Influence of Meterological Parameters and Traffic on PM2.5 Level at Katraj Area, Pune, Maharashtra, India

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Abstract: ***This study investigates the relationship of meteorological parameters (temperature, relative humidity, wind) and traffic volume over the Katraj ward in the city of Pune, India for the months of May, July and November 2016.Data was collected from the Indian Institute of Tropical Meteorology. In this study , the temporal and seasonal variation of PM2.5 were observed and peak hours data for traffic was observed. Results show that temperature and relative humidity represent highest correlation with $PM_{2.5}$ wind speed has an insignificant effect on the behaviour of $PM_{2.5}$.Traffic volume also has an insignificant effect on the levels of $PM_{2.5}$ and depend upon the emissions of the vehicles.***

Keywords: Particulate Matter (PM), Trace elements, Transportation, Pune Katraj, NAAQS, Source Apportionment

1. Introduction

1.1 Definition of Air Pollution

The condition in which air is contaminated by foreign substances, or the substances themselves. Air pollution consists of gaseous, liquid, or solid substances that, when present in sufficient concentration, for a sufficient time, and under certain conditions, tend to interfere with human comfort, health or welfare, and cause environmental damage. Air pollution causes acid rain, ozone depletion, photochemical smog, and other such phenomena.

Air pollution has been a problem in the industrial nations of the west. It has now become an increasing source of environmental degradation in the developing nations of East Asia. India and China in particular, because of its rapid push to industrialize, is experiencing dramatic levels of aerosol pollution over the large portion of the country (Kahn & Yardley, 2007). Air pollution becomes a significant challenge all over the world, especially in the developing countries (C. K.Chan & Yao, 2008). In recent years, particulate matter (PM) is considered the most important air pollutant from the public health point of view (Hu, Jia, Wang, & Pan, 2013; Qiu et al., 2012). Respirable (PM10), and fine ($PM_{2.5}$) particulate matters are suspended particles with aerodynamic diameters ≤ 10 μm and 2.5 μm respectively. Their
multiple sources include natural, industrial and traffic (Tian, Qiao, & Xu, 2014).

1.2 Rationale & Significance of the study

The city has joined the list of the country's most polluted cities, with high level of particulate matter being detected in downtown Pune. $PM_{2.5}$ is an air pollutant that if found in high levels severely harms human health. These tiny particles are two and one half microns or even less in width and the primary source is emission from car, truck, bus and other vehicles. These particles travel deep into the respiratory tract, causing itching of respiratory tract and other breathing problems. The initial result of the data collected from Shivajinagar area shows the concentration of $PM_{.5}$ varying between 89 to 42ug/m^3 during the past eight days, whereas the National Ambient Air Quality Standard is 60 ug/m^3.The dip in the temperature does not allow the particulate matter to escape and hence, the air pollution levels rise. Also, as a secondary cause, the increasing vehicular pollution has resulted in the rise in air pollution levels in the city. The increase in air pollution levels has also resulted in a rise in cases of respiratory illness including asthma. Vehicles plying on pucca roads blow 6,456 tonne dust every year while the dust raised by vehicles plying on kuccha road is 1,229 tonne every year. Though India has norms to control vehicular pollution, there is no norm related to road dust management," the ESR stated (2010). The rise in industrial activities around Pune has also contributed in the air pollution. Small and medium industries are responsible for 303 tonne PM10 emission every year. Fossil fuels used in slums contribute to the air pollution. About 93,000 commercial properties which include hotels, malls and hospitals emit 204 tonne PM10 every year. roads have not been developed in proportion to population growth even though vehicles have multiplied alarmingly the use of diesel generators in housing societies, malls and industrial units has gone up. Collectively, they emit 379.61 tonne PM10 every year.

2. Literature Review

Spatial distribution of particles in cities mainly a product of the spatial configuration of emissions sources and dispersion process. Various researches have been done around the world to show the spatial variation of particulate matter with meteorological parameters (Krishna and Kunhikrishnan, 2004).

(Langer el at, 2011) studied the behaviour of particulate matter in the Berlin cities. The data collected with the help of the Sigma-2 samplers, which was the robust method, gave only 7 days average and no information about particles less than 3μm was available from these instruments .Mostly all the study sites pertaining to monitor the behaviour of particulate matter have kept their study sites near the heavily industrialized areas, which owing to their emissions and also, the presence of traffic nearby, leads these areas to be a hotspot for such researches.

(Yusuf and Surkurite,2013)studied the interaction of PM with meteorological parameters around a steel plant in Nigeria, and on a free highway in a Greater City of Cincinnati and at a toll station in Taipei City, respectively.

(Grigoropoulos et al, 2009) studied the spatial distribution patterns during two extreme Saharan dust episodes in Athens, Greece, which were carried out by using a Kriging method using a GRIMM aerosol sampler for measurement of mass concentrations of the particulate matter, and a Beta gauge monitor for monitoring of PM_{10} and $PM_{2.5}$.

(Reddy, 2012)Diurnal variations are very important in understanding the role of atmospheric process and the role of local human activities. Seasonal variation help us understand the variation in the season.

(Deshmukh et al 2013)The city of Raipur has been deemed one of the most hazardous ,in terms of air pollution, it also competes with the other studies done in heavily industrialized zones, has done just that by focusing on that zone sandwiched between the National Highway. Comparison has done with other studies in order to show Raipur has become a hub for commercial and industrial activities and also a rapidly increasing pollution area.

Particular matter (PM) is the air pollutant that is most harmful to public health and the environment when compared to other measured criteria pollutants. These particles are mainly of anthropogenic origin and predominately from transport–related sources (Bilkis A. Begum et al. (2008).

Exposure to urban airborne particulate matter (PM) is associated with adverse health effects. PM2.5 (≤ 2.5 µm mean aerodynamic diameter) could be more important as a human health risk because this smaller PM has the potential to reach the distal lung after inhalation (Claudia Garcia-Cuellar et al. (2003).

Particulate matter in the atmosphere that will result in significant benefits for human health, with associated positive economic consequences. Successful management of particulate matter requires scientific knowledge about particulate matter "from cradle to grave", covering sources of particles, processes that govern their formation, composition, dispersion and fate in the atmosphere, as well as knowledge about human exposure and associated health and well being. Such knowledge allows designing and performing effective and efficient abatement measures and monitoring (Milena et al. (2010).

Major sources of Particulate matter (PM) are vehicles & industries (Mohammad Razif & Ahmad Adib (2006).

There are different techniques to study particulate matter concentration one of them used in Hong Kong, by utilization of MODerate Resolution Imaging Spectroradiometer (MODIS) Aerosol Optical Thickness (AOT) 500 m data and visibility data to derive aerosol extinction profile, then converted to aerosol and PM2.5 vertical profiles. A Geographic Information Systems (GIS) prototype was developed to integrate atmospheric PM2.5 vertical profiles with 3D GIS data (Wenzhong Shi et al.(2012).

3. Methodology

High volume sampler which measures PM shall be kept at katraj junction for 8 hours weekly twice for mansoon winter and summer season of 2016- 17 for determination of $PM_{2.5}$ and lead contain in it. The meteorological parameters shall be measured during sampling period Temporal variation were shown of PM2.5 by plotting graphs of daily concentrations of the pollutants verses the number of days. Seasonal variation with respect to the meteorological parameters were shown by plotting the daily concentration with parameters for each of the three study months. Counting the number of vehicles has been done in Katraj junction during the peak hours of the day. Traffic counts during Monday morning and Friday evening rush hours may show expectionally high volumes and are not normally used in analysis; therefore, counts are usually conducted on Tuesday, Thursday and Sunday. The size of the data collection depends upon the length of the counting period, the type of count being performed and number of lanes or crosswalks being observed, and the volume level of traffic.

Site Description

Pune city is located at 559 meters from the mean sea level. It is located between 18.32° North and 73.51° East Pune city is located in the Deccan Plateau and is about 100 kms East from Konkan coast and at a distance of about 160 kms from Mumbai. It is located at the confluence of Mula-Mutha River. There is hilly area on western side of Pune and on South side Sinhagad- Katraj hilly area is observed. . The "Katraj Square" is one of the crowded junction in pune city having an average traffic density over 1000 vehicles per hour.Katraj Bus Terminal is located adjoining to katraj square which is prominent source of vehicular emission.

Figure 1: Map of Katraj Chowk

4. Result and Discussion

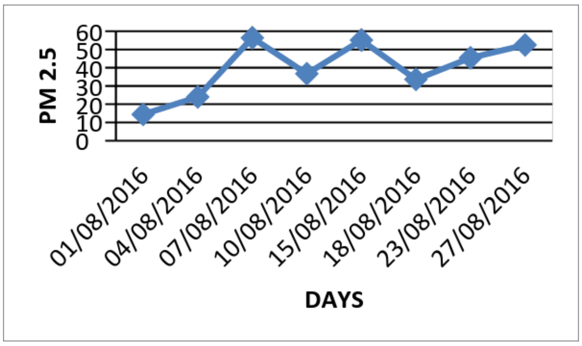

Figure 2: Graphical representation showing temporal variation of PM 2.5 in August 2016

In the monsoon season, the process of removal of aerosols is greater because of the wet deposition.

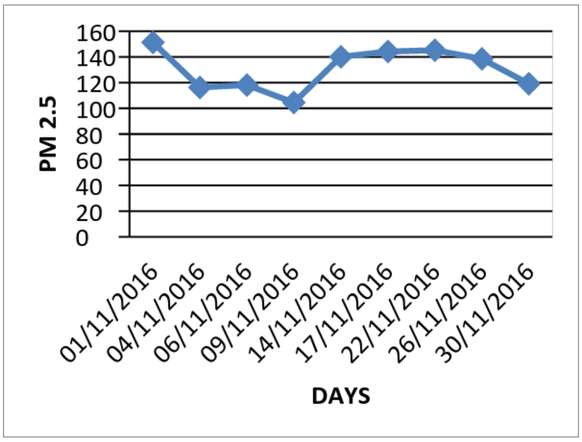

Figure 3: Graphical representation showing temporal variation of PM 2.5 in November 2016

In winter season, due to weak radioactive inversion, the pollutants may get trapped and therefore reach a higher concentration.

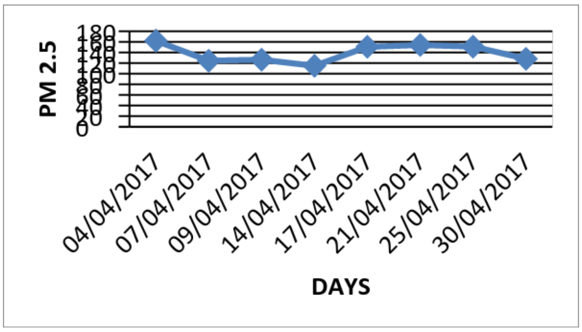

Figure 4: Graphical representation showing temporal variation of PM 2.5 in April 2017

In summer season, generally due to the high temperatures, the removal process becomes slower or not at all. Given the addition of vehicles more and more pollutants are released into the air.

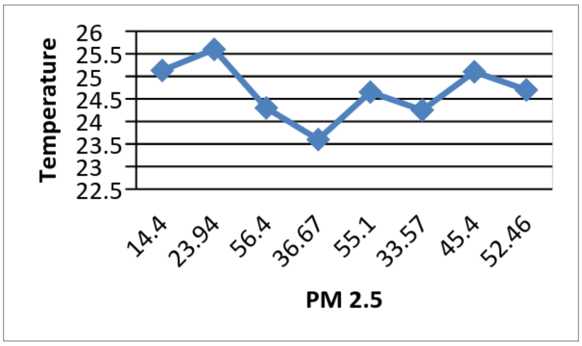

Figure 5: Graphical representation showing variation in temperature with respect to PM 2.5 in month of August 2016

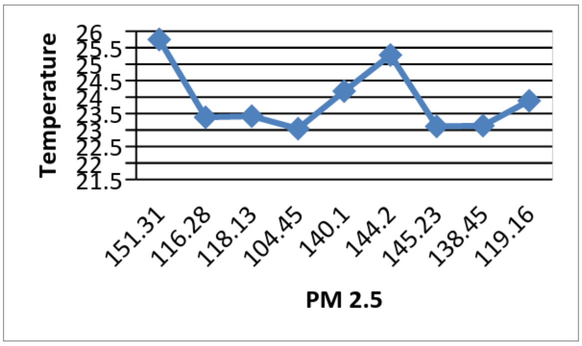

Figure 6: Graphical representation showing variation in temperature with respect to PM 2.5 in month of November 2016

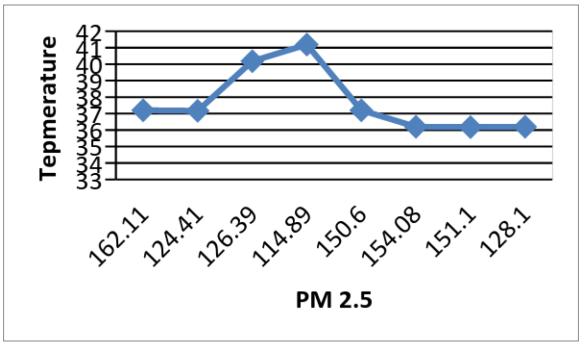

Figure 7: Graphical representation showing variation in temperature with respect to PM 2.5 in month of April 2017

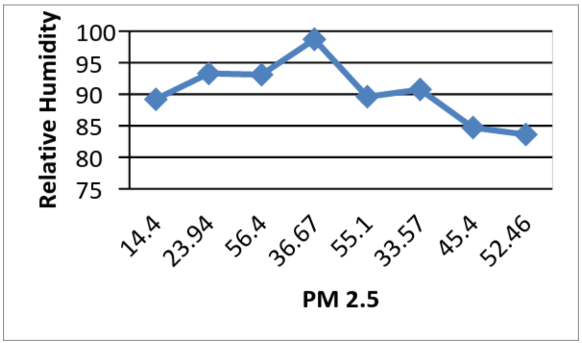

Figure 8: Graphical representation showing variation in relative humidity with respect to PM 2.5 in month of August 2016

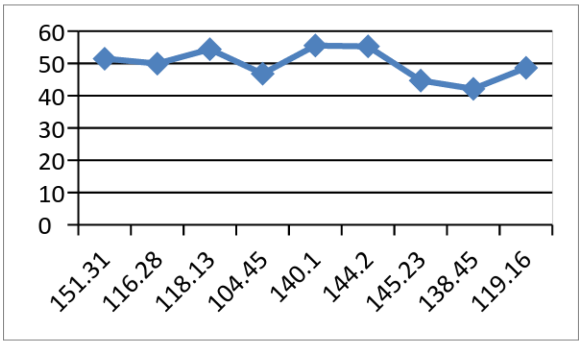

Figure 9: Graphical representation showing variation in relative humidity with respect to PM 2.5 in month of November 2016

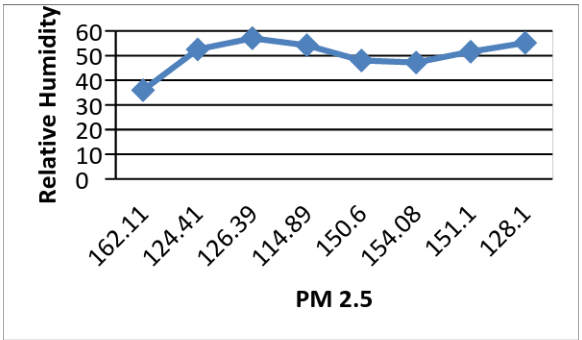

Figure 10: Graphical representation showing variation in relative humidity with respect to PM 2.5 in month of April 2017

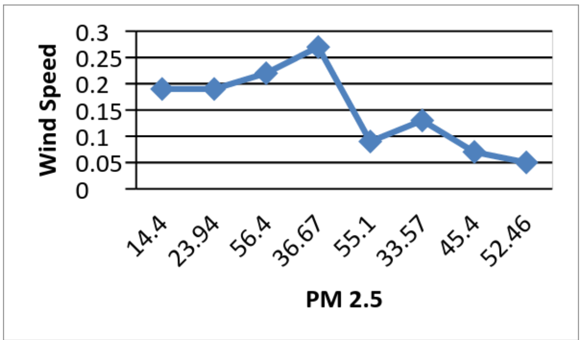

Figure 11: Graphical representation showing variation in wind speed with respect to PM 2.5 in month of August 2016

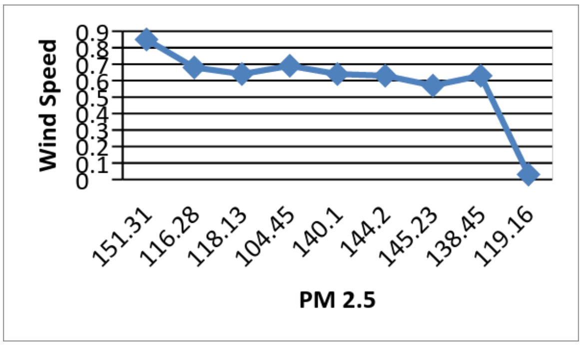

Figure 12: Graphical representation showing variation in wind speed with respect to PM 2.5 in month of November 2016

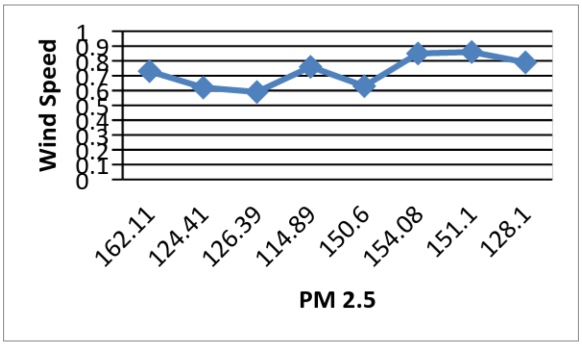

Figure 13: Graphical representation showing variation in wind speed with respect to PM 2.5 in month of April 2017

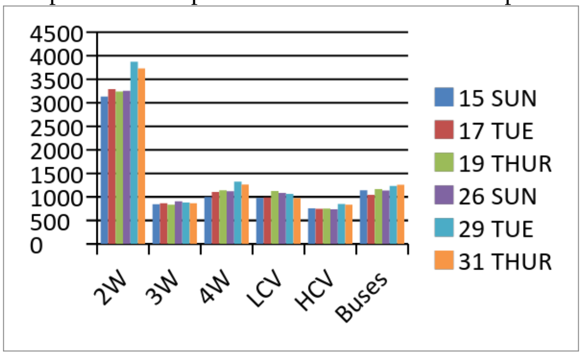

Figure 14: Density of vehicle for the month of April

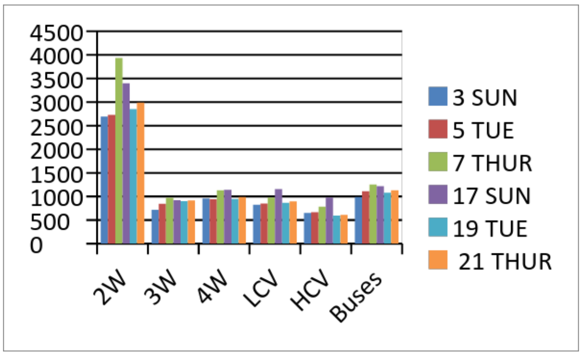

Figure 15: Density of vehicle for the month of August

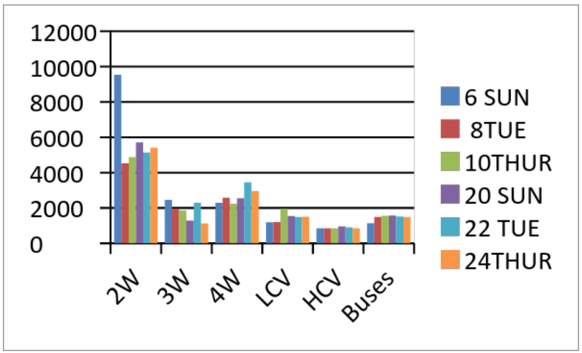

Figure 16: Density of vehicle for the month of November

5. Conclusion

The PM2.5 concentration varies with the summer, monsoon and winter season, the concentration of the PM2.5 in the Katraj area varied greatly and can be seen clearly through the temporal variation from this study. The meteorological parameters have also played a great role in the variation of PM2.5levels. The concentration of PM2.5 was much higher in the month of April 2017 as compared to August and November 2016.All the seasons change the concentration of PM2.5 remaining in the atmosphere also changes. The change caused can be due to less dispersion of pollutant or can be due to more accumulation. The concentration of PM2.5 was reduced in monsoon as Pune received good rainfall in 2016 as the rainfall washout the particles from the atmosphere. The average PM measured in August 2016 showed that concentration was less than the NAAQ standard (60 µg/m³) but was more in the month of November 2016 and April 2017 indicating that pollution level was high in Katraj area in these months. Levels of $PM_{2.5}$ does have an insignificant with the increase in volume of traffic but are more influenced by the emission factor, type of fuel and engine technology.

6. Acknowledgment

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References

[1] Code of federal regulations, “Reference Method for the Determination of suspended particulate Matter in the Atmosphere(High-Volume Method), 40CFR Part 50, AppndixB,”U.S. Government Printing office, Washington, DC ,July 1(1994).

[2] Federal Register, “Revisions to the National Ambient Air Quality Standards for Particulate matter, 40 CFR Part50,” Federal Register 52”2434 July 1 (1987).

[3] Federal Register, “Reference Method for the Determination of Particulate Matter as PM10 in the Atmosphere,” Federal Register 52”24664 July 1 (1987).

[4] Federal Register, “Regulations for Implementing Revised Particulate Matter Standards: 40 CFR Parts 51 and 52,” Federal Register 52”24672 July 1 (1987).

[5] Federal Register, “Air Programs: Particulate Matter (PM1(I) Fugitive Dust Policy: 40 CFR Parts 50 and 52, ” Federal Register 52”24716 July 1 (1987).

[6] Federal Register, “Ambient Air Monitoring Reference and Equivalent Methods: 40 CFR Part 53,” Federal Register 52”24724 July 1 (1987).

[7] Federal Register, “Ambient Air Quality Surveillance and Equivalent Methods: 40 CFR par 53, ” Federal Register 52”24736 July 1 (1987).

[8] Federal Register, “Rules and Regulations, “Federal Register 52”29383 August 7 (1987).

[9] Federal Register, “Reference Method for the Determination of Particulate matter as PM10 in the Atmosphere,” Federal Register 52”29467 August 7 (1987).

[10] J.C. Chow, J. G. watson, D.M.Ono,C.V.Mathai, “PM10 Standards and Nontraditional Particulate Source controls: A Summary of the A&WMA/EPA International Specialty Conference,” Air waste Manage. Assoc. 43:74-84(1993).

[11] U.S. Environmental Protection Agency, “PM SIP Development Guifrlines,” Document# EPA -450/2-86-001, U.S. Environmental protection Agency, Research Triangle Park, NC(1987).

[12] Federal Register, “Environmental Protection Agency: National Primary and Secondary Ambient Air Quality, standards,” Federal Register 36:81867 (1971).

[13] Federal Register, “National Primary and Secondary Ambient Air standards Appendix B: Reference Method for the Determination of Suspended Particulates in the Atmosphere,” Federal Register 36:84 ,Part II, April 30 (1971).

[14] U.S. Environmental Protection Agency, Air Quality Criteria for Particulate Matter and Sulfur Oxides, Volumes I and II, Doxument#EPA-600/8-82-029a, U.S. Environmental Protection Agency. Research Triangle Park, NC(1982)

[15] C. Cowherd Jr., Ed., in the Technical basis for size specific Particulate standard Proceeding , Parts I&II, APCA Specialty Conference, Air Pollution Control Assoc. Pittsburgh PA(1980)

[16] C.V. Mathai, D.H. Stonefield, Transactions, (PMm Implementation of Standards APCA/EPA International Specialty Conference, Air Pollution Control Assoc. Pittsburgh, PA (1988).

[17] C.V. Mathai, D.H. Stonefield, J.G. Watson, “PMK1Implementation of Standards- Summary of the APCA/EPA International Specialty Conference, ”JAPCA 38:888 (1988)