Evaluating DIY air cleaner variability and potential for post-construction emission of aromatic VOCs during wildfire events

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BACKGROUND

- Wildfires elevate fine particulate matter ($PM_{2.5}$) to hazardous concentrations.
- Variability in construction/performance of DIY air cleaners is an ongoing concern.
- Materials used during construction may emit harmful volatile organic compounds (VOCs).

MATERIALS AND METHODS

- Using the same set of instructions, materials, and location of assembly, seven Corsi-Rosenthal Boxes (CR Boxes) were built by individuals with no prior DIY air cleaner experience (*Fig.1*).
- A point system was created to track qualitative number of mistakes made during construction.

***Fig. 1*:** Images of CR Box

- Using the pull-down method, $PM_{2.5}$ clean air delivery rates (CADRs) were determined in an environmentally controlled chamber (*Fig. 2*) under simulated wildfire conditions.
- Results were compared to the literature to explore variability in CR Box efficacy across studies.
- Freshly constructed CR Boxes were allowed to off-gas VOCs in the chamber for 24–72 hours.

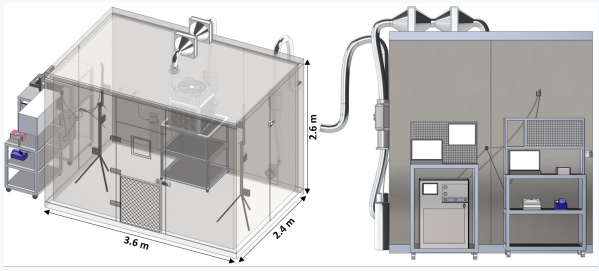

***Fig. 2*:** 3D model of environmentally controlled chamber

- Using experimentally determined CADRs and VOC emission rates, $PM_{2.5}$, benzene, toluene, and C8 aromatics concentrations were modeled at four air exchange rates (AERs) during a hypothetical wildfire event; the tradeoff between building airtightness, particle removal effectiveness, and VOC off-gassing from a newly built CR Box was assessed.

RESULTS AND DISCUSSION

- Average (± SD), particle number-based CADR = 352 ± 40 m^3/h *(Fig. 3)*; many higher-cost commercial air cleaners are outperformed by CR Boxes
- Relative standard deviation = 7.6%; CADRs are modestly variable
- Modest correlation (R^2 = 0.64) exists between CADR and mistakes made during construction; builds with 3–4 vs. 0–2 mistakes produce CADRs ~12% lower
- Wide range of experimentally determined CR Box CADRs observed across the literature (285–1448 m^3/h); likely due to differences in materials (including filter type), challenge aerosols tested, and evaluation protocol (*Fig. 4*)

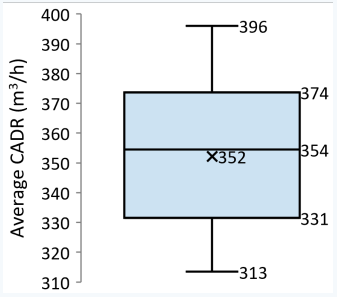

***Fig. 3*:** Box plot of $PM_{2.5}$ CADRs (m^3/h) for this study

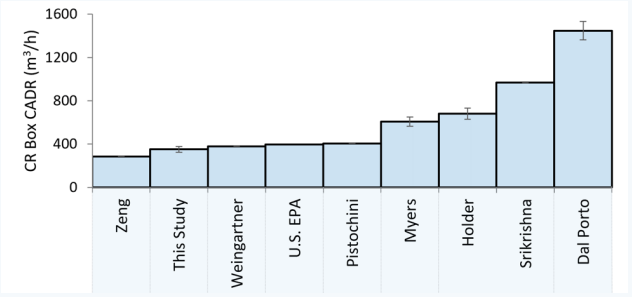

***Fig. 4*:** Average (± SD when applicable) CADR (m^3/h) for 8 studies that have evaluated CR Box efficacy

- VOC off-gassing due to duct tape use
- Toluene and C8 aromatics emission rates are initially 2289 and 89 µg/h, respectively, but decrease by 94% and 82% after 12 hours (*Fig. 5*)
- While VOC emissions are well below short-term permissible exposure limits, toluene concentrations approach the odor threshold for sensitive individuals (160 ppb)

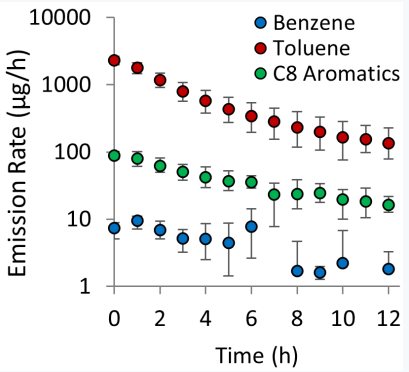

***Fig. 5*:** Log-scale average (± min. and max) VOC emission rates (µg/h) over 12 hours

- CR Box effectiveness ranges from 0.881–0.954; $PM_{2.5}$ concentrations are brought to steady state in <30 minutes at all AERs (*Fig. 6a*)
- CR Boxes bring $PM_{2.5}$ concentrations below the U.S. EPA's 24-hour outdoor threshold (35 $\mu g/m^3$) in <5 minutes at all AERs (*Fig. 6a*)
- Even when the room is most airtight (0.1 h^{-1}), VOC concentrations remain well below governmental exposure limits (*Figs. 6b, c,* and *d*)

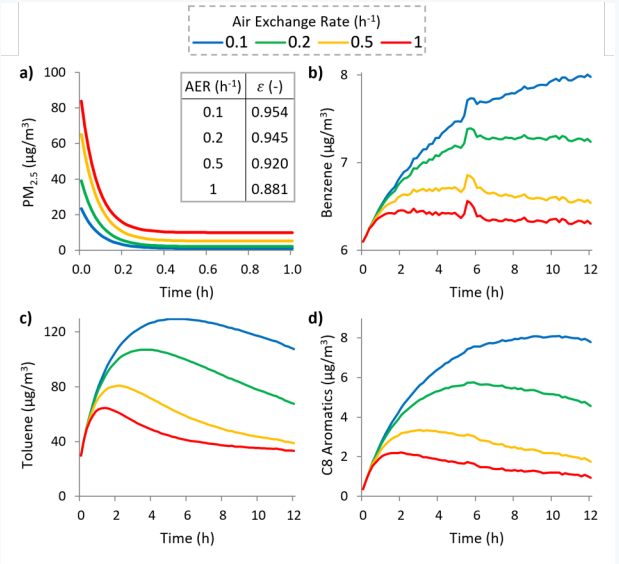

***Fig. 6*:** *a)* Modeled $PM_{2.5}$ concentration vs. time plot at four AERs over 1 hour. Modeled *b)* benzene, *c)* toluene, and *d)* C8 aromatics concentration vs. time plots at four AERS over 12 hours

CONCLUSION

- Benefits associated with $PM_{2.5}$ reduction during a wildfire event outweigh adverse impacts from short-term VOC emissions. CR Boxes are a safe, effective, and inexpensive alternative to commercially available portable air cleaners.