Daily Intake Estimates of PBDEs Associated with Consumption of Catfish in the U.S.

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Introduction

Polybrominated diphenyl ethers (PBDEs) are used as flame retardants in a wide variety of consumer products. Concerns surrounding these compounds are primarily due do their ubiquitous presence in the environment as well as in human tissue, such as milk, coupled with evidence indicating the potential for adverse effects. Despite these concerns, relatively few studies are available in the literature which characterize and quantify intake by humans. It has commonly been assumed that dietary intake is the primary exposure pathway, although recent analyses indicate that inhalation and dermal contact with dust contribute significantly to total body burdens as well. The few studies which have evaluated PBDEs in food from the U.S. suggest that fish contain higher levels of PBDEs than other sources in the diet (Huwe et al. 2005, Schecter et al. 2004, 2006). However, dietary consumption patterns vary by region, as do PBDE concentrations, and therefore the contribution of daily intake due to fish consumption also varies by region. In an effort to understand these relationships, we measured PBDE concentrations in Southern Mississippi catfish and determined the daily intake of these compounds from a primary food source for residents in this area of the United States. We also compared the daily intake of PBDEs from Southern Mississippi catfish to catfish from other regions as well as other food types in the United States.

Materials and Methods

Sixty-one catfish samples from Southern Mississippi were collected in March 2006 and analyzed for a total of 43 PBDE congeners. Wild catfish (n=33) were caught by local fisherman at four locations and farm-raised catfish (n=28) samples were purchased from a Mississippi farm or from local seafood markets and/or grocery stores. Previously, we briefly reported PBDE concentrations (Staskal et al. 2006) in Southern Mississippi catfish; wild-caught catfish fillets had an average concentration of 3.85 ng/g (410.46 ng/g lipid weight, lw), whereas farm-raised catfish fillets had an average PBDE concentration of 0.45 ng/g (5.71 ng/g lw, Table 1). BDEs 47, 99, 100, 153, 154 and 209 were the dominant contributors to the total PBDE concentrations; however, relative contributions of each congener between fish type and sample type were different. Furthermore, PBDE concentrations in the wild catfish varied slightly by collection location. The catfish samples (i.e., fillets) used in the intake analyses ranged from 0.381-11.42 ng/g ww.

To compare PBDE intake due to catfish consumption in the United States, we relied on two other key datasets which measured PBDE levels in catfish collected in Washington State (WA, Johnson and Olson 2004) and Florida (FL, Johnson-Restrepo et al. 2005). Johnson and Olson (2004) collected Channel catfish samples from the Snake River in Southeastern Washington State in 1995. Reported PBDE

concentrations (Table 1) were based on replicate analyses of composite samples consisting of five individual fish each. Johnson-Restrepo et al. (2005) collected eight hardhead catfish samples from estuarine waters of the Indian River Lagoon and adjacent offshore coastal waters of Florida in 2004 as part of a study which evaluated biomagnification factors. Resulting PBDE concentrations are listed in Table 1.

Study	# Cong.	∑PBDE	47	99	100	153	154	Reference
Mississippi, Wild Catfish Fillets	43	3.85	1.77	0.75	0.55	0.15	0.12	Staskal et al. 2006
Mississippi, Farm-Raised Catfish Fillets	43	0.45	0.13	0.10	0.03	0.01	0.01	Staskal et al. 2006
Washington, Channel Catfish Fillets	5	8.00	4.30	3.00*		0.72*		Johnson & Olson 2004
Florida, Hardhead Catfish Muscle	13	0.79	0.24	0.16	0.07	0.09	0.08	Johnson-Restrepo et al. 2005

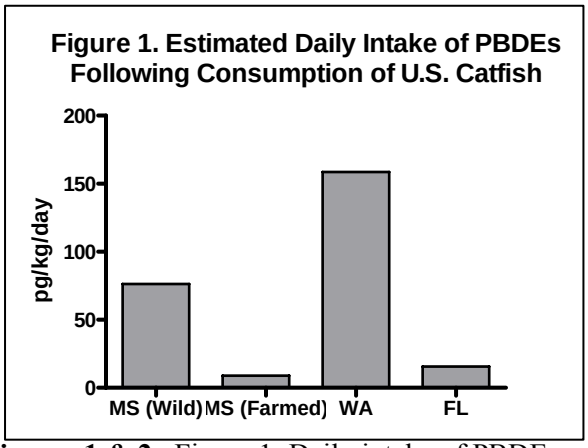
Table 1. Concentrations (ng/g ww) of PBDEs utilized in the assessment of daily intake values related to catfish consumption in the United States. The ∑PBDE refers to the sum of PBDEs as reported in the study. *Johnson & Olson (2004) report PBDE concentrations as total PBDEs, TBDE, PeBDEs and HxBDEs although BDEs 47, 99, 100, 153 and 154 were individually quantitated.

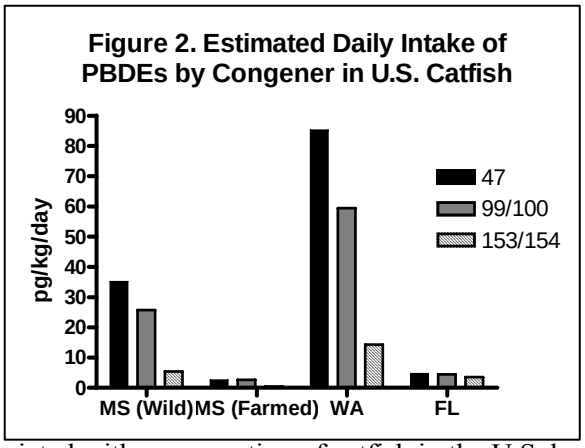
Daily intake was calculated using values reported in the USEPA Exposure Factors Handbook (EPA 1997). Intake factors were based on the estimated mean consumption of uncooked catfish as reported by combined USDA and CSFII sources (USEPA 1997). A standard body weight of 70 kg was applied. Intakes are reported as pg PBDE/kg body weight/day based using wet weight concentrations. Analyses were carried out using Microsoft Excel and Prism.

Results and Discussion

The estimated daily intake of PBDEs from wild catfish from Mississippi relative to catfish from Washington and Florida are compared in Figure 1. The estimated daily intake of PBDEs from wild catfish from Mississippi (76 pg/kg/day) was less than the estimated intake from wild catfish from Washington (159 pg/kg/day), but greater than the estimated PBDE intake of wild catfish from Florida (16 pg/kg/day) (Figure 1); however, the congener-dependent proportion of the daily intake values varied by region and fish type (Figure 2). In addition, estimated daily intake of PBDEs from farmed catfish from Southern Mississippi was significantly less than the estimated daily intake values associated with wild catfish (Figure 1). While it is generally accepted that the large differences between farmed and wild fish are a function of diet, the differences between the levels and subsequent intake between regions where the wild catfish were collected is less clear. For example, BDE 47 accounted for approximately half of the

total PBDE intake in wild catfish from Mississippi and Washington versus only one-third in Florida. In contrast, the daily intake of BDEs 153 and 154 (combined) were approximately the same as the intake from BDE 47 in the Florida catfish but less than one-quarter of the intake in the other catfish. While the dominant congeners were similar between the catfish studies, the authors recognize that caution should be used when making such comparisons as the methods of analyses and the number of congeners studied varied between studies. Nonetheless, the ratios (i.e. concentration of BDE 47 relative to BDE 99, 100 or 153) of dominant congener concentrations varied between catfish collected from different regions. Assuming that the species of catfish evaluated in this study have similar metabolic capabilities, these comparisons further support the idea that environmental surroundings have a major impact on PBDE concentrations found in biological media and subsequent levels of human exposure.





Figures 1 & 2. Figure 1: Daily intake of PBDEs associated with consumption of catfish in the U.S. based on the ∑PBDEs as reported in each study. Figure 2: Estimated daily intake of PBDEs by congener from U.S. catfish (note: congener-specific intake was calculated for PeBDEs combined and HxBDEs combined considering PBDE concentrations for the Washington catfish samples were reported based on this approach).

Estimated daily intake of PBDEs through dietary consumption of U.S. catfish was also compared to previously reported intake values for other food types in the U.S (Figure 3). Using these comparisons, the daily intake of PBDEs associated with consumption of catfish in Southern Mississippi appears to be considerably lower than the relative intake of PBDEs associated with consumption of other food types. However, because region-specific intake values were not available for this food source, the authors recognize that applying generic intake values may underestimate the daily intake of PBDEs for Southern Mississippi residents. Schecter et al. (2005) also reported levels of PBDEs in two individual catfish samples collected from supermarkets in Texas. For these samples, intake values associated with fillets (31.7 pg/kg/day) and whole fish (48.6 pg/kg/day) were higher than the intake values associated with consumption of farmed catfish collected in Southern Mississippi.

Catfish in the Southern Mississippi region were chosen as the focus of this study because these fish have traditionally been a common staple in the diet of this region and could potentially contribute significantly to the intake of PBDEs in this population. When generic intake values were applied, the intake of PBDEs

associated with dietary consumption of Southern Mississippi catfish was generally similar to intake values from other studies which have evaluated levels of PBDEs in catfish, but was lower than daily intakes associated with the consumption of meat and other food products. This finding is consistent with other studies which have evaluated intake of fish relative to other products in the U.S. These results provide a reasonable data set describing intake of PBDEs from catfish consumption for residents in Southern Mississippi.

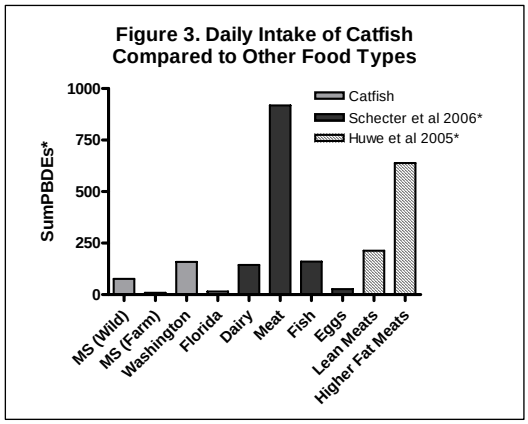


Figure 3. Daily intake values for various food types in the U.S. *Values from Schecter et al. (2006) drawn from Table 6 for a 70kg male aged 20-39. Values from Huwe et al. (2005) calculated from Table 5 for a 70 kg person.

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