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Impact of Biomass Combustion on Indoor Air Quality in Developing Countries

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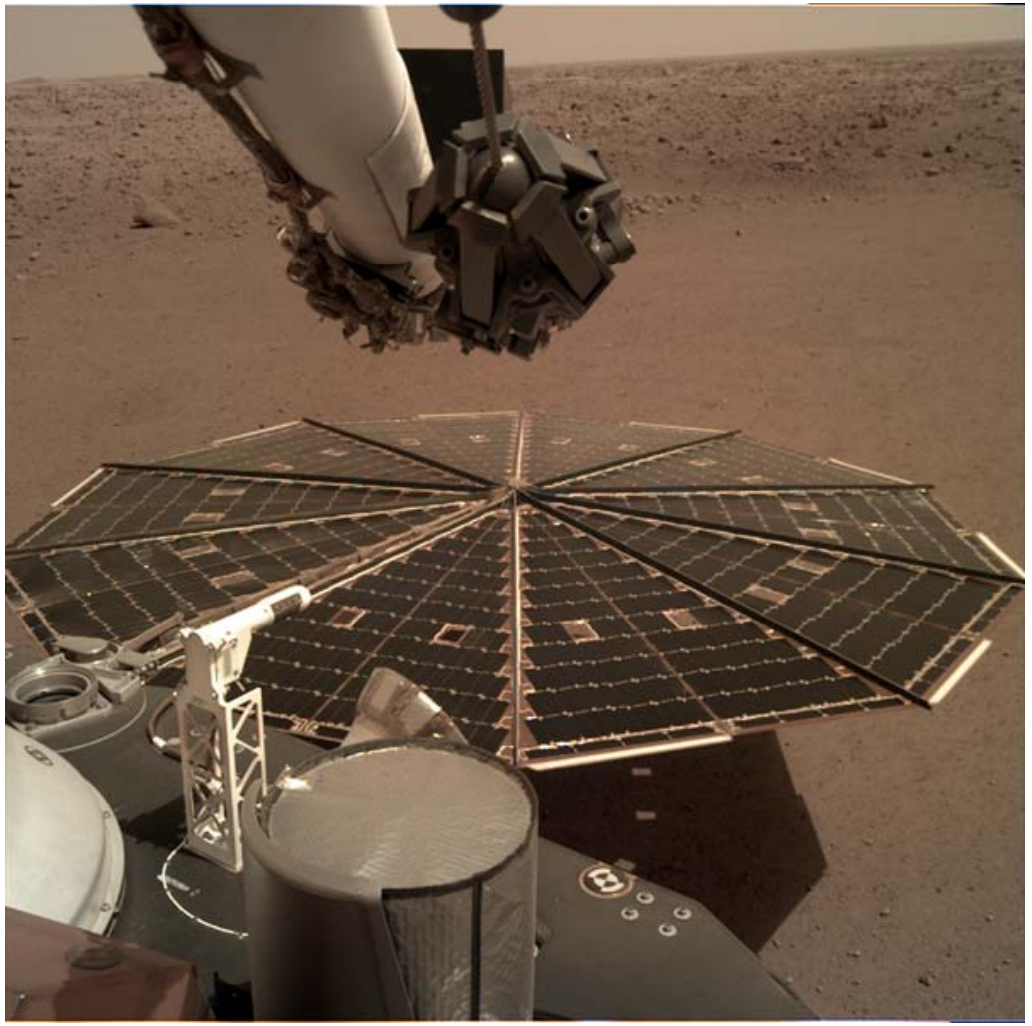
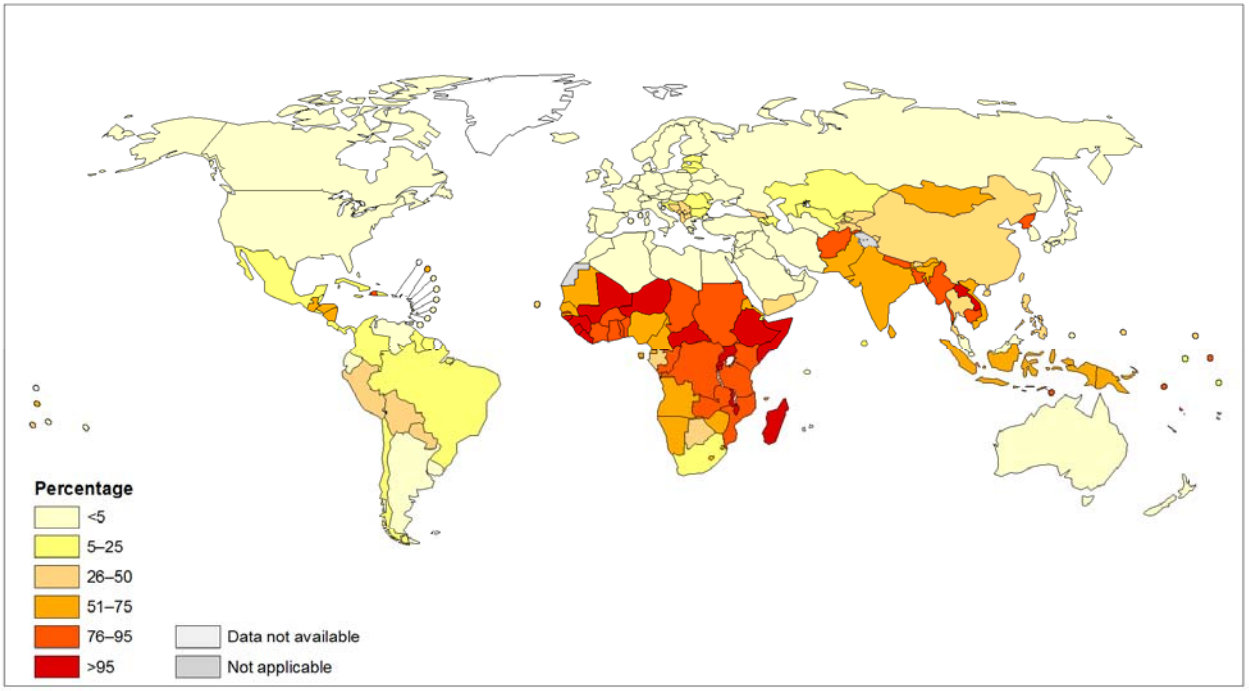
What Does Mars Sound Like? InSight Just Recorded Martian Wind



In Earth

- **Population using solid fuel (%) at 2010**

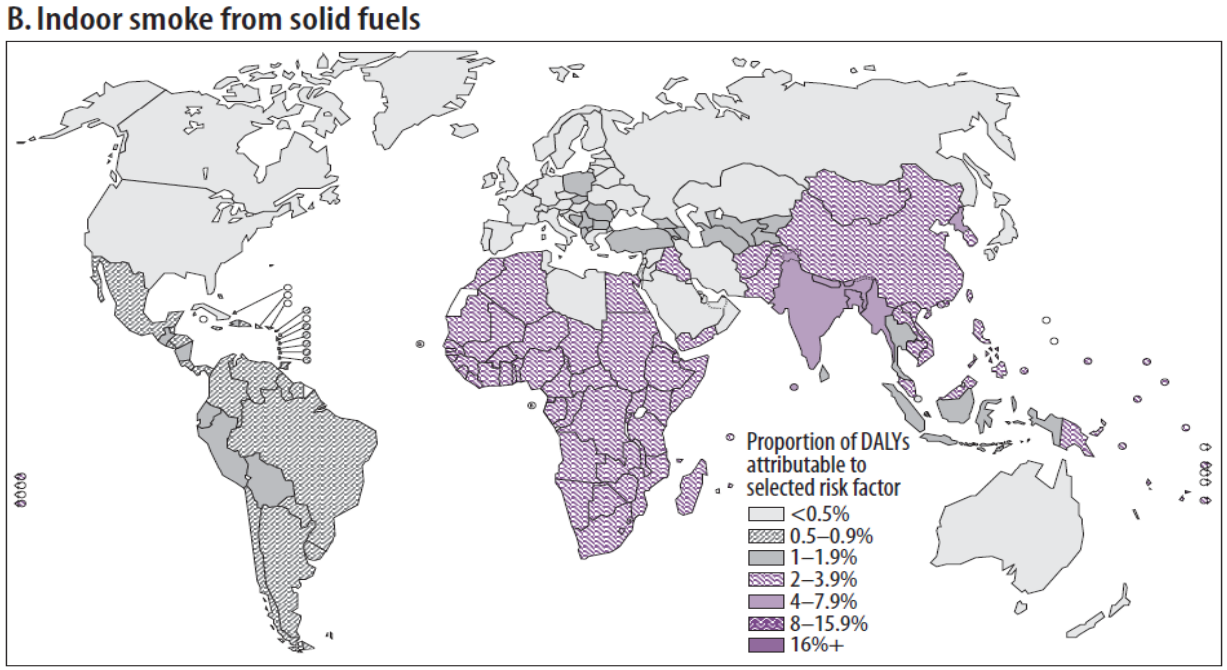


(WHO, 2014)

- When solid fuel is incompletely burned in the room, indoor air pollutants such as $PM_{2.5}$ and volatile organic compounds may occur at a high concentration.

Impact of solid fuels

- Indoor air pollution (IAP) resulting from solid fuels which burn in open fires or simple stoves is a major threat to health of residents.



(WHO, 2002)

Burden of disease attributable to selected environmental risk factors (% DALYs in each subregion)

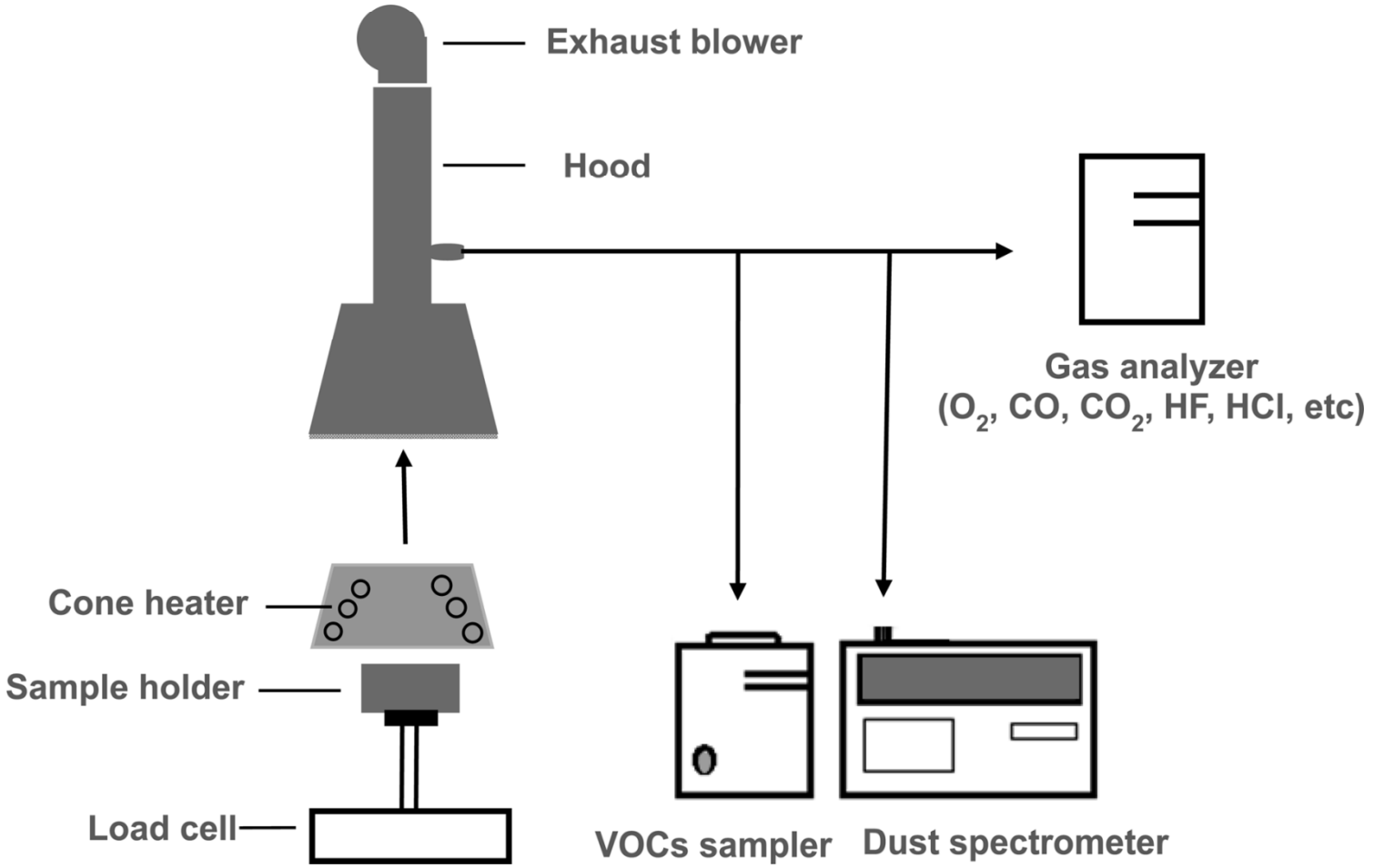
- Women and vulnerable groups, including children and the elderly who spent most of their time in the house had higher health risk.

Biomass Combustion in Developing Countries in ASIA

- More than 50% of those living in developing countries rely on biomass fuel.
- The major sources of domestic biomass fuels are wood, **dung**, and crop residue.
- Biomass fuels are often burnt without a proper ventilation system -> causing indoor air quality problems.
- WHO recommends that **unprocessed coal** should not be used in residence.

Cow Dung as Fuel

Experimental Methods



PM emission factor

	15 kW/m^2 (Ignition stage)	25 kW/m^2	50 kW/m^2 (burning stage)
$PM_{2.5}$ (mg/kg)	1309	589	41
PM_{10} (mg/kg)	3476	589	43

If the typical amount of dried cow dung for each meal preparation is assumed to be 0.7 kg, 30 mg of PM_{10} could therefore be generated (based on 50 kW/m^2). Most of them were $PM_{2.5}$.

VOCs emission factors

	EF (mg/kg)		
heat flux (kWm^2)	15	25	50
Methylchloride	114.3 ± 32.2	29.6 ± 23.4	NA
1,3-butadiene	116.9 ± 27.4	143.0 ± 30.9	85.7 ± 2.3
Acetone	1420.1 ± 99.0	1522.0 ± 25.5	277.5 ± 4.4
Vinyl acetate	229.2 ± 28.7	454.8 ± 18.2	81.1 ± 0.7
Methyl ethyl ketone	471.0 ± 14.1	471.3 ± 20.5	61.9 ± 1.4
Hexane	69.5 ± 3.6	77.6 ± 1.4	8.0 ± 0.2
Benzene	312.5 ± 9.5	372.6 ± 6.5	154.8 ± 1.1
Heptane	60.9 ± 2.3	101.9 ± 63.9	19.3 ± 0 .3
Methyl isobutylketone	20.0 ± 0.9	16.7 ± 0.8	5.3 ± 0.1
Toluene	495.3 ± 7.5	607.0 ± 5.2	121.5 ± 3.3
Ethylbenzene	67.5 ± 0.6	83.8 ± 1.7	19.6 ± 0.1
m,p-Xylene	88.7 ± 1.1	113.3 ± 2.4	27.5 ± 0.1
Styrene	119.0 ± 2.1	160.6 ± 2.9	42.1 ± 0.4
o-Xylene	42.7 ± 0.3	55.2 ± 1.0	13.4 ± 0.1
1,2,4-Trimethylbenzene	21.6 ± 0.6	27.5 ± 0.7	11.1 ± 0.0
Benzyl chlororide	35.3 ± 3.1	35.9 ± 2.7	27.0 ± 0.7
1,2,4-Trichlorobenzene	23.7 ± 20.5	NA	NA

Cancer implication

- If the amount of dried cow dung used for the preparation of each meal is 0.7 kg, 108−261 mg of benzene can be generated. With a typical kitchen volume of 50 m^3, the benzene concentration could reach 2.17−5.22 mg/m^3 (0.68−1.6 ppm) without ventilation.
- This level is higher than the occupational exposure standards of 0.5 ppm [ACGIH threshold limit value time-weighted average (TLV TWA)] and 0.1 ppm [NIOSH recommended exposure limit (REL) TWA].

Air pollution in Mongolia

Background

- Ger, traditional dwelling of Mongolian is a one-room type house without a window and used individual stoves to heat and cook.

Observation

- Solid fuel Usage Pattern

Traditional Stove

Improved Stove

Other fuel included plastic, tire piece, vinyl, garbage etc.

The amount of fuel usage : 8758±4155 g during day time (N=26)

PM emission factor of coal samples

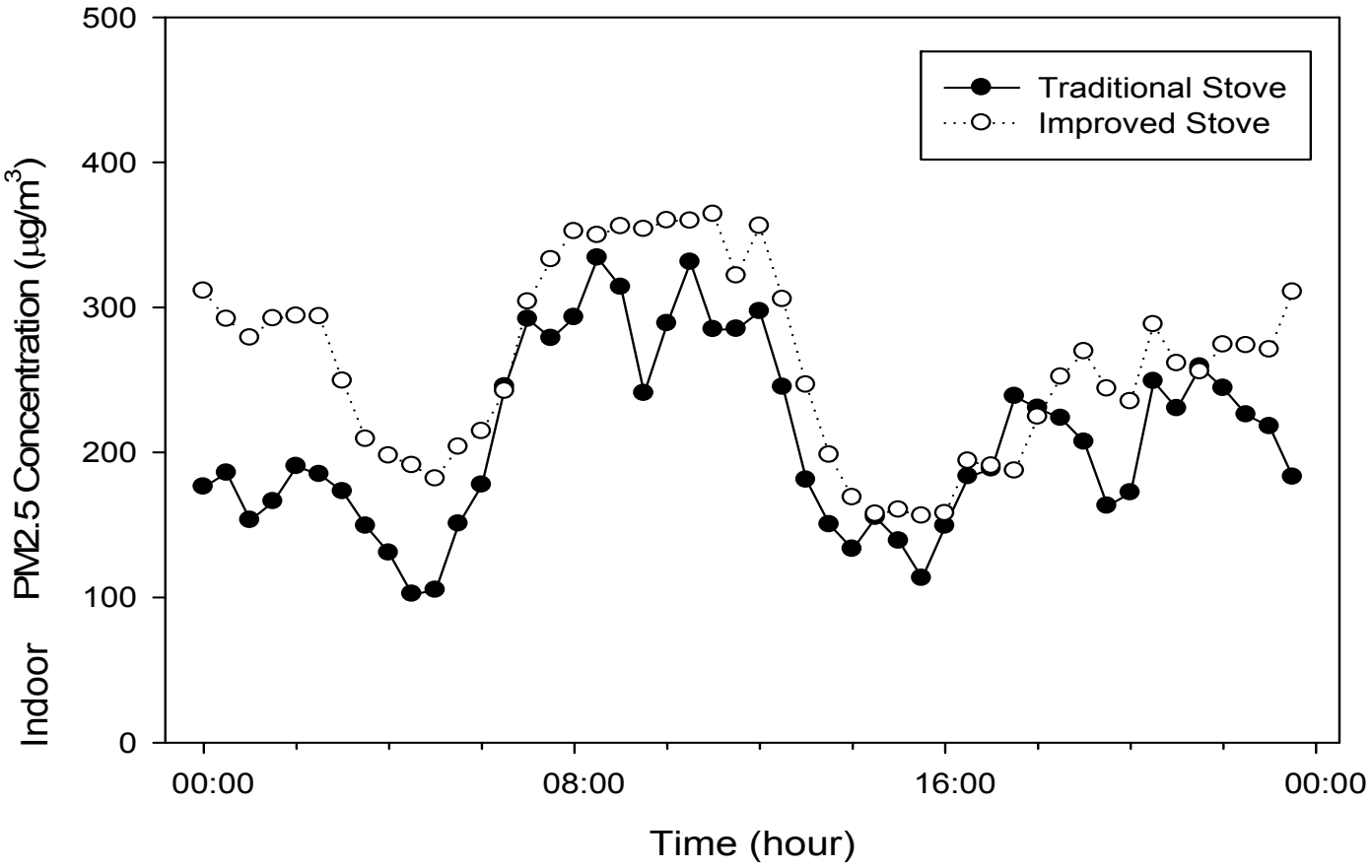
	Alag Tolgoi (coal 1)	Baganuur (coal 2)	Nalaikh (coal 3)
$PM_{1.0}$ (mg/kg)	1,002.5 ± 422.1	822.8 ± 504.6	461.2 ± 56.0
$PM_{2.5}$ (mg/kg)	1,043.5 ± 458.0	892.7 ± 545.5	471.5 ± 57.0
PM_{10} (mg/kg)	1,122.9 ± 135.4	958.1 ± 584.0	472.0 ± 57.1

Combustion stage only

VOC emission factor (mg/kg)

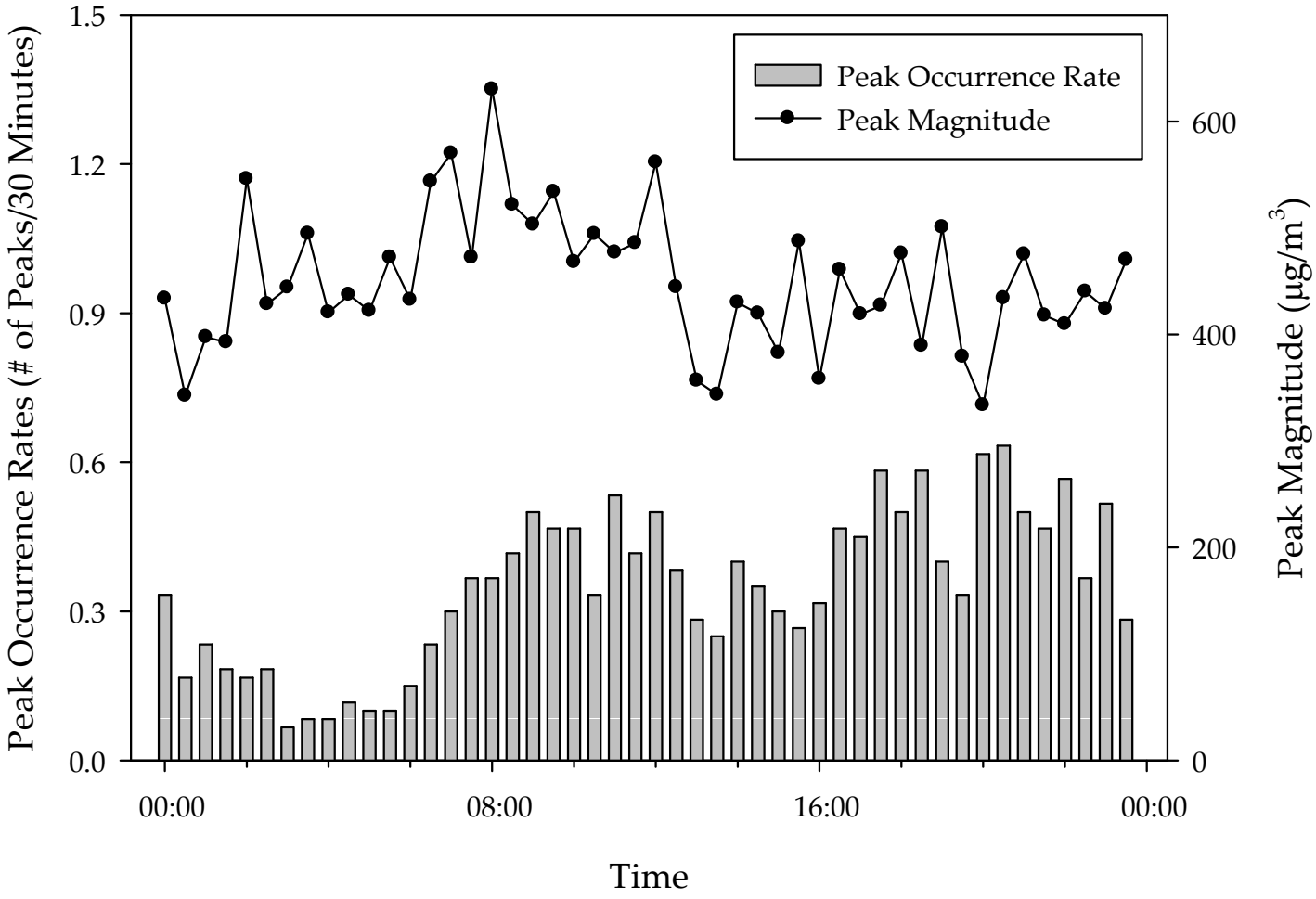
Compounds	Alag Tolgoi (coal 1)	Baganuur (coal 2)	Nalaikh (coal 3)
Acetone	88.6±17.2	161.5±68.9	158.2±88.5
Isopropyl alcohol	88.1±4.1	103.6±14.2	89.3±26.9
Methyl ethyl ketone	66.1±30.0	125.8±54.6	151.7±134.4
Tetra hydrofuran	78.8±15.4	132.9±5.1	115.8±32.2
Benzene	105.1±27.8	180.2±134.9	79.8±20.7
Toluene	102.7±13.7	152.2±128.2	98.7±58.2
m,p-xylene	49.3±6.8	73.5±60.5	59.8±38.4
Heptane	43.4±3.4	34.4±23.6	22.7±9.4
o-xylene	26.8±4.2	29.4±22.8	21.9±13.1
Ethylbenzene	19±1.8	33.5±24.6	19.6±11.6
1,2,4-Trimethylbenzene	22.6±4.6	23.2±11.3	21.6±11.5

$PM_{2.5}$ by stove type



30 Minutes average of $PM_{2.5}$ concentrations by stove types

Factors of $PM_{2.5}$ profile



Conclusion

- Use of biomass in indoors can cause serious indoor air pollution.
- Dung combustion can cause high benzene concentration.
- Unprocessed coal combustion in Mongolia can cause serious indoor and outdoor air pollution.
- Other fuels may be more serious problem.
- Application of improved stove needs evaluation in lab and field.

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