RESEARCH PAPER:

A correlation of suspended particulate matter with lead concentration in ambient air at different traffic junction of Madurai city

D. SARALA THAMBAVANI AND M.VIDYA VATHANA

Asian Journal of Environmental Science, (June, 2011) Vol. 6 No. 1 : 74 -79

See end of the article for authors' affiliations

Correspondence to :

M. VIDYA VATHANA
Dept. of Chemistry, Sacs M.A.V.M.M. Engg. College, MADURAI (T.N.) INDIA

SUMMARY

Rise in population, urbanization, tourist activity and expansion of the Madurai region has resulted in the considerable increase of vehicular traffic. This problem particularly manifests itself around the commercial and bus station. Particulate matter and lead monitoring was conducted in an urban area of Madurai in a state of Tamil Nadu. Statistical analysis of particulate matter and lead metal concentration in the air of Madurai city was performed. Three sites namely, industrial, traffic and residential area based on the activities were selected to determine the variation in the concentration levels. The study focuses the key air pollution problem arising from vehicular pollution. The significant differences were observed between all the concentrations of pollutants and at all three sites. The correlation study of Suspended Particulate Matter with lead have been established. The average concentration of suspended particulate matter and lead in ambient air was found 217.5 µg\m^3 and 0.38 µg\m^3 which ranged 130.8 to286.8 and 0.11 – 0.69 µg\m^3, respectively. The correlation of suspended particulate matter and lead (r = +0.605, and R^2 = 0.366) was found to be significantly and positively correlated.

Thambavani, D. Sarala and Vathana, M.Vidya (2011). A correlation of suspended particulate matter with lead concentration in ambient air at different traffic junction of Madurai city. *Asian J. Environ. Sci.*, **6**(1): 74-79.

Key words : SPM, Vehicular pollution, Lead, Air pollution, Correlation

The urban population is exposed to higher levels of suspended particulate matter and lead metal due to urbanization and industrialization. Concentration of ambient air particulates has been found to be associated with a wide range of effects on human health (Dockery and Pope, 1994; Schwartz, 1991; Schwartz, 1994; Zmirou *et al.,* 1998). Approximately fifty thousand premature deaths occur annually due to particulate matter pollution in India (Brandon and Hommann, 1995).

The high concentration of particulate matter in the environment has become a problem for many countries (Elbir *et al.,* 2000). Air pollution has been aggravated by development that typically occurs as countries become industrialized: growing cities, increasing traffic, rapid economic development, industrialization and higher levels of energy consumption. The high influx of population to urban areas increase in consumption patterns and unplanned urban and industrial development have led to the problem of air pollution currently in India. Air pollution is widespread in urban areas where vehicles are the major contributors and in a few other areas with a high concentration of industries and thermal power plants. Vehicular emissions are of particular concern since these are ground level sources and thus have the maximum impact on the general population. Also, vehicles contribute significantly to the total air pollution load in many urban areas. The rate of increase of pollutant concentration in the developing countries like India are higher than those of developed countries and hence atmospheric pollution is often severe in cities of developing countries all over the world .The exhaust gas from automobile is one such significant source .There have been many investigations in recent years relating to the distribution and accumulation of lead emanating from automobile exhaust.

The objective of the present investigation is to determine suspended particulate matter (SPM) and lead present in the atmosphere. The lead burden of environment is related to vehicular traffic. Singer and Hanson (1960) and Page and Ganji (1970) found that the lead level in the atmosphere increases with increase in traffic density. In light of the above, the

Received: *April, 2011*
Accepted : *May, 2011*

present work was undertaken to make a detailed study on the amount of SPM and lead concentration present in the ambient air of Madurai.

MATERIALS AND METHODS

Study area:

Madurai known as the Athens of South India is carrying its glory and splendor from 2000 BC. Madurai has an area of 52 square km (now extended up to 130 square km) and is located at 9.93^0 North and 78.12^0 East. The average elevation is 101 meters above mean sea level. The climate is dry and hot, with rains during October to December. Temperature during the summer reaches to maximum of 40.0^0C and minimum of 26.3^0C, whereas during winter the temperature reaches to a maximum of 29.6^0C and a minimum of 18.0^0C. The average annual rainfall is 85 cm (850mm).

The study was conducted in Madurai city. The three study sites namely industrial, traffic and residential area with different vehicular traffic density: one with >40,000 vehicles per day, second with>15,000 vehicles per day and third with $\leq$3000 vehicles per day. Number of vehicles was counted twice in a month. As there was no significant variation in traffic density, they were presented as average value. The study focuses the key air pollution problem arising from vehicular pollution. SPM is one of the most critical air pollutants in most of the urban areas. Lead is one of the toxic metals is present in numerous products including gasoline, paint, storage batteries and metal containers of pesticides.

Sampling:

Air sampling is the segregation of a portion of matter that is air with its impurities for analysis in various locations within a defined geographical area. In this sampling method, ambient air is drawn in to a liquid reagent, which is kept in bubblers. The pollutants are removed from the sampled air stream by getting dissolved in it. The high volume air sampling method adopts the same adsorption sampling method, which is followed by chemical analysis to estimate the amount of lead concentration.

Ambient air is drawn through the filter by means of a high flow rate blower at a suitable flow rate that allows suspended particles having diameter of less than 100 m to pass to the filter surface. Particles within the size range of 100-0.1 m in diameter were collected on Whatmann glass micro fibre filter of size 20x25 cm. The difference in weight of filter paper gives the dust collected and the concentration is determined. The Central Pollution Control Board (CPCB) has prescribed a maximum permissible level for each air pollutant for specific areas and this is known as NAAQ standards, which are the levels of air quality with an adequate margin of safety, and these standards are necessary to protect the public health, vegetation and property. Whenever and wherever two consecutive values exceed the air quality levels specified for the respective category of areas, it would be considered as an adequate reason for regular/continuous monitoring and for further investigations.

Data analysis:

Mean value of the parameters were calculated to find out a typical representative of all the observations of a parameter. The mean value of parameter is given by Trivedy and Goel (1986):

$$\textbf{Mean } (\bar{X}) = \frac{\Sigma x}{n}$$

Range signifies the fluctuation of parameters and is given by:

$$\textbf{Range} = \textbf{Maximum} - \textbf{Minimum}$$

Statistical software SPSS (Statistical package for social sciences, Version 7.5) is used to compute the correlation (r values) for all possible correlations among soil parameter. The software is used to calculate the regression parameters A and B of the straight line Y = A + BX by applying the well-known method of least squares (Wonnacott and Wonnacot, 1981; Gupta, 1974) to fit the experimental data to give straight line. Correlation is merely a tool of ascertaining the degree of linear dependence between parameters. It refers to the method by which estimates are made of the values of one or more other parameters. Statistical analysis was represented in flow chart as follows:

Standard deviation, which shows the degree of spread of a normal curve of distribution and is determined by using the relationship given below:

$$\textbf{Standard deviation} = \frac{\left[\Sigma(X - \bar{X})^2\right]}{[N-1]}$$

The correlation coefficient between the variables x and y (Trivedy and Goel, 1984) is:

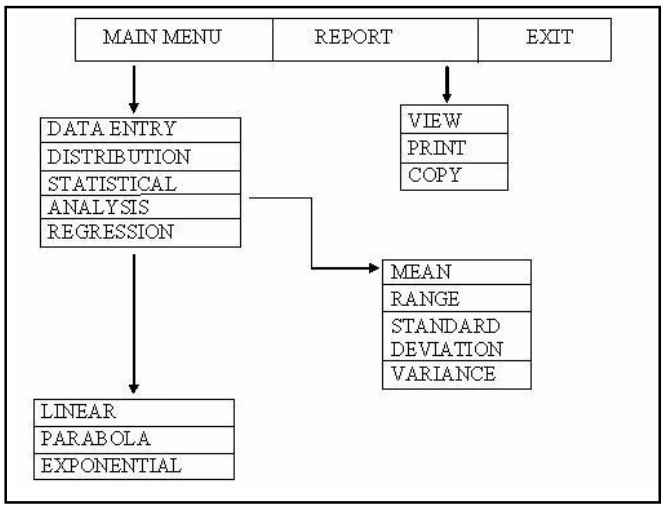
$$r = \frac{\Sigma XY - \bar{X}\Sigma Y}{[(\Sigma(^2 - (\bar{X})(\Sigma\Sigma^2 - (\bar{X})\Sigma\Sigma Y)}$$

Regression analysis tries to find out the average relationship between parameters. It refers to the method by which estimates are made out of the values of one or

more other parameters. The following forms of relationship are considered for the software development. The values of empirical parameters a and b were calculated with the help of equation.

$$n = \frac{X\Sigma\Sigma - \bar{X}\Sigma X}{\Sigma X^2 - \bar{X}\Sigma X}$$

$$a = \bar{y} - bx$$



Keeping the above observations in mind, a linear relationship was proposed.

$$y = a + bx$$

RESULTS AND DISCUSSION

Lead and Suspended Particulate Matter metal concentration in the ambient air of Madurai was found out at three different sampling sites and have been shown in the Table 1 and 2.

The average concentration of lead present in the traffic area, industrial area and residential area were 0.51µg\m^3 and 0.32 µg\m^3 and .15 µg\m^3 , respectively (Table 1). The average minimum lead concentration was found in residential area .The lead concentration in the residential area was very much below than the TNPCB standard(1.0µg\m^3).The average concentration of lead in the traffic area was more than 200% greater compared to residential area. It is very much obvious from the result that the lead concentration was high and very critical due to the extensive urbanization (Fig. 1).

Ambient air quality study:

Lead concentration (µg/m^3):

The average minimum and maximum concentration of SPM in residential area ranged from 130.8µg\m^3 to 235.7µg\m^3,while in industrial area the average ranged from 186.7µg\m^3 to 272.5µg\m^3 and in traffic area the average ranged between 150.2µg\m^3 to 330.5 µg\m^3 (Table 2).The average SPM in residential area (189.1µg\m^3) was very much closer standard of Tamil Nadu Pollution Control Board (200µg\m^3). But the average SPM concentration in traffic and industrial area were 222.3µg\m^3 and 241.1µg\m^3 , respectively and this SPM concentration was very much below than the TNPCB standard (Fig. 2).

SPM concentration (µg/m^3):

The average concentration of lead present in SPM ranged from 0.19% to 0.28% in the traffic area while for industrial area it ranged from 0.11% to 0.19% and in the residential area it has minimum 0.05% and maximum 0.15 (Table 3). The %of lead concentration present in the SPM clearly showed that the traffic area predominated the lead concentration compared to the other two sampling sites.

Table 1 : Lead concentration (µg\m^3)

Sampling site	Traffic density	Date of sampling					
		7/8/10	6/9/10	10/10/10	7/11/10	10/12/10	7/01/11
Traffic area (Kalavasal)	≥40,000	0.48	0.45	0.42	0.62	0.69	0.41
Industrial area (Kochadai)	≥15,000	0.31	0.32	0.28	0.35	0.36	0.29
Residential area (Alagar kovil)	≥3000	0.11	0.14	0.16	0.17	0.19	0.11

Table 2 : SPM concentration (µg\m^3)

Sample site	Traffic density	Date of sampling					
		7/8/10	6/9/10	10/10/10	7/11/10	10/12/10	7/01/11
Traffic area (Kalavasal)	≥40,000	190.3	195.4	150.2	330.5	286.8	180.5
Industrial area (Kochadai)	≥15,000	250.2	263.7	258.3	186.7	215.3	272.5
Residential area (Alagar kovil)	≥3000	205.2	235.7	160.5	197.4	130.8	205.2

Table 3 : Percentage of lead concentration in the collected SPM

Sample site	Traffic density	Date of sampling					
		7/8/10	6/9/10	10/10/10	7/11/10	10/12/10	7/01/11
Traffic area (Kalavasal)	≥40,000	0.252	0.23	0.28	0.19	0.24	0.23
Industrial area (Kochadai)	≥15,000	0.12	0.12	0.11	0.19	0.17	0.11
Residential area (Alagarkovil)	≥3000	0.05	0.06	0.09	0.08	0.15	0.05

Table 4 : Concentration (µg\m^3) of particulates in ambient air

Monitoring station	N	Lead		Suspended particulate matter	
		Mean	Standard deviation	Mean	Standard deviation
Traffic area	6	0.51		222.3	
		0.41-0.69	0.105	150.2-286.8	63.98
Industrial area	6	0.32		241.1	
		0.28 – 0.36	0.076	186.7-272.5	30.27
Residential area	6	0.15		189.1	
		0.11-0.19	0.075	130.8-235.7	34.09

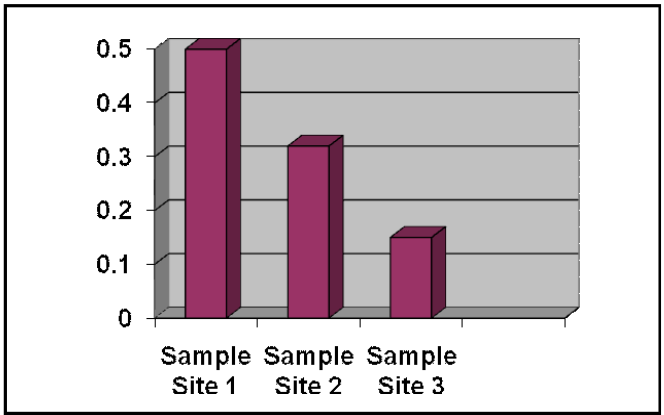


Fig: 1 : Lead concentration (µg/m^3)
Sample site 1 – Traffic area (Kalavasal)
Sample site 2 – Industrial area (Kochadai)
Sample site 3 - Residential area (Alagarkovil)

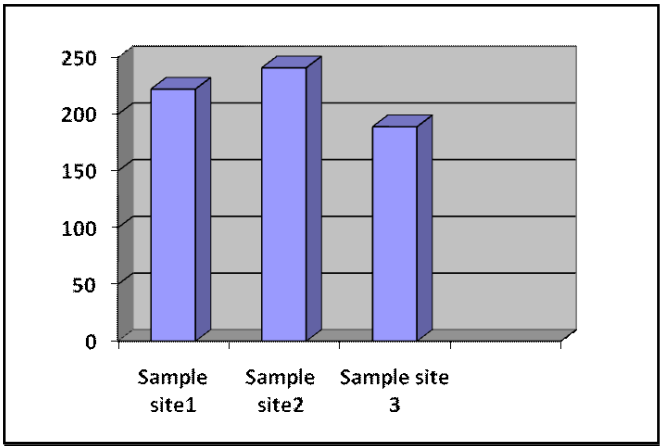


Fig: 2 : SPM concentration (µg/m^3)
Sample site 1 – Traffic area (Kalavasal)
Sample site 2 – Industrial area (Kochadai)
Sample site 3 - Residential area (Alagarkovil)

The air quality of Madurai city with respect to criteria, pollutant has been compared with NAAQS and has been categorized into four broad categories based on an Exceedence Factor (EF). When exceedence factor is more than 1.5 it is said to be critical pollution. When the exceedence factor is between 1 - 1.5 it is know as high pollution. When the exceedence factor is between 0.5 – 1.0 it is called as moderate pollution, whereas the exceedence factor is less than 0.5 it is understood to be low pollution area. With regard to the ambient lead concentration in the atmosphere showed that the traffic, industrial and residential area have the exceedence factor 0.34, 0.213 and 0.15, respectively. As the exceedence factor lies below 0.5, the lead pollution due to industries and automobile is lying within the low pollution.

The ambient air quality status of the study areas based on the exceedence factor for Suspended Particulate Matter was found to be 0.95 at the residential area, whereas 0.44 and 0.48 at traffic and industrial area, respectively. The moderate pollution category is likely to violate a standard in future, as the pollution level is continuously maintained at moderate rating. Due to Suspended Particulate Matter pollution, the residential area lay in the moderate pollution category. Whereas traffic and the industrial area ly in the low pollution category which has a pristine air quality and such areas are to be maintained at low pollution levels by adopting preventive and control measures.

The correlation between suspended particulate matter and lead is illustrated with the plot in Fig. 3

The ambient mean concentration of suspended particulate matter was 217.5(µg\m^3), (SD= 42.78) with the range of 130.8 – 286. 8(µg\m^3). The mean

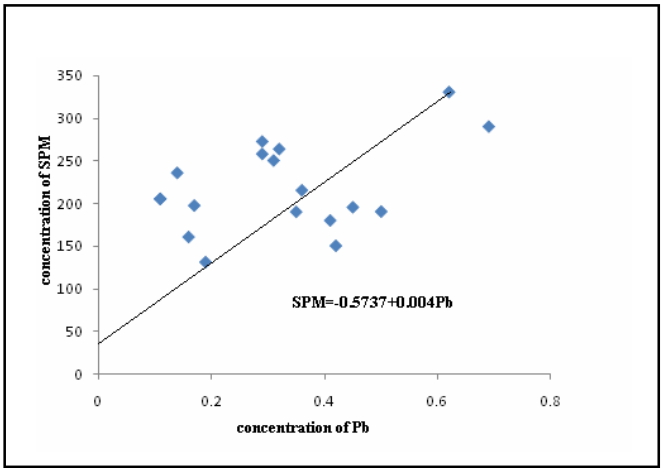


Fig: 3 : Correlation diagram of SPM-Pb

concentration of lead was 0.33 (µg\m^3), (SD = 0.0853) with the range of 0.11-0.69 (µg\m^3). The correlation between suspended particulate matter and lead levels in ambient air was r= 0.605, R^2 = 0.366 and ρ = 0.76 (Table 4 and Fig. 3).

Conclusion:

Clean air is important because human cannot live without air for more than few seconds. Air pollution harms animals, plants and human beings which result in damages to structure, properties and interfere visibility. It damages natural environment and causes chronic health esthete on human beings. Suspended particulate matter can penetrate deep in to the lungs and cause more damage. Lead is a cumulative poison to the human beings. Large exposure causes clumsiness, weak memory, changes in attitude, severe depression of nervous system and leads to death.

Madurai city hosts a variety of human activities of which transport and tourism are two significant sectors which have been found to be the major cause of the continuously increasing air pollutant level in the urban area. Important observations made from the present study are :

– It was observed generally that the concentration of suspended particulate matter in the industrial area was high (241.1µg/m^3) followed by traffic area (222.3µg/m$^{3)}$ and residential area (189.1µg/m^3). It is a key point to consider that it may become major problem in future due to the growth of industries.

– The study area wise comparison revealed that the lead concentration was recorded a peak at the traffic area (0.51µg/m^3) followed by industrial area (0.32 µg/m^3) and residential area (0.15µg/m^3). The alarming increase in vehicular population in recent years is one of the main reasons that contributed to the prevalence of high level of lead concentration in the ambient air in the city of Madurai.

– The percentage of lead present in suspended particulate matter was found to be high in traffic area (0.24µ g/m^3) followed by industrial area (0.14 µ g/m^3) and residential area (0.08 µg/m^3)

– The regression analysis was carried out with positive significant correlation and the result showed that the relationship between Suspended Particulate Matter – Lead was positive significant correlation.

The ambient air quality status of the study area revealed that the concentration of air pollutant of suspended particulate matter and lead concentrations were maintained within the level of Tamil Nadu Pollution Control Board. Vehicular pollution is in fact more harmful than industrial pollution because pollution from stationary force like industry is localized but the vehicular pollution is not so. It would be consider as a sufficient reason to ascertain that there are ample scope for serious public health thrust to the inhabitance of the Madurai city.

Authors' affiliations:

D. SARALA THAMBAVANI, Department of Chemistry, Sri Meenakshi Govt. Arts College, MADHURI (M.S.) INDIA

REFERENCES

Brandon,C. and Hommann, K. (1995). The cost of inaction : Valuing economy wide cost of environmental degradation in India. Paper presented at the United Nations University Conference on the sustainable future of the global systems Tokyo, 16-17 October, 1995.

Dockery, D.W. and Pope, C.A. (1994). Acute respiratory effects of particulate air pollution. *Annu.Rev. Public Health*, **15** : 107-132.

Elbir, T., Muezzinoglu, A. and Bayram, A. (1996). Particulate air pollution and daily mortality:Who is at risk? *J. Aerosol Med.*, **9** : 43-53.

Elbir, T., Muezzinoglu, A. and Bayram, A. (2000). Evaluation of some air pollution indicators in Turkey. *Environ. Internat.*, **26** : 5-10.

Gupta, S.P. (1974). *Advanced practical statistics*, 2nd Ed., S.Chand New Delhi.

Page, A.L.and Ganji, T.J. (1970). Accumulation of lead in soils for regions of high and low motor vehicle traffic density. *Environ. Sci. Technol.,* **4** : 140-142.

Schwartz, J. (1991). Particulate air pollution and daily mortality: *A synthesis. Public Health Rev.,* **19** : 39-60.

Schwartz, J. (1994). Air pollution and daily mortality. A review and meta analysis. *Environ. Res.*, **64** : 36-52.

Singer, M.J. and Hanson, L. (1960). Lead accumulation in soils near high ways in the twin city metropolitican area. *Proc. Soil Sci. Soc. Am.*, **33**: 152-153.

Trivedy, R.K. and Goel, P.K. (1984). Chemical and biological methods for water pollution studies, Environmental publication, Karad.

Trivedy, R.K., and Goel, P.K. (1986). Chemical and biological methods for water pollution studies, Environmental, Publication, Karad.

Wonnacott, T.H. and Wonnacott, R.J. (1981). *A second course in statistics*, John Wiley and Sons, New York.

Zmirou, D., Schwartz, J., Sacz, M., Zanobetti, A. (1998). Time-series analysis of air pollution and cause specific mortality. *Epidemiology*, **9**: 495-501.