HB-2545
Ecological Effects of Selected Flame Retardants (non-human biota)

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Road Map

- Flame retardants identified in HB-2545
- Ecorisk assessment: comparison of exposure and effects data
  - exposure data (WA state, metrics)
  - effects data, i.e., toxicity thresholds (metrics, data sources)
  - risk characterization (HQ method, uncertainties)
- Results
  - risk to aquatic biota (assessed with concentrations in water, sediment, tissue)
  - risk to terrestrial biota (assessed with concentrations in soil, as well as dose analysis)
- Conclusions
- More details provided in narrative version posted online
- Questions

Flame retardants in HB-2545 listed for evaluation

CAS#	Acronym	Name
115-86-6	TPP	Triphenyl phosphate
13674-84-5	TCPP	Tris (1-chloro-2-propyl) phosphate
26040-51-7	TBPH	Bis (2-ethylhexyl) tetrabromophthalate
38051-10-4	V6	Bis (chloromethyl) propane-1,3-diyl tetrakis-(2-chloroethyl) bis(phosphate)
68937-41-7	IPTPP	Isopropylated triphenyl phosphate
183658-27-7	TBB	2-ethylhexyl-2,3,4,5-tetrabromobenzoate

Environmental Data in WA (exposure data)

- WA study locations and environmental media sampled
  - Clark County-stormwater and stormwater sediment (Medlen, 2018)
  - 10 lakes-surface water, sediment, fish (Mathieu, in prep)
  - Columbia River-surface water (Alvarez et al, 2014) and sediment (Counihan et al, 2014)
- Notes on WA data
  - surface water and sediment: [stormwater conc] > [river or lake conc]
  - not all flame retardants were measured in all media
  - no soil sampled for these flame retardants in WA

Metrics for Environmental Data

- Exposure Point Concentration (EPC) in soil, water, or sediment
  - applicable to species inhabiting environ media, e.g., plants, soil invertebrates, aquatic invertebrates, fish
  - measured or modeled
- Fish tissue concentration
- Total Daily Intake (TDI) or dose
  - applicable to higher trophic level species, e.g., birds, mammals
  - modeled from ingestion of food and environ media and incorporates bioaccumulation

Metrics and Endpoints for Ecotox Data (effects data)

- Toxicity Reference Value (TRV)-acceptable concentration or dose, e.g.,
  - Predicted No Effect Concentration (PNEC) in environ media (e.g., soil, water)
    - applicable to plants, soil invertebrates, aquatic invertebrates, fish
  - modeled no effect dietary dose (mg/kg BW/d)
    - applicable to birds, mammals
  - reflects most sensitive species and most sensitive endpoint
  - established by an authoritative scientific and regulatory source (e.g., EPA, ECHA)
    - typically represents weight of evidence and consensus
- Fish tissue concentration has been related to effects
  - e.g., Environmental Residue-Effects Database (ERED) (USACE, 2018)
- Preferred endpoints for ecorisk: growth, reproduction, survival
  - relevant to protection of local population or community

Sources of Ecotox Data

- Aquatic biota (e.g., aquatic invertebrates, fish)
  - EPA/DfE (2015) has compiled aquatic ecotox data on flame retardants
    - acute (e.g., LC50) and chronic (e.g., LOAEC)
    - ECOSAR modeling (structure-activity relationships)
  - equilibrium partitioning (EU, 2008a,b)
    - derive PNEC[sed] from PNEC[water]
- Terrestrial biota (e.g., plants, soil invertebrates, birds, mammals)
  - relatively few terrestrial ecotox data on flame retardants
    - EU (2008a,b), ECHA (2013, 2018b), EC (2016a,b)
  - equilibrium partitioning (EU, 2008a,b)
    - derive PNEC[soil] from PNEC[water]
  - searched several databases for terrestrial ecotox data on flame retardants
    - EPA/ECOTOX (2018), ORNL/RAIS (2018)

Risk Characterization-HQ estimate

- Compare exposure to effects via a simple ratio
  - Hazard Quotient (HQ)= Exposure/Effects
    - exposure and effects in same units (conc or dose), so HQ is unitless
    - **HQ conservatively calculated with highest exposure and lowest or no effect**
  - HQ interpretation
    - [HQ<1] indicates adverse effects are unlikely
    - [HQ>1] indicates adverse effects are possible

Risk Characterization-Uncertainty

- Uncertainty in exposure and effects data
  - incomplete or nonrandom sampling for exposure data
    - e.g., nonrandom sampling precludes generalization to underlying population of contaminant data
  - incomplete effects data from an authoritative scientific and regulatory source
    - e.g., acute to chronic data extrapolation, few trophic levels represented in data set, species sensitivity differences--accounted for with an "assessment factor" (AF)
    - most notably: limited effects data for terrestrial receptors
  - modeled exposure (e.g., EUSES, TDI) and effects (e.g., ECOSAR, equilibrium partitioning)
    - model uncertainty (necessary simplification of real world processes)
    - parameter uncertainty (analytical or sampling errors in inputs)

Note on Results tables—order and format

- Table order
  - aquatic biota (water, sediment, fish tissue)
  - terrestrial biota (soil, dose)
- Each table (columns from left to right)
  - flame retardant
  - exposure data (EPC, PEC, TDI)
  - effects data, i.e., toxicity thresholds (PNEC, TRV)
  - HQ estimate (=Exposure/Effects)
- Highlight a subset of these data (not all)

Results for Aquatic Biota-water

Flame Retardant	EPC Summary	EPC	Ecotox Data (EPA/DfE, 2015)	Ecotox Conc	AF	PNEC=Ecotox Conc/AF	HQ=EPC/PNEC
TPP	max, Clark County, WA, stormwater, 2017, Medlen (2018)	83 ng/L	30 d LOEC (chronic), rainbow trout, experimental, ECHA (2013), DFE class-very high tox	37000 ng/L	50 (ECHA, 2018a)	740 ng/L	0.11
TCPP	max, Clark County, WA, stormwater, 2017, Medlen (2018)	857 ng/L ("J" qualified)	static 96 hr LC50 (acute), fathead minnow, experimental, EC (2016a), DFE class-moderate tox	51000000 ng/L	30 (EC, 2016a)	1700000 ng/L	0.00050
TBPH	max, Clark County, WA, stormwater, 2017, Medlen (2018)	<50 ng/L (nondetect at RL)	ECOSAR predicts NES due to low water solubility (2E-9 mg/L) and high log Kow (12), DFE class-low tox, dietary uptake may be relevant (EC, 2016b)	79000 ng/L 15 d LC50 (acute), Daphnia carinata, experimental, EC (2016b)	100 (EC, 2016b)	790 ng/L	0.063

Results for Aquatic Biota-water(continued)

Flame Retardant	EPC Summary	EPC	Ecotox Data (EPA/DfE, 2015)	Ecotox Conc	AF	PNEC=Ecotox Conc/AF	HQ=EPC/PNEC
V6	max, Clark County, WA, stormwater, 2017, Medlen (2018)	10 ng/L	23 d NOEC (chronic), reproduction, Daphnia magna, experimental, EU (2008b), DFE class-moderate tox	3680000 ng/L	50 (EU, 2008b)	73600 ng/L	0.00014
IPTPP	No data		ECOSAR predicts NES due to high log Kow (9.1), DFE class-very high tox	1500000 ng/L LC50 (acute), Daphnia magna, experimental, TOXNET/HSDB (2018)	1000 (ECHA, 2018a)	1500 ng/L	
TBB	max, Clark County, WA, stormwater, 2017, Medlen (2018)	<50 ng/L (nondetect at RL)	ECOSAR predicts NES due to low water solubility (1.1E-5 mg/L) and high log Kow (8.8), DFE class-low tox, dietary uptake may be relevant (EC, 2016b)	79000 ng/L 15 d LC50 (acute), Daphnia carinata, experimental, EC (2016b)	100 (EC, 2016b)	790 ng/L	0.063

Results for Aquatic Biota-sediment

Flame Retardant	EPC Summary	EPC	Ecotox Data	PNEC	HQ=EPC/ PNEC
TPP	max, Clark County, WA, stormwater sediment, 0-12 cm, 2017, Medlen (2018)	36.1 ng/g dw	No data		
TCPP	max, Clark County, WA, stormwater sediment, 0-12 cm, 2017, Medlen (2018)	2040 ng/g dw ("E" qualified)	Equilibrium partitioning method, K[susp/water]=5.25 m3/m3, susp matter density=1150 g/L, PNEC[water]=0.64 mg/L, EU (2008a), sediment biota	PNEC[sed]=2920 ng/g ww (13270 ng/g dw) ww to dw (EU, 2008c)	0.15
TBPH	max, Clark County, WA, stormwater sediment, 0-12 cm, 2017, Medlen (2018)	<43 ng/g dw (nondetect at RL)	No data		

Results for Aquatic Biota-sediment (continued)

Flame Retardant	EPC Summary	EPC	Ecotox Data	PNEC	HQ=EPC/PNEC
V6	max, Clark County, WA, stormwater sediment, 0-12 cm, 2017, Medlen (2018)	7.12 ng/g dw	Equilibrium partitioning method, K[susp/water]=7.03 m3/m3, susp matter density=1150 g/L, PNEC[water]=0.0736 mg/L, EU (2008b), sediment biota	PNEC[sed]=455 ng/g ww (2068 ng/g dw) ww to dw (EU, 2008c)	0.0034
IPTPP	No data		No data		
TBB	max, WA lake sediment, 0-2 cm, 2018, Mathieu (in prep)	<25 ng/g dw (nondetect at RL)	No data		

Results for Aquatic Biota-fish tissue

Flame Retardant	EPC Summary	EPC	Ecotox Data	PNEC	HQ=EPC/PNEC
TBB	max, bass, sucker, pikeminnow, fillet, WA lake, 2017, Mathieu (in prep)	<3 ng/g ww (nondetect at RL)	No data		
All other flame retardants in this analysis	No data for WA fish		No data		

Results for Terrestrial Biota-soil

Flame Retardant	PEC Summary	PEC	Ecotox Summary	Ecotox Conc	AF	PNEC=Ecotox Conc/AF	HQ=PEC/PNEC
TPP	No data		ECHA (2013)			0.218 mg/kg soil dw	
TCPP	PEC regional soil, EUSES model, EU (2008a)	0.00265 mg/kg soil ww	NOEC (chronic), lettuce seedling emergence/growth, experimental, EU (2008a)	17 mg/kg soil dw	10 (EU, 2008a)	1.7 mg/kg soil dw (1.5 mg/kg soil ww)	0.0018
TBPH	No data		No data				

Results for Terrestrial Biota-soil (continued)

Flame Retardant	PEC Summary	PEC	Ecotox Summary	Ecotox Conc	AF	PNEC=Ecotox Conc/AF	HQ=PEC /PNEC
V6	PEC regional soil, EUSES model, EU (2008b)	0.0000635 mg/kg soil ww	Equilibrium partitioning method, K[soil/water]=7.55 m3/m3, soil density=1700 g/L, PNEC[water]=0.0736 mg/L, EU (2008b)			PNEC[soil]=0.327 mg/kg soil ww	0.00019
IPTPP	No data		NOEC (chronic), earthworm reproduction, experimental, ECHA (2018b)	250 mg/kg soil dw	50 (ECHA, 2018a)	5 mg/kg soil dw	
TBB	No data		No data				

Results for Terrestrial Wildlife-dose

Flame Retardant	TDI Summary	TDI	Ecotox Summary	AF	TRV	HQ=TDI/TRV
TBB	mink (piscivorous), BAF=8446 L/kg, FIR=0.22 g/g BW/d, dietary dose model, EC (2016b) water EPC=RL=50 ng/L, nondetect, Medlen (2018)	0.093 mg/kg BW/d	23 mg/kg BW/d, derived from a rat study on reduction in birth wt of second generation pups, EC (2016b)	10 (EC, 2016b)	2.3 mg/kg BW/d	0.040
TBB	river otter (piscivorous), BAF=8446 L/kg, FIR= 0.16 g/g BW/d, dietary dose model, EC (2016b) water EPC=RL=50 ng/L, nondetect, Medlen (2018)	0.068 mg/kg BW/d	14 mg/kg BW/d, derived from a rat study on reduction in birth wt of second generation pups, EC (2016b)	10 (EC, 2016b)	1.4 mg/kg BW/d	0.049
TCPP	No data		22 ng/g BW/d, 21 d NOEL, weight, American kestrel, Fernie et al (2015)			

Conclusions

- Environmental and ecotox data are limited for the six flame retardants (specified in HB-2545) evaluated in this effort
- Three WA environmental data sets indicated that exposure estimates for aquatic biota did not exceed screening values
- Effects in aquatic biota appear unlikely, although more robust data would be needed to confirm this conclusion
- Relevant data for terrestrial biota were sparse or lacking
- Due to more extensive data gaps, impacts to terrestrial biota remain inconclusive
- Further research would be needed to more fully characterize ecorisk to flame retardants in WA

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