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"Black Carbon Emissions and Their Relation to Emission Characteristics from Traditional Cookstoves in Rural India"

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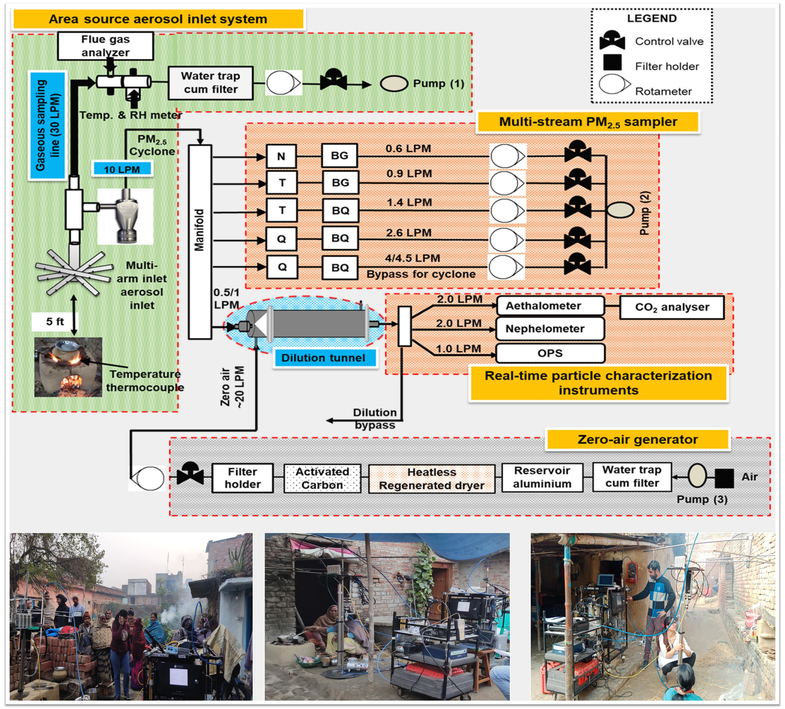
INTRODUCTION

- 819 million people in India use traditional biomass fuel in inefficient traditional mud stoves for routine cooking activity.
- Residential solid biomass fuel use contributes to 40-45% of total PM2.5 emissions in India (Pandey et al. 2014)
- The emissions from SBFs are primarily carbonaceous in chemical composition, with OC and BC contributing the major % of the emissions.
- Limited number of field measurements monitoring real-time black carbon emissions.

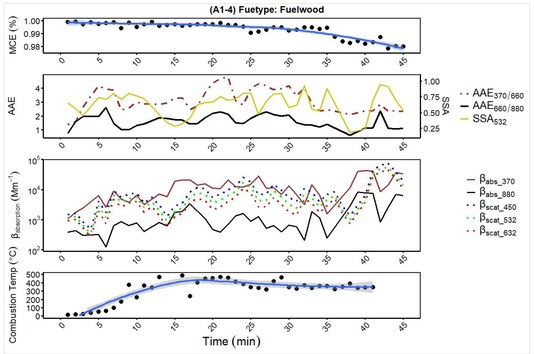
EXPERIMENTAL SET-UP AND MEASUREMENTS

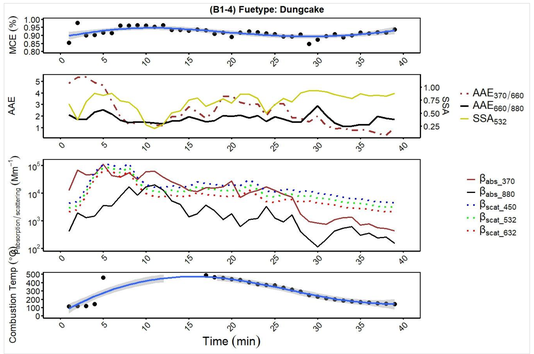
- The versatile source sampler (VS3) (Kumari et al. 2024) used for on-field measurement is shown below along with the experiments conducted on the field in Haryana and Bihar.
- A total of 78 experiments were conducted.
- The Aerosol Magee Scientific Aethalometer AE-33 was used for black carbon measurement.

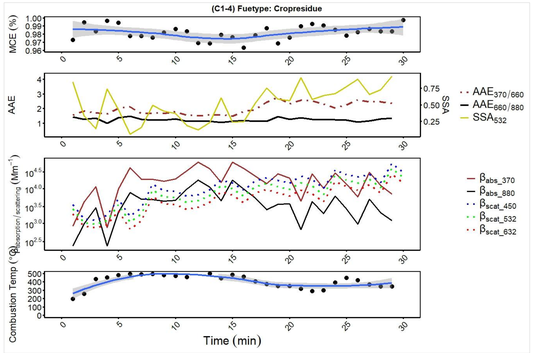


RESULTS

- AAE370/660 captures absorption at shorter wavelengths, while AAE660/880 reflects absorption at longer wavelengths. Lower AAE660/880 values indicate the dominance of black carbon (BC).
- Compared to other biomass fuels, fuelwood burns more efficiently, showing a high modified combustion efficiency (MCE) ranging from 0.98 to 1.0.
- Fuelwood is a significant emitter of BC, evident from its low AAE660/880 (~1) and high absorption coefficients (β_abs).
- The single scattering albedo (SSA) for fuelwood ranges between 0.5 and 0.75, indicating that the emitted particles are more absorbing than scattering.
- Dung cake shows lower initial combustion efficiency (MCE ~0.95), emits more CO, and burns at lower temperatures, though combustion quality improves over time.
- Emissions from dung cake are dominated by organic carbon (OC), with high AAE values (~2–4) and enhanced scattering properties, resulting in a relatively high SSA (~0.75).
- CR combustion shows the emission characteristics between FW and DC being a lighter fuel.

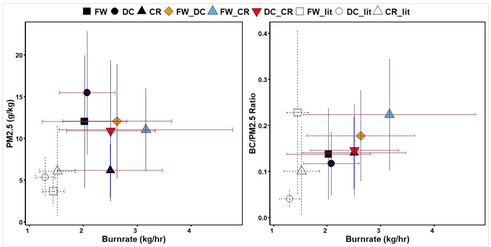






RESULTS

- Slow combustion in lab experiments (Habib et al., 2008) shows high fraction of OC and less fraction of EC.
- Elevated PM2.5 emission factors are often linked to the increased combustion rate observed during in-situ measurement conditions.



CONCLUSIONS

- Fuelwood combustion is characterized by high black carbon (BC) emissions, making it absorption-dominated with limited scattering.
- Dung-cake combustion is strongly scattering-dominated due to its high organic carbon (OC) fraction.
- Crop residue represents an intermediate case, exhibiting a balance between scattering and absorption properties.
- These findings emphasize the need for interventions to reduce emissions from traditional stoves, either by improving combustion conditions or transitioning to cleaner fuels.
- While high-scattering aerosols may mitigate global warming effects, they contribute significantly to localized health risks.

LITERATURE REFERENCES

1. Pandey et al., Atm. Environ. **2014**,99,341-352
2. Kumari et al., Aer. Sci. Tech. **2024**, 12, 1333-1346
3.JaiPrakash et al.,, **2006**, Aer. Sci. Tech. 7, 717–731
4.Habib et al., **2008**, Environ. Sci. Technol. 42, 8829-8834

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