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Cooking-generated $PM_{2.5}$ and PM_{10} in Residential Buildings with Different Cooking Stoves

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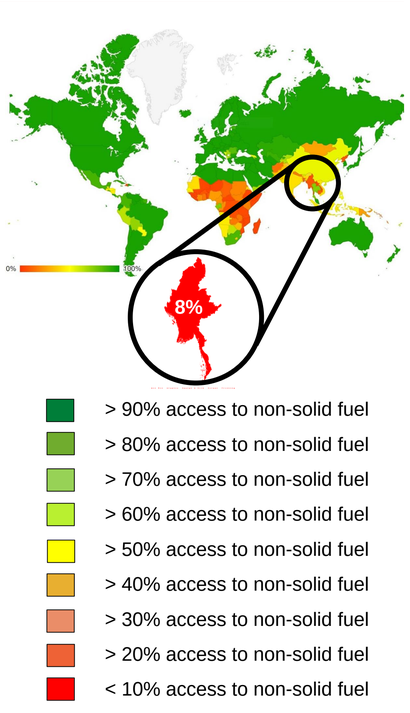
Background and Aim

- Household air pollution is one of the leading causes of premature death in the developing world.[1]
- Every year, around 3.8 million people die prematurely from illnesses attributable to household air pollution caused by inefficient use of solid fuels for cooking.[2]
- Most people from developing countries cook by using unclean and unsafe fuels in open fires and inefficient stoves.
- Burning fuels in inefficient stoves produces various types of health damaging materials which include particulate matters (PM) and gases.
- Measurement of PM can exhibit the impact of fuel burning on kitchen air pollutant concentrations.
- The present study was designed to determine the concentrations of $PM_{2.5}$ and PM_{10} generated from different cooking stoves in residential buildings.

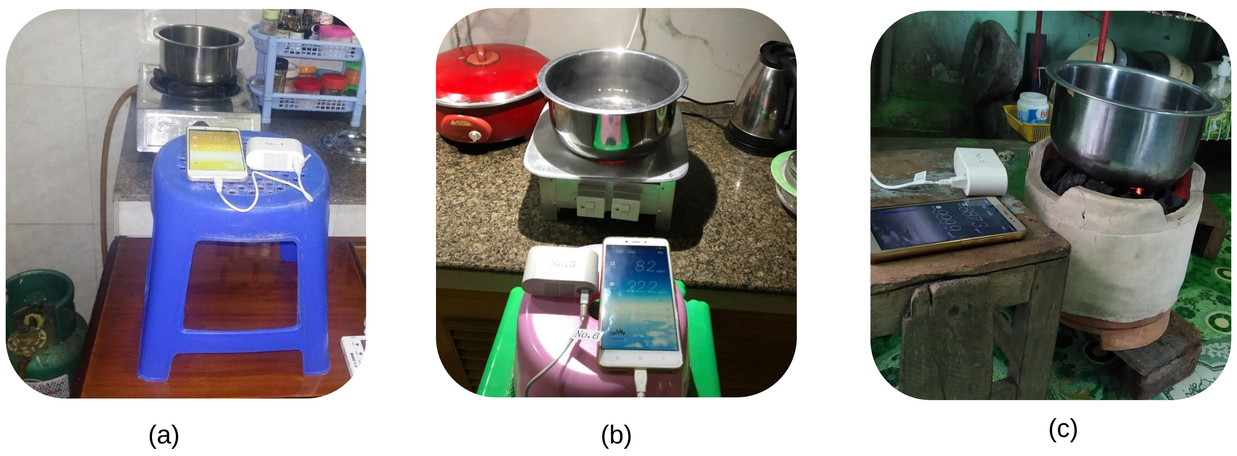


A map showing the percentage of a country's population that had access to non-solid fuel in 2010.[3]

Materials and Methods

- Particulate matter concentrations released from different cooking stoves in residential buildings were measured during August and September, 2019.

Gas stoves (n=7) | **Electric stoves (n=5)** | **Charcoal stoves (n=4)**



(a) (b) (c)

Fig 1.
(a) Measuring $PM_{2.5}$ and PM_{10} in kitchen with gas stove
(b) Measuring $PM_{2.5}$ and PM_{10} in kitchen with electric stove
(c) Measuring $PM_{2.5}$ and PM_{10} in kitchen with charcoal stove

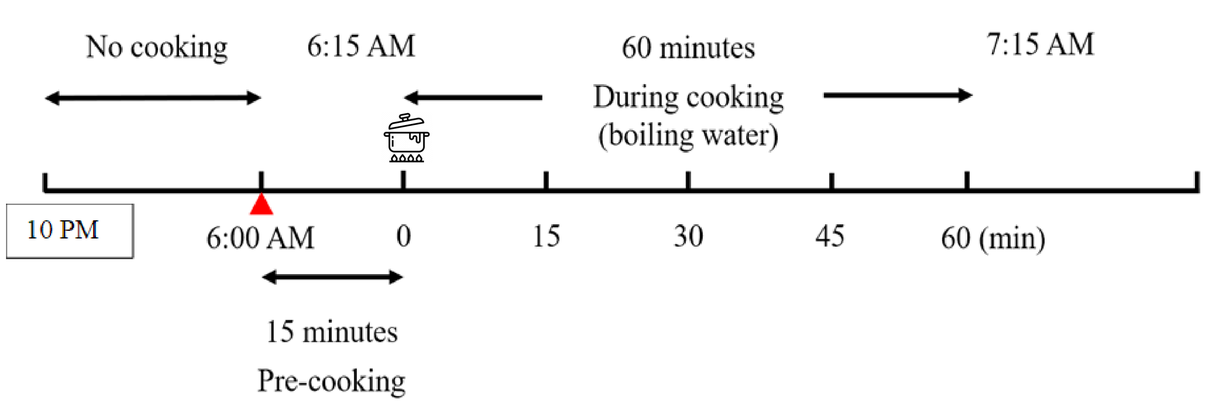


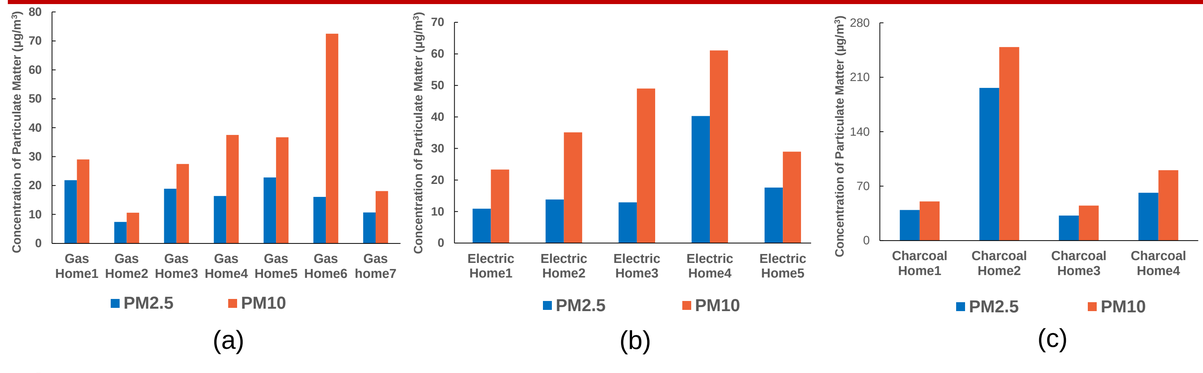
Fig 2. Experimental study design

- The particulate matter concentrations were measured with Pocket $PM_{2.5}$ Sensor (Yaguchi Electric Co., Ltd., Miyagi, Japan; provided by National Institute for Environmental Studies, Japan)

(a) (b)

Fig 3.
(a) Pocket $PM_{2.5}$ Sensor and a smart phone running android OS
(b) Color variations for level of $PM_{2.5}$ concentration

Results



(a) (b) (c)

Fig 4.
(a) PM concentrations measured in kitchens with gas stoves
(b) PM concentrations measured in kitchens with electric stoves
(c) PM concentrations measured in kitchens with charcoal stoves

Table 1.
Comparison of particulate matter concentrations among kitchens with different cooking stoves

Particulate matter concentrations	Gas stoves (n=7) (mean±SD)	Electric stoves (n=5) (mean±SD)	Charcoal stoves (n=4) (mean±SD)
$PM_{2.5}$ (µg/m³)	16.6±5.6	18.7±13.1	133.0±222.5ϕ₹
PM_{10} (µg/m³)	33.8±19.0	38.7±17.4*	157.2±245.6ϕ₹

One-Way ANOVA test with Post Hoc Boneferroni test
*** indicates significant difference between gas stoves and electric stoves (p<0.05)**
ϕ indicates significant difference between electric stoves and charcoal stoves (p<0.05)
₹ indicates significant difference between gas stoves and charcoal stoves (p<0.05)

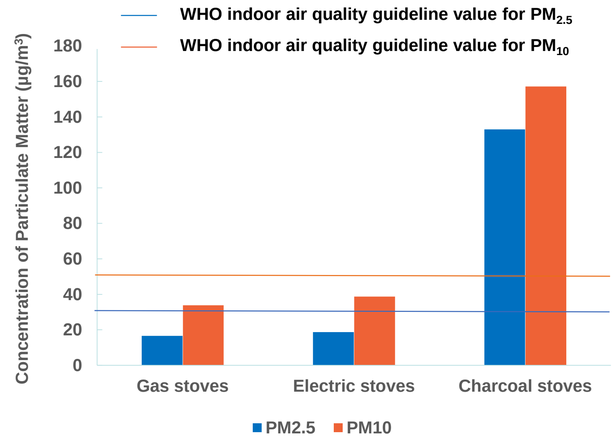


Fig 5.
Comparison of PM concentrations from kitchens with different cooking stoves with WHO indoor air quality guideline value

Discussion

- Particulate matter concentrations (both $PM_{2.5}$ and PM_{10}) released from charcoal stoves were significantly higher than both electric and gas stoves.
- The measured PM concentrations (both $PM_{2.5}$ and PM_{10}) emitted from charcoal stoves were above WHO's indoor air quality guideline values.
- $PM_{2.5}$ and PM_{10} emitted from the electric stoves were higher than those from the gas stoves but significant differences were observed only in PM_{10} but not in $PM_{2.5}$.

Conclusion and Recommendations

- The use of solid fuel - charcoal is found as a significant source of pollutant compared to gas and electricity.
- Therefore, the use of charcoal stoves should be replaced with stoves using cleaner sources of fuel in order to reduce kitchen related household air pollution and subsequent health hazards.
- Knowledge on indoor air pollution from cooking stoves is of great importance since majority of people were found to spend 80-90% of their time indoors.

References

1. Abudullahi, K.L., Delgado-Saborit, J.M. & Harrison, R.M. Emission and indoor concentrations of particulate matter and its specific chemical components from cooking: A review.
2. World Health Organization (2018) Household air pollution and health [https://www. who.int/news-room/ fact-sheets/detail/ household-air-pollution- and-health].
3. Energy education [https:// energyeducation.ca/ encyclopedia/ Charcoal #cite_ note-9]

No conflict of interest