Efficacy of Ubreathe-Air Rain model (A Ubreathe product) for improving Indoor Air Quality

Analysis and interpretation by

Indian Institute of Technology Bombay

INDIAN INSTITUTE OF TECHNOLOGY BOMBAY

POWAI. MAHARASHTRA

400076

A. Chakraborty

Signed by Prof. Abhishek Chakraborty

ABHISHEK CHAKRABORTY
Assistant Professor
Environmental Science And Engineering Department,
Indian Institute of Technology Bombay,
Powai- 400076.

Executive Summary:

Keeping air quality good where we live is essential for our overall well-being. In the 21st century, we breathe mostly in indoor environments, either in our homes or offices. Monitoring and maintaining indoor air quality is crucial for human health and overall well-being. The air purifier is a device that can enhance the exfiltration efficiency of particulate matter from indoors. This has been used in urban homes and workplaces to improve indoor air quality. Traditional air purifiers typically use HEPA filters, which are effective but often need to be replaced and create solid waste issues. This current study was designed to test the efficiency of a new type of air purifier named Ubreathe Air (Ubreathe-Air Rain model). This air purifier does not use a HEPA filter. Instead, it uses indoor plants and water droplets to purify the indoor air. Two types of tests were performed in a faculty cabin inside the Indian Institute of Technology, Bombay. One, with normal occupant activities, and two, the introduction of aerosol by incense burning. When no aerosol was introduced by incense burning, the average PM concentration was 12.32,10.75,9.79 $\mu g/m^3$ for PM_{10}, $PM_{2.5}$, and PM_1, respectively. The concentrations were significantly lower than India's National Ambient Air Quality standards. Even in this low concentration, the air purifier worked efficiently, and PM was reduced by 49.54 %, 54.28%, and 55.60% for PM_1, $PM_{2.5}$, and PM_{10}, respectively, in 120 minutes, indicating decent performance at very low levels of PM as well. For the second type of experiment, aerosol was introduced using incense stick burning, and the highest concentration reached more than 300 $\mu g/m^3$ for all three PM sizes. Before the aerosol introduction, the concentration was measured and went back to near the same concentration, i.e., the concentration before the incense burning was started; it took 120 minutes with the air purifier in operation. Though the same concentration was not achieved, the concentration decreased to more than 90% of the initial concentration of incense burning in 120 minutes. Apart from the mass concentration reduction, PM of all sizes ranging from nano (very harmful) to fine to coarse particles was removed at> 90% efficiency after 2 hours of continuous operation. So, the air purifier can be a sustainable and environment-friendly alternative to traditional air purifiers.

1. Introduction:

Monitoring indoor air is essential as we mostly breathe in Indoor air. Poor indoor air can cause various acute health effects, e.g., headache, nausea, and eye irritation, affecting human well-being and work efficiency. Apart from that, ischaemic heart disease (ICHD) and chronic obstructive pulmonary disease (COPD) are the long-term effects of air pollution. So, keeping the indoor air clean is crucial for human health. There has been a growing interest in implementing sustainable technologies to keep the indoor air clean and maintain the indoor air quality (IAQ). Using indoor plants as an air purifier can be an environment-friendly, sustainable solution. In this study, particle number and mass reduction in an office is monitored using an Optical Particle Counter (OPC) and Naneos Pertector, a nanoparticle counter. The air purifier used in this experiment was Ubreathe Air Rain model.

2. Methodology

2.1 Description of the instruments:

Optical Particle Counter (OPC, make Grimm, model 11A) can accurately count particle numbers in 31 size channels from 0.25 μm to 32 μm using the light scattering principle. It can indirectly give the mass of the mentioned size channels by taking the particles' density as 1g/cc by default.

Naneos Partector 2 is a lightweight handheld particle counter which counts particles in the nano ranges. It uses dual non-contact detection stages to measure particle count in eight size channels. It directly reports the number concentration per size bin. The unit is $dN/dlogD_p$ where N= number and D_p = Particle diameter. The difference between the adjacent log scales is multiplied to get the absolute number of values in each channel of each size.

2.2 Description of study locations and experiments

The room where the experiments were conducted was an office room. The room was 15 ft*9 ft*10 ft (L*B*H). The experiments were conducted (a) with normal conditions when no aerosol was introduced and (b) when aerosol was introduced by burning incense (Dhoop).

3. Results and Discussions:

When no aerosol was introduced, the PM levels of the room were quite low (mean ~15 $\mu g/m^3$). The maximum value of PM_{10} reached up to ~50 $\mu g/m^3$ in some instances. After running the air purifier, the PM_{10}, $PM_{2.5}$, and PM_1 concentrations decreased further (Figure 1).

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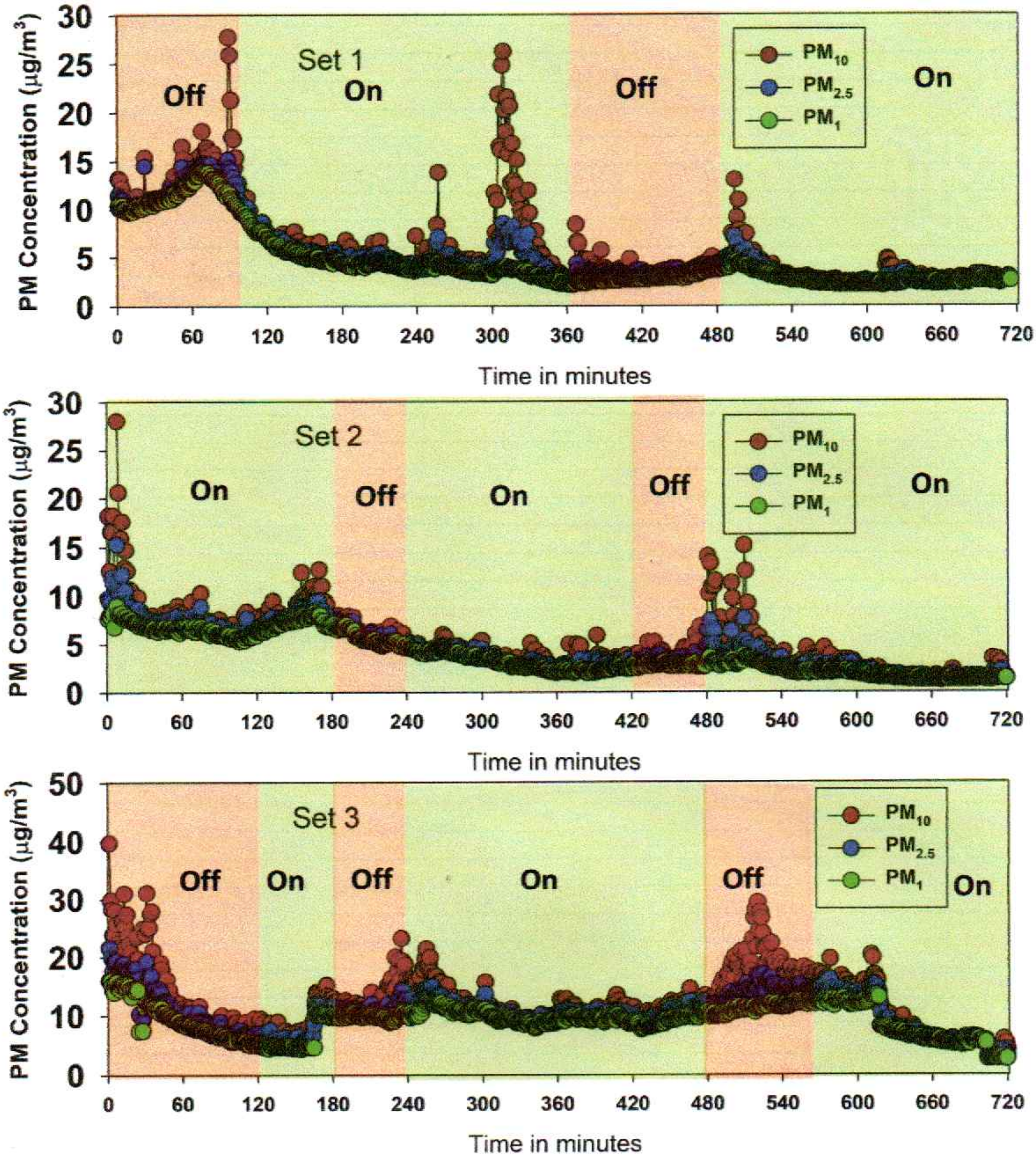

Figure 1 Time series of PM data in the office room. Off implies purifier off, and On implies purifier on.

Some sudden spikes are observed from the time series plots due to occupant activities (moving and other office work). The exact time is noted, and those particular data are removed to make the average (Figure 2). After the air purifier was switched on, the PM reduced by 49.54 %, 54.28% and 55.60% for PM_1, $PM_{2.5}$, and PM_{10}, respectively, in ~2 hours. So even though the PM concentrations were very low, the air purifier was able to reduce the PM levels further.

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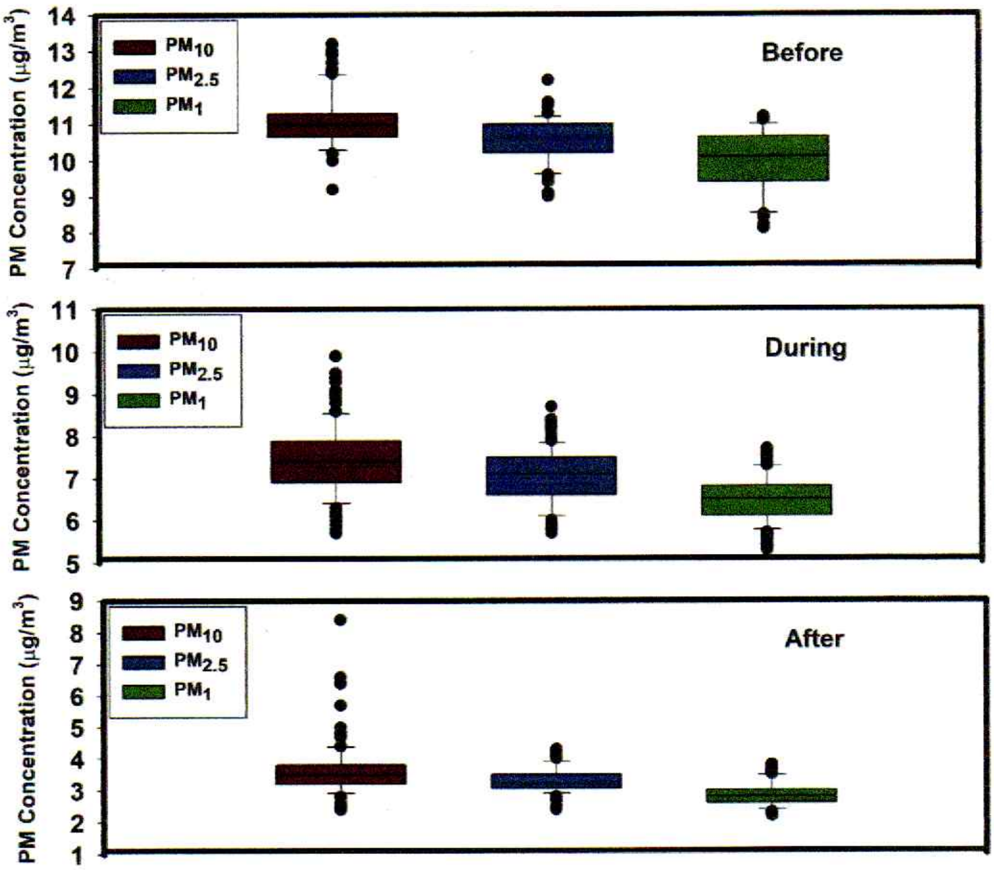

Figure 2 PM concentration before, during, and after the purifier run; a significant drop was observed during the run.

Particle number concentration was also plotted for the same set of monitoring. As mentioned earlier, apart from OPC (GRIMM, Germany), data from the Partector pro 2 (Naneos, Switzerland), the nanoparticle counter was also used. So, the total size range was 0.01 to 32µm. The number count became almost zero after 5µm; so, the higher size range efficiency was not calculated.

To better understand the air purifier's efficiency, aerosols were introduced using incense burning, and the purifier was kept running. It was noted that the purifier took ~2 hours (120 minutes) to clean the air; in other words, the particle level returned to the pre-incense burning concentration (before aerosol introduction) after almost 120 minutes. The base run was also performed, keeping all the conditions the same but without using the purifier; then, the time to reach near the initial concentration was almost 7 hours. During this experiment, the $PM_{2.5}/PM_{10}$ was observed 0.95±0.03; so more than 90% of the PM_{10} was $PM_{2.5}$; hence only $PM_{2.5}$ was

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plotted here (Figure 3). percentage variation in each 15 minutes is shown below (Table 1). The concentration in which the monitoring started or the initial concentration was never attended.

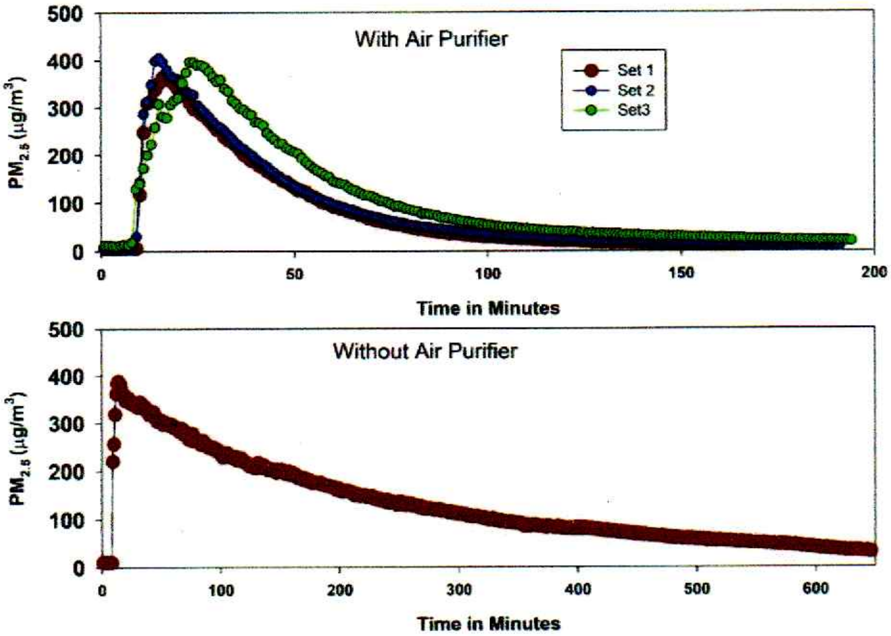

Figure 3 $PM_{2.5}$ time series, at the beginning (Time =0), the burning of incense sticks began. The line indicates the time when the purifier was on

Table 1 Percentage reduction of PM using Air Purifier; all the concentrations are in µg/m³

Timeline	PM_{10}	$PM_{2.5}$	PM_1	PM_{10} Drop (%)	$PM_{2.5}$ Drop (%)	PM_1 Drop (%)
Background	9.18	6.29	5.03			
After incense burning	343.73	331.00	313.58			
15 minutes	293.03	289.42	279.22	14.75	12.56	10.96
30 minutes	181.57	180.45	175.99	47.18	45.48	43.88
45 minutes	110.28	108.94	106.75	67.92	67.09	65.96
60 minutes	67.97	66.24	64.95	80.22	79.99	79.29
75 minutes	43.69	42.20	41.12	87.29	87.25	86.89
90 minutes	30.20	29.88	29.15	91.21	90.97	90.70
105 minutes	10.21	9.94	9.43	97.03	97.00	96.99
120 minutes	9.16	6.25	5.01	97.34	98.11	98.40

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Particle size distribution was also measured using particle number concentration. Partector 2 pro (Naneos, Switzerland) and OPC (GRIMM, Germany) data were used. Combining Partector 2 pro and OPC, we can get the entire aerosol size range of 0.01-32 µm. The large particle (3.00 µm or more) was removed at 100% at 105 min, and particle size >1.60 µm was removed 100% after 120 min. Besides, all other sized particle was removed with > 95% efficiency (Table 2a and 2b). Removal of nanoparticles with > 90% efficiency indicates that the purifier could remove and prevent harmful impacts of aerosols of a wide size range.

Table 2a Percentage reduction of particle number in submicron size ranges (0.01-1.00µm)

	0.01-0.30	0.30-0.35	0.35-0.40	0.40-0.45	0.45-0.50	0.50-0.65	0.65-0.70	0.70-0.80	0.80-1.00
15 min	47.37	47.36	55.68	60.29	60.06	63.85	63.10	63.31	62.56
30min	71.61	73.65	79.70	82.12	80.96	83.32	83.02	83.51	82.08
45 min	82.61	84.90	88.68	89.94	88.92	90.53	90.21	90.69	89.65
60 min	89.08	91.18	93.46	94.17	93.22	94.21	93.97	94.06	93.76
75 min	91.99	93.83	95.48	95.88	95.24	95.83	95.86	95.68	95.01
90 min	94.66	96.46	97.31	97.55	97.18	97.34	96.45	97.27	95.77
105 min	95.32	97.24	97.99	98.15	97.67	97.70	97.11	97.75	97.38
120 min	95.33	97.90	98.45	98.55	98.22	98.29	97.73	97.75	98.19

Table 3b Percentage reduction of particle number in super-micron size ranges (1-5.00µm)

	1.00-1.30	**1.30-1.60**	**1.60-2.00**	**2.00-2.50**	**2.50-3.00**	**3.00-3.50**	**3.50-4.00**	**4.00-5.00**
15 min	62.06	60.04	57.20	51.83	61.61	64.58	50.00	73.33
30min	80.73	81.40	75.47	67.23	67.86	62.50	46.88	60.00
45 min	89.68	88.03	82.15	79.23	82.92	91.80	61.52	41.25
60 min	93.56	91.98	86.02	80.95	79.46	66.67	71.88	93.33
75 min	94.21	95.20	88.78	82.80	92.02	92.06	89.45	62.08
90 min	93.52	96.97	94.91	88.57	100.00	68.75	100.00	100.00
105 min	98.70	95.96	87.00	86.28	86.61	100.00	100.00	100.00
120 min	98.70	97.98	100.00	100.00	100.00	100.00	100.00	100.00

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Conclusions:

- The Ubreathe air purifier is proved to be efficient particle remover from indoor air.
- This could be a better sustainable alternative to traditional air purifiers that can be used in offices and homes.
- Even at low concentrations, it can work effectively.
- In ~120 minutes, more than 90% of particles of all sizes can be removed.
- Particles more than 1.60 µm in diameter can be removed 100% in 2 hours.

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