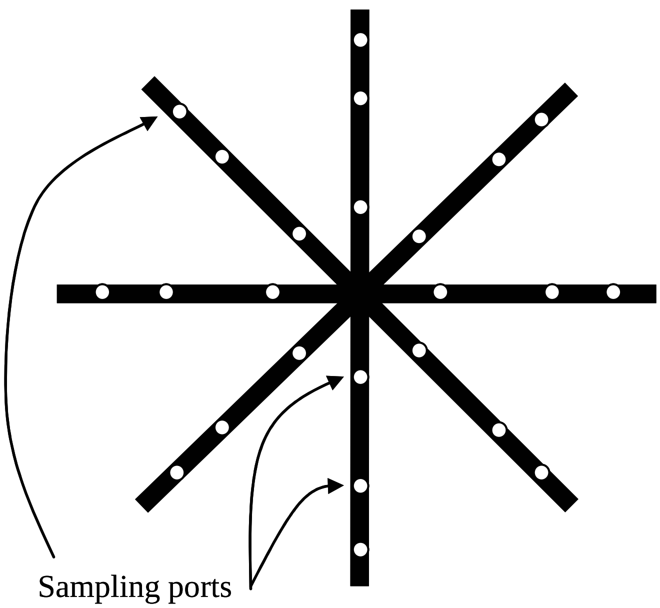
Supporting Information

Roden *et al.*, Emission Factors and Real-time Optical Properties of Particles Emitted from Traditional Wood Burning Cookstoves, es052080i

Sampling Probe

Sketch and drawing, including dimensions

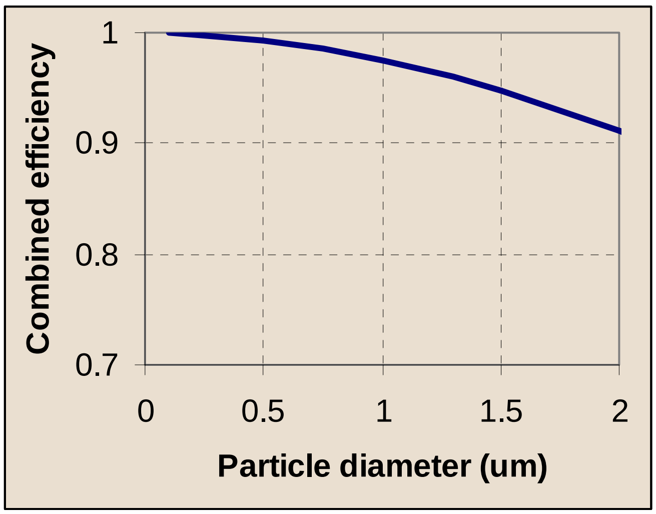


8 sampling arms each with a length of 50 cm (1m across).
Each Sampling arm has three holes.
Holes are located at 14.5, 33, and 43.5 cm out from the center.
Each hole has a diameter of 0.35 cm.

Particle Losses

Probe Efficiency:

We estimated the probe efficiency using relationships given by Brockmann (1993) for aspiration efficiency and bend efficiency. We used estimated aspiration efficiency due to sampling at a 90 degree angle, which provides a conservative (high) estimate of loss. We also accounted for the two 90-degree bends. We then applied the mass size distribution measured by Kleeman *et al.* (1999) for pine combustion. Number particle size distributions measured in our laboratory for cookstoves are similar; they show number peaks at 80-200 nm, but these data are unpublished.



References:

Brockmann, J.E. (1993) Sampling and Transport of Aerosols. In K. Willeke, and P.A. Baron, Eds. *Aerosol Measurement: Principles, Techniques and Applications*, p. 77-111. Van Nostrand Reinhold, New York.

Kleeman, M.J.; Schauer, J.J.; Cass, G.R. Size and composition distribution of fine particulate matter emitted from wood burning, meat charbroiling, and cigarettes. *Environ. Sci. Tech.* **1999**, *33*, 3516-3523.

Conductive tubing and nephelometer

We estimated the particle loss in the conductive tubing, and in the nephelometer, by generating representative aerosols, pulling them through our system, and measuring the concentration at different points. We generated wood smoke separately in both flaming and smoldering conditions and pulled it into a sealed vessel. The sealed vessel provides a steady source of representative size aerosol, without the fluctuations that a real fire provides. We continuously removed the smoke from the vessel and drew it through the sampling system. We measured particle concentrations with a TSI 3010 condensation particle counter (CPC) at three locations: the input to our system (directly after the probe), a point after 3 meters of conductive tubing, and a point directly after the Radiance Research M903 Nephelometer. These sampling points are designated S1, S2, and S3 respectively. The system flow rate was set to mimic our field conditions. Every minute, we alternated between the sampling locations (S1, S2, and S3) and recorded the particle concentration.

The continuous flow out of the sealed vessel produced a declining aerosol concentration (filtered air is allowed to enter the vessel to maintain a constant pressure, close to ambient conditions). We used the measurements taken at S1 to estimate the decreasing particle concentration in the vessel as a function of time. The difference between this concentration and the concentration measured at the test points S2 and S3 gives the percentage of particles lost in only the conductive tubing, and in both the conductive tubing and nephelometer respectively.

We also examined the size distribution with a TSI 3071 electrostatic classifier (Model 3934 SMPS) at each test point, to verify that particle loss was not due to either only large or only small particles. If the largest particles were being lost, there could be a significant change in mass even if particle number did not change. There was no significant change in particle size distribution between the starting and ending test points (S1 and S3) when measured in direct succession.

Losses	Total Observations	Flaming (% loss)	Smoldering (% loss)	Average (% loss)
Conductive tubing (S1 to S2) at 7 lpm	7	2.1 ± 0.5	1.28 ± 0.8	1.69 ± 0.7
Nephelometer M903 (S2 to S3) at 4 lpm	8	1.32 ± 1.0	1.71 ± 1.0	1.51 ± 0.9

Temperature Profile for EC/OC Analysis, Sunset Laboratory Carbon Analyzer:

Step duration (sec)	End temperature (C)	Atmosphere
10	-	He
70	310	He
60	475	He
60	615	He
90	870	He
35	cool down	He
45	550	He+Ox
45	625	He+Ox
45	700	He+Ox
45	775	He+Ox
45	850	He+Ox
120	890	He+Ox
Calibration		

Uncertainty Calculations:

Corrections and Uncertainty Calculations	Average value used	Single Sigma Stdev	Method used to determine
CO2 repeatability (ppm)		18	Measured in lab
CO2 span correction	0.95	0.06	Measured in lab
CO2 pressure correction : ambient (mbar)	amb	10	Ambient Measurement
CO2 pressure correction : system drop(mbar)	-11	5	Measured in lab
CO2 and CO temperature correction (deg K)	amb	3	Ambient Measurment
CO repeatability (ppm)		11	Measured in lab
CO span correction	1	0.01	Measured in lab
Methane, NMHC & particles (ch4+nm+part)/C	2.4	1.8	references noted in text
Wood %C	50%	2%	references noted in text
Percent CO2 from respiration (%)	2.2	1.7	Est. based on fuel usage & resp. rates
Flow variation due to filter pressure drop (%)	0	1	Measured in lab
Particle loss entering probe (%)	1.0%	1%	Calculated
Particle loss in conductive tubing (%)	1.7%	0.7%	Measured in lab CPC & DMA
Particle loss through nephelometer (%)	1.5%	0.9%	Measured in lab CPC & DMA
Background PM	test depnt		Optical background/sample ratio
CO % for tests missing CO data (as % CO2)	10.1%	5.5%	Estimated from test with CO data
Truncation error of Neph	4%	1%	Ref for TSI Neph
Neph uncertainty		10%	
PSAP - Bond PSAP correction Equation			reference noted in text

Change in RH Calculations, based on maximum CO_2 Concentrations.

The total change in RH is estimated by including water from fuel moisture, water from fuel hydrogen, and steam from the cooking pot. Water boiling rates are high estimates from Aprovecho Research (personal communication).

Test	Dry wood carbon content	Moisture content	Water from wood moisture/ carbon	Dry Wood Hydrogen content	Water from wood hydroger/ carbon	Wood burn rate (kg/hr)	Water release rate (g/min)	Water boiled/ carbon burned	Max delta CO2 conc	H2O conc	Psat at 80deg F	Patm (kPa)	fractional change in RH	Total change in RH
	(g_C / g_wood)	(g_H2O / g_wood)	mole_H2O /mole_C	(g_H/ g_wood)	mole_H2O /mole_C	(kg/hr)	(g/min)	mole_h2o /mole_C	(ppm)	(ppm)	(kPa)	(kPa)		(%)
1	50%	15.6%	0.2077	6%	0.72	1.5	15	0.8	412	713	3.1	88.7	0.0204	2.0%
2	50%	15.3%	0.2042	6%	0.72	1.5	15	0.8	769	1325	3.1	88.7	0.0379	3.8%
3	50%	15.4%	0.2052	6%	0.72	1.5	15	0.8	1075	1855	3.1	89.1	0.0533	5.3%
4	50%	14.6%	0.1952	6%	0.72	1.5	15	0.8	520	893	3.1	88.9	0.0256	2.6%
5	50%	14.4%	0.1920	6%	0.72	1.5	15	0.8	1071	1834	3.1	88.5	0.0523	5.2%
6	50%	13.1%	0.1744	6%	0.72	1.5	15	0.8	879	1490	3.1	88.5	0.0425	4.3%
7	50%	16.0%	0.2127	6%	0.72	1.5	0	0	1099	1025	3.1	88.6	0.0293	2.9%
8	50%	23.8%	0.3179	6%	0.72	1.5	15	0.8	893	1641	3.1	88.8	0.0470	4.7%
9	50%	10.4%	0.1389	6%	0.72	1.5	15	0.8	705	1169	3.1	88.9	0.0335	3.4%
10	50%	10.4%	0.1389	6%	0.72	1.5	15	0.8	146	242	3.1	88.9	0.0069	0.7%
11	50%	18.3%	0.2434	6%	0.72	1.5	15	0.8	577	1017	3.1	89.3	0.0293	2.9%
12	50%	26.3%	0.3509	6%	0.72	1.5	15	0.8	488	913	3.1	89.0	0.0262	2.6%
13	50%	11.3%	0.1504	6%	0.72	1.5	15	0.8	316	527	3.1	88.8	0.0151	1.5%
14	50%	30.1%	0.4007	6%	0.72	1.5	15	0.8	305	586	3.1	89.2	0.0168	1.7%
15	50%	22.2%	0.2960	6%	0.72	1.5	0	0	146	148	3.1	88.1	0.0042	0.4%

Pictures of stoves

Traditional stove from test 5

Traditional stove from test 4

Improved stove from test 7