D-O-6

INDOOR AND OUTDOOR CONCENTRATION OF CARBON IN FINE PARTICLES AT A CONTROL SITE IN MUMBAI CITY: A CASE STUDY

Abba Elizabeth Joseph[#], Seema Unnikrishnan
National Institute of Industrial Engineering
abba1@rediffmail.com, seemaunnikrishnan@gmail.com

Rakesh Kumar
National Environmental Engineering Research Institute
rakeshmee@rediffmail.com

Introduction

Particulate Matter (PM) is the general term used for a mixture of solid particles and liquid droplets found in the air and are produced by a wide variety of natural and manmade sources. Recently, the U.S Environmental Protection Agency announced to strengthen EPA's previous daily fine particle standard by nearly 50 percent from 65 to 35 micro grams per meter cube[1]. This standard increases protection of the public from short-term exposure to fine particles. Such proactive changes in standards indicate the increasing evidence of its importance with regard to human health. According to The World Health Organization report of 2002 indoor air pollution is responsible for 2.7 percent of the global burden of disease[2]. Exposure to contaminated indoor air has been identified as a significant cause of health problems affecting the poor in developing countries, especially women and younger children. According to recent estimates in India, indoor exposures to particulates appears to be responsible for more than 7 percent of the national burden of disease[3]**.** Indoor and outdoor air studies in the USA have determined that smoking and cooking are the predominant activities associated with elevated concentrations of fine particulate matter[4]. Previous studies mainly have measured mass levels in indoor and outdoor environment. The concentration of Particulate Matter in the India is being estimated with more rigor than before. The present study attempts to monitor indoor and outdoor fine particles in a control site in Mumbai city, India during summer season for 10 days. Elemental carbon and organic carbon data for 5 days is also reported. This study will discuss on indoor and outdoor (I/O) sources and their relationship. The current findings will improve our understanding of the sources.

Author for Correspondence : abba1@rediffmail.com

Methodology

The fine particles were measured using AirMetrics MiniVol at the rate of 5 liters per minute for 24 hours on a Teflon and Quartz filter. The Teflon filters were equilibrated at 20^{o}C and 40% RH for 24 hours before and after sampling. The particulate mass on Teflon filter was determined by weighing on an electronic microbalance with 1 μg sensitivity. The quartz filters were preheated at 900^{o}C for 3 hours before monitoring. After air sampling loaded filters were stored in a freezer at –20^{o}C to prevent the evaporation of volatile compounds until analysis.

The DRI thermal optical analyzer was used for measuring Organic carbon (OC) and Elemental carbon (EC). This method is based on preferential oxidation of organic carbon and elemental carbon compounds at different temperatures. The principal function of the

optical component of the analyzer is correction for pyrolysis of organic carbon. The eight fractions OC1, OC2, OC3, OC4, EC1, EC2, EC3 and OPC are reported. The improve protocol defines OC as OC1+OC2+OC3+OC4+OPC and EC as EC1+EC2+EC3-OPC. The analyzer was calibrated with known quantities of Carbon dioxide. Replicate analyses were performed at the rate of 1 per 10 samples. The precision was within 5 percent for Total carbon.

Results and Discussions

As reported in **Table 1**, the concentration of fine particles in outdoor area ranged between 20-106 µg/m^3 whereas indoor area ranged between 35-150 µg/m^3 respectively. The indoor and outdoors $PM_{2.5}$ ratios were found to be in the range of 1.2-3.1. **Table 2** presents preliminary data on OC, EC concentration which was in the range of 13.01-17.40µg/m^3 and 2.49-4.28 µg/m^3 for outdoor site and 24.14-39.16µg/m^3 and 1.59-33.97µg/m^3 respectively for the indoor site. The indoor concentration was higher as compared to outdoor concentration although site selected was supposed to be a control area in Mumbai city. Apart from infiltration of outdoor air pollutants, cooking activity and smoking are likely to be the major sources for $PM_{2.5}$ and carbon concentration. Discussions with family members of Indoors household revealed that Kerosene (500ml/day) was used for cooking on a stove. Fuel use and cooking device could be the source for elevated pollutants levels indoor as compared to ambient air data. Outdoor site is close to the seacoast and effects of sea breeze helps in dilution and dispersion of pollutants. The I/O ratio for $PM_{2.5}$ and carbon concentration was more, indicating strong indoor sources [5]. Study describes that the ratio between indoor and carbonaceous species gives an indication as to whether PM found indoors are the result of indoor generation or derive from the outdoor environment. In absence of indoor sources, the I/O will be less than, or equal to one. Previous studies [5,6] have used the value of R^2 between indoor and outdoor data as an indicator to understand infiltration of outdoor air. In the present study, as seen in the **Figure1** below, R^2=0.4 shows poor correlation indicating that infiltration rate is not good. The indoor high values, therefore, are indicative of different sources.

Table1: $PM_{2.5}$ levels in Indoor and Outdoor Environment

	Outdoor (µg/m^3)	**Indoor (µg/m^3)**	**Ratio**
C1	40	46	1.2
C2	54	78	1.4
C3	53	80	1.5
C4	48	89	1.9
C5	20	35	1.8
C6	50	101	2.0
C7	43	92	2.1
C8	106	130	1.2
C9	58	150	2.6
C10	36	110	3.1
Count	10	10	
Minimum	20	35	
Maximum	106	150	
Average	50.8	91.1	
Stdev	22.28	34.83	

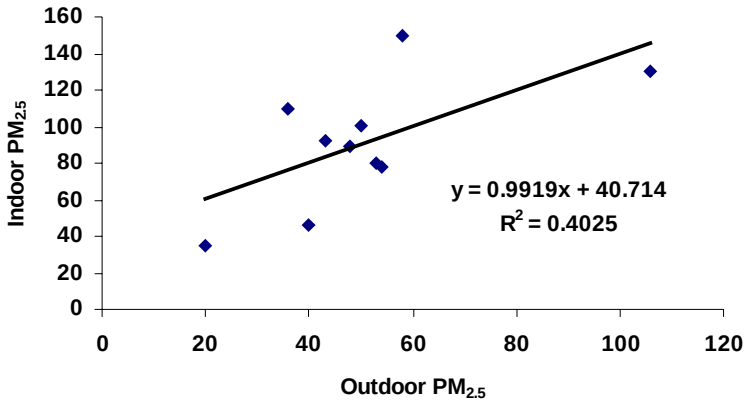

Figure 1. Correlation of Indoor and Outdoor $PM_{2.5}$

Table 2: Concentration of OC and EC in Outdoor and Indoor Environment and Their Ratios

Sites	OC ($\mu g/m^3$)	EC ($\mu g/m^3$)	TC ($\mu g/m^3$)	OC/EC	OC/TC	EC/TC	I/O OC	I/O EC
A1	15.14	2.51	17.65	6.025084	0.857653	0.142347	1.734195	1.540741
A2	14.29	2.89	17.18	4.936291	0.831545	0.168455	2.393992	8.555396
A3	14.98	3.03	18.01	4.93662	0.83162	0.168459	2.614452	11.19664
A4	17.40	4.28	21.68	4.063161	0.802495	0.197505	1.599538	1.399539
A5	13.01	2.49	15.49	5.231542	0.839526	0.160474	1.855762	0.638956
I1	26.25	3.87	30.12	6.781589	0.871492	0.128508		
I2	34.21	24.77	58.98	1.381285	0.580059	0.419941		
I3	39.16	33.97	44.47	1.152717	0.880703	0.764024		
I4	27.83	5.99	33.82	4.643801	0.822814	0.177186		
I5	24.14	1.59	39.44	15.1943	0.611957	0.040275		

Conclusions

An attempt was made to assess the status of indoor and outdoor $PM_{2.5}$ levels along with their composition with regard to Elemental Carbon and Organic Carbon in a control area of Mumbai City. Indoor levels of fine particles and carbon concentration were higher as compared to outdoor levels with all higher I/O ratios (>1). The study also indicated that indoors values assumed to be better is not so even in areas, which are clean. This was a preliminary study, further research in understanding composition of fine particles w.r.t metals; ions and marker compounds in different season will improve scientific understanding of sources. This knowledge will assist in source apportionment studies, which help to design control strategies.

Acknowledgements

The authors thank staff of National Environmental Engineering Research Institute, Delhi Zonal Center in providing support for analyzing Elemental and Organic carbon.

References

1. EPA, 2006, http://epa.gov/pm/naaqsrev2006.html
2. WHO, Indoor Air Pollution, http://www.who.int/indoorair/en/
3. CAI-Asia,IndoorAirPollution(IAP),http://www.cleanairnet.org/caiasia/1412/article-4696 .html
4. Wallace, L., 1996. Indoor particles: a review. Journal of the Air and Waste Management Association 46, 98-126.
5. Ho, K.F., Cao, J.J., Harrison, R.M., Lee, S.C., Bau, K.K., 2004. Indoor/Outdoor relationships of organic carbon (OC) and elemental carbon (EC) in $PM_{2.5}$ in roadside environment of Hong Kong.
6. Colome, S., Kado, N., Jaques, P., Kleinman, M., 1992. Indoor –outdoor air pollution relations: particulate matter less than 10um in aerodynamic diameter ($PM_{10)}$ in homes of asthmatics. Atmospheric Environment 26A, 2173-2178.