D- 2.3 Bioaccumulation of Hazardous Chemicals in Bottom Fish Species by the Benthic Food Chain

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Total Budget for FY1995 - FY1997 41,379,000 Yen (FY1997; 12,573,000 Yen)

Abstract

The bioaccumulation of dioxins (PCDDs and PCDFs), coplanar- PCB (Co- PCB) and organotins (TBT and TPT) in higher trophic organisms through the benthic food chain was studied with the field survey and the rearing experiment using polychaete.

The ratios of concentration of dioxins, Co-PCB, TBT and TPT in organisms to those in sediments were determined in the several coastal waters. The ratios for Co-PCB, TBT and TPT were larger than 1, however, the ratios of dioxins were smaller than 1. These results suggested that Co-PCB, TBTand TPT were accmumulated in bottom fish from sediments.

The concentrations of Co-PCB and TPT were increased gradually with becoming higher trophic level of organisms in the food chain. On the other hand, dioxins and TBT concentrations in organisms were not related to the trophic level. It was recognized from these results that the hazardous chemicals having the larger biomagnification factor (BMF) were able to significantly accumulated in the higher trophic organisms through the food chain.

Rearing experiments using polychaete showed that BMFs of PCDDs and PCDFs were smaller than 1, however those of Co-PCB, TBT and TPT were larger than 1. It was obvious that Co-PCB, TBT and TPT were accumulated in polychaete from sediments. These results also suggested that polychaete played an imporatnt role in the transfer of chemicals from sediments to the higher trophic organisms.

Key Words Bioaccumulation, Food chain, Organotins, PCDDs, PCDFs, Coplanar-PCB

1. Introduction

The hydrophobic chemicals are not easily dissolved in seawater, adsorbe on the suspended materials, and eventually deposite on the sediments. The concentrations of hazardous chemicals in sediments are higher than those in seawater. Sediments act as the source of pollutants in the marine environment. It is recognized that hazardous chemicals in sediments are accumulated in organisms by mainly two pathways; a direct uptake from seawater after the liberation from sediments and the dietary uptake from sediments by the feeding behavior of benthic organisms. Bioaccumulation chracteristics through the benthic food chain are not studied in detail, therefore, it is an important research to demonstrate the contribution of hazardous chemicals in sediments to the concentration in organisms.

2. Research objective

The main purpose of this research is to demonstrate the bioaccumulation of hazardous chemicals through the benthic food chain from sediments, and to estimate the influence of the hazardous chemicals on the marine environment.

For this purpose, 1) the benthic food chain structure, 2) bioaccumulation of hazardous chemicals in flounder from sediments, and 3) the relationships between hazardous chemicals concentations in organisms and their trophic level in the food chain were analyzed in the field surveys. The transfer of hazardous chemicals from sdiments to benthic organisms was also studied with the rearing experiments of polychaete.

3. Research method

The several surveys were carried out in the coastal waters such as Tokyo Bay, Suho Nada and Nanao Bay from 1995 to 1997. Several kinds of organisms including benthos (polychaete and crustacea) and several fish species were caught by bottom trawl net in these coastal waters. Seawater and sediments were also collected.

The trophic level of these organisms was estimated from the both methods of prey-predator relationships and the ^{15}N concentration in organisms. Dioxins (PCDDs and PCDFs), coplanar PCB (Co-PCB) were analyzed by using the gaschromatograph - masspectrometry (GC-MS), and concentrations of organotins (TBT and TPT) were determined by using gas chromatograph equipped with flame photometric detector (GC-FPD).

Polychaeta (*Perinereis nuntia* var. *vallata*) was reared for 8 weeks in the aquarium containing sediments polluted by hazardous chemicals. The concentrations of dioxins, Co-PCB and organotin in sediments and polychaeta were also analyzed periodically by GC-MS and GC-FPD.

4. Results and Discussion

(1) Relatioships between the hazardous chemical concentrations in flounder and those in sediments

The ratios of hazardous chemical concentrations in flounder to those in sediments were studied in several coastal waters. These rations were as follows; PCDDs: 0- 0.03, PCDFs: 0.04- 0.08, Co- PCB: 3.22- 4.27, TBT: 9.03- 28.33, TPT: 13.64- 21.33. These ratios did not significantly change in several coastal waters. It was supposed from these results that the hazardous chemicals concentrations in flounder were influenced by the concentration of chemicals in sediments. As the ratios of PCDDs and PCDFs were smaller than 1, PCDDs and PCDFs in sediments were not accumulated in the organisms through the benthic food chain. It was supposed that Co- PCB, TBT and TPT were transfered and accumulated in bottom fish from sediments, because the ratios of Co- PCB, TBT, and TPT were larger than 1.

(2) Biomagnification of hazardous chemicals through food chain.

The relationships of the hazardous chemical concentrations in organisms and their trophic level were studied with the surveys carried out in Nanao Bay. The concentrations of chemicals were determined in seawater, sediments and several kinds of organisms caught by demersal trawl net.

The concentration of PCDDs, PCDFs and Co- PCB were 0.84, 0.49, and 0.50 pg/l, respectively. As those were very low, it was supposed that the accumulation of these chemicals from the direct uptake was very small. PCDDs, PCDFs and Co- PCB were detected in sediments, and the concentrations were 1700 pg/g dry for PCDDs, 150 pg/g dry for PCDFs, and 18 pg/g dry for Co- PCB. 1368- TeCDD and 1379- TeCDD were detected as major components in dioxins, it was supposed that major source of dioxins in Nanao Bay was a contaminant contained in the herbicides[1].

The concentration of TBT in seawater was 2.90 ng/l, however, TPT was not found in seawater. Considering from the concentration in seawater, considerable amount of TBT in organisms derived from the direct uptake from seawater. The concentrations in sediment were 4.8 ng/g dry for TBT and 0.9 ng/g dry for TPT, and these TBT and TPT concntrations were lower values in the japanese coastal waters.

The food chain structure was analyzed by the prey- predator relationships, and was summerized as shown in Fig 1. The bottom fish in Nanao Bay were divided into 5 groups by their feeding behavior; 1) feeding detritus(ex. flathead), 2) feeding polychaete (ex. sand borer), 3) feeding small crustacea (ex. goby), 4) feeding large crustacea and polychaeta (ex. flatfish), and 5) feeding small fish (ex. flounder). Because good relatioships between the trophic level determined by the prey- predator analysis and ^{15}N concenttation in organisms were obtained, the food chain structure shown in Fig. 1 was reliable.

The relationships between the hazardous chemical concentrations in organisms and the

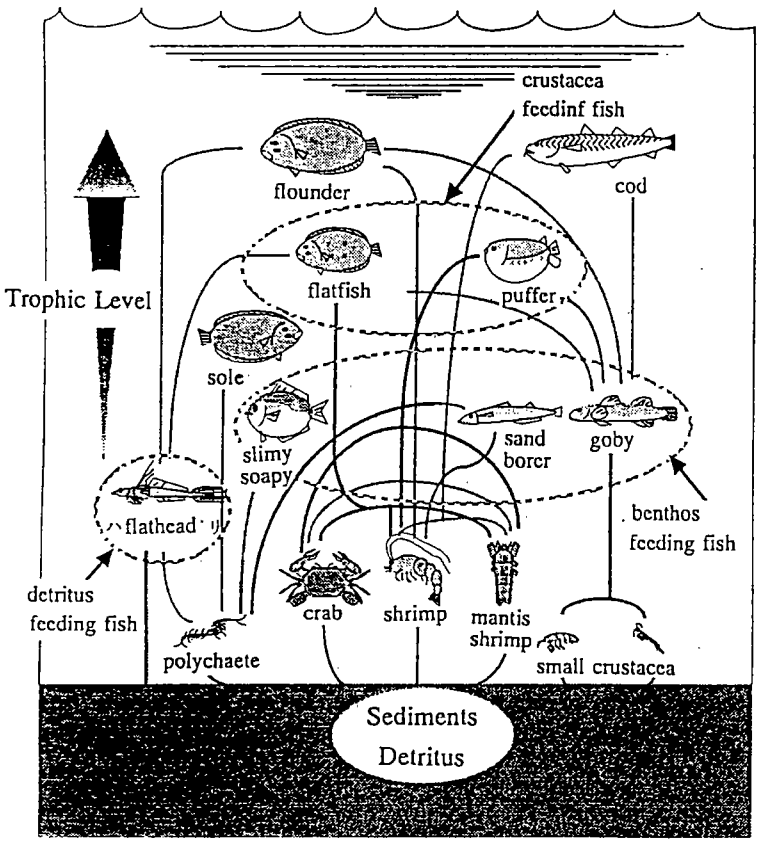

Fig. 1. Benthic food chain structure in Nanao Bay

trophic level (^{15}N concentration) were analyzed, and the typical relationships for dioxins and TPT were shown in Figs. 2 and 3. Because the concentrations of PCDDs and PCDFs were not related to the ^{15}N concentration, it was clear that PCDDs and PCDFs are not accumulated in the higher trophic organisms through the food chain.

The ratios of the hazardous chemical concentrations in organisms to those concentration in sediments (concentration factor from sediments: CFS) were determined, and CFS of PCDDs was 0.077 for polychaete, 0.52- 1.4 for crustacea, 0.65- 1.4 for squid and octpas, 0- 1.3 for the bottom fish. CFSs of PCDFs was ranged from 0 to 2.4. These results suggested that PCDDs and PCDFs were not transfered to organisms from sediments, and were not accumulated in the higher trophic organisms through the food chain.

The concentration of Co- PCB increased with becoming higher trophic level. CFSs of Co- PCB were also higher than dioxins, and was 5.1 for polychaete, 10- 21 for crustacea, 16- 21 for squid and octopas, 2.8- 91 for fish. From these results, it was considered that Co- PCB was transfered and accumulated in the higher trophic organisms through the food chain, and that bioaccumulation characteristics of Co- PCB differed from those of dioxins.

The TBT concentrations in organisms did not increased with increasing the trophic level. CFSs of TBT in several organisms were ranged from 1.4 to 23.3, however, CFSs were not related to the trophic level of organisms. These results suggested that TBT was not

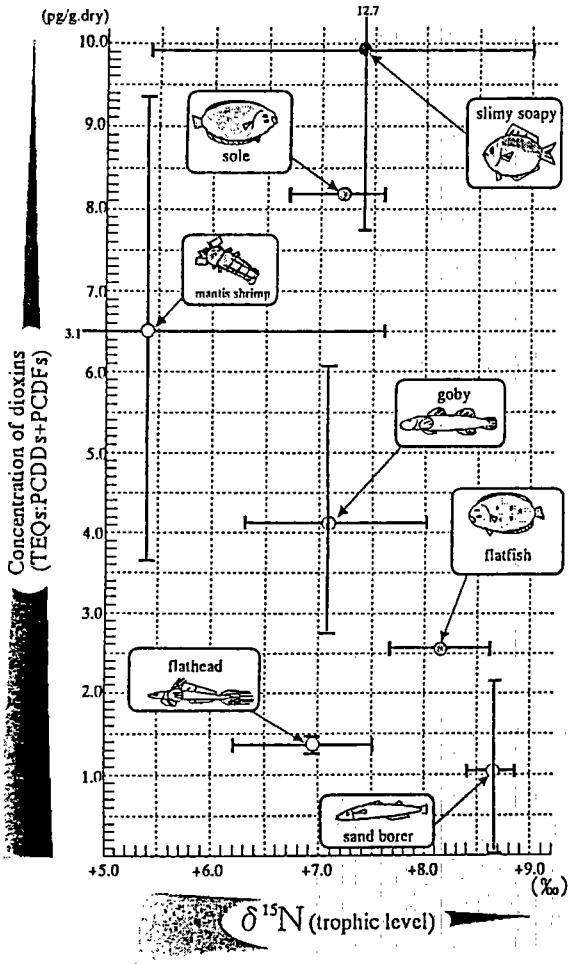

Fig. 2. The relationships between the concentration of dioxins in organisms and their trophic levels

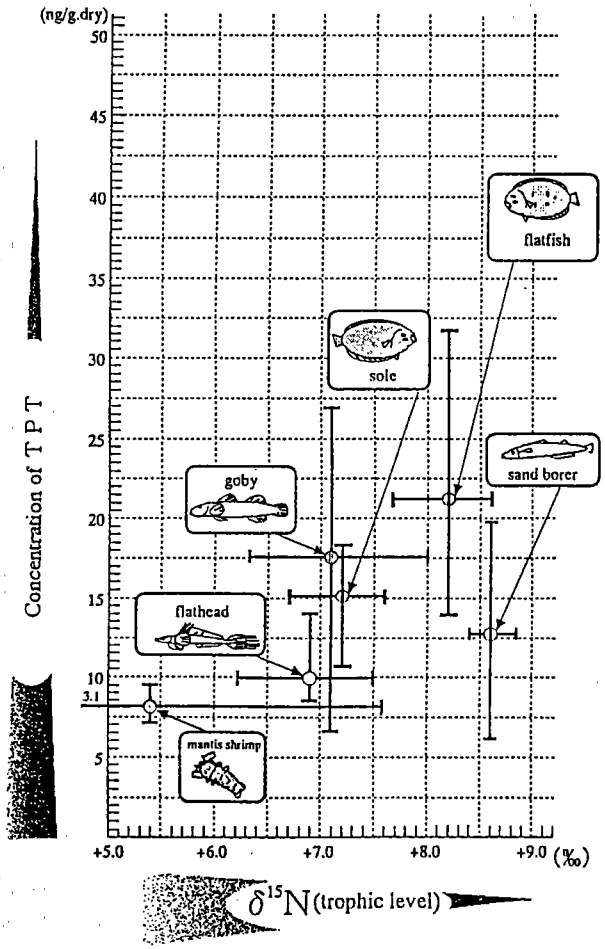

Fig. 3. The relationships between the concentration of TPT in organisms and their trophic levels

accumulated through the food chain from sediments.

As shown in Fig. 3, TPT concentrations in organisms increased with becoming higher trophic level of organisms. CFSs of TPT were larger than those of TBT, and those were between 3.5 and 86.1. CFSs of TPT were larger in fish feeding polychaete than in polychaete, it was recognized that TPT was accumumulated in the higher trophic organisms through polychaete from sediments.

It was recognized from the rearing experiments of fish that BMFs of Co- PCB and TPT by the dietary uptake were larger than MBFs of dioxins and TBT.[2] These findings suggest that the persistent chamicals having the large BMF were accumulared in the higher trophic organisms through the food chain.

(3) Accumulations of hazardous chemicals in polychaete from sediments

Because the CFSs in polychaeta were 0.32 for PCDDs, 0.26 for PCDFs and 2.2 for Co-PCB, it was obvious that Co- PCB was accumulated in polychaete from the sediments.

CFSs of TBT and TPT were determined as 1.0 - 3.1and 1.8- 11.0, respectively, with the rearing experiment of polychaete. CFSs determined in the field surveys were 1.1- 23.3 for TBT and 4.2- 16.7 for TPT. Excluding the CFS obtained in Nanao Bay, the differences in CFSs of TBT were small, and CFS of TPT was larger than TBT.

The present results demonstrate that polychaete play an imporatant role in the transfer and the accumulations of hazardous chemicals through the benthic food chain from sediments.

5. Conclusion

The followings were pointed out as conclusions of this research.

(1) The concentrations of hazardous chemicals in flounder were related to those concentrations in sediments. Therefore, it was obvious that the concentrations in flounder were influenced by the hazardous chemicals in sediments.

(2) The concentrations of Co- PCB and TPT in organisms increased with becoming higher trophic level, and these chemicals were accumulated through the food chain. However, the concentrations of dioxins were not related to the trophic level, these chemicals were not accumulated. These results suggest that the persistent chamicals having the large BMF were accumulared in the higher trophic organisms through the food chain.

(3) CFSs of Co- PCB, TBT and TPT in polychaete were larger than 1, however, those of dioxins were very small, and lower than 1. These results demonstrated that polychaete accumulated these chemicals from sdiments, and that polychaete played an imporatant role in the transfer of chemicals through the benthic food chain from sediments.

6. Refference

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