



COMMONWEALTH of VIRGINIA

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VIRGINIA DEPARTMENT OF HEALTH (VDH) GUIDELINE FOR ISSUANCE OF FISH-EATING ADVISORY DUE TO CONTAMINATION OF FISH WITH POLYBROMINATED DIPHENYL ETHERS (PBDEs)

Polybrominated diphenyl ethers (PBDEs) are dicyclic aromatic ethers that are formed by the direct bromination of biphenyl. PBDEs are closely related to polychlorinated biphenyls (PCBs) in their chemical, physical, and, environmental properties. There are 209 different PBDE compounds, termed isomers or congeners, based on the possible bromine substitution patterns. PBDEs are resistant to breakdown in the environment and tend to bioaccumulate in the food chain. PBDEs are virtually insoluble in water, soluble in fat, and slightly to highly soluble in various organic solvents; their solubility decreases with increasing bromine number.

Production and Use of PBDEs

The total annual worldwide PBDE production in 1992 was estimated at roughly 80 million pounds (lbs) (60,000,000 lbs deca-BDE; 12,000,000 lbs octa-BDE, and 8,000,000 lbs penta-BDE). Three major commercial mixtures of PBDEs are produced: deca-BDEs (97-98% deca-BDE and 0.3-3% nona-BDE); octa-BDEs (43-44% hepta-BDE, 31-35% octa-BDE, 9-11% nona-BDE, and 0.1% deca-BDE); and penta-BDE (50-62% penta-BDE, 24-38% tetra-BDE, and 4.8% hexa-BDE). Deca-BDE is the major product (about 75% of the PBDE production).

PBDEs are currently used as flame retardant additives in polymers, textiles, plastics, coatings, and electrical components found in common goods including computers, televisions, and other electrical appliances.

Sources of PBDEs in the Environment

PBDEs have not been reported to occur naturally in the environment, but some PBDEs have been found in sponges and algae. PBDEs in the environment were first identified in sediments in the United States in 1979 and in fish from Sweden in 1981. Since then, several studies of PBDEs in the environment have been conducted in Sweden and other countries. PBDEs have also been found in human blood plasma, adipose tissue, and milk. Tetra- to hexa- BDEs have been reported in fish tissue. However, 2,2',4,4'-tetra-BDE (PBDE-47) congener is the one that is most prevalent in fish tissue. Therefore, the fish-eating advisory guideline is based on tetra-BDE.

Toxicity of PBDEs

No studies are available on the toxicity of PBDEs in humans. In general, PBDEs have low acute oral toxicity in experimental animals. Some chronic animal studies have shown that commercial PBDEs induce liver enzymes (cytochrome P-450) that are related to toxic effects. Deca-, octa-, and penta-BDEs

were evaluated by the U.S. Environmental Protection Agency's (EPA) Integrated Risk Information System (IRIS) database. Based on available toxicological data, reference doses (RfDs) for deca-, octa-, and penta-BDEs in milligrams per kilogram of body weight per day (mg/kg/day) are 0.01, 0.003, and 0.002, respectively. No information is available in IRIS database on the toxicity of tetra-BDE. In the absence of such information and given the trend of decreasing RfD with decreasing bromination, EPA has derived an interim RfD of 0.001 mg/kg/day for tetra-BDE (EPA, Brominated diphenyl ethers in fish from Virginia, April 13, 2000). These RfDs indicate that tetra-BDE is relatively more toxic than deca-, octa- and penta-BDEs. The RfD for tetra-BDE used in the current risk assessment is conservative which would also be protective of human health from consumption of fish contaminated with deca-, octa-, and penta-BDEs.

Derivation of Acceptable Concentration of Tetra-BDE in Fish

The formula for calculating an acceptable concentration corresponding to a recommended two meals per month of PBDEs in edible fish tissue for protecting fish consumers from noncancer health effects is as follows:

$$C = \frac{RfD \times BW \times T}{MS \times NM}$$

Where:

- C** = acceptable concentration of PBDE in edible portions of fish in milligrams per kilograms (mg/kg)
- RfD** = reference dose (RfD) for tetra-BDE in milligrams per kilogram per day (0.001 mg/kg/day)
- BW** = consumer adult body weight in kilograms (70 kg)
- T** = time period 30 day (days/month)
- MS** = average fish meal size of 8 oz (0.227 kg)
- NM** = number of allowable fish meals per month (2 meals/month)

Substituting for assumptions in the above equation, an acceptable PBDE concentration of 5 mg/kg in edible fish tissue was derived.

$$\begin{aligned} C &= \frac{0.001 \text{ mg/kg/day} \times 70 \text{ kg} \times 30 \text{ day/month}}{0.227 \text{ kg/meal} \times 2 \text{ meals/month}} \\ &= 4.62 \text{ mg/kg} \approx 5 \text{ mg/kg} \end{aligned}$$

Based on this calculation, VDH would use 5 mg/kg or 5 parts per million (ppm) tetra-BDE in fish as the trigger level for issuance of a fish-eating advisory. VDH will use a three-tiered approach when issuing a fish-eating advisory.

- Average fish tissue concentrations ranging from non-detectable to below 5 ppm, will not warrant issuance of a fish-eating advisory.

- When the average concentrations in fish range from 5 ppm to below 10 ppm, VDH will recommend limiting consumption of contaminated species to two 8-ounce (oz) meals per month.
- When the average concentrations in fish exceed 10 ppm, VDH will recommend that contaminated fish should not be consumed.

Assumptions are briefly described below:

Concentration (C)

Concentrations of PBDE (mg/kg) detected in edible portions of fish tissue.

Reference Dose (RfD)

The RfD is an estimate of a daily exposure to the human population (including sensitive subpopulations) that is likely to be without appreciable risk of deleterious effects during a lifetime.

Average Body Weight (BW)

A body weight of 70 kilograms for the average adult male is widely accepted by many regulatory agencies for risk assessment and establishing guidelines and standards for chemical exposure.

Time (T)

Time period (30 day/month) was used to calculate fish meal consumption limits in a 30-day period as a function of meal size.

Meal Size (MS)

Meal size is defined as the amount of fish (in kilograms) consumed at one meal. An 8-oz (0.227 kg) meal size was assumed.

Number of Meals (NM)

Number of meals consumption limit is expressed as the maximum allowable fish meals in a 30-day time period (meals/month). These are based on the total dose allowable over a 1-month period (based on the RfD).

Conclusion

VDH would use 5 mg/kg or 5 parts per million (ppm) tetra-BDE in fish as the trigger level for issuance of a fish-eating advisory. VDH will use a three-tiered approach when issuing a fish-eating advisory.

- Average fish tissue concentrations ranging from non-detectable to below 5 ppm, will not warrant issuance of a fish-eating advisory.

- When the average concentrations in fish range from 5 ppm to below 10 ppm, VDH will recommend limiting consumption of contaminated species to two 8-ounce (oz) meals per month.
- When the average concentrations in fish exceed 10 ppm, VDH will recommend that contaminated fish should not be consumed.
- Reproductive or developmental effects of tetra-BDE have not yet been evaluated. However, for sensitive populations, such as pregnant women, nursing mothers, and young children, it would be prudent to avoid consumption of fish contaminated with PBDEs. VDH would recommend that pregnant women, nursing mothers, and young children should not consume fish contaminated with tetra-BDE at concentrations above 5 ppm.

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