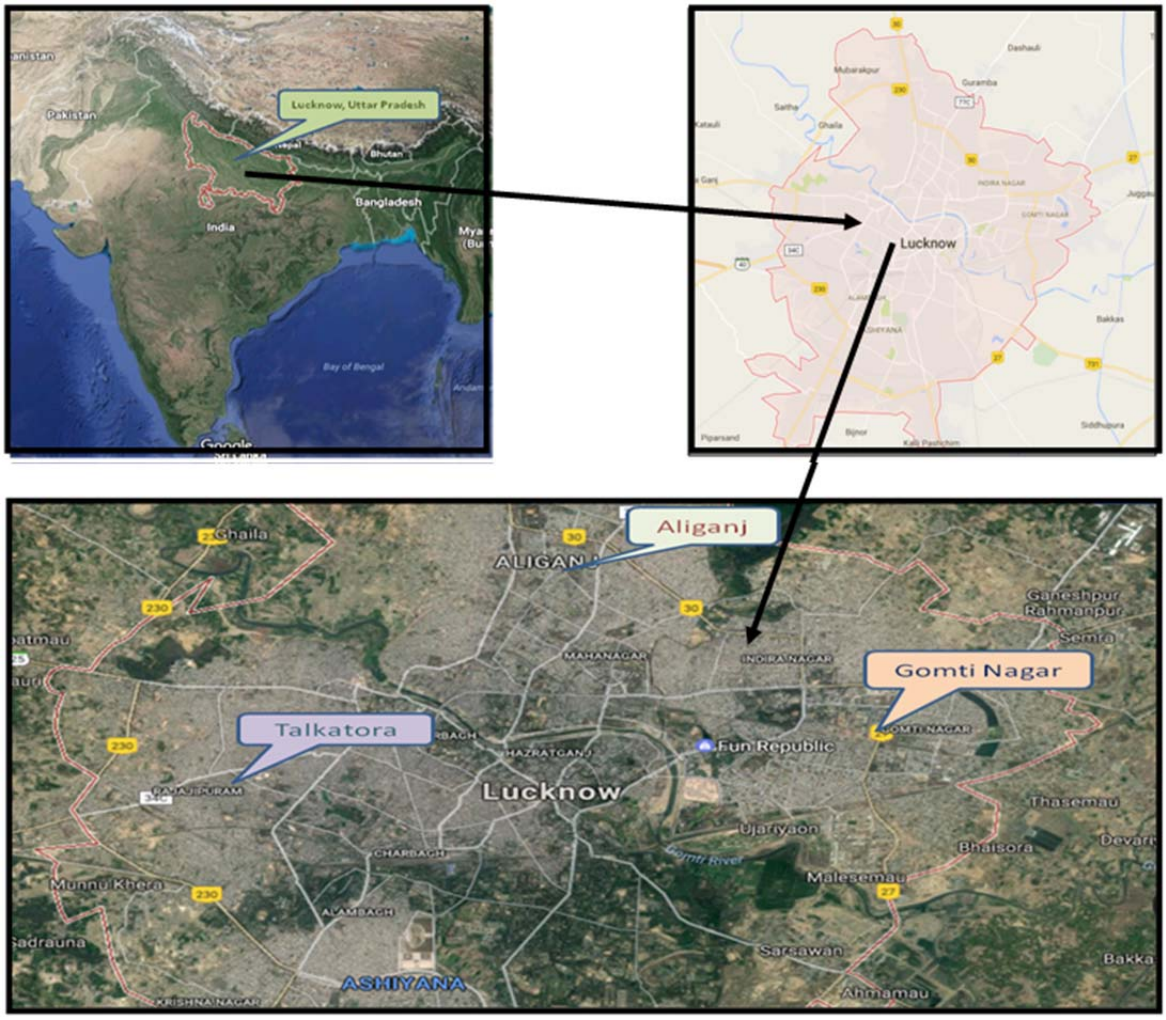

Fig-1 Location Map of Lucknow City

B- Methodology

Monitoring and Analysis

Monitoring of Particulate Matter ($PM_{2.5}$ & PM_{10}) was carried out using Respirable Dust Sampler (Model Envirotech) at a flow rate of 1.0-1.2 m3/ min for 24 hour (6:00Am to 6:00Am). The respirable Dust Sampler (RDS) has been provided with a cyclone for the separation of $PM_{2.5}$. The suspended particles enters the cyclone, coarse, non-respirable dust is separated from the Air steam by centrifugal forces. The suspended particulate matter falls through the cyclone's conical hopper and gets collected in the cyclonic-cup. This fine dust comprising the respirable fraction of Particulate Matter ($PM_{2.5}$) passes through the cyclone and gets collected on filter paper. [17]

Preweighted cellulose filters, Whatman (EPM- 2000) of 20x 25 cm size were used and reweighted after sampling in order to determine the mass of the particles collected $PM_{2.5}$. The concentration of the particulate matter in the ambient air was then computed on the net mass collected divided by the volume of air sampled. The amount of non- respirable suspended particulate matter (NRSPM) was summed up with Respirable Particulate Matter $PM_{2.5}$ for calculation of PM_{10}. The sampling instrument was fixed at a breathing height of 1.5 m above the ground level. [17]

Metal Analysis

Cut a 1"x 8" strip or half the filter from the 8" x 10" filter using a stainless steel pizza cutter + 1 blanked (unexposed filter paper) were punched out in triplet from the sampled filter paper and digested with concentrated nitric acid on hot plate till white fumes arose and reduce to 2-3 ml. The content was filtered through Whatman filter paper no. 42 and final volume make up to 25 ml by double distilled water. The filtrate

was examined for the concentration of Pb and Ni by Atomic Absorption Spectrophotometer (AAS) (Model Lab INDIA). The AAS values of blank filter papers of each metal were deducted from the sample value for final calculations. [17]

IV. RESULTS AND DISSCUSSION

Lucknow city is the capital city of Uttar Pradesh in india. Lucknow is an administrative headquarters of Lucknow District and Lucknow Division. It is historically known as the Awadh region, Lucknow has always been a multicultural city. Lucknow is popularly known as the City of Nawabs. It is also known as the Golden City of the East and is rapidly emerging as a manufacturing, commercial and retailing hub. Lucknow has developed as a metro city of Uttar Pradesh and is second largest city in the states. Lucknow, which has a population of 3.3 million ,area of 310 km2 and its graphical position is $26^0$52'N latitude to $80^0$56'E longitude; 128m above the sea level. Vehicular traffic is main source of particulate air pollution in Lucknow city. The number of different categories of vehicles registered with RTO (Regional Transport Office) Lucknow is 15, 52,695 as on 31.03.2014 which is 9.0% higher over the last year. Uttar Pradesh State Transport Corporation (UPSRTC) introduced bus services under the banner "Lucknow Mahanagar Parivahan Sewa" on different routes of Lucknow city. In Lucknow city there are 100 filling stations for petrol, diesel and CNG operated by different oil companies.

As per Indian Oil Corporation (IOC), the consumption/ sale of petrol and diesel were 1, 38,755 and 1, 55,226 KL as on 31-03-2014. It is observed that petroleum sale has increased by 8.03% whereas sale of diesel has increases by 13.41%. In Lucknow there are six CNG filling stations and consumption of CNG in the last year was approximately 2, 62, 55,742 Kg (2013-14) which was 10.26% higher than the previous year (2012-13) (Green Gas Limited, Lucknow). [18]

The result of ambient air quality parameters of Lucknow city were compared with their reference range prescribed by CPCB 2009. Their comparison of different parameters such as Particulate Matter ($PM_{2.5}$ & PM_{10}) and heavy metal lead & nickel are mentioned in Table II.

TABLE I. CONCENTRATION OF $PM_{2.5}$, PM_{10}, LEAD (PB), NICKLE (NI)

S No.	Location	Parameter	Minimum	Maximum	Average
1.	Aliganj	**$PM_{2.5}$** ($\mu g/m^3$)	74.24	172.33	124.77
		PM_{10} ($\mu g/m^3$)	140.14	352.84	244.42
		Lead ($\mu g/m^3$)	19.62	48.24	30.04
		Nickel (ng/m^3)	10.37	32.52	21.75
2.	Gomti Nagar	**$PM_{2.5}$** ($\mu g/m^3$)	62.45	178.86	116.68
		PM_{10} ($\mu g/m^3$)	112.38	338.24	243.18
		Lead ($\mu g/m^3$)	18.78	58.08	35.36
		Nickel (ng/m^3)	8.34	31.06	20.62
3.	Talkatora	**$PM_{2.5}$** ($\mu g/m^3$)	65.15	192.46	125.46
		PM_{10} ($\mu g/m^3$)	151.24	356.15	255.50
		Lead ($\mu g/m^3$)	16.26	68.19	41.96
		Nickel (ng/m^3)	11.24	36.41	20.5

Respirable Suspended Particulate matter ($PM_{2.5}$)

The graph show (as shown in fig -2) that the minimum concentration of $PM_{2.5}$ in the Aliganj (residential area), Gomti nagar (commercial area) & Talkatora (industrial area) is 74.24$\mu g/m^3$, 62.45$\mu g/m^3$ & 65.15$\mu g/m^3$ respectively is above the permissible limit of the NAAQS standards.

The maximum concentration of $PM_{2.5}$ in the Aliganj (residential area), Gomti nagar (commercial area) & Talkatora (industrial area) is 172.83$\mu g/m^3$, 178.86$\mu g/m^3$ & 192.46$\mu g/m^3$ respectively is above the permissible limit of the NAAQS standards.

The average concentration of $PM_{2.5}$ in the Aliganj (residential area), Gomti nagar (commercial area) & Talkatora (industrial area) is 124.77$\mu g/m^3$, 116.68$\mu g/m^3$ & 125.36$\mu g/m^3$ respectively is above the permissible limit of the NAAQS standards.

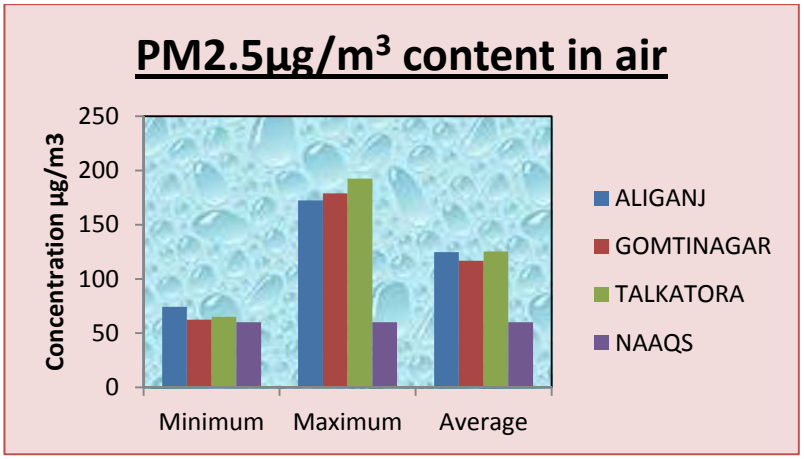

Fig-2: Concentration of $PM_{2.5}$ in different location of Lucknow city during Dec2016-Feb2017

Suspended Particulate matter (PM_{10})

The graph show (as shown in fig -3) that the minimum concentration of PM_{10} in the Aliganj (residential area), Gomti nagar (commercial area) & Talkatora (industrial area) is 140.14µg/m^3, 112.38µg/m^3 & 151.24µg/m^3 respectively is above the permissible limit of the NAAQS standards.

The maximum concentration of PM_{10} in the Aliganj (residential area), Gomti nagar (commercial area) & Talkatora (industrial area) is 352.84µg/m^3, 338.24µg/m^3 & 356.15µg/m3 respectively is above the permissible limit of the NAAQS standards.

The average concentration of PM10 in the Aliganj (residential area), Gomti nagar (commercial area) & Talkatora (industrial area) is 244.42 µg/m^3, 243.18µg/m^3 & 255.50µg/m^3 respectively is above the permissible limit of the NAAQS standards.

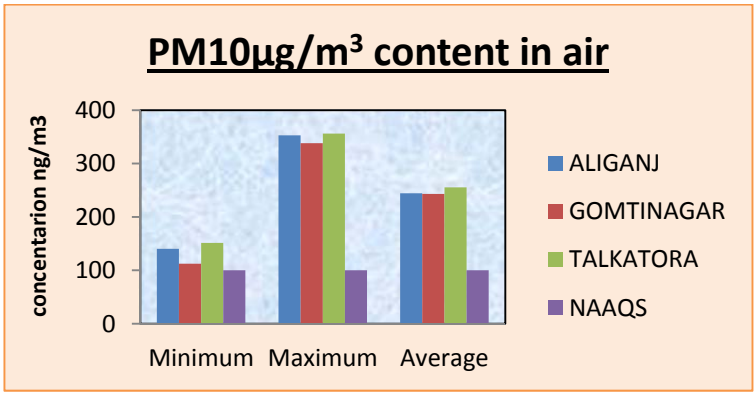

Fig-3: Concentration of PM10 in different location of Lucknow city during Dec2016-Feb2017

Heavy Metal Lead (Pb)

The graph show (as shown in fig -4) that the minimum concentration of Pb in the Aliganj (residential area), Gomti nagar (commercial area) & Talkatora (industrial area) is 19.62µg/m^3, 18.78µg/m^3 & 16.26µg/m^3 respectively is above the permissible limit of the NAAQS standards.

The maximum concentration of Pb in the Aliganj (residential area), Gomti nagar (commercial area) & Talkatora (industrial area) is 48.24µg/m^3, 58.08µg/m^3 & 68.19µg/m^3 respectively is above the permissible limit of the NAAQS standards.

The average concentration of Pb in the Aliganj (residential area), Gomti nagar (commercial area) & Talkatora (industrial area) is 30.04µg/m^3, 35.36µg/m^3 & 41.96µg/m^3 respectively is above the permissible limit of the NAAQS standards.

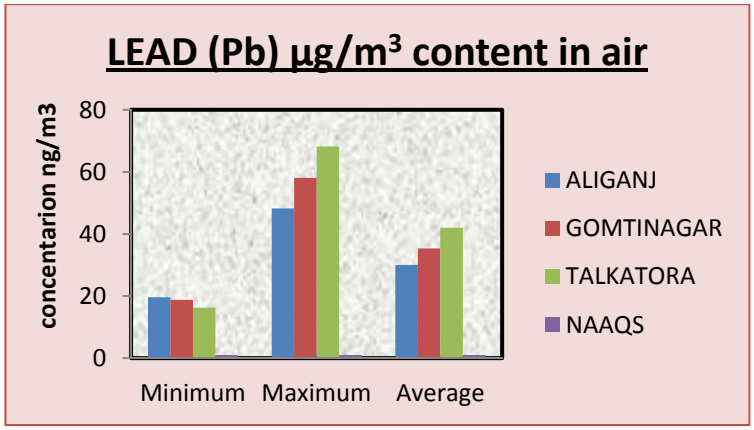

Fig-4: Concentration of Lead (Pb) in different location of Lucknow city during Dec2016-Feb2017

Heavy metal nickel (Ni)

The graph show (as shown in fig -5) that the minimum concentration of Ni in the Aliganj (residential area), Gomti nagar (commercial area) & Talkatora (industrial area) is 10.37ng/m^3, 8.34ng/m^3 & 11.24ng/m^3 respectively is above the permissible limit of the NAAQS standards.

The maximum concentration of Ni in the Aliganj (residential area), Gomti nagar (commercial area) & Talkatora (industrial area) is 32.52ng/m^3, 31.06ng/m^3 & 36.41ng/m3 respectively is above the permissible limit of the NAAQS standards.

The average concentration of Ni in the Aliganj (residential area), Gomti nagar (commercial area) & Talkatora (industrial area) is 21.75ng/m3, 20.62ng/m3 & 20.54ng/m3 respectively is above the permissible limit of the NAAQS standards.

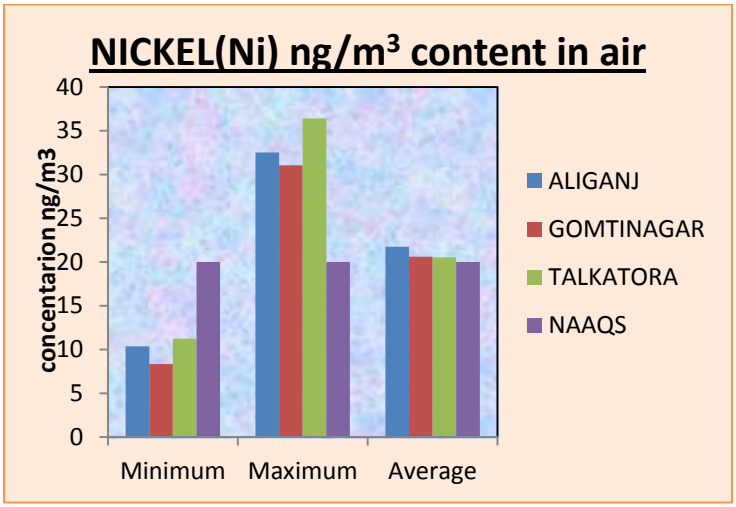

Fig-5: Concentration of Nickel (Ni) in different location of Lucknow city during Dec2016-Feb2017

V. Conclusion

The monitoring at 3 locations viz: Aliganj, Gomtinagar, And Talkatora were undertaken during winter season (Dec 2016 - Feb 2017) at Lucknow. The assessment of ambient air quality was undertaken on the basis of following air pollutants which were particulate matter (PM2.5 & PM10), heavy metal lead (Pb) & nickel (Ni). The rspm (pm2.5) level at aliganj is above the naaqs limits of 60µg/m3 and in the Gomtinagar and Talkatora is higher than the NAAQS limits of 60µg/m^3. The spm (PM10) levels at all the monitoring locations were higher than the NAAQS limits of 100µg/m^3. The concentrations of the heavy metal lead (pb) higher at all locations than the NAAQS limit 1.0µg/m^3. The concentrations of the heavy metal nickel (ni) higher at all locations than the NAAQS limit 20ng/m^3. Overall results indicate that PM2.5 and PM10 are one of the major causes for deterioration of ambient air quality in Lucknow city. Heavy vehicular density and construction activity at road side, unpaved road is the causes of increase particulate matter in atmosphere. These are some recommendation for improvement of the ambient air quality viz. 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 and increase use of alternative fuel e.g. CNG.

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