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MONITORING OF PARTICULATE MATTER (SPM, RSPM AND DUST FALL) IN AMBIENT AIR OF GHAZIABAD AND MEERUT AREA OF NATIONAL CAPITAL REGION, INDIA

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ABSTRACT

Due to industrialization, Ghaziabad area of National Capital Region (NCR) has become a well developed industrial estate to be considered as industrial hub of Uttar Pradesh, India contemporary to the industrial growth, the environmental quality also gradually deteriorated. Hence a need was felt to know the status of ambient air quality for proper planning of the future growth of industries. The ambient air quality was monitored at 3 stations in and around industrial estate.2 station in commercial and 2 station in residential colonies during four seasons for the period of two years during July 2009 to June 2011. The results are discussed as to the status of the ambient air quality and suggestions have also been made for improvement.

KEYWORDS: Particulate Matter, Ambient Air Quality, Air Pollution Profile, Trend Analysis

INTRODUCTION

Ghaziabad and Meerut area of National Capital Region is located in the extreme part of Western Uttar Pradesh, state of India. Ghaziabad covers an area of 2950 km with 30 lakh approximate population. It lies between 28º 26 and 28º 59 North latitude and 77º 12 and 78º 13 East longitude while Meerut covers an area of 3911 Sq.km with 38 lakh app. population. It lies between 77º 7 and 78º 7 East longitude and 28º 45 and 29º 16 North latitude. Ghaziabad and Meerut area of NCR is bounded by Muzaffarnagar district while Bulandshahr lies to the South.. The desert area of Rajasthan to West and South West, the Gangatic plains of U.P. to East, across which the monsoon air travels and reaches Ghaziabad and Meerut. Both have their respective share in affecting the climate of the region. Extremely dryness with an intensely not summer and a cold winter from Oct. to Feb. and warm monsoon period from July to Sept. which cases increased humidity, cloudiness and perspiration. A large no. of industries and enterprises are located in the city. More than 5 lakh vehicles and more than 60 lakh population of both the area also add considerable contaminants every day. (Figure 1).

Industrial activities and high vehicular Traffic density contribute to suspended particulate matter in the atmosphere. The particulate matter include particles from molecular size up to 500µ in diameter. Particulate matter consist of separate classes of pollutant i.e. fine particles and coarse particles[1]. A few attempts have also been made to determine the composition and size distribution of aerosol[2-6]. Smelters, Iron foundries, craft, pulp and paper mills, coal cleaning & refuse, coke (used in steel manufacturing), Iron and steel mills, grain mills and grain handlings, cement manufacturing and fertilizer plants which emits different types of particulate matter. Particulate matter causes various type of diseases like Pneumoconiosis, bronchitis, asthmatic rhinitis, bronchial asthma, conjunctivitis skin diseases[7-9]. The particle in ambient air $\leq 2.5\mu m$ indicating it's potential to effect human health & plants[10-14]. The objectives of the study were

- To study the influence of some atmospheric pollutants in the ambient air of Ghaziabad and Meerut area.
- To find out the relationship between ambient air quality and the existing source of pollution in these area.
- To assess the seasonal variations in particulate matter.
- To assess the trend of particulate matter in residential, commercial and industrial area.

EXPERIMENTAL METHODOLOGY

Location of Sampling Station

To assess air quality seven representative monitoring stations were selected by taking the available information on meteorology; namely wind speed/direction as also the critical targets and source of pollution into account. The monitoring stations and brief description of pollution activities are given in Table 1.

Collection of Samples and Analysis

The samples were collected during 4 major seasons of two year from July 2009 to June 2011. The parameters for ambient air quality monitoring included SPM, RSPM and dust fall rate. High volume sampler and respirable dust sampler is recommended by inter committee[10] were used to collect SPM and RSPM. SPM and RSPM were analyzed gravimetrically as per BIS Method, IS-5182 (Part-IV)[11-12] and dust fall was collected by dust fall Zar. It was analyzed gravimetrically as per recommended Method[13-15].

RESULTS AND DISCUSSIONS

The result of the particulate matter (SPM, RSPM and dust fall) are summarized in table 2 and figure 2 (seasonal average values are given in $\mu g/m^3$). The seasonal average values of corresponding monthly particulate matter values are as follows:

Moonson (July to Sept.), Post Monsoon (Oct to Nov.), Winter (Dec. to Feb.) & Summer (March to June).

SPM, RSPM and Dust Fall in Residential Area

- The average seasonal SPM levels are above the critical level viz.200 $\mu g/m^3$ (24 hrs. average) and 140 $\mu g/m^3$ (annual average) standard adopted by Central Pollution Control Board (CPCB) at both the Residential area. The higher value was found at Railway Road i.e. 509 $\mu g/m^3$ during Summer due to heavy storms and traffic activities.
- The average seasonal RSPM levels are above the critical level viz.100 $\mu g/m^3$ (24 hrs. average) and 60 $\mu g/m^3$ (annual average) standard adopted by CPCB at both the Residential area. The higher value was found at Railway Road i.e. 195 $\mu g/m^3$ during Summer due to heavy storms and traffic activities.
- The average value of dust fall was found to be high at Railway Road i.e. 26 Mt Km^{-2} $month^{-1}$ during Summer and lowest value was found to be 9 Mt Km^{-2} $month^{-1}$ during Post Monsoon at Raj nagar, Residential area.

SPM, RSPM and Dust Fall in Industrial Area

- The average seasonal SPM levels are above the critical level viz.500 $\mu g/m^3$ (24 hrs. average) and 360 $\mu g/m^3$ (annual average) standard adopted by CPCB at all the three Industrial area. The higher value was found to be at Sahibabad Industrial area, Ghaziabad i.e. 646 $\mu g/m^3$ during Summer due to industrial and traffic activities.

- The average seasonal RSPM levels are above the critical level viz.150 µg/m^3 (24 hrs. average) and 120 µg/m^3 (annual average) standard adopted by CPCB at all the three Industrial area. The higher value was found to be at Sahibabad Industrial area and Bulandshahr Industrial area, Ghaziabad i.e. 330 µg/m^3 during Summer and Post Monsoon due to industrial and traffic activities.
- The average value of dust fall was found to be high at Sahibabad Industrial area, Ghaziabad i.e. 43Mt Km^{-2} month^{-1} during Summer and lowest value was found to be 19 Mt Km^{-2} month^{-1} during Monsoon at Bulandshahr Industrial area.

SPM, RSPM and Dust Fall in Commercial & Mixed use Area

- The average value of SPM was found to be high at Begum Bridge, Meerut i.e. 543 µg/m^3 during Summer and lowest value was found to be 331 µg/m^3 during Monsoon at Modinagar, Bus stand, Ghaziabad.
- The average value of RSPM was found to be high at Begum Bridge, Meerut i.e. 282 µg/m^3 during Summer and lowest value was found to be 109 µg/m^3 during Monsoon at Begum Bridge, Meerut.
- The average value of dust fall was found to be high at Modinagar, Bus stand, Ghaziabad i.e. 31 Mt Km^{-2} month^{-1} during Summer and lowest value was found to be 18 Mt Km^{-2} month^{-1} during Monsoon at Modinagar.

Seasonal SPM, RSPM and Dust Fall Trends Analysis

The seasonal SPM, RSPM and dust fall trends analysis in different areas based on land use and utility pattern depicted in figure 2, 3 and 4 shows that

- The average seasonal SPM, RSPM and dust fall rate levels gradually increases from Residential area to Commercial & Mixed use area and Commercial to Industrial area as given in table 4.
- The highest SPM, RSPM and dust fall levels have been observed during summer in all areas.
- The average SPM, RSPM and dust fall rate has increases from Monsoon to Post Monsoon, Post Monsoon to Winter and Winter to Summer in all areas.

Inter Comparison and Statistical Analysis of Data

Correlation among different pollutants taking two year combined annual average SPM, RSPM and dust fall were observed highest at Industrial area 597 µg/m^3 (SD 88.18, % CV 17.01) 309 µg/m^3 (SD 60.50, % CV 24.36) & 36 MtKm^{-1} month^{-2} (SD 6.02, % CV 20.29) respectively while lowest at Residential area 266 µg/m^3 (SD 72.50, % CV 21.42), 95 µg/m^3 (SD 22.03, % CV 18.93) & 12 MtKm^{-1} month^{-2} (SD 5.68, % CV 30.98) respectively. These variation may be attributed to varying traffic density and emission from local stationary sources. Concentrations were dependent on land use pattern & local activities i.e. residential, commercial, industrial and traffic intersection.

Location Effects

Two year combined annual average SPM, RSPM and dust fall were observed highest at Sahibabad Industrial Area (646 µg/m^3,330 µg/m^3,43 MtKm^{-1} month^{-2}) respectively while lowest at Raj nagar Residential Area (190 µg/m^3, 90 µg/m^3, 9 MtKm^{-1} month^{-2}) respectively. These variation may be attributed to varying traffic density and emission from local stationary sources. Concentrations were dependent on land use pattern & local activities i.e. traffic intersection, industrial pollution, commercially used area and residential areas and were found the highest pollution due to highest industrial

operations and vehicular density in among all sites. Wind roses of Ghaziabad and Meerut (appendix-I) and location map (figure 1) shows the prevalent wind direction in both area from North to West of the year.

Meteorological Effects

Rainfall (appendix-II), wind, temperature (appendix-III) and inversion play an important role in distribution and concentration levels of air pollutants. This is also applicable to the present study in both area. Occassional elevation is SPM, RSPM and dust fall at different sites demonstrate these effects. Lowest concentration during monsoon may be due to rain washout and high humidity. While highest concentration of SPM, RSPM and dust fall during summer may be attributed to high temperature and inversion conditions.

Correlation of SPM, RSPM and Dust Fall with Temperature, Wind Velocity, Precipitation Rain Fall and Sunshine

Pearson correlation calculated for seasonal SPM, RSPM and dust fall concentration with seasonal mean temperature, wind velocity, precipitation and sunshine shows strong positive correlation with temperature, negative correlation with precipitation while poor correlation with wind velocity. Negative correlation with sunshine due to photolysis process during bright sunshine. It is also evidenced from higher SPM, RSPM and dust fall concentration during summer and lower values during monsoon. Negative correlation with precipitation is evidenced from lowest SPM, RSPM and dust fall concentration during monsoon due to washout. Poor correlation with wind velocity may be indicative of local transportation of air pollutant from different sources to monitoring sites in Ghaziabad and Meerut area of National Capital Region.

CONCLUSIONS

The results of monthly (8hrly) data for two years study during july 2009 to june 2011 shows that gradual increase in SPM, RSPM and dust fall from Residential area to Commercial & Mixed use area and Commercial to Industrial area was observed. Average seasonal SPM, RSPM and dust fall levels gradually increases from residential area to commercial area to industrial area. It has also increased from Monsoon to Post Monsoon, Post Monsoon to Winter and Winter to Summer in all areas indicating overall increase in pollution load in the atmosphere. Two years combined annual average of SPM, RSPM and dust fall for different sites in the order of concentration was Rajnagar <Railway road <Modinagar <Begumbridge <Partapur industrial area<Bulandsahar industrial area<Sahibabad industrial area. Maximum value occurred in Summer however overall highest SPM, RSPM and dust fall levels 646 $\mu g/m^3$,330 $\mu g/m^3$ and 43 $MtKm^{-1}$ $month^{-2}$ respectively observed at Sahibabad Industrial area was well above the highest SPM, RSPM observed in Delhi 464 $\mu g/m^3$ and 401 $\mu g/m^3$ respectively by CPCB. However the SPM, RSPM and dust fall rate levels in all seasons and in all areas under study in Ghaziabad and Meerut area of NCR exceeded the critical levels and therefore demands the necessity of phase wise SPM, RSPM and dust fall reduction from the all areas.

Variation in the levels of different pollutants i.e. SPM, RSPM and dust fall at different sites shows the location and Meteorological effects, which may be attributed to varying nature and quantum of emissions from stationary and mobile sources, wind pattern and transported pollution load from other sources/areas etc. It is further supported by analysis of variance of monthly SPM, RSPM and dust fall data which revealed significant variation between sites and months.

Strong correlation was found among all the pollutants SPM, RSPM and dust fall indicate their common major source and coexistence in the urban atmosphere of National Capital Delhi. The above findings on attempt will be useful to regulatory authorities and administration to understand problems of air pollution in the specific area of the National Capital Delhi and shall be helpful in prevention of pollution.

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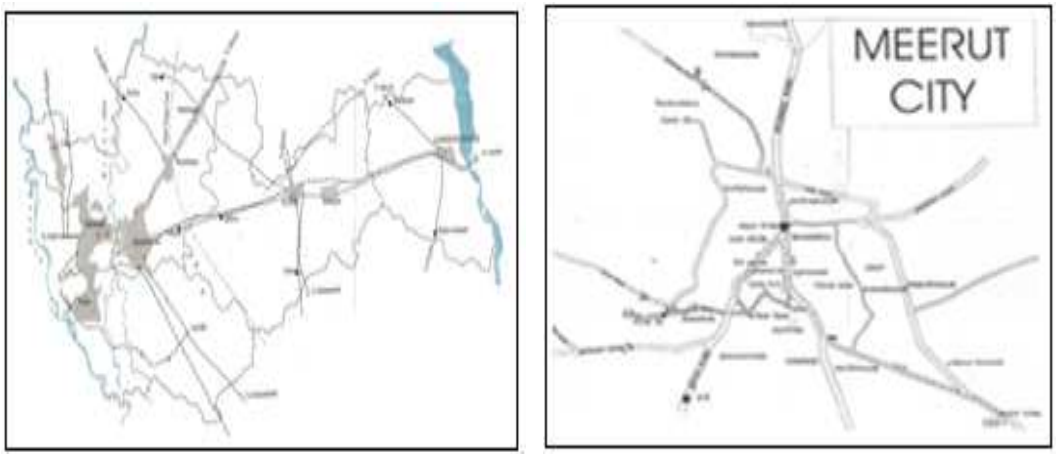
APPENDICES

Table 1: Sampling Station in Ghaziabad and Meerut Area of NCR Location

Area	Location
Ghaziabad	
Residential	Rajnagar, (roof of house app.200m away from main Road)
Commercial	*Modinagar (N.H. Road side)
Industrial	**Sahibabad G.T. Road, Industrial area (heavy and small scale Industry). Bulandshahr Road, Industrial area (small and medium scale Industry).
Meerut	
Residential	Railway Road (roof of house along with Sadar Bajar and Keshar Bazar)
Commercial	Begum Bridge (Road side along with B*us stand and Lal Kurti Commercial area)
Industrial	Partapur Industrial area (Small Scale Industry)

*Modinagar Station is surrounded by Air polluting industries.
**Sahibabad, Bulandshahr Station is surrounded by Air polluting industries.



Ghaziabad **Meerut**

Figure 1: Map Showing Location of Sampling Station in Ghaziabad & Meerut of NCR

Table 2: Seasonal (8 Hrly) 2 Years Combined Concentration (µg/m^3) of SPM, RSPM and Dust Fall (Mt Km^{-2} Month^{-1}), Period July 2009 to June 2011

Name of Station	Moonson (July to Sept.) Pollutant			Post Moonson (Oct. to Nov.) Pollutant			Winter (Dec. to Feb.) Pollutant			Summer (March to June) Pollutant		
	SPM	RSPM	Dust Fall	SPM	RSPM	Dust Fall	SPM	RSPM	Dust Fall	SPM	RSPM	Dust Fall
Residential Area												
Rajnagar (Ghaziabad)	190	90	10	268	108	9	267	118	13	337	180	21
Railway Road (Meerut)	342	100	13	403	120	15	450	128	20	509	195	26
Commercial & Mixed use Area												
Modinagar Bus Stand (Ghaziabad)	331	120	18	410	144	20	484	185	24	526	213	31
Begum Bridge (Meerut)	346	109	21	487	196	20	503	135	22	543	282	27
Industrial Area												
Sahibabad Industrial area (Ghaziabad)	458	135	30	544	330	29	537	305	34	646	330	43

Table 2: Contd.,

Bulandshahr Industrial area (Ghaziabad)	433	169	19	499	228	22	515	288	26	568	303	34
Partapur Industrial area (Meerut)	341	113	21	500	195	23	499	270	26	576	295	32
Average	348.51	119.42	18.85	444.42	188.71	19.71	465	204.14	23.57	529.28	256.85	30.57
Standard Deviation	86.27	26.12	6.41	92.93	76.19	6.31	91.35	81.55	6.42	95.64	59.47	6.99
% CV	24.73	21.87	34	20.91	40.36	32.03	19.64	39.94	27.23	18.06	23.15	22.86

Table 3: Combined SPM, RSPM (µg/m^3) and Dust Fall (Mt Km^{-2} Month^{-1}) in Ghaziabad and Meerut Area of NCR, Period July 2009 to June 2011

Name of Station	Moonson (July to Sept) Pollutant			Postmoonson (Oct. to Nov.) Pollutant			Winter (Dec. to Feb.) Pollutant			Summer(March to June) Pollutant		
	SPM	RSPM	Dust Fall	SPM	RSPM	Dust Fall	SPM	RSPM	Dust Fall	SPM	RSPM	Dust Fall
Residential Area												
Rajnagar (Ghaziabad)	266	95	12	335	114	12	359	123	17	423	188	24
Railway Road(Meerut)												
Commercial & Mixed use Area												
Modinagar Bus Stand (Ghaziabad)	338	115	20	448	170	20	493	166	23	535	248	29
Begum Bridge (Meerut)												
Industrial Area												
Sahibabad Industrial area (Ghaziabad)												
Bulandshahr Industrial area (Ghaziabad)	411	139	23	514	251	25	517	287	29	597	309	36
Partapur Industrial area (Meerut)												
Average	338.33	116.33	18.33	432.33	178.33	19	456.33	192	23	518.33	248.33	29.66
Standard Deviation	72.50	22.03	5.68	90.52	68.87	6.55	85.14	85.03	6	88.18	60.50	6.02
% CV	21.42	18.93	30.98	20.93	38.61	34.47	18.65	44.28	26.08	17.01	24.36	20.29

Table 4: Seasonal SPM, RSPM (µg/m^3) and Dust Fall (Mt Km^{-2} month^{-1}) Trends, Period July 2009 to June 2011

Site	Pollutant	Monsoon	Post Monsoon	Winter	Summer
Residential area	SPM	266	335	359	423
	RSPM	95	114	123	188
	Dust fall	12	12	17	24
Commercial & Mixed use area	SPM	338	448	493	535
	RSPM	115	170	166	248
	Dust fall	20	20	23	29
Industrial area	SPM	411	514	517	597
	RSPM	139	251	287	309
	Dust fall	23	25	29	36

Table 5: Seasonal SPM (µg/m^3) Concentration Trends, Period July 2009 to June 2011

Site	Monsoon	Post Monsoon	Winter	Summer
Residential area	266	335	359	423
Commercial & Mixed use area	338	448	493	535
Industrial area	411	514	517	597

Table 6: Seasonal RSPM (µg/m^3) Concentration Trends, Period July 2009 to June 2011

Site	Monsoon	Post Monsoon	Winter	Summer
Residential area	95	114	123	188
Commercial & Mixed use area	115	170	166	248
Industrial area	139	251	287	309

Table 7: Seasonal Dust Fall (Mt Km^{-2} Month^{-1}) Concentration Trends, Period July 2009 to June 2011

Site	Monsoon	Post Monsoon	Winter	Summer
Residential area	12	12	17	24
Commercial & Mixed use area	20	20	23	29
Industrial area	23	25	29	36

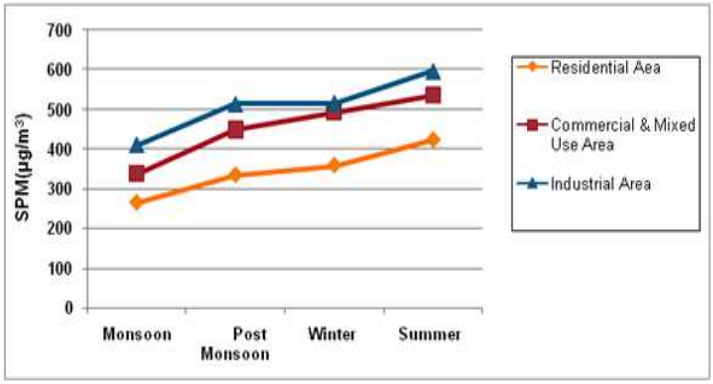


Figure 2

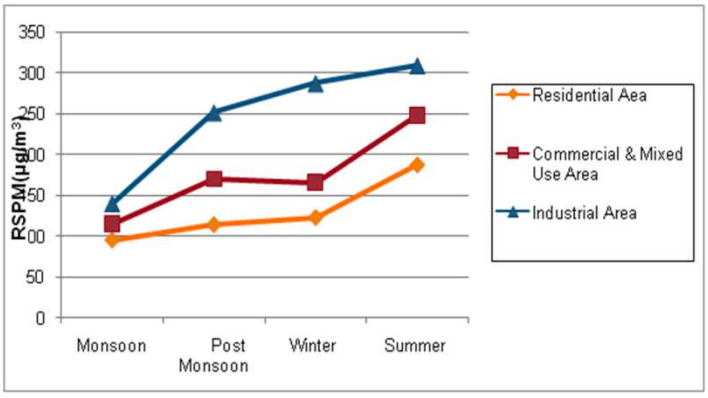


Figure 3

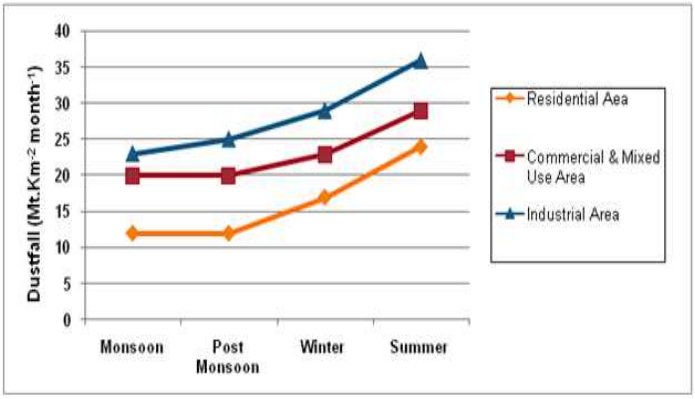


Figure 4

Appendix-I

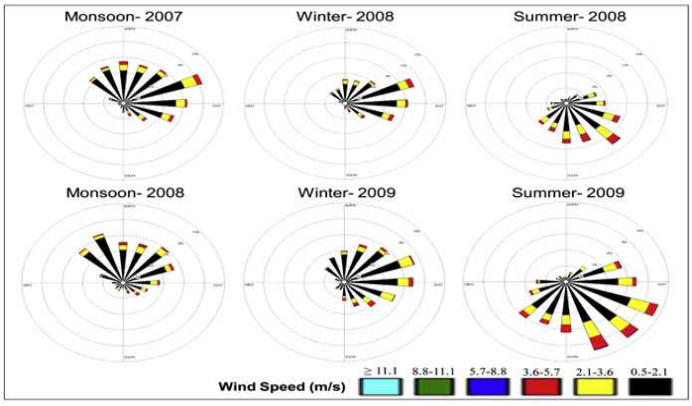


Figure 5

Appendix-II

Table 8: Rainfall (mm)

Month/Year	Jan.	Feb.	Mar.	Apr.	May	June	July	Aug.	Sep.	Oct.	Nov.	Dec.	Total
Normal	19.8	16.7	16.6	9.9	16.9	54.1	227.2	238.0	131.6	25.3	5.7	7.5	769.3
2006	3.2	0.0	17.8	2.8	93.2	90.2	263.6	66.3	78.5	0.4	0.3	2.4	618.7
2007	0.0	49.8	54.4	0.0	40.4	83.8	83.6	216.8	72.8	0.0	0.0	0.0	601.6
2008	1.8	0.0	0.0	31.0	136.6	100.7	166.2	299.1	115.6	0.0	0.0	0.0	815.0
2009	4.2	6.5	3.9	2.0	43.0	5.4	124.2	188.6	201.9	0.3	14.2	1.0	595.5
2010	0.0	14.2	0.0	1.2	7.6	4.6	236.8	338.8	314.2	22.0	13.4	0.3	953.1
2011	0.0	49.9	2.3	2.2	33.4	104.2	33.8	272.4	163.6	0.0	0.0	0.0	661.8