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ASSESSMENT OF PM_{10} IN AURANGABAD CITY OF CENTRAL INDIA

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Abstract

Almost 670 million people comprising 54.5% of our population reside in regions that do not meet the Indian NAAQS for fine particulate matter. Numerous studies have revealed a consistent correlation for particulate matter concentration with health than any other air pollutant. Aurangabad city a rapidly growing city with population of 1.5 million is home to five major industrial areas, the city is also known for its historical monuments which might also be adversely affected from air pollution. Therefore, this research aims at estimating PM_{10} concentrations at several locations across Aurangabad. The concentration of PM_{10} was highest at the Railway Station followed by Waluj (an industrial zone) and City chowk is the centre of the city which has high population, tall buildings, few open spaces which causes high congestion and does not allow the particulates to disperse. Other locations with high concentrations of PM are Mill corner, Harsul T-point, Kranti Chowk, Seven Hill, TV centre and Beed Bye pass. All these locations have narrow roads, high traffic density, poor road condition with pot holes and few crossing points which cause congestion and vehicle idling which are responsible for high pollution. Therefore, it is evident that air pollution is a serious issue in the city which may be further aggravated if it is not brought under control. Hence, strategies have to be adopted for combating the menace of air pollution.

Keywords: PM_{10}, Aurangabad, sampling, Respirable sampler, standards

Introduction

All over the world air pollution has become a public health problem. In 2012, air pollution was declared as the largest environmental health risk with almost seven million deaths globally attributed to it (WHO, 2014). According to the Global Burden of Disease 2010 report it was estimated that particulate matter (PM) air pollution was responsible for about 6% of deaths on a global basis (IHME, 2013; Lim et al., 2012). India is an important country in South Asia with a rapidly growing economy and a large but young workforce. However, rapid industrialization and urbanization in the country have resulted in a significant deterioration in urban air quality (Kulshrestha et al., 2009). Data from the country's major Regulator - Central Pollution Control Board (CPCB), showed that 77% of Indian urban clusters clearly exceeded the National Ambient Air Quality Standard (NAAQS) for respirable suspended particulate matter (PM_{10}) in 2010 (CPCB, 2012). Another key estimate from WHO points that out of 20 world's worst particulate air polluted cities around 13 are in India including the capital Delhi, which is the worst ranked city in terms of air pollution (WHO, 2014). It is quite alarming to note that the satellite measures of fine particulates created for the entire India reveal that our populations living both in urban and rural areas are exposed to hazardously high levels of particulates. Almost 670 million people comprising 54.5% of the population reside in regions that do not meet the Indian NAAQS for fine particulate matter (GreenStone et al., 2015; Dey, 2012). Numerous studies have revealed a consistent correlation for particulate matter concentration with health than any other air pollutant. Studies show a statistically significant correlation between mortality and ambient particulate matter concentration (Lee et al., 2006).

Particulate Matter - Significance

The term "Particulate Matter" (PM) refers to tiny particles which remain suspended in air, in the form of either solid or liquid droplets which originate from various sources that pollute the ambient air. Particulate matter comprises of various organic and inorganic components; the major components include acids, ammonia, sodium chloride, black carbon, water and mineral dust. These respirable particulates having aerodynamic diameter $\leq 10\mu m$ (PM 10) are an important part of the atmosphere. PM is widespread and affects more people than any other ambient air pollutant. These particles have a high probability of deposition deeper into the respiratory tract and are likely to trigger respiratory diseases such as asthma, bronchitis, cardio-pulmonary infections (GreenStone et al., 2015; WHO, 2014). Epidemiological evidence has even attributed PM_{10} in cancer and in some cases even premature death. The relative strength of association of air pollutants with mortality were reported as follows: $PM_{2.5} \geq PM_{10} \geq SO_2 \geq H^+ \geq O_3 \geq NO_x$ (Dockery et al., 1992; Das et al., 2006). Further it has been found that for each 10 $\mu g/m^3$ increase in PM_{10} Concentration, there is an estimated increase in mortality by almost 1 per cent (Dockery and Pope, 1994; Ostro, 1996; Das et al., 2006).

These particles have also been implicated as carriers of toxic air pollutants including heavy metals and organic compounds (Satsangi et al., 2011). According to WHO Guidelines when PM_{10} particles are present in excess of $50 \mu g/m^3$ these are known to adversely affect human health. In view of the air quality status, some of the Indian cities are considered to be among the most polluted cities in the world (Mitra and Sharma, 2002). It is well known that PM_{10} is a better indicator of total suspended particulate matter (Das et al., 2006). These findings therefore, highlight the need for monitoring of PM_{10} particles for the quantification of particulate load in the ambient air and also to suggest control measures for these particles in the air.

However, to the best of our knowledge no detailed study has been reported on the PM_{10} concentration in Aurangabad city of the state of Maharashtra. Aurangabad city is home to five major industrial areas with presence of various MNCs still city infrastructure is not as per industrial standards. In addition the city is known for its historical monuments such as Ellora caves, Bibi ka Makbara which might be adversely affected from air pollution. Therefore, this research is aimed at estimating PM_{10} concentrations at several locations across Aurangabad city in order to highlight the air quality status of this rapidly growing city.

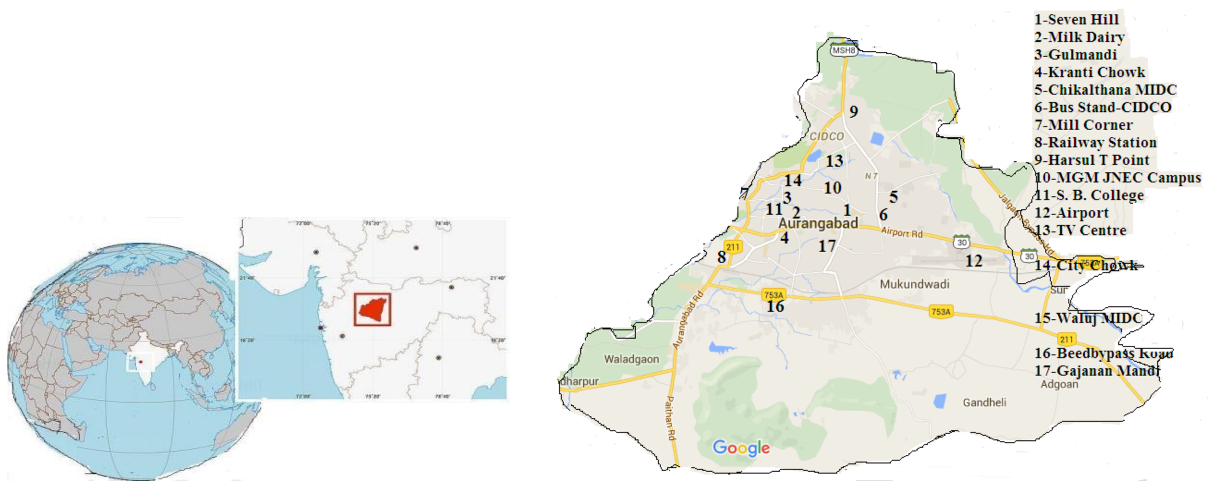

Figure 1 - Aurangabad city highlighted in map of India and the various sampling locations

Site description

Aurangabad city in Maharashtra is the site of headquarters of Marathwada region (Fig.1). It has a rich historical background and is a popular tourist place for both domestic and international tourists. The city is situated at a latitude of 19°53'59" North and longitude 75°20' East. Aurangabad's area is about 138 km^2. The climate of Marathwada region is generally hot and dry. The average temperature for day ranges from 27.7°C to 38.0°C while it ranges from 26.9°C to 20.0°C during the night. Average annual rainfall in the city and adjoining areas is 725.8 mm while the relative humidity is extremely low in this region for a major part of the year and ranges between 35 to 50%, while it is the highest (85%) during monsoon. The total area under forest cover is about 557 km^2 which comprises of only 7.6% area of the total land area in Aurangabad (Chavan and Rasal, 2012). Recent census data revealed that the population of city is about 1,500,000 (AMC, 2011). The city boasts of a total number of industrial units (small, medium and large-scale) as about 1020 and almost 35,000 workers find their employment in these units (Bhosale et al., 2010). The rapid industrial growth of Aurangabad has resulted in urbanization of the city and has also increased air pollution. The number of vehicles has also increased making a significant contribution to the vehicular traffic. The sampling sites according to their different land use patterns, populations and traffic densities have been selected or monitoring particulate matters. The measurements of PM_{10} have been carried out on the terrace of the building (above 3-5m above the ground) at each site (Table 1).

Table 1: Sampling locations

Location	Description	Traffic Density	Land use pattern
1. Seven Hill	Near to Flyover and commercial complex	High	Mixed
2. Doodh Diary	Site of office of government entity, MSEDCL	High	Commercial
3. Gulmandi	Busy densely populated market area	Medium	Mixed
4. Kranti Chowk	Near to Flyover and commercial complex	High	Commercial
5. (MIDC) Chikalthana	Open industrial area with only few units functioning	Medium	Industrial
6. CIDCO - Bus stand	City bus stand buzzing with commuters and bus drivers and cleaning staff	High	Commercial
7. Mill corner	City Police Commissioner Office	High	Mixed
8. Railway Station	City Railway Station with high rush of visitors and also the residents	High	Commercial
9. Harsul T point	Outskirt of city interstate buses, vans pass through the area	High	Mixed
10. JNEC- MGM campus	Educational Institution with around 8000 students and 500 faculty members	Medium	Institution
11. SB College, Aurangpura	Unpaved roads, high population density	High	Institution
12. Airport, Chikalthana	Airport is on city outskirts, large open area	Low	Airport
13. TV Centre	Government TV transmission centre	High-Medium	Mixed
14. City Chowk	Densely populated residential area with market	Medium	Mixed
15. MIDC-Waluj	Over 1200 industries	High	Industrial
16. Beed bypass	City outskirts where vehicles meant for other locations bypass the city. Heavy truck traffic	High	Commercial
17. Gajanan Mandir Chowk	Centre of city, densely populated	High	Mixed

Materials and Methods

PM_{10} monitoring was carried out in selected city locations during Dec, 2015-Jan, 2016. The samples were collected for 24h. PM_{10} samples were collected on Whatman filter papers with the help of a Respirable Dust Sampler (Model - APM 460 DXNL, Envirotech, New Delhi). The high volume sampler was operated at a flow rate of 1.1 m^3/min. Field blanks were also collected.

Before beginning the sampling all the filter papers were pre-weighed with the help of a Metler analytical weighing balance. Then the filter papers were desiccated for the duration of 24h. In order to avoid any sort of contamination, conditioned and pre-weighed filter papers were kept in a zip lock polybag for taking to the field for sampling. Prior to loading the filter papers on the sampler, the initial manometer and timer readings were noted. Subsequently the filter papers were loaded on the sampler and after ensuring that the sampler was properly screwed the sampler was started. At the end of sampling period, the loaded filter paper was removed with the help of forceps, wrapped in aluminium foil and placed in a zip lock polybag. In the laboratory the filter paper was conditioned and was again weighed to determine the PM_{10} mass concentration (Satsangi et al., 2011).

Meteorological Observations

During the air quality monitoring the wind direction (WD) and speed (WS), temperature, relative humidity (RH) and the rainfall were also recorded. The average minimum and maximum temperatures were 14^{o}C and 30^{o}C. Average minimum and maximum RH were 26 and 51, while the prominent WD was East with WS ranging from 6 to 14 km hr^{-1}. During the period of sampling there was no rainfall (IMD, 2016).

Results

The concentration of PM_{10} is highest at the Aurangabad Railway Station (Table 2). The reason for which could be narrow road, high traffic, numerous encroachments and high floating population greater than 0.1 million commuting from nearby regions to work in the industries. This creates congestion and idling of vehicles which results in the generation of high quantities of particulate matter.

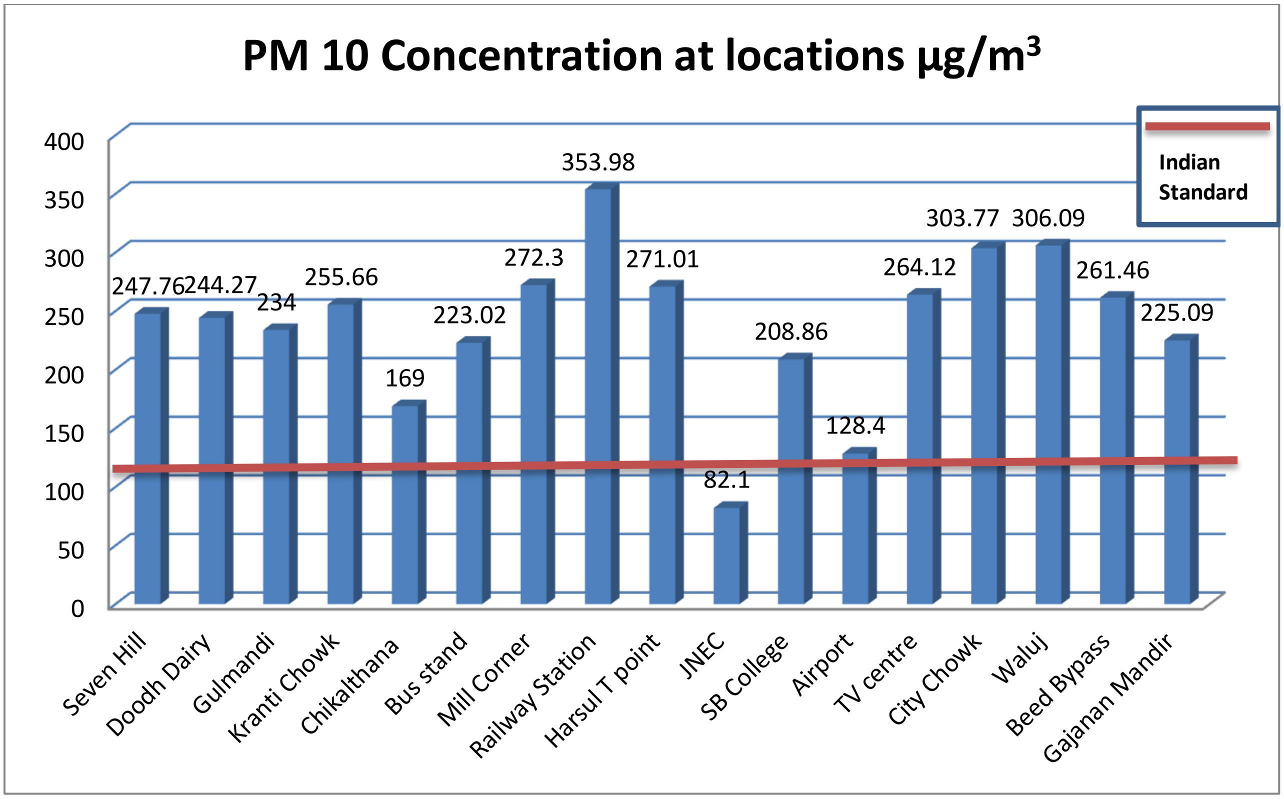

Figure 2: PM_{10} Concentration at locations

Waluj is an industrial zone which has a high concentration of the critical Red industries so it is probable that these industries contribute to PM generation. In addition the control equipments for controlling PM release are neither effective nor efficient there by contributing to a high PM concentration. Another very important reason is that the public response is very low with regard to pollution which does not motivate the industries to focus on controlling pollution. The other industrial zone at Chikalthana shows low PM levels on account of relocation of major industries as well as its being converted into a residential zone. City chowk is the centre of the city which has high population, tall buildings, few open spaces or vegetated areas which causes high congestion and does not allow the particulates generated from traffic, waste disposal and biomass burning to disperse. Other locations with high concentrations of PM are Mill corner, Harsul T-point, Kranti Chowk, Seven Hill, TV centre and Beed Bye pass. All these locations have narrow roads, high traffic density, poor road condition with pot holes and few crossing points which cause congestion and vehicle idling which are responsible for high pollution. Airport being an open spread out area with low population, less traffic and or industries in the vicinity has a low PM concentration. It is also important to note that the PM_{10} concentrations exceed the WHO standard (50µg m^{-3}) and Indian standard of CPCB (100µg m^{-3}). It is clear that the concentrations were almost 3.5 to 3 times higher than the Indian standards suggesting that more efforts should be taken to control the particulate pollution in Aurangabad. When the study results were correlated with MPCB (Maharashtra Pollution Control Board) data for January for SB College it was found that the PM values were 203 µg m^{-3} which were close to the values (208 µg m^{-3}) reported by this study. It is also clear from the MPCB data (Table 2) that PM pollution is lowest in monsoon season followed by summer and is highest in winter season. In monsoon rainfall washes the particles resulting in their low concentration while in summers strong winds result in re-suspension of dust causing higher PM concentration. Winter season of the year is associated with low wind speeds and negligible rainfall resulting in increase of the air pollution level of the studied location (Kavuri and Paul, 2013). Further, the lower solar insulation rates during the winter months lead to lower atmospheric inversion layers where pollutants become trapped close to the ground, further increasing fine particle concentrations (Gummeneni et al., 2011). PM2.5 data confirms the pronounced seasonal peaks coinciding with lower mixing heights of the winter months. The measured PM pollution in the winter is at least double the concentrations measured during the rest of the season (Guttikunda, 2009).

Table 2: MPCB data for January, 2016

	SBES College Particulate values in µg m^{-3}	**CADA Office** Particulate values in µg m^{-3}
Summer		
April	105	75
May	89	68
Monsoon		
June	78	50
July	76	42
Aug	66	31
Winter		
Nov	123	90
Dec	135	126
Jan	203	140

http://mpcb.gov.in/envtdata/demoPage1.php

Discussion

Various studies have been conducted in different parts of India to assess the PM_{10} concentration. Joshi and Jain (2000) estimated the RSPM concentrations in Indore city at 11 locations, mostly at outer city areas. The average values of respirable dust varied between 39.78 - 649.92 µg/m^3. Mohanraj and Azeez (2005) assessed the RSPM levels at six sampling locations in urban and sub-urban Coimbatore. It was found that average RSPM levels ranged between 30 - 149 µg/m^3. They inferred that urban areas with frequent vehicular traffic and traffic congestion had comparatively high RSPM which exceeded the prescribed Indian standards. Chalka et al, (2006) conducted monthly and seasonal analysis of RSPM at industrial, traffic, residential and sensitive locations of Ajmer (Rajasthan) in 2004. They observed highest level of RSPM (488.0 µg/m^3) in months of December and June at industrial site. The level of RSPM crossed the limits of NAAQS laid down by CPCB. Karar et al., 2006 investigated the seasonal and spatial variations of PM 10 in residential and industrial sites in urban area of Kolkata. They found that daily average PM 10 concentrations ranged between 68.2 to 280.6 µg/m^3 in residential area and 62.4 to 401.2 µg/m^3 in an industrial area. Higher PM values at industrial area was attributed to heavy traffic flow, emission from nearby industrial area and re-suspension of road and soil dust. Seasonal study showed maximum value of PM 10 in winter and minimum in monsoon season. Higher winter concentration was attributed to low winds and low mixing heights leading to accumulation of pollutants. Kapoor et al, (2009) studied the RSPM in and around Udaipur city (Rajasthan) for the duration Nov, 2007 to Oct, 2008. They concluded that minimum values for RSPM ranged from 48.01 -369.76 µg/m^3 and maximum values varied between 81.43 to 1032.1 µg/m^3. They concluded that air pollution levels were minimum in residential areas, higher on roads and highest in industrial area. Clearly the reports in literature are in agreement with our results suggesting that Industrial areas and high traffic density areas have high particulate matter pollution.

Similar studies in other developing countries such as Nepal, Pakistan, Tanzania etc have concluded high particulate matter concentration in high traffic areas. Jackson, 2005 assessed the contribution of road traffic to air PM pollution level from 11 different sites in Dar-Es-Salam city of Tanzania during 2002—03. Hourly SPM ranged from 98-1161 µg/m^3 far exceeding WHO standards. Simkhada et al., 2005 assessed RPM at six selected locations in Bishnumati corridor, Nepal. They found in all locations PM to be in harmful and hazardous zone ranging in concentration from 387.20 - 918.92 µg/m^3. Colbeck et al., 2010 reviewed data on PM in Pakistan and compared it with WHO guidelines. They reported several times higher levels of PM and concluded PM to be most serious air pollutant in the country. Colbeck et al., 2011 assessed PM along major roads of Lahore in Pakistan and found average roadside PM_{10} concentration to be 489.

Another very important point which supports the harmful impact of particulate matter pollution is highlighted by the fact that the higher PM during 2007 as compared to 2006 was associated with an increase in hospitalization for respiratory problems such as asthma and bronchitis. Cases of premature death due to heart attack were also on the increase in men in the age group of 40-59 which may be attributed to higher PM_{10} levels (Hospital records in Aurangabad, 2006-07). Therefore, it is evident that air pollution is a serious issue in the city which may be further aggravated if it is not brought under control. Hence, strategies have to be adopted for combating the menace of air pollution.

Control Measures

In this regard it should be mentioned that the present study was in a short duration and it is important to develop and set a comprehensive monitoring network to provide more accurate information regarding the particulate load especially in highly populated and congested areas. Particulate matter in ambient air could be controlled by adopting the following measures as given in Table 3.

Table 3: Control measures to reduce Particulate Pollution

SNo.	Policy	Legal	Institutional	Technical
1.	Cleaner fuels like CNG to be promoted in the city	Strict implementation of Air Act should be done by State Boards.	Various NGOs and other city based educational institutions along with the industrial organizations should partner and undertake joint monitoring programs as well as mass awareness for educating public about harmful effects of PM pollution	Development of low cost sensitive monitoring network for PM.
2.	Vehicles older than 15 years should be taken off the roads	Air quality management initiatives should be undertaken through judicial interventions on public grievances voiced in PIL on air pollution		Apportionment studies for fine PM in the city
3.	Vehicular emission check should be made compulsory and imposition of fine for non-compliance.			
4.	Monthly stack monitoring should be undertaken by Pollution control Boards			
5.	Vehicles not meant for the city should be made to			

bypass for reducing congestion and pollution

Conclusion

Rapidly growing Indian cities such as Aurangabad have a high concentration of particulates which is attributed to automobiles, industries, biomass burning and re-suspension of road dust. Particulate matter has been implicated in various respiratory, cardio-pulmonary diseases and even cancer. Therefore, cleaner air should be India's focus for economic growth with regard to benefits of longer lives and fewer incidences of PM related sickness. Also people who survive longer are able to contribute to the Indian economy for more years. Need of the hour is to undertake policy, institutional and technical measures to curb particulate pollution.

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