Ministry of Housing and Urban Affairs
Government of India

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$PM_{2.5}$ Exposure at a Busy Traffic Intersection in Varanasi, India

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Contents

1. Introduction

- 99% of population lives in places that exceed WHO air quality standards (WHO 2022)
- $PM_{2.5}$ can easily penetrate a human's small airways and alveoli (Brook et al. 2004; Ill 1999; Xie et al. 2014)
- Exposure to PM increases mortality and morbidity rates (Hamanaka and Mutlu 2018)
- Traffic Intersection (TI) is a pollution hotspot (Choudhary and Gokhale 2019)

2. Literature Review

- 25% of PM doses intake in a trip by spending 2% of commuting time at TIs (Goel and Kumar 2015)
- $PM_{2.5}$ level is higher during peak traffic hours (Adeniran, Yusuf, and Olajire 2017; Kumar and Goel 2016; Piotrowicz and Polednik 2019; Wang et al. 2017)
- $PM_{2.5}$ level is higher during off-peak traffic hours (Song et al. 2020)

3. Objectives

- To find the PM exposure patterns during different traffic states
- To establish the relationship between PM and meteorological parameters
- To quantify the inhaled dose for different hours of the day

4. Methodology

a. Study Location

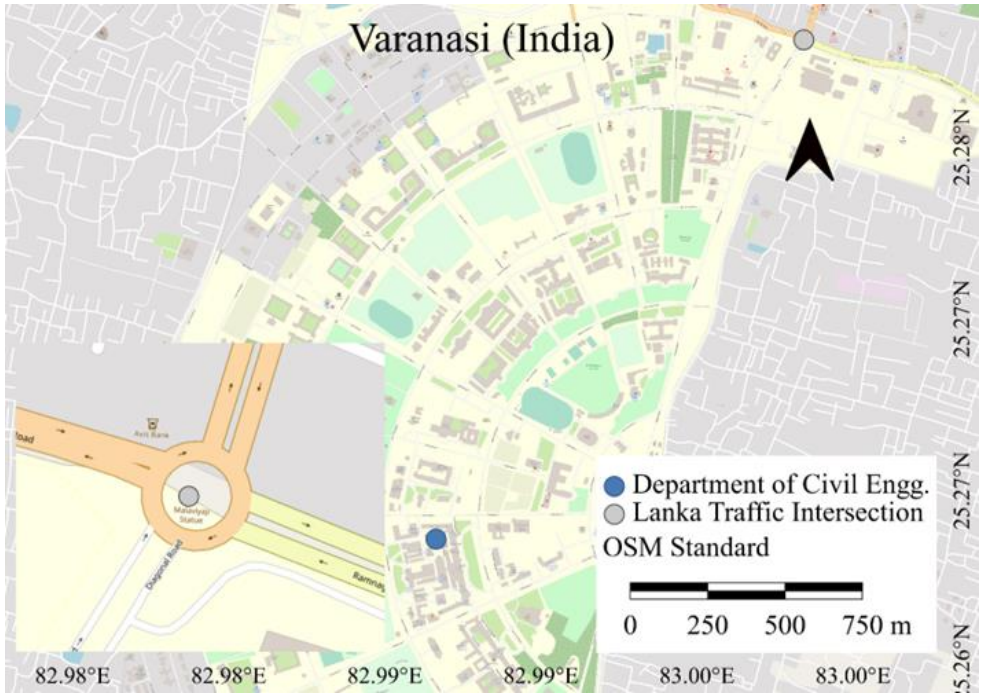

Fig. 1. PM monitoring location
Image Credit: QGIS, Version 3.28.9

Table 1. Data collection time of the day

Time of Day	Traffic Type
Early Morning-06:00am	Off-peak
Morning-09:00am	Peak
Midday-12:00pm	Off-peak
Afternoon-03:00pm	Peak
Evening-06:00pm	Off-peak

4. Methodology

b. Instrumentation and Data Collection

- DustTrak for PM measurements
- Data logger for meteorological data
- Study period: Aug 31 to Sept 06, 2021

c. Processing and Estimation

- Humidity correction
- PM exposure pattern
- Inhaled dose estimation

Fig. 2. Instrumentation

5. Results

Table 2. Descriptive statistics of all parameters (n = 34)

Measures	PM and Meteorological Parameters		
	$PM_{2.5}$ (μgm^{-3})	AT (^oC)	RH (%)
Mean	37.07	29.61	57.00
Std. Deviation	15.98	2.05	11.83
Minimum	13.00	25.80	42.00
Maximum	79.00	32.50	84.00

Table 3. The diurnal mean values of the PM and meteorological parameters

Time of Day	PM and Meteorological Parameters		
	$PM_{2.5}$ (μgm^{-3})	AT (^oC)	RH (%)
Early Morning-06:00am	26.15	26.12	77.67
Morning-09:00am	38.52	30.27	54.14
Midday-12:00pm	40.87	31.36	47.57
Afternoon-03:00pm	37.46	31.16	48.00
Evening-06:00pm	40.79	28.66	60.57

5. Results

Table 4. Pearson correlations between $PM_{2.5}$ and meteorological parameters

	Meteorological Parameters	
Time of Day	AT	RH
06:00am	0.20	-0.77
09:00am	0.82	0.40
12:00pm	-0.12	0.52
03:00pm	-0.21	0.49
06:00pm	-0.21	0.12

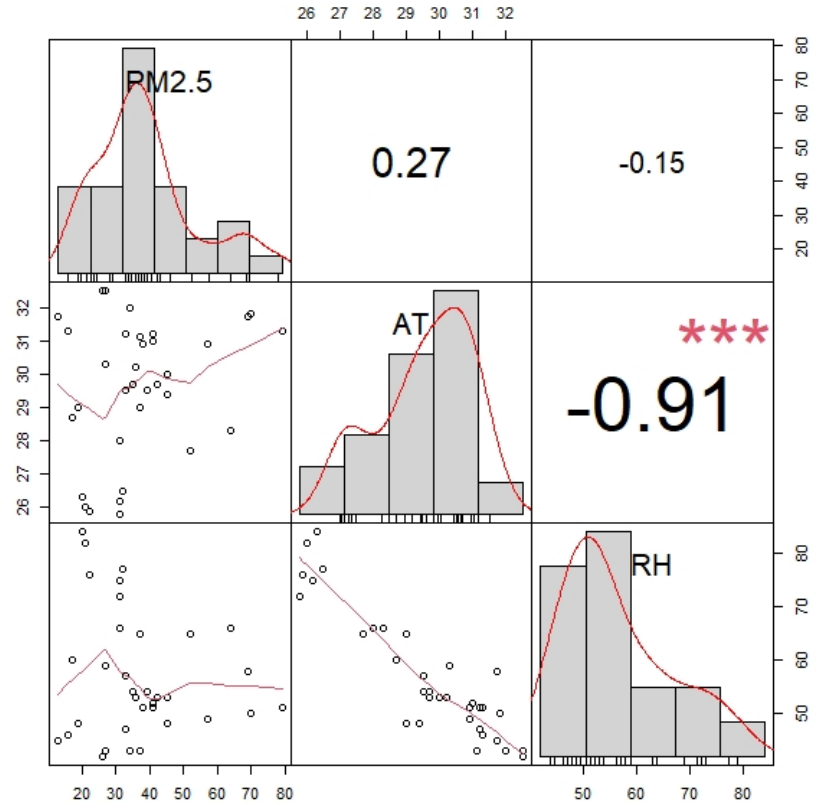

Fig. 3. Correlation among PM and meteorological parameters

Note : *** indicates P-value of 0.001

5. Results

- The inhaled dose pattern followed the exposure pattern.
- Inhaled dose for the travelers will be different.

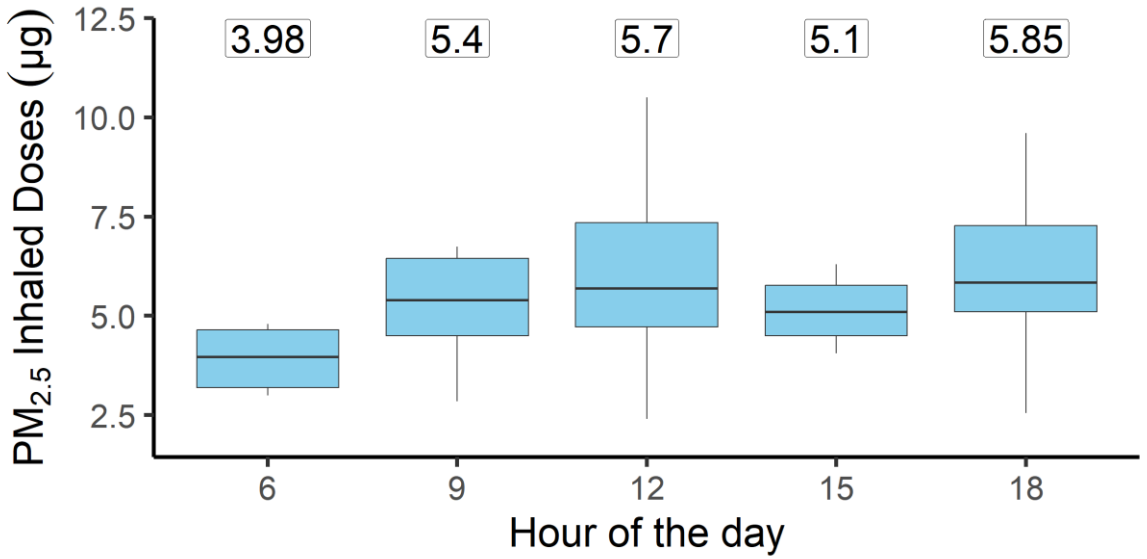

Fig. 4. Estimated inhaled dose for 15-minutes stay at the traffic intersection

6. Conclusion

- **Lower traffic and dispersion of pollutants** during night was responsible for lowest pollutant exposure during early morning.
- Higher concentration during off-peak hours could be attributed to **cumulative emission effects of peak hours**.
- PM exposure at the intersection was independent of the **hour of the day and the meteorological parameters**.
- The amount of $PM_{2.5}$ inhaled dose follows the exposure pattern.

Limitation

- No conclusive evidence of meteorological parameters' effect on PM exposures due to the **missing seasonality data**.
- The **number of study locations** may be increased to get daily pattern of PM exposure.

References

1. Adeniran, J. A., R. O. Yusuf, and A. A. Olajire. 2017. “Exposure to Coarse and Fine Particulate Matter at and around Major Intra-Urban Traffic Intersections of Ilorin Metropolis, Nigeria.” Atmospheric Environment 166:383–92. doi: 10.1016/j.atmosenv.2017.07.041.
2. Brook, Robert D., Barry Franklin, Wayne Cascio, Yuling Hong, George Howard, Russell Luepker, Murray Mittleman, Jonathan Samet, Sidney C. Smith, and Ira Tager. 2004. “The Online Version of This Article, along with Updated Information and Services, Is Located on the World Wide Web At:” 2655–71. doi: 10.1161/01.CIR.0000128587.30041.C8.
3. Choudhary, Arti, and Sharad Gokhale. 2019. “On-Road Measurements and Modelling of Vehicular Emissions during Traffic Interruption and Congestion Events in an Urban Traffic Corridor.” Atmospheric Pollution Research 10(2):480–92. doi: 10.1016/j.apr.2018.09.008.
4. Goel, Anju, and Prashant Kumar. 2015. “Characterisation of Nanoparticle Emissions and Exposure at Traffic Intersections through Fast-Response Mobile and Sequential Measurements.” Atmospheric Environment 107:374–90. doi: 10.1016/j.atmosenv.2015.02.002.
5. Hamanaka, Robert B., and Gökhan M. Mutlu. 2018. “Particulate Matter Air Pollution: Effects on the Cardiovascular System.” Frontiers in Endocrinology 9(November):1–15. doi: 10.3389/fendo.2018.00680.
6. Ill, C. Arden Pope. 1999. “Epidemiology of Fine Particulate Air Pollution and Human Health : Biologic Mechanisms and Who ’ s at Risk ?” Environment Health Perspective 108(August)

References

7. Kumar, Prashant, and Anju Goel. 2016. “Concentration Dynamics of Coarse and Fine Particulate Matter at and around Signalised Traffic Intersections.” Environmental Science: Processes and Impacts 18(9):1220–35. doi: 10.1039/c6em00215c.
8. Laulainen, N. S. (1993) ‘Summary of conclusions and recommendations from a visibility science workshop; technical basis and issues for a national assessment for visibility impairment’. Available at: http://www.osti.gov/energycitations/product.biblio.jsp?osti_id=10149541.
9. Piotrowicz, Adam, and Bernard Polednik. 2019. “Exposure to Aerosols Particles on an Urban Road.” Journal of Ecological Engineering 20(5):27–34. doi: 10.12911/22998993/105329.
10. Song, J. et al. (2020) ‘Prediction of pedestrian exposure to traffic particulate matters (PMs) at urban signalized intersection’, Sustainable Cities and Society, 60(November 2019), p. 102153. doi: 10.1016/j.scs.2020.102153.
11. Wang, Zhanyong, Qing Chang Lu, Hong Di He, Dongsheng Wang, Ya Gao, and Zhong Ren Peng. 2017. “Investigation of the Spatiotemporal Variation and Influencing Factors on Fine Particulate Matter and Carbon Monoxide Concentrations near a Road Intersection.” Frontiers of Earth Science 11(1):63–75. doi: 10.1007/s11707-016-0564-5.
12. WHO (2022) ‘Ambient (outdoor) air pollution Key facts’, World Health Organization, Geneva, Switzerland, (December), pp. 1–9. Available at: https://www.who.int/news-room/fact-sheets/detail/ambient-(outdoor)-air-quality-and-health.
13. Xie, Wuxiang, Gang Li, Dong Zhao, Xueqin Xie, Zaihua Wei, Wei Wang, Miao Wang, Guoxing Li, Wanru Liu, Jiayi Sun, Zhangrong Jia, and Qian Zhang. 2014. “Relationship between Fi Ne Particulate Air Pollution and Ischaemic Heart Disease Morbidity and Mortality.” 1–7. doi: 10.1136/heartjnl-2014-306165.

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