Brominated Compounds: Biotic Levels, Trends, Effects
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Analyses of polybrominated compounds in fish from various origin show that these compounds are found in fish world-wide at levels from low ppb up to low ppm on lipid bases, corresponding to high ppt up to low ppb on a wet weight basis. Several studies on the occurrence of brominated compounds in fish and seafood are presented in the session. Päpke et al. find that concentrations of PBDE in fish from the German market in 2003, including fish from The North See, Chile, North Atlantic, Denmark, Kenya and The Netherlands, had total levels of PBDEs from 0.42 to 48 ppb (lipid based). Interestingly, BDE-209 accumulation is shown to occur in several fish species as reported in this study and also in large verity of wild ocean fish species as reported by Luksemburg and coworkers. Luksemburg et al., Hites et al. and Hayward et al. compare PBDE levels and congeners in some farmed and wild fish. Luksemburg et al. find that, with the exception of swordfish, total PBDE levels were generally higher in fish products from farm-raised species than in wild-caught species. Hayward et al. find that PBDE and PCB levels are correlated in wild and farm-raised fish fillets, the slopes however may differ. Hites et al. measured PBDEs in about 700 farmed and wild salmon collected from around the world. It was shown that the total PBDE levels in farmed salmon were significantly more 'concentrated' as a group than in the wild salmon. PBDE levels were significantly higher in farmed salmon from Europe than in samples from North America, in farmed salmon from North America than in Chile, and in farmed salmon from Chile than in wild salmon. Store-bought samples from North America as well as Europe had average PBDE concentrations higher than in wild salmon. The congener profiles in wild and farmed salmon are similar and this is seen as an indication that the exposure is from the same source. Additional studies of contaminant sources, particularly in feed used for farmed salmon, would be useful in reducing the contents of dioxin-like compounds, Hites et al. concludes.

Levels of BFRs in fish and seafood are further discussed in six presentations in the session. Bethune et al. measure levels of PBDE in Norwegian fish feed (3-19 ng/g lipid),

herring (11-24 ng/g lipid) and farmed salmon (8-34 ng/g lipid). The average level found in 20 Atlantic farmed salmons was 19.5 ng/g lipid, which is an order of magnitude lower than those found recently for salmon from the Atlantic and more polluted waters of the Baltic. For crab, substantial levels of PBDE 153 were observed in the shell meat (4.11 ng/g lipid). According to the authors it is possible that the high levels of PBDE 153 observed in crab shell meat may be due to biotransformation of PBDE 209. Spatial and temporal trends of BFRs in Atlantic cod and Polar cod in the North-East Atlantic was studied by Bytingsvik et al. An increase of 3-4 times seen in wet weight concentrations of all BDE congeners when comparing Atlantic cod from Hvalar, outer Oslo fjord, in 1998 and 2003. The study indicates that there has been an increase in concentrations of PBDEs and especially HBCD in Hvalar during the last five years. HBCD was also found to be present at relatively high concentrations even at remote areas like Bear Island. The HBCD shows a strong regional differentiation also along the Swedish coast and Asplund et al. suggest that this is an indication of ongoing inputs to the southern part of the Baltic Sea. In two studies presented by Janák et al. the diastereomers of HBCD are studied in marine biota from the Western Scheldt Estuary. They use a chiral LC-MS-MS method for the determination of enantiomeric fractions for á-HBCD, the most abundant diastereomer. The results show that enantioselective accumulation of HBCD is species dependent. In studying freshwater mussels and fish from Flandern, Belgium, Covaci et al. find PBDE in all samples, and concentrations as well as variations are suggested to be attributed to different industrial activities along the sampling sites.

Biotic levels and trends of BFRs in human milk and seabird eggs from the US are presented in two studies by She et al. The unusual pattern in some samples of human milk from Northwest US is seen in the level of PBDE 153 exceeding PBDE 47, which usually is the main congener in biological tissue. In seabird eggs from the San Francisco Bay Area the levels of total PBDEs were found to be as high as 7.8 ppm (in Leastern tern egg), 36 ppm (in Foster tern egg) and 63 ppm (in Caspian tern egg) (lipid-based) which includes the highest level so far reported in wildlife. Two studies of BFRs in birds of pray from Belgium, by Voorspoels et al. and Jaspers et al., find great differences in species and tissue concentrations. Compared to the eggs from the San Francisco Bay Area the levels in owl eggs from Belgium contained only a maximum of 0.57 ppm of total PBDEs. In monitoring of PBDEs in Australian fauna Symons et al. also find birds of pray being most contaminated, with concentrations up to 0.22 ppm in Peregrine Falcon.

Of totally 25 contributions in the session 10 deal with *effects* of brominated compounds. Effects related to thyroid function are studied in four contributions. Darnerud et al. studies the relation between serum levels of PBDEs in rats and effects on serum thyroxine levels. In the study on T4 effects in rats, Bromkal seemed to have a stronger potency than BDE 47 at similar plasma PBDE concentrations. Kuriyama et al. observed changes in maternal levels of thyroid hormones and hepatic enzyme activity during lactation following a single low dose administration of PBDE 47 and Andrade et al. report disruption of thyroid hormone homeostatsis in the developing male rat after exposure to low doses of PBDE 47. Mure concludes in his update on the relationship between the rise in thyroid and neurodevelopmental health effects in North America, and the rise in concentrations in the environment that given the present trends for PBDEs,

even looked at in isolation, a proportion of the North American population could already, or in as little as 3 or so years, be exposed to toxicologically relevant concentrations of PBDEs. Toxicokinetics of TBBPA, HBCD and lower brominated diphenyl ethers are studied in to contributions. Staskal et al. calculate the whole animal half life of BDE 47 (after a single oral dose in mice) as approximately two days. Geyer et al. estimate the terminal elimination half-lives of the main BFRs in adult humans by two different methods. The data suggests that there are differences in retention of PBDEs 47, 99, 100, 154 and 153, and that they are much longer (1.5-12.4 years) than for HBCD (0.06-0.6 years). It is indicated that the long retention times of these PBDEs are of concern in the risk assessment and that further human exposure should be limited.

The major prerequisite for the TEF system is that when a compound does not activate the Ah receptor the compound is not assigned a TEF value. Peters et al. state that the lack of CYP1A1 induction by the PBDEs, tested in Cynomolgus Monkey Primary Hepatocytes, supports the exclusion of these compounds in the TEF concept. Data presented by Lichtensteiger et al. demonstrates that exposure to PBDE 99 during perinatal development can interfere with expressions and estrogen sensitivity (demonstrated in rats). They state that the developing neuroendocrine brain should receive more attention besides peripheral endocrine and reproductive organs. The sex-dependent behavioural changes in rat offspring after *in utero* administration of a single low dose PBDE 47 was investigated by Kuriyama et al. and the evidence of neurobehavioural changes were observed, at doses pertinent to human exposure levels, indicating that neurotoxic risks of PBDE 47 should be further studied. Larsen et al. studies the binding of PBDE 100 in mammalian biliary carrier proteins. Daily excretion of [^{14}C] BDE-100 into urine or bile of male rats was minimal. TLC analysis showed that metabolism was necessary for BDE-100 elimination in bile and that the metabolism of BDE-100 into water soluble metabolites by the xenobiotic metabolizing cytochrome was an unfavourable process.

The discussions and conclusions concerning levels, trends and effects presented in the 25 oral and poster contributions in this session show that BFRs in the environment have to be considered as a potential risk to wildlife and human health.