Bull. Environm. Contam. Toxicol. 21,448-452 (1979)

Remobilization of Sediment-associated PCBs by the Worm *Nereis diversicolor*

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Chlorinated hydrocarbons have been found in sediments taken from rivers, coastal areas and the open oceans (DEXTER and PAVLOU 1973, HOM et al. 1974, NADEAU and DAVIS 1976, ELDER et al. 1976). Because they are, in general, highly refractive substances, they tend to persist for a long time after being deposited. This suggests the possibility that contaminated sediments could act as a source of chlorinated hydrocarbons after these compounds cease to be manufactured or introduced into the aquatic environment. Thus, chlorinated hydrocarbons could become available to food webs if contaminated sediments are resuspended, if the chlorinated hydrocarbons diffuse from the sediment into the water column, or if they become associated with benthic organisms through ingestion, absorption or adsorption.

YOUNG et al. (1977) found that in spite of a marked decrease in their input, DDT and PCB concentrations continued to be higher in bottom-dwelling fish taken from areas where PCB and DDT concentrations in sediment were high than in fish from areas with low concentrations of PCB and DDT in the sediment. It was concluded that the PCB-rich and DDT-rich sediments were the source of contamiation for the fish. In order to test experimentally the existence and degree of importance of such a transport route, we have initiated several laboratory studies of PCB uptake and loss by the sediment-dwelling polychaete Nereis diversicolor using spiked sediment as a PCB source. Our initial results are reported here.

MATERIALS AND METHODS

Approximately 20 kg of sediment was dredged from 150 m depth 1.5 km off Monaco and transported to the laboratory. There it was divided into several portions, each one placed in a glass container. One portion was spiked by adding successive aliquots of an acetone solution of the commercially produced polychlorinated biphenyl mixture Phenochlor DP-5, to a seawater-sediment slurry. Each addition of DP-5 was followed by a thorough mixing. After the final addition, mixing was continued and periodically a sediment sample was taken and analyzed for DP-5. This process was continued until a group of 5 successive random samples indicated a homogeneity of $\pm$ 10%. The final concentration of PCB in the spiked sediment was 0.65 ppm (dry weight). A control sediment was produced by treating part of the collected sediment in an identical manner but without adding DP-5.

0007-4861/79/0021-0448 $01.00

Spiked and unspiked sediments were transferred to separate basins which were placed under running seawater. After several days about 750 Nereis diversicolor (purchased from Maison Lecarpintier, Ouistreham, France) were added to each of the basins where they established themselves in less than one hour by burrowing into the sediment, thus initiating the uptake phase of the experiment. For the duration of the experiment, worms were not given food other than that which they derived incidentally by ingesting sediment particles during their collecting and filtering activities (GREZE 1971).

Worms were sampled periodically and analyzed in the following manner. A prescribed number of individuals were teased out of the sediment and carefully rinsed with seawater to remove adhering sediments and mucous sacs. Worms were then transferred to containers of non-contaminated sediment which they were allowed to ingest for 24 hrs, thus displacing residual spiked sediment. Afterwards, individuals were transferred to a bedding of wet marine algae for 24 hrs during which time they voided their gut of all residual sediment. Following a final seawater rinse, the worms were weighed, freeze dried, re-weighed, pulverized and then extracted with hexane in a Soxhlet apparatus. The hexane extracts were reduced in volume, subjected to Florisil clean-up, further reduced in volume and analyzed by electron capture gas chromatography using published methods (PESTICIDE ANALYTICAL MANUAL).

Samples of sediment were analyzed by the same procedures at the beginning and end of the uptake phase to ensure that the DP-5 concentrations remained constant with time. Periodic monitoring of the seawater indicated that no significant fluctuation of PCB concentration in the water supply occurred during our experiment. After the PCB concentration in the worms appeared to reach equilibrium, the two groups were carefully transferred to new basins containing non-contaminated sediment to determine the rate at which PCBs were lost. The loss phase lasted approximately two months during which time the worms were sampled and analyzed as before except that they were transferred directly to the wet alga bed prior to analysis.

RESULTS AND DISCUSSION

During the uptake phase the DP-5 concentration increased in worms kept in the spiked as well as unspiked sediments (Fig. 1). In both, an increase in PCB concentration was apparent after a few days and reached equilibrium within 40 to 60 days. At equilibrium the concentration factor (CF = PCB concentration in wet worms divided by PCB concentration in wet sediment) for both groups was approximately 3.5. The increase in PCB concentration in the population in unspiked sediment is probably due to the fact that the worms had previously lived in an environment of lower PCB concentration than that of our Mediterranean unspiked sediment system, or that they had undergone loss after collection or both.

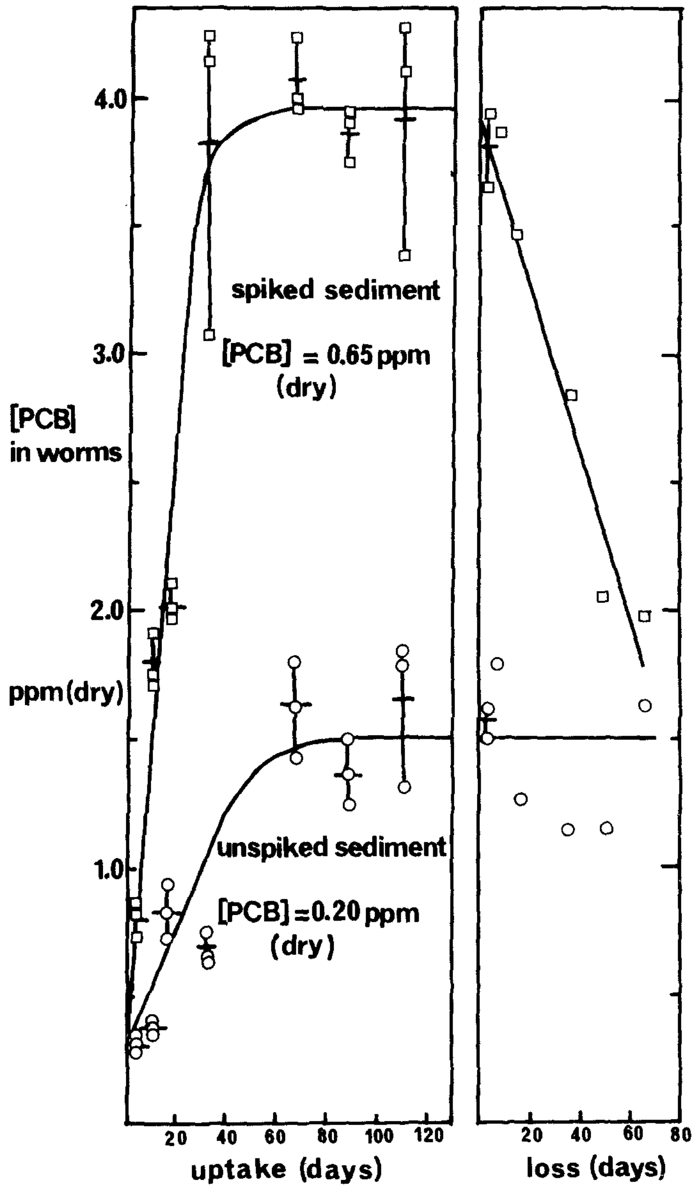

Fig. 1. Uptake and loss of PCB (phenochlor DP-5) by *N. diversicolor* from sediments. Each symbol represents a composite sample of either 5 or 10 individuals. Horizontal lines intersecting vertical range bars indicate mean concentration. The wet/dry weight ratio for sediment and worms was 2.8 and 5.6, respectively

After contaminated worms were transferred to unspiked sediments their PCB concentrations steadily decreased, reaching levels that approached those of the worms living in unspiked sediments after about two months (Fig. 1). The loss data were fitted by a single exponential model and a biological half-life for incorporated PCBs of about 27 days was computed. (A background PCB concentration in worms of 1.5ppm was used in calculating this half-time). It should be noted that the depuration rate for these compounds is likely to be dependent upon the PCB level in the sediments in which the worms are residing; therefore the biological half-life reported here is probably specific to our particular experimental conditions. Further work needs to be done to elucidate effects of various background PCB concentrations on biological half-life.

Epifaunal organisms such as crabs and shrimp living on contaminated sediments have been shown to accumulate PCBs (NIMMO et al. 1971). We have demonstrated that N. diversicolor, a typical infaunal polychaete, readily accumulates PCBs from the sediments which they inhabit. Furthermore, the degree of PCB accumulation (CF > 1) appears to be relatively high compared to the characteristically low uptake of radionuclides from sediments (CF << 1) by the same species (RENFRO 1973, BEASLEY and FOWLER 1976). The question of whether PCB incorporation occurs via absorption from ingested material or whether it is by cuticular absorption of PCBs from the interstitial waters or both, remains to be answered. Nevertheless, once contaminated with sediment-derived PCBs N. diversicolor could act as a source of these compounds for its predators. Moreover, if the PCBs accumulated from sediment by N. diversicolor are depurated into the water column they would then be available for direct uptake and recycling by an additional pathway. It seems increasingly clear then that sediment-associated PCB compounds cannot be considered as being isolated from the biosphere.

ACKNOWLEDGEMENTS

The International Laboratory of Marine Radioactivity operates under a tripartite agreement between the International Atomic Energy Agency, the Government of the Principality of Monaco and the Oceanographic Institute at Monaco. This work was funded in part by the United Nations Environment Programme, Contract FP/053-76-09(978). We thank Messrs P. Parsi and J.P. Villeneuve for technical assistance during all phases of this work and L.F. Small for critical comments on the manuscript.

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