A correlation of particulate matter with gaseous pollutants in ambient air of Dindigul town

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SUMMARY

The importance of correlation and regression among air pollutants such as gaseous pollutants (SO_2 and NO_x) and particulate matter (SPM and RPM) in ambient air quality were studied. Air pollutant in the ambient air at leather tanneries, traffic-cum-commercial and residential area were collected from Dindigul town. Air quality deterioration especially in Dindigul town was one of the must altering problems of modern civilization. The concentration of gaseous pollutants and particulate matter were found to be high and the results showed good correlation among them. All the correlations were found to be good to excellent indicating an ecosystem under identical or near identical natural condition. Present investigation shows significant positive correlation among the particulate matter and gaseous pollutant.

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The urban population is exposed to higher levels of SO_2 and NOx due to urbanization and industrialization, concentration of ambient air particulates have been found to be associated with a wide range of effects on human health (Dockery and Pope, 1994; Gold berg, 1996; Schwartz, 1991; Zmirou *et al.,* 1998). Approximately 50,000 premature deaths occur annually due to PM10 pollution in India (Brandon and Hommann, 1945). The high concentration of particulate matter (PM) in the environment has become a problem for many countries. (Elbir *et al.,* 2000). PM consists of primary aerosols as well as secondary aerosols such as sulfate, nitrate, sulfur dioxide (SO_2) and oxides of nitrogen (NO_x), if present in excess in ambient air, affect the respiratory tract causing irritation and increasing airway resistance (Tsai and Cheng, 1991).

Several investigators (Keeler *et al.,* 1990; Pope *et al.,* 2002 and Schwartz *et al.,* 1996) have studied the chemical composition of atmospheric aerosols in different parts of India. Dindigul town lies on the banks of Kudavanar river in Tamil Nadu. The population of this town is around 4 lakhs. There are about more than 200 both registered and non-registered tanneries in and around Dindigul.

The increase of tanneries in Dindigul is causing severe environmental degradation as the untreated effluent used in the training process is released into nearby water reservoirs. In addition, air pollution is on the rise with the tanneries burning residuals from the tanning process into the atmosphere. There are reports on gaseous pollutants that get associated with particulate matter (PM) and cause more impact therefore the objective of the present study is to characterize estimate and find out association of SPM and RPM of gaseous pollutant concentration in ambient air.

Correlation among ambient air quality parameters in a specific environmental conditions have been shown to be useful (Shrivastava *et al.,* 1996) Correlation study of ambient air quality would be highly advantageous.

This may greatly facilitate the task of rapid monitoring status of pollution in Dindigul town. In this town, different types of industries emit different types of pollutants. The concentration of each pollutant depends upon the situation of point with respect to the industries that emit the pollutants. As there is large number of variables, the statistical methods only are useful for prediction of

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concentration of pollutants at selected points by correlation and regression techniques. Moore (1990), Di Battisa and Ficarra (1998) and Voroshnin and Protasevich (1987) have studied correlation and regression analysis of ambient air quality data.

Materials and Methods

Sampling of air and analysis was carried out as per the standards of Central Pollution Control Board, India.

Suspended particulate matter (SPM):

Sampling was done with handy and personal samplers manufactured by Envirotech. Small circular filter disc of Whatman GF/A42 filter paper was used for SPM sampling. Dry weight of the above-mentioned filter paper was taken after drying in an oven at 105^0C. The process was repeated thrice and the average weight was taken. Thus, the dry weight of filter papers was determined before and after sampling and the difference of weight constituted the suspended particulate matter.

Respairable particulate matter (RPM):

The amount of RPM was determined for 8 hours on pre-weighed glass fibre filter paper (Whatman EPA 200 A grade) of 20.3 x 25.4 cm size and reweighed after sampling in order to avoid humidity factor and other material losses, the filter papers were always dried in oven, later cooled and kept in desiccators before weighing.

Sulphur dioxide (SO_2):

Sampling was done with the Envirotech make handy sampler (APM 820). The sampling and analysis were done as per IS 5182 (Part II) 2001. Sodium tetrachloride mercurate was used to absorb SO_2 at a constant flow data of 11pm for 90 minutes. Spectrophotometric analysis was used and sample of sodium tetrachloro mercurate containing SO_2 absorbed from air was analyzed in Ultra violet spectrophotometer.

Oxides of nitrogen (NO_x):

Sampling was done with the Envirotech make handy sampler (APM 820). The sampling and analysis were done as per 1S 5182 (Part VI) 1998. Sodium hydroxide was used to absorb NO_x at a constant flow rate of 1 ppm for 90 minutes. Spectrophotometric analysis was used and sodium tetrachloro mercurate containing SO_2 absorbed from air analyzed in Ultra violet spectrophotometer.

Monitoring schedule:

Monitoring was carried out at three locations in the Dindigul town, broadly classified into three main categories, tanneries, commercial cum traffic and residential. All these locations are prominent places in the Dindigul town and are typical representatives of their respective categories. At each site the instruments were mounted at a height of about 10 to 15 meter above the ground. Sampling was carried out for sulfur dioxide, oxides of nitrogen, suspended particulate matter and respirable particulate matter. The frequency of monitoring for SPM and RPM was 24 hourly and 8 hourly with respect to SO_2 and NO_x.

Calculation of correlation co-efficient and linear regression:

The correlation co-efficient (r) between variables x and y (that is gaseous pollutants and particulate matter in this case) was calculated using well-known equation. (Trivedy and Goal, 1984).

$$r = \frac{\sum xy - \bar{x}\sum y}{\sqrt{\left(\sum x^2 - \bar{x}\sum x\right)\left(\sum y^2 - y\sum y\right)}} \quad (1)$$

where, the summations are taken from 1 to 0 (0 is number of observation). The values of empirical parameters a and b were calculated with the help of following equations:

$$r = \frac{\sum xy - \bar{x}\sum y}{\sqrt{\left(\sum x^2 - x\sum x\right)}} \quad (2)$$

$$a = y - bx \quad (3)$$

where,

$x = \sum x/n, y = \sum y/n$

After calculating the values of a and b, the value of Y was calculated for any of the two X values for the regression line with the help of the equation:

$$y = a + bx$$

Results and Discussion

The concentration of SPM and RPM, SO_2 and NOx was carried out at three different sampling sites such as tannery area, commercial-cum-traffic area and residential area which are given in Table 1. The estimated SPM concentration in ambient air of three sampling sites was 105.3mg/m^3, 153 mg/m^3 and 81.75 mg/m^3. The concentration of SPM was found to be higher in the commercial cum traffic area followed by tanneries and residential area. The concentration of RPM for the three observed sites were 44.75 mg/m^3, 59.83 mg/m^3, and 46.15 g/m^3. The minimum RPM concentration was found at residential area. SO_2 values found in the three different sampling sites were 10.45 mg/m^3, 16.85 g/m^3 and 12.05 mg/m^3. Minimum concentration of SO_2 was found at the tanneries. All the sampling sites exhibited NOx concentration in the range of 32.65 mg/m^3, 27.65 mg/m^3 and 17.35 mg/m^3. Maximum SPM, RPM and SO_2 concentration was found in the commercial-cum-traffic and tannery area. The maximum NOx concentration was observed at the tannery area in comparison with other two sites. The gaseous pollutants SO_2 and NOx were within permissible limit 80mg/m^3 for residential and 120mg/m^3 for industrial area prescribed by TNPCB standards. The average concentration of SPM in ambient air at observed sites was within the permissible limit (200g/m^3) for residential area and (500mg/m^3) for industrial area prescribed by TNPCB standards. The average concentration of RPM in the ambient air at the observed sites was within the permissible limit (100mg/m^3) for residential area and (150mg/m^3) for industrial area prescribed by TNPCB standards. The air quality monitoring data clearly shows lower concentration of gaseous pollutants SO_2 and NO_X and higher concentration of SPM and RPM.

Table 1 : Concentration of gaseous pollutants (SO_2 and NO_x) and particulate pollutant (SPM and RPM) in tannery, commercial-cum-traffic and residential areas, in μg/m^3

Sites of sample collection	Parameters (μg/m^3)			
	SPM	RPM	SO_2	NO_x
Tanneries area	105.3	44.75	10.45	32.65
Commercial cum traffic	153.0	59.8	16.85	27.65
Residential area	81.75	46.15	12.05	17.35

Overall difference was based on two way ANOVA. Test was performed for comparison of parameter at their respective locations, where F values in ANOVA are significant. (Significant difference at ñ < 0.001 by multiple comparison tests).

Correlation among gaseous pollutants (SO_2 and NO_x) and particulate matter (SPM and RPM):

Any correlation will be statistically significant only if its 'r' values (correlation co-efficient) is very close to +1 or –1. In the present investigation, Table 2 shows the correlation coefficient of gaseous pollutants and particulate matter at the tannery area.

Table 2: Correlation co-efficient (r) between gaseous pollutants and particulate matter in the tannery area

Parameter	Parameters (μg/m^3)			
	SPM	RPM	SO_2	NO_x
SPM	1.00	-		
RPM	0.98	1.00	0.92	-0.96
SO_2	0.93	0.88	1.00	-.094
NO_x	-0.89	-0.90	-0.95	1.00

Table 2 shows correlation coefficient of gaseous pollutant and particulate matter in the tannery area. High positive correlation was found between SPM and RPM, SPM and SO_2, RPM and SO_2 whereas negative correlations were found between NO_x and RPM, NO_x and SO_2, NO_x and SPM. In the tannery area, it was found that gaseous pollutants such as SO_2 have positive correlation with particulate matter (SPM and RPM). The gaseous pollutant such as NO_x has negative correlation with particulate matter.

Table 3 shows the regression coefficient of all the possible pairs of parameters at the tannery area.

Table 3 : Regression coefficient (a and b) between gaseous pollutants and particulate matter of tannery area

Parameter pair	A	B
SPM and RPM	0.381	4.593
SPM and SO_2	6.211	40.400
SPM and NO_x	-0.11	44.251
RPM and SO_2	2.368	20.000
RPM and NO_x	-0.289	45.578
SO_2 and NO_x	-0.684	39.8

Table 4 indicates the correlation coefficient of gaseous and particulate pollutants in the ambient air at commercial cum traffic area. There existed a high positive correlation between SPM and RPM, SO_2 and NOx where as negative correlations were found in between SPM and SO_2, SPM and NO_x, RPM and SO_2, RPM and NO_x. It

Table 4 : Correlation coefficient (r) between gaseous pollutants and particulate matter in commercial-cum-traffic area

Parameter	SPM	RPM	SO_2	NO_x
SPM	1.00	-	-	-
RPM	0.94	1.00	-0.97	-0.95
SO_2	-0.91	-0.93	1.00	0.93
NO_x	-0.94	-0.94	0.99	1.00

was found that there was high positive correlation between gaseous pollutants (SO_2 and NO_x) and particulate matter (SPM and RPM). It was interesting to note that there was negative correlation between particular matter (SPM and RPM) and gaseous pollutants (SO_2 and NO_x). Gaseous and particulate pollutants were dependent on each other.

Table 5 shows the regression co-efficient for all possible parameters of gaseous and particulate pollutant at commercial-cum-traffic area.

Table 5 : Regression coefficient (a and b) between gaseous pollutant and particulate matter of commercial- cum-traffic area

Parameter pairs	A	B
SPM and RPM	0.806	104.803
SPM and SO_2	-0.343	69.267
SPM and NO_x	-0.380	85.733
RPM and SO_2	-0.276	33.362
RPM and NO_x	-0.306	45.947
SO_2 and NO_x	1.108	8.978

Table 6 shows the correlation coefficient (r) between gaseous pollutants and particulate matter in the residential area. High positive correlation was found between gaseous pollutants and particulate matter. The positive correlation was observed in the parameters pairs, namely, SPM and RPM, SPM and SO_2. SPM and NO_x, RPM and SO_2, RPM and NO_x, SO_2 and NO_x.

Table 6 : Correlation coefficient between gaseous pollutants and particulate matter in the residential area

Parameter	SPM	RPM	SO_2	NO_x
SPM	1.00			
RPM	0.99	1.00	0.959	0.91
SO_2	0.978	0.967	1.00	0.982
NO_x	0.953	0.986	0.972	1.00

Table 7 shows the regression coefficient of various possible parameter pairs of gaseous pollutant and particulate matter of residential area. Pairs having very high positive correlation between them showed the dependency of gaseous pollutant and particulate matter with each other. The values of regression coefficient (a and b) greatly helped in finding out the regression equation between the two parameters such as the gaseous pollutant and the particulate matter.

Table 7 : Regression coefficient (a and b) between gaseous pollutants and particulate matter of residential area

Parameter pairs	A	B
SPM and RPM	0.249	25.775
SPM and SO_2	0.132	1.234
SPM and NO_x	0.163	4.019
RPM and SO_2	1.884	23.451
RPM and NO_x	1.528	19.634
SO_2 and NO_x	1.233	2.498

Conclusion:

Based on the above result and discussion, the following noticeable points were observed during this analysis.

– The concentration of SPM, RPM, SO_2 and NO_x were found to be within the prescribed limit with standards laid down by TNPCB.

– The concentration of gaseous pollutants (SO_2 and NO_x) and particulate matter (SPM and RPM) were found to be low in all the three sites compared to the standard values.

– At the tannery area, particulate matter (SPM and RPM) has positive correlation with each other. Similar positive correlation was also found between gaseous pollutants SO_2 and particulate matter (SPM and RPM). There was very high negative correlation between oxides of nitrogen (gaseous pollutant) and particulate matter (SPM and RPM).

– In the commercial cum traffic area, there was high positive correlation between particulate (SPM and RPM) and also between gaseous pollutants (SO_2 and NO_x). It was observed that there was negative correlation between gaseous pollutant and particulate matter.

– In the residential area, there was very high positive correlation between particulate matter that was SPM and RPM pair, and gaseous pollutants that was SO_2 and NO_x pair and particular matter with gaseous pollutant. It was inferred that at the residential area, gaseous pollutants were dependent on particulate matter.

– All the correlation coefficients showed high value that has alignment among themselves. Most of the correlation coefficient has positive values which increased in x, giving corresponding linear increase in y. Some of the correlation coefficients among pollutants were negative as well as positive. But most of them were positive this implies that concentration of all the pollutant (gaseous and particulate matter) varies positively linearly with each other.

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