Appendix H

Estimating Carcinogenic Potency for Mixtures of Polycyclic Organic Matter (POM) for the 1996 National-Scale Assessment

Appendix H. Estimating carcinogenic potency for mixtures of polycyclic organic matter (POM) for the initial NSA.

Introduction

The polycyclic organic matter (POM) category within the Clean Air Act's section 112(b) list of hazardous air pollutants comprises a broad spectrum of compounds having widely varying toxic potencies. Because all these compounds have been listed as a single category under the Act, the 1996 National Toxics Inventory (NTI) also records them only as a group for the great majority of sources, usually in terms of total polynuclear aromatic hydrocarbons (PAH – one type of POM) or total POM. Most of these entries do not include information on the method used to estimate the emission rate.

For this reason, the NTI data could not support modeling of individual POM compounds for the initial national-scale assessment. The alternative – modeling POM as a group – was a significant simplifying step because different types of emission sources may be expected to produce different characteristic mixtures of POM compounds. These different mixtures have the potential to vary substantially in toxic potency per unit mass.

The EPA Cumulative Exposure Project (CEP) faced a similar problem in its treatment of POM. To work around this limitation, Woodruff et al. (2000) used a potency estimate for POM mixtures based on past analyses of carcinogenic potency for individual compounds. Potency estimates were combined with the proportion of each compound in the CEP's 1990 emission inventory, and combined to develop a potency estimate for the total POM mixture by weight. The CEP estimated that carcinogenic potency for all environmental POM combined ranged from 6 to 16% of the potency of pure benzo[a]pyrene.

These potency estimates were developed from the POM speciation profile of the CEP inventory, which was compiled by methods that were substantially different from the "bottom-up" strategy used to develop the 1996 National Toxics Inventory used for the initial NSA. POM emissions may have also changed qualitatively due to regulatory measures and voluntary actions between 1990 and 1996. Therefore, EPA judged that POM mixtures should be assessed to the extent possible using the characteristics of the 1996 NTI rather than the CEP analysis.

Methods

The approach used here is similar to that of Woodruff et al. (2000), but tailored to match the 1996 NTI. It combines estimates of relative potency for carcinogenic PAHs (the best-characterized subgroup within the POM category) with emission factors used in the development of the 1996 NTI (EPA, 1997).

Dose-response information (summarized in Table 1) was gathered and prioritized according to methods described in Appendix G. UREs were obtained for 25 individual POM compounds. However, EPA (1997) provides emission factors for only seven of these 25 compounds (chrysene, indeno[1,2,3-cd]pyrene, benzo[b]fluoranthene, benzo[k]fluoranthene, dibenz[a,h]anthracene, benzo[a]anthracene, and benzo[a]pyrene), plus 9 additional non-carcinogenic POM compounds (acenaphthene, anthracene, benzo[g,h,i]perylene, fluoranthene, fluorene, 1-methylnaphthalene, 2-methylnaphthalene, phenanthrene, and pyrene), so this analysis was limited to those 16 compounds. The 7 carcinogenic compounds in combination are referred to as "7-PAH," carcinogenic and noncarcinogenic PAHs combined are called "16-PAH," and the 16-PAH group in combination with "other PAHs" is called "total PAH."

To select representative POM source categories, sources were ranked in terms of mass of POM or PAH emitted nationally, using (1) total POM emissions data extracted from the 1996 NTI, and (2) 16-PAH emissions data tabulated in EPA (1997). Four source categories (Tables 2-5) that ranked highly on both lists were selected to represent national POM emissions. Using 16-PAH emissions data in EPA (1997) as a measure, these four source categories emitted 12,590 tons per year out of a national total from all sources of ***16,019*** tons per year, representing approximately ***77%*** of the total mass.

Each of the four source categories was represented by emission factors taken from one type of source within the category, as per EPA (1997):

- Residential woodstoves – represented by conventional (pre-1997) woodstoves;
- Electric generation – represented by bituminous cyclone boilers with electrostatic precipitators;
- Primary aluminum production – represented by prebaked anode cell;
- Wildfires – represented by burning of pine needles.

Emission factors for each compound were adjusted to benzo[a]pyrene equivalence (BaPeq) by multiplying by the compound's potency relative to BaP (i.e., the ratio of the URE for the compound to the URE for BaP, shown in Table 1). The percentage of BaPeq contributed by each compound was then calculated for each source category (Tables 2-6).

Table 1. Dose-response assessments for POM compounds, including unit risk estimates (1/ug/m3) and percent equivalence to carcinogenic potency of benzo[a]pyrene.

		WOE		CHRONIC CANCER		
CHEMICAL NAME	CAS NO	EPA	IARC	1/(ug/m3)	BaP eq.	SOURCE
Acenaphthene	83329	-	-			-
Anthracene	120127	D	3			-
Benzo(a)anthracene	56553	B2	2A	0.00011	10.00%	CAL EPA
Benzo(b)fluoranthene	205992	B2	2B	0.00011	10.00%	CAL EPA
Benzo(k)fluoranthene	207089	B2	2B	0.00011	10.00%	CAL EPA
Benzo(g,h,i)perylene	191242	D	-			-
Benzo(a)pyrene	50328	B2	2A	0.0011	100.00%	CAL EPA
Carbazole	86748	B2	3	5.7E-006	0.52%	CONV. ORAL
beta-Chloronaphthalene	91587	-	-			-
Chrysene	218019	B2	3	1.1E-005	1.00%	CAL EPA
Dibenz[a,h]acridine	226368	-	2B	0.00011	10.00%	CAL EPA
Dibenz[a,j]acridine	224420	-	2B	0.00011	10.00%	CAL EPA
Dibenz(a,h)anthracene	53703	B2	2A	1.20E-03	109.09%	CAL EPA
7H-Dibenzo[c,g]carbazole	194592	-	2B	0.0011	100.00%	CAL EPA
Dibenzo(j)fluoranthene	205823	-	2B			
Dibenzo[a,e]pyrene	192654	-	2B	0.0011	100.00%	CAL EPA
Dibenzo[a,h]pyrene	189640	-	2B	0.011	1000.00%	CAL EPA
Dibenzo[a,i]pyrene	189559	-	2B	0.011	1000.00%	CAL EPA
Dibenzo[a,l]pyrene	191300	-	2B	0.011	1000.00%	CAL EPA
9,10-dimethyl anthracene	781431	-	-			-
7,12-Dimethylbenz(a)anthracene	57976	-	-	7.10E-02	6454.55%	CAL EPA
1,6-Dinitropyrene	42397648	-	2B	0.011	1000.00%	CAL EPA
1,8-Dinitropyrene	42397659	-	2B	0.0011	100.00%	CAL EPA
Fluoranthene	206440	D	-			-
Fluorene	86737	D	-			-
Indeno(1,2,3-cd)pyrene	193395	B2	2B	0.00011	10.00%	CAL EPA
3-Methylcholanthrene	56495	-	-	6.30E-03	572.73%	CAL EPA
5-Methylchrysene	3697243	-	-	0.0011	100.00%	CAL EPA
1-Methylnaphthalene	90120	-	-			-
2-Methylnaphthalene	91576	-	-			-
2-Naphthylamine	91598	-	-			-
5-Nitroacenaphthene	602879	-	2B	3.70E-05	3.36%	CAL EPA
6-Nitrochrysene	2043937	-	2B	0.011	1000.00%	CAL EPA
2-Nitrofluorene	607578	-	2B	1.1E-005	1.00%	CAL EPA
1-Nitropyrene	5522430	-	2B	0.00011	10.00%	CAL EPA
4-Nitropyrene	57835924	-	-	0.00011	10.00%	CAL EPA
Pyrene	129000	D	-			-

Table 2. Residential wood combustion (EPA, 1997, Table 4.1-1, pg. 4-11). Emission factors are expressed as lb of pollutant emitted per ton of wood combusted.

CHEMICAL NAME	CAS NO	BaP TEF	Emission Factor (lb/t)	Adjusted EF (lb/t BaP eq.)	Percentage of Total
Acenaphthene	83329	0.00%	0.01	0	0.00%
Anthracene	120127	0.00%	0.014	0	0.00%
Benzo(a)anthracene	56553	10.00%	0.02	0.002	40.65%
Benzo(b)fluoranthene	205992	10.00%	0.006	0.0006	12.20%
Benzo(k)fluoranthene	207089	10.00%	0.002	0.0002	4.07%
Benzo(g,h,i)perylene	191242	0.00%	0.004	0	0.00%
Benzo(a)pyrene	50328	100.00%	0.002	0.002	40.65%
Carbazole	86748	0.52%		0	0.00%
beta-Chloronaphthalene	91587	0.00%		0	0.00%
Chrysene	218019	1.00%	0.012	0.00012	2.44%
Dibenz[a,h]acridine	226368	10.00%		0	0.00%
Dibenz[a,j]acridine	224420	10.00%		0	0.00%
Dibenz(a,h)anthracene	53703	109.09%	0	0	0.00%
7H-Dibenzo[c,g]carbazole	194592	100.00%		0	0.00%
Dibenzo(j)fluoranthene	205823	0.00%		0	0.00%
Dibenzo[a,e]pyrene	192654	100.00%		0	0.00%
Dibenzo[a,h]pyrene	189640	1000.00%		0	0.00%
Dibenzo[a,i]pyrene	189559	1000.00%		0	0.00%
Dibenzo[a,l]pyrene	191300	1000.00%		0	0.00%
9,10-dimethyl anthracene	781431	0.00%		0	0.00%
7,12-Dimethylbenz(a)anthracene	57976	6454.55%		0	0.00%
1,6-Dinitropyrene	42397648	1000.00%		0	0.00%
1,8-Dinitropyrene	42397659	100.00%		0	0.00%
Fluoranthene	206440	0.00%	0.02	0	0.00%
Fluorene	86737	0.00%	0.024	0	0.00%
Indeno(1,2,3-cd)pyrene	193395	10.00%	0	0	0.00%
3-Methylcholanthrene	56495	572.73%		0	0.00%
5-Methylchrysene	3697243	100.00%		0	0.00%
1-Methylnaphthalene	90120	0.00%		0	0.00%
2-Methylnaphthalene	91576	0.00%		0	0.00%
2-Naphthylamine	91598	0.00%		0	0.00%
5-Nitroacenaphthene	602879	3.36%		0	0.00%
6-Nitrochrysene	2043937	1000.00%		0	0.00%
2-Nitrofluorene	607578	1.00%		0	0.00%
1-Nitropyrene	5522430	10.00%		0	0.00%
4-Nitropyrene	57835924	10.00%		0	0.00%
Pyrene	129000	0.00%	0.024	0	0.00%
Other	-	0.00%	0.302	0	0.00%
	Sum of all PAH:		0.44	0.00492	
	Adj EF/EF for all PAH:		1.12%		
	Sum of 7-PAH:		0.042	0.00492	
	Adj EF/EF for 7-PAH:		11.71%		
	Sum of 16-PAH:		0.138	0.00492	
	Adj Ef/EF for 16-PAH:		3.57%		

Table 3. Primary aluminum production: prebaked cell (EPA, 1997, Table 4.4.1-10, pg. 4-222).
Emission factors are in lb of pollutant emitted per ton of aluminum produced.

CHEMICAL NAME	CAS NO	BaP TEF	Emission Factor (lb/t)	Adjusted EF (lb/t BaP eq.)	Percentage of Total
Acenaphthene	83329	0.00%		0	0.00%
Anthracene	120127	0.00%	5.18E-02	0	0.00%
Benzo(a)anthracene	56553	10.00%	1.26E-02	0.00126	11.94%
Benzo(b)fluoranthene	205992	10.00%	0.0097	0.00097	9.19%
Benzo(k)fluoranthene	207089	10.00%	0.0097	0.00097	9.19%
Benzo(g,h,i)perylene	191242	0.00%	2.74E-03	0	0.00%
Benzo(a)pyrene	50328	100.00%	5.74E-03	0.00574	54.37%
Carbazole	86748	0.52%		0	0.00%
beta-Chloronaphthalene	91587	0.00%		0	0.00%
Chrysene	218019	1.00%	1.79E-02	0.000179	1.70%
Dibenz[a,h]acridine	226368	10.00%		0	0.00%
Dibenz[a,j]acridine	224420	10.00%		0	0.00%
Dibenz(a,h)anthracene	53703	109.09%	1.14E-03	0.001243636	11.78%
7H-Dibenzo[c,g]carbazole	194592	100.00%		0	0.00%
Dibenzo(j)fluoranthene	205823	0.00%		0	0.00%
Dibenzo[a,e]pyrene	192654	100.00%		0	0.00%
Dibenzo[a,h]pyrene	189640	1000.00%		0	0.00%
Dibenzo[a,i]pyrene	189559	1000.00%		0	0.00%
Dibenzo[a,l]pyrene	191300	1000.00%		0	0.00%
9,10-dimethyl anthracene	781431	0.00%		0	0.00%
7,12-Dimethylbenz(a)anthracene	57976	6454.55%		0	0.00%
1,6-Dinitropyrene	42397648	1000.00%		0	0.00%
1,8-Dinitropyrene	42397659	100.00%		0	0.00%
Fluoranthene	206440	0.00%	4.94E-02	0	0.00%
Fluorene	86737	0.00%	1.28E-03	0	0.00%
Indeno(1,2,3-cd)pyrene	193395	10.00%	1.94E-03	0.000194	1.84%
3-Methylcholanthrene	56495	572.73%		0	0.00%
5-Methylchrysene	3697243	100.00%		0	0.00%
1-Methylnaphthalene	90120	0.00%		0	0.00%
2-Methylnaphthalene	91576	0.00%	3.00E-05	0	0.00%
2-Naphthylamine	91598	0.00%		0	0.00%
5-Nitroacenaphthene	602879	3.36%		0	0.00%
6-Nitrochrysene	2043937	1000.00%		0	0.00%
2-Nitrofluorene	607578	1.00%		0	0.00%
1-Nitropyrene	5522430	10.00%		0	0.00%
4-Nitropyrene	57835924	10.00%		0	0.00%
Pyrene	129000	0.00%	0.0414	0	0.00%
Other	-	0.00%	2.68E-02	0	0.00%
	Sum of all PAH:		0.232215	0.010556636	
	Adj EF/EF for all PAH:		4.55%		
	Sum of 7-PAH:		0.05872	0.010556636	
	Adj EF/EF for 7-PAH:		17.98%		
	Sum of 16-PAH:		0.20534	0.010556636	
	Adj Ef/EF for 16-PAH:		5.14%		

Table 4. Wildfires & prescribed burning: pine needles (EPA, 1997, Table 410.1-1., pg. 4-469).
Emission factors are in lb of pollutant emitted per ton of fuel burned.

CHEMICAL NAME	CAS NO	BaP TEF	Emission Factor (lb/t)	Adjusted EF (lb/t BaP eq.)	Percentage of Total
Acenaphthene	83329	0.00%		0	0.00%
Anthracene	120127	0.00%	9.95E-03	0	0.00%
Benzo(a)anthracene	56553	10.00%	1.27E-02	0.00127	35.23%
Benzo(b)fluoranthene	205992	10.00%	0.00257	0.000257	7.13%
Benzo(k)fluoranthene	207089	10.00%	0.00257	0.000257	7.13%
Benzo(g,h,i)perylene	191242	0.00%	5.08E-03	0	0.00%
Benzo(a)pyrene	50328	100.00%	1.48E-03	0.00148	41.05%
Carbazole	86748	0.52%		0	0.00%
beta-Chloronaphthalene	91587	0.00%		0	0.00%
Chrysene	218019	1.00%		0	0.00%
Dibenz[a,h]acridine	226368	10.00%		0	0.00%
Dibenz[a,j]acridine	224420	10.00%		0	0.00%
Dibenz(a,h)anthracene	53703	109.09%		0	0.00%
7H-Dibenzo[c,g]carbazole	194592	100.00%		0	0.00%
Dibenzo(j)fluoranthene	205823	0.00%		0	0.00%
Dibenzo[a,e]pyrene	192654	100.00%		0	0.00%
Dibenzo[a,h]pyrene	189640	1000.00%		0	0.00%
Dibenzo[a,i]pyrene	189559	1000.00%		0	0.00%
Dibenzo[a,l]pyrene	191300	1000.00%		0	0.00%
9,10-dimethyl anthracene	781431	0.00%		0	0.00%
7,12-Dimethylbenz(a)anthracene	57976	6454.55%		0	0.00%
1,6-Dinitropyrene	42397648	1000.00%		0	0.00%
1,8-Dinitropyrene	42397659	100.00%		0	0.00%
Fluoranthene	206440	0.00%	6.73E-03	0	0.00%
Fluorene	86737	0.00%		0	0.00%
Indeno(1,2,3-cd)pyrene	193395	10.00%	3.41E-03	0.000341	9.46%
3-Methylcholanthrene	56495	572.73%		0	0.00%
5-Methylchrysene	3697243	100.00%		0	0.00%
1-Methylnaphthalene	90120	0.00%		0	0.00%
2-Methylnaphthalene	91576	0.00%		0	0.00%
2-Naphthylamine	91598	0.00%		0	0.00%
5-Nitroacenaphthene	602879	3.36%		0	0.00%
6-Nitrochrysene	2043937	1000.00%		0	0.00%
2-Nitrofluorene	607578	1.00%		0	0.00%
1-Nitropyrene	5522430	10.00%		0	0.00%
4-Nitropyrene	57835924	10.00%		0	0.00%
Pyrene	129000	0.00%	0.00929	0	0.00%
Other	-	0.00%	1.56E-02	0	0.00%
	Sum of all PAH:		0.069426	0.003605	
	Adj EF/EF for all PAH:		5.19%		
	Sum of 7-PAH:		0.02273	0.003605	
	Adj EF/EF for 7-PAH:		15.86%		
	Sum of 16-PAH:		0.05378	0.003605	
	Adj Ef/EF for 16-PAH:		6.70%		

Table 5. Electrical generation: bituminous cyclone utility boilers with ESP (EPA, 1997, Table 4.1.2-9, pg. 4-76). Emission factors are in lb of pollutant emitted per ton of coal fired.

CHEMICAL NAME	CAS NO	BaP TEF	Emission Factor (lb/t)	Adjusted EF (lb/t BaP eq.)	Percentage of Total
Acenaphthene	83329	0.00%	2.65E-08	0	0.00%
Anthracene	120127	0.00%	2.07E-08	0	0.00%
Benzo(a)anthracene	56553	10.00%	3.72E-09	3.72E-10	10.18%
Benzo(b)fluoranthene	205992	10.00%	3.49E-09	3.49E-10	9.55%
Benzo(k)fluoranthene	207089	10.00%	3.49E-09	3.49E-10	9.55%
Benzo(g,h,i)perylene	191242	0.00%	1.16E-09	0	0.00%
Benzo(a)pyrene	50328	100.00%	1.16E-09	1.16E-09	31.75%
Carbazole	86748	0.52%		0	0.00%
beta-Chloronaphthalene	91587	0.00%		0	0.00%
Chrysene	218019	1.00%	8.84E-09	8.84E-11	2.42%
Dibenz[a,h]acridine	226368	10.00%		0	0.00%
Dibenz[a,j]acridine	224420	10.00%		0	0.00%
Dibenz(a,h)anthracene	53703	109.09%	1.16E-09	1.26545E-09	34.64%
7H-Dibenzo[c,g]carbazole	194592	100.00%		0	0.00%
Dibenzo(j)fluoranthene	205823	0.00%		0	0.00%
Dibenzo[a,e]pyrene	192654	100.00%		0	0.00%
Dibenzo[a,h]pyrene	189640	1000.00%		0	0.00%
Dibenzo[a,i]pyrene	189559	1000.00%		0	0.00%
Dibenzo[a,l]pyrene	191300	1000.00%		0	0.00%
9,10-dimethyl anthracene	781431	0.00%		0	0.00%
7,12-Dimethylbenz(a)anthracene	57976	6454.55%		0	0.00%
1,6-Dinitropyrene	42397648	1000.00%		0	0.00%
1,8-Dinitropyrene	42397659	100.00%		0	0.00%
Fluoranthene	206440	0.00%	2.70E-08	0	0.00%
Fluorene	86737	0.00%	3.14E-08	0	0.00%
Indeno(1,2,3-cd)pyrene	193395	10.00%	6.98E-10	6.98E-11	1.91%
3-Methylcholanthrene	56495	572.73%		0	0.00%
5-Methylchrysene	3697243	100.00%		0	0.00%
1-Methylnaphthalene	90120	0.00%	1.58E-08	0	0.00%
2-Methylnaphthalene	91576	0.00%	3.74E-08	0	0.00%
2-Naphthylamine	91598	0.00%		0	0.00%
5-Nitroacenaphthene	602879	3.36%		0	0.00%
6-Nitrochrysene	2043937	1000.00%		0	0.00%
2-Nitrofluorene	607578	1.00%		0	0.00%
1-Nitropyrene	5522430	10.00%		0	0.00%
4-Nitropyrene	57835924	10.00%		0	0.00%
Pyrene	129000	0.00%	1.4E-08	0	0.00%
Other	-	0.00%	8.45E-08	0	0.00%
	Sum of all PAH:		2.81E-07	3.65365E-09	
	Adj EF/EF for all PAH:		1.30%		
	Sum of 7-PAH:		2.256E-08	3.65365E-09	
	Adj EF/EF for 7-PAH:		16.20%		
	Sum of 16-PAH:		1.433E-07	3.65365E-09	
	Adj Ef/EF for 16-PAH:		2.55%		

Results & Discussion

Table 6 and Figure 1 show the distribution of BaPeq among the 7 carcinogenic compounds that comprise the 7-PAH group, for four dominant POM source categories. With the exception of 2 compounds (benz[a]anthracene and dibenz[a,h]anthracene), the distribution of BaPeq appears similar across source categories.

Table 7 and Figure 2 show total BaPeq for each source category as a percentage of the mass of 7-PAH, 16-PAH, and total-PAH. Results for total PAH ranged from about 1% of pure BaP for residential wood burning and utilities to about 5% of pure BaP for aluminum smelting and wildfires. Results for 7-PAH ranged from about 12% of pure BaP for residential wood burning to 18% of pure BaP for aluminum smelting.

Because the 1996 NTI provides most POM data in terms of either 7-PAH, total PAH, or total POM, the results of this analysis of POM potency were used as follows for the NATA national-scale assessment:

- 7-PAH exposure estimates were adjusted to 18% BaPeq;
- Total PAH and total POM data from the NTI were used interchangeably in ASPEN and HAPEM4 modeling, and expressed as total POM; and
- Total POM exposure estimates were adjusted to 5% BaPeq.

This analysis has made the following tacit assumptions, each of which may contribute potentially important uncertainties to the analysis:

- In basing calculations on four dominant sources of POM, the analysis assumes that these source categories (comprising about three-quarters of all POM emissions) have POM emission profiles representative of all POM sources;

- By using one specific type of operation to represent each of the four dominant source categories, the analysis assumes these operations have POM emission profiles representative of the entire source category;

- By using a BaP equivalency approach, the analysis assumes that carcinogenic risks associated with the 7-PAH compounds are additive;

- In using the BaPeq : total PAH ratio to also represent BaPeq : total POM, the analysis assumes that non-PAH compounds within the POM group have exactly the same amount of carcinogenic potency per mass as PAH compounds. Woodruff et al. (2000) made a similar assumption, and the estimate of 5% BaPeq for total POM is similar to the CEP's base estimate of 6%.

- Because they are based on the upper end of the range of estimated BaPeq for 7-PAH and total POM, the risk estimates may be biased high;

Because environmental POM mixtures comprise thousands of individual compounds, these simplifications are admittedly substantial. Nevertheless, this analysis is better-informed than the formerly-used, simpler alternative of assuming that all carcinogenic PAHs are equal in potency to benzo[a]pyrene. Although currently there does not appear to be any more rigorous way of address cumulative risks of multiple POMs, EPA has already taken steps to improve POM speciation in the next (1999) inventory, and has identified dose-response of POM mixtures as an area in need of future research.

Figure 1. Distribution of BaP equivalence among 7 carcinogenic PAHs emitted from 4 large POM sources

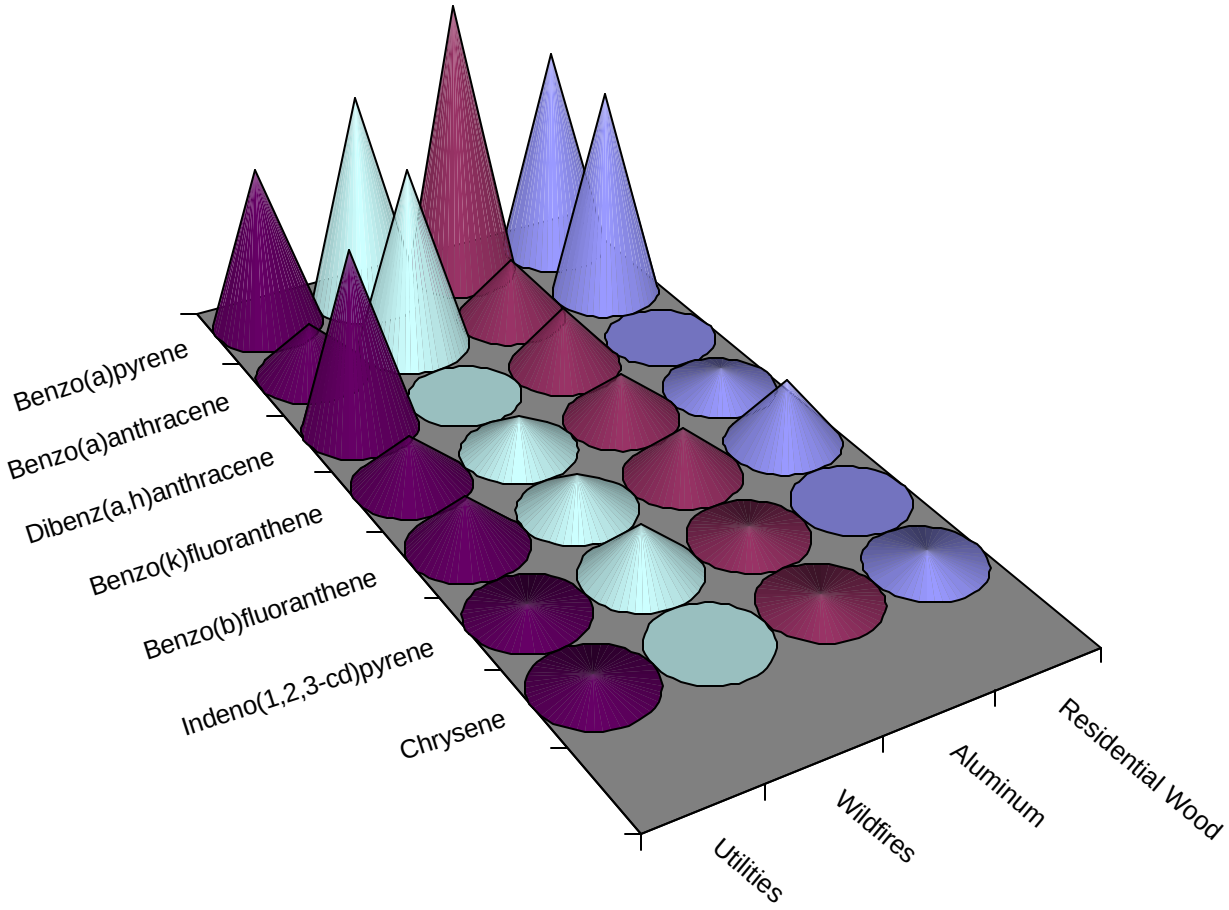

Table 6. Percentage of benzo[a]pyrene equivalence contributed by each of 7 carcinogenic PAH compounds for five source categories.

CHEMICAL NAME	Residential Wood	Aluminum	Wildfires	Utilities
Chrysene	2.44%	1.70%	0.00%	2.42%
Indeno(1,2,3-cd)pyrene	0.00%	1.84%	9.46%	1.91%
Benzo(b)fluoranthene	12.20%	9.19%	7.13%	9.55%
Benzo(k)fluoranthene	4.07%	9.19%	7.13%	9.55%
Dibenz(a,h)anthracene	0.00%	11.78%	0.00%	34.64%
Benzo(a)anthracene	40.65%	11.94%	35.23%	10.18%
Benzo(a)pyrene	40.65%	54.37%	41.05%	31.75%

Figure 2. Benzo[a]pyrene equivalence for four large POM sources

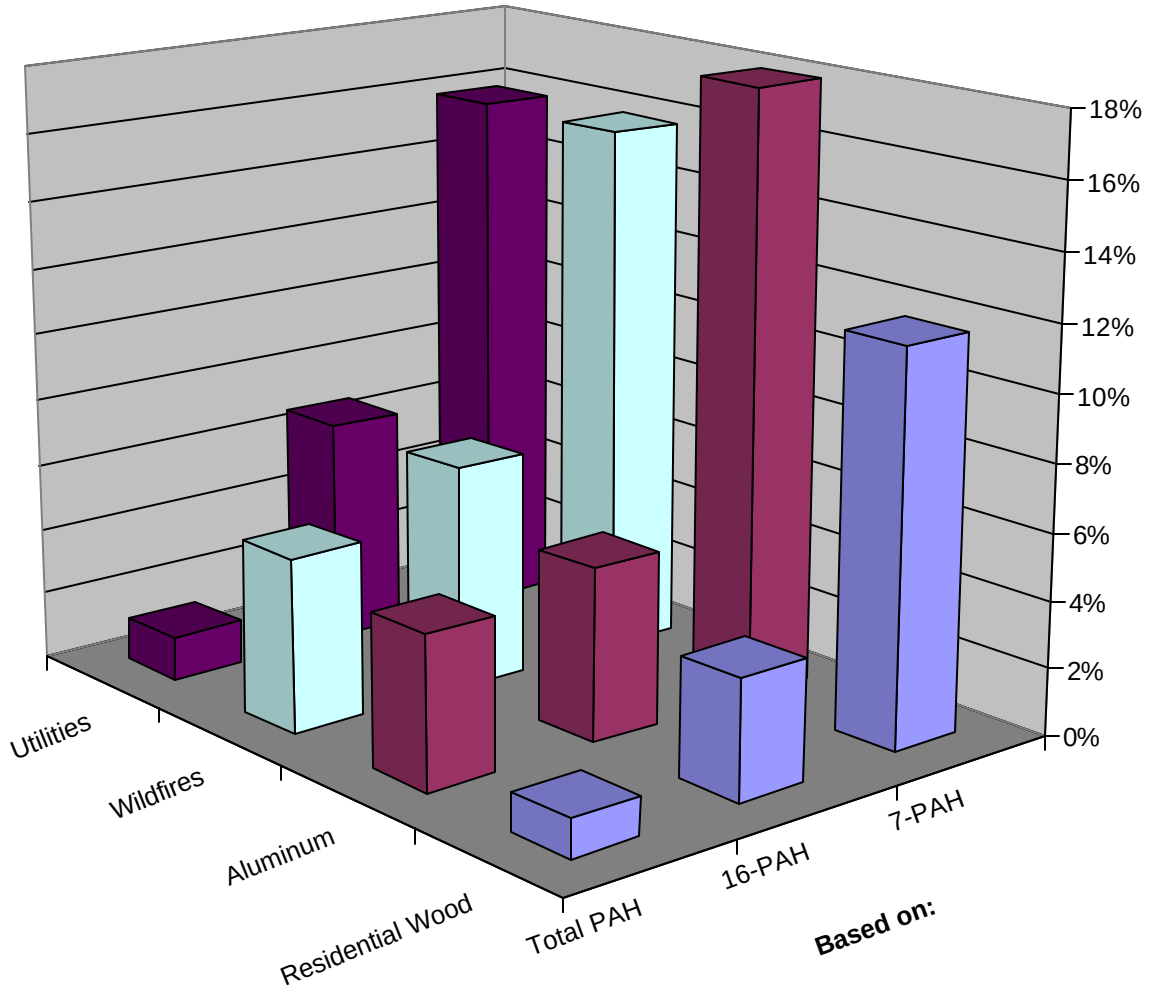

Table 7. Total BaP equivalence for 5 source types, as a percentage of total mass of all PAHs, 16 PAH compounds, and 7 PAH compounds.

BASIS	Residential Wood	Aluminum	Wildfires	Utilities
BaPeq/Total PAH	1.12%	4.55%	5.19%	1.30%
BaPeq/16-PAH	3.57%	5.14%	6.70%	6.70%
BaPeq/7-PAH	11.71%	17.98%	15.86%	15.86%

References

Woodruff, T.J., J. Caldwell, V.J. Cogliano, and D.A. Axelrad. 2000. Estimating cancer risk from outdoor concentrations of hazardous air pollutants in 1990. Environmental Research Section A 82, 194-206.

US EPA. 1997. Locating and estimating air emissions from sources of polycyclic organic matter. Final report. EPA/OAQPS.