A Study On Atmospheric Suspended Particulate Matter Near Thermal Power Station, Tuticorin, Tamil Nadu.

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Abstract

Air pollution causes breathing ailments like bronchitis, asthma, tuberculosis, pneumonia, lung cancer. It affects the central nervous system due to carbon monoxide poisoning. The chemical nature and size of the particles are more important than the particulate matter load in the atmosphere. Particles in the size range 0.001-1μm exert several important effects. They are responsible for electrical phenomena in the atmosphere, cloud and fog formation. They play an important role in determining the heat balance of the earth's atmosphere through light reflection. They serve as nuclei for the formation of ice crystals and water droplets. They are involved in several chemical reactions in the atmosphere, such as Neutralization reactions in water droplets, catalytic effects of small particles of metal oxides on oxidation reactions and photochemical oxidation reactions. This paper deals with all the study techniques that were involved in the collection of aerosol particles and analysis of chemical composition of particulates for a period of three months from March 2014 to June 2014 in Tuticorin industrial area. The present research was envisaged to cover the objectives to assess the concentration of the Suspended Particulates Mater (SPM) in the study area, to assess the concentration of the Respirable Suspended Particulates Mater in the study area (RSPM), to find distribution pattern of Respirable Suspended Particulates Mater and Suspended Particulates Mater in the study area.

Key words: Respirable; Suspended Particulates Matter,air pollution, health effect, pollutants,Thermal.

Study Area

Tuticorin district is a part of South Tamil Nadu, India. Located in the southeastern corner of Indian Peninsular between 8º 35' 12'' and 8º 40' 10'' N and 78º 3' 90'' to 78º 10' 26'' E bound on the North by the districts of Virudhunagar and Ramanathapuram, on the East and Southeast by Gulf of Mannar, West and Southwest by Tirunelveli district. The study area falls in the Survey of India topo sheet no, 58L/1. The climate of this region is hot and dry. This district, particularly in and around Tuticorin, is the major salt producer of the country.

Apparatus

Respirable particulate sample, Envirotech APM was used to collect atmospheric aerosol particulates. This High volume sampling is an internationally accepted standard technique for measuring the concentration of suspended particulates in the atmosphere. A large volume (~1500 cubic meters) of atmospheric air can be passed through Whatman glass microfibre filter papers over a period of eight hours. Thus measurable amount of dust

samples in the area with dust levels as low as one microgram and up to 10 microns were collected for further analysis.

Locations of Air Sampling

In order to determine the chemical composition of collected aerosol particles the sampling area was selected near to the thermal power plant camp - I where a residential area is also located near by the sampling station.

Suspended Particulate Matter

Suspended particulate matter was collected by drawing atmospheric air through a size selective inlet and through 20.3 x 25.4 cm (8 x10 inches) glass microfibre filters at a flow rate of about 1.1 m^3/minute. The mass of this particle is determined by the difference in filter weighs before and after weighing. The concentration of suspended particulate matter is calculated by dividing the weight gain of the filter by the volume of air sampled.

Characteristics of Filter used for SPM collection

Area	:	20.3 x 25.4 cm
Manufacturer	:	Whatman, England.
Void size	:	<1(μm)
Fiber diameter	:	0.5–0.75(μm)
Thickness (μm)	:	260(μm)
Weight/area	:	5.3 (mg/cm^2)
Ash content	:	Not available
Maximum operation temperature	:	540^0C
Textile strength	:	500g/cm

Glass fiber filter was used for aerosol sampling due to their reduced hygroscopic quality, ability to withstand high temperature and higher collection efficiencies at a comparable pressure drop. In addition to this, they can also be used to make nitric acid extracts for metal analysis from particulate matter collected on them.

Field Sampling

The top of the high volume dust sampler was lifted. The faceplate and wing nuts were loosened. Filter paper from the jacket was removed and centered on the support screen with the rough side of the filter paper facing upward. The faceplate was replaced and wing nuts were tightened to secure the rubber gasket against the filter edge. The top cover of the high volume samplers (HVS) was closed tightly. Timer was set for the desired start and stop time. The instrument was connected to the power card and made to run for the desired time of eight hours. Flow rate was measured every hour.

After the completion of the sampling, final flow, rate and time were recorded. The filter paper was collected and folded length wise by handling it along its edge with the exposed side inward. The filter was inserted in its jacket and taken to the laboratory for further analysis.

Calculations of sampling volume of air

$$V = \frac{(Q_1 + Q_2)\,T}{2} \qquad (1)$$

V = volume of air sample, m^3

Q_1 = initial flow rate m^3/min

Q_2 = final flow rate m^3/minute

T = sampling time, min

Calculation of Aerosol Concentration

$$C = \frac{(M_f - M_i)}{V} 10^6 \qquad (2)$$

where,

C = mass concentration of aerosol particle µg/m^3

Mf = weight of exposed filter, in gram

Mi = weight of blank filter paper, in gram

V = Volume of air sampled, (m^3)

Result and discussion

Airborne sub micron, solid particles, and liquid droplets are commonly known as suspended particulates. In higher concentrations, they pose a serious pollution threat. In the air pollution field the terms particulate matter, particles and aerosols are used interchangeably and all refer to finely divided solids and liquids dispersed in the air. SPM is the weight of any particulate matter collected on the filter of a high volume air sampler. The high volume sampler collects particles that are less than about 30–40 µm in diameter. The life period of particulates varies from a few seconds to several months. Smaller the particle, larger the life time of suspension of the particle.

Polycyclic aromatic hydrocarbons (PAH) are associated with health hazards (Henning Richter et al, 2000). Composition processes are major sources of PAH in the atmosphere (Dockery et al, 1973). Many PAH identified in aerosol have been found to be mutagenic (Durant et al, 1996).

Averaged worldwide, anthropogenic aerosols—those made by human activities—currently account for approximately 10 percent of our atmosphere. Increased levels of fine particles in the air are linked to health hazards such as heart disease(Cass et al,1983) altered lung function and lung cancer.

Urban air contains particulates mainly of 0.1–10µm. Finest the particulates more the damage they cause to health. Particles in the size range of 0.01–2.5 µm are particularly effective in overcoming the body's natural protection against the inhalation of foreign matter. Particles, which reach the inner lung, can exert a toxic effect by interfering with normal respiratory function, by being intrinsically toxic or by acting as a carrier of an adsorbed toxic substance.

The study has been conducted in the hot weather. March to May prevails hot weather in Tuticorin. The results of suspended particulate matter (SPM) and Respirable suspended particulate matter (RSPM) in March, April and May 2014 are listed in Table 1,2, 3 and in Figure 1-9. The eight hours value shows that maximum values of 208.9µg/m^3 of SPM were reported during the month of May. The minimum value of 82.6 µg/m^3 was reported during the month of March. The daily average value shows a maximum 155.5 µg/m^3 of SPM during the month of May and a minimum concentration of 127.7 µg/m^3 in the month of April. Indian standards presently consider only the Respirable suspended particles which are inhalable and are more potent in the environmental damage and produced more stringent standards to control these killer particulates. The RSPM results during the study period of March to May, a higher concentration of 139.8 µg/m^3 of RSPM in the month of May and a lower concentration of 38.3 µg/m^3 of RSPM in the month of March. The day's average concentration exhibits a maximum of 94.6 µg/m^3 in the month of May and a minimum of 46 µg/m^3 in the month of March in the study periods. During the hot weather seasons in Tuticorin i.e. from March to May an increasing trend in the concentrations of SPM and RSPM was found. High wind speed, high atmospheric temperature, and less humidity are the common phenomena during this period in Tuticorin. This characteristic atmospheric condition leads to more earthen crust air borne in to the atmosphere

Table -1

Concentration of atmospheric particulate in Tuticorin during the month of March- 2014

Sampling date	Shift	Initial weight	Final weight	Con.RSPM µg	Average flow	Sampling period (m)	Net volume of air sampled (m3)	RSPM con µg/m^3
15.03.14 and 16.03.14	1	2.7212	2.7464	25200	1.1	480	528	47.7
	2	2.6707	2.6989	28200	1.1	480	528	53.4
	3	2.6956	2.7158	20202	1.1	480	528	38.3
Sampling date	**Shift**	**Initial weight**	**Final weight**	**Con.SPM µg**	**Average flow**	**Sampling period (m)**	**Net volume of air sampled (m3)**	**SPM con µg/m3**
15.03.14 and 16.03.14	1	2.7212	2.7893	68100	1.1	480	528	129
	2	2.6707	2.7854	94700	1.1	480	528	179.4
	3	2.6956	2.7392	43600	1.1	480	528	82.6

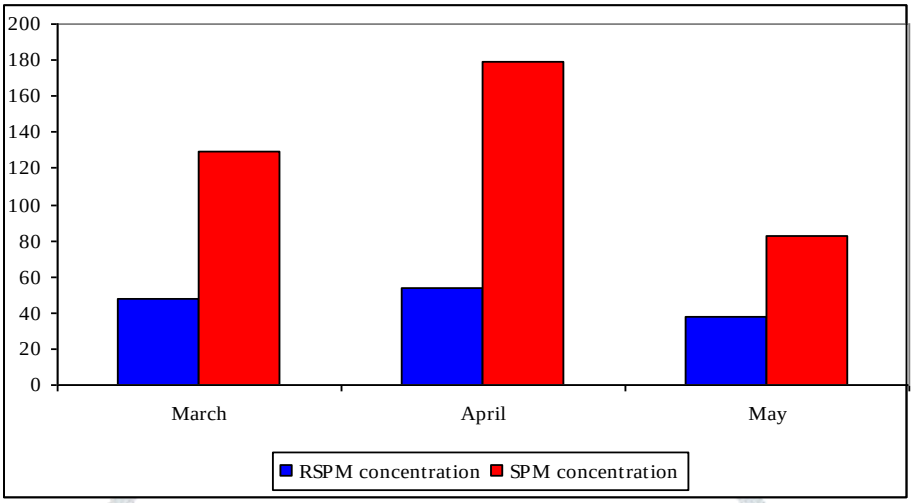

Fig.1 RSPM and SPM Concentration μg/m³

Table -2 Concentration of atmospheric particulate in Tuticorin during the month of April- 2014

Sampling date	shift	Initial weight	Final weight	Con. RSPM μg	Avg. Flow	Sampling period (m)	Net. Vol. of air sampled (m3)	Con.RSPM μg/m3
15.4.14 & 16.4.14	1	2.7057	2.7359	30200	1.1	480	528	57.2
	2	2.6014	2.6490	47600	1.1	480	528	90.2
	3	2.7397	2.7660	26300	1.1	480	528	49.8
Sampling date	shift	Initial weight	Final weight	Con. SPM μg	Avg. Flow	Sampling period (m)	Net. Vol. of air sampled (m3)	Con.SPM μg/m3
15.4.14 & 16.4.14	1	2.7057	2.7513	45600	1.1	480	528	86.4
	2	2.6014	2.7009	99500	1.1	480	528	188.4
	3	2.7397	2.7921	52400	1.1	480	528	99.2

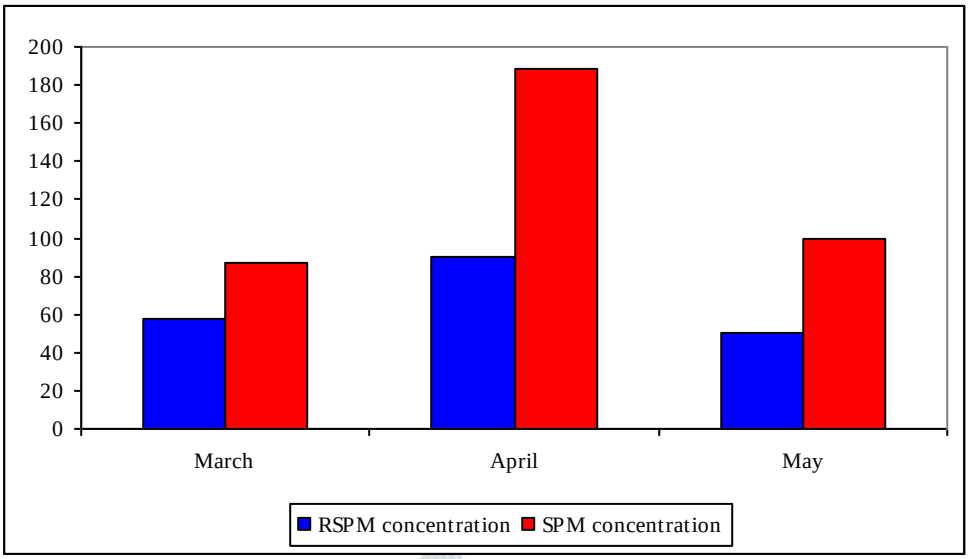

Fig.2 RSPM and SPM Concentration μg/m³

Table -3 Concentration of atmospheric particulate in Tuticorin during the month of May- 2014

Sampling date	shift	Initial weight	Final weight	Con. RSPM μg	Avg. Flow	Sampling period (m)	Net. Vol. of air sampled (m^3)	Con.RSPM μg/m^3
15.5.14 & 15. 5.14	1	2.6489	2,6913	42400	1.1	480	528	80.3
	2	2.8888	2.9626	73800	1.1	480	528	139.8
	3	2.7420	2.7756	23600	1.1	480	528	63.6
Sampling date	shift	Initial weight	Final weight	Con. SPM μg	Avg. Flow	Sampling period (m)	Net. Vol. of air sampled (m^3)	Con. SPM μg/m^3
15.5.14 &16.5.14	1	2.6489	2.7356	86700	1.1	480	528	164.2
	2	2.8888	2.9991	110300	1.1	480	528	208.9
	3	2.7420	2.7913	49300	1.1	480	528	93.4

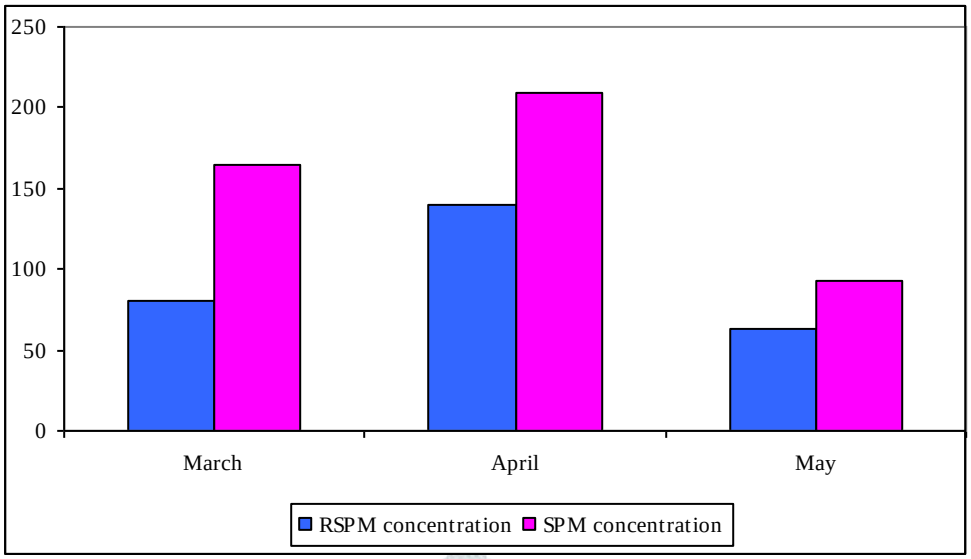

Fig.3 RSPM and SPM Concentration μg/m^3

The particulate concentration in the study area varies with respect to the emission from the source, wind speed, direction and other meteorological influences. The higher concentration most obtained from the second shift, may be attributed to the mobile sources in addition to the point sources (TTP). Lower concentration of the particulate matter is obtained in other shifts during lower concentration of mobile sources in the mornings and in the night.

While analyzing all the results, during the month of May the RSPM recorded above 100 μg/m^3, which is the standard ambient limit for RSPM as per Central pollution control board (CPCB). In addition to the atmospheric suspended particulates, contribution of considerable quantity from re suspension of surface soil is expected during surface transport. The suspended surface soil of industrial areas like coal based thermal power plants possesses substantial accumulation of trace elements contributed from spillage both during operation and transport of coal, ash and other raw materials. Earthen crust may also have contributed to the suspended particulate load due to high wind speed and high temperature during this month. These natural earthen particulates together with the anthropogenic particulates may be the reason for higher concentration of RSPM.

Ammonia (NH_3) - emitted from agricultural processes. Ammonia is a compound with the formula NH_3. It is normally encountered as a gas with a characteristic pungent odor. Ammonia contributes significantly to the nutritional needs of terrestrial organisms by serving as a precursor to foodstuffs and fertilizers. Ammonia, either directly or indirectly, is also a building block for the synthesis of many pharmaceuticals. Although in wide use, ammonia is both caustic and hazardous. In the atmosphere, ammonia reacts with oxides of nitrogen and sulfur to form secondary particles (Jaya Sekher,2009).

Another appealing feature which needs to be considered while discussing the air pollution and aerosol in a seashore area is the sea / land breeze. The sea breeze in the study area usually sets between 08.00 and 10.00 h local time in the morning and the land breeze sets on between 18.00 and 20.00 h in the evening. This leads to shifting winds at the coast between land and sea and a neutral condition prevails similar to a dynamic equilibrium before the breeze finally takes over and gets established. During neutral conditions / period of shifting winds, a horizontal convergence occurs within the boundary layer leading to increase in the aerosol concentration. (Yaday ,2003) This explains that the sea salt aerosol produced in the sea

is also transported and adds to the particulate concentration in addition to the particulates produce by anthropogenic means.

Submicron aerosol particles are also produced by the condensation of metals or organic compounds that are vaporized in high-temperature combustion processes. They can also be produced by condensation of gases that have been converted in atmospheric reactions to low vapour- pressure substances (Lacis(1995), Kaufman(2002), Lewtas(1993), Martin Eberet(2012)).

Particulates matter is of great human health concern as this can penetrate deep into the lungs and get absorbed into the blood system (WHO,1979). The direct effect of aerosol particles relates to their ability to scatter solar radiation back into space, increasing the planetary albedo and reducing absorption. Ability of the aerosol particles to act as cloud condensation nuclei (CCN), influencing cloud droplet number, precipitation processes and lifetime of cloud are some of the indirect impact**. (**Hamilton (1974), Friberg (1974)). Expert Group (1972) and the WHO Task Group (1979) concluded that increases in deaths were evident when 24 hrs of average concentration of smoke exceeded 500 µg m^{-3} of SO_2 (Vega,1999) .

Study of the respirable suspended particulate matters distributed in the atmosphere is gaining momentum in recent times due to its health related properties and environmental degradation properties. Tuticorin, which is one of the fast developing port cities in India, such pollution studies are very much important due to the establishment of coal based industrial activities for producing thermal power and the developmental processes followed. As discussed the very fine particulates having sources from high temperature processes, the control measures are limited. The Electro Static Precipitators (ESP) provided to control the particulate pollution is known to be less effective in the case of very fine particulates having thickness less than 10 microns.

Conclusion

In the study area, which falls near to the thermal power plant, the particulate pollution produced from other sources also add the concentration of suspended and respirable particulate load. In addition to the anthropogenic source, earthen crust may also have contributed to the suspended particulate load due to high wind speed and high temperature during summer seasons when the study was conducted. The sea salt aerosol produced in the sea is also transported which adds to the particulate concentration in addition to the particulates produced by anthropogenic means since the study area is located in a sea-shore area. The RSPM collected on filter paper are subjected to chemical analysis using ICP-MS. Appropriate planning shall be done before commissioning any industrial establishments to isolate the human population from direct hit by pollutants. Hospitals, schools, and dwelling complexes have to be located away from pollution sources and these may be established at places after carefully studying the meteorological aspects and the pattern of dispersion of air pollutants.

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