Quantifying long-term exposures to fine particulate matter ($PM_{2.5}$) using real-time low-cost sensors in the Tamil Nadu Air Pollution and Health Effects (TAPHE-II) cohort, India

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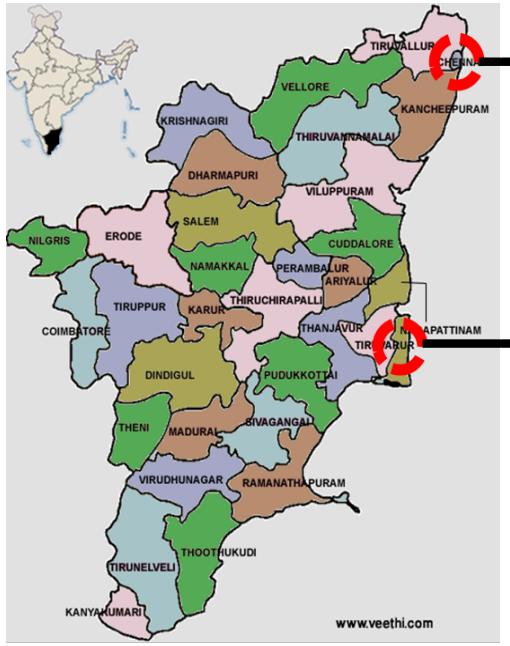
Background

- **Household combustion sources contribute significantly to ambient $PM_{2.5}$ levels in India**
- **Most health-effect studies rely on 24- or 48-h measurements**
- **Long-term monitoring of indoor PM may help improve *exposure* – *response* analyses**
- **Low-cost sensors (LCS) provide a platform for long-term indoor PM monitoring in health-effect studies**

Objectives and Sampling Method

1. Evaluate **sensor performance** in indoor and ambient environments
2. Measure indoor PM levels **over a 21-day period** in rural and urban households



District Map of State of Tamil Nadu

URBAN site: Chennai city
Study population: 150 pregnant women

Major sources of indoor PM: transport, dust, industries, open waste burning, brick kilns

RURAL site: Nagapattinam
Study population: 150 pregnant women

Major sources of indoor PM: biomass combustion, open waste burning, agriculture activities

Location	Fuel category	Number of households	Monitoring days, mean (SD)	Data availability (%)
Rural (N=53)	Biomass	20	21 (6)	99
	Mixed-fuel	12	23 (11)	97
	LPG	21	24 (10)	98
Urban (N=20)	LPG	20	24 (5)	99

Reference Grade for $PM_{2.5}$
~ $ 40,000

Low cost sensors for $PM_{2.5}$
~ $ 500 – 800

Indoor PM monitoring: Air quality monitors

SKC Air Sampler

UPAS

LCS-Atmos

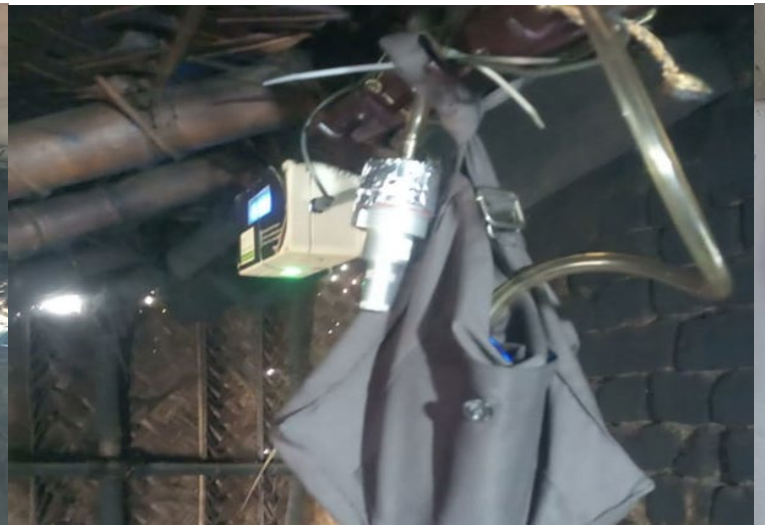
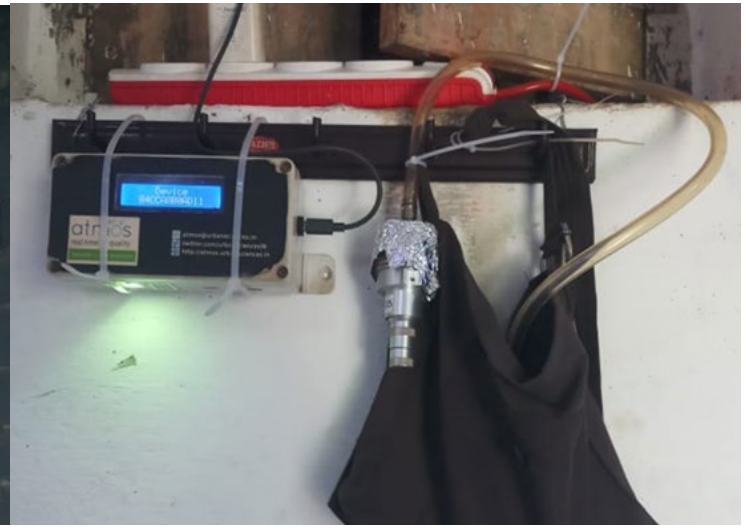
LCS-Aerogram

Personal- UPAS

Collocation: Ambient and Indoor

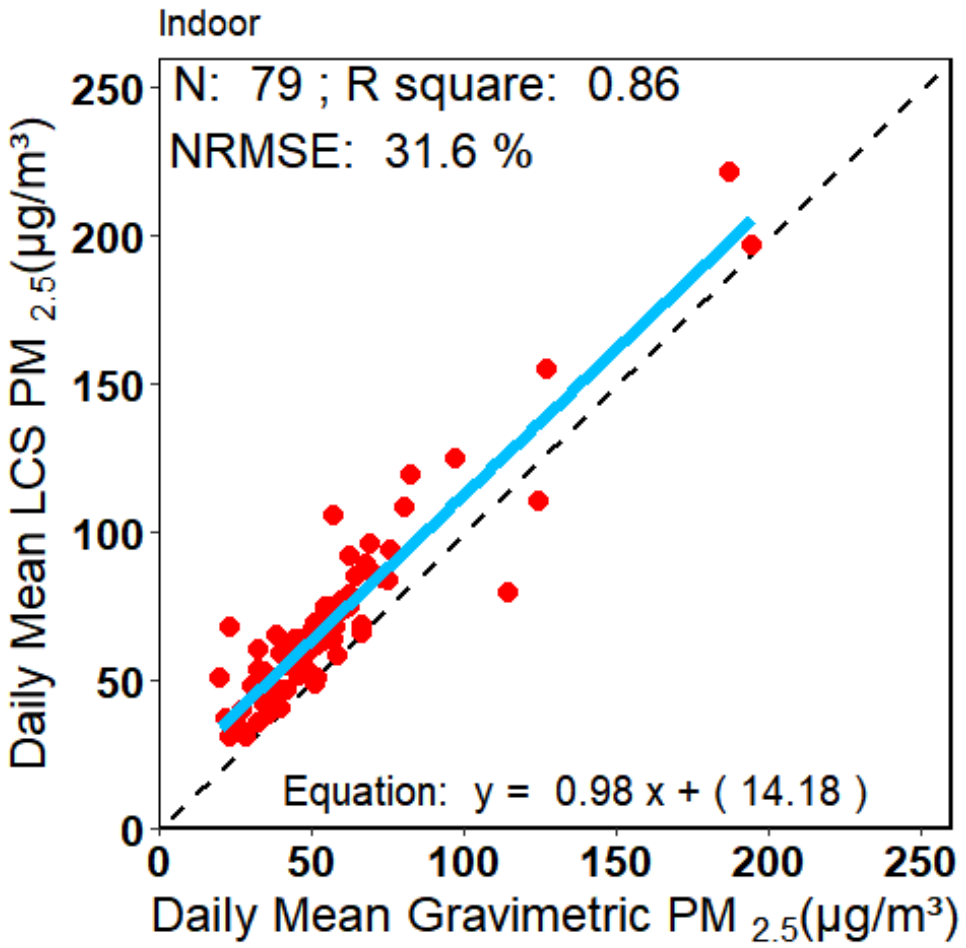




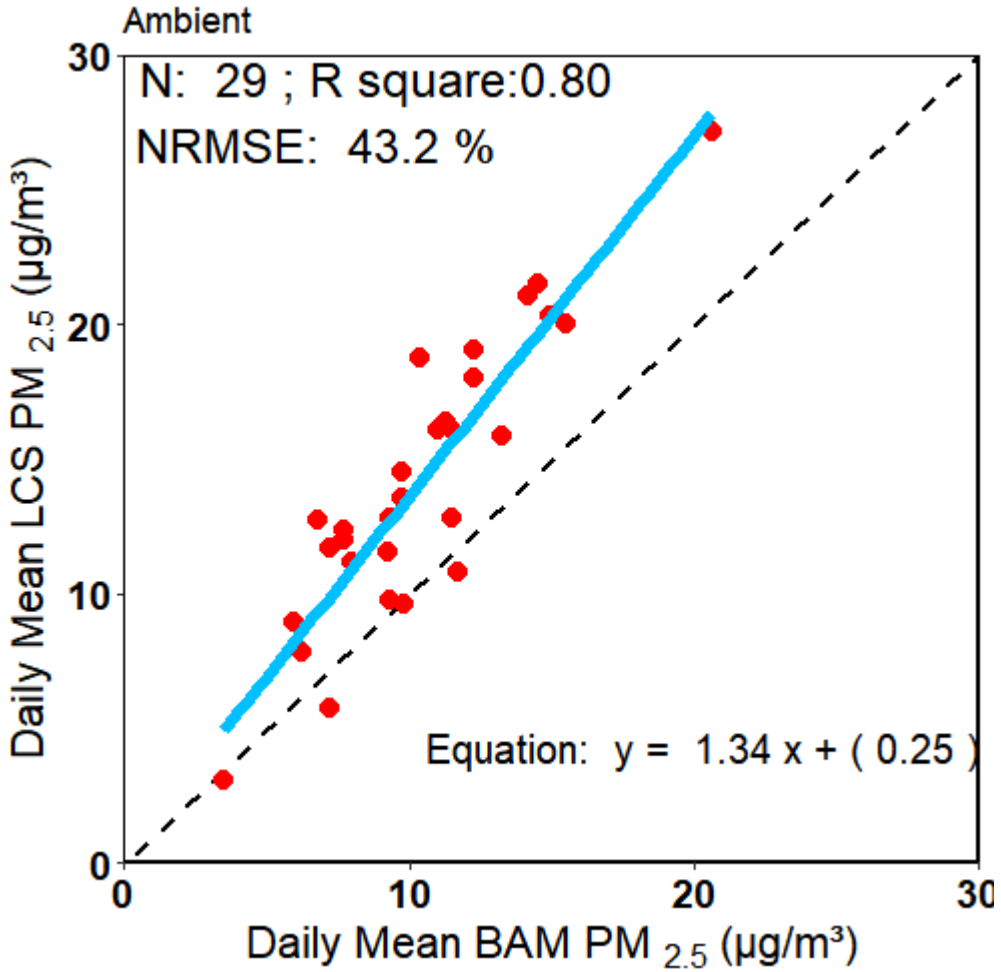



COLLOCATION and CALIBRATION Results

Collocation: Indoor and Ambient

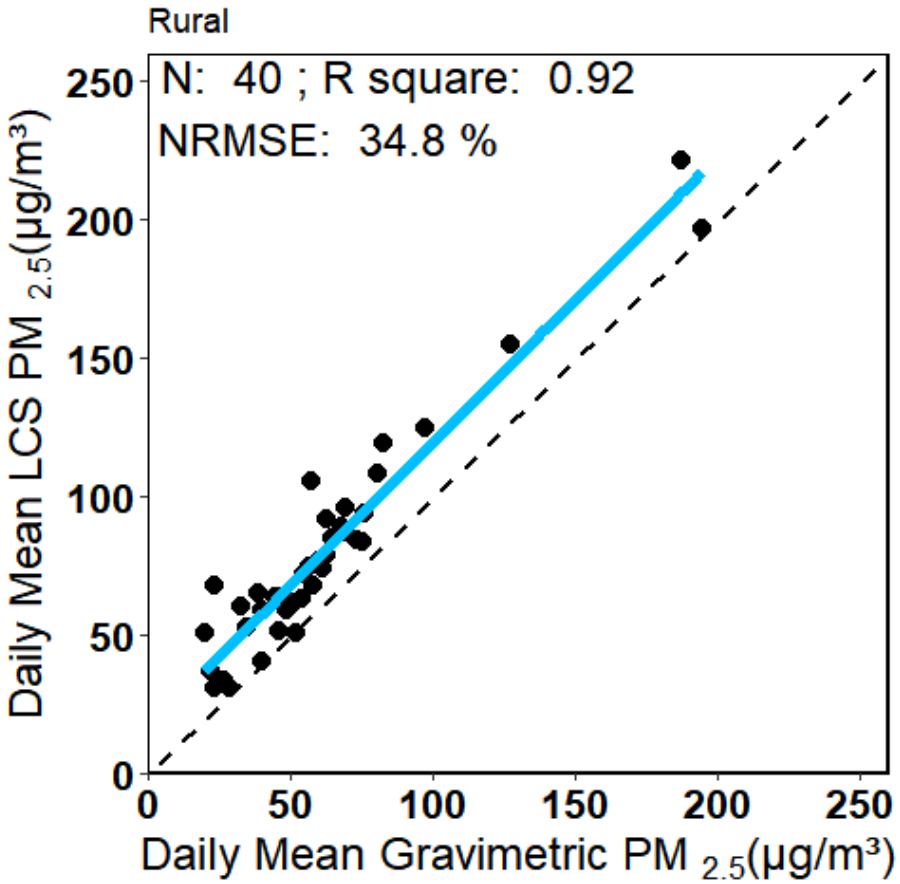


Median: 62.8 µg/m³
IQR : 24.6 µg/m³
Range: 30.7 - 221.6 µg/m³



Median: 12.8 µg/m³
IQR : 6.7 µg/m³
Range: 3.1 – 27.2 µg/m³

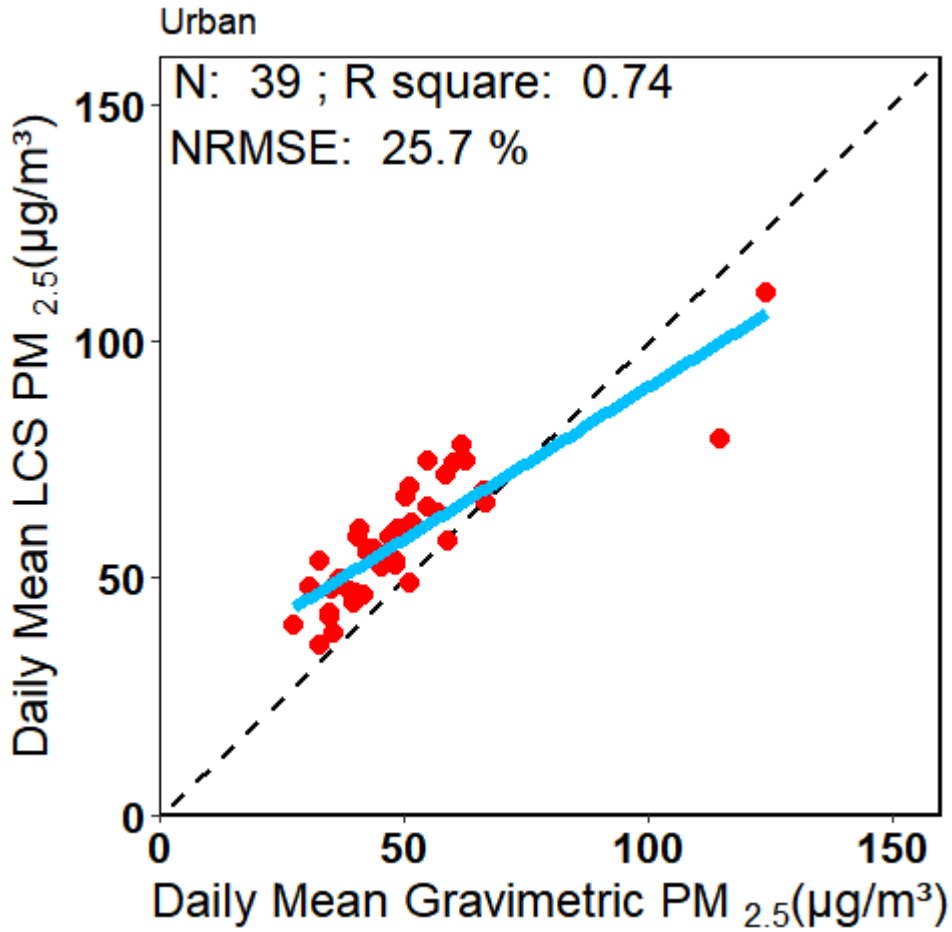
Indoor Collocation: Rural and Urban Households



Median: 69.9 µg/m³

IQR : 30.5 µg/m³

Range: 30.7 - 221.6 µg/m³

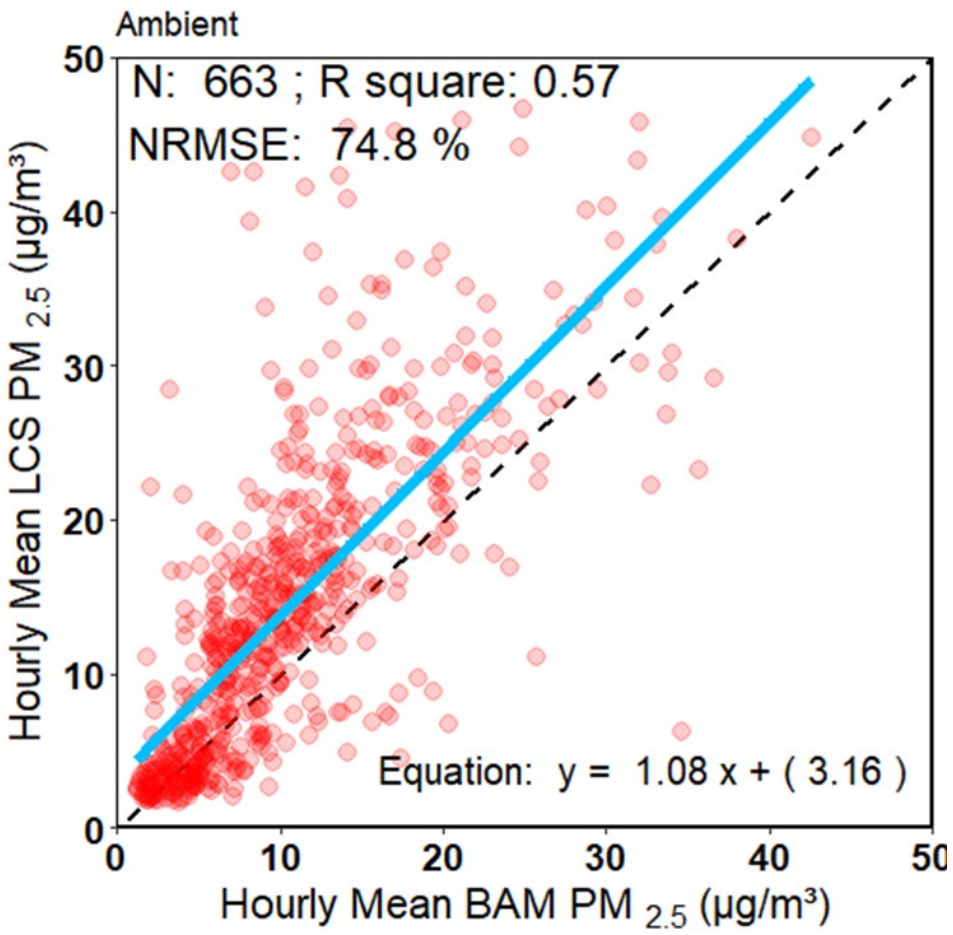


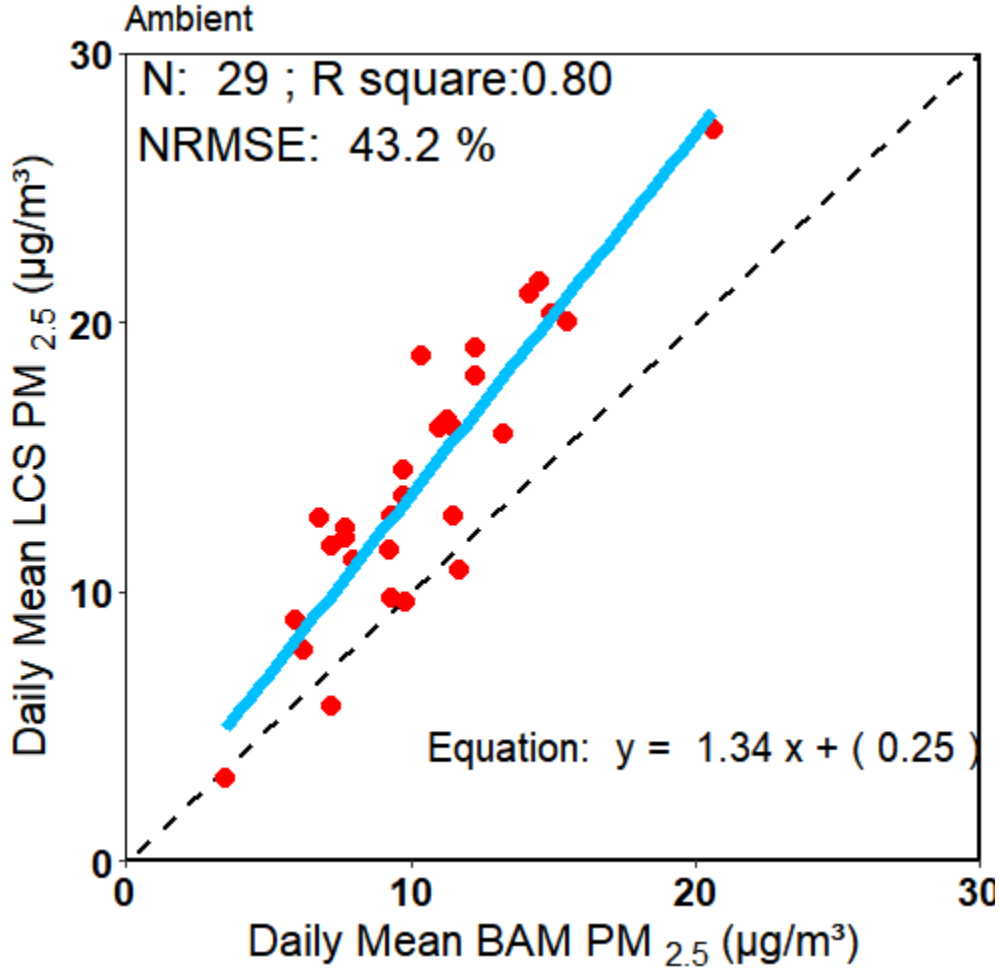
Median: 56.2 µg/m³

IQR : 18.6 µg/m³

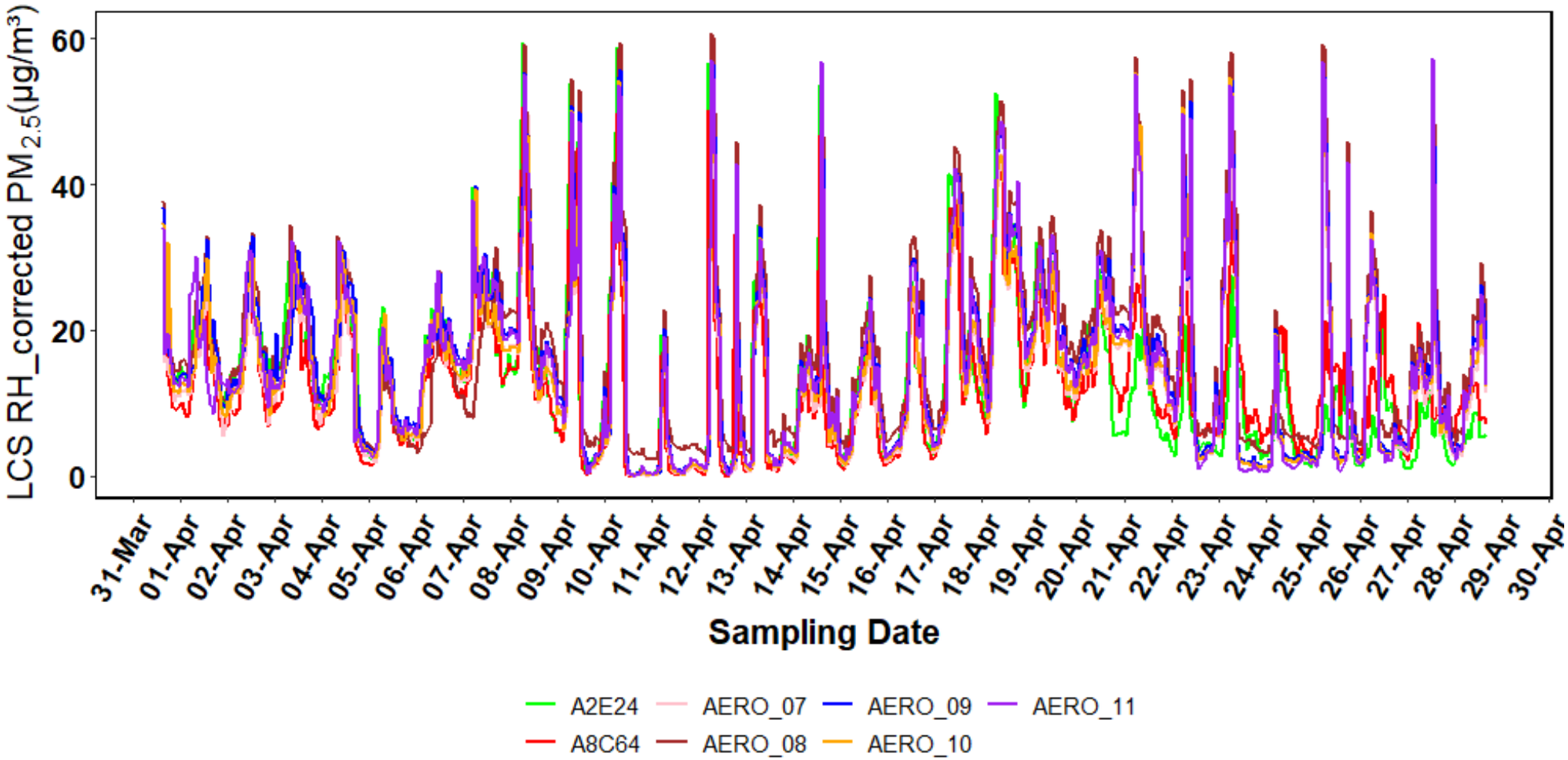
Range: 35.6 –110.3 µg/m³

Ambient Collocation: 1- and 24-hour averaging times



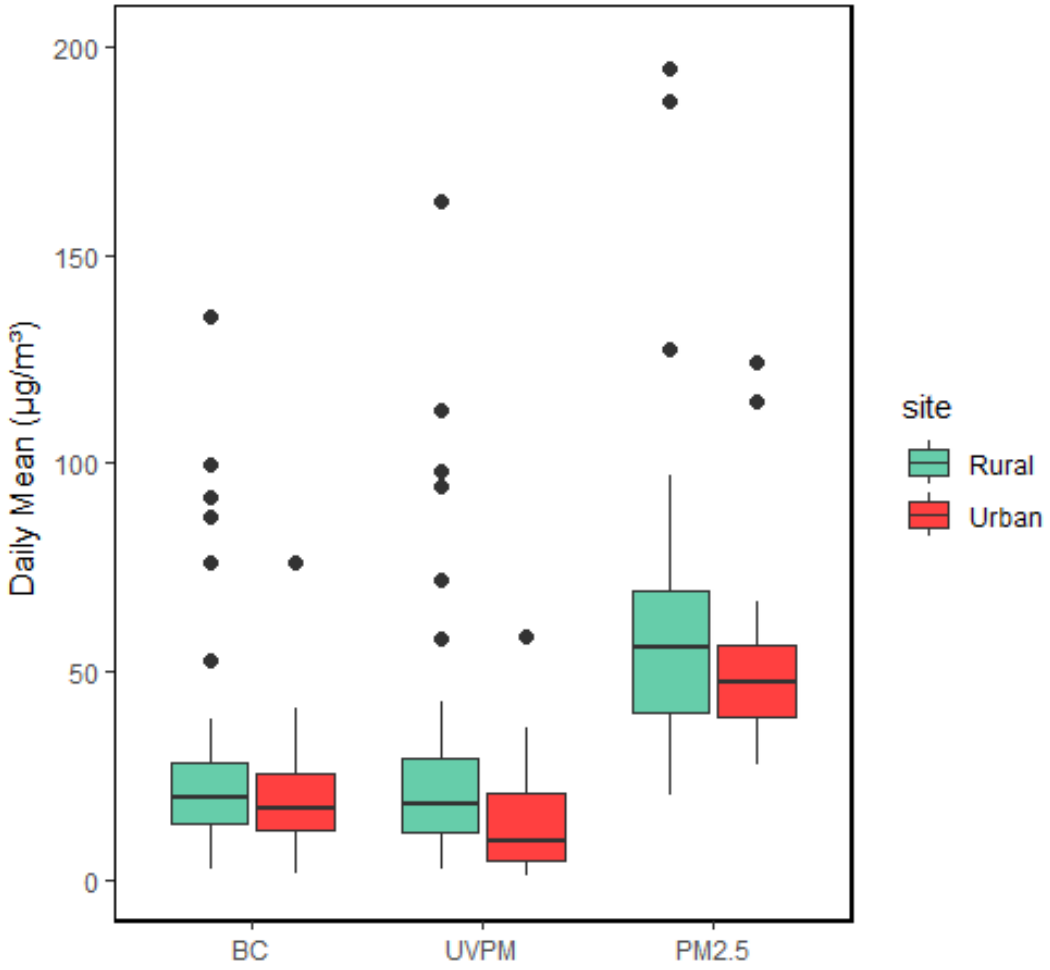


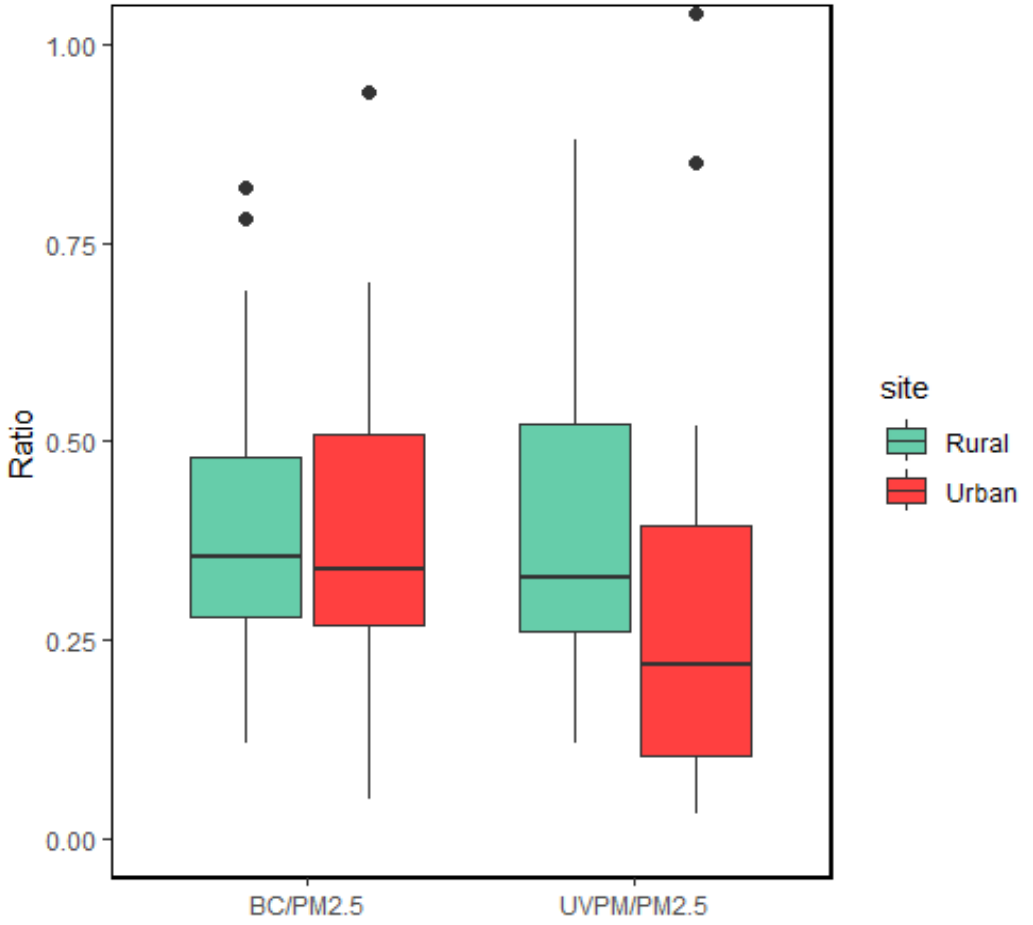
Ambient PM monitoring: Precision test



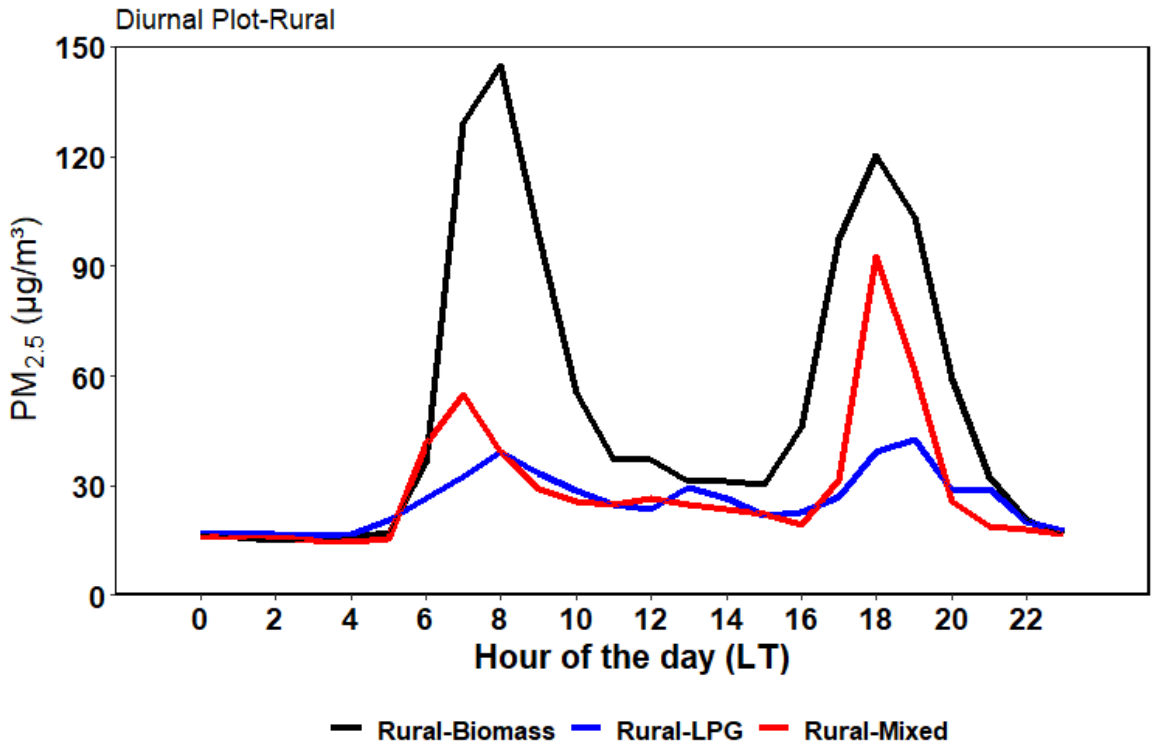
SD = 2.2 (µg/m³)
CV = 15.6%

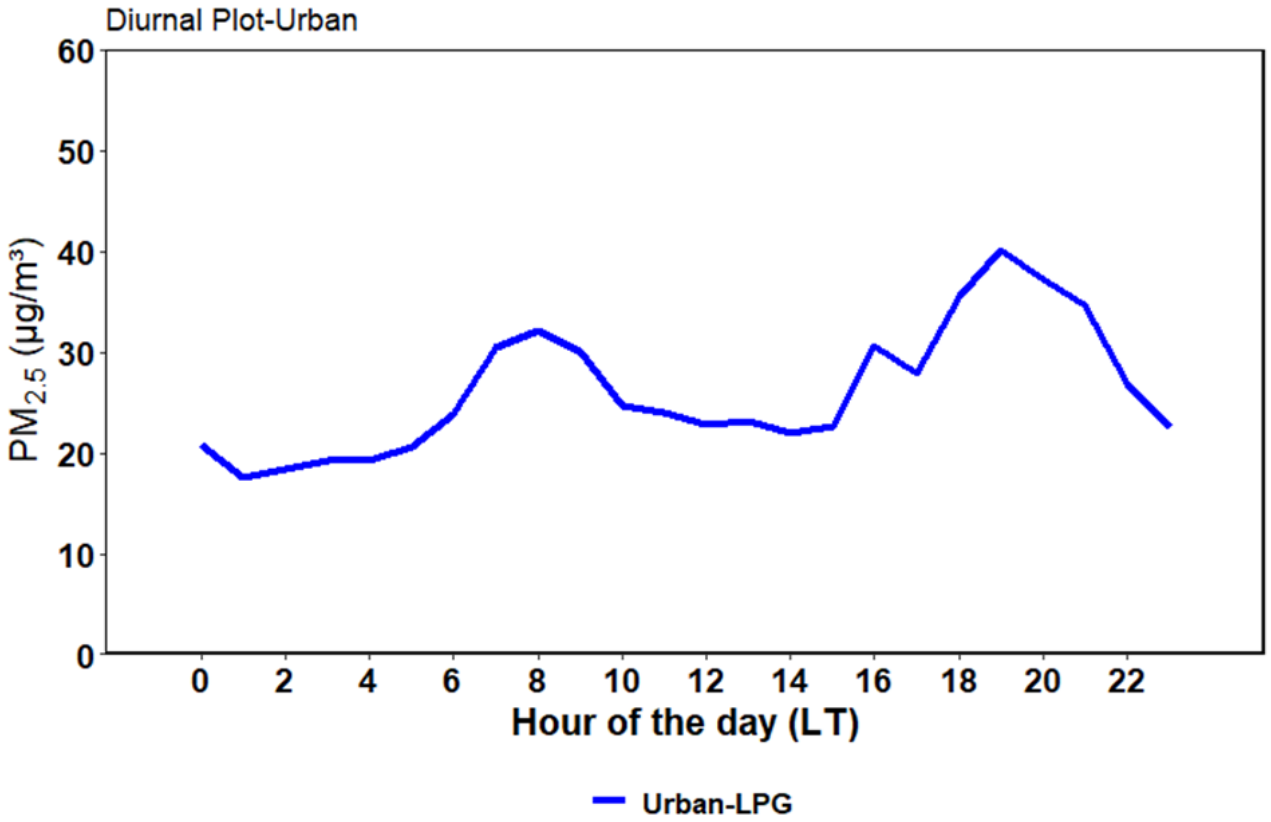
Black Carbon:PM ratio



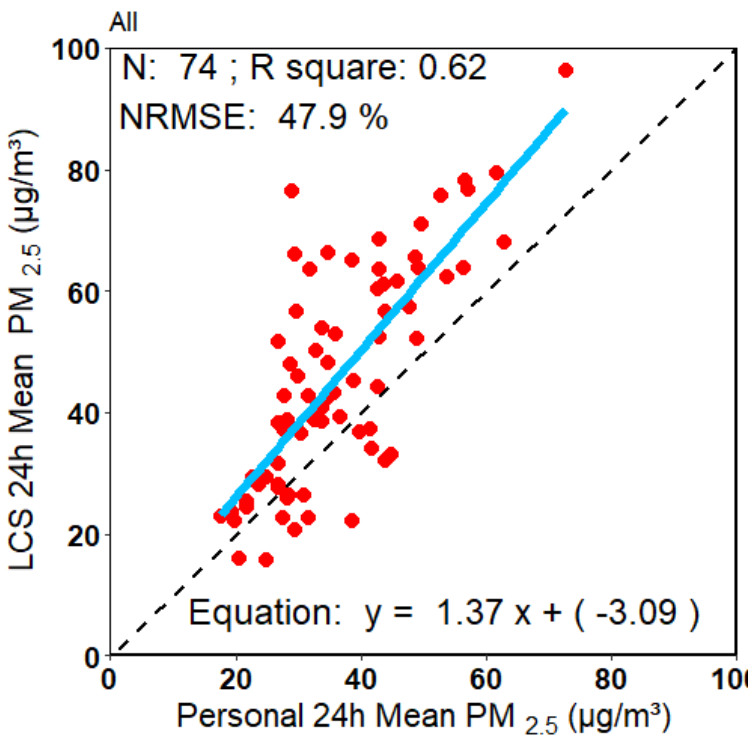


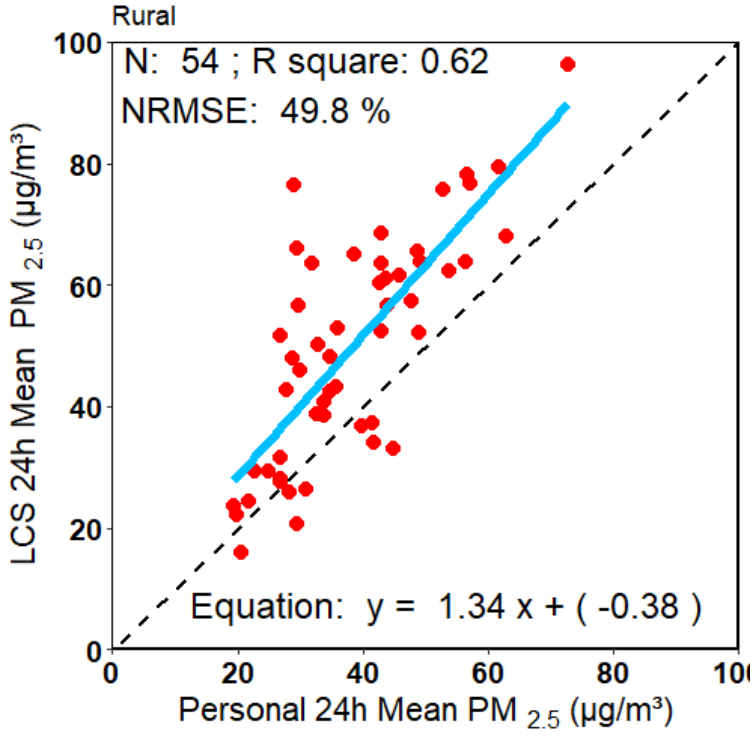
Indoor PM monitoring: Hour of the day

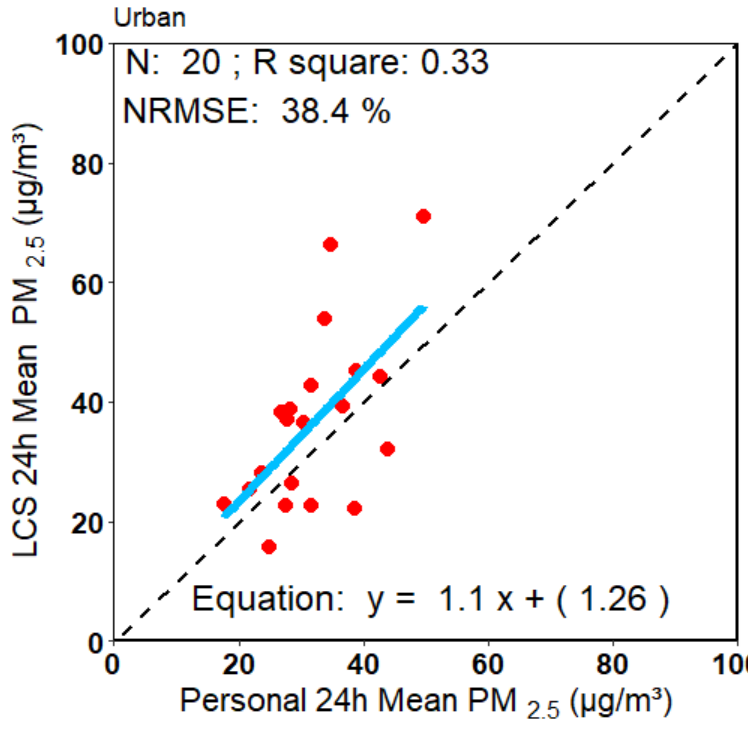




Personal exposures *vs* LCS PM levels

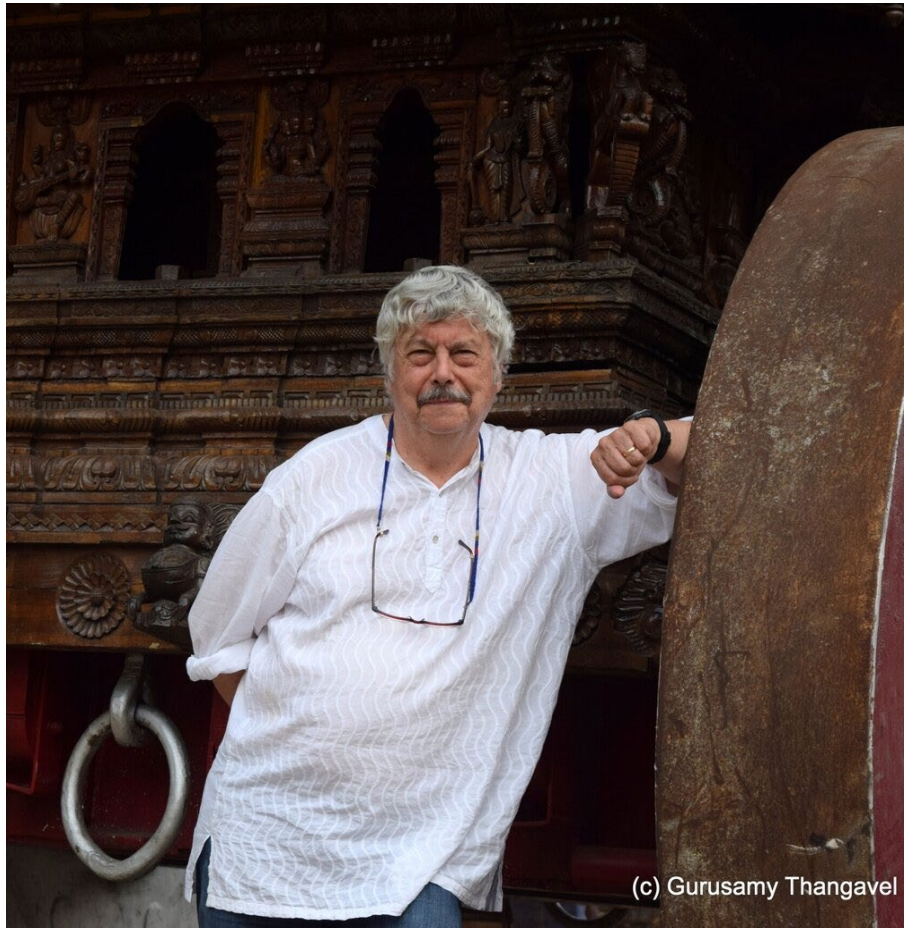






CONCLUSION

- The bias in indoor LCS collocation was almost constant, while it increased with increase in ambient PM2.5 values
- Humidity correction of LCS is key to reducing bias
- 24-h personal exposures were significantly correlated with 24-h LCS living room PM2.5 concentrations
- Low-cost sensors offer a suitable platform for long-term monitoring of indoor PM in health-effect studies



Dedicated to the memory of and inspired by

KIRK R. SMITH

Jan. 19, 1947 – June 15, 2020

- **Crusader of '*clean household energy*'**
  - First person in human history to measure personal exposures to HAP in women in India in 1981
  - Worked in India for over 4 decades on HAP
  - His relentless efforts advocating HAP mitigation in India influenced PMUY policy and research
- **His legacy continues to inspire many of us.**

Kirk R. Smith • Professor of Global Environmental Health • University of California, Berkeley (kirkrsmith.org)

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Study participants
TAPHE-2 Research staff

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