
Ethylene Furan Ratios as Indicators of High and Low Temperature p-PAH Emissions from Household Stoves in Haryana India

Robert M. Weltman ¹, Rufus D. Edwards ^{1,2,*}, Norbert Staimer ³, Ajay Pillarisetti ⁴, Narendra K. Arora ⁵ and Sergey A. Nizkorodov ⁶

¹ Department of Environmental and Occupational Health, University of California Irvine, Irvine, CA 92697, USA

² Department of Epidemiology, Room 1361 SE II, University of California Irvine, Irvine, CA 92697, USA

³ BioAssayPro LLC, La Jolla, CA 92037, USA

⁴ School of Public Health, University of California Berkeley, Berkeley, CA 94720-7360, USA

⁵ INCLEN Trust International, New Delhi 110020, India

⁶ Department of Chemistry, University of California Irvine, Irvine, CA 92697, USA

* Correspondence: edwardsr@uci.edu

Supplementary Information



Figure S1. Chulha (left) and angithi (right) used during this project. The angithi is loaded with smoldering cow dung patties and used to simmer animal feed.



Figure S2. Chulha stove using brushwood.

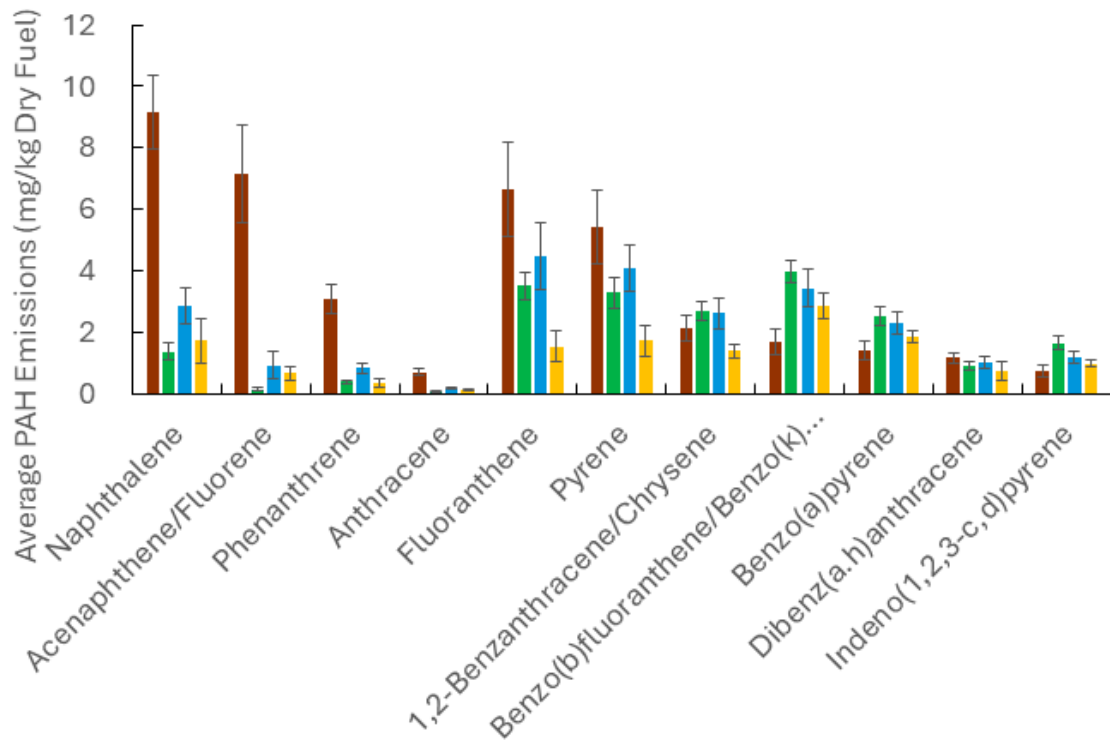


Figure S3. Average particulate PAH emissions by species for the angithi stove (brown), chulha with mixed fuels (green), chulha with dung (blue), and chulha with wood (orange). Error bars show one standard error of the mean. Benzo(b) and Benzo(k)fluoranthene are summed together.

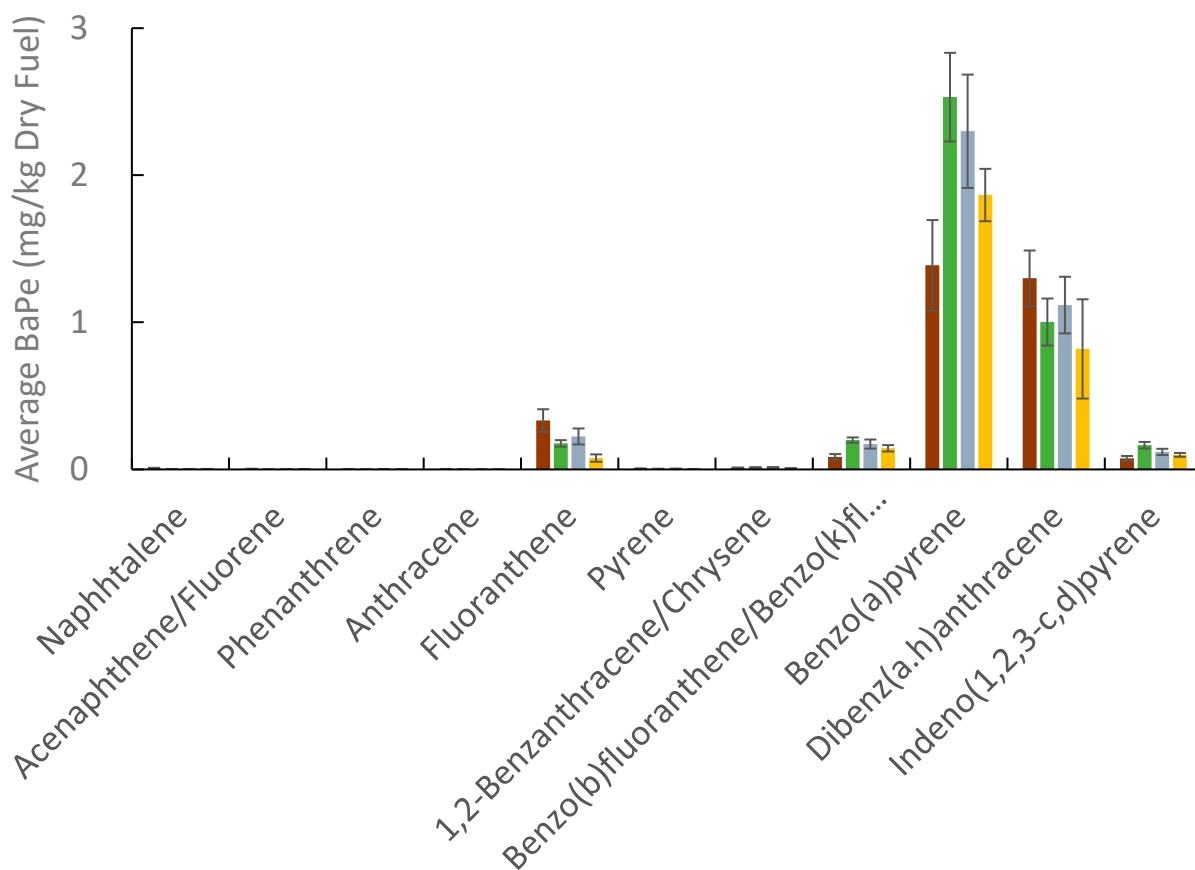


Figure S4. Average particulate PAH emissions by BaP-equivalency for each species for the angithi stove (brown), chulha with mixed fuels (green), chulha with dung (blue), and chulha with wood (orange). Error bars show one standard error of the mean. Benzo(b) and Benzo(k)fluoranthene are summed together.

Table S1. % of Samples above LoD for all samples where PAHs were detected.

Species	% of Samples above LoD
Naphthalene (NAP)	87% (39/45)
Acenaphthene/Fluorene (ACE/FLO)	76% (34/45)
Phenanthrene (PHE)	96% (43/45)
Anthracene (ANT)	80% (36/45)
Fluoranthene (FLT)	96% (43/45)
Pyrene (PYR)	98% (44/45)
1,2-Benzanthracene/Chrysene (BaA / CHY)	100% (45/45)
Benzo(b)fluoranthene/Benzo(k)fluoranthene (BbF / BkF)	98% (44/45)
Benzo(a)pyrene (BaP)	98% (44/45)
Dibenz(a,h)anthracene (DahA)	100% (45/45)
Indeno(1,2,3-c,d)pyrene (IcdP)	100% (45/45)

Table S2. PAH emissions by compound for each stove/fuel combination are presented on a milligram BaPe per kilogram of dry fuel basis. The final column lists the % of total mgTEF that the Σ PAHs add up to. Only the measured compounds that contribute over 1% of total calculated BaPe are listed here.

Stove / Fuel Type	FLA		BbK / BkF	BaP		DahA	IcdP	% of Total mgTEF
Angithi Dung	0.3 ± 0.1	0.1 ± 0.0	1.4 ± 0.3	1.3 ± 0.2	0.1 ± 0.0	99.0%		
Chulha Dung	0.2 ± 0.0	0.2 ± 0.0	2.5 ± 0.3	1.2 ± 0.2	0.1 ± 0.0	99.5%		
Chulha Mixed	0.2 ± 0.0	0.2 ± 0.0	2.5 ± 0.3	1.0 ± 0.2	0.2 ± 0.0	99.6%		
Chulha Wood	0.1 ± 0.0	0.1 ± 0.0	1.9 ± 0.2	0.8 ± 0.3	0.1 ± 0.0	99.6%		

Table S3. Concentrations of individual PAH species in standard reference material 1648a, urban particulate matter, measured in this study by HPLC-FLD and values reported by the manufacturer via GC-Soxhlet/pressurized fluid extraction. .

PAH Species	HPLC-FLD/Sonication*	GC-Soxhlet/PFE**
Phenanthrene	3.72 ± 0.35	4.86 ± 0.17
Anthracene	0.52 ± 0.02	0.46 ± 0.01
Fluoranthene	6.74 ± 0.24	8.07 ± 0.14
Pyrene	5.81 ± 0.19	5.88 ± 0.07
1,2-Benzanthracene/Chrysene	3.01 ± 0.15	2.71 ± 0.15 / 6.12 ± 0.06
Benzo(b)fluoranthene	7.81 ± 0.19	8.89 ± 0.05
Benzo(k)fluoranthene	2.96 ± 0.14	3.03 ± 0.24
Benzo(a)pyrene	5.18 ± 0.45	2.57 ± 0.10
Indeno(1,2,3-cd)pyrene	5.70 ± 0.35	4.17 ± 0.17

* Means of mass fractions from triplicate samples (extractions in triplicate) with STDV. **Weighted means of the mass fractions from multiple analytical methods with STDV.

Table S4. Recovery (in %) of individual PAH species on quartz Filters (47 mm) spiked with 1 mL of 50 ng/mL PAH Standard Mix, extracted and analyzed by HPLC-FLD following NIOSH Method 5506.

PAH Species	15 Minutes	24 Hours
Naphthalene	63.0 ± 4.0	< 10%
Phenanthrene	84.4 ± 5.3	< 10%
Anthracene	83.1 ± 3.0	< 10%
Fluoranthene	91.1 ± 2.4	< 10%
Pyrene	97.9 ± 1.7	< 10%
1,2-Benzanthracene/Chrysene	104.3 ± 1.1	64.5 ± 1.9
Benzo(b)fluoranthene	102.6 ± 1.5	94.9 ± 2.8
Benzo(k)fluoranthene	104.1 ± 1.4	99.7 ± 2.8
Benzo(a)pyrene	69.6 ± 9.8	91.4 ± 5.5
Dibenz(a,h)anthracene	99.6 ± 1.5	99.8 ± 3.0
Indeno(1,2,3-c,d)pyrene	91.4 ± 6.4	101.5 ± 4.1

Table S5. Toxic equivalency factors for individual PAH species presented in this paper.

PAH Species	Toxic Equivalency Factor
Naphthalene	0.001
Acenaphthene/Fluorene	0.0005
Phenanthrene	0.0005
Anthracene	0.0005
Fluoranthene	0.05
Pyrene	0.001
1,2-Benzanthracene/Chrysene	0.005
Benzo(b/k)fluoranthene	0.05
Benzo(a)pyrene	1
Dibenz(a,h)anthracene	1.1
Indeno(1,2,3-c,d)pyrene	0.1

Disclaimer/Publisher's Note: The statements, opinions and data contained in all publications are solely those of the individual author(s) and contributor(s) and not of MDPI and/or the editor(s). MDPI and/or the editor(s) disclaim responsibility for any injury to people or property resulting from any ideas, methods, instructions or products referred to in the content.