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**U.S. Department of State**

Bureau of Overseas Buildings Operations

June 13, 2019

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## **Reducing Exposure to Air Pollution by Improving Indoor Air Quality**

EPA Webinar - Clean Air Spaces

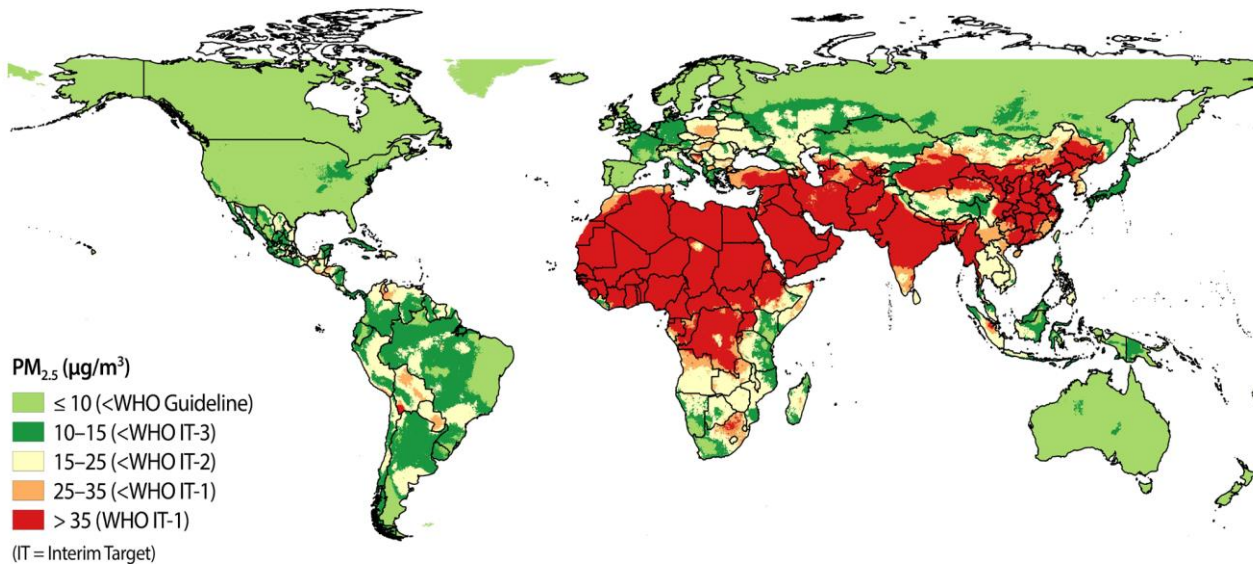
# Indoor Air Pollution Mitigation

## Challenge

Reduce exposure to US Dept. of State Employees and family members serving at high pollution posts.

## Approach

Can't control outdoor environment; investigate controlling indoor environment.



*95% of the world's population live in areas exceeding WHO's Guideline*

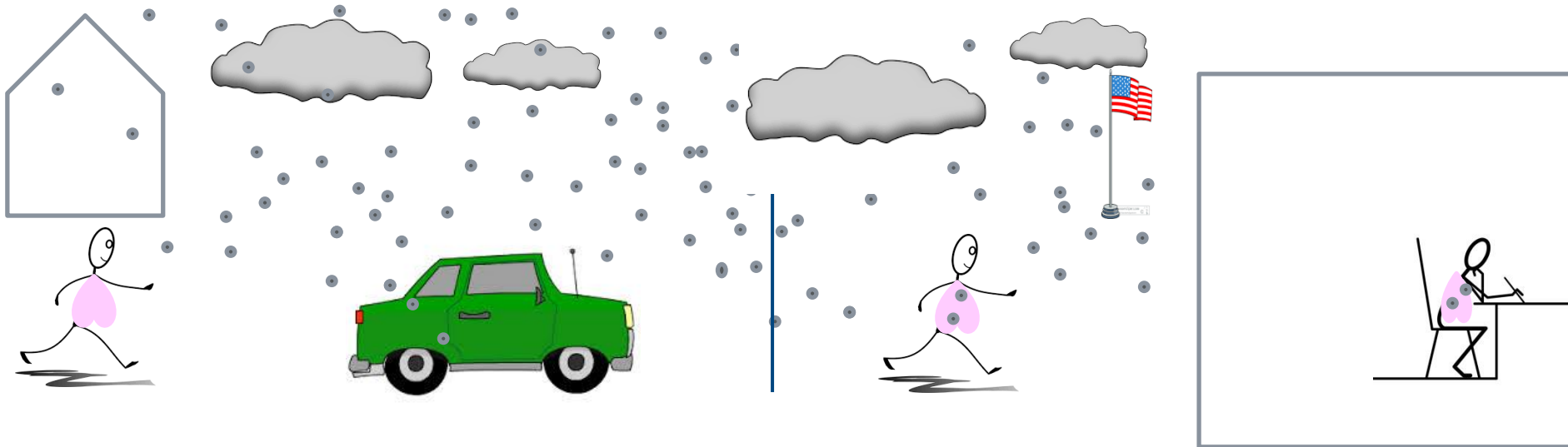
# Indoor Air Pollution Mitigation

## Goal

Attain USEPA 24-hr average of  $35 \mu\text{g}/\text{m}^3$  (NAAQS)

## Factors

- Pollution Concentration
- Duration of Exposure
- Breathing Rate



# Indoor Air Pollution Mitigation

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## To do list

### 1. Reduce infiltration

Tighten buildings to exclude infiltration of polluted air

Minimize opening doors/windows and using exhaust fans

### 2. Filter indoor air

Use centralized air filtration if available

Use room air cleaners (RACs)

Use vehicle cabin air filters

### 3. Minimize indoor sources

Smoking

Vacuuming

Burning candles/incense

Frying foods

### 4. Respiratory protection?

# Indoor Air Pollution Mitigation

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Tighten buildings to exclude infiltration of polluted air

Look for leaks around windows, doors, transoms, etc. and seal.

- Visually inspect for obvious openings



- Use smoke tubes to find leaks



- Thermal imaging is another option



# Indoor Air Pollution Mitigation

## Tighten buildings to exclude infiltration of polluted air (continued)

- Perform blower door tests



- Goal is to achieve no more than 5 air changes per hour.
- Benefit: energy savings

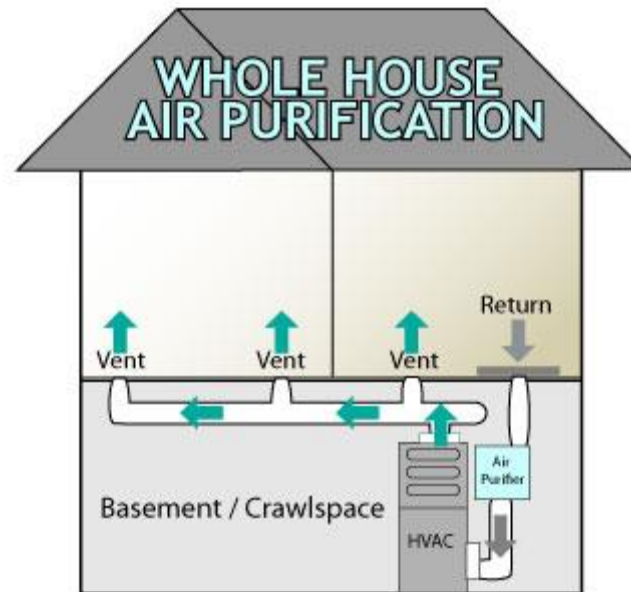
# Indoor Air Pollution Mitigation

Minimize opening doors/windows and using exhaust fans



# Indoor Air Pollution Mitigation

Use centralized air filtration if available

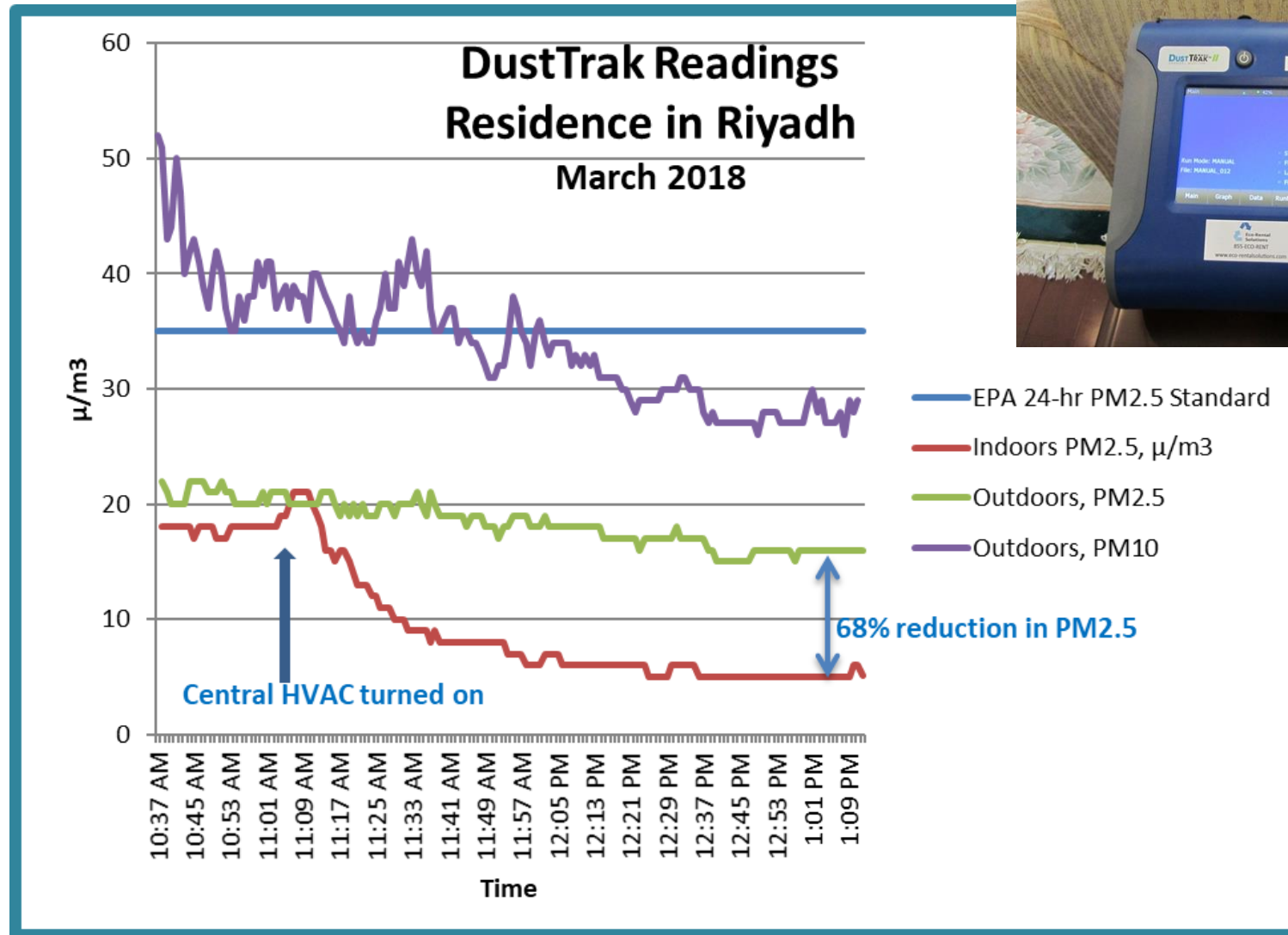


Preferably MERV 13 filters



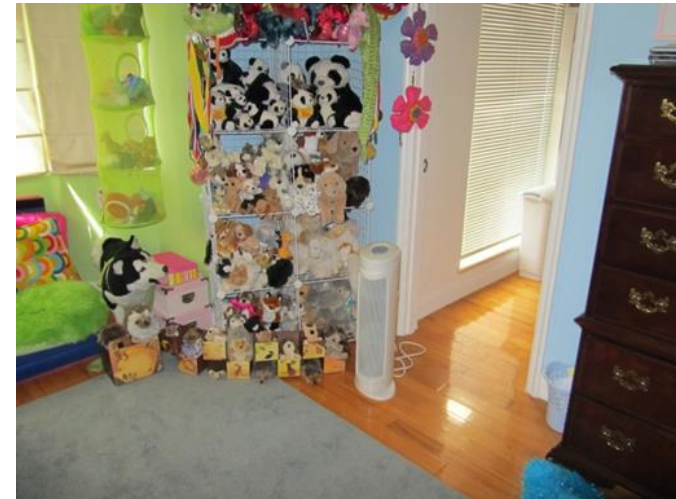
# Indoor Air Pollution Mitigation

## Centralized air filtration



# Indoor Air Pollution Mitigation

## Use Room Air Cleaners (RACs)



# Indoor Air Pollution Mitigation

## Use room air cleaners (RACs) (continued)

How many are needed?

Goal: 4 room air changes per hour based on the Clean Air Delivery Rate

Air Changes Per Hour	Minutes Required for Removal of Airborne Particles	
	99% Removal	99.9% Removal
2	138	207
4	69	104
6	46	69
8	35	52
10	28	41
12	23	35
15	18	28
20	14	21
50	6	8

From: Centers for Disease Control and Prevention. Guidelines for environmental infection control in health-care facilities: recommendations of CDC and the Healthcare Infection Control Practices Advisory Committee (HICPAC). MMWR Morb Mortal Wkly Rep [serial on the Internet] 2003; 52(RR-10): 1-48 [cited 2005 Sept. 11]. Available at: [www.cdc.gov/ncidod/hip/enviro/guide.htm](http://www.cdc.gov/ncidod/hip/enviro/guide.htm) (7)

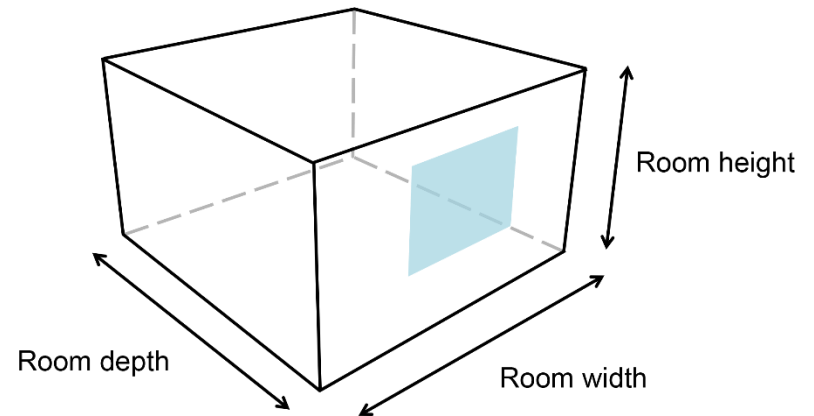
# Indoor Air Pollution Mitigation

How many are needed?

Sizing a Room to Select an RAC

Example:

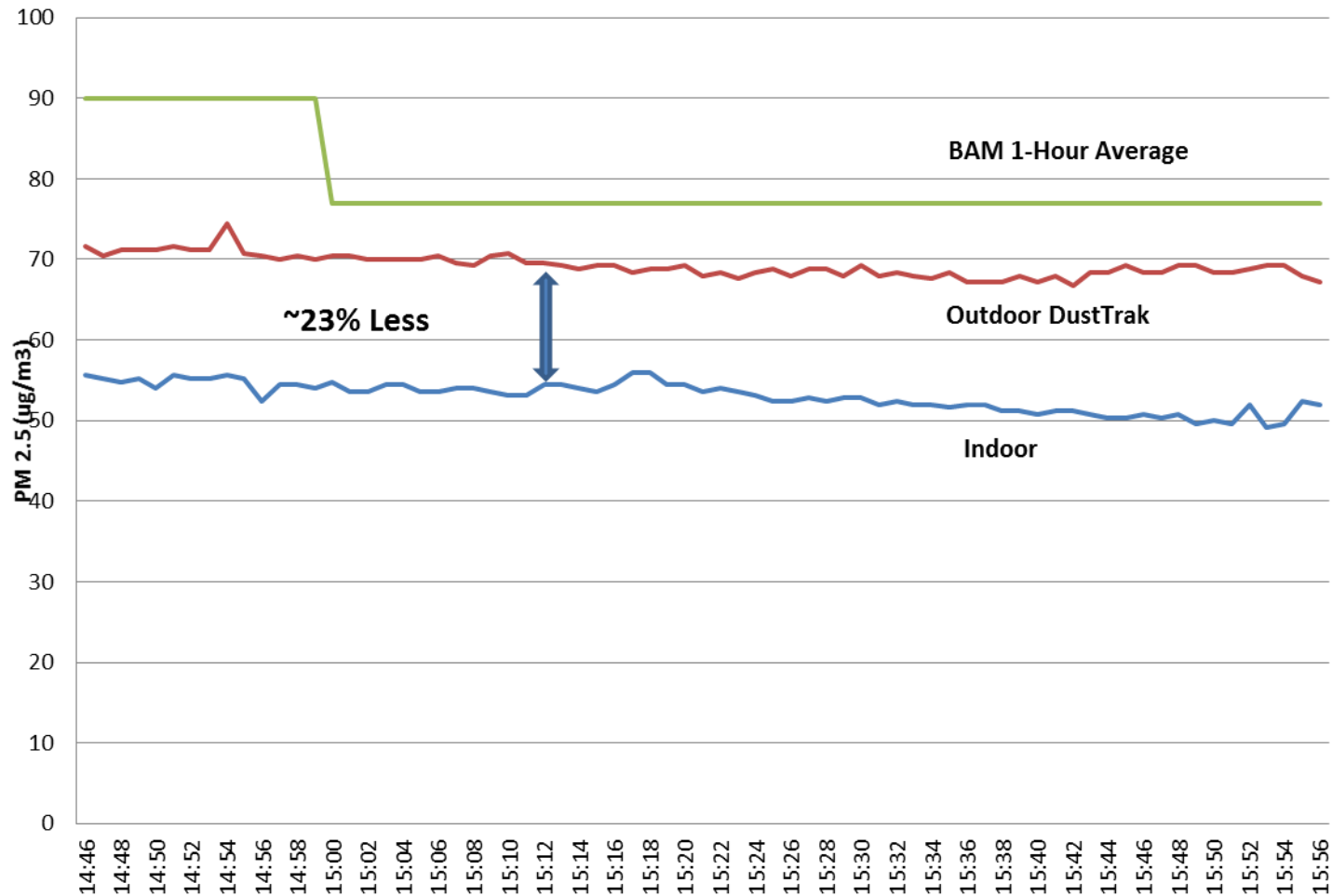
- Room Size: 12 ft x 12 ft x 10 ft high
- CADR: 240 CFM (use CADR for smoke)
- ACH:  $[\text{CADR in CFM} \times 60 \text{ min/hr}] / [\text{Interior room volume (ft}^3\text{)}]$
- ACH:  $[240 \times 60] / [12 \times 12 \times 10] = 10$



# Indoor Air Pollution Mitigation

## Chengdu Waterfront Apt.

March 4, 2013  
No RACs in Use

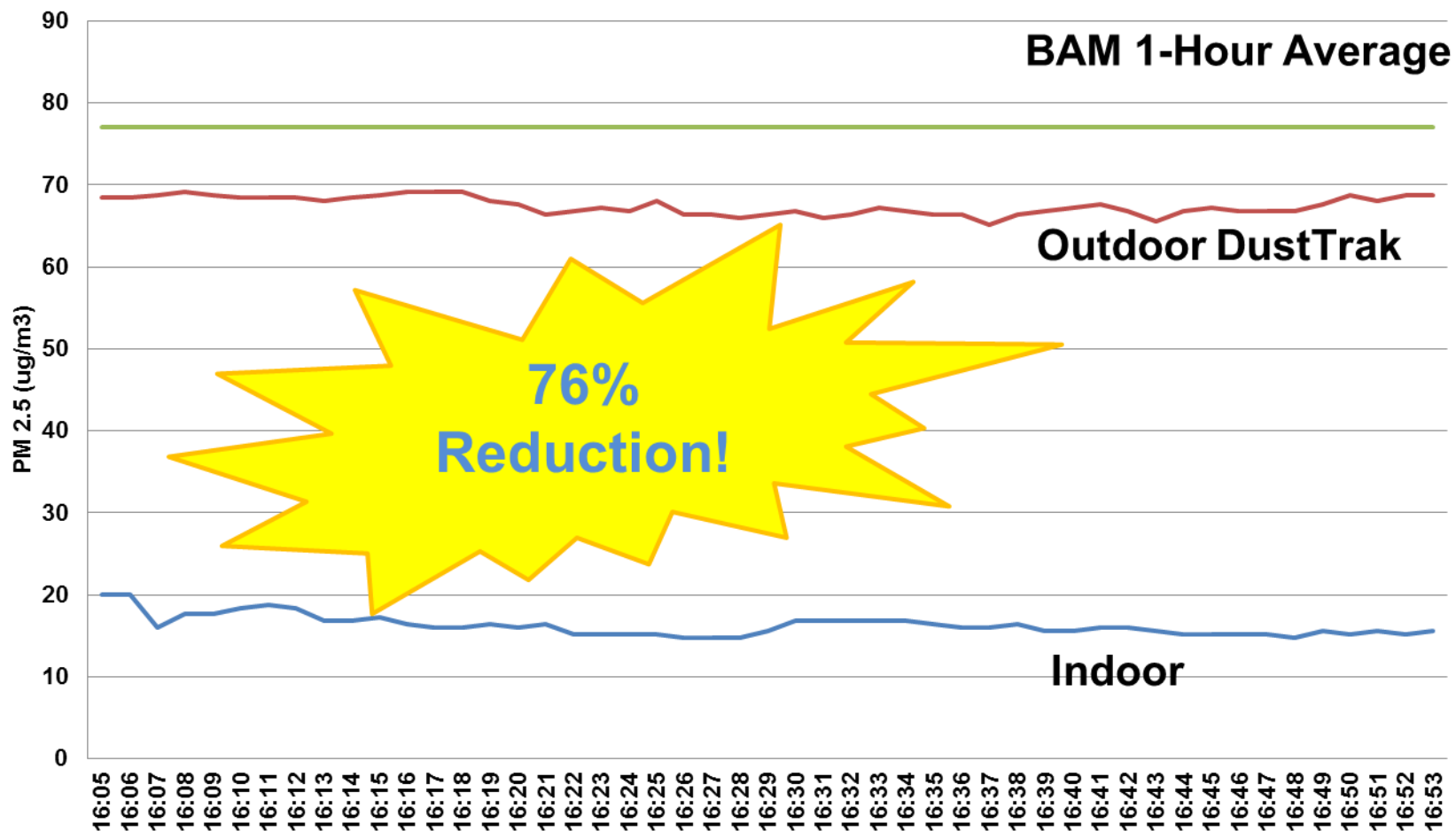


# Indoor Air Pollution Mitigation

## Chengdu: Waterfront Apt

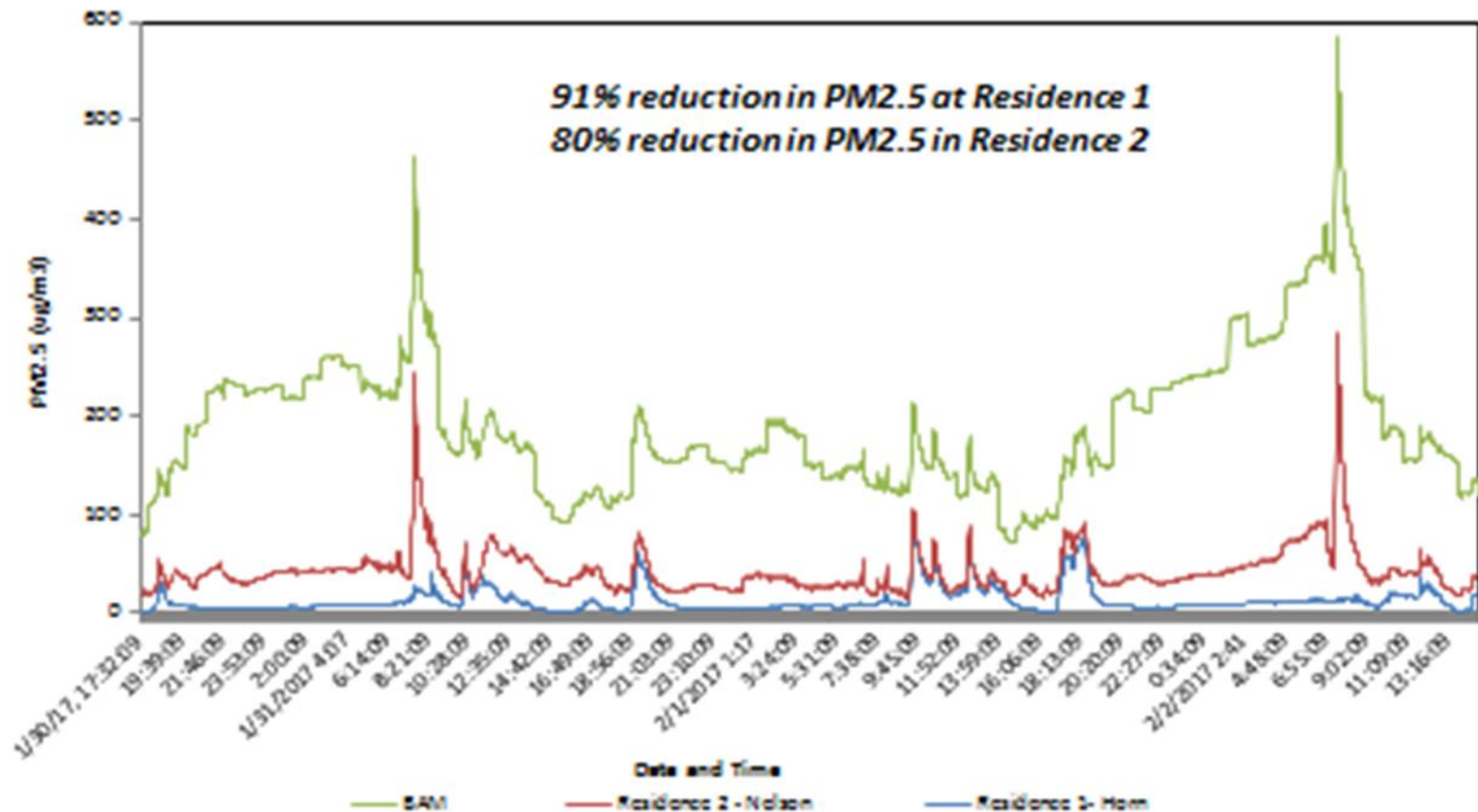
March 4, 2013

RACs In Use



# Indoor Air Pollution Mitigation

**PM2.5 Level Measured Using the Ambient Beta Attenuation Monitor (BAM) Outdoors, at Residence 1 (on the US Embassy Enclave), and at Residence 2 (off the Enclave\*), US Embassy In New Delhi, India, January 30 - February 2, 2017**





# Indoor Air Pollution Mitigation

## Improvising a Room Air Cleaner

If you're on a budget...



Increase the filter area to decrease the effect of air resistance



Source:  
<https://tombuildstuff.blogspot.com/2013/06/better-box-fan-air-purifier.html>



# Indoor Air Pollution Mitigation

## Improvising a Room Air Cleaner

Kathmandu, May 2019

Test Chamber

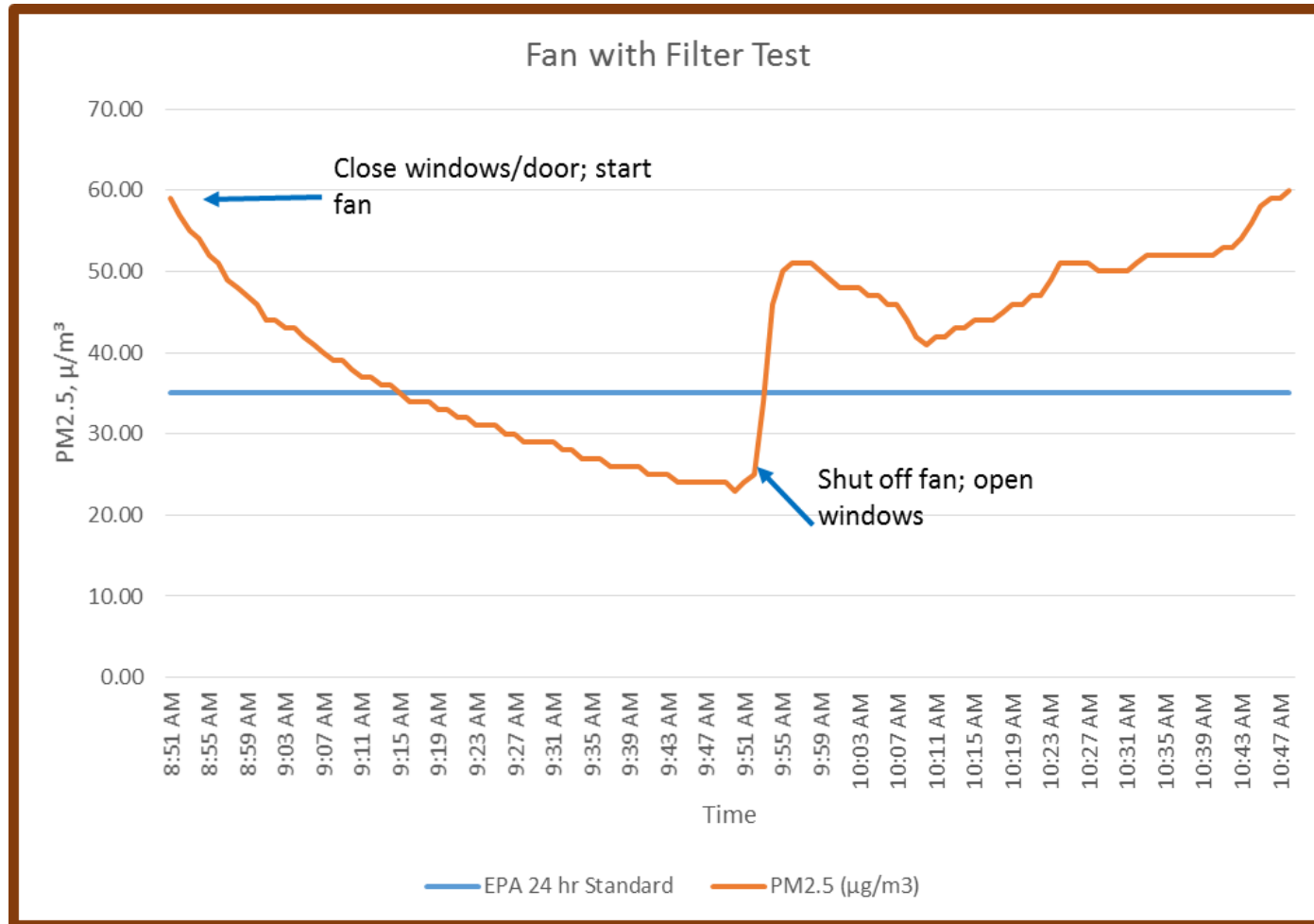


DustTrak and Fan/Filter



# Indoor Air Pollution Mitigation

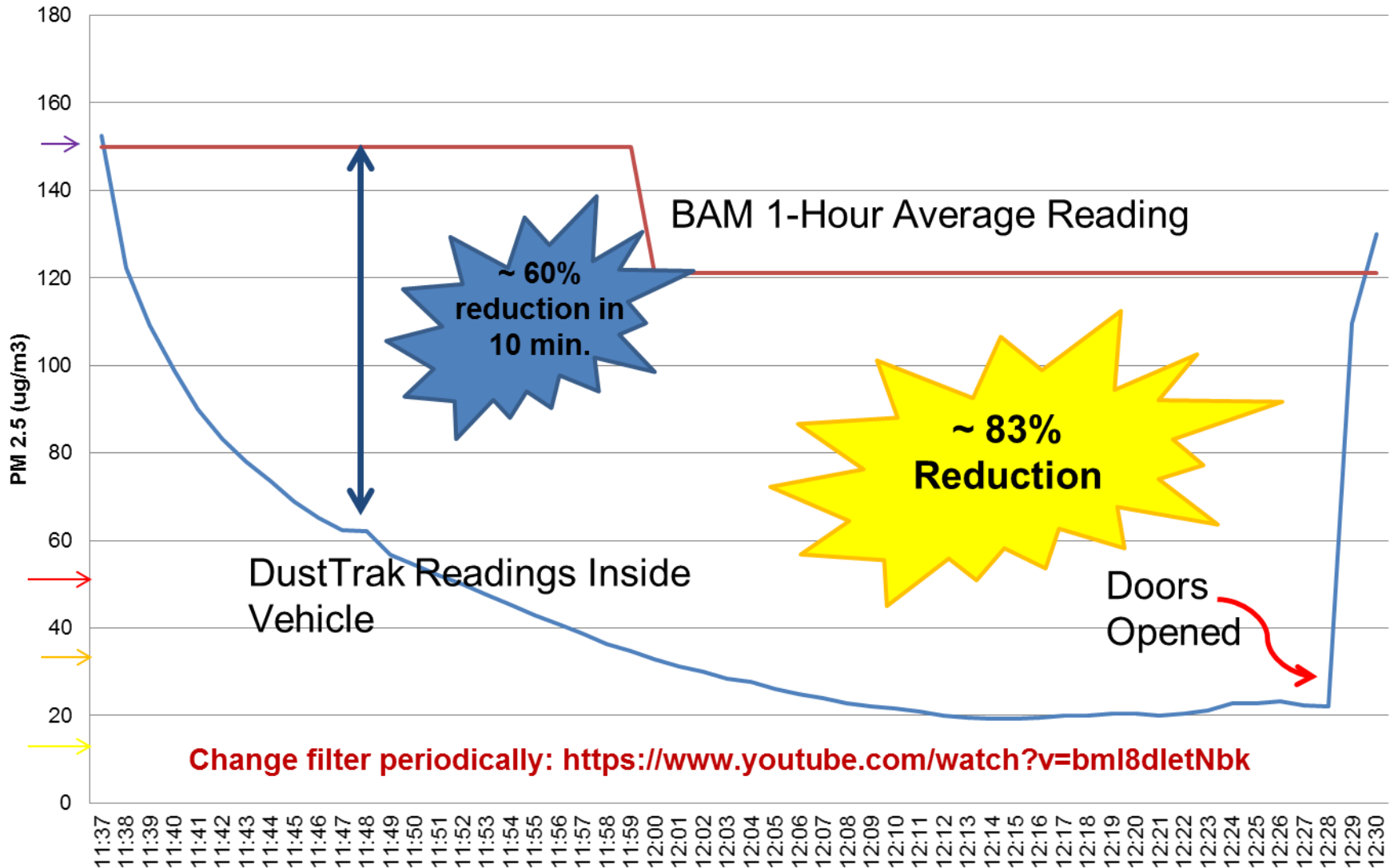
## Fan with Filter Test Results (FPR 4 Filters)



# Indoor Air Pollution Mitigation

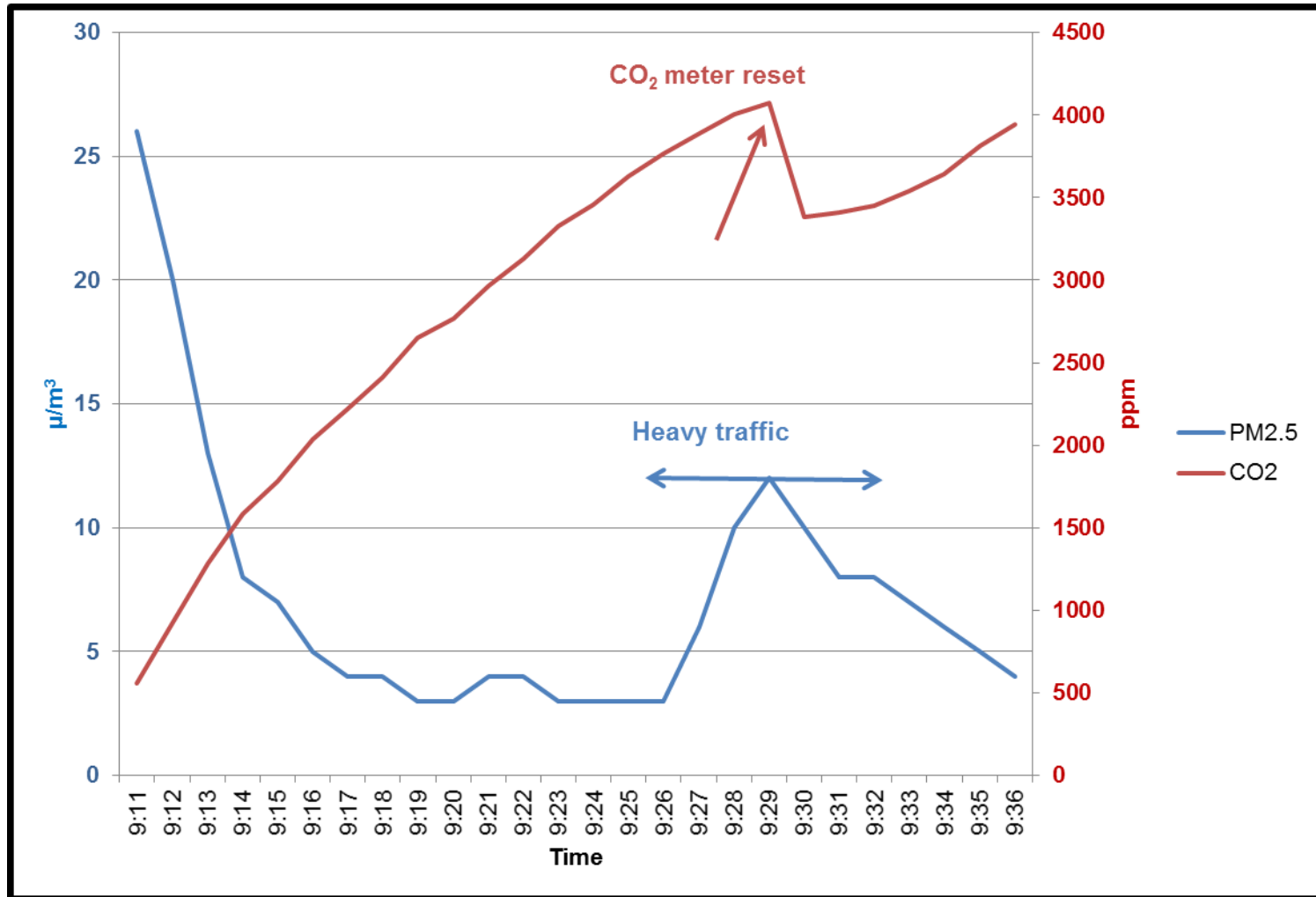
## In-Vehicle Monitoring w/ Cabin Air Filtration

Chengdu, March 5, 2013 - Trip 1, CGR to Consulate



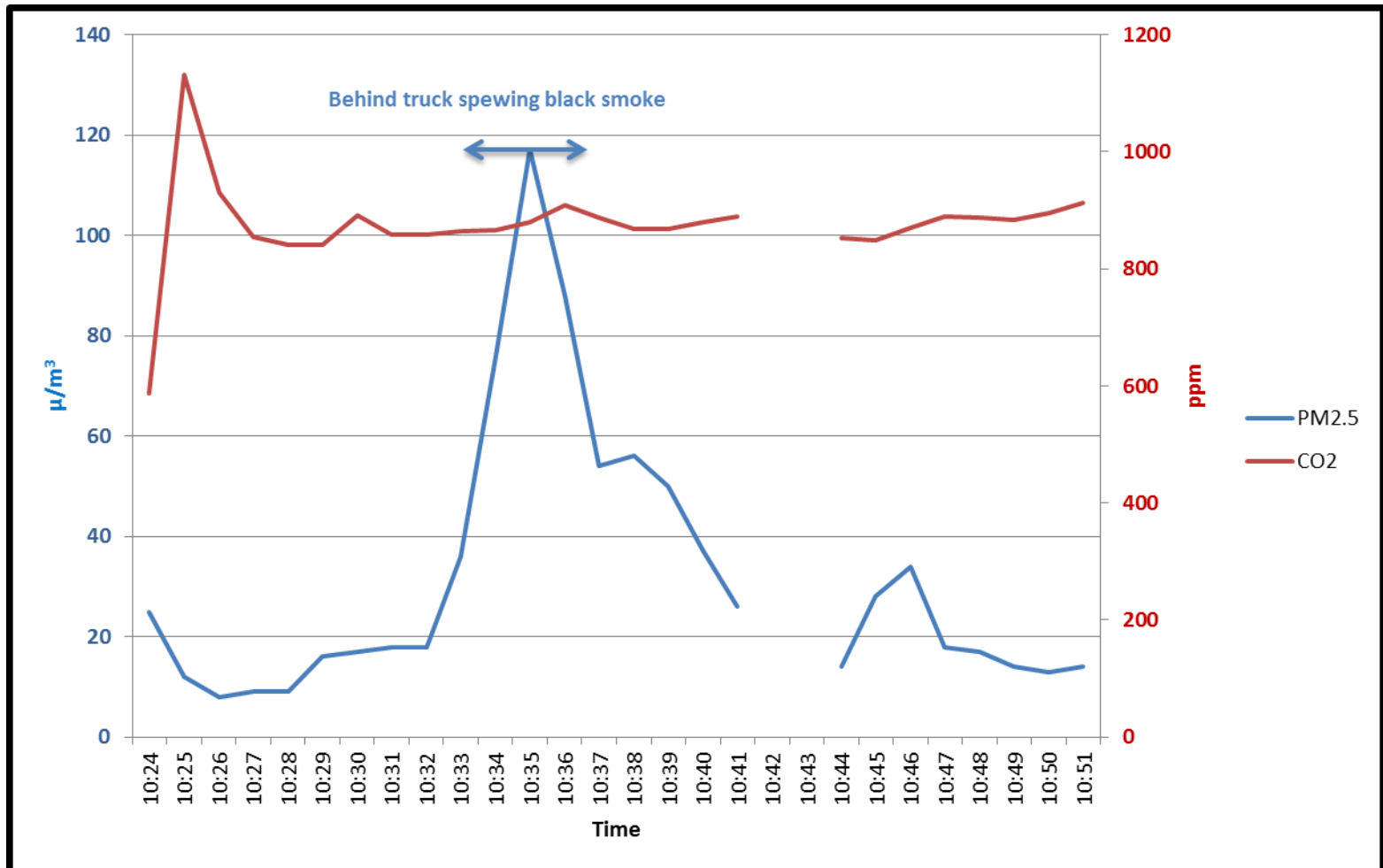
# Indoor Air Pollution Mitigation

PM<sub>2.5</sub> and CO<sub>2</sub> Levels in Vehicle with Cabin Air Filters  
Recirculating Ventilation  
Kampala Uganda – July 2017



# Indoor Air Pollution Mitigation

PM<sub>2.5</sub> and CO<sub>2</sub> Levels in Vehicle with Cabin Air Filters  
Pass-Through Ventilation  
Kampala Uganda – July 2017



# Indoor Air Pollution Mitigation

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## Vehicle Air Filtration

### What

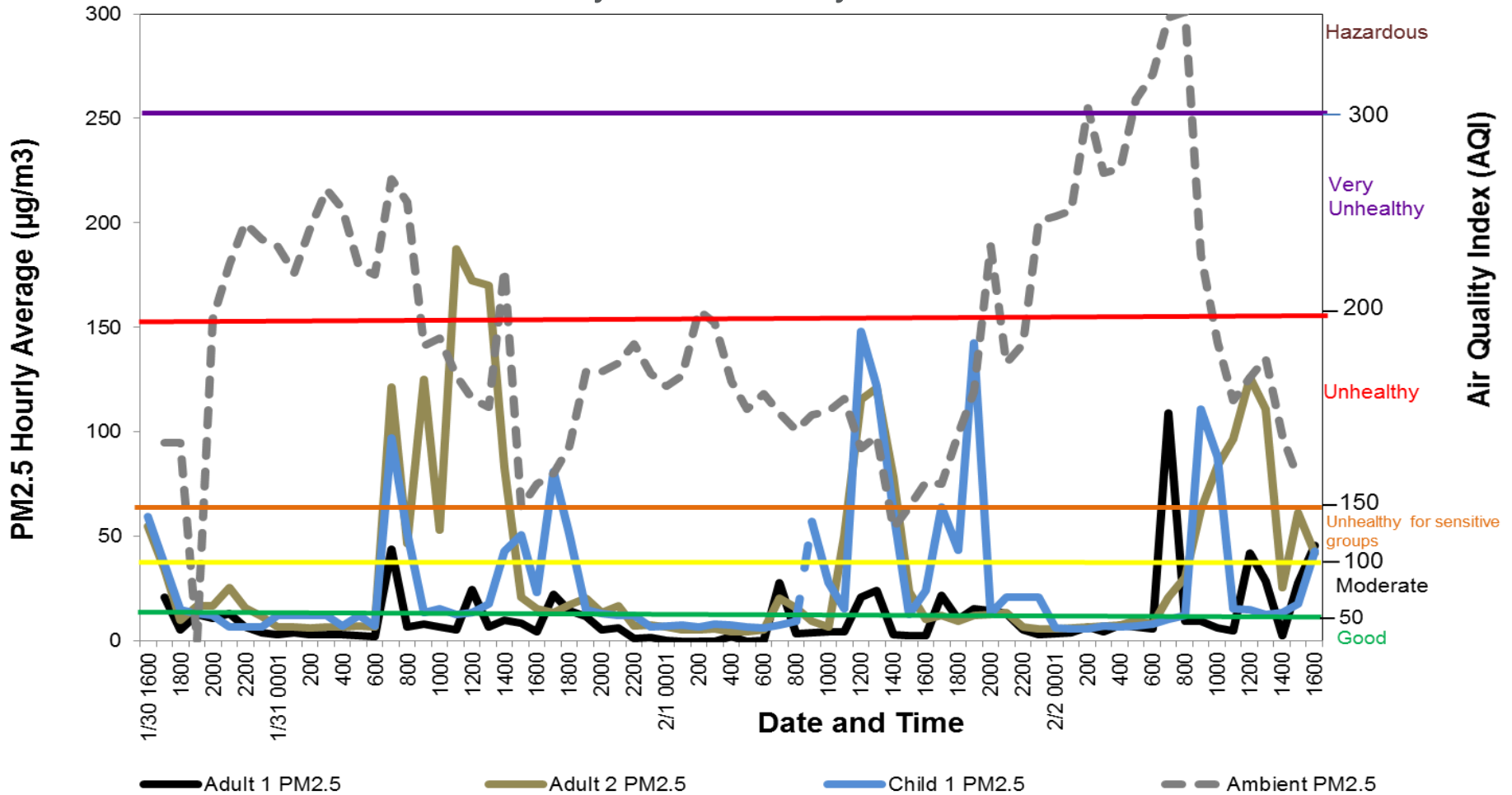
- High Efficiency Cabin Air Filters
- Do it yourself (Save \$\$\$)

### Operation in Air Pollution

- Close windows
- Avoid recirculation




# Indoor Air Pollution Mitigation and Average Daily Exposure

Family 1: PM2.5 Personal Exposure Monitoring  
New Delhi India  
January 30 – February 2, 2017



# Indoor Air Pollution Mitigation

## Respirators Should we use them?

MEDICALLY OK?	QUALITY RESPIRATOR?	GOOD FIT?
 <p>Lung, cardiac, or other medical conditions? If so, discuss respirator use with your health provider.</p>	<ol style="list-style-type: none"> <li>1. NIOSH certified</li> <li>2. HEPA/N100, N99, or N95</li> <li>3. P2 or P3</li> <li>4. Other hallmarks or signs</li> <li>5. Holds mask in place (e.g., 2 straps)</li> </ol> 	<ul style="list-style-type: none"> <li>• S, M, or L ?</li> <li>• Try multiple brands &amp; models</li> <li>• Test face seal</li> <li>• Facial hair, weight change +/- 20 lbs (9 kg), etc. affect fit</li> <li>• Get fit tested!</li> </ul>
WORN PROPERLY?		
<p>When do you wear it? Minimize outdoor time &amp; exertion if AQI &gt; <u>200</u></p> <p>Wearing procedures:</p> <ol style="list-style-type: none"> <li>1. Inspect filters, seal area, and straps.</li> <li>2. Put on. Adjust straps. Seal to face and nose. Check for leaks. Re-adjust to achieve seal.</li> <li>3. Dizzy or nauseous? Go indoors and remove the respirator. Seek medical attention.</li> <li>4. Remove and store respirator with care. See manufacturer's instructions.</li> <li>5. Replace filter if misshapen, soiled, wet, or if end of filter life.</li> </ol> <div style="display: flex; justify-content: space-between; align-items: center;">  <div> <p>If air leaks around the respirator edges, adjust the panels on the face and the position of the straps along the sides of the head and make certain respirator edges fit snugly against face.</p> </div> </div>		





# Indoor Air Pollution Mitigation

## Respirators Particulate Air Purifying

- Filtering Facepiece
  - Cost: ~\$0.50 – \$3.00
- Half-Face Elastomeric
  - Cost: ~\$10 - \$40
  - Plus ~\$2- 10 for filters
- Air Pollution Masks
  - Cost: ~\$35-75



# Indoor Air Pollution Mitigation

## Respirators Fit and Seal Testing



Wearer/ Respirator		Unit Cost	NIOSH Approved ?	Pass/Fail
1	<a href="#">3M Aura 9211</a> (disposable)	~\$2.25	Yes	Fail
2	<a href="#">Vogmask®</a> (reusable)	~\$30	No	Fail
3	<a href="#">Vogmask®</a> (reusable)	~\$30	No	Pass
4	<a href="#">Honeywell Antipollution RY-D7051-DB2V-IND</a> (disposable)	\$2	No <sup>1</sup>	1 <sup>st</sup> Fail
				2 <sup>nd</sup> Pass
5	<a href="#">Vogmask®</a> (reusable)	~\$30	No	Fail
6	<a href="#">3M 8293 P100 Disposable Particulate</a> <sup>2</sup>	\$9	Yes	Pass
	<a href="#">Vogmask®</a> (reusable)	~\$30	No	Fail

# Indoor Air Pollution Mitigation - Summary Recommendations

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- Seal residences
  - Visual inspections
  - Blower door testing
- Minimize the opening and closing of exterior doors and windows and use of exhaust fans in kitchens and bathrooms
- Be aware of and control indoor sources of air contaminants
- Use high efficiency air filters if there's a central HVAC system
- Use RACs
  - Recommend 4 air changes per hour. – easier to achieve in smaller rooms
  - DIY RACs appear effective
  - Run room air cleaners on the highest setting that noise is acceptable. Turn up to maximum when the room or residence is vacated.
- If you must travel, do so in a vehicle that preferably has a high-efficiency cabin air filter, keep windows closed, and don't recirculate or carbon dioxide levels will quickly climb. Avoid following spewing trucks!
- Consider respirators but be cautious – you may not be getting great protection!