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EFFECTS OF COMMERCIAL CHLORINATED HYDROCARBONS AND SPECIFIC CHLOROBIPHENYLS ON THE GROWTH OF SEVEN SPECIES OF MARINE PHYTOPLANKTON[1]

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INTRODUCTION

The polychlorinated biphenyl mixture, Aroclor 1242, is reported to inhibit growth and the synthesis of RNA and chlorophyll in *Cylindrotheca closterium*[1], and to induce a lag in the growth of *Chlamydomonas reinhardtii*[2]. Several recent reports indicate that Aroclor 1254, a commercial chlorobiphenyl mixture, will inhibit the growth of 2 marine diatom species[3,4], and *Chlorella pyrenoidosa*[5].

Commercial chlorobiphenyls are a mixture of isomers[6], but no evidence has been presented as to whether the observed biological effects are due to specific isomers or whether all chlorobiphenyls are deleterious to phytoplankton. We report the growth response of several marine species incubated with chlorinated hydrocarbon mixtures, or with specific chlorobiphenyls.

MATERIALS AND METHODS

Chlorinated hydrocarbons were generously supplied by the manufacturers under registered trade names Aroclors 1221, 1232, 1242, 1248, 1254D, 1260, 1262, 5460 (Monsanto); Phenoclors DP3, DP4, DP5, DP6 (Prodelec); Halowax 1099 (Koppers); and Uniclor 50 (Neville). Specific chlorobiphenyls were prepared by synthesis[7].

The phytoplankton represent 6 classes of marine algae as follows: Bacillariophyceae - *Skeletonema costatum* (Grev.) Cleve, *Thalassiosira fluviatilis*

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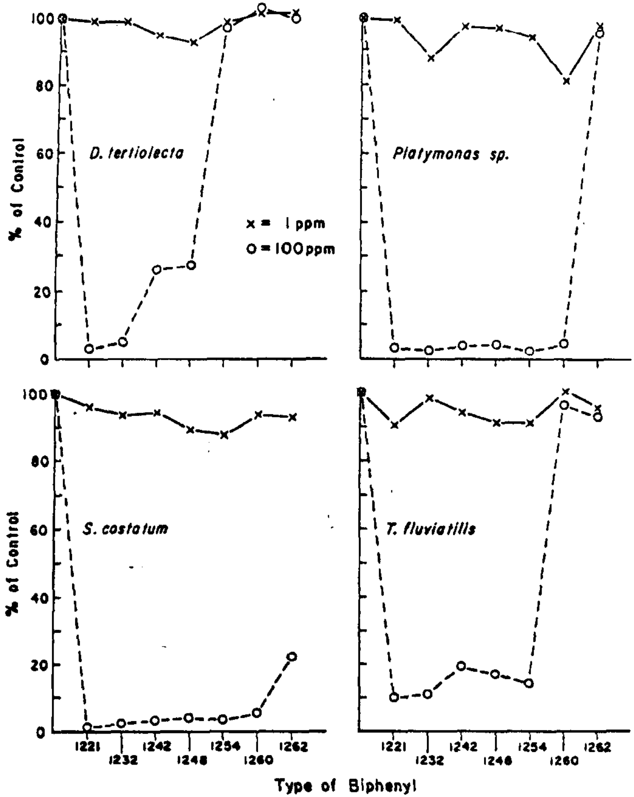

FIGURE 1. Growth of four species of phytoplankton in the presence of 1 or 100 ppm of Aroclors 1221 to 1262.

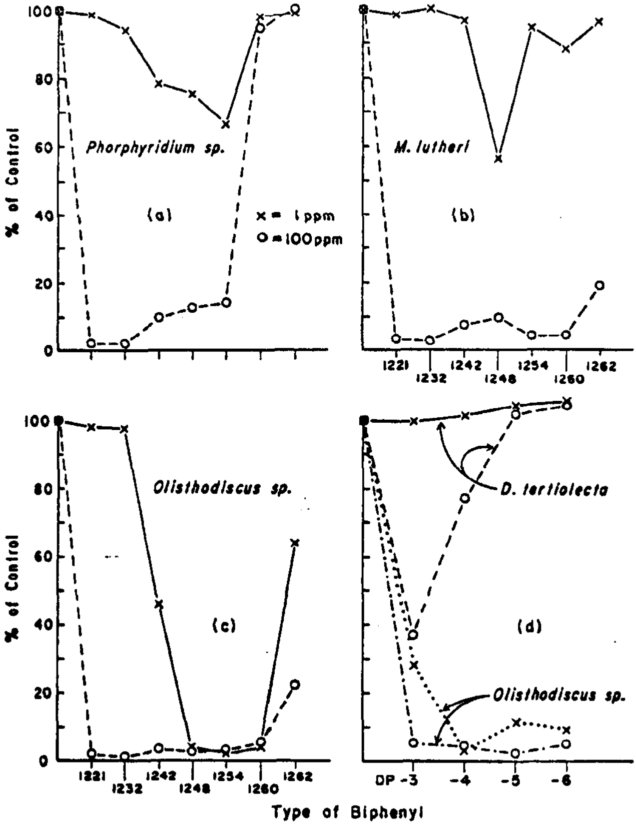

FIGURE 2. Growth of three species of phytoplankton in the presence of Aroclors 1221-1262 (a-c). Growth of D. tertiolecta and Olisthodiscus sp. in the presence of 1 or 100 ppm of Phenoclors DP3 - DP6 (d).

Hustedt; Chlorophyceae - Dunaliella tertiolecta Butcher; Chrysophyceae - Monochrysis lutheri Droop; Prasinophyceae - Platymonas (Tetraselmis) sp.; Rhodophyceae - Porphyridium sp.; and Xanthophyceae - Olisthodiscus sp. The source of these cultures has been reported[8,9]. All were axenic and were grown in 125 ml Erlenmeyer flasks for 6 days under cool-white fluorescent lamps with a 12 h photoperiod at 20°.

Each compound was dissolved in acetone and an appropriate volume was dispensed into each experimental flask. The acetone was evaporated just to dryness under a jet of filtered air at room temperature. Thirty ml of a natural seawater medium, SWM I[8], were added immediately and the flasks were stopped with cotton plugs and autoclaved. The chlorinated hydrocarbon concentrations were 1 or 100 ppm based upon the volume of medium added and no attempt was made to measure the concentration of hydrocarbon that dissolved. Next day a 1 ml inoculum of a 3 or 4 day old culture was added aseptically. Duplicate control and experimental flasks were set up and a minimum of 2 separate experiments were performed with each compound. Flasks were shaken by hand twice daily, and at 6 days the turbidity was measured at 750 nm in a 1 cm cell. Representative O.D. values for the control cultures were 0.519, 0.194, 0.897, 0.745, 0.601, 0.426, and 0.471 for each of the above species, respectively. Growth in replicate experiments was quite reproducible being within ± 5% of the average value.

RESULTS and DISCUSSION

Figs. 1 & 2 show the growth of phytoplankton after incubation in the presence of 1 or 100 ppm of chlorinated biphenyls. The response to a given Aroclor sample was species dependent with the least sensitive being D. tertiolecta and the most sensitive being Olisthodiscus sp. At 1 ppm relatively little inhibition was recorded for D. tertiolecta, Platymonas sp. S. costatum or T. fluviatilis, whereas Porphyridium sp. and M. lutheri were intermediate, and Olisthodiscus sp. was completely inhibited by Aroclors 1248, 1254, 1260, and Phenoclor DP4. The Phenoclor series was more toxic to Olisthodiscus than the Aroclors but whether this is due to contaminants such as chlorobenzofurans[11] was not investigated. No growth was recorded for any

TABLE 1

Effect of chlorobiphenyls and other chlorinated hydrocarbons on phytoplankton cultures. Data are expressed as a percentage of the turbidity of the controls.

Chlorobiphenyl	4-		2,4-		3,4-		4,4'-	
ppm	1	100	1	100	1	100	1	100
Dunaliella tertiolecta	-	-	97	5	97	14	-	-
Olisthodiscus sp.	92	1	100	7	98	4	96	11
Platymonas sp.	100	6	-	-	-	-	101	39
Skeletonema costatum	93	9	-	-	-	-	92	6
Thalassiosira fluviatilis	84	5	-	-	-	-	89	15

Chlorobiphenyl	2,2',4,4'-		2,2',5,5'-		3,3',4,4'-		2,3,4,5-	
ppm	1	100	1	100	1	100	1	100
D. tertiolecta	100	4	101	91	98	102	102	101
Olisthodiscus sp.	8	5	79	1	103	99	100	33

Chlorobiphenyl	2,2',4,4',5,5'-		Deca-	
ppm	1	100	1	100
D. tertiolecta	104	105	100	105
Olisthodiscus sp.	78	19	100	107

Compounds	Aroclor 5460		Halowax 1099		Uniclor 50	
ppm	1	100	1	100	1	100
D. tertiolecta	100	98	94	97	96	97
Olisthodiscus sp.	99	97	89	3	97	99
T. fluviatilis	100	100	105	44	100	105

species when 100 ppm of the biphenyls containing the lower percentages of chlorine were tested. All survived 100 ppm of Aroclor 1262 although growth of S. costatum, M. lutheri and Olisthodiscus sp. was strongly depressed. The data of Table 1 also show that highly chlorinated biphenyls are less toxic than those with only 1-4 chlorine atoms per molecule.

Experiments with biphenyls containing identical percentages of chlorine show that the biological response depends upon the molecular structure. Thus the 2,2',4,4'-tetrachlorobiphenyl is more toxic to both D. tertiolecta and to Olisthodiscus sp. than is the 2,2',5,5' isomer, and both are more deleterious than either the 2,3,4,5 or the 3,3',4,4' isomers (Table 1). The latter was not toxic even when added at 100 ppm.

Neither the chlorinated terphenyl, Aroclor 5460, nor the Uniclor 50 is toxic to the phytoplankton tested (Table 1). Halowax 1099, however, killed Olisthodiscus and strongly depressed the growth of T. fluviatilis at 100 ppm.

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