International Journal of Geology, Earth & Environmental Sciences ISSN: 2277-2081 (Online)
An Online International Journal Available at http://www.cibtech.org/jgee.htm
2013 Vol.3 (3) September-December, pp.52-60/Ragi et al.

Research Article

SHORT-TERM ASSESSMENT OF FPM CONCENTRATION IN THE URBAN AND RURAL AMBIENT AIR ENVIRONMENTS OF AN INDIAN TROPICAL AREA AT THIRUVANANTHAPURAM, KERALA

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ABSTRACT
In the present global environmentparticulate pollution has got great concern because of its adverse effect on human and plant population. Due to the rapid urbanization of the world population, better understanding of the detrimental effects of exposure to urban air pollution on chronic lung disease is necessary. The deposition of particulate matter (PM) in the respiratory tracts depends predominantly on the size of the particles, with larger particles deposited in the upper and larger airways and smaller particles penetrating deep into the alveolar spaces. The present study was undertaken with an objective to assess the particulate matter concentration of 12 selected areas in Thiruvananthapuram city using Grimm Aerosol Spectrometer (Model 1.108). In order to account for the spatial and temporal variations of the sources of particulate matter exposure, measurements were carried out on three different times of the 3 days during the May-June (2012) months. The instrument in the environmental mode was exposed for one hour at different out door environments. Data was transferred to measure continuous real time particle size distribution of PM1, PM2.5 and PM10. From the above study, it can be concluded that English IndianClays was having higher values of FPM followed by Thampanoor. Particulate matter concentration was observed above the safe limit in English Indian Clays.This is a matter of concern with regard to the health effects and mitigatory measures are suggested.

Key Words: *Air pollution, PM10, Aerosol*

INTRODUCTION
Environmental pollution is a common problem in both developing and developed countries. Assessment of the risk, to the community resulting from exposure to airborne pollutants should ideally include measurements of concentration levels of the pollutants in all microenvironments where people spend their time. Due to the multiplicity of different microenvironments, it is usually, however, not possible as it is too expensive to conduct measurements in all of them (Morawska *et al.,* 2001).All the self-balanced natural ecosystems are affected by man induced environmental changes. Man is responsible for deteriorating quality and standard of natural environment leading to its pollution. Any solid or liquid droplet with diameter between~0.002µm and~100µm is termed as particulate matter (Rajkumar and Esha, 2007). Particulate matter is produced by natural as well as anthropogenic sources. Among the many pollutants highlighted for adverse health effects, particular attention has been focused recently on fine particulate matter (Schwartz, 1994; Dockey and Pope, 1994; Pope *et al.,* 1995). Results from numerous investigations of human respiratory and other diseases have shown a consistent statistical association between human exposuresto the outdoor levels of particulates or dust and adverse health impacts. These hazards are more pronounced in the vicinity of industries where these particles become air-borne and inhalable (Sasmita and Pramila, 2012). The urban population is mainly exposed to high levels of air pollution including metals because of motor vehicle emissions, which is also the main source of fine and ultrafine particles (Sharma *et al.,* 2006) which influence the air quality. These particles can penetrate deep into respiratory system, and studies indicate that the smaller the particle, more severe the health impacts (Pope *et al.,* 1995b). Human exposure to particulate matter can have significant harmful effects on the

respiratory and cardiovascular system. These effects vary with number, size, and chemical composition of particulate matter, which vary significantly with space and time. Air borne respirable particulates originating from vehicles may be a threatening respiratory hazard potentially affecting thousands of roadside workers. Respirable size particles are of particular concern because they can reach the gas-exchange regions of the lungs, thus introducing a potentially higher risk to workers because of potential adverse effects to health. Symptoms like chronic cough, wheezing and breathlessness have been reported on exposure to these pollutants (Chabra *et al.,* 2001).

The particulate matter PM10 fraction and especially PM2.5 fraction can reach conductive airways and adversely affect the respiratory system (Duhme *et al.,* 1998). Recent epidemiological studies have demonstrated that air borne PM in urban areas has a clear co-relation with the respiratory and cardiovascular diseases responses (Pope *et al.,* 2004). The mechanisms behind these effects include oxidative stress and inflammation (Pope *et al.*, 2002) determined that each 10µg/m^3 increase in fine particulate concentration was associated with an approximate 4%, 6% and 8% increase in risk of all cause cardiopulmonary and lung cancer mortality, respectively.India has 23 major cities of over 1 million people and ambient air pollution exceeds the WHO standards in many of them (Gupta *et al.*, 2002). Suspended particulate matter in ambient air is a complex, multiphase system consisting of particle sizes ranging from <0.01µm to >100 µm (Wan-kuen *et al.*, 2006). The high levels in developing countries and the apparent scale of its impact on the global burden of disease underline the importance of particulate as an environmental health risk and the consequence need for monitoring them particularly in indoor microenvironment (Massey *et al.,* 2009).

Vehicular emissions have adverse effect on respiration and immune systems of human beings and also have potential for carcinogenicity. Aerosols especially submicron particles are one of the major products of vehicular emissions. The traffic emission differs from that of industries. Traffic emissions are more harmful as they are released into atmosphere at low height and also they do not get silent scope to disperse due to surrounding density of high buildings. The deposition of particulate matter in the respiratory tract depends predominantly on the size of the particles, with larger particles deposited in the upper and larger air ways and smaller particles penetrating deep into the alveolar spaces. Worldwide epidemiological studies show a consistent increase in cardiac and respiratory morbidity and mortality from exposure to particulate matter (Andre, 2012). Although particulate levels seem to be closely related to health effects, they generally appear in association with other pollutants and it is not clear that they are always the primary direct cause of the ill health and not just an indicator of effect of the mixture. Thus there is need to better differentiate types of particles so as to assist in identifying the actual culprit and how they can be controlled (Smith and Jantunen, 2002).

The global burden of disease (GBD) assessment for 1990-2010 quantified the trends of more than 200 causes of deaths and listed outdoor air pollution among the top 10 causes of deaths for India. For India, total premature mortality due to outdoor particulate matter (PM) pollution is estimated at 627,000. Public health concerns in India are focused on particulate matter (PM) that contributes to a host of respiratory and cardiopulmonary ailments and increasing the risk of premature death. In 2011-2012, a first-of-its-kind study in the country estimates it resulted in a whopping 80,000 to 1,15,000 premature deaths and more than 20 million asthma cases from exposure to a total PM10 (particulate matter) pollution. In 2011-12, the emissions from coal-fired power plants, resulted in an estimated 80,000 to 115,000 premature deaths and more than 20.0 million asthma cases from exposure to total particulate pollution, which cost the public and the government an estimated 16,000 to 23,000 crores of Rupees (USD 3.2 to 4.6 billion). The largest impact of these emissions is felt over the states of Delhi, Haryana, Maharashtra, Madhya Pradesh, Chhattisgarh, Indo-Gangetic plain, and most of central-east India (Urban Emissions Info, 2013).

All in all, this is bad news. This is when we know that half of India's urban population lives in cities where particulate pollution levels exceed the standards considered safe. And as much as one-third of this population breathes air having critical levels of particulate pollution, which is considered to be extremely harmful. Half of the urban population breathes air laced with particulate pollution that has exceeded the

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standards. As much as one-third of the population is exposed to critical levels of particulate pollution. Smaller and more obscure cities are among the most polluted. About 78 per cent cities (141) exceed the PM_{10} standard. Ninety cities have critical levels of PM_{10}; 26 have the most critical levels, exceeding the standard by over three times. Gwalior, West Singhbhum, Ghaziabad, Raipur, and Delhi are the top five critically polluted cities (Down to Earth, 2013).
The objective of the study was to assess particulate matter concentration (PM10, PM2.5, and PM1.0) in different selected sites.

MATERIALS AND METHODS

Sampling Procedure

In this study, the GRIMM series 1.108 Aerosol Spectrometer (GRIMM Technologies, Inc., Douglasville, GA,USA), a portable optical particle counter, was utilized to measure particle mass concentrations and size distributions since this kind of monitor is light weight, easy to operate, and effective for time resolution. For this study, the air samples were drawn at the height of 1.5-3.0m from the ground level in order to monitor the particulate matter. The GRIMM Aerosol Spectrometer measures the number of particles per unit volume of air using light scattering technology. The instrument provides four operational modes that isEnvironmental, Occupational, Massand Count mode. The instrument measures Fine Particulate Matter (FPM) concentration in an optical size of 0.23-20µm in 16 channels. Ambient air is drawn into the unit via an internal volume controlled pump at a rate of 1.2 L/min. At the start of each measurement, the instrument initiates a system self-test. A stainless steel tube provided by the manufacturer was utilized as the spectrometer inlet. The measured real-time Environmental concentration data are transferred at 6-seconds intervals to a data storage card. Measured data in the environmental mode was then downloaded from the storage card via the Grimm 1177 program on to the computer.

The study areas were situated in Thiruvananthapuram district. The study areas are presented in the figure1. Thiruvananthapuram District is the southernmost district of the coastal state of Kerala, in South India. Thiruvananthapuram district is situated between north latitudes $8^0 17'$ and $8^0 54'$ and east longitudes $76^0 41'$ and $77^0 17'$. The major air pollution source in Thiruvananthapuram is vehicular emission. But the constructional activities (road construction and maintenance) aggravated the increase in particulate matter concentration.
The sampling sites are Karamana(S1), Plamood(S2), Thampanoor(S3), Veli– Near English Indian Clays(S4), Medical College(S5), MuseumGate (S6), Zoo Gate (S7), Palayam(S8), Akkulam (S9), Pothencode(S10), Chempazhanthy(S11) and Keraladithyapuram(S12). Among the 12 selected sites Museum premises, Zoo premises, Medical College, Veli-Near English Indian Clays Ltd (EICL), Karamana, Plamood, Thampanoor, Akkulamand Palayamare within the corporation area. Veli- Near English Indian claysis also an industrial area. EICL is the supplier and exporter of china clay, kaolin clay, engineered clay, metakaolin and calcined clay. MedicalCollege is said to bea sensitive area because of the presence of three hospitals. Sri Chithra Medical Centre, Government MedicalCollege and Regional Cancer Centreare located here. Sampling sites in Chempazhanthy, Pothencode and Keraladithyapuramare coming under rural category.

RESULTS AND DISCUSSION

Using the GRIMM Aerosol Spectrometer (Model 1.108), data is collected continuously during May-June 2012 in morning, afternoon and evening from 12 selected locations. The concentration of particulate matter in the environmental mode can be measured through 3 channels, PM 10, PM2.5, PM1. We consider measurements of each one hour in morning, afternoon and evening at each location. The average particulate matter values of all the different sites are presented in (Table 1). The average contribution of particulate matter of all sites is calculated and plotted in graph (Figure 14), with aerosol size in x-axis and mass concentration in y-axis. The averageconcentration of particulate matter of all the selected sites in morning, afternoon, evening is represented in the (Table 2). The average contribution of particulate matter in each sites separately is calculated and plotted in graphs (Figure 2-13), with aerosol size in x-axis and mass concentration in y-axis.

From the results it is clearly observed thatlarger particles havegreater concentration. A comparison between different micro Environments has been attempted.From thevalues it is noted that EICL have higher concentration and Zoo premises was having lesser concentration of particulate matter. The average concentration of PM 10 in EICLand Zoo premise was 115.04µg/m^{3}and 18.57µg/m^3 respectively. Moreover English India clays have higher concentration of particulate matter concentration in the evening, than in morning and afternoon. The results were compared with National Ambient Air Quality Standards prescribed by CPCB (2009). From the Standards, it is very clear that EICL is having values above the prescribed limit. The higher concentration of particulate matter in EICL is due to the ultra-fine clay particles. From the site observation it is found that even though Zooarea is present in the city it is rich in vegetation, also source for particulate matter is absent.

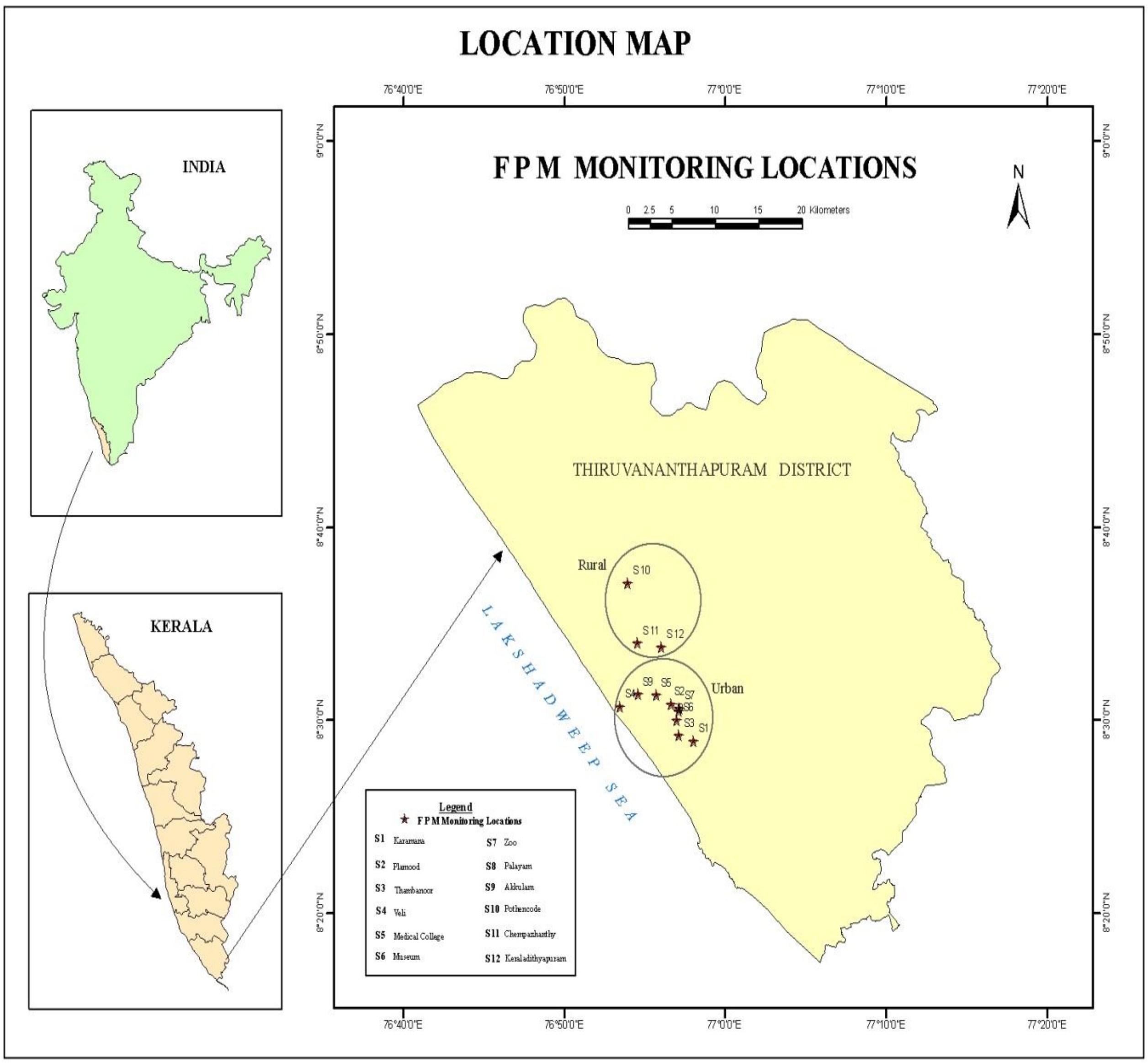

Figure 1: The location map of the study area

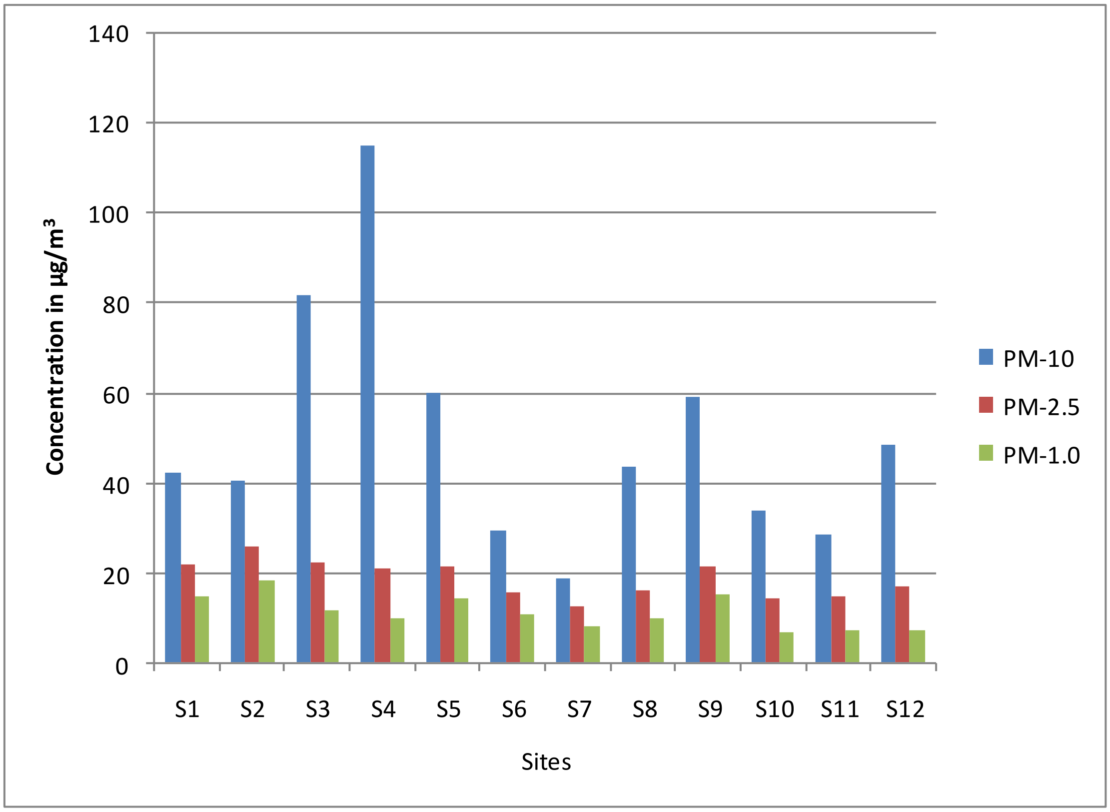

Figure 2: Average particulate mass concentration of all the selected sites

Table 1: The average values of particulate matter concentration of all the selected sites

SITES	**PM 10(µg/m^3)**	**PM2.5(µg/m^3)**	**PM1(µg/m^3)**
S1	42.26	21.61	14.73
S2	40.45	25.6	18.15
S3	81.64	22.09	11.53
S4	115.04	20.74	9.6
S5	60.14	21.45	14.26
S6	29.4	15.46	10.72
S7	18.57	12.37	8.07
S8	43.69	15.85	9.89
S9	59.25	21.36	15.14
S10	33.9	14.12	6.68
S11	28.25	14.67	6.93
S12	48.48	16.89	7.15

Table 2: Average concentration of particulate matter in the Environmental mode

SITES	TIME	PM-10(µg/m^3)	PM-2.5(µg/m^3)	PM-1.0(µg/m^3)
	Morning	52.55	26.99	19.27
KARAMANA(S1)	Afternoon	37.88	19.23	12.66
	Evening	36.35	18.6	12.28
	Morning	50.2	35.58	26.85
PLAMOOD(S2)	Afternoon	39.26	25.37	17.68
	Evening	31.89	15.88	9.91
	Morning	90.59	25.41	14.72
THAMPANOOR(S3)	Afternoon	82.99	20.92	10.02
	Evening	71.36	19.95	9.85
	Morning	81.35	17.46	9.17
ENGLISH INDIAN CLAYS(S4)	Afternoon	59.41	17.09	9.39
	Evening	204.38	27.29	10.23
	Morning	58.02	21.21	14.16
MEDICAL COLLEGE(S5)	Afternoon	51.93	14.76	8.47
	Evening	70.48	28.37	20.15
	Morning	31.83	19.85	15.25
MUSEUM(S6)	Afternoon	26.68	11.6	7.12
	Evening	29.72	14.93	9.75
	Morning	25.72	17.65	12.56
ZOO(S7)	Afternoon	17.64	11.83	8.09
	Evening	17.12	11.16	6.54
	Morning	53.49	23.74	16.48
PALAYAM(S8)	Afternoon	40.84	14.06	8.49
	Evening	43.27	14.94	9.09
	Morning	89.55	32.85	25.24
AKKULAM(S9)	Afternoon	45.91	16.62	11.22
	Evening	42.3	14.62	8.95
	Morning	41.07	14.43	6.55
POTHENCODE(S10)	Afternoon	28.74	15.08	7.74
	Evening	31.88	12.88	5.76
	Morning	35.02	17.17	8.35
CHEMPAZHANTHY(S11)	Afternoon	27.39	14.37	6.62
	Evening	22.39	12.47	5.84
	Morning	72.28	19.95	8.24
KERALADITHYAPURAM (S12)	Afternoon	42.69	16.71	6.72
	Evening	30.48	14	6.5

From all the sites it is seen that, the nature of aerosol distribution for larger particles (PM 10) have larger count. Thampanoor has the second largest amount of aerosol concentration (81.64µg/m^3). Heremaximum particulate matter is noted during morning. It may be mainly due to the heavy traffic. Central Railway station and KSRTC central bus terminal is located in Thampanoor. Fuel burning emission, construction activities may be the other sources of pollution. Medical College (Sensitive area) and Akkulam is also having higher particulate matter concentration. This is mainly due to heavy traffic and also constructional activities aggravated the increase.

The roads are paved but the by-lane and the area adjacent to the roads are dry, unpaved surfaces. Also, the roads have lots of potholes and due to out-of-track driving problems there are high concentrations of both fine and coarse PM fractions. It is observed that the average mass concentration of PM 10 in the sensitive areas such as Medical College and Museum premises are 60.14 and 29.4µg/m^3 respectively. Even though Plamood and Palayam are in the heart of the city, they are having comparatively lower values because the roads and the area adjacent to the roads are paved also thereby reducing the PM sources from the open ground for mixing with ambient air of those areas. We have collected values from rural areas such as Pothencode, Chempazhanthy, Keraladithyapuram. The average mass concentration in Pothencode, Chempazhanthy, Keraladithyapuramare 33.9, 28.25 and 48.48µg/m^3 respectively.

Conclusion

From the present study it can be concluded that the highest concentration of particulate matter is observed in the EICL and the lowest is observed in the Zoo area. Also, it is observed that at all the 12 locations the PM concentrations are higher for PM 10 followed by PM 2.5 and PM 1. A peak PM concentration of 115.04µg/m^3 is observed in EICL, which is above the limit prescribed by CPCB. While the concentration values at EICL were crossing the CPCB limits, PM concentration values at Thampanoor and Akkulam were found nearer to the limits.

From the previous references it is very clear that continuous exposure to lesser concentration is also harmful for health. The overall result reveals that the air quality of selected microenvironments is deteriorating rapidly due to particulate pollutants. In future, if proper management measures are not taken as mentioned below the concentration will be increased above the limits in other locations too, and it will affect the health of human beings especially. This is being a short-term assessment of particulate matter concentration, continuous and seasonal monitoring for a longer period is very much necessary.

Recommendations

- Proper implementation of National Ambient Air Quality Standards. The national air quality planning and city action plans need a roadmap for each source of pollution. Penalty should be imposed on cities if air quality standards are violated. Strengthen implementation plans for critically polluted notified areas
- Atmospheric particulate emission can be reduced by choosing cleaner fuels. Natural gas used as a fuel emits negligible amount of particulate matter. Oil based processes also emit significantly by particulates than coal fired combustion process.

Low ash fossil fuel contain less non - combustible, ashes forming mineral matter and thus generate lower level particulate emissions. Lighter distillate oil based combustion results in lower levels of particulate emission than heavier residual oils. However the choice of fuels is usually influenced by economic as well as environmental considerations.

- Reduce travel on days with poor air quality. Avoid vigorous physical activity on days that have poor air quality. Keeping any open area or vacant plots you own or responsible for stabilized. Apply water to form a crust or apply gravel or a soil stabilizer, plant vegetation. Roads have to be paved and if possible by-lane and the area adjacent to the roads also have to be paved. Completing constructional activities (road construction and maintenance) in time.
- The concept of ambient air quality standards an essential part of the so called air quality management approach to air pollution control. Special attention should be given to pollution abatement measures in areas where toxic associated with particulate emission may pose a significant environmental risk.
- By improving combustion efficiency the amount of products of incomplete combustion efficiency the amount of products of incomplete combustion (PICs) a component of PM, can be significantly reduced. Proper fuel fixing particles and combustion zone configuration along with an adequate amount of excess air can achieve low PICs.

AKNOWLEDGEMENT
Authors are thankful to the Director, CESS, Thiruvananthapuram for providing all the encouragement and support.

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