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Marine Environmental Research 50 (2000) 217–221

MARINE ENVIRONMENTAL RESEARCH

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PCB uptake and accumulation by oysters (*Crassostrea virginica)* exposed via a contaminated algal diet

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Received 24 April 1999; received in revised form 2 August 1999; accepted 17 December 1999

Abstract

Reproductively active oysters were fed daily with 0.2 g algal paste containing 0, 0.1, and 1.0 μg polychlorinated biphenyls (PCBs) (1:1:1 mixture of Aroclor 1242, 1254 and 1260) for either 15 or 30 days, and accumulation of PCBs in different organ tissues and eggs assessed. The effects of PCB exposure on lipid content, lipid class and fatty acid composition were also evaluated. PCBs were accumulated by the oysters and transferred to the eggs. PCB accumulation in oysters was dose, time and tissue dependent. Mean PCB contents were 3150, 1970, and 250 ng/g dry wt., respectively, in the visceral mass, gills + mantle and muscle of oysters fed algal paste containing 1.0 μg PCBs for 30 days. The PCBs in the eggs from the same oysters reached 671 ng PCBs/g dry wt. Feeding oysters with PCB-sorbed algal paste for 30 days significantly increased phospholipid and free fatty acid contents in gills + mantle tissues compared to the same tissues in the undosed control.

Keywords: PCBs; Uptake; Accumulation; Oysters; *Crassostrea virginica*

Nonpolar lipophilic contaminants pose a severe ecological risk. Polychlorinated biphenyls (PCBs) are of particular concern because of their environmental stability, and bioaccumulation potential. This may be particularly problematic for filter feeders due to the association of PCBs with natural particulate organic matter. High PCB levels in the aquatic environment have adversely affected not only commercial finfish and shellfish, but also the ecology of entire aquatic communities (Sanders, 1989). Reproduction and subsequent recruitment of ecologically important species,

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0141-1136/00/$ - see front matter
PII: S0141-1136(00)00070-2

such as oysters, can be affected in the process. PCBs accumulated in adult oysters could also be transferred to the gametes (Hummel, Bogaards, Nieuwenhuize, De Wolf & van Liere, 1990), affecting larval development and performance.

This study examined the uptake and accumulation of PCBs sorbed to algal paste by the oyster (*Crassostrea virginica*), and determined if any subsequent changes in lipid class and fatty acid composition occurred in oyster tissues and gametes.

Reproductively active oysters (gametogenesis initiated at the beginning of the experiment) were fed PCB-sorbed algal paste for either 15 or 30 days, and the uptake and distribution of PCBs in different tissue compartments (visceral mass, gills + mantle, and adductor muscle) and eggs examined. PCB-sorbed algal paste was prepared by mixing PCBs (1:1:1 mixture of Aroclor 1242, 1254, and 1260) dissolved in acetone with algal paste (5 μg/g algal paste). To determine the absorption efficiency of PCBs by algal paste, PCBs were extracted from the filtered paste and analyzed for PCBs. The PCBs were found readily sorbed (> 99.8%) to the algal paste. Oysters were maintained in individual containers and fed daily with 0.2 g algal paste containing 0, 0.1, or 1.0 μg PCBs. After either 15 or 30 days of exposure, 15 oysters from each treatment group were thermostimulated to spawn, eggs collected, and tissues dissected. Six oysters were analyzed for PCBs and lipids.

PCBs were extracted from tissues and eggs by supercritical fluid extraction and analyzed by gas chromatography with electrolytic conductivity detection (Hale & Gaylor, 1995). Total lipids were extracted from tissues (Bligh & Dyer, 1959) and total lipid content, lipid class and fatty acid composition determined (Chu & Ozkizilcik, 1995).

PCB accumulation was dose, time, and tissue dependent (Fig. 1). After feeding oysters with PCB-sorbed algal paste of a daily dose 1.0 ng PCBs for 30 days, mean total PCBs were accumulated in the following descending order: visceral mass (3150 ng/g dry wt.), gills + mantle tissue (1970 ng/g dry wt.) and adductor muscle (250 ng/g dry wt.). Only trace amounts of PCBs were detected in adductor muscle after 15 days of daily exposure (data not shown). Highest bioaccumulation was in lipid-rich tissues. Total lipid contents in the visceral mass and the gills + mantle in the high PCB dose were 88.9 mg/g dry wt. and 87.9 mg/g dry wt., respectively (Table 1). The lipid content of adductor muscle was not analyzed in this study. Previous work indicated this tissue in Pacific oyster (*Crassostrea gigas*) contained less than 50 mg lipid/g dry wt. (Soudant, Van Ryckeghem, Marty, Moal, Samain & Sorgeloos, 1999). PCB accumulation was higher in the visceral mass than in gills + mantle. This may be because the visceral mass has a higher triacylglycerol content than the gills + mantle, 19 versus 1.3 mg/g dry wt., respectively (Table 1). PCBs partition primarily into nonpolar lipids (Hummel, UitOudeGroeneveld, Nieuwenhuize, van Liere, Bogaards & De Wolf, 1989).

After 15 and 30 days exposure to 1.0 μg PCBs, the oyster eggs contained 250 and 671 ng/g dry wt. of PCBs (Fig. 1), respectively. Considering the high lipid content in eggs (up to 300 mg/g dry wt., data not shown), the PCB transfer from visceral mass to the gametes appeared to be relatively low. It has been previously hypothesized that decreases in PCB burdens in mussels after spawning were related to the release of gametes (Hummel et al., 1990). However, low PCB content found in the eggs of

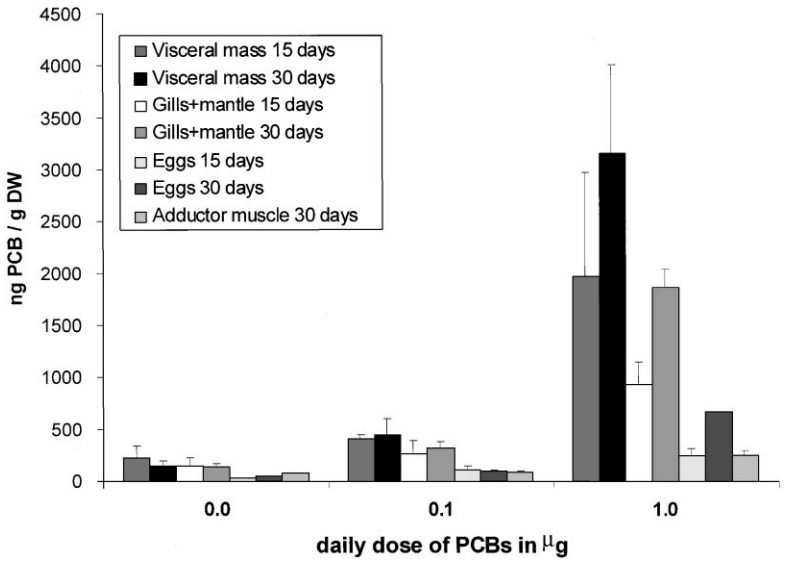

Fig. 1. Total polychlorinated biphenyl (PCB) accumulation in visceral mass, gills + mantle, eggs and adductor muscle after 15 days (except adductor muscle) and 30 days of daily exposure to 0, 0.1, 1.0 μg of PCBs. Only trace amounts of PCBs were detected in adductor muscle after 15 days of daily exposure (data not shown).

Table 1
Total lipid content and lipid class composition of visceral mass and gills + mantle from oysters exposed daily to 0, 0.1, 1.0 μg of polychlorinated biphenyls (PCBs) for 30 days[a]

Daily PCB dose	0 μg			0.1 μg			1 μg		
	Mean	S.D.		Mean	S.D.		Mean	S.D.	
Visceral mass (mg/g dry wt)									
Phospholipids	63.9	14.0		52.1	20.3		59.8	6.0	
Sterols	6.1	0.5		4.7	1.0		6.5	2.1	
Free fatty acids	1.7	1.3		2.5	2.5		3.5	0.7	
Triacylglycerol	14.7	6.5		6.9	9.6		19.1	18.7	
Steryl ester	1.3	0.7		1.3	1.3		1.8	1.2	
Total lipids	86.5	15.8		66.1	20.5		88.9	14.9	
Gills + mantle (mg/g dry wt.)									
Phospholipids	51.9	2.6	a	77.5	28.3	b	69.8	15.5	b
Sterols	8.1	2.6		10.9	1.4		10.6	2.7	
Free fatty acids	2.0	0.7	a	8.3	5.6	b	6.1	3.6	b
Triacylglycerol	2.6	2.4		0.2	0.3		1.3	2.6	
Steryl ester	0.2	0.3		0.4	0.6		0.7	0.8	
Total lipids	64.6	3.2		89.8	19.0		87.9	19.6	

[a] Mean; S.D., $n = 5$. Statistical differences ($P < 0.05$) between treatments are indicated by differing letters (a and b).

oysters fed PCB-sorbed algal paste in the present study suggest that some other processes may be involved in the post-spawning PCB depuration.

The PCB congener accumulation profiles differed in the organs examined (data not shown). While highly chlorinated congeners were preferentially accumulated in the tissues of the visceral mass and gills + mantle, a higher proportion of low chlorinated congeners was found in the muscle. This difference suggests that low chlorinated PCBs may partition into more polar lipids, which predominate in adductor muscle lipids (Soudant et al., 1999), whereas highly chlorinated PCBs partition into the nonpolar lipids of the visceral mass. Relative PCB polarity is generally inversely proportional to the degree of chlorination.

Partially biodegradable and the more recalcitrant PCBs were bioaccumulated in similar concentrations by the oysters (data not shown). This supports the view that molluscs metabolize PCBs poorly compared to other invertebrates, such as crustaceans and annelids (Fries & Lee, 1984; Livingstone, 1985). Thus, it appears that PCB bioaccumulation in oysters is largely related to equilibrium partitioning under controlled feeding regimes and culture conditions. Interestingly, it was observed that PCB congener 180 was bioaccumulated to a limited extent in all tissues.

Feeding oysters with PCB-sorbed algae for 30 days significantly increased the phospholipid content of gills + mantle (77.5 and 69.8 mg phospholipids/g dry wt.) in oysters exposed to a low or high dose of PCBs, compared to control oysters (51.9 mg/g dry wt.) (Table 1). This increase was accompanied by a significant increase in gills + mantle free fatty acid content (8.3 and 6.1 mg/g dry wt., respectively) in both PCB-dosed oysters compared to control oysters (2.0 mg/g dry wt.) (Table 1). This suggests that cellular lysis may have occurred. The apparent increase in phospholipid synthesis could be a compensatory metabolic response. However, no statistically significant alterations in reserve lipid (such as triacylglycerol) were observed. Triacylglycerol content of oysters was previously reported to be depleted during PCB-associated toxic stress (Ferreira & Vale, 1998; Madureria, Picado, Ferreira, Mondonca, Le Gal & Vale, 1993). The polyunsaturated fatty acids, which are essential in bivalve reproduction and development, were also insensitive to PCB exposure (data not shown).

The general physiological state of reproductively active oysters did not appear to be detrimentally affected by PCB exposure. In the present study, although bioaccumulation in the visceral mass was as high as 3150 ng/g dry wt., no significant differences were observed in condition index, fecundity, or sex ratio between PCB-exposed and control oysters (data not shown). Ferreira and Vale (1998) found greater metabolic and physiological damage in small (< 50 mm) than in large oysters (> 60 mm) fed contaminated algae for 60 days. Time of exposure, initial energetic status and age may explain different responses to PCB toxic stress between experiments.

Acknowledgement

This work was supported by a grant from the Exploratory Research Program of the Environmental Protection Agency (EPA, Grant No. R825349-01-0). The views

expressed herein are those of the authors and do not necessarily reflect the views of EPA or any of its sub-agencies. The authors want to thank Drs. Peter De Lise, Morris H. Roberts, and Aswani K. Volety for their critical reviews of the manuscript. Contribution No. 2237 from the Virginia Institute of Marine Science, College of William and Mary.

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