gtz HERA Poverty-oriented basic energy services

Short Overview on Indoor Air Pollution (IAP) Reduction and Measuring Options

What are the most relevant pollutants in emissions from non-electric cook-stoves?

Particulate **Matter (PM)**: Aerosols, with focus on respirable particles that stay in the lungs like particles with diameters <1 micron (=PM 1), PM 2,5 and 10, considered most relevant for human health. Out of the PM the soot particles or Black Carbon have probably most severe impact on global warming.

Carbon Monoxide (CO): inodorous toxic gas mostly due to incomplete combustion, levels are closely related to PM when burning wood.

Greenhouse Gases: Nitrogen oxides (NO_x), Sulfur Oxides (So_x), Carbon Dioxide (CO_2), Methane (CH_4) and other gases are suspected to contribute to global warming.

What is important to measure to determine the impact and effects on human health?

Pollution levels: Type and concentration of indoor and outdoor pollutants

Personal exposure: Duration of exposure to peak and background concentration levels (indoor and outdoor), resulting in different doses of pollutants e.g. of CO in breath.

What can be done to reduce IAP in the system 'Fuel - Stove - Living Environment - User'?

Changing the source of pollution:

- **Improved fuels:** Gaseous and liquid fuels tend to have less emissions, depending on how they are burnt. With solid fuels the moisture content has a great impact on the emissions: dry fuels tend to have less emissions than the same fuel with a high moisture content. Where applicable: Solar cooking = zero emissions.
- **Improved cooking devices / stoves:**
  Better fuel efficiency: less absolute pollution per cooking task.
  Chimneys: guide flues outside kitchen and reduce IAP (= user exposure levels), but increase outdoor pollution at expense of neighbours. No absolute emissions reduction, on the contrary: chimneys often increase fuel use per cooking task.
  Cleaner combustion: cleans up pollution at source and reduces both indoor and outdoor pollution. Currently among the stoves depending on solid fuels, Gasifier Stoves and other stoves with forced air have lowest emission levels.
- **Reduced need for fire**
  Technologies to reduce need for fire: retained heat cooker (haybox), pressure cooker, windshield ('skirt') around pot, efficient housing design and construction, solar water heating.

Improving the living environment:

- **Kitchen design**: Kitchen separate from houses reduces exposure of family, higher stove placement reduces exposure of cook leaning over fire.
- **Improved ventilation** (windows, ventilation slots, eaves spaces, smoke hoods) can reduce exposure levels up to 70%.

Modifying user behaviour:

- Sensitizing user on negative impact of IAP on health and modifying user behavioral.
- Training of user to operate stove in an optimised way: use of dry optimally sized fuels, use pots with lids, food preparation to reduce cooking time, stove maintenance.

What are measuring options for the pollutants CO and PM considered most damaging to human health?

CO- Area monitoring: stationary monitoring of CO in ambient air over time with

- bag collection and lab analysis (only snapshot data, no continuous data-logging)
- electrochemical sensors (in off-the-shelf products like HOBOs Aprovecho meter etc, converts CO gas to electrical signal, cont. data logging).

CO- Personal monitoring: mobile monitoring of breathable CO by devices that can be worn by a person:

- Colour-change diffusion tubes (total exposure, not specifying time-activity data or concentrations, cost 10US$/unit).
- Electro-chemical monitors (real-time data reflecting peak concentrations, precision 0.2-2 PPM, cost 250-600 US$).

CO inside the human body:

- Exhaled breath (measured in parts per million (PPM) of CO with a tube to blow-in, not usable for children, as they don't have the strength required).
- Blood carboxyhemolgobin:
  - ➢ Invasive by extracting blood sample for analysis in lab: Optical CO-oximetry or Gas chromatography.
  - ➢ Non-invasive: Signal Extraction Pulse on thumb: new RAD57 by Masimo (less suited for low levels, better for high exposure e.g. firefighters, people living in poorly ventilated homes).

PM main detection methods:

- Gravimetric (sucking air through a filter and weighing the particles deposited in a climate-controlled lab with a high-precision scale).
- Light-scattering (measuring the scatter of laser light resulting from suspended particles in the air, real-time data, particle size-sensitive).

Overview on devices for measuring PM

	Data measured	**Air flow**	**Real-time data logging**	**5-day options**	**Portability for personal monitoring**	**Size selection**	**Minimum detection limit**	**Detection method**	**Estimated cost (USD) per unit**
Pump & Filter (needs climate controlled lab)	PM, size depending on cyclone	External Pump	no	yes	Normally not, can be placed in backpack	Specify with cyclone	Depends on balance and volume sampled	Gravi-metric	1,000 unit, + $40/sample +cost of lab balance
TSI DustTrak	PM 1, 2.5, 10	Internal Pump	yes	yes	Portable, but too heavy for backpack	New models measure all sizes at once	~1 $\mu g/m^3$	Light scattering	6,500
TSI SidePak	PM 2.5, 10	Internal Pump	yes	yes	Suitable for wearing	Depends on filter	~1 $\mu g/m^3$	Light scattering	5,400
UCB Particu-late Monitor	0.5 µm – 5 µm	No pump	yes	yes	No	None	50 $\mu g/m^3$	Light scattering	400-500
Aprovecho IAP meter	PM 1, 2.5, and CO	Internal Pump	yes	yes	Suitable for wearing	None	~30 $\mu g/m^3$	Light scattering	2,000

Aprovecho Research Laboratory have also developed a bigger variation of the IAP meter: the PEMS (Portable Emissions Monitoring System) is better suited for more accurate stationary stove tests, but not suited for personal exposure monitoring.

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Sources: Kyra NAUMOFF (2005): Presentation to PCIA, Center for Entrepreneurship in International Health and Development at the Univ. of California at Berkeley; WHO (2008): Evaluating household energy and health interventions: A catalogue of methods.
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