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Original Research Article

Evaluation of Air Quality: Air Pollutants of air at Kanpur by using Correlation Study

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Abstract

We present an extensive investigation of pollutants respirable suspended particulate matter (RSPM) and suspended particulate matter (SPM), oxides of nitrogen (NOx), sulphur dioxide (SO_2) of Kidwai Nagar (S1), Darshanpurva (S2), Panki site (S3), Shastri Nagar (S4), Awas Vikas (S5) Meteorological parameters (temperature, relative humidity, wind speed and rainfall) present in air samples of Kanpur for Jan -2010 to Dec-2011. Each air pollutant is marked with a subscript k,d,p,s,a representing the name of area from which it belong to. In the present study, it was noticed that the observed values of SPM and RSPM levels at all selected stations exceeds the standard limits recommended by Central Pollution Control Board (CPCB) New Delhi, India. SO_2 and NOx levels in residential, industrial and commercial areas remain under recommended limits of CPCB. Correlation coefficients were calculated between different pairs of pollutants and Meteorological parameters. To identify the highly correlated and interrelated air quality parameters, t-test was applied for checking significance. Pollutants RSPM and SPM show significant positive correlations with *p*<0.01. An appreciable significant positive correlation have been found for RSPMk with SPMk, RSPMd, SPMd, RSPMp, SPMp, Noxp, SPMs and SPMa. A significant positive correlation was also found between wind speed and relative humidity. Relative humidity bears negative correlation with RSPMp, SPMp, RSPMs and SPMs Similarly rain fall also shows negative correlation with RSPMk, SPMk, RSPMd, SPMd, RSPMp, SPMp and SPMs.

Keywords: Air pollutants, Pollutants, Respirable Suspended Particulate Matter (RSPM), Suspended Particulate Matter (SPM), t-test

INTRODUCTION

Defining "air pollution" is not simple. One could claim that air pollution started when humans began burning fuels. In other words, all man-made (anthropogenic) emissions into the air can be called air pollution, because they alter the chemical composition of the natural atmosphere. The increase in the global concentrations of greenhouse gases CO_2, CH_4, and N_2O, can also be considered as increase in air pollution, Air pollution occurs when the air contains substances in quantities that could harm the comfort or health of humans and animals, or could damage plants and materials. These substances are called air pollutants and can be either particles, liquids or gaseous in nature (Alias M. et al, 2007).

In most urban areas, emissions from traffic are a major contributor of harmful pollutants such as nitrogen oxides (NOx) and particulate matter (PM) (Lim Ling L., 2005), (Naik S., 2005)

Kanpur is one of the most polluted cities in India today. Kanpur's climate can be characterized by a very hot and dry summer and very cold winter, the temperature during summer can go up to 50 °C and winter it can drop below 5°C. The city's population is around 6 million at present and it is dangerously congested and overcrowded and due to the onset of

Table 1. Ambient Air Quality Standards of Central Pollution Control Board (CPCB, 2009).

S.No.	Pollutant	Time-weighted average	Concentration in ambient air		
			Industrial Areas, Residential, Rural & other Area	Ecological Sensitive Area	Methods of Measurement
1	Sulphur Dioxide (SO_2)	Annual Average	50 µg/ m3	20 µg/ m3	-Improved West and Greek method -Ultraviolet Fluorescence
		24 hours	80 µg/ m3	80 µg/ m3	
2	Oxides of Nitrogen as (NOx)	Annual Average	40 µg/ m3	30 µg/ m3	-Modified Jacob and Hochheiser -Chemiluminescence
		24 hours	80 µg/ m3	80 µg/ m3	
3	Suspended Particulate Matter (SPM)	Annual Average	60 µg/ m3	60 µg/ m3	-Gravimetric -TOEM -Beta attenuation
		24 hours	100 µg/ m3	100 µg/ m3	
4	Respirable Suspended Particulate Matter (RSPM)	Annual Average	40 µg/ m3	40 µg/ m3	-Gravimetric -TOEM -Beta attenuation
		24 hours	60 µg/ m3	60 µg/ m3	
5	Ozone (O_3)	8 hours	100 µg/ m3	100 µg/ m3	-UV Photometric -Chemiluminescence - Chemical Method
		1 hours	180 µg/ m3	180 µg/ m3	
6	Lead	Annual Average	0.5 µg/ m3	0.5 µg/ m3	-AAS/ICP method after sampling on EPM 2000 or equivalent filter paper - ED-XRF using Teflon filter
		24 hours	1.0 µg/ m3	1.0 µg/ m3	

Table 2. Different Paired Samples Correlations (SPSS Advanced Models™ 12.0 Web site at http://www.spss.com)
Note: Significan't' if t 0.05 >2.14

S.No.	parameters	r	[t]
Pair 1	Temp & Wind Speed	.869	8.245
Pair 2	Temp & RelHum	.773	-6.360
Pair 3	Temp & SPMd	-.598	-55.383
Pair 4	Temp & RSPMs	-.539	-25.531
Pair 5	Wind Speed & RelHum	.816	-8.368
Pair 7	RelHum & RSPMp	-.514	-21.822
Pair 8	RelHum & SPMp	-.588	-35.747
Pair 9	RelHum & RSPMs	-.597	-16.071
Pair 10	RelHum & SPMs	-.564	-35.525
Pair 11	Rainfall & RSPMk	-.645	-69.473

Table 2. Continue

Pair 12	Rainfall & SPMk	-.604	-61.604
Pair 13	Rainfall & RSPMd	-.517	-81.720
Pair 14	Rainfall & SPMd	-.567	-75.984
Pair 15	Rainfall & RSPMp	-.723	-61.059
Pair 16	Rainfall & SPMp	-.735	-59.017
Pair 17	Rainfall & SPMs	-.620	-62.571
Pair 18	RSPMk & SPMk	.951	-53.943
Pair 19	RSPMk & RSPMd	.789	-1.754
Pair 20	RSPMk & SPMd	.758	-60.090
Pair 21	RSPMk & RSPMp	.838	-9.900
Pair 22	RSPMk & SPMp	.844	-47.560
Pair 23	RSPMk & NOxp	.633	62.856
Pair 24	RSPMk & SPMs	.756	-46.108
Pair 25	RSPMk & SPMa	.807	-58.350
Pair 36	SPMk & RSPMd	.783	44.691
Pair 27	SPMk & SPMd	.718	.586
Pair 28	SPMk & RSPMp	.758	45.357
Pair 29	SPMk & SPMp	.756	-4.782
Pair 30	SPMk & NOxp	.536	58.603
Pair 31	SPMk & SPMs	.641	2.879
Pair 32	SPMk & SPMa	.793	4.721
Pair 33	NOxk & NOxd	.663	2.621
Pair 34	RSPMd & SPMd	.917	-65.618
Pair 35	RSPMd & RSPMp	.719	-6.523
Pair 36	RSPMd & SPMp	.785	-43.663
Pair 37	RSPMd & NOxp	.523	73.288
Pair 38	RSPMd & SPMs	.716	-42.853
Pair 39	RSPMd & SPMa	.702	-50.640
Pair 40	SPMd & RSPMp	.715	55.536
Pair 41	SPMd & SPMp	.827	-6.284
Pair 42	SPMd & RSPMs	.547	47.459
Pair 43	SPMd & SPMs	.721	2.950
Pair 44	SPMd & SPMa	.673	3.786
Pair 45	SO2d & NOxd	.667	-42.408
Pair 46	NOxd & NOxp	.570	-6.799
Pair 47	RSPMp & SPMp	.950	-53.797
Pair 48	RSPMp & NOxp	.664	55.525
Pair 49	RSPMp & SPMs	.851	-50.141
Pair 50	RSPMp & SPMa	.782	-55.697
Pair 51	SPMp & NOxp	.566	56.363
Pair 52	SPMp & SPMs	.861	10.539
Pair 53	SPMp & SPMa	.762	8.978
Pair 54	NOxp & SPMs	.530	-59.403
Pair 55	NOxp & RSPMa	.515	-49.537
Pair 56	NOxp & SPMa	.572	-69.656
Pair 57	NOxp & NOxa	.531	9.923
Pair 58	RSPMs & SPMs	.566	-40.540
Pair 59	SPMs & SPMa	.663	.684
Pair 60	RSPMa & SPMa	.594	-49.773

Note: Subscript k,d,p,s,a stand for Kidwai Nagar, Darshanpurva, Panki, Shastry Nagar, Awas Vikas stations respectively.

leather industries pollution levels have risen dangerously high, according to the CPCB (central pollution control board) the RSPM (respirable suspended particulate matter) concentration in the city is 178µg/m3 which is far more than the specified under the National Ambient Air Quality Standards (NAAQS). Alarming vehicular and population growth rate, frequent traffic jams and not much improvement in the quality and number of roads has resulted in a significant rise in the RSPM level of Kanpur. However, although vehicles and industries are two of the biggest contributors to the Kanpur's ambient RSPM level but contributions from other pollution sources, such as roadside dust, trans-boundary migrations, power plants, solid waste and local sources can't be ruled out. A. Chakraborty and T. Gupta.

Analysis

Air samples were collected from five monitoring stations during year Jan 2010 to Dec 2011. The first one is Kidwai Nagar, a commercial cum residential area of Kanpur, posses a very high number of motor vehicles running throughout the day and night (S1), The second station is commercial area, Darshanpurwa (S2), one of the main and busy area of the city, posses a high number of two wheelers, three wheelers and four wheelers vehicles running throughout the day. The third station is industrial area Panki site-5 (S3), which is the developed state industrial belt, Lots of industries have already started functioning and some are yet to arrive in this area. The fourth station (S4) is Shastri Nagar and nearby industrial area which is the well known residential cum traffic area .The fifth station S5 is Awas Vikas is a residential area. All the air pollutants are analyzed by using Repairable dust samplers (RDS). The frequency of the sampling was twice a week, and in total 104 air samples were collected in a year. The collected samples were analyzed for various parameters using standard methods prescribed by central pollution control board (CPCB) and originally described by APHA (1977). Particulate matter that is SPM and RSPM were estimated by gravimetric method. A known amount of air is drawn through pre weighed glass fibre filter paper, GF/A at a flow rate of 0.8-1.3 m^3/min on 8-hourly basis for 24 hours. Gaseous pollutants namely SO_2 and NO_x were collected on four hourly bases for 24hours by drawing air flow of 1L/min and were analyzed by West and Geake (1956) and Jacob and Hochheiser (1968) method respectively. Concentrations of the pollutants were measured in micrograms/cubic meter (µg/m^3). The observed values of various air pollutants of air samples were compared with standard values recommended by Ambient Air Quality Standards of Central Pollution Control Board (CPCB) given in Table-1. The objective is to minimize the complexity and dimensionality of large set of data. Systematic calculation of correlation coefficient between air pollutants has been carried out and significant correlation has been further verified by using t-test (Bhandari and Nayal, 2008; Garg et al., 1990; Sarkar et al., 2006).

Statistical analysis

To evaluate the relationship between air pollutants and meteorological parameter, Person's correlation coefficient values (r) were calculated at each monitoring stations using SPSS software (SPSS Inc., version 18.0) for assessing the significance of quantitative changes in different pollutants. Correlation coefficients were calculated between different pairs of pollutants PM_{10} (RSPM), suspended particulate matter (SPM), sulphur dioxide (SO_2) and oxides of nitrogen (NO_x) and Meteorological parameters like temperature, relative humidity, wind speed and rainfall which were also recorded simultaneously during the sampling period. To identify the highly correlated and interrelated air quality parameters, t-test was applied to calculated correlation coefficients, for checking significance and values are given in Table - 2.

RESULTS AND DISCUSSION

Correlation coefficients were calculated between different pairs of pollutants and Meteorological parameters like temperature, relative humidity, wind speed and rainfall to identify the highly correlated and interrelated air quality parameters and t-test was applied for checking significance (Chauhan et al., 2010).

The observed Temperature value were found out be ranging from 0.0 to 36.60 ^{0}C. Other parameters like wind speed was found to be ranging from 0.00 to 3.00m/s, relative humidity from 0.00 to 80.20%, and rain fall from 0.00 to 0.52mm. we also observed that air pollutants RSPMk ranged from164.48 to 219.74 µg/ m^3, SPMk from 361.06 to 495.67 µg/ m^3, SO_2k from 6.41 to 9.63 µg/ m^3, NOxk from 31.61 to 46.45 µg/ m^3, RSPMd from177.55 to 228.07 µg/ m^3), SPMd from 393.69 to 522.34 µg/ m^3, SO_2d from 6.47 to 8.60 µg/ m^3, NOxd from 28.37 to 41.83 µg/ m^3, RSPMp from174.9 to 250.25 µg/ m^3.

In the present study for the year Jan 2010 to Dec.2011, Temperature shows significant positive correlation with wind speed (r = 0.869, t = 8.245) and relative humidity (r = 0.773, t= 6.360) and significant negative correlation with SPMd (r= -0.598, t= 55.383) and RSPMs (r= -0.539, t=25.531) is given Figure 1, showing with increase or decrease in the values of temperature, the values of wind speed and relative humidity .The values of SPMd and RSPMs decreases or increases with increasing or decreasing values of temperature.

A significant positive correlation was found between wind speed and relative humidity (r= 0.816, t= 8.368). Relative humidity bears negative correlation with RSPMp (r= -0.514, t= 21.822), SPMp (r= -0.588, t= 35.747), RSPMs (r= -0.597, t= 16.071) and SPMs (r= -0.564, t= 35.525). This shows that with increase the value of relative humidity, values of RSPMp, SPMp, RSPMs and SPMs will decrease. Similarly rain fall also shows negative correlation with RSPMk (r= -0.645, t= 69.473), SPMk (r= -0.604, t= 61.604), RSPMd (r= -0.517, t= 81.720), SPMd (r= -0.567, t= 75.984), RSPMp (r= -0.723, t= 61.059), SPMp (r= -0.735, t= 59.017) and SPMs (r= -0.620, t= 62.571). It shows clearly with increase of rain fall, level of pollution in atmosphere will decrease .Consequently showing that from point of pollutants, monsoon season will have least pollutants. (Figure 2)

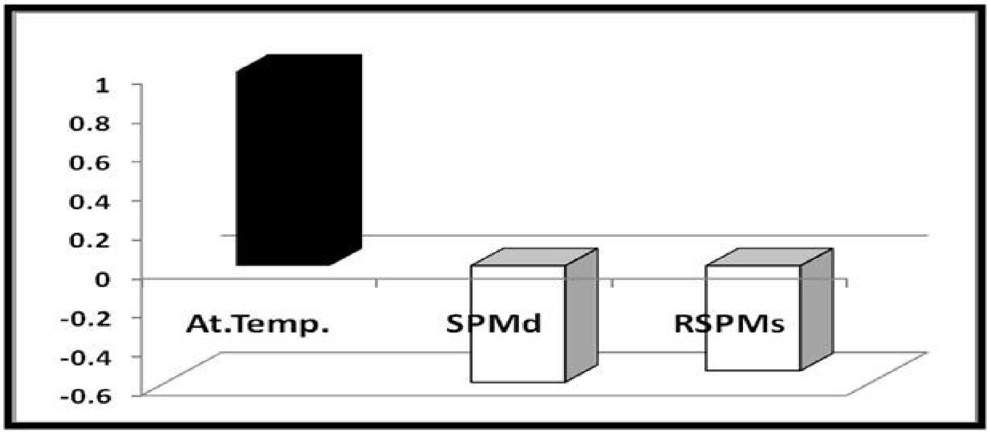

Figure 1. Temperature shows significant negative correlation with SPMd and RSPMs

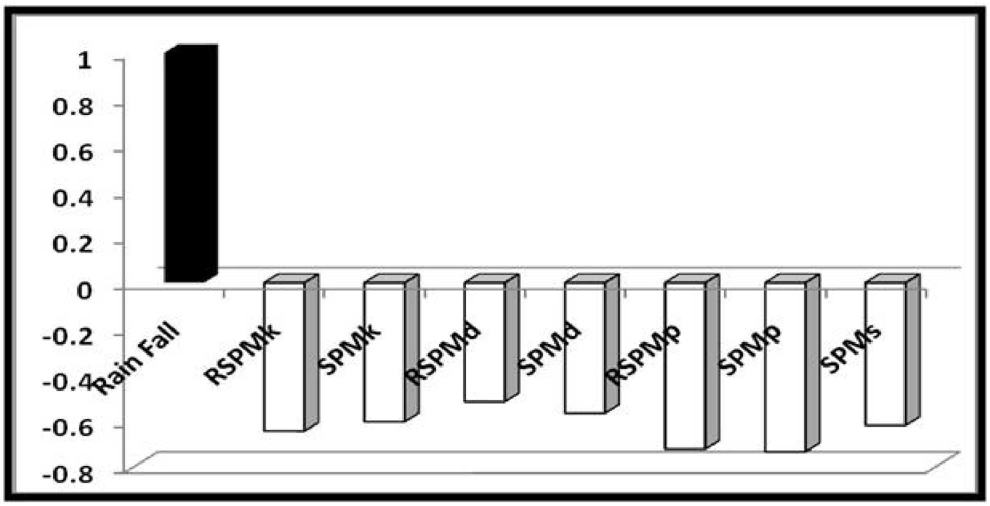

Figure 2. Rain fall also shows negative correlation with RSPMk, SPMk, RSPMd, SPMd, RSPMp, SPMp and SPMs.

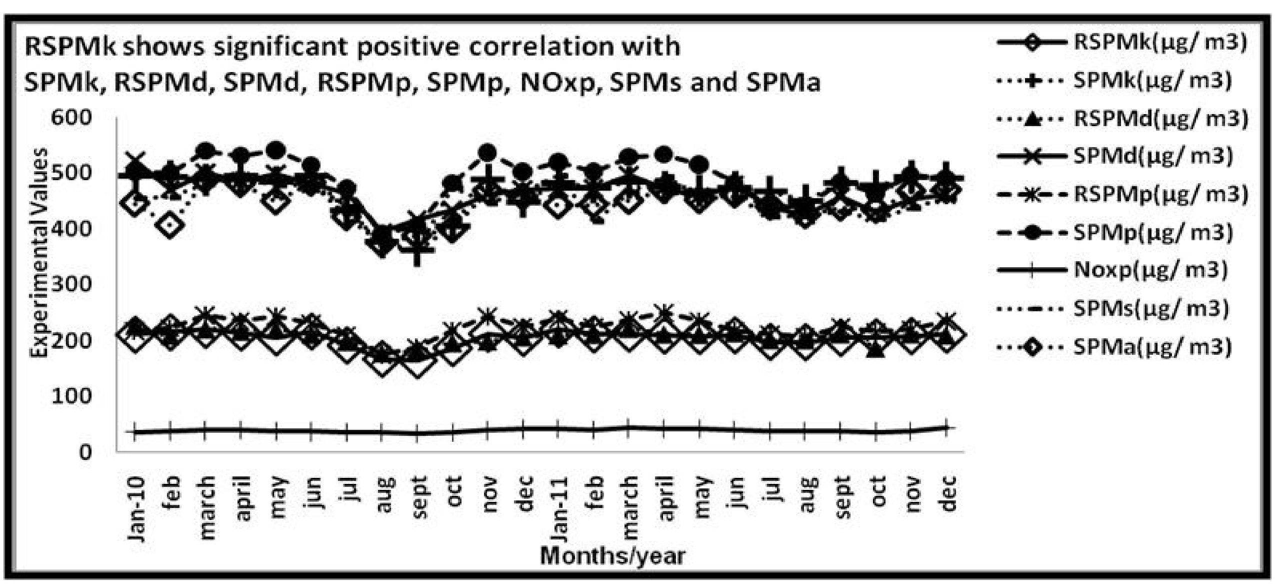

Figure 3. Month wise oserved values of RSPMk; SPMk, RSPMd, SPMd, RSPMp, SPMp, NOxp, SPMs and SPMa

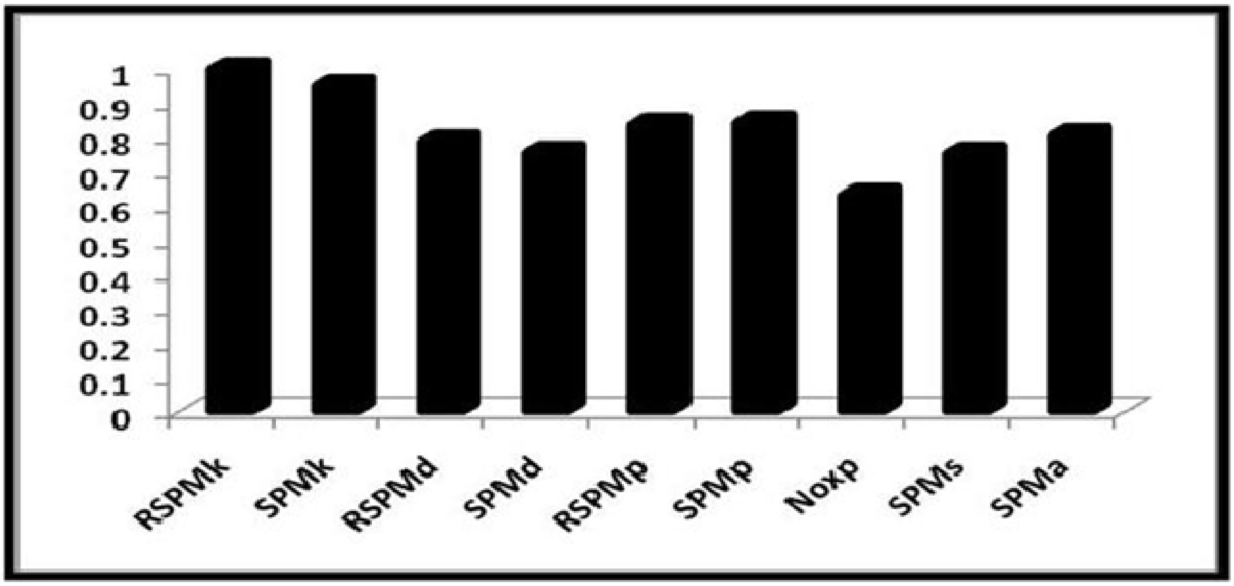

Figure 4. RSPMk shows significant positive correlation with SPMk, RSPMd, SPMd, RSPMp, SPMp, NOxp, SPMs and SPMa

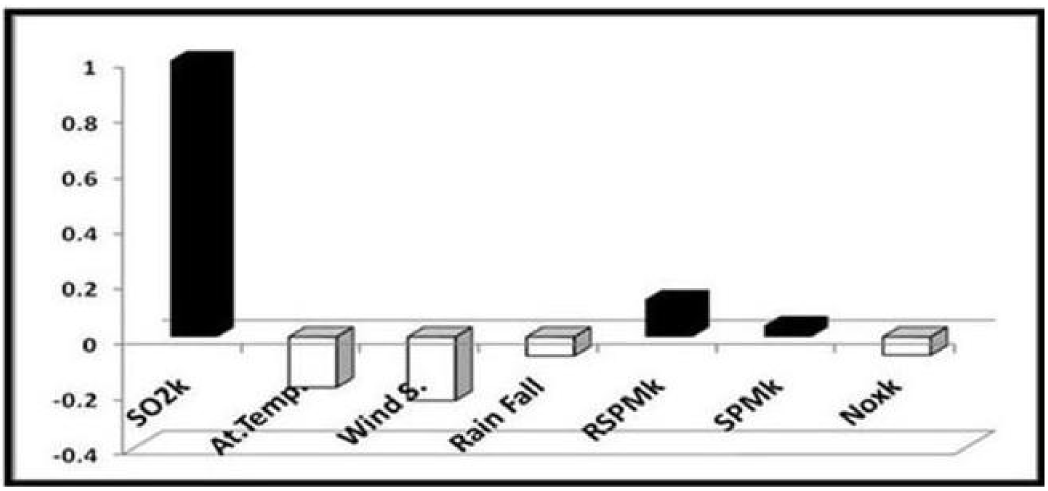

Figure 5. SO2k shows no correlation with At. Temperature, Wind speed, Rain fall, RSPMk, SPMk, NOxk

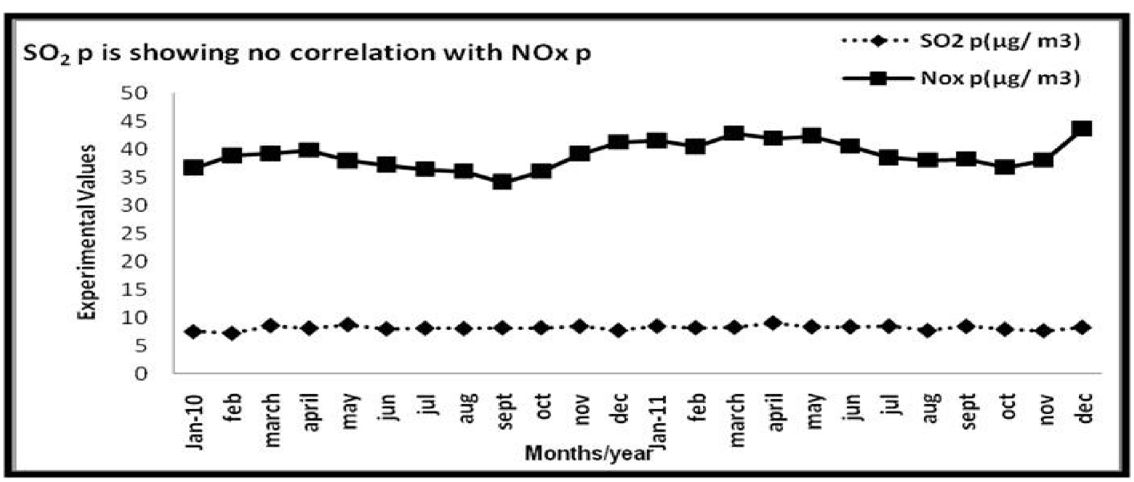

Figure 6. Observed values for pollutant SO_2p and NOxp from January 2010 to December 2011

RSPMk bears significant positive correlation with SPMk(r= 0.951, t= 53.943), RSPMd (r= 0.789, t= 1.754), SPMd (r= 0.758, t= 60.090), RSPMp (r= 0.838, t= 9.900), SPMp (r= 0.844, t= 47.560), NOxp (r= 0.633, t= 62.856), SPMs (r= 0.756, t=46.108) and SPMa(r= 0.807, t= 58.350). This is shown in figure 3 above ie with increase or decrease in the values of RSPMk; SPMk, RSPMd, SPMd, RSPMp, SPMp, NOxp, SPMs and SPMa also exhibit decrease or increase in values of RSPMk.

Similarly RSPMk shows positive correlation with SPMk, RSPMd, SPMd, RSPMp, SPMp, NOxp, SPMs and SPMa is shown in figure 4. NOxd shows positive correlation with NOxk (r= 0.663, t= 2.621), SO2d(r= 0.667, t= 42.408), and Noxp (r= 0.570, t= 6.799). Few pollutants like RSMP, SMP are showing no correlation with any pollutant like SO_2k, SO_2p, SO_2s and SO_2a. Observed values of SO_2 in each station under study are with in prescribed limits, recommended by Central Pollution Control Board (CPCB) except station 2(S2) i.e, Darshanpurwa. (Figure 5-6)

CONCLUSIONS

A large number of pollutants and metrological parameters influence the correlations between different pairs of air pollutants of air samples directly or indirectly. RSPM and SPM are dominating pollutants in Kanpur.

In the present study, it was noticed that the SPM and RSPM levels at all selected locations exceeds the prescribed limits recommended by Central Pollution Control Board (CPCB, 2009) .RSPM and SPM shows significant correlations with *p*<0.01. The highest concentrations of RSPM and SPM have been also been reported in various part of India (Chelani and Devotta, 2007: Nidhi and Jayaraman, 2007) in Haridwar region (Joshi and Swami, 2007; Joshi et al., 2006' Joshi and Chauhan, 2008**,** Chauhan, 2008, Chauhan and Joshi, 2010) and also in Dehradun (Chauhan, 2010).

An appreciable significant positive correlation has been found for RSPMk with SPMk, RSPMd, SPMd, RSPMp, SPMp, NOxp, SPMs and SPMa.

A significant positive correlation was found between wind speed and relative humidity. Relative humidity bears negative correlation with pollutants RSPMp, SPMp, RSPMs and SPMs.

Similarly rain fall also shows negative correlation with RSPMk, SPMk, RSPMd, SPMd, RSPMp, SPMp and SPMs for year January2010-December 2011.

SO_2 and NO_x are not dominating pollutants in Kanpur. Pollutants SO_2p and NOxp are not correlated.

Observed values of SO_2 in each station under study are with in prescribed limits, recommended by Central Pollution Control Board (CPCB) except station 2 (S2) i.e, Darshanpurwa. SO_2k, SO_2p, SO_2s and SO_2a are not correlated with pollutants RSPM and SPM.

To minimize the contaminations of air quality of Kanpur the values of correlation coefficients and their significance level will help in selecting the proper government policies to keep purity of Kanpur air at highest level. To create increasing awareness among the people to maintain the Air quality at its highest quality and purity levels, the present study may prove to be useful in achieving this goal.

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