ASIA CLEAN ENERGY FORUM 2018

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Track: Innovations in Energy Efficiency

Session: Multiple Benefits of Energy Efficiency – A Focus on Air Pollution

Impact of Energy Efficiency of Cook stoves on Indoor Air Quality

A Case Study in the Estate Sector Households of Sri Lanka

Thusitha Sugathapala

Department of Mechanical Engineering

University of Moratuwa

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BACKGROUND

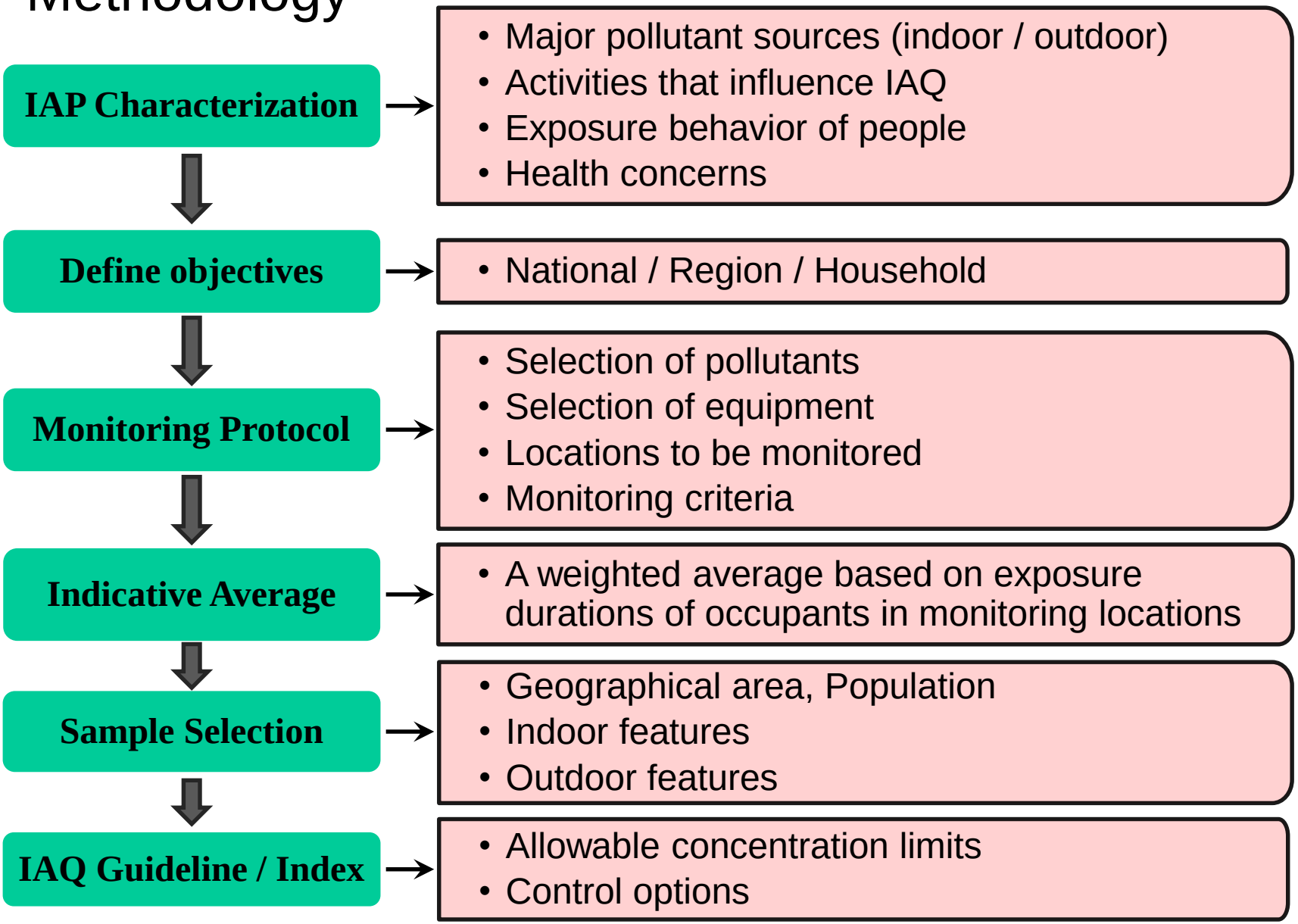
- Energy Efficiency Initiatives in Sri Lanka
  - A key intervention in energy sector
    - ✓ DSM programmes in the power sector
    - ✓ Modern biomass energy programme in the thermal energy sector.
  - Biomass energy
    - ✓ Main source of energy in domestic, commercial & industrial sectors
    - ✓ Use of conventional technologies is still prominent
    - ✓ Fuel quality and technology standards are being developed.
- Air Quality Management
  - Represents the overall intervention in environment sector
    - ✓ Includes monitoring, modelling, impact assessments, regulations,..
    - ✓ Covering both indoor and outdoor air quality issues.
  - Indoor air quality (IAQ)
    - ✓ More severe issue than outdoor AQ (concentrations, exposure)
    - ✓ IAQ guidelines are being developed.

BIOMASS COOKSTOVES IN SRI LANKA

- Fuel
  - Mainly fuel-wood (in stick form)
  - Limited use of agro-residues (sawdust / paddy husk), pellets, charcoal and biogas.
- Process
  - Mainly direct combustion of solid fuel (limited use of gasification).
- Technology
  - Both conventional and improved cookstove technologies
  - Single pot and two pot.
- Issues
  - Low efficiency
  - High emissions.

INDOOR AIR QUALITY GUIDELINE

- Methodology



CASE STUDY

- Biomass Cooking in Estate Sector Households
  - Objectives
    - ✓ To establish energy and environmental performances of biomass cookstoves
    - ✓ To assess the degree and effects of indoor air pollution.
  - Parameters
    - ✓ Sample: 70 Households
    - ✓ Variations:
      - House design
      - Location of the kitchen,
      - Location of the stove,
      - Cookstove design,
      - Presence of a chimney.
    - ✓ Energy conversion efficiency – Water boiling test
    - ✓ Emissions factors (CO_2, CO, CH_4, TSP, SO_X, NO_X)
    - ✓ Ambient air quality (CO and $PM_{2.5}$).

CASE STUDY

- Types of Houses

Temp. Shed

Self- Help / Single Cottage

Twin Cottage

Single Barrack

Double Barrack

Multistory

CASE STUDY

- Location of the Kitchen

Within the House / Separate Room

Within the House / Simple Partisan

Separate from the House

CASE STUDY

- Cookstove Design

Most common types

CASE STUDY

- Elevation of the Stove

- Ventilation

CASE STUDY

- Performance of Stoves
  - Three main variants:
    - ✓ Three-stone stoves
    - ✓ Semi-enclosed stoves
    - ✓ Two or multi-pot stoves with liners
  - Energy efficiency:

Type of stove	Efficiency (%)	Fuel type
Three stone	6.0 – 9.5	Fuel-wood
Semi-enclosed	11.5 – 15.0	Fuel-wood
Two or multi-pot stoves with liners	16.0 - 22.0	Fuel-wood

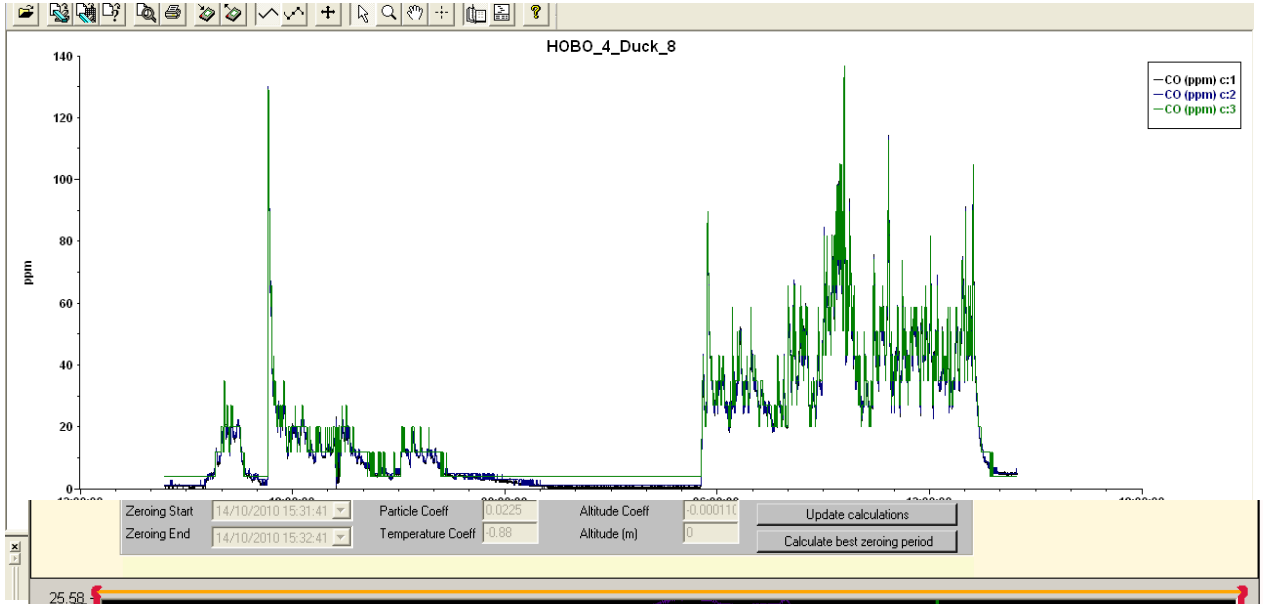
  - Emission Factors:

Type of stove	Mean Emission Factors (g/kg of fuelwood)				
	CO_2	CO	CH_4	TSP	NO_x
Three stone	1151.4	46.6	7.6	7.6	1.3
Semi-enclosed	1104.0	74.8	8.7	8.8	1.3
Two or multi-pot stoves with liners	1056.7	103.0	9.8	10.0	1.2

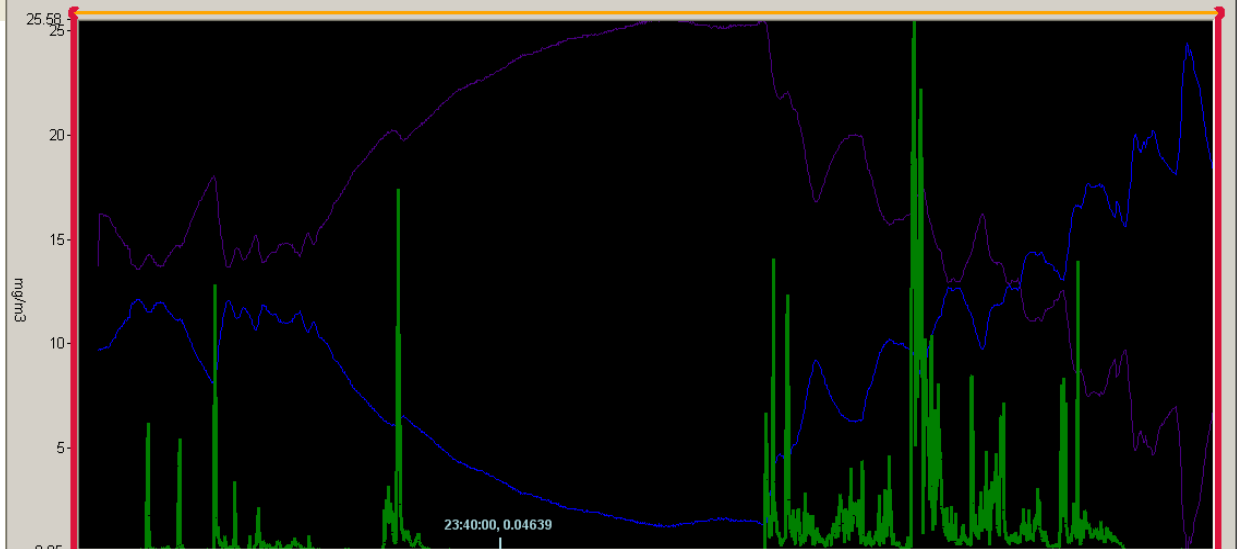
CASE STUDY

- Indoor Air Quality
  - Time series data:

CO

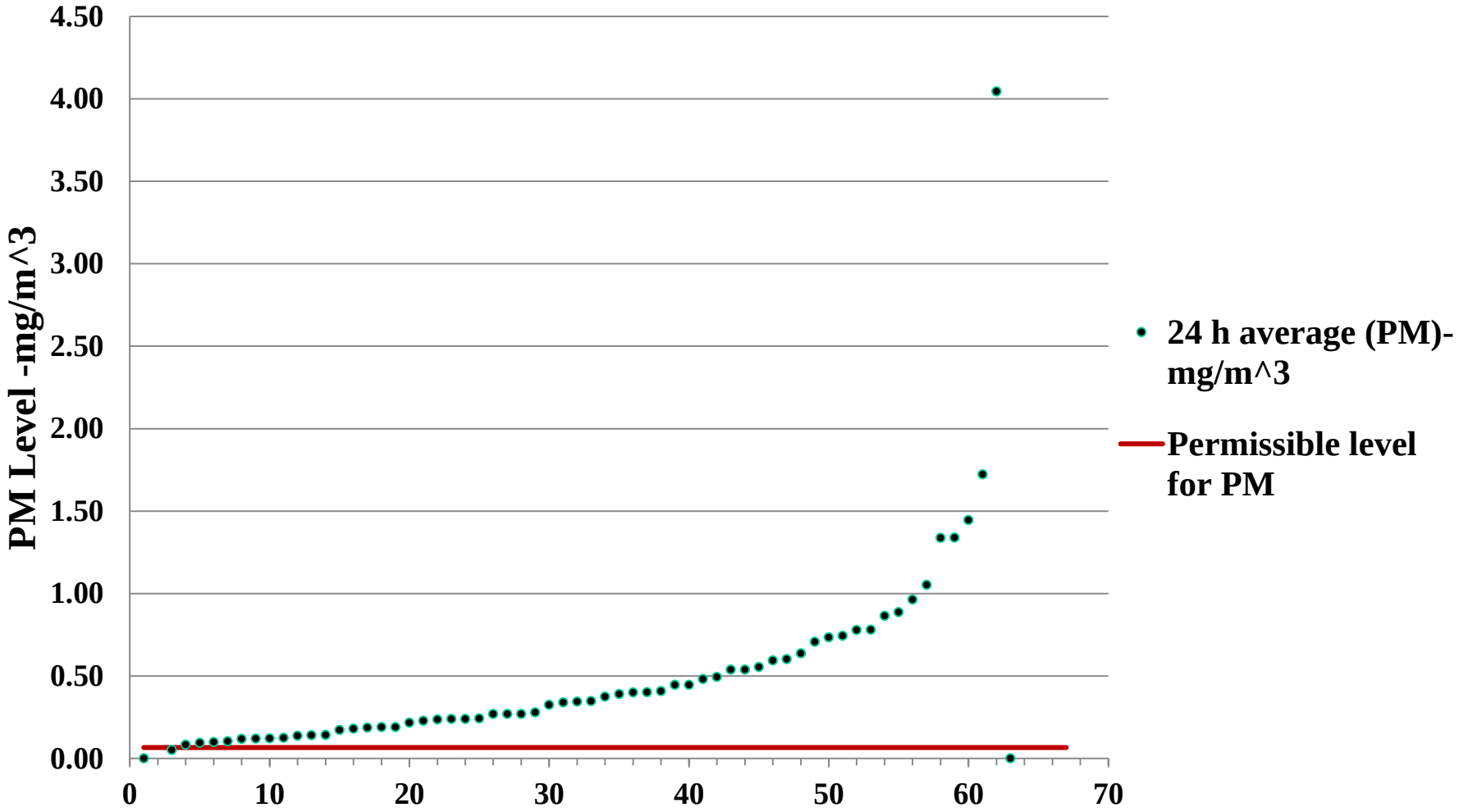


$PM_{2.5}$



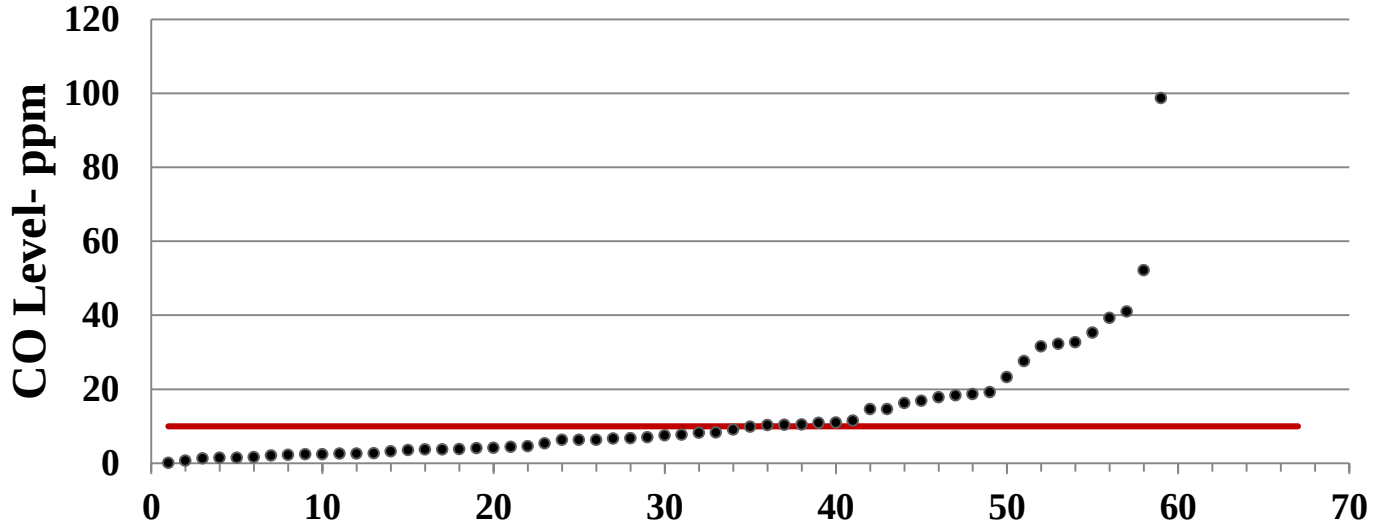
CASE STUDY

- Indoor Air Quality
  - Particulate Matter ($PM_{2.5}$):

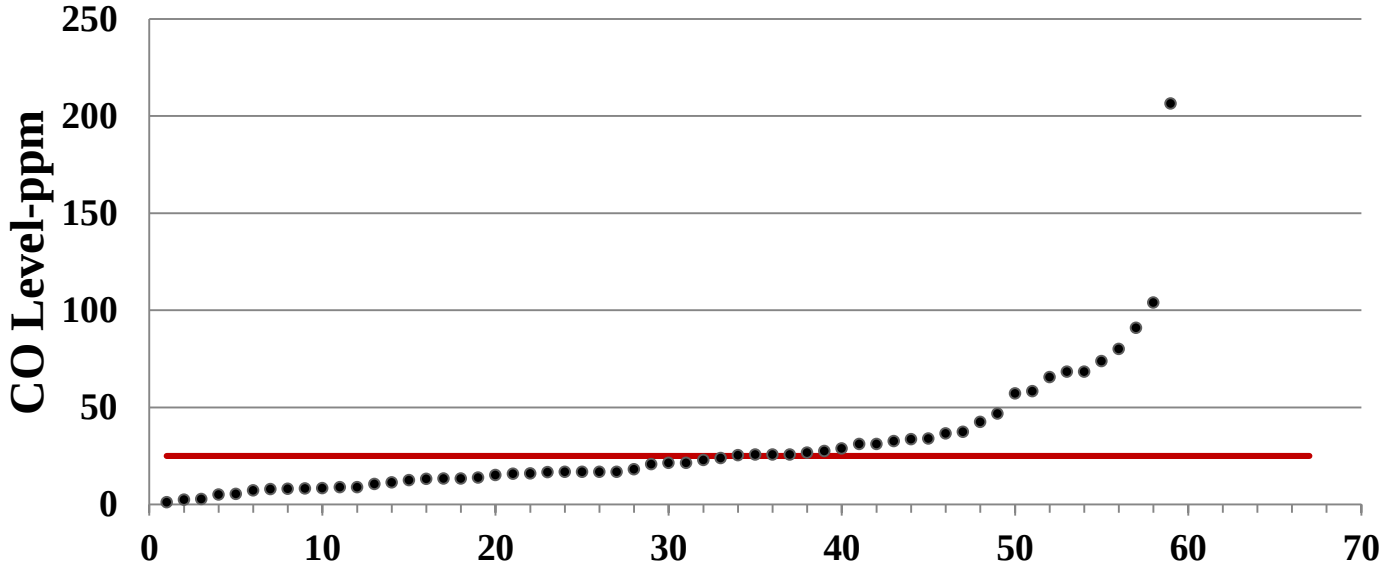


CASE STUDY

- Indoor Air Quality
  - Carbon Monoxide (CO):



8 hr Average



1 hr Average

CONCLUSIONS

- Majority of the households use low efficient conventional stoves
  - ✓ Emissions are directly related to energy conversion efficiencies.
- Very high level of PM concentrations in all HHs, exceeding WHO IAQ guidelines
  - ✓ Combustion of solid biomass fuels.
- 50% of the HHs exceed CO levels
  - ✓ Incomplete Combustion
  - ✓ Conventional stoves.
- Significant improvements in IAQ with the use of improved cookstoves and a chimney.
- Considerable opportunities for fuel-wood saving through introduction of improved cooksotves
  - ✓ And associated social, environmental (and economic) benefits.

Thank You