

Testing DIY Air Filter



MCEN 5131: Air Pollution Control with Professor Shelly L. Miller

University of Colorado Boulder

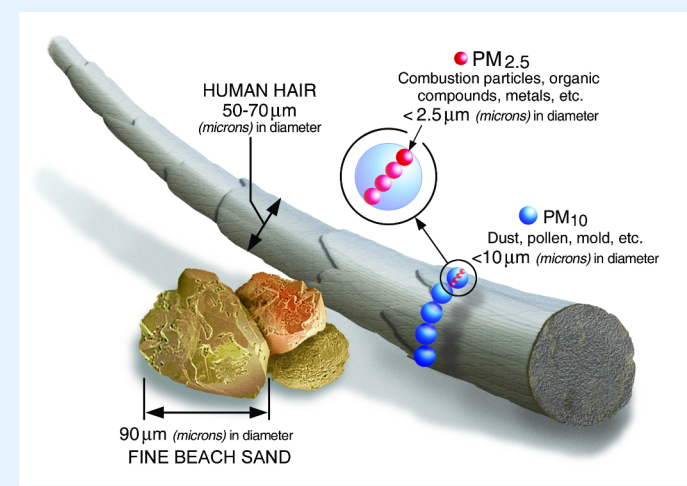
Mechanical Engineering

April 23, 2021

Tahni Jungst

Review of PM_{2.5}

- Fine particulate matter < 2.5 microns wide
- Sources:
 - Agriculture
 - Factories
 - Combustion (diesel and gasoline vehicles, burning fossil fuels)
- WHO recommends limiting exposure to 5 µg/m³
- Health effects
 - Greatest effects on heart and lungs (i.e. irregular heartbeat, asthma, irritation)
- Vulnerable populations:
 - People with heart and lung conditions
 - Young children
 - Pregnant women
 - Elderly



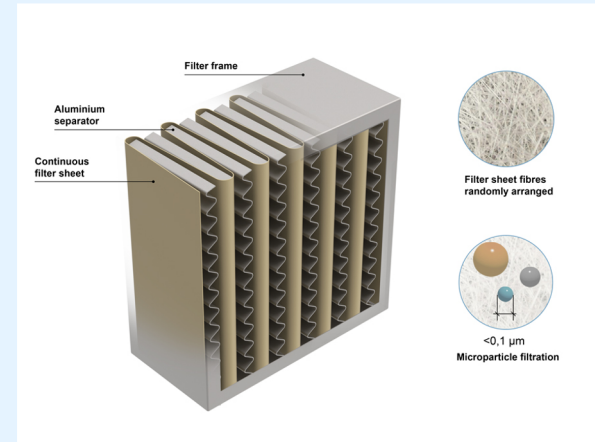
Particulate Matter (PM) Pollution, EPA

Filtration

- ASHRAE recommends MERV 13 filter for HVAC systems to efficiently capture $PM_{2.5}$
- MERV Rating?
 - MERV 13: 85% efficient at capturing 1 - 3 μm particles
- High-efficiency particulate air (HEPA) filters?
 - At least 99.97% efficient at capturing 0.3 μm particles
- Trade-off between particle capture efficiency and energy efficiency exists



MERV 13 Pleats, Tex-air filters



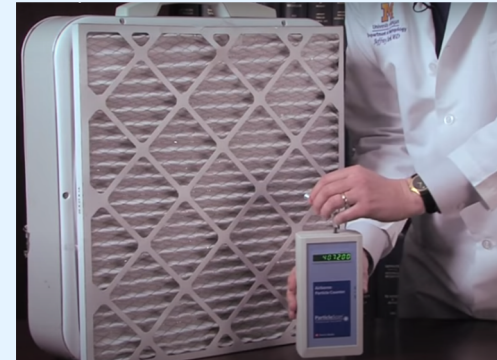
HEPA filters, airtecnicos

Cost Comparison

- DIY air filter
 - Box fan = \$20 - \$40
 - MERV 13 filter 20x20x2 = \$55 / box of 4
- Air purifier with HEPA filter
 - ~ \$250 - \$400 for similar space



Box Fan with MERV 13 Filter, Tex-air filters



Build a do-it-yourself air purifier for about \$25, Michigan Medicine

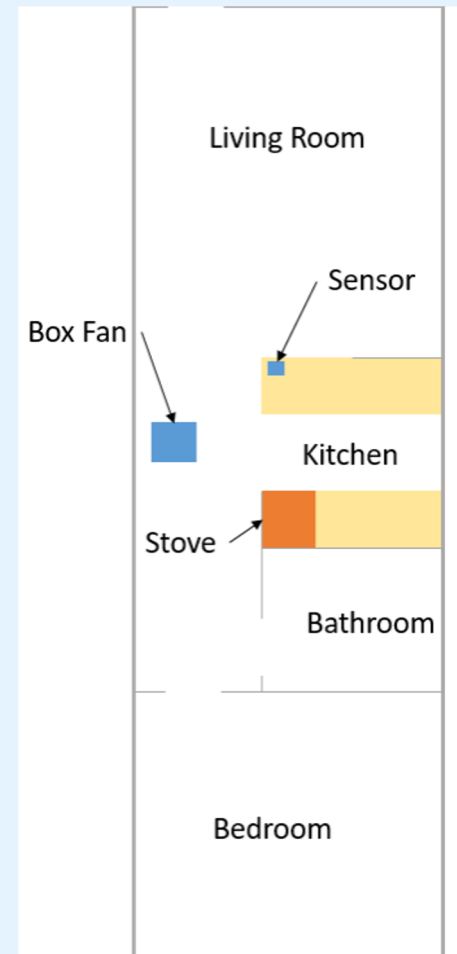
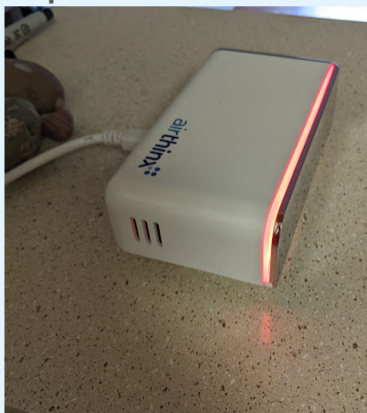


LEVOIT Air Purifier with H13 HEPA filter, Amazon



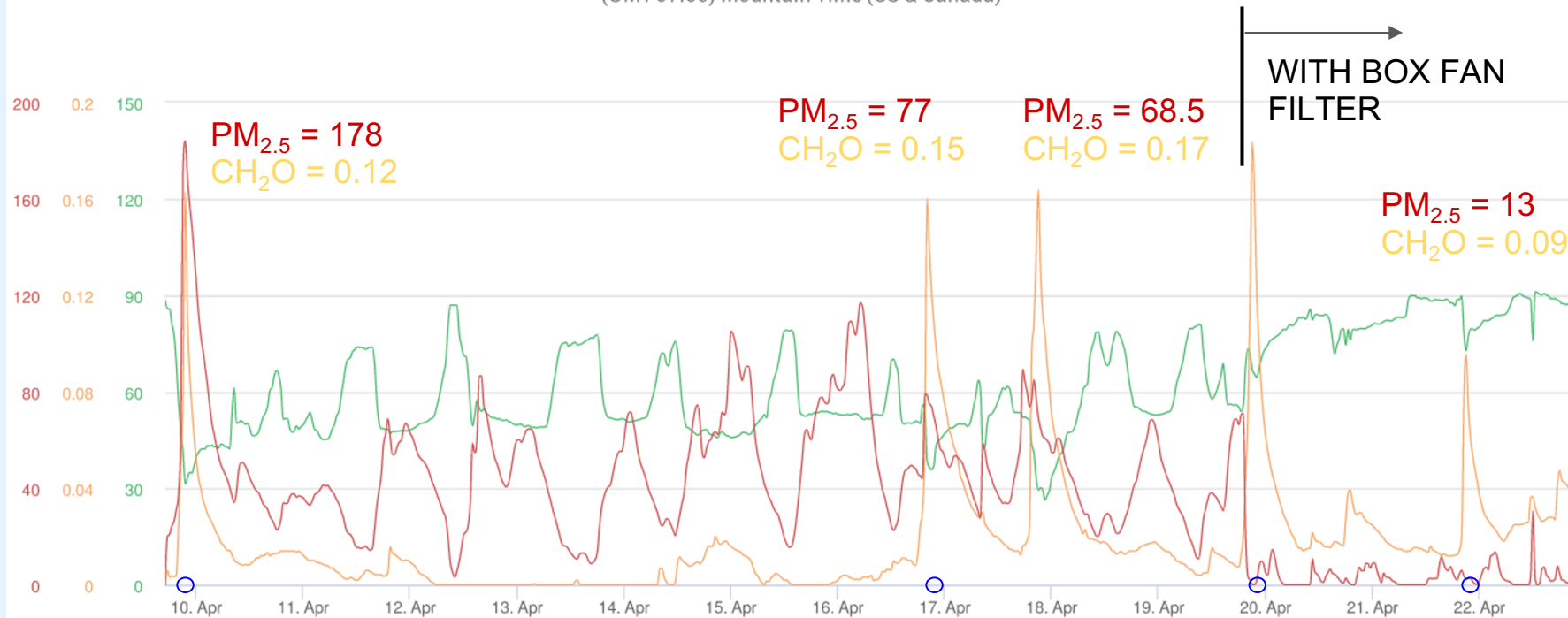
Methods

- Apartment = 520 SF, built in ~1970s
- Construct box filter
- Prepare the same meal 2x with and without box fan filter
- Sensor: Airthinx IAQ
 - AQ, PM, CH₂O (formaldehyde), CO₂, VOCs (EtOH and Isobutylene)
- Collect & interpret continuous sensor data



04/09/2021 16:00:00 – 04/22/2021 20:27:00

(GMT-07:00) Mountain Time (US & Canada)



AQ
AirThinx

MIN
24

AVG
62

MAX
93

CH₂O mg/m³
AirThinx

MIN
0

AVG
0.019

MAX
0.323

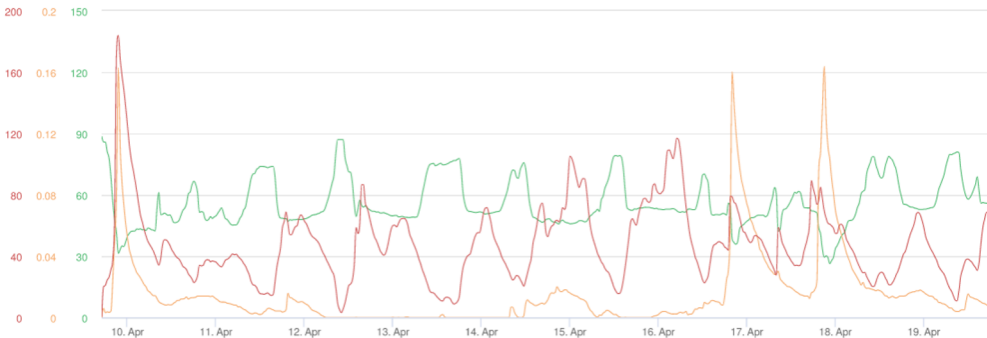
PM_{2.5} µg/m³
AirThinx

MIN
0

AVG
38

MAX
194

04/09/2021 16:00:00 – 04/19/2021 19:20:00
(GMT-07:00) Mountain Time (US & Canada)

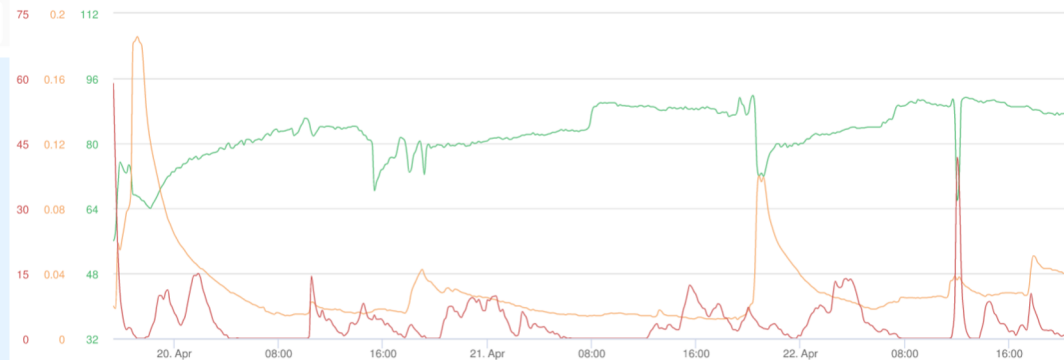


WITH BOX FAN FILTER
Average PM_{2.5} ~ 91.7% reduction

04/19/2021 19:25:00 – 04/22/2021 20:27:00
(GMT-07:00) Mountain Time (US & Canada)

AQ AirThinx			CH ₂ O mg/m³ AirThinx			PM _{2.5} µg/m³ AirThinx		
MIN	AVG	MAX	MIN	AVG	MAX	MIN	AVG	MAX
24	56	89	0	0.015	0.323	0	48	194

WITHOUT BOX FAN FILTER



AQ AirThinx			CH ₂ O mg/m³ AirThinx			PM _{2.5} µg/m³ AirThinx		
MIN	AVG	MAX	MIN	AVG	MAX	MIN	AVG	MAX
55	83	93	0.01	0.03	0.202	0	4	62

Citations

1. ASHRAE, *Filtration and Disinfection FAQ*. <https://www.ashrae.org/technical-resources/filtration-and-disinfection-faq>
2. Rosenthal, J., *A Variation on the “Box Fan with MERV 13 Filter” Air Cleaner*. Tex-Airfilters.
<https://www.texairfilters.com/a-variation-on-the-box-fan-with-merv-13-filter-air-cleaner/>
3. EPA, *Particulate Matter (PM) Pollution*. US EPA <https://www.epa.gov/pm-pollution>
4. EPA, *Indoor Air Quality (IAQ)*. US EPA <https://www.epa.gov/indoor-air-quality-iaq/what-merv-rating-1>
5. Xiang, J., Huang, C., Shirai, J., Liu, Y., Carmona, N., Zuidema, C., Austin, E., Gould, T., Larson, T., Seto, E. *Field measurements of PM_{2.5} infiltration factor and portable air cleaner effectiveness during wildfire episodes in US residences*, Science of The Total Environment, Volume 773, 2021, 145642, ISSN 0048-9697,
<https://doi.org/10.1016/j.scitotenv.2021.145642>.