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RESEARCH ARTICLE

ENRICHMENT OF HEAVY METAL IN AMBIENT AIR OF LUCKNOW CITY AND ITS POTENTIAL HEALTH HAZARDS.

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Abstract

PM₁₀ and PM_{2.5} were collected in Lucknow city at 4 locations in three different seasons. Concentration of particulate matter (PM₁₀ and PM_{2.5}) was found maximum in winter season followed by summer and monsoon. The correlation coefficients in different areas between PM_{2.5} and PM₁₀ ranged from 0.86 to 0.96 thus that most of the PM_{2.5} and PM₁₀ are originally from same sources. In the present study mean quantum of heavy metals associated with particulates examined and found in order of Fe>Pb>Ni>Cu>Cr>Cd. Total metal concentration was found in the following order in study area i.e. Talkatora>Charbagh>Chowk>Aliganj. It has been observed that in Aliganj which is purely residential zone shown lesser amount of respiratory and ocular symptoms as compared to all other locations. During winter season particulates are also observed higher, suggesting that it may have a role in respiratory disorders or aggravation of respiratory problems among the residents.

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Introduction:-

Air pollution due to vehicular emission in urban area, is a matter of concern. Vehicular emission is responsible for higher level of air pollutants like SPM, RSPM, SO₂, NO_x and other organic and inorganic pollutants including trace metals and their adverse effects on human and environmental health [1]. In recent years, atmospheric pollution due to fine particles in urban areas has attracted concern since exposure to increased levels of particulate matter concentration is related to mortality and number of pulmonary health effects [2]. Particulates in atmosphere released by line source emission or burning of gasoline or diesel and also form in the atmosphere through chemical reactions [3]. Over the past decades, the rapid growth in travel has increased traffic congestion, especially in the major metropolitan areas which leads to significant increase in air pollutants [4]. However, current facilities have not kept pace with increased travel demands. Not only the occupationally exposed people like traffic policemen, drivers, conductors and near shopkeepers but also the common residents and pedestrians in big cities are getting exposed to high level of particulate matter.

Lucknow, India has acquired pace in commercial and industrial activities and with the dense population load the city has been under stress due to increasing urbanization. The introduction of CNG in Lucknow for public transport, has resulted in the increased emission of finer particulates [5].

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The alteration in ambient air quality is mainly attributed by the frequent traffic halt, crawling speed, poor maintenance of vehicles, poor road conditions and erratic driving pattern coupled with the presence of high rise buildings, wind pattern resulting the high temperature built up within the Lucknow city. High traffic densities due to population pressure resulting abnormal behavior of meteorological parameters, also adversely influencing the ambient air quality of Lucknow city, tempted the authors to study the status of ambient air quality with reference to particulate matter concentration (PM_{10} and $PM_{2.5}$) and enrichment of toxic metals, during different seasons i.e. winter (November to February), summer (March to June) and monsoon (July to October). The findings of the study correlated with epidemiological survey of the study area.

Materials and methods:-

Study Area:-

Lucknow, the capital of Uttar Pradesh, the one of the most populous state of India, is situated between $26^{\circ}52'N$ latitude and $80^{\circ}56' E$ longitude and 120 meter above sea level in the central plain of the Indian subcontinent. The city is spread over an area of 79 km^2 . It has distinct tropical climate with a marked monsoonal effect. The year is divided in to three distinct seasons i.e. summer (March to June), monsoon (July to October) and winter (November to February). The temperature ranges from $5^{\circ}C$ in winter to $45^{\circ}C$ in summer. The mean average relative humidity is 60% and rainfall 1006.8 mm [6]. Over the last few decades Lucknow has shown a rapid growth of population. In 1981 it was 1.0 million which reached to 1.7 million in 1991 and more than 4.5 million in 2011. To meet the requirement of growing population, city has marked substantial growth its infrastructure facilities and vehicular population. Since 2005 every year 70 to 80 thousands vehicles were registered in Lucknow. In this study monitoring of $PM_{2.5}$ and PM_{10} was carried out across the city of Lucknow at following four locations, Aliganj (Residential), Chowk (Commercial), Charbagh (Commercial) and Talkatora (Commercial/ Industrial).

Sampling:-

Sampling of respirable particulates was conducted continuously on 24 hourly basis in three distinct seasons i.e. summer (March to June), monsoon (July to October) and winter (November to February). Fine particles $PM_{2.5}$ were sampled using Fine Particulate Sampler (FPS, Envirotech, APM 550) which runs at a constant flow rate of 16.6 L/min. It has a portable Wins-Anderson impactor for the sampling of $PM_{2.5}$. Respirable Dust Sampler (RDS, Envirotech, APM 460) was used for PM_{10} sampling which has a flow rate of $1.1 \text{ m}^3/\text{min}$. The samplers were installed at the breath height at each sampling site. Glass fiber filter of 8 x 10 inches and Teflon filter paper of 47 mm diameter were used for sampling of PM_{10} and $PM_{2.5}$ respectively. The filters were equilibrated in desiccators containing silica gel for 24 hours before and after sample collection and weighed on pre-calibrated electronic balance (capable to weigh up to 0.01 mg) before and after the sampling to know the weight of collected dust. The ambient air mass concentration was calculated by dividing the weight of collected dust by volume of air sampled. For metal analysis filter papers were digested in acid mixture and then analyzed by AAS.

Health Survey:-

A statistically suitable valid data using the statistical tool for epidemiological survey work. Subjects who are exposed for longer duration at main traffic junction like traffic police, vendors, drivers, open shop keepers, motor cyclist, rickshaw pullers, sweepers, bicyclers were randomly selected for the study the common air pollution related diseases which are directly proportional to the number and concentration of fine particles or can aggravate the diseases related to symptoms of different human body i.e. respiratory (tuberculosis, asthma, bronchitis, lung cancer), cardiovascular and ophthalmology, decrease of immune system and susceptible to diseases, through questionnaire. A questionnaire was developed and used for personal interview among 200 people residing in all four sampling area. No particular effort was made to conduct the survey in the context of asthma patients. Information about the study was given to all objects, and for those who indicated a willingness to participate, an eligibility questionnaire was completed. Research protocols and questionnaire form were approved by the institutional review board for human subjects at Indian institute of Toxicology Research, CSIR laboratory, Lucknow, Uttar Pradesh India. Before entering the study, all participants read and signed a questionnaire pertaining to background information, medical history.

Results and discussion:-

Arithmetic average concentration of $PM_{2.5}$, PM_{10} and $PM_{10-2.5}$ were found in order of 101.05 ± 22.55 , 204.07 ± 26.75 and $103.63 \pm 16.92 \text{ } \mu\text{g}/\text{m}^3$ respectively (Table 1). The average levels of $PM_{2.5}$ and PM_{10} were lowest at Aliganj i.e. 75.87 and $163.96 \text{ } \mu\text{g}/\text{m}^3$ respectively whereas it was highest at Chowk i.e. $129.85 \text{ } \mu\text{g}/\text{m}^3$ and $218.43 \text{ } \mu\text{g}/\text{m}^3$ respectively (Fig 1 & 2).

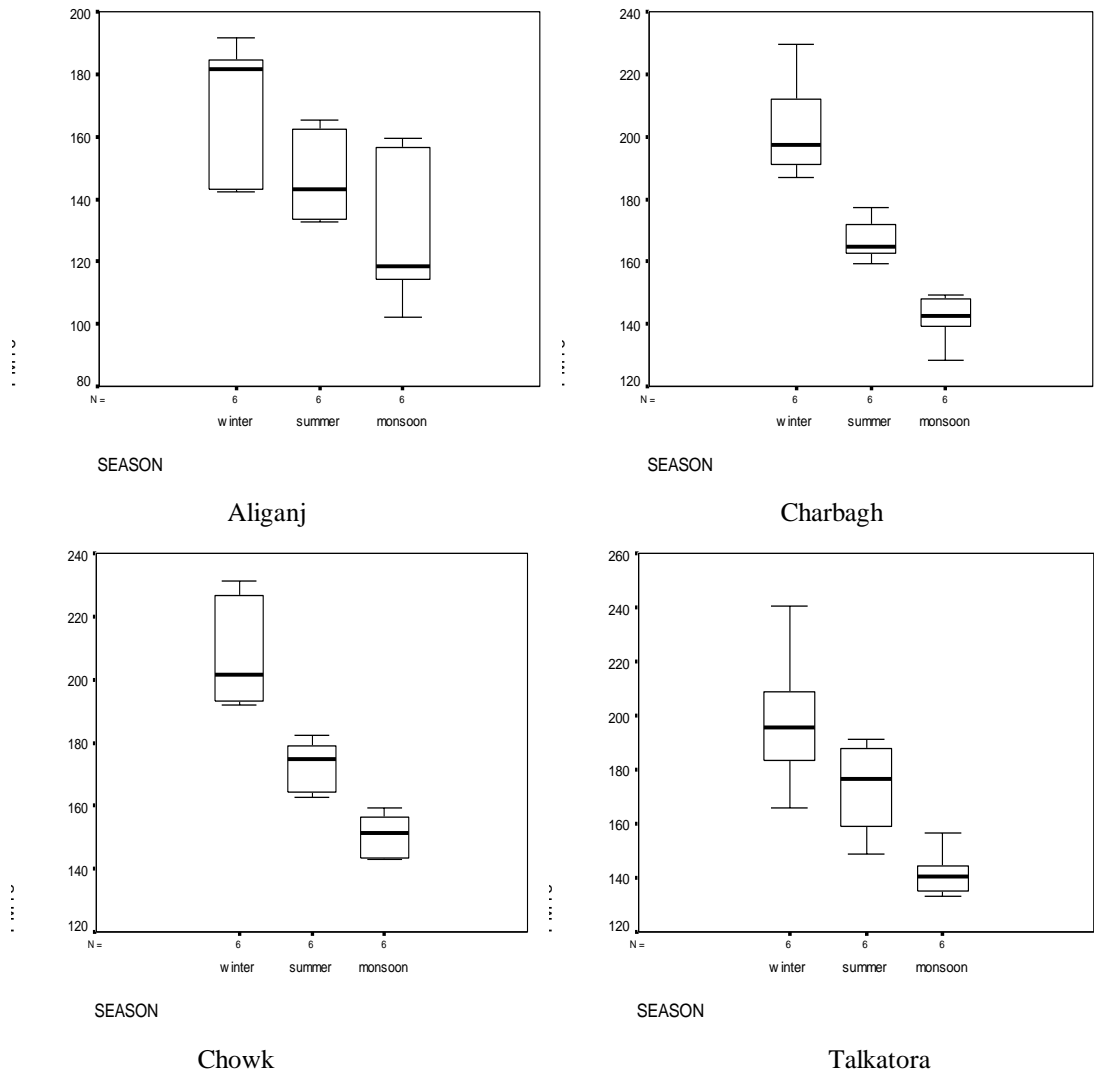
Concentration of $PM_{2.5}$ (seasonal average) found in order of 39.83 ± 4.6 , 212.35 ± 55.0 and $45.65 \pm 1.4 \mu\text{g}/\text{m}^3$ during monsoon, winter and summer respectively whereas concentration of PM_{10} found in order of 155.72 ± 22.7 , 269.32 ± 42.9 and $187.17 \pm 17.1 \mu\text{g}/\text{m}^3$ during monsoon, winter and summer respectively (Table 2). Concentration of both studied parameters was found inversely proportional to precipitation (rainfall). This is the main cause of lowering value of particulates in Monsoon season. During winter the high concentration of particulates w.r.t. both PM_{10} and $PM_{2.5}$, clearly indicates the progressive increase in the concentration as decrease in ambient temperature. As reported by the [7] that urban population are getting exposed to a high level of fine and ultrafine particles which is mainly contributed by the line sources and affecting the human health. Relationship between average PM_{10} and $PM_{2.5}$ during study period of Lucknow city, exhibits a high degree of correlation ($r=0.90$). [8] And [9] reported similar observations on PM_{10} with $PM_{2.5}$ at Kolkata and Mumbai city.

Table 1:-Arithmetic average Concentration of Respirable Particulate Matter (PM_{10} and $PM_{2.5}$)

Monitoring Station	$PM_{2.5}$	PM_{10}	$PM_{10-2.5}$	$PM_{2.5}/PM_{10}$	$PM_{(10-2.5)}/PM_{10}$
Aliganj	75.87 (34.8-175.24)	163.96 (111.8 -215.7)	88.09 (26.6-130.7)	0.42 (0.20-0.87)	0.58 (0.13-0.79)
Chowk	129.85 (25.67-289.34)	218.43 (148.72-308.76)	91.03 (16.56-173.16)	0.49 (0.16-0.94)	0.51 (0.05-0.83)
Charbagh	104.53 (37.24-299.37)	216.65 (169.76-303.45)	112.11 (4.08-158.67)	0.42 (0.20-0.98)	0.58 (0.01-0.79)
Talkatora	93.94 (29.2-299.40)	217.23 (157.81-315.63)	123.3 (16.26-170.48)	0.37 (0.17-0.94)	0.63 (0.05-0.82)
Average	101.05	204.07	103.63	0.43	0.57
SD	22.55	26.75	16.92	0.049	0.049

Table 2:-Average Concentration ($\mu\text{g}/\text{m}^3$) of Particulates at all locations in different seasons during study period

	Monsoon		Winter		Summer	
	$PM_{2.5}$	PM_{10}	$PM_{2.5}$	PM_{10}	$PM_{2.5}$	PM_{10}
Aliganj	34.84 (29.43-49.32)	123.46 (111.8-138.0)	147.38 (128.24-175.24)	206.91 (199.34-215.72)	45.39 (38.74-51.24)	161.52 (148.64-173.92)
Charbagh	43.65 (37.24-49.67)	175.92 (172.0-187.63)	222.44 (147.84-299.37)	277.39 (219.87-303.45)	47.54 (37.24-67.21)	196.63 (184.57-210.76)
Chowk	43.96 (25.67-68.94)	157.8 (148.72-169.62)	280.08 (270.37-289.34)	303.07 (298.67-308.76)	44.21 (32.41-65.97)	194.43 (187.54-207.43)
Talkatora	36.86 (29.21-52.24)	165.69 (157.81-178.54)	199.5 (99.33-299.37)	289.91 (269.82-315.63)	45.46 (35.47-58.28)	196.11 (189.63-203.82)
Average	9.83 ± 4.6	155.72 ± 22.7	212.35 ± 55.0	269.32 ± 42.9	45.65 ± 1.4	187.17 ± 17.1



Note: The boundary of the box closest to zero indicates 5th percentile and a line with in the box marks the mean, and the boundary line of the box farthest from the zero is indicates the 95th percentile. Whiskers below and above the box indicates the minimum and maximum values.

Fig 1:-Statistical Values of PM₁₀ for each season during the whole study period.

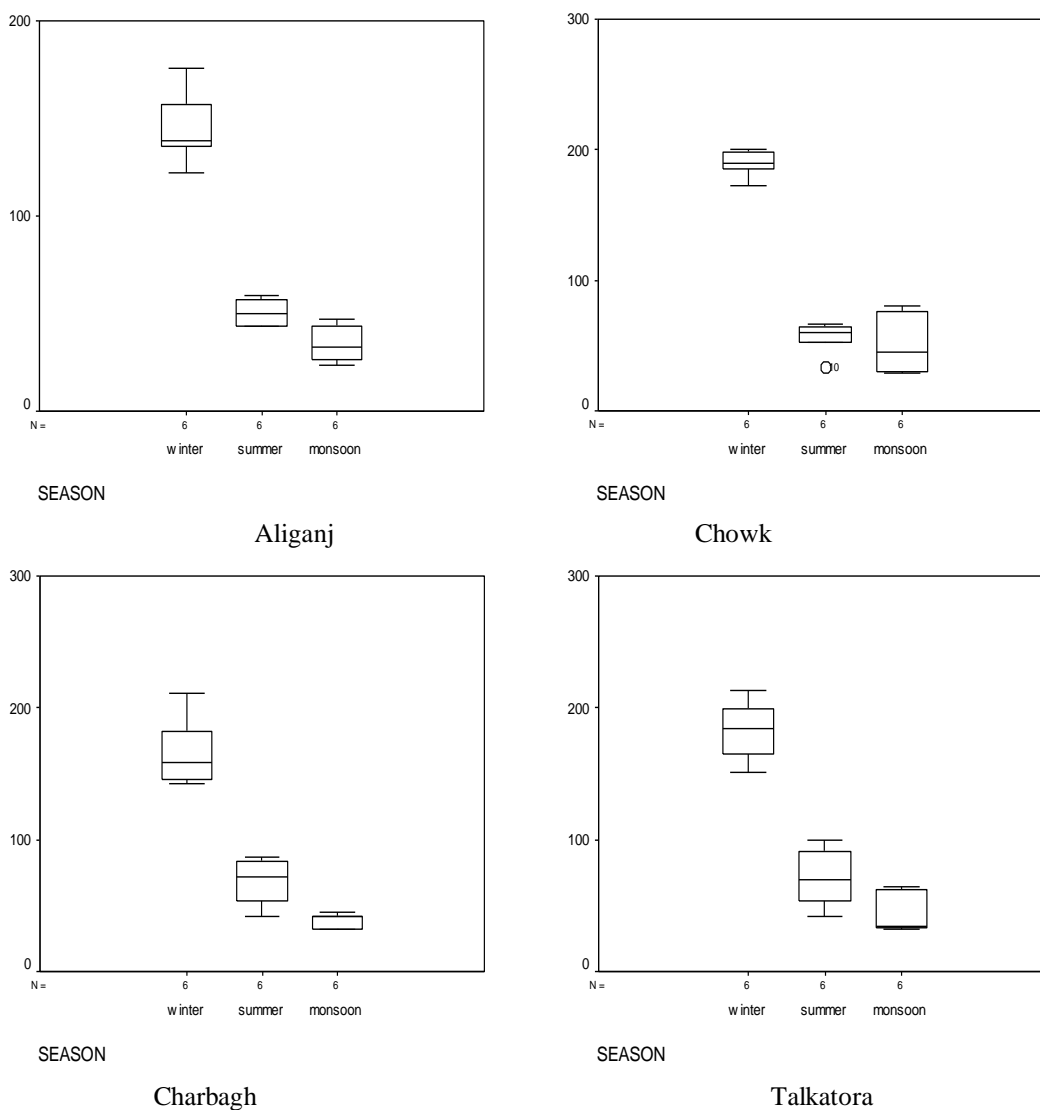


Fig 2:-Statistical Values of PM_{2.5} for each season during the study period

Observed PM_{2.5} and PM₁₀ values in the study area were exceeding from NAAQS at all locations. The lowest exceedance factor for PM_{2.5} and PM₁₀ i.e. 1.3 and 1.6 was observed at Aliganj, while highest (2.2) was found at Chowk (**Table 3**) this finding is also getting support of the other researchers i.e. [6] in their study. The average concentrations of PM₁₀ and PM_{2.5} were 4.1 times and 4.0 times higher than the value quoted by the World Health Organization (WHO) air-quality guidelines [10] i.e. 50 µg/m³ and 25 µg/m³ for 24 hrs basis in case of PM₁₀ and PM_{2.5} respectively.

In the present study mean quantum of heavy metals examined was in order of Fe>Pb>Ni>Cu>Cr>Cd. Distribution of metals in PM₁₀ in different locations are summarized in table 4 & 5. Distribution of metals in PM₁₀ for Pb ranged between 19.26-70.91 ng/m³. It was found to be lower than earlier studies done by [13]. Like Pb other metals also found to be lower in concentration. The decrease of metal concentration might be due to the composition of the vehicles type, improvement of fuel quality (unleaded petrol) and introduction of CNG vehicles in recent past ten years [12]. In this study Cd ranged between 8.36-28.35, Cu 16-56, Fe 191-309, Ni 22.1- 42.3, Cr 16.74- 30.35 ng/m³. Total metal concentration was found in the following order, Talkatora>Charbagh>Chowk>Aliganj. At Charbagh and Chowk area, the major source of metals may be due to vehicular activity, which is rich in Ni, Zn, Fe due to activities like wear and tear of tyres, oil burning, abrasion of mechanical parts of road vehicles, oil lubricants.

This study is supported by earlier studies of [13] and [14]. Talkatora comprises small scale industries like plastic, ceramic etc which may contribute higher metal concentration as compared to other locations. Another study reported [15] the concentration of Cr=5, Cu=158, Fe=1620, Mn=40.39, Pb=100.6, Zn=260 ng/m³ in residential area of Mumbai. A study done by [16] observed average concentration of Cr 0.007- 0.044 µg/m³, Cd ranged from 0.004-0.027 µg/m³, Ni 0.012- 0.056 µg/m³, Zn 0.62-1.52 µg/m³ and Fe was 1.72-5.8 µg/m³.

Table 3:-Status of Particulate Matter with NAAQS

Location	PM _{2.5}	NAAQS*	Exceedance Factor	PM ₁₀	NAAQS*	Exceedance Factor
Aliganj	75.8	60	1.3	164.0	100	1.6
Charbagh	104.5		1.7	216.7		2.2
Chowk	129.8		2.2	218.4		2.2
Talkatora	93.9		1.6	217.2		2.2

* NAAQS 24 hourly average, Exceedance Factor= Ratio of observed value to standards

PM₁₀ concentration showed good positive relation of Pb (r= 0.371), Ni (r= 0.484), Fe (r= 0.365), Cd (r=0.399) while other metals Cr (r=0.232) and Cu (r=0.194) (Fig 3). The level of significance is 0.005. It concludes that Pb, Ni, Fe and Cd are the major fraction of PM₁₀.

Table 4:-Variation in distribution of heavy metal in PM₁₀ (mean ± SD)

Metal	Aliganj	Charbagh	Chowk	Talkatora
Pb	19.26 ±7.39	38.74 ±14.52	34.89 ±5.91	70.91 ±36.73
Cd	09.16 ±7.75	08.36 ±90.90	20.28 ±6.78	28.35 ±10.85
Cu	18.00 ±08.0	16.00 ±05.00	22.00 ±9.00	56.00 ±16.00
Fe	191.0 ±87.0	214.0 ±54.00	309 ±136.0	211.0 ±72.00
Ni	22.10 ±6.00	42.30 ±14.50	39.00 ±5.90	39.10 ±7.00
Cr	19.87 ±1.76	30.35 ±08.08	23.37 ±5.64	16.74 ±2.75

Table 5:-Distribution of metals of PM₁₀ in during seasons (mean ± SD)

Metal	Winter	Summer	Monsoon
Pb	54.90 ±28.83	46.73 ±28.33	21.21 ±6.68
Cd	25.79 ±9.02	15.97 ±12.40	07.85 ±6.97
Cu	37.00 ±23.0	27.00 ±16.00	18.00 ±12.0
Fe	317.0 ±107.0	230.0 ±64.00	146.0 ±27.0
Ni	42.60 ±10.80	37.60 ±10.10	26.60 ±9.00
Cr	26.82 ±7.55	23.44 ±7.00	17.49 ±2.72

Distribution of metals in PM_{2.5} in all locations is given in table 6. In case of lead concentration was found in order of 11.30 to 44.8, for Cd 0.01 to 41.61, Cu 2.71 to 60.07, Fe 22.41 to 57.30, Ni 1.79 to 50.61 and Cr 1.79 to 6.94 ng/m³. Seasonwise distribution of different metals in study area is tabulated in table 7. All the metals are significantly differently distributed as the p-values of all metals are less than 0.05.

Total metal concentration in PM_{2.5} is also found higher in winter and lowest in monsoon (Table 7) like metals in PM₁₀ and concentration of PM₁₀, PM_{2.5}. PM_{2.5} showed correlation with Pb (r= .657), Cd (r=.607), Ni (r=0.411), Cr (r=0.225) (Fig 4).

Table 6:-Distribution of metals of PM_{2.5} at all locations (mean ± SD)

	Aliganj	Charbagh	Chowk	Talkatora
Pb	21.89±9.64	31.49±10.34	39.44±10.66	41.14±16.9
Cd	8.012±8.48	11.59±11.21	14.23±13.5	15.09±15.5
Cu	10.727±2.33	27.29±5.82	33.44±8.99	46.09±6.89
Fe	47.959±7.22	54.83±8.89	57.77±6.60	56.79±4.16
Ni	34.49±6.32	38.78±7.88	43.17±7.99	43.94±11.01
Cr	3.39±0.96	5.06±1.67	10.15±5.65	15.11±8.70

Table 7:-Distribution of metals of PM_{2.5} in during seasons (mean ± SD)

Metal	Winter	Summer	Monsoon
Pb	46.45±11.52	30.03±7.91	23.99±8.78
Cd	1.83±0.49	1.30±0.35	0.099±0.08
Cu	32.91±17.62	32.43±14.29	22.78±12.60
Fe	60.31±2.82	53.87±8.14	48.83±4.94
Ni	48.72±5.98	37.47±7.22	34.10±2.23
Cr	11.85±8.49	9.56±6.32	3.81±1.25

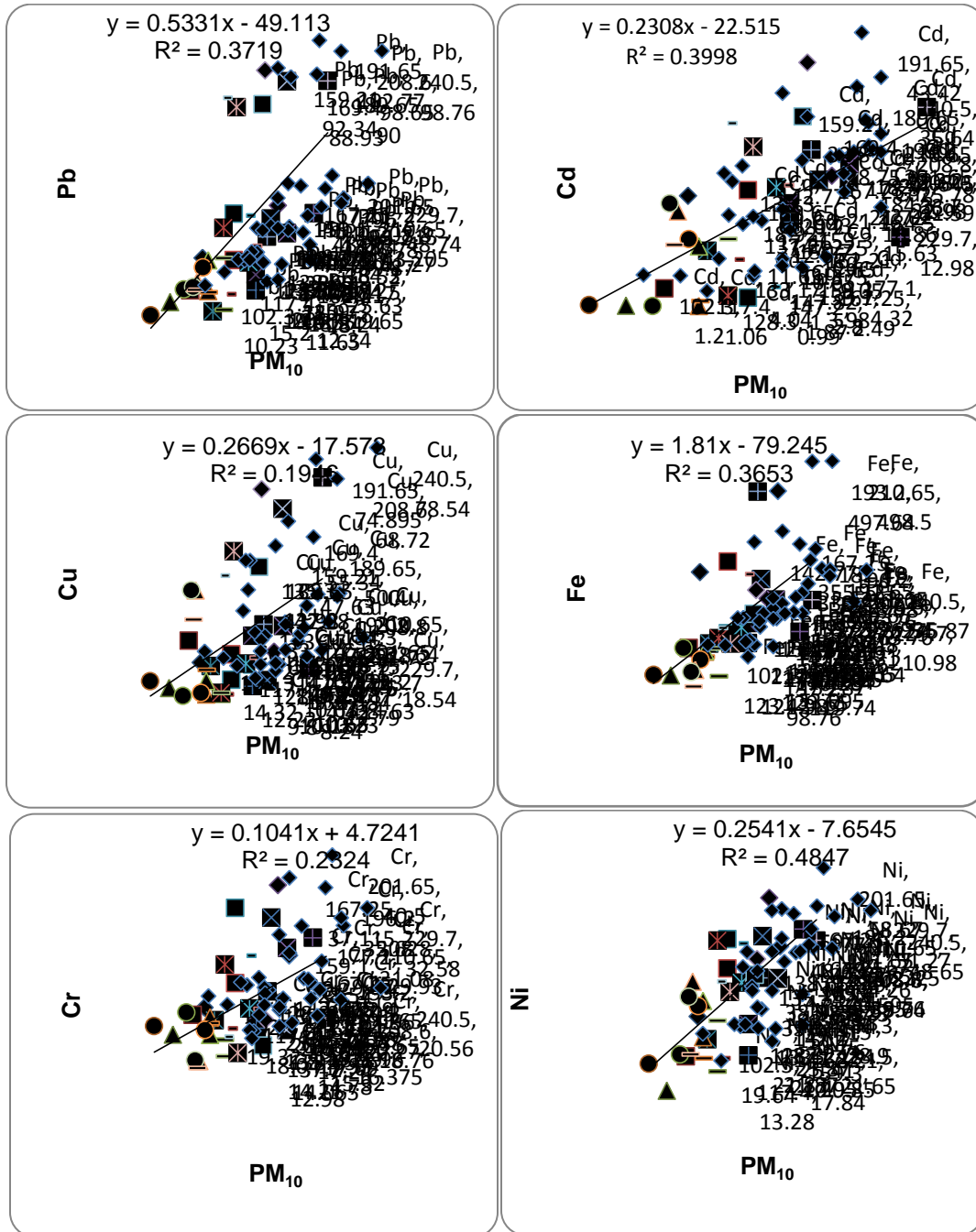


Figure 3:-Scatter plot and linear regression of PM₁₀ and Metals

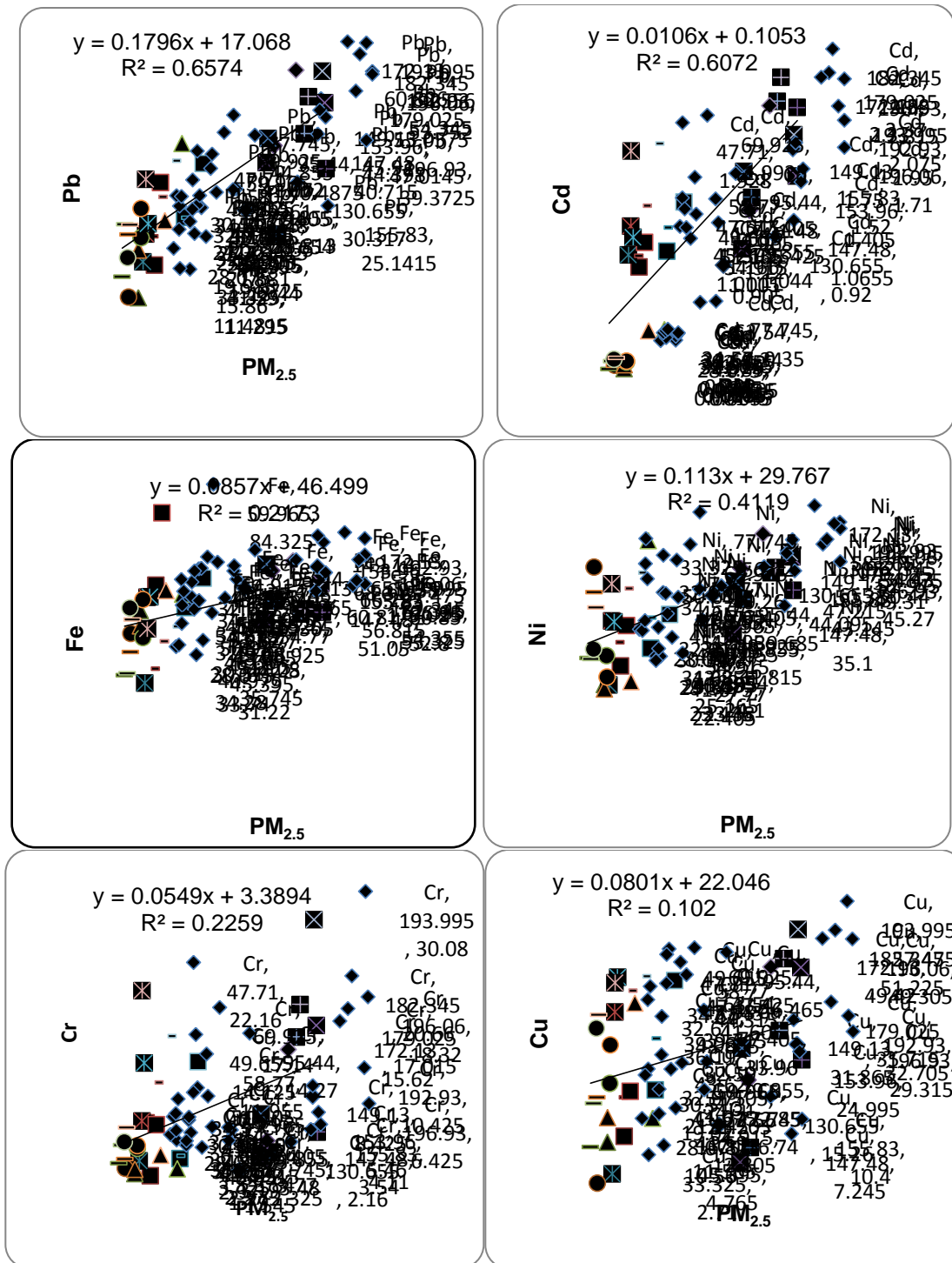


Figure 4:-Scatter plot and linear regression of PM_{2.5} and Metals

While Fe and Cu is not contributes major portion of PM_{2.5}. It has been also observed that correlation of metals with PM_{2.5} stronger than PM₁₀. It may conclude that the metals are found more in finer fraction than coarser fraction. It is also stated in another study by [17] and [6].

The location ($F_{3,24}=3.7, p=0.024$) and season affects ($F_{2,24}=9.16, p=0.001$) were found to be statistically significant. The mean concentration of lead in Talkatora areas was found significantly higher compared to all other areas i.e. Aliganj ($p=0.011$), Charbagh ($p=0.017$) and Chowk ($p=0.009$). The mean concentration of lead was found

statistically higher in summer ($p=0.027$) and winter ($p=0.000$) compared to mean levels in monsoon season. In case of cadmium the location ($F_{3,24}=40.812$, $p=0.000$) and season affects ($F_{2,24}=51.762$, $p=0.000$) were found to statistically insignificant. The mean concentration of cadmium in Talkatora areas was found to be insignificantly higher compared to all other areas i.e. Aliganj ($p=0.000$), Charbagh ($p=0.000$) and Chowk ($p=0.002$). The mean concentration of cadmium was found statistically higher in summer ($p=0.000$) and winter ($p=0.000$) compared to mean levels in monsoon season.

Concentration of copper was found in order of 8.24- 78.54 ng/m^3 . The location ($F_{3,24}=170.759$, $p=0.000$) and seasonal affects ($F_{2,24}=44.251$, $p=0.000$) were found to statistically insignificant. Interaction effects between season and location was also insignificant. Chromium level was found in the range of 12.98-40.5 ng/m^3 . The location ($F_{3,24}=34.967$, $p=0.00$) and seasonal affects ($F_{2,24}=36.706$, $p=0.000$) were found to statistically insignificant. Iron was found in the range of 98.76- 355.1 ng/m^3 . The mean concentration of iron found statistically significant higher in summer ($p=0.006$) and winter ($p=0.000$) compared to mean level concentration in monsoon season and also in winter ($p=0.22$) compared to monsoon. The locationwise ($F_{3,24}=7.041$, $p=0.001$) and seasonwise concentration of iron were found to statistically insignificant. The concentration of nickel was found in the range of 13.28-58.67 ng/m^3 . The mean concentration of Ni in Aliganj area found insignificantly higher compared to all other areas i.e. Talkatora ($p=0.707$), Charbagh ($p=0.859$) and Chowk ($p=0.702$). While in Charbagh it was found insignificantly higher ($p=0.838$) in comparison to Chowk. The locationwise ($F_{3,24}=79.047$, $p=0.068$) and seasonwise affects ($F_{2,24}=2.777$, $p=0.082$) were found statistically insignificant. It is clear that except Cadmium ($p<0.05$) all the metals i.e. lead, copper, iron, nickel and Cr are significantly differently distributed in studied locations.

Out of 200 questionnaires information infer from 128 objects. Ambient air pollution causes deleterious effects on the health of the exposed population. Details of survey with their demographic distribution are summarized in Table 8. All the observations are confined in middle and higher age group (18-70) and ratio of female and male was equal at each location. A higher prevalence was observed among drivers, vendors, traffic policemen and labors. Among respiratory symptoms cough, sneeze, nose block, shortness of breath, sinus problem has been observed. Among the surveyed people 116 people suffering from cough, 111 from sneeze, 64 from Nose block, 102 from shortness of breath, 99 from sinus problem, 124 from headache, 110 from redness in eye, 79 from watering in eye and 95 from burning in eye.

Table 8:-Summary of Health Survey data

Demographic & Lifestyle	n=32	n=32	n=32	n=32
	Aliganj	Chowk	Charbagh	Talkatora
Age	41.34 (17-65)	35.67 (27-48)	38.56 (26-49)	41.23 (25-56)
Sex ratio (M/F)	1:01	1:01	1:01	1:01
Height Avg \pm SD (range)	154.8 (129-158)	157.64 (137-158.3)	157.8 (148-158.4)	156.2 (147.2-158.3)
Weight Avg \pm SD (range)	55.65 (32-70)	56.2 (33-72)	56.3 (34-75)	59(42- 62.1)
Smoking	10 (31.25%)	12 (37.5%)	11 (34.37%)	26 (81.25%)
Drinking	5 (15.62%)	4(12.5%)	3 (9.37%)	6 (18.75%)
Fuel used (LPG/ Kerosene in %)	100	100	100	100
Occupation				
Student/tution	6	7	6	8
salesman/traffic police/shopkeeper/driver rickshaw	4	6	10	16
office/teacher/doctor/eng	15	12	12	7
house	3	7	4	1
Demographic & Lifestyle				
Duration of working	8 hrs	8-9 hrs	8 hrs	8 hrs-10 hrs
Travelling				
Mode				
2-wheeler	12	13	18	16
public transport	17	15	10	10
rickshaw	3	6	7	6
Time in Hrs	4-hrs	3-4 hrs	5 hrs	4 hrs
Time spend in front of computer	4-5 hrs	4 hrs	3-4 hrs	1-2 hrs

Affect of pollution on population in study area				
Symptoms respiratory				
Cough	28 (87.5%)	27 (84.37%)	30 (93.75%)	31 (96.87%)
Sneeze	30 (93.7%)	32 (100%)	27 (84.37%)	22 (68.75%)
Nose block	12 (37.5%)	17 (53.12%)	15 (46.8%)	20 (62.5%)
Shortness of breath	20 (62.5%)	23(71.87%)	30 (93.75%)	29 (90.62%)
Sinus Problem	19 (59.37%)	27 (84.37%)	25 (78.12%)	28 (87.5%)
Headache	30 (93.75%)	30 (93.75%)	32 (100%)	32 (100%)
Symptoms Ocular				
Redness in eye	24(75%)	28(87.5%)	27 (84.37%)	31 (96.87%)
Watering in eye	14 (43.75%)	19 (59.37%)	17 (53.12%)	29 (90.62%)
Burning in eye	21 (65.67%)	29 (90.62%)	22 (68.75%)	23 (71.87%)

Prevalence of sneezing problem in Aliganj and Chowk areas were significantly higher ($p < 0.01$) in comparison to Talkatora. However no significant difference could be established in Charbagh area compared to Talkatora. Shortness of breath was found to be significantly higher in both Charbagh and Talkatora areas ($p < 0.01$) compared to Aliganj and Chowk. Sinus problem were less prevalence ($p < 0.05$) in Aliganj area compared to rest of the areas. Prevalence of watering in eyes was found to be significantly higher ($p < 0.001$) compared to rest of the area (Aliganj, Chowk, Charbagh). Same study conducted [18] in Coimbatore city reported a positive correlation with health problem increase with increase in vehicular pollution. Study also reported number of visitors in hospitals and clinics increasing during the winter and post monsoon season.

No association between symptoms of cough, nose block, headache, redness and burning of eyes established with the different studied area. It has been observed that in Aliganj which is purely residential zone shown lesser amount of respiratory and ocular symptoms as compared to all other locations. While in Talkatora most of the subjects was labours and poor (belong the low income group) people shown occupational exposure and maximum respiratory and ocular symptoms

Conclusions:-

The whole world is severely affected with the ill effect of air pollution problem in one or the other way. So, it should be one of our most important priorities that we all should make effort together to fight this problem and work towards the reducing air pollution. The results found in this study show that concentration of $PM_{2.5}$ and PM_{10} were higher than the prescribed NAAQS 24 hourly standards and may lead to the air pollution aggravated diseases. The average levels of $PM_{2.5}$ and PM_{10} and associated metals were higher in winter as compared to monsoon and summer. Seasonal peaks coinciding with lower mixing heights of the winter months. Level of toxic metals such as Pb, Cd, Ni associated with particulates indicates that these metals also get enters in our respiratory system along with the air. Motor vehicles, especially two-stroke engine vehicles are increasing which are also important source of air pollution emissions in Lucknow city. Besides that, various types of vehicles and their different operating modes such as idling, stop and start, accelerating and decelerating, combined with a high density of vehicles leads to pollution source. Reduction in traffic congestion and optimize vehicle speed on roads can reduce the line source of air pollution, which is the major contributor of air pollution.

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