WATER AS AN IMPORTANT SOURCE FOR ACCUMULATION OF POLYCHLORINATED BIPHENYLS IN AQUATIC BIOTA

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Introduction

Nonlinear concentration relationships between environmental organic contaminants in sediment v biota[1] and water v biota[2] systems have been reported. High levels of PCBs have been found to accumulate in biota even after removal of contaminated sediments[3]. This is in contrast to risk assessment theory, where it is assumed to be constant partitioning coefficients between the different environmental compartments. The aim of the study was to investigate the PCBs concentration relationship between sediment and biota in Norwegian harbours and confirm the fact that water could be an important accumulation pathway for PCBs[4].

Methods and Materials

Literature

A literature study was conducted on reports describing the environmental condition of several Norwegian harbours[5, 6]. PCB (Seven Dutch) concentrations in sediment and biota, from the same location, were extracted from the results in the reports. The harbours were situated both in the southern and the northern parts of Norway. The correlation between the PCB concentration in biota (ng/g wet weight) and sediment (ng/g dry weight) was estimated as a bioaccumulation factor, BAF.

Aqueous uptake

An experimental study was conducted to detect uptake of PCBs in rainbow trout from water. An ensemble of 24 rainbow trout, ~125 g, were placed in two different flow-through aquaria, containing 200 L of fresh water. The water flow was set to 400 ml/min. Aquarium 2 continuously received PCB#4 and PCB#153 dissolved in 10 % DMSO and 90% water during the whole experiment (8 weeks). Only DMSO was added to aquarium 1, which worked as a control. The nominal concentration of each congener in aquarium 2 was 10 ng/L, reflecting a moderately contaminated environment. The fish were fed daily with pellets equivalent to approximately 1 % of their body weight and an oxygen pump aerated the water. Three fish were removed with a sampling rate at 1, 2, 6 and 8 weeks and stored in a freezer until analysis.

Dietary uptake

An experimental study was conducted to detect uptake of PCBs in rainbow trout from food. The same experimental designs as in the aqueous uptake experiments was used, but without any contamination of the water and additionally four aquaria were utilized. Pellets containing PCB#4 and PCB#153 were fed to the fish in aquarium 2-6. The nominal concentration of each congener in the pellets for aquarium 2-6 was 1, 10, 100, 1000 and 10000 mg/kg respectively, reflecting a broad spectrum of contamination levels. Fish in aquarium 1 received pellets without added PCBs and thus served as a control. The fish were fed daily with pellets equivalent to approximately 1 % of their body

weight and an oxygen pump aerated the water. Three fish were removed with a sampling rate at 1, 2, 6 and 8 weeks and stored in a freezer until analysis.

Determination of PCBs in water, rainbow trout and pellet

Liquid-liquid extraction was used on five liter of water added 25 ml heptane in a separating funnel.

Microwave assisted extraction was used on 25 g whole fish homogenate and 2 g pellet homogenate with acetone and heptane. Cleanup was performed with sulphuric acid after fat determination. A congener specific, gas chromatography method, with an electron capture detector and internal standard calibration was performed.

Calculations; Aqueous versus dietary uptake

Concentration levels of PCB#4 and PCB#153 from the control fish in the aqueous exposure experiment were subtracted from the levels measured in fish from aquarium 2 in the same experiment. These levels would only reflect the aqueous uptake of PCB#4 and PCB#153 and were compared to the concentrations measured in the fish from aquaria 2-6 in the dietary exposure experiment. The relative contributions from food and water were plotted as a function of the ratio between the measured PCB concentrations in food and the measured concentration in water from aquarium 2 in the aqueous exposure experiment

Results and Discussion

Prediction based on the assumption that the partitioning between water and the lipid content in the "food-particles" equals the partitioning between water and octanol (K_{OW}) gives the result that food is less important as an accumulation pathway than water when the lipid content in food is low (Fig 1). This is even clearer for the lower chlorinated PCBs (Fig 2). Fish on a higher trophic level would eat food that has been subject to biomagnification and thus accumulate more PCBs from food than from water.

PCB concentrations in sediments do not seem to have a linear correlation to the level of PCBs in biota (Fig 3,4 and 5). The BAF values are increasing with reduced concentrations of PCBs in the sediment, indicating that low concentration level of PCBs in the sediment would lead to a disproportionate high level of PCBs in biota. This means that PCB contamination in biota do not reflect the local sediment conditions. An explanation to this could be that the low solubility of PCBs in the water leads to a saturation of water at even very low sediment concentrations. In addition the water turbidity leads to a homogenous PCB contamination of the water column, which also implies a distribution to a much wider geographical area. This distribution will be reflected in organisms at low trophic positions that, according to Fig 2, accumulate PCBs from water. As a consequence of biomagnification the distribution will eventually be reflected in fish.

The importance of water as a medium for bioaccumulation should be taken into account when future risk assessments are made and remedial actions are planned. A reduction of a local sediment concentration, which has been thought to be the primary reason for high levels of PCBs in biota, may not be reflected in the same proportion in biota concentration.

References

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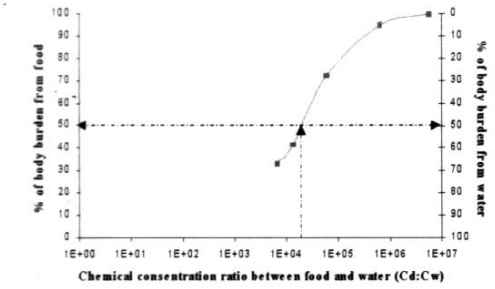

Fig. 1 The food:water PCB#153 concentration ratio (Cd:Cw) where food and water contribute equally to the total body burden in rainbow trout is indicated.

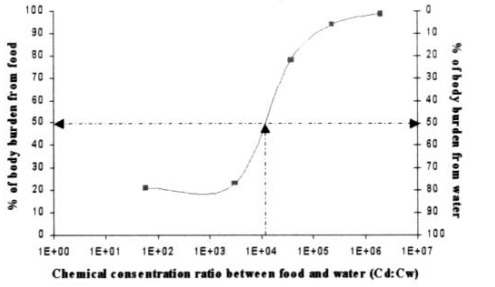

Fig. 2 The food:water PCB#4 concentration ratio (Cd:Cw) where food and water contribute equally to the total body burden in rainbow trout is indicated.

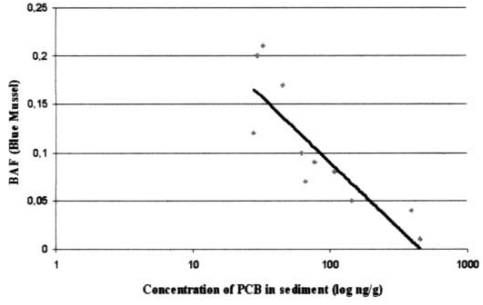

Fig. 3 Bioaccumulation factor for PCB in Blue Mussel as function of log sediment concentration.

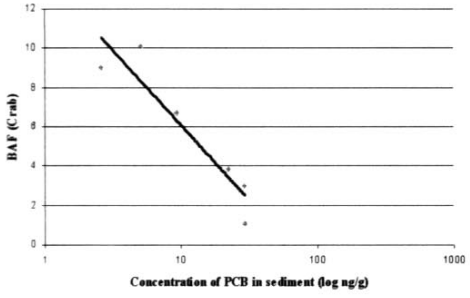

Fig. 4 Bioaccumulation factor for PCB in Crab as function of log sediment concentration

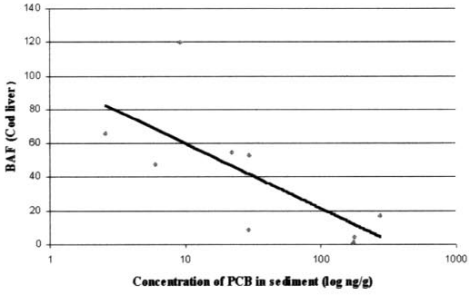

Fig. 5 Bioaccumulation factor for PCB in Cod liver as function of log sediment concentration.

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