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Characterization of Air Pollutants in Sub-Urban Area of Lucknow

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***Abstract* - In Indian cities, air pollution are mostly visible now days due to rapid increase in urbanization, commercialization and industrialization. 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. Indira nagar (Residential area), Alambagh (Commercial area), Amousi (Industrial area) of Lucknow city. The air quality was based on measuring Specific air pollutants namely Particulate Matter ($PM_{2.5}$ & PM_{10}), and gaseous pollutant sulphur dioxide (SO_2), nitrogen dioxide (NO_2) & Heavy Metal Lead (Pb) & nickel (Ni). The $PM_{2.5}$ & PM_{10} level at all the locations were higher than the NAAQS limits. The SO_2 & NO_2 levels at Indira nagar were below than the NAAQS limits and in Almabhag & Amousi, NO_2 concentrations were higher than the NAAQS limits. At all locations, the concentrations of the Heavy Metal Lead (Pb) and Nickel (Ni) higher than the NAAQS limit.**

Keywords: Air quality, Air pollutants, Particulate Matter ($PM_{2.5}$ & PM_{10}), SO_2 & NO_2, Lead (Pb) & Nickel (Ni).

I.INTRODUCTION

Most of the developing countries are facing the problem of air pollution due to pressure from increasing population, transport, industrialization and other activities (Chaudhari et.al. 2015). 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. (Mumtaz et al. 2017)

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 sources (Banerjee et.al. 2011). 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 (Sharma et. al. 2006). 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 (Ahmad et.al. 2015).

Air pollution associated with these activities and its adverse impacts on human health and welfare is a key environmental problem faced by all mega cities in India (Sahu et.al. 2011).Rapid increases of vehicular as well as human population is the major concern, because are responsible for environment and human health. 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 (Gupta et.al. 2006).

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 (USEPA 1996). Heavy metals can be transported from one place to another air through wind blow dust (US EPA 1999).

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 (Sharma et.al. 2013). Pollutants released in the ambient environment interact with other existing pollutants and micrometeorological factors may form more intricate pollutants and that are more harmful to human health. A large number of urban people are at the edge of health risk due to adverse air quality (Tiwari et. al 2014).

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 (Guptaet.al. 2006). Nitrogen dioxide (NO_2) and carbon monoxide (CO) are good indicators

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of traffic exhaust emissions as they contribute most of the total emission. Epidemiological studies have shown that short- term exposure to NO_2 and CO is associated with increased cardiovascular mortality, including cerebrovascular diseases and ischemic heart disease.

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. 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 (Bahargava et.al. 2010).

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 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 (Berman et.al. 2008).

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 1-

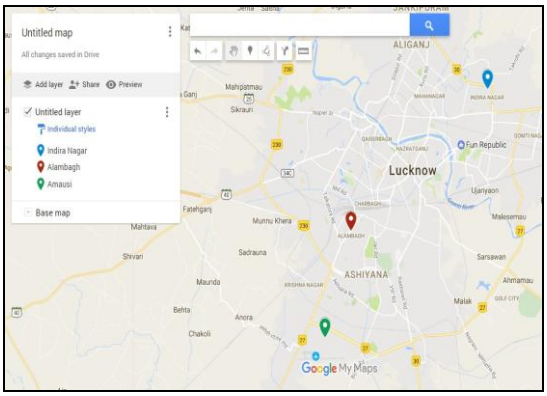

Fig-1 Location Map of Lucknow City

TABLE 1- THE PERCENTAGE CONTRIBUTION FROM VARIOUS SOURCES

Sources	Percentage (%)
Roadside dust	15 - 30
Vehicles	10 - 22
Industries	8 - 12
Construction	25
Domestic	5 - 10
DG sets	8 - 15

The level of Particulate Matter ($PM_{2.5}$ & PM_{10}) and gaseous pollutant (SO_2 & NO_2), Heavy metal Lead (Pb) and Nickel (Ni) was measured to check the ambient air quality at three different activity areas of the Lucknow city. To The objectives of the present study are to assess the ambient air quality with respect to Particulate Matter ($PM_{2.5}$ & PM_{10}) and gaseous pollutant (SO_2 & NO_2), heavy metal lead (Pb), nickel (Ni): To the preliminary information of the study area and principal source of pollution. To study trends of pollutants over a period of time, to create a database for future use and space.

II.STUDY AREA

Lucknow city 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 26052'N latitude to 80056'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.

The present study deals with the quantitative effect of vehicular emission on ambient air quality during Dec2016-Feb 2017 in three locations viz. Indira Nagar (Residential area), Alambagh (Commercial area), Amousi (Industrial area) of Lucknow.

III.DATABASE AND METHODOLOGY

A. 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 (CPCB 2009).

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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 (CPCB 2009).

The analysis of SO_2 and NO_2 was done by Bureau of Indian Standard (BIS) methods Indian standard (2001): IS: 5182 (Part II) and Indian Standard (1975): IS: 5182 (Part VI), respectively. A known quantity of air was passed through the impinger containing known volume of absorbing solution; SO_2 is absorbed in absorbing solution, sodium tetracholoromercurate. A dichlorsulphitomercurate complex is formed which made to react with para rosaniline and methysulphonic acid. The absorbance of the solution was measured at a wavelength of 560nm on spectrophotometer. Whereas, Nitrogen dioxides was absorbed in absorbing solution, sodium hydroxide which formed a stable solution, sodium hydroxide which formed a stable solution, sodium nitrite. The nitrite ion produced was determined colorimetrically at a wavelength 540 nm by reacting the exposed absorbing reagent with phosphoric acid, sulphanilamide and N (1 – naphthyl) ethylenediamine dihydrochloride.

B. 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 (CPCB 2009).

IV.RESULTS AND DISCUSSION

Lucknow city is the capital city of Uttar Pradesh in India. Which is a fast growing city, In 1951, area of Lucknow was 48 sq km which has now increased to 310 sq km in 2011. 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 26052'N latitude to 80056'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).

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 gaseous pollutant (SO_2 & No_2), heavy metal lead & nickel are shown in table 2.

Table 2- CONCENTRATION OF $PM_{2.5}$, PM_{10} SO_2 & NO_2 LEAD (PB), NICKEL (NI)

S No.	Location	Parameter	Minimum	Maximum	Average
1.	Indira Nagar	$PM_{2.5}$ µg/m3	68. 9	185.4	171.6
		PM_{10} µg/m^3	155.6	362.7	284.9
		SO_2 µg/m^3	12.7	25.8	17.5
		NO_2 µg/m^3	36.5	59.8	49.5
		Lead µg/m^3	21.6	51.4	34.8
		Nickel µg/m^3	12.7	35.6	26.8
2.	Alambagh	$PM_{2.5}$ µg/m^3	71.5	192.4	176.6

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		PM_{10} µg/m^3	159.4	368.8	286.2
		SO_2 µg/m^3	13.5	27.9	18.2
		NO_2 µg/m^3	48.8	84.7	68.7
		Lead µg/m^3	24.8	56.9	38.7
		Nickel ng/m3	15.8	38.9	28.2
3.	Amousi	$PM_{2.5}$ µg/m^3	75.4	198.7	182.6
		PM_{10} µg/m^3	165.4	376.8	294.4
		SO_2 µg/m^3	15.3	32.5	22.7
		NO_2 µg/m^3	52.8	86.2	72.4
		Lead µg/m^3	28.6	62.8	46.8
		Nickel ng/m^3	18.9	40.5	32.4

A. 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 Indira nagar (residential area), Alambagh (commercial area) & Amousi (industrial area) is 68.9µg/m^3, 71.5µg/m^3 & 75.4µg/m^3 respectively is above the permissible limit of the NAAQS standards.
- The maximum concentration of $PM_{2.5}$ in the Indira nagar (residential area), Alambagh (commercial area) & Amousi (industrial area) is 185.4µg/m^3, 192.4µg/m^3 & 198.7µg/m^3 respectively is above the permissible limit of the NAAQS standards.
- The average concentration of $PM_{2.5}$ in the Indira nagar (residential area), Alambagh (commercial area) & Amousi (industrial area) is 171.6µg/m^3, 176.6µg/m^3 & 182.4µg/m^3 respectively is above the permissible limit of the NAAQS standards.

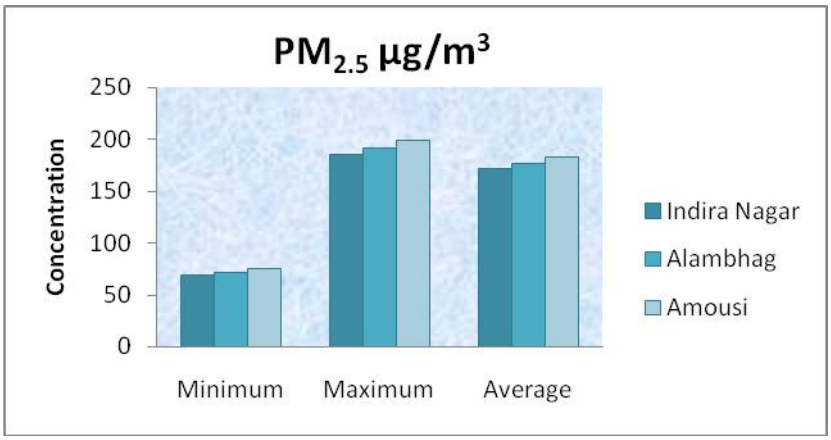

Fig-2: Concentration Of $Pm_{2.5}$ In Different Location Of Lucknow City During Dec2016-Feb2017

B. Suspended Particulate matter (PM_{10})

- The graph show as shown in fig -3 that the minimum concentration of PM_{10} in the Indira nagar (residential area), Alambagh (commercial area) & Amousi (industrial area) is 155.6µg/m^3, 159.4µg/m^3 & 165.4µg/m^3 respectively is above the permissible limit of the NAAQS standards.
- The maximum concentration of PM_{10} in the Indira nagar (residential area), Alambagh (commercial area) & Amousi (industrial area) is 362.7µg/m^3, 368.8µg/m^3 & 376.8µg/m3 respectively is above the permissible limit of the NAAQS standards.
- The average concentration of PM_{10} in the Indira nagar (residential area), Alambagh (commercial area) & Amousi (industrial area) is 284.9 µg/m^3, 286.2µg/m^3 & 294.4µg/m^3 respectively is above the permissible limit of the NAAQS standards.

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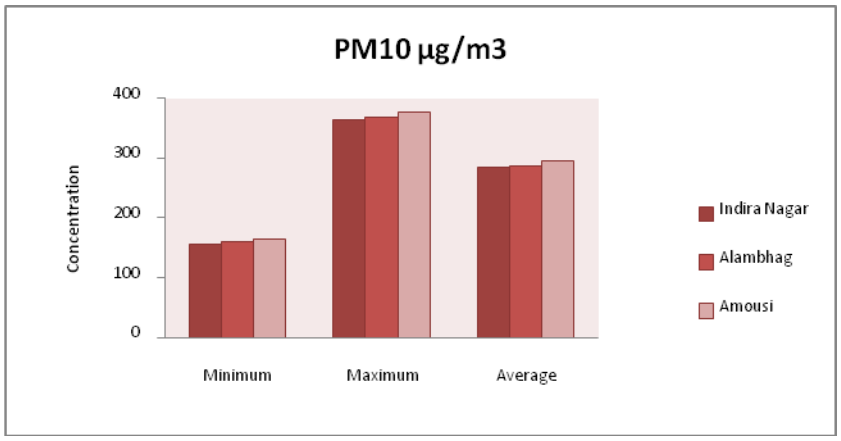

Fig-3: Concentration of Pm_{10} in Different Location of Lucknow City During Dec2016-Feb2017

C. Sulphur dioxide (SO_2)

- The graph show as shown in fig -4 that the minimum concentration of SO_2 in the Indira nagar (residential area), Alambagh (commercial area) & Amousi (industrial area) is 12.7µg/m^3, 13.5µg/m^3 & 15.3µg/m^3 respectively is above the permissible limit of the NAAQS standards.
- The maximum concentration of SO_2 in the Indira nagar (residential area), Alambagh (commercial area) & Amousi (industrial area) is 25.8µg/m^3, 27.9µg/m^3 & 32.5µg/m^3 respectively is above the permissible limit of the NAAQS standards.
- The average concentration of SO2 in the Indira nagar (residential area), Alambagh (commercial area) & Amousi (industrial area) is 17.5µg/m^3, 18.2µg/m^3 & 22.7µg/m^3 respectively is above the permissible limit of the NAAQS standards.

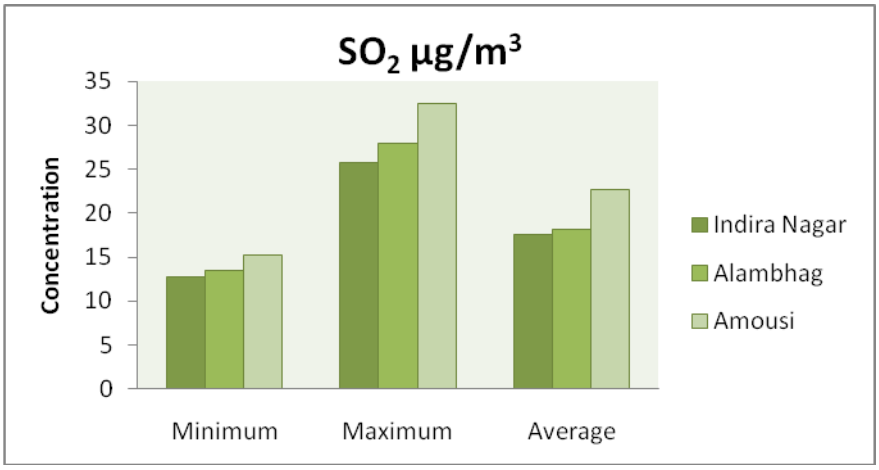

Fig-4: Concentration of So_2 in Different Location of Lucknow City During Dec 2016 – Feb2017

D. Nitrogen dioxide (NO_2)

- The graph show as shown in fig -5 that the minimum concentration of NO_2 in the Indira nagar (residential area), Alambagh (commercial area) & Amousi (industrial area) is 36.5µg/m^3, 48.8µg/m^3 & 52.8µg/m^3 respectively is above the permissible limit of the NAAQS standards.
- The maximum concentration of NO_2 in the Indira nagar (residential area), Alambagh (commercial area) & Amousi (industrial area) is 59.8µg/m^3, 84.7µg/m^3 & 86.2µg/m^3 respectively is above the permissible limit of the NAAQS standards.
- The average concentration of NO_2 in the Indira nagar (residential area), Alambagh (commercial area) & Amousi (industrial area) is 49.5µg/m^3, 68.7µg/m^3 & 72.4µg/m^3 respectively is above the permissible limit of the NAAQS Standards.

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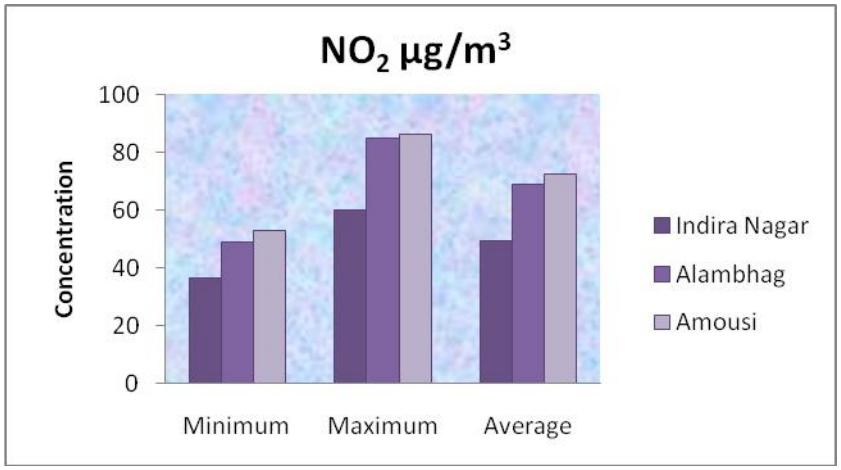

Fig-5: Concentration of No_2 In Different Location of Lucknow City During Dec 2016 – Feb2017

E. Heavy Metal Lead (Pb)

- The graph show as shown in fig -6 that the minimum concentration of Pb in the Indira nagar (residential area), Alambagh (commercial area) & Amousi (industrial area) is 21.6µg/m^3, 24.8µg/m^3 & 28.6µg/m^3 respectively is above the permissible limit of the NAAQS standards.
- The maximum concentration of Pb in the Indira nagar (residential area), Alambagh (commercial area) & Amousi (industrial area) is 51.4µg/m^3, 56.9µg/m^3 & 62.8µg/m^3 respectively is above the permissible limit of the NAAQS standards.
- The average concentration of Pb in the Indira nagar (residential area), Alambagh (commercial area) & Amousi (industrial area) is 34.8µg/m^3, 38.7µg/m^3 & 46.8µg/m^3 respectively is above the permissible limit of the NAAQS standards.

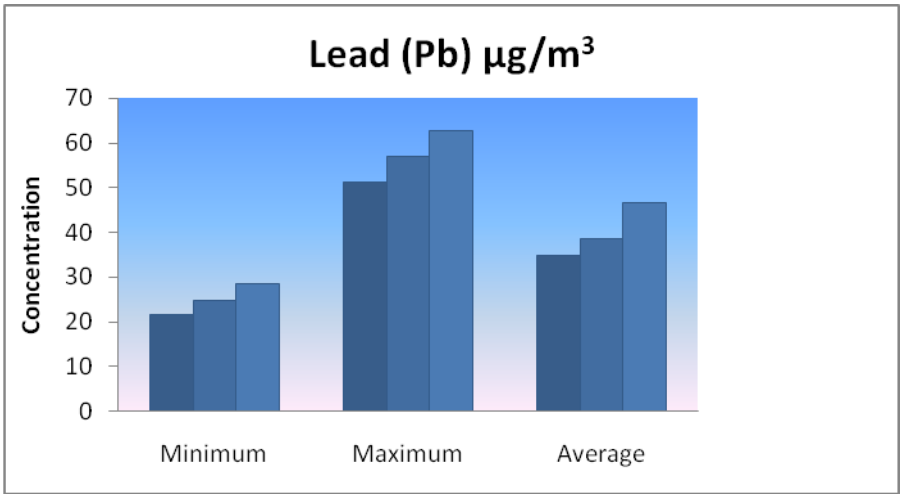

Fig-6: Concentration of Lead (Pb) In Different Location of Lucknow City During Dec2016-Feb2017

F. Heavy metal nickel (Ni)

- The graph show as shown in fig -7 that the minimum concentration of Ni in the Indira nagar (residential area), Alambagh (commercial area) & Amousi (industrial area) is 12.7ng/m^3, 15.8ng/m^3 & 18.9ng/m^3 respectively is above the permissible limit of the NAAQS standards.
- The maximum concentration of Ni in the Indira nagar (residential area), Alambagh (commercial area) & Amousi (industrial area) is 35.6ng/m^3, 38.9ng/m^3 & 40.5ng/m3 respectively is above the permissible limit of the NAAQS standards.
- The average concentration of Ni in the Indira nagar j (residential area), Alambagh (commercial area) & Amousi (industrial area) is 26.8ng/m3, 28.2ng/m3 & 32.4ng/m3 respectively is above the permissible limit of the NAAQS standards.

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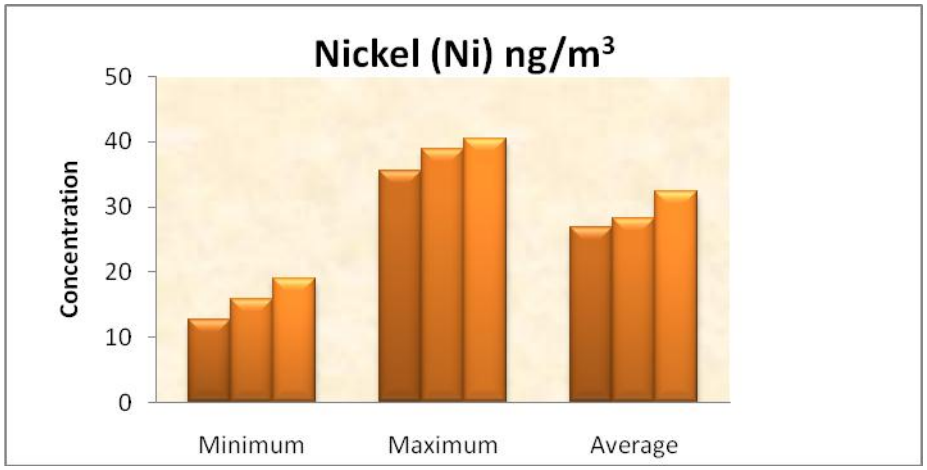

Fig-7: Concentration of Nickel (Ni) In Different Location of Lucknow City During Dec2016-Feb2017

V.CONCLUSION

Lucknow is not an industrial town but scattered industries in the industrial areas of the city and small workshops are a also adding to the air pollution to some extent. At present, metro rail section in luck now is under process. This activity may affect air quality of the area due to construction activities as well as traffic congestion.

The RSPM ($PM_{2.5}$), SPM (PM_{10}), SO_2 & NO_2, Heavy Metal Lead & nickel level at Indira nagar, Alambagh, and Amousi is higher than the NAAQS limits of 60µg/m^3, 100µg/m^3, 80µg/m^3 & 80µg/m^3, 1.0µg/m^3, 20ng/m^3, respectively. 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.

Overall, continuous accumulation of different types of pollutants and their exposure to human beings need immediate attention of the policy maker and regulatory agencies.

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

- Subsidized public mass transport (Metro, Monorail etc.) must be introduced/ strengthened to minimize use of personal vehicles.
- 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.
- Increase use of fuel e.g. CNG.
- Restore foot path for pedestrians.
- Regular sweeping of roads to avoid re- suspension of soil dust.

The monitoring at 3 locations viz: Indira nagar, Alambagh, and Amousi 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 ($PM_{2.5}$ & PM_{10}), sulphur dioxide (SO_2), nitrogen dioxide (NO_2), Heavy Metal Lead (Pb) & Nickel (Ni).

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