

## **Factors Affecting Suspended Particulate Matter Concentration in Multi-storied Buildings**

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### **Abstract**

In this study the concentration of Suspended Particulate Matter (SPM) was studied with the help of a self-fabricated portable particulate sampler. The experiments were carried out in two halls of residence in Aligarh Muslim University, Aligarh- Sarojini Naidu hall and Nadeem Tarin hall. The results indicated that concentration of SPM decreased with increase in height of the building. It was seen to be least on the top floor and highest on the ground floor. Of the two halls of residence, interestingly, Sarojini Naidu hall was seen to have a lower SPM content ( $0.1307 \text{ mg/m}^3$  at 0 m) as compared to Nadeem Tarin hall ( $0.1594 \text{ mg/m}^3$  at 0 m). This can be explained by closer proximity of Nadeem Tarin Hall to the high traffic activity road and lesser plantation in that area. Moreover, in Nadeem Tarin hall the main plantation is that of palm trees, while S.N. Hall has Gulmohar, Neem, and Guava trees all of which branch wider than the palm trees, adding a scrubbing effect to reduce SPM. In both the halls of residence the SPM levels were found to be within the safe limit prescribed by the Central Pollution Control Board.

**Keywords:** Air pollution, suspended particulate matter.

### **1. Introduction**

Rapid urbanization has blurred the demarcations between industrial and residential areas. The development of more cities and industries has not only resulted in greater air pollution but also a greater infiltration of these pollutants into our living space. It is very well known that continuous exposure to these pollutants results in pulmonary

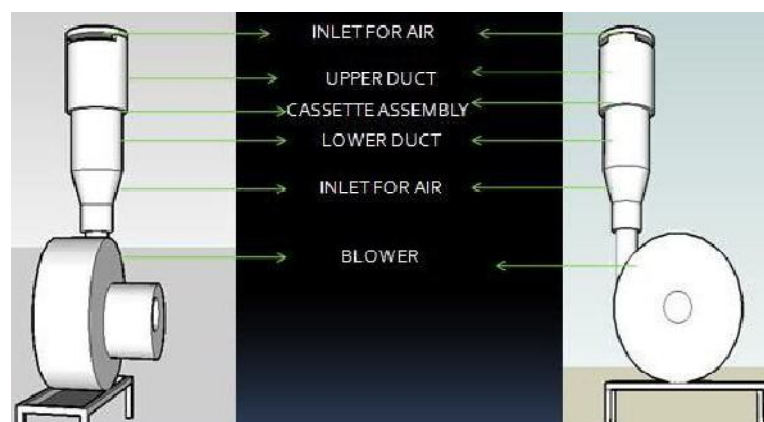
diseases such as bronchitis, allergies etc. to which children are even more susceptible. Adding to the threat posed by air pollution, in a recent report released by the International Agency for Research on Cancer (IARC), the specialized cancer agency of W.H.O., outdoor air pollution has been classified as carcinogenic to human beings. Not only was air pollution found to cause lung cancer but a positive association with an increased risk of bladder cancer was also found. Particulate matter, a major component of outdoor air pollution, was evaluated separately and was also classified as carcinogenic to humans. Cohen et al (Cohen et al, 2005) found that Outdoor Particulate Matter air pollution is estimated to be responsible for about 3% of cardiopulmonary disease mortality; about 5% of trachea, bronchus, and lung cancer mortality; and about 1% of mortality in children from acute respiratory infection in urban areas worldwide. Of the total number of deaths occurring in the world as a consequence of air pollution 65% were found to occur in Asia alone.

This makes it very important to analyze the factors that affect suspended particulate matter (SPM) levels in residential areas. In this study a portable particulate sampler was developed and used to study the change in concentration of SPM on different floors of multi-storied buildings.

## 2. Experiments and Results

### 2.1 Portable Particulate Sampler

The portable particulate sampler is an air pollution monitoring device. It gives a measure of the particulate matter present in the ambient air. The sampling is done by filtration with the help of high efficiency glass fibre filter. The method of particulate content measurement is gravimetric. The device consists of two PVC ducts of diameter 0.1016 m and length 0.250 m fitted into one another by means of a sliding fit and fixed onto a welded stand. One of the ducts is connected to blower by means of a reducer. The glass fibre filter is placed between the two ducts. It is mounted on a wire mesh which is fixed onto a collared support. The upper duct is fitted with another collar to hold the filter in place. This collar has a base of an elastic material like polyurethane foam to account for expansion due to rise in temperature.



Given the equation:

$$Q=Av$$

Where, Q is the volume flow rate of air through the ducts given by capacity of the blower, A is the area of the ducts, v the velocity of air through the ducts. In the above equation only one quantity is known which, is the volume of air drawn by the blower per unit time. The velocity and the diameter of the ducts are unknown. However, for the two unknowns we have a constraint. The velocity gradient and hence the pressure gradient of air across the glass fibre filter should not be so large as to rupture it. This sets a minimum limit for the duct diameter. On the other hand, if the velocity gradient is too small that is the area will be too large, the sampler will lose its portable nature. In the present design a duct of diameter 0.1016 m is used, a conclusion arrived to by hit and trial method.

## **2.2 Methodology**

- The glass fibre filter is placed on a high precision electronic balance and its weight is recorded.
- It is then mounted on the wire mesh and the assembly will be fitted onto the blower. When the power supply is turned on the particulate laden air is drawn into the duct due to suction.
- The particulate matter is retained on the filter while the air molecules pass through. After operating the sample for a period of 2 hours during which 192 m<sup>3</sup> of air is passed through the filter, the glass fibre filter is removed.
- It is weighed again and the difference in the initial and final weights is noted down. This gives the weight of the particulate matter.

When operated at different vertical levels the sampler will furnish an estimation of the concentration of particulate matter at various heights.

### **2.2.1 Sample calculation**

Location: Ground floor, Nadeem Tarin Hall.

Weight of the particulate matter deposited in 2 hrs. = 0.0306 g

Weight of the particulate matter collected in 1 min = 0.0306/120 = 0.000255 g = 0.255 mg.

Capacity of the Blower = 1.6 m<sup>3</sup> per min

Therefore, the particulate matter concentration = 0.255/1.6 = 0.1594 mg/ m<sup>3</sup>

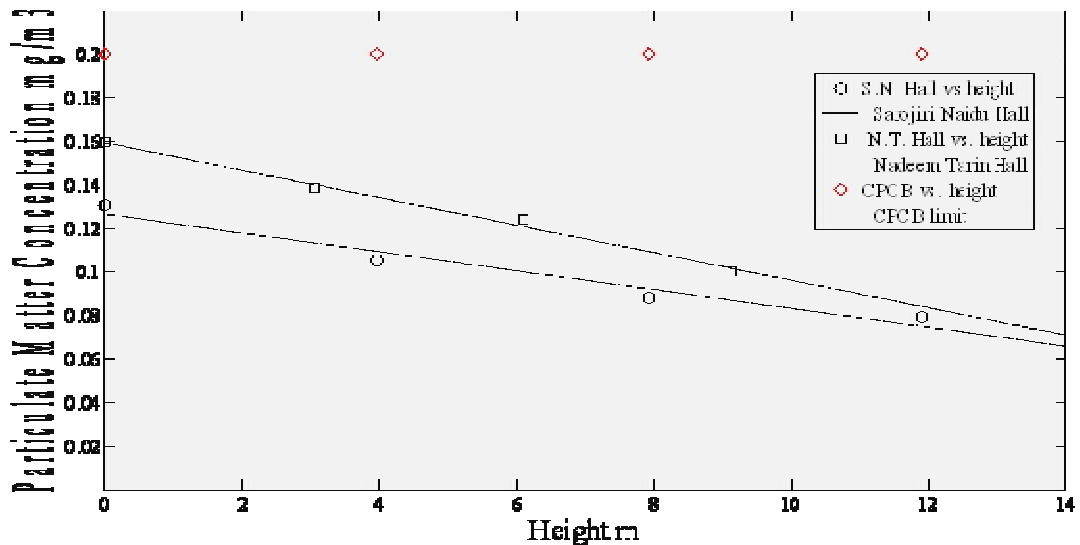
### 2.2.2 Results

**Table 1:** Nadeem Tarin Hall (N.T.)

S. No.	Floor	Height from datum (m)	SPM conc. (mg/m <sup>3</sup> )
1	Ground	0	0.1594
2	First	3.048	0.1385
3	Second	6.096	0.1240
4	Third	9.144	0.1000

**Table 2:** Sarojini Naidu Hall (S.N.)

S. No.	Floor	Height from datum (m)	SPM conc. (mg/m <sup>3</sup> )
1	Ground	0	0.1307
2	First	3.9624	0.1052
3	Second	7.9248	0.0882
4	Third	11.8872	0.0792



**Fig. 1:** Particulate Matter concentration variation with height.

Following the aforementioned procedure (methodology), the outcome of the samples taken at various locations has already been presented above. The particulate concentration so obtained is plotted as a function of height from the base (datum). Since the height of the portable particulate sampler is somewhat approximately close to the average height of the human beings of this region, the samples collected at that height are the representative of the particulate pollution at the receptor levels. On extrapolation it was found that the Central Pollution Control Board (CPCB) limit of 0.2 mg/m<sup>3</sup> SPM concentration would be reached at a height of -16.75 m in Sarojini

Naidu Hall and at a height of -6.5 m in Nadeem Tarin Hall. An interesting implication of this inference is that construction of a basement is feasible in Sarojini Naidu Hall but is not safe in Nadeem Tarin Hall.

### **3. Conclusions**

The SPM levels were seen to decrease with increase in height from the base level. This behaviour is very much according to the expected pattern, since due to the effect of gravity particles tend to remain suspended closer to the ground level. Interestingly, the residential hall Nadeem Tarin being closer to high traffic activity road and having lesser plantation is observed to have a higher level of suspended particulate matter ( $0.1594 \text{ mg/m}^3$  at 0 m) as compared to that of Sarojini Naidu Hall ( $0.1307 \text{ mg/m}^3$  at 0 m). Another point to be registered is that the plantation in Nadeem Tarin hall is mainly that of palm trees, while S.N. Hall has Gulmohar, Neem, and Guava trees all of which branch wider than the palm trees, adding a scrubbing effect to reduce SPM. Although if the SPM levels are compared to the residential places of other cities it can be inferred that the particulate pollution is lower in AMU as compared to Kanpur ( $0.558 \text{ mg/m}^3$ ) and Lucknow ( $0.358 \text{ mg/m}^3$ ). Another significantly positive inference is that, both the residential halls have an SPM lower than the critical limit defined by the Central Pollution Control Board (CPCB), that of  $0.200 \text{ mg/m}$ . It was also deduced that for buildings closer to high traffic roads construction of naturally-ventilated basements is not a safe option.

### **References**

- [1] A. J. Cohen, A. Pope, Bart Ostra , H. R. Anderson, I. Romieu, J.M. Samet, K.D. Pandey, K.Smith M. Krzyzanowski, N. Künzli (2005), *Journal of Toxicology and Environmental Health, Part A*, 68, pp.1–7
- [2] A. Michael, A. Richard, C. Eugene, and E. Keith (1997), *Measurement of airborne and floor dust in a Non-problem building*, *American Industrial Hygiene Association Journal*,58, pp.432-438.
- [3] E.W. Saaski, C.C. Jung, D.A. McCrae, *Air Samplers* (2003), U.S. Patent Application Publication, U.S. Pub. No. US2003/0115975
- [4] IARC: *Outdoor air pollution a leading environmental cause of cancer deaths*, press release, dated 17-10-2013
- [5] [www.cpcb.nic.in](http://www.cpcb.nic.in), last updated: 29-11-2013

