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Research Paper :

Suspended particulate matter and zinc concentration in ambient air at different traffic junction of Madurai city

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ABSTRACT

As industrialization and urbanization is increasing, the concentration of smoke, dust and ash are increasing in the ambient air and the natural environment is in deterioration. Particulate matter and zinc monitoring is conducted in an urban area of Madurai in a state of Tamil Nadu. The study is carried out in three sites namely industrial, traffic and residential area based on the activities. It is selected to determine the variation in the concentration levels. This study focuses the key air pollution problem arising from industrial pollution. Data analysis of suspended particulate matter and zinc metal concentration showed the significant differences between all the concentration of pollutants and at all three sampling sites. The genesis of urban air pollution is mainly due to anthropogenic activities, including industrial pollution. Air pollution cause negative impact directly or indirectly on human beings, vegetation, climate and buildings. The present study is carried out for useful planning and control measures of air pollution in traffic and industrial area to avoid air quality deterioration.

KEY WORDS : Particulate matter, Zinc, Air pollution, Air quality deterioration, Industrial pollution

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Air pollution level from industrial sectors are increasing at an alarming rate in many developing countries, including India. Vaisanen (1986) and Wen et.al, emphasized that the emissions of air pollutants from industries have already led to damages in natural communities and environment round the world. Various effects have been made for environmental restoration in India, but still it seems to be a formidable task. Degradation of air quality, particularly in urban areas of developing countries, is one of the most alarming problems of modern civilization. Anthropogenic activities release a variety of gaseous and particulate matters to the atmosphere (Yadav and Rajamani, 2003). The response reaction by metals includes the changes in growth and various metabolic processes of plants (Lycholat and Bilchuk, 1998). Increasing human influences on the environment, especially pollution loadings have caused negative changes in natural ecosystems; its biodiversity, structure and productivity (Shparyk and Parpan,2004).

Heavy metals are predominately transferred as molecules or particulate matter via the atmosphere, mostly at large scales. Focal points of metal emissions are congested urban areas with high densities of industries and traffic (Komarnicki, 2005).

Heavy metals are extremely persistent in the environment, as they are non-biodegradable and non-thermo degradable and thus readily accumulate to toxic levels (Sharma *et al.,* 2007). The biota requires heavy metals in trace amounts but may be sensitive to higher concentration of metals (Rout *et al.,* 2001). Heavy metals have been the object of many studies since they are persistent and belong to the most widely dispersed industrial pollution (Carreras and Pignata, 2002). Several aims have been pursued such as the impact of heavy metal pollution on natural or urban ecosystems, but very few studies have been conducted on accumulation of heavy metals from atmospheric pollution.

The main focus of this work to determine suspended particulate matter (SPM) and zinc (Zn) present in the atmosphere. The zinc burden of environment is related to industrial and vehicular pollution. Zinc occurs naturally in air, water and soil (Lindroos *et al.,* 2007), but as a result of human activities, its concentration are rising unnaturally. In light of the above, the present work was undertaken to

make a detailed study on the amount of suspended particulate matter and zinc concentration present in the ambient air of Madurai.

Suspended particulate matter (SPM)

Suspended particulate matter consists of different solid and liquid particles that are suspended in the atmosphere and includes soil, soot, lead, asbestos and sulphuric acid droplets. Suspended particulates reduce visibility by scattering and absorbing sunlight, they corrodes metals, erodes buildings and works of sculpture when the air is humid and soils clothing and draperies. Smaller particles are inhaled in to the respiratory system and can cause health problems lead and asbestos particles are especially harmful.

EXPERIMENTAL METHODOLOGY

Descriptive of the study area:

Madurai is the oldest inhabited city in the Indian peninsula. The cynosure of Madurai is the great Meenakshi temple around which the town has been planned. It started as a small township of about 2.56km^2 around this temple in the year 1986 with a population of little over 41,000 and at present it has grown as the second largest and most densely populated city in the southern state of India namely Tamil Nadu.

The study was conducted in Madurai city. The three study sites namely traffic, industrial 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 > 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. zinc is one of the toxic metals which enter into the environment due to galvanization industry, alloy industry, coal burning and burning of wastes.

Table A : Sample site

Site No	Site	Local description	Category
1	Kalavasal	Traffic area	Traffic
2	Kochadai	Industrial area	Industrial
3	Alagarkovil	Residential area	Residential

Sampling:

Samples of air pollutant was collected fortnightly with the help of Respiratory Dust Sampler (APM-415) from each site. The apparatus was kept at a height of 2m from the surface of the ground, for the collection of samples of SPM at each sampling site. Glass fibre/A filter paper was used. It was weighed before and after sampling gravimetrically. The filter paper was digested in concentrated nitric acid (Sharma *et al.,* 2006). The content was filtered through whatman filter paper no.42 and final volume made upto 25ml by deionised water. The filtrate was examined for the concentration of zinc by Atomic Absorption Spectroscopy (AAS) at wavelength 213.91nm with sensitivity of 0.009µg/ml of zinc.

Table B : Monitored pollutants and the methodologies employed for ambient air quality study

Methodology	Suspended particulate matter	Zinc
Indian standard No.	Is:5182 Part:4-2005	Is:5182 Part:22-2004
Sampling equipment	High volume sampler	High volume sampler
Duration sampling	8 hour	8 hour
Collection media	GF/A filter paper	GF/A filter paper

EXPERIMENTAL FINDINGS AND ANALYSIS

Zinc metal and suspended particulate matter concentration in the ambient air of Madurai is found at three different sampling site and shown in the Table 1 and 2.

Zinc:

Atmospheric deposition of metals has a direct effect on the contamination of crops used for human and animal consumption (De Temmerman, 2005). Heavy metals have been the object of many studies since they are persistent and belong to the most widely dispersed industrial pollution (Carreras and Pignata, 2002). Several aims have been pursued such as the impact of heavy metal pollution on natural or urban ecosystem.

The zinc concentration at the traffic area is 2.91µg/m^3 as the minimum and 3.15µg/m^3 as the maximum. The average zinc concentration at the traffic area is 3.01µg/m^3. The per cent of variation compared to the residential area is found to be maximum. There is hundred fold increase in the zinc concentration at the traffic area compared to the residential area.

The zinc concentration at the industrial area is 5.58µg/m^3 as the minimum and 5.72g/m^3 as the maximum. The average zinc concentration at the industrial area is 5.66µg/m^3.The per cent of variation compared to the traffic area is found to be maximum.

Table 1 : Zinc 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	3.15	3.10	3.06	2.91	2.94	2.93
Industrial area(Kochadai)	≥15,000	5.71	5.62	5.66	5.72	5.69	5.58
Residential area (Alagar Kovil)	≥3000	0.41	0.43	0.39	0.40	0.37	0.34

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

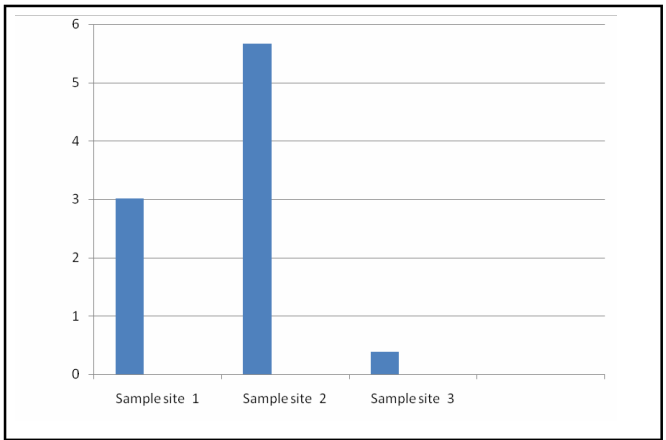

Fig. 1 :
Sample site 1 – Traffic area (Kalavasal)
Sample site 2 – Industrial area (Kochadai)
Sample site 3 – Residential area (Alagarkovil)

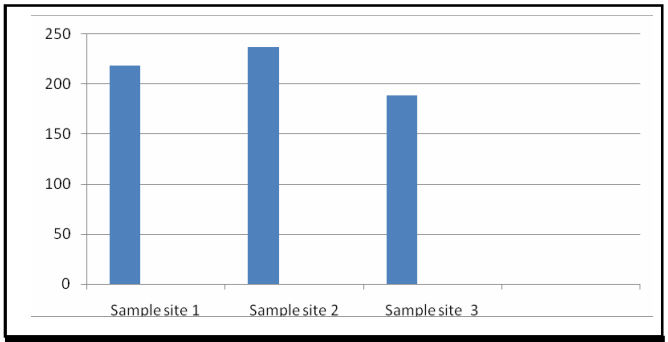

Fig. 2 :
Sample site 1 – Traffic area (Kalavasal)
Sample site 2 – Industrial area (Kochadai)
Sample site 3 – Residential area (Alagarkovil)

It indicates that there is hundred fold increase in the zinc concentration at the industrial area compared to the traffic area.

Ambient air quality study:

Zinc concentration (µg/m^3):

Suspended particulate matter:

During the study it was observed that 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. The average SPM in residential area (189.1µg\m^3) is very much closer standard Tamil Nadu Pollution Control Board (200µg\m^3). But the average SPM concentration in traffic and industrial area are 222.3µg\m^3 and241.1µg\m^3, respectively and this SPM concentration is very much below than the TNPCB standard (500 µg\m^3).

Ambient air quality study:

SPM concentration (µg/m^3):

Air quality index:

Air quality index was calculated based on Tiwari and Ali (1987) method. The air quality was categorized as per Mudri (1990). The calculated values of air quality index are given in Table 3. The air quality rating if each parameter is considered, is obtained by:

$$q = 100 \times V/Vs$$

Table 3 : Air quality index and air quality categories for Madurai town with SPM

Site	Mean SPM	Ambient air quality standards prescribed by CPCB,New Delhi in µg/m3	Air quality index (AQI)	Air quality category
Site 1	222.2	500	44.4	Moderately polluted
Site 2	241.11	500	48. 2	Moderately polluted
Site 3	189.13	200	94.5	Polluted

Table 4 : Percentage of zinc 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	1.65	1.65	2.03	0. 88	1.02	1.62
Industrial area(Kochadai)	≥15,000	2.28	2.13	2.19	3.06	2.64	2.04
Residential area (Alagar Kovil)	≥3000	0.19	0.18	0.24	0.20	0.28	0.16

where q = quality rating

V= observed value of the parameter

Vs= standard value recommended for the parameter.

If ' n ' number of parameter are considered, the geometric mean of these 'n' number of quality rating is found out. This is known as air quality index (AQI).

The average concentration of zinc present in suspended particulate matter ranged from 1.02 per cent to 2.03per cent in the traffic area while for industrial area it is ranged from 2.04 per cent to 3.06 per cent and in the residential area it has minimum 0.16 per cent and maximum 0.2 per cent. The per cent of zinc concentration present in the SPM clearly shows that the industrial area predominates in the zinc concentration compared to that of other two sampling sites.

Conclusion:

Burning of fossil fuel by industries and automobiles are the important anthropogenic sources of particulate matter. These particles remain suspended in the air for a long time, and distribute or redistribute other pollutants absorbed with them, especially metals. Particulate matters may also account for climatic changes as they have the property of absorption of light energy. The movement and fate of particulate matter depends on the physical nature of the particulate matter and meteorological conditions of the surrounding areas (Fernandez *et al.,* 2000; Kim *et al.,* 2002).

Since the metals are natural constituents of the earth's crust and are widely distributed in environmental matrices, the humans are easily exposed to them even at trace levels (AMAP, 1997) by either anthropogenic activities or by necessity. When these metals are concentrated in the environment, food and water, they affect the health of humans and animals (Abulude *et al.,* 2003). At elevated concentrations all the metals are harmful to living beings including humans (Yasutake and Hirayama, 1997). Exposure can occur through a variety of routes; inhalation of particles (<10µm) is one of the important routes.

Madurai city host a variety of human activities of which tourism and industry 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 is observed that the concentration of suspended particulate matter in the industrial area is 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 concentration of zinc is found to be maximum in the industrial area (5.72 µg/m^3) followed by traffic area (3.15µg/m^3) and the residential area (0.40 µg/m^3). The alarming increase in industries and vehicles in recent years is one of the main reason that contributed prevalence of high level of zinc concentration in the ambient air of Madurai city.

– The percentage of zinc present in suspended particulate matter is found to be high in industrial area (3.06%) followed by traffic area (2.03%) and residential area (0.28%).

– The minimum concentration of suspended particulate matter in the residential area is 130.8µg\$m^3$ which is less that the TNCPCB standard (200 µg/m^3). But the maximum concentration of suspended particulate matter in the residential area (235.7 µg\$m^3$) is very much higher than that of TNCPCB standard. The utmost care should be taken in the residential area. The air quality index with regard to suspended particulate matter concentration in the ambient air reveals that the residential area is more polluted compared to the industrial and traffic area. Many small scale industries are found in the vicinity of the residential area. The source for the air pollutant in the residential area is due to increasing vehicles and poor road conditions. Each family is equipped with maximum number of two and four wheelers.

– The minimum concentration of Suspended particulate matter in traffic area and industrial areas is 150 µg\$m^3$ which is less that the TNCPB standard (500µg\$m^3$). The maximum concentration of suspended particulate matter in the above said area is 330.5 µg\$m^3$. Even though it is less than the standard, the air quality study reveals that it is moderately polluted. Sites located near the industrial and traffic area are quite influenced by the vehicular activities. The increase of air pollutant is due to high traffic density, industrial emissions and heavy

tonnage vehicles. A standing vehicle with its engine switched on emits seven times higher smoke level than a vehicle running on the road (Mariappan *et al.,* 1993). Vehicular pollution control may be made more stringnent. Checking of vehicles for pollution may be made effective in all places of Madurai town. Hence, more red lights and traffic jams means more pollution, so greater emphasis may be given for effective traffic management and the standard of roads should be increased.

– Description of air quality for sampling site reveals that none of the monitored sites belonged to the " clean" category. Hence all the sites have been influenced by air polluting activities and if proper measures are not taken air quality will be worse in future.

– It would be considered that earth is everybody's home and nobody likes to live in a dirty home. Together we can make the earth a cleaner, healthier and more pleasant place to live.

Recommendation:

According to the results the authors suggest some of the measure that can be adapted for prevention, abatement and control of air pollution. It may be understood that these measures are suitable to applied at the source itself, since the pollutants are released in the atmosphere, it is only by virtue of the natural phenomena of wind, thermal convection and rain wash out that their extent can be reduced:

– Vehicular pollution can be reduced or controlled through the implementation of Euro/Bharat norms and phase out of old and ill maintained vehicles.

– Compressed Natural Gas (CNG) may be introduced in lieu of petrol.

– Traffic rules should be implemented properly avoiding traffic jams, smooth traffic flow and it should be regularized by imposing nominal pollution tax for those who float the city traffic rules and regulations.

– Polluting industries should be away from the city.

– Road should be well maintained. Bye-pass roads may be provided for inter city traffic. Flyover may be built to avoid traffic jams.

– Green belt may be provided throughout city. This will help to reduce excess carbon dioxide, provide health giving oxygen, trap aerosols, supply biomass and timber and create social forestry.

– Pollution level may be monitored regularly.

– Environmental pollution should be introduced in school and college as syllabus one of the compulsory subject of studies.

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