

Supplementary Material

Flame Retardant Exposures in California Early Childhood Education Environments

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QA / QC : Flame Retardants in Dust

Flame retardant dust method detection limits and analytical spike recoveries are presented in Tables S1 and S2. For flame retardants in dust, three lab spikes were analyzed for recovery. The average lab spike recovery was 85.5% (SD=12.6). One dust sample was analyzed in duplicate for PBDE flame retardants and two dust samples were analyzed in duplicate for Firemaster 550 and tris phosphate ester flame retardants. The average relative standard deviation (RSD) for flame retardants analyzed in duplicates was 25.6% (SD=31.4).

Table S1. BDE Flame Retardant Recoveries and MDLs in Dust

	Mean Lab Matrix Spike Recovery (%)	MDL (ng/ml)	MDL (ng/g) ¹
BDE-47	80.8	4	6.9
BDE-99	83.9	4	6.9
BDE-100	82.9	5	8.6
BDE-118	83.7	4	6.9
BDE-153	84.8	5	8.6
BDE-154	82.7	6	10.3
BDE-183	77.3	6	10.3
BDE-190	79.9	8	13.8
BDE-197	68.7	8	13.8
BDE-203	70.3	8	13.8
BDE-205	67.7	9	15.5
BDE-206	83.1	18	31.0
BDE-207	77.3	4	6.9
BDE-209	116.9	17	29.3

¹MDL in ng/g calculated using the average mass of dust used in BDE analyses per volume of extract solvent (0.58 g/mL)

Table S2. Non-BDE Flame Retardant Recoveries and MDLs in Dust

Analyte	Mean Lab Matrix Spike Recovery (%)	MDL (ng/g)
EHTBB	101.1	1
BEHTBP	95.4	1
TCEP	97.9	1
TDCPP	107.3	1

QA / QC : Flame Retardants in Air

Flame retardant air sampling analytical spike recoveries and method detection limits are presented in Table S2. Two lab and field matrix spikes were analyzed for PBDE flame retardants in PUF by Battelle Laboratories. The average recovery for lab and field matrix spikes was 82.0% (SD= 9.2) and 86.2% (SD 16.9), respectively. Two indoor duplicates air samples were collected for BDEs, Firemaster 550 constituents and tris phosphate flame retardants. The average RSD was 42.1% (SD=41.7).

BDE 209 was an original target analyte for air analysis. However, after the first set of PUF analysis, the calibration curves and/or its C13-labelled analogue did not meet laboratory QA/QC standards. Therefore, only BDE 209 values for the first set of analysis are presented. For the non-BDE flame retardants in air, MDLs ranged from 0.2 to 0.5 ng for the non-BDE flame retardants. Using the average indoor air volume for SVOCs (1.9 m³), the MDL as a concentration for non-BDE flame retardants had a range of 0.1 to 0.3 ng/m³. BEHTBP was not detected in the spike analysis due to sensitivity problems in the EI GC/MS mode.

Table S3. Lab and Field Matrix Spike Recovery and Method Detection Limits for BDE Analytes in PUFs

Analyte	Mean Lab Matrix Spike Recovery (%)	Mean Field Matrix Spike Recovery (%)	MDL (ng)	MDL (ng/m ³) ¹
BDE-47	90.4	98.6	0.02	0.01
BDE-99	87.8	108.6	0.02	0.01
BDE-100	86.7	96.1	0.02	0.01
BDE-153	88.2	90.0	0.02	0.01
BDE-154	83.5	93.5	0.02	0.01
BDE-126 ²	87.5	92.4	.	.
EHTBB	62.0	61.0	0.2	0.1
BEHTBP ³	.	.	0.2	0.1
TCEP	79.0	59.8	0.5	0.3
TDCPP	73.2	76.0	0.2	0.1

¹ MDL in ng/m³ calculated with average total sample volume SVOCs (1.9 m³)

² Surrogate recovery standard

³ Not detected in spike analysis

Table S4. Summary of Flame Retardant Loading (ng/m²) in Dust (n=39)

Analyte	Mean	SD	Min	25th %	Median	75th %	90th %	95th %	Max
BDE-47	4,818.8	8,345.7	80.5	541.7	1,534.0	3,843.9	15,306	29,719	39,928
BDE-99	7,392.1	14,404	107.0	855.6	1,883.8	5,002.2	23,062	45,331	72,995
BDE-100	1407.1	2,646.7	30.1	172.2	406.6	969.9	3,866.5	7,588.4	13,873
BDE-118	88.4	99.9	<MDL	10.2	41.6	136.8	285.7	313.2	339.4
BDE-153	901.6	1,698.2	18.1	99.2	255.7	608.0	2,945.6	4,724.4	8,871.7
BDE-154	686.0	1,248.9	17.3	83.8	190.6	562.9	2,124.4	3,718.5	6,309.6
BDE-183	75.1	79.8	<MDL	15.7	38.0	121.3	229.9	268.8	276.7
BDE-190	41.9	42.4	<MDL	<MDL	<MDL	<MDL	<MDL	<MDL	24.6
BDE-197	73.8	71.1	<MDL	15.2	38.5	102.3	203.7	232.0	241.1
BDE-203	48.6	55.4	<MDL	<MDL	<MDL	<MDL	71.7	162.8	179.8
BDE-205	44.8	45.1	<MDL	<MDL	<MDL	<MDL	<MDL	<MDL	<MDL
BDE-206	274.1	443.6	<MDL	<MDL	60.0	179.1	675.9	1,545.8	2,281.8
BDE-207	254.9	372.4	11.5	60.3	104.1	350.9	614.3	1,386.3	1,804.1
BDE-209	8,437.2	14,569	280.6	1,234.4	2,923.6	8,260.5	28,538	35,882	78,443
∑ BDE	24,550	42,288	736.9	4,295.4	7,380.6	24,207	51,993	130,033	225,119
EHTBB	4,216.3	13,989	57.4	396.2	682.8	1,788.0	9,978.1	18,952	86,007
BEHTBP	1,364.4	3,232.3	32.4	122.3	282.0	742.9	5,596.5	9,583.1	17,040
TCEP	5,311.1	15,175	96.7	244.8	837.9	1,590.2	19,669	31,757	88,535
TDCPP	13,128	21,697	730.7	2,566.0	6,045.8	11,017	37,960	89,044	90,756

Table S5. Comparison of Flame Retardant Dust Concentrations (ng/g) between Facilities with and without any Upholstered Furniture or Napping Equipment Present in Child Care Room

	Any Upholstered Furniture Present (n=29)^a				No Upholstered Furniture Present (n=10)			
	25th %	Median	75th %	Max	25th %	Median	75th %	Max
BDE-47*	288.6	939.0	1,638.6	15,115.6	235.1	463.2	685.8	1,326.5
BDE-99*	395.2	1,201.6	3,070.9	25,521.8	322.0	574.7	789.1	1,222.2
BDE-100*	87.6	257.9	475.2	5,525.0	72.9	120.5	147.8	211.5
BDE-153*	64.1	155.1	299.3	3,783.3	50.8	73.8	98.0	128.1
BDE-154*	60.1	119.9	251.0	3,031.6	40.5	57.5	68.2	94.1
∑ PentaBDE*	851.6	2,642.1	5,543.9	52,977.0	577.3	1,361.7	1,583.9	2,941.6
EHTBB	232.9	362.4	900.4	14,811.9	175.0	296.7	438.5	1,301.2
BEHTBP	85.2	144.2	259.4	7,489.7	62.0	88.2	417.6	571.6
TCEP	206.3	301.0	663.5	6,834.9	203.1	367.2	569.0	2,442.4
TDCPP	1,508.3	2,533.3	5,803.1	70,930.7	1,131.4	1,538.5	3,471.5	8,478.2

* Mann-Whitney p-value<0.05.

∑ Penta-BDE congeners: sum of BDE-47, BDE-99, BDE-100, BDE-153 and BDE-154.

Table S6. Comparison of flame retardant dust concentrations (ng/g) between facilities with and without foam napping equipment present in child care room

	Foam Napping Equipment (n=17)				No Foam Napping Equipment (n=22)			
	25th %	Median	75th %	Max	25th %	Median	75th %	Max
BDE-47	288.6	939.0	1,175.2	15,116	235.1	671.9	1,326.5	5,786.6
BDE-99	395.2	1,118.9	1,631.4	25,522	357.1	740.4	1,299.2	10,579
BDE-100	86.8	257.3	366.2	5,525.0	101.1	149.7	279.2	2,010.6
BDE-153	61.7	145.1	270.9	3,783.3	69.9	91.8	166.8	1,285.8
BDE-154	49.7	106.9	199.0	3,031.6	49.8	68.8	126.8	914.4
∑ PentaBDE	851.6	2,553.0	3,642.7	52,977	721.3	1,581.8	2,941.6	20,576
EHTBB	232.9	354.0	656.0	6,557.9	192.2	383.4	712.3	14,812
BEHTBP	85.2	144.2	235.2	1,299.3	63.9	115.4	327.6	7,489.7
TCEP*	220.1	642.9	2,139.0	6,835	173.3	260.9	382.2	2,442.4
TDCPP*	2,051.5	2,836.7	6,789.5	36,927	1,336.4	1,538.5	3,202.5	70,931

*Mann-Whitney p-value<0.05.

Table S7. Summary of Flame Retardant Outdoor Air Concentrations (ng/m³)

Analyte	N	>MDL (%)	Mean	SD	Min	25th %	Median	75th %	90th %	Max
BDE-47	16	56.3	1.16	2.67	<MDL	<MDL	0.09	0.60	4.08	10.20
BDE-99	16	75.0	0.06	0.05	<MDL	<MDL	0.05	0.09	0.14	0.15
BDE-100	16	12.5	0.01	0.01	<MDL	<MDL	<MDL	<MDL	0.01	0.03
BDE-153	16	37.5	0.25	0.60	<MDL	<MDL	<MDL	0.17	0.62	2.40
BDE-154	16	0.0	0.01	0.00	<MDL	<MDL	<MDL	<MDL	<MDL	<MDL
EHTBB	16	12.5	0.14	0.39	<MDL	<MDL	<MDL	<MDL	0.55	1.53
BEHTBP	16	12.5	0.30	1.00	<MDL	<MDL	<MDL	<MDL	0.62	4.02
TCEP ¹	14	50.0	0.72	0.54	<MDL	<MDL	0.19	1.17	1.59	1.60
TDCPP ¹	14	100	0.72	1.20	0.06	0.21	0.32	0.39	2.36	4.41

¹ Tris-chlorinated flame retardants analyzed in separate PUF cartridges from BDEs and were collected at 14 facilities.

Table S8. Summary of indoor to outdoor (I/O ratio) flame retardant air concentrations

Analyte	N	Mean	SD	Min	25th %	Median	75th %	Max
BDE-47	16	17.6	21.3	0.1	0.7	12.5	29.7	77.2
BDE-99	16	10.0	16.5	0.5	1.5	5.2	11.0	68.2
BDE-100	16	1.2	0.8	0.2	0.8	1.0	1.4	3.3
BDE-153	16	9.2	24.1	<0.1	0.5	0.8	6.3	97.0
BDE-154	16	0.8	0.2	0.4	0.7	0.8	0.9	1.0
EHTBB	16	0.7	0.3	<0.1	0.6	0.8	0.9	1.0
BEHTBP	16	2.5	7.2	<0.1	0.6	0.8	1.0	29.5
TCEP	14	6.0	8.7	0.5	0.7	2.7	6.6	31.2
TDCPP	14	2.6	2.5	0.1	1.3	2.1	2.7	10.5

Table S9. Spearman Rank Correlation Coefficients Testing the Relationship between Flame Retardant Air and Dust Concentrations and Loading in Dust

	Air to Dust Concentration (rho)	Air to Dust Loading (rho)
BDE-47	0.32	0.30
BDE-99	0.29	0.28
BDE-100	0.29	0.06
BDE-153	0.15	0.16
BDE-154	-0.11	-0.05
EHTBB	0.04	0.29
BEHTBP	0.20	0.37*
TCEP	0.13	0.09
TDCPP	0.34*	0.07

*p<0.05.

Exposure factor calculation

The exposure factor (EF) is calculated:

Where,

F = frequency of exposure (days/year)

ED = exposure duration (years)

AT = averaging time (ED x 365 days/year)

Since children are not present in ECE facilities all hours of the day, we calculated the exposure factor (EF) based on the scenario that a child spends five days per week and 48 weeks per year (which accounts for four weeks away from day care for holidays and vacation). The averaging time will depend on how many years the child is in child care but is assumed to be one year in our calculations.

Table S10. Mean Child Body Weights Used for Dose Calculations

Age Group	Mean Body Weight (kg)
Birth to <1	6.75 ¹
1 to <2 Years	11.4
2 to <3 Years	13.8
3 to <6 Years	18.6

¹ Value based on average of three age groups (birth to <1 month, 2 to <6 months, and 6 to <12 months) from Arcus-Arth and Blaisdell, 2007.

Reference

¹ Arcus-Arth A, Blaisdell RJ. Statistical Distributions of Daily Breathing Rates for Narrow Age Groups of Infants and Children. Risk Analysis 2007;27:97-110.

Table S11a. Hazard Quotients for PBDE Non-dietary Ingestion Dose Estimates Compared to Oral Reference Doses (RfDs) by Age Group: Birth to <1 Year

Chemical	Age Group						
	Birth to <1 year						
	Dose Estimates			Oral RfD (mg/kg-day)	Hazard Quotient		
	50 th %	95 th %	Max		50 th %	95 th %	Max
BDEs							
BDE-47	4.5E-06	6.9E-05	8.9E-05	0.0001	0.05	0.7	0.9
BDE-99	6.0E-06	7.8E-05	0.00015	0.0001	0.06	0.8	1.5
BDE-153	7.3E-07	7.5E-06	2.2E-05	0.0002	0.004	0.04	0.1
BDE-209	8.5E-06	6.7E-05	9.8E-05	0.007	0.001	0.01	0.01

Table S11b. Hazard Quotients for PBDE Non-dietary Ingestion Dose Estimates Compared to Oral Reference Doses (RfDs) by Age Group: 1 to <2 Years

Chemical	Age Group						
	1 to <2 years						
	Dose Estimates			Oral RfD (mg/kg-day)	Hazard Quotient		
	50 th %	95 th %	Max		50 th %	95 th %	Max
BDEs							
BDE-47	4.4E-06	6.8E-05	8.7E-05	0.0001	0.04	0.7	0.9
BDE-99	6.0E-06	7.7E-05	0.00015	0.0001	0.06	0.8	1.5
BDE-153	7.2E-07	7.4E-06	2.2E-05	0.0002	0.004	0.04	0.1
BDE-209	8.4E-06	6.6E-05	9.7E-05	0.007	0.001	0.009	0.01

Table S11c. Hazard Quotients for PBDE Non-dietary Ingestion Dose Estimates Compared to Oral Reference Doses (RfDs) by Age Group: 2 to <3 Years

Chemical	Age Group						
	2 to <3 years						
	Dose Estimates			Oral RfD (mg/kg-day)	Hazard Quotient		
	50 th %	95 th %	Max		50 th %	95 th %	Max
BDEs							
BDE-47	3.7E-06	5.6E-05	7.2E-05	0.0001	0.04	0.6	0.7
BDE-99	4.9E-06	6.3E-05	0.00012	0.0001	0.05	0.6	1.2
BDE-153	6.0E-07	6.1E-06	1.8E-05	0.0002	0.003	0.03	0.09
BDE-209	6.9E-06	5.4E-05	8.0E-05	0.007	0.001	0.008	0.01

Table S11d. Hazard Quotients for PBDE Non-dietary Ingestion Dose Estimates Compared to Oral Reference Doses (RfDs) by Age Group: 3 to <6 Years

Chemical	Age Group						
	3 to <6years						
	Dose Estimates			Oral RfD (mg/kg-day)	Hazard Quotient		
	50 th %	95 th %	Max		50 th %	95 th %	Max
BDEs							
BDE-47	2.7E-06	4.1E-05	5.4E-05	0.0001	0.03	0.4	0.5
BDE-99	3.7E-06	4.7E-05	9.1E-05	0.0001	0.04	0.5	0.9
BDE-153	4.4E-07	4.6E-06	1.3E-05	0.0002	0.002	0.02	0.07
BDE-209	5.1E-06	4.0E-05	6.0E-05	0.007	0.001	0.006	0.009

Table S12. Oral TDCPP Dose Estimates Compared to Child-adjusted NSRL values by Age Group

Birth to <1 year						1 to <2 years				
	Dose estimate (mg/kg/day)	Dose estimate (µg/day)	NSRL (µg/day) (adult) ¹	NSRL (µg/day) (adjusted)	Ratio (NSRL)	Dose estimate (mg/kg/day)	Dose estimates (µg/day)	NSRL (µg/day) adult ¹	NSRL (µg/day) (adjusted)	Ratio (NSRL)
50th %	1.3E-05	0.09	5.4	0.052	1.7	1.3E-05	0.15	5.4	0.088	1.7
75th %	3.4E-05	0.23	5.4	0.052	4.4	3.4E-05	0.38	5.4	0.088	4.4
95th %	2.2E-04	1.46	5.4	0.052	28.1	2.1E-04	2.44	5.4	0.088	27.7
2 to <3 years						3 to <6 years				
	Dose estimate (mg/kg/day)	Dose estimate (µg/day)	NSRL (µg/day) (adult) ¹	NSRL (µg/day) (adjusted)	Ratio (NSRL)	Dose estimates (mg/kg/day)	Dose estimates (µg/day)	NSRL (µg/day) ¹	NSRL (µg/day) (adjusted)	Ratio (NSRL)
50th %	1.1E-05	0.15	5.4	0.106	1.4	8.0E-06	1.49	5.4	0.143	1.04
75th %	2.8E-05	0.38	5.4	0.106	3.6	2.1E-05	0.38	5.4	0.143	2.7
95th %	1.8E-04	2.4	5.4	0.106	22.9	1.3E-04	2.4	5.4	0.143	17.0

¹ OEHHA, 2011. Office of Environmental Health Hazard Assessment (OEHHA). Evidence on the Carcinogenicity of Tris(1,3-Dichloro-2-Propyl) Phosphate. July 2011. http://oehha.ca.gov/prop65/hazard_ident/pdf_zip/TDCPP070811.pdf