Chlorinated Hydrocarbons in Plankton from the Gulf of Mexico and Northern Caribbean

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INTRODUCTION

The world-wide distribution of DDT, its metabolites and polychlorinated biphenyls (PCBs) in marine biota has been well documented. Recently, attention has also been focused on the residue levels of the chlorinated hydrocarbons in marine plankton. However, data are still very limited. DDT residues in marine phytoplankton have been reported to increase from 1955 to 1969 (1). The chlorinated hydrocarbons, DDT (2-5) and PCBs (6,7) were found to be toxic to certain planktonic species at very low concentrations (parts per billion level). Thus the determination of the concentrations of these compounds in open ocean plankton is an important aspect in monitoring environmental pollution.

During 1971 and 1972 a baseline study of pollutants in the open Gulf of Mexico and Northern Caribbean, sponsored by the International Decade of Ocean Exploration, was conducted. Plankton samples were collected over extensive areas of the Gulf of Mexico and Northern Caribbean (Figures 1 and 2). The samples were analyzed for DDT, its metabolites and PCBs, in order to determine the concentration and distribution of these contaminants in the lowest levels of the marine food chain.

METHODS

The plankton samples were collected by the research vessel Alaminos during three cruises designated 71-A-5 (June, 1971), 71-A-12 (October, 1971) and 71-A-14 (November, 1971). Samples were collected with either 00 or 60 mesh nylon plankton nets. They were then stored in glass jars with aluminum foil

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Bulletin of Environmental Contamination & Toxicology,
Vol. 9, No. 6, © 1973 by Springer-Verlag New York Inc.

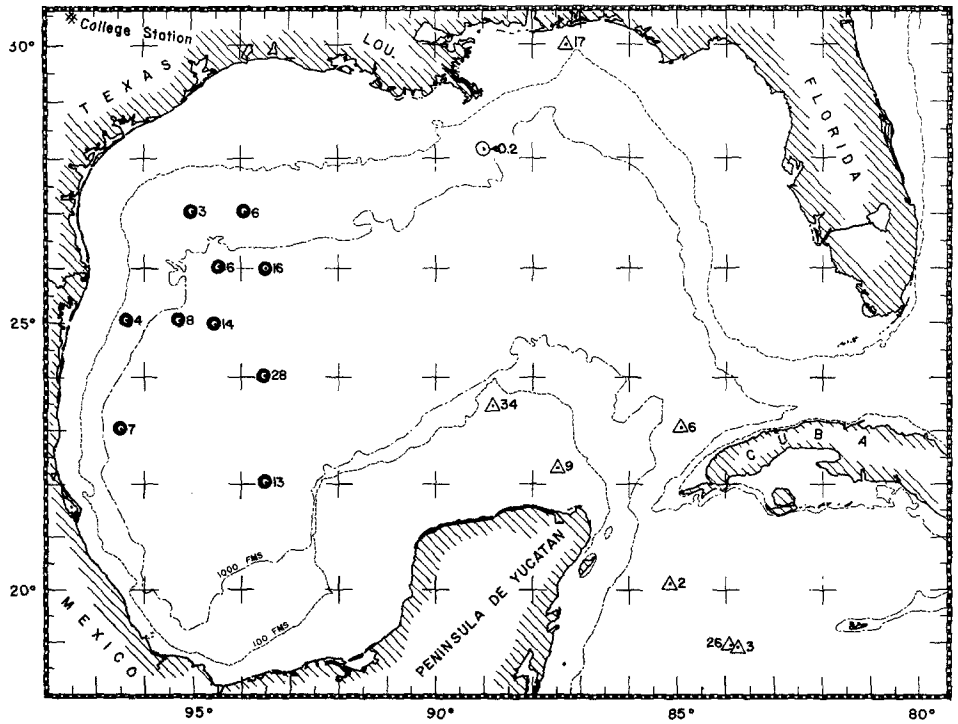

FIGURE 1. Total DDT in Plankton

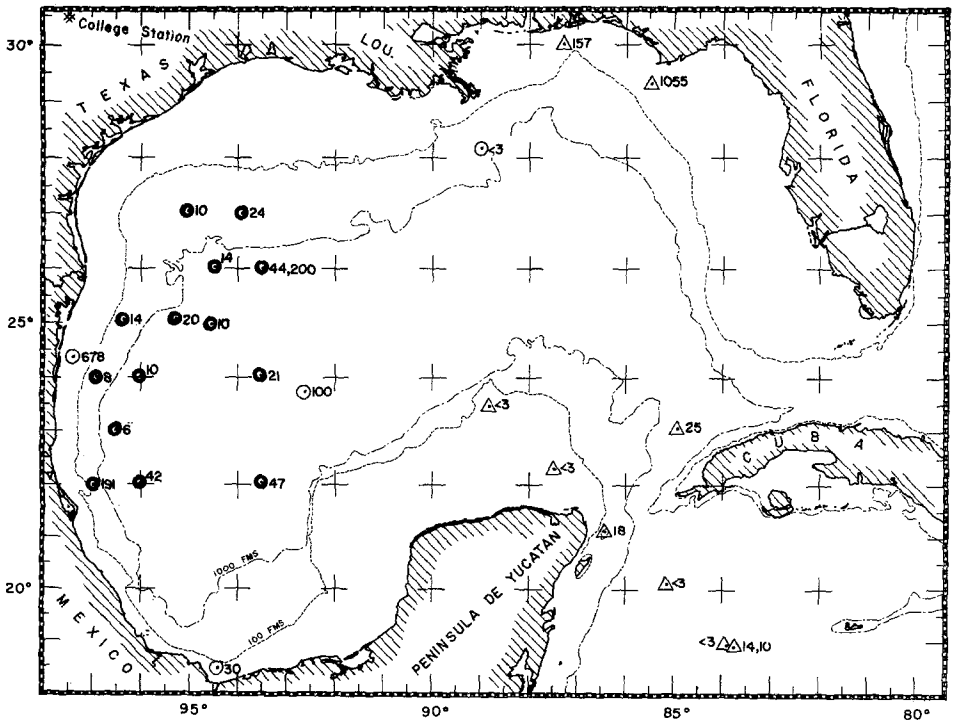

FIGURE 2. PCB in Plankton (µg per kg wet weight)

lined lids and were frozen until analysis. Both jars and foil had been prerinsed with residue-free absolute alcohol. All samples were comprised mainly of zooplankton (varies from 80% to 100%). The remainder consisted of phytoplankton.

The extraction and clean-up procedure was essentially that described in the "Pesticide Analytical Manual" of the U.S. Food and Drug Administration. The "Non-fatty Food Method," utilizing acetonitrile as the extracting solvent, was used (8). The cleaned-up sample extract was adjusted to a suitable volume (from 2 to 10 ml) for gas chromatographic analyses. All heatable glassware, materials and reagents used in the extraction and clean-up were decontaminated by heating at 300-350°C overnight. Then prior to use, the glassware was rinsed several times with nanograde solvents (acetone and petroleum ether). Materials that could not be heated were extracted with petroleum ether before use.

The plankton extracts were analyzed on a Tracor MT 220 gas chromatograph equipped with a ^{63}Ni electron capture detector. The columns used in the chromatograph were 6' x 1/4" o.d. U-shaped glass tubes fitted with demisters at the injection ports. Non-polar liquid phases used for quantification were either a 5% DC-200 or a 5% OV-1 on 80/100 mesh Chromosorb W(HP). The mixed column used for confirmatory work was a 6% OV-17 and QF-1 (in the ratio of 7:9) on 80/100 mesh Chromosorb W(HP). The injector temperature was set at 225°C, the oven at 200°C, and the detector at 275°C. The flow rate of the pre-purified nitrogen carrier was 60 cc/min.

Identification of PCBs as commercial Aroclor* formulation (Aroclor 1242, 1248, 1254 and 1260) was based on good matching of the sample peaks with those of standard mixtures. The standard Aroclor most closely matching the chromatogram of the sample was used for quantification. Further characterization of some samples was performed using the alkaline hydrolysis method (9) and the silica gel method of DDT-PCB separation reported by Snyder and Reinert (10).

The detection limits, based upon a 15g wet sample weight, were 3 µg per kg for PCB and 0.2 µg per kg for p,p'DDT and p,p'DDE.

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*Registered trademark, Monsanto Co., St. Louis, Mo.

RESULTS AND DISCUSSION

The results of the study are summarized in Table 1.

TABLE 1

Chlorinated hydrocarbons in Gulf of Mexico and Caribbean sea plankton samples. (µg per kg wet weight)

Cruise	Station	Position	Total DDT	PCB (As A-1254)	Ratio PCB/DDT
71-A-5	6	24°23.4' 97°23.9'	T[1]	678	
	9	23°45.8' 92°37.4'	T	100	
	12	18°27.5' 94°24.0'	T	30	
	26	28°09.5' 88°58.0'	0.2	< 3	
71-A-12	7	23°27.0' 88°48.5'	34	< 3	<0.1
	8	22°16.4' 87°27.3'	9	< 3	<0.3
	9	21°04.9' 86°25.5'	T	18	
	10	20°05.4' 85°07.7'	2	< 3	<1
	11	18°56.3' 83°51.9'	26	< 3	<0.2
	12	18°54.1' 83°44.4'	T	14	
	12(II)	"	3	10	3.3
	13	23°02' 84°54'	6	25	4.2
	17	29°19.5' 85°28.0'	T	1055	

Cruise	Station	Position	Total DDT	PCB (As A-1254)	Ratio PCB/DDT
71-A-12	18	30°00.5' 87°17.5'	17	157[2]	9.2
71-A-14	1	26°58.8' 93°56.8'	6	24	4.0
	3	26°00.7' 93°30.5'	T	44	
	3	"	16	200	12.5
	7	24°01.5' 93°33.0'	28	21	0.8
	9	22°02.2' 93°30.5'	13	47[2]	3.6
	12	22°00.0' 96°00.0'	T	42	
	14	21°59.0' 97°00.0'	T	191	
	16	23°00.0' 96°30.0'	7	6[2]	0.9
	22	24°00.0' 96°00.0'	T	10	
	24	24°00.0' 96°54.0'	T	8	
	25	25°00.0' 96°22.0'	4	14	0.4
	28	25°00.0' 95°18.0'	8	20	2.5
	29	24°57.8' 94°25.5'	14	10	0.7
	31	24°27.0' 94°27.0'	6	14[2]	2.3
	33	27°00.0' 95°02.0'	3	10	3.3

[1]Not quantitated due to low level of DDTs and severe interference by PCB peaks. The concentration of total DDT in these samples were estimated to be less than 1 µg per kg wet weight.

[2]As Aroclor 1260.

In interpreting the results of the analyses, caution has to be exercised. Firstly, species composition in plankton varies from sample to sample and may be partly responsible for the variability in our results. Secondly, the method of collection of plankton samples, using a standard-mesh net, may result in the collection of much extraneous material. The occurrence of petroleum lumps (11,12) and plastic particles (13) on the sea surface have been reported in literature. Sea surface slicks as concentrators of pesticides have also been noted (14). Inclusion of any of these materials, plus garbage waste, in the plankton samples may drastically increase the values of the chlorinated hydrocarbons.

From the results, it appears that DDTs and PCBs are widely spread, although the level is generally low. There are few discernible geographic trends in the sampled areas (Figures 1 and 2). However, it is interesting to note that of the six samples containing PCBs above 100 µg/kg wet weight, four of them are near coastal areas, including the two samples with the highest PCB values.

About 70% of the samples gave higher PCB than DDT values. However, no definite trend can be observed from the PCB/DDT ratio of the samples analyzed. Generally, the total DDT and PCB levels in plankton samples is comparable to that in small whole fish and muscle of some larger fish (15).

ACKNOWLEDGEMENT

We thank the National Science Foundation (International Decade of Ocean Exploration program) for financial support of this work.

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