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Ambient concentration of suspended particulate matter and manganese in urban area of Madurai City

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ABSTRACT:

Air quality in cities is the result of a complex interaction between natural and anthropogenic environmental conditions. Air pollution in cities is a serious environmental problem-especially in the developing countries. In India, millions of people breathe air with high concentrate of dreaded pollutants. The air is highly polluted in terms of suspended particulate matter in most cities. The pollutants, namely suspended particulate matter and Manganese have been named as criteria by environmental protection agency, USA. Suspended particulate matter monitoring was conducted in the urban environment of Madurai in the state of Tamil Nadu. Three ambient air sampling stations were indentified for the collection of suspended particulate matter each at residential, traffic and industrial area. The particulate matter sampling was conducted using recommended instrument for ambient air sampling (high volume sampler). The concentration of Manganese is found to be maximum at industrial area (0.09µg/m^3) followed by traffic (0.06µg/m^3) and residential area (0.01µg/m^3). The concentration of suspended particulate matter in the industrial area is high followed by traffic and residential area (241.1µg/m^3, 222.3 µg/m^3 and 189.1µg/m^3). The results of the study indicate that the air quality of the sampling stations falls under the polluted category.

Keywords:
Sampling, Particulate Matter, high volume sampler, monitoring, ambient, Manganese, air quality.

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INTRODUCTION

Air pollution is a widespread problem in Madurai city. These pollutants can act synergistically, exacerbating health problems. It is thus natural that greater emphasis should be laid on the study of emissions and dispersion in the atmosphere. Finer solid particles and liquid droplets, collectively called suspended particulate matters, are present in the air in great numbers and at times they give rise to a serious pollution problem. Numerous natural processes release particulate matter in the atmosphere. Typical of these processes are volcanic eruptions and the blowing of dust and soil by the wind. The activities of man also release dust from construction activity; fly ash from smelters and mining operation and smoke from incomplete combustion processes.

Particulate matter is unique among atmospheric constituents in that it is not defined on the basis of its chemical composition. It may include a broad range of chemical species, including elemental and organic carbon compound, oxides of silicon, aluminium and iron trace metals, sulphates, nitrates and ammonia (Sharma 2002). Particulate matter has been natural and anthropogenic sources. Natural sources of primary particulate matter include wind blown soil and material particles, volcanic dust, sea salt spray, biological material such as pollen, spores and bacteria; and debris from forest fire. Windblown agricultural soil, dust from roads, construction sites and quarrying operations all contribute primarily to the coarse fraction.

According to a report in Canada 1990, the source sector breakdown for primary particulate matter emissions is as follows: 42% industrial sources, 2 % forest fires, 15% non-industrial fuel combustion, 11% transportation and 2% each incineration and miscellaneous sources (EPA-Timonen and Pekkanen (1997) have demonstrated the effect of particulate air pollution on respiratory health among children. Health effects of long term exposures to fine particulate matter have been reported in the form of lung cancer, cardiopulmonary mortality (Pope et al; 2002). Dominici et.al (2002) has estimated the relationship between air pollution and mortality, dost-response relationship. Many other investigators (Saini et. al, 1994; Kulshresth et.al.1994, Joshi and Mishra.1998; Naik and purohit; 1998; Sarangi and Mishra 1997) have reported ambient air quality of various Indian cities, either for selected criteria pollutants (or) for particulate matter only.

The main objective of this work is to determine Suspended particulate matter (SPM) and Manganese (Mn) present in the atmosphere due to the emission of gases from automobile exhaust and industries. Manganese occurs naturally in air, water and soil, but as a result of anthropogenic activities its concentrations 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 manganese concentration present in the ambient air of Madurai.

Particulate Matter

Suspended Particulate Matter

These are fine particles of soot and dust. They are found in ambient air due to the combined effect of various natural factors. In the case of Madurai, presence of extensively large arid and semi arid regions in north-west, loss of moisture from top soil strata and anthropogenic factors that is extensive urbanization and construction activities, increasing vehicular population, captive and domestic power generation are some of the major contributors to Suspended Particulate Matter in ambient air. High suspended particulate matter levels cause respiratory diseases and reduce visibility.

The particulate matter contains nearly 22 metallic elements. The most abundant elements are Calcium, Sodium, Silicon, Aluminium and Iron. Considerable quantities of Zinc, Lead, Copper, Magnesium and Manganese are also present in air. The concentration of these particulate pollutants depends upon the nature of industrial \emission.

Manganese

Manganese is naturally occurring metal that is ubiquitous in the environment. Exposure to low levels of manganese in the diet is considered to be nutritionally essential for people and animals (ATSDR, 1997). However exposure to elevated concentrations of manganese are harmful to human health and have been associated with subtle neurological effects, such as slaved eye-head coordination.

The environmental effects of manganese reveals that the manganese compounds exist naturally in the environment as solids in the soils and small particles in the water. Manganese particles in air are present in dust particles. These usually settle to earth within a few days. Humans enhance manganese concentrations in the air by industrial activities and through burning fossil fuels. Manganese that drives from human sources can also enter surface water, ground water and sewage

water.

MATERIALS AND METHODS

Descriptive of the study area

Madurai is the oldest inhabited city in the Indian peninsula. Madurai has an area of 52 square km and is located at 9.93˚ North, 7 .12˚ East. At present it has grown as the second largest and most densely populated city in the southern state of India namely Tamil Nadu. At most of the subsequent developments of the city were multiplied without a scientific planning, the air pollution sources are heterogeneous and widespread all over the city. This lead to the emissions of different air pollutants and air pollution loads and hence different degrees of ambient air pollution are experienced with respect to various places of the city.

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. Manganese is one of the toxic metal. The main source of manganese is alloy industry, dry cell battery factories, power plants, and coke ovens.

Table : 1 Descriptive of the study area

Site No	Location of the Site	Type of the site
1	Kalavasal	Traffic area
2	Kochadai	Industrial area
3	Alagarkovil	Residential area

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 whatmann filter paper no.42 and final volume made up to 25ml by de ionised water. The filtrate was examined for the concentration of Manganese by Atomic Absorption Spectroscopy (AAS) at wavelength 279nm with sensitivity of 0.21µg/ml of manganese.

Table 2 Monitored Pollutants and the methodologies employed for ambient air quality study

Methodology	Suspended Particulate Matter	Manganese
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

RESULTS AND DISCUSSION

Manganese metal and Suspended Particulate Matter concentration in the ambient air of Madurai is found at three different sampling site and shown in the **Table 3 and 4.**

The manganese concentration at the traffic area is 0.01(µg/m^3) as the minimum and 0.06 (µg/m^3) as the maximum. The average manganese concentration at the traffic area is 0.04 (µg/m^3). The percent of variation compared to the residential area is found to be maximum The manganese concentration at the industrial area is 0.05 (µg/m^3) as the minimum and 0.09(µg/m^3) as the maximum. Thus, the average manganese concentration at the industrial area is 0.07(µg/m^3). The percent of variation compared to the residential area is found to be maximum. It indicates that there is hundred fold increase in the manganese concentration at the traffic and industrial area compared to the residential area.

The average Suspended particulate matter concentration in the residential area ranged from

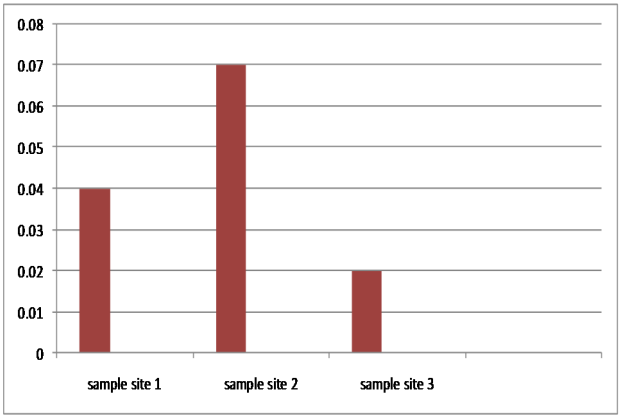

Fig : 1. Sample site 1 – Traffic area (Kalavasal)
Sample site 2 – Industrial area (Kochadai)
Sample site 3 – Residential area (Alagarkovil)

Table 3. Manganese 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	0.06	0.05	0.06	0.04	0.01	0.02
Industrialarea (Kochadai)	≥15,000	0.05	0.07	0.06	0.07	0.09	0.08
Residential area (Alagar Kovil)	≥3000	0.01	0.03	0.02	0.01	0.04	0.02

Table 4. 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

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 to 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 which are very much below than the TNPCB standard 500 µg\m^3.

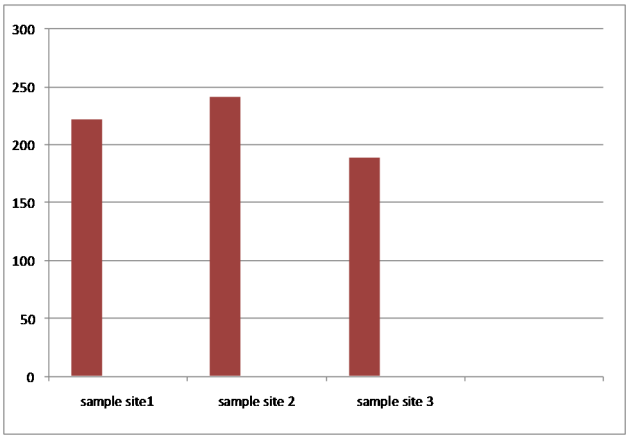

Fig : 2. Sample site 1 – Traffic area (Kalavasal)
Sample site 2 – Industrial area (Kochadai)
Sample site 3 – Residential area (Alagarkovil)

Ambient Air Quality Study

SPM Concentration (µg/m^3)

The percentage of Manganese concentration in the collected Suspended Particulate Matter is tabulated in **Table 5.**

The average concentration of Manganese present in suspended particulate matter ranged from 0.011 percent to 0.039 percent in the traffic area, while for industrial area it is ranged from 0.019 percent to 0.041 percent and in the residential area it has minimum 0.004 percent and maximum 0.012 percent. The percent of Manganese concentration present in the Suspended particulate matter clearly shows that the industrial area predominates in the Manganese concentration compared to that of other two sampling sites.

Air Quality Index

For indexing of the air quality status an assumption is made that all the pollutants are of equal importance. Using observed and standard values calculated the quality rating for each pollutant and the geometric mean of all the parameters gives the quality index for air. Based on this assumption, the quality index was derived in the manner outlined below. The existing pollution levels of pollutants were compared with ambient air quality standards (with the standard being assumed as reference baseline for each pollutant) and then converted to the concentration of pollutants into ratio of the standard.

$$Q_i = C_i/S_i$$

Where Q_i = Quality rating for a particular pollutant
C_i = Concentration of particular pollutant
S_i = Air quality standard for particular pollutant

A typical rating scale for air quality index (AQI) is given in **Table 6.**

The air quality index attempt to measure the air quality and index value represent the most

Table : 5 Percentage of Manganese 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	0.032	0.026	0.039	0.012	0.014	0.011
Industrial area (Kochadai)	≥15,000	0.019	0.027	0.023	0.037	0.041	0.029
Residential area (Alagar Kovil)	≥3000	0.004	0.012	0.012	0.005	0.030	0.009

Table : 6

Index Value	Remark
≤ 0.3	Least polluted
> 0.3-0.6	Slightly polluted
> 0.6-0.9	Moderately polluted
> 0.9-1.2	Highly polluted
> 1.2-1.5	Severely polluted
> 1.5	Extremely polluted

desirable air quality. The air quality status of traffic area and industrial area with respect to suspended particulate matter shows that they are slightly polluted, but the air quality status at the residential area is highly polluted. With reference to the manganese concentration in the atmosphere reveals that the residential area is slightly polluted whereas traffic and industrial area are moderately and severely polluted respectively.

Reference Concentration (RFC)

The reference concentration is an estimate of a continuous inhalation exposure to the human population (including sensitive subgroups) that is likely to be without an appreciable risk of deleterious effects during a life time (U.S.EPA, 2008). The reference concentration is an estimate of a chronic inhalation exposure that is likely to be without appreciable risk of adverse non-cancer effects during a life time. The reference concentration for manganese is 0.05 micrograms per cubic meter (µg\m^3), based on impairment of neurobehavioral function in people. At exposures increasingly greater than the reference concentration, the potential for harmful effects increases (ATSDR, 1997; U.S.EPA,1999).

CONCLUSION

Suspended Particulate Matter and fine particles can penetrate into the lungs and cause more ill effects to human being. Large exposure to Manganese leads to hypertension, skin problem, change of hair color, blood clotting, pneumonia and other respiratory infections has been found in

Ambient Manganese metal and Suspended particulate matter concentration at selected sites in Madurai city

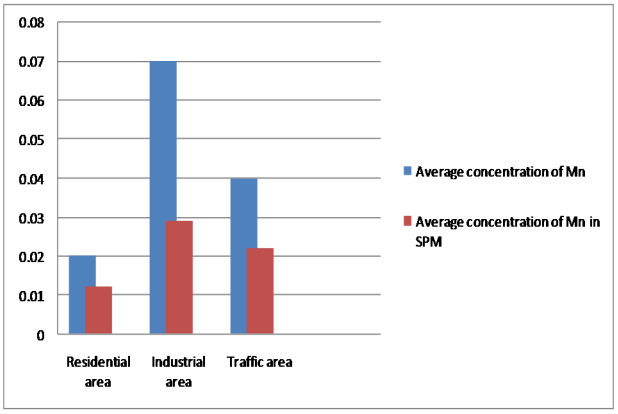

Fig : 3

workers exposed to dust or fumes of manganese compounds.

Important observations made from the present study are:

1. 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.
2. The study area wise comparison revealed that the concentration of Manganese is found to be maximum in the industrial area (0.09 µg/m^3) followed by traffic area (0.06µg/m^3) and the residential area (0.01 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 Manganese concentration in the ambient air of Madurai city.
3. The percentage of Manganese present in Suspended particulate matter is found to be high in industrial area (0.041%) followed by traffic area (0.039%) and residential ar

Table : 7 Air Quality Monitoring results for different locations

Location	Q_{SPM}	Air quality status	Q_{Mn}	Air quality status
Traffic area	0.44	Slightly polluted	0.8	Moderately polluted
Industrial area	0.48	Slightly polluted	1.4	Severely polluted
Residential area	0.94	Highly polluted	0.43	Slightly polluted

(0.004%).

4. With regard to the Suspended particulate matter the residential area is highly polluted whereas traffic and industrial area is slightly polluted. With respect to Manganese the residential area is slightly polluted whereas the traffic and industrial area are moderately polluted and severely polluted respectively. The survey indicates that the city of Madurai has a serious air pollution problem that may aggravate all the more if not controlled immediately.

Recommendation

1. Public awareness about air pollution programme receive greater attention from local man media which include newspaper, cable channels and projects like free emissions testing camps with assistance from NGO'S.
2. Educate the people regarding the ill effects of the growing transport problems in urban areas especially on their health and well being.
3. The campaigns would seek their support for the initiatives, like greater use of public transport and non-monitored vehicles, the proper maintenance of their vehicles and replacement of very old vehicles.

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