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Polychlorinated Biphenyls in Plankton from the Turku Archipelago

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Polychlorinated biphenyls (PCB´s) are industrial chemicals that have become widespread contaminants of the biosphere. Coastal ecosystems in particular receive substantial input loads of PCB´s the main sources being water drainage, dumping and aerial fallout (NELSON et al. 1972).

Investigations carried out on chlorinated hydrocarbons in fish, plankton and sediment from the Baltic Sea give strong evidence of local PCB pollution in coastal areas (JENSEN et al. 1972a,b, OLSSON et al. 1973, LINKO et al. 1974a,b, VOIPIO et al. 1977). Moreover, according to OLSSON et al. (1973) and LINKO et al. (1974b), it is apparent that plankton is an important link in the introduction of PCB´s into aquatic food chains.

Furthermore, an OECD monitoring study carried out in Finland in 1973-1975, where Baltic herring (Clupea harengus) from the Turku archipelago, which feed mainly on plankton, were annually sampled and analysed for PCB and DDT residues, revealed in herring a significant decrease only in the DDT concentrations while their PCB content remained nearly at the same level (PAASIVIRTA et al. 1976). The partial control on the uses of PCB´s starting at the beginnig of 1970 in Finland does dot seem to have effected a decrease in the PCB contamination.

The aim of the present study was to further clarify the PCB contamination of plankton in Turku archipelago during 1974-1976.

MATERIALS AND METHOD

Plankton samples were collected during 1974-76 from the Turku archipelago situated at the outset of the northern part of the Baltic Sea. During 1974 samples were taken about once a month from May to October beginning off the shore near the cities of Turku, Raisio and Naantali and ending at the open sea (Fig. 1). During 1975-76 the collection of plankton was carried out from May to December from only two sampling sites (5 and 6). Preliminary investigations on the PCB content of plankton have been carried out in this area during 1972/73 (LINKO et al. 1974b).

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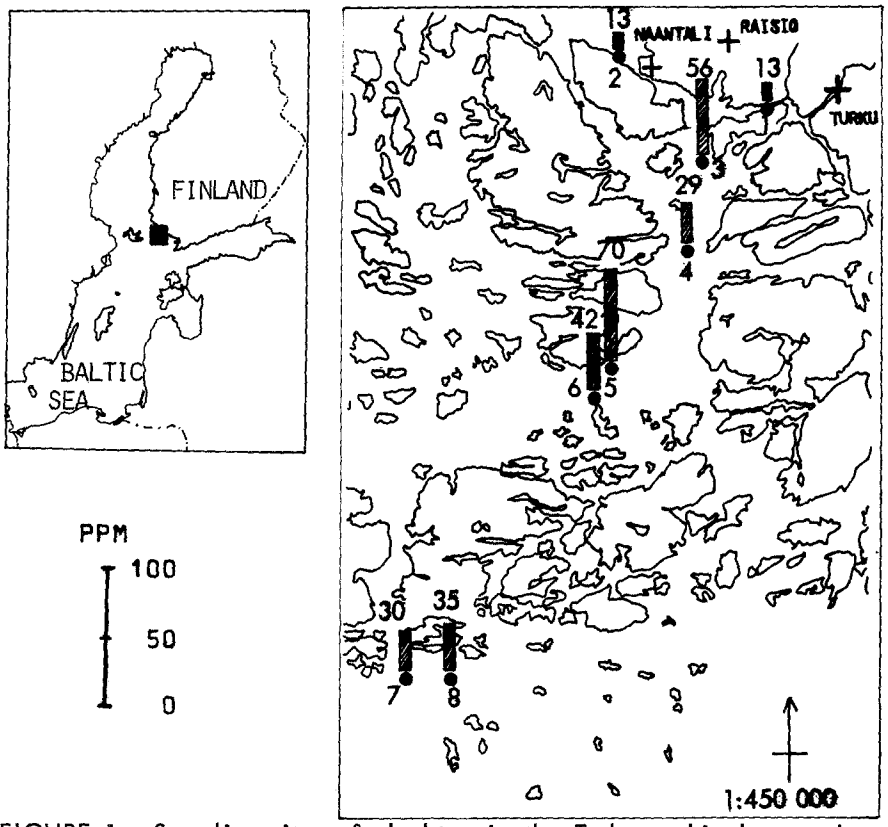

FIGURE 1. Sampling sites of plankton in the Turku archipelago and the regional average contents of PCB ppm lipid weight in 1974 (see Table 1).

Samples were taken with a 150 μ Hensen net either towing it at the distance of 20 - 30 meters from the boat and at a depth of 1 - 1.5 meter for 5 - 15 minutes at a speed of about 2 knots (i.e. surface catching) or alongside of a standing boat at a depth of 10 - 30 meter (i.e. depth catching). In the latter case the top of the net was closed at a depth of about half a meter before lifting it from the water to minimize the contact of both net and the sample with surface films and floatables. Precautionary measures were taken to prevent accidental contamination during collection, handling and storage (RIESEBROUGH et al. 1972, LINKO et al. 1974b).

Plankton was sieved through a 106 μ net and the quantity remaining on the sieve was packed in aluminium foil pouches and frozen. Some plankton samples were taken for determination of their taxonomical composition.

The analytical procedure used for plankton samples was similar to that used earlier by the authors (LINKO et al. 1974b).

PCB's were measured on a Varian Aerograph Model 2440, equipped with ^{3}H-electron capture detectors. The stationary phase was 6 % GE SF-96 (methyl silicone) on Chromosorb W (60-80 mesh, acid washed and DMCS treated) packed in 0.2 cm-i.d., and 183 cm long silanized Pyrex glass tubes. In most cases the GLC pattern matched closely that of the commercial mixture Clophen A 60 (BAYER A.G., BRD), which was used as a standard. Further confirmation was obtained for selected samples by identifying mass fragmentation patterns on a LKB, model 2091 GLC-MS apparatus. The measurements were performed in Karolinska Institutet, Stockholm, Sweden. Recovery experiments were performed with spiked plankton samples to test the efficiency of the extraction and clean-up procedures for PCB's and other chlorinated hydrocarbons (p,p'-DDT, p,p'-DDE and p,p'-DDD). In general the recoveries were better than 87 %.

RESULTS AND DISCUSSION

The results of the analyses of the PCB content in plankton collected during 1974 from eight different sampling sites in the Turku archipelago are shown in Table 1. The values are expressed as parts per million (ppm = mg/kg) by weight on an extractable lipid as well as on a fresh tissue basis.

Surprisingly high PCB concentrations were obtained in some plankton samples collected in October. Also in some other investigations very high PCB values in plankton have been found, e.g. in plankton from the Northwest Atlantic Shelf and from the open South Atlantic, the amounts being 260 ppm and 120 ppm, respectively, on a lipid basis (RIESEBROUGH et al. 1972). WARE and ADDISON (1973) have noted even 31 ppm PCB on a fresh weight basis in plankton from the Gulf of StLawrence. On the other hand, the high PCB values in plankton may originate from sample contamination by surface slicks and floatables during field collection despite of all precautions. HARVEY and TEAL (1973) pointed out that in a plankton tow the entire water column (water, detritus, plankton etc.) is really being sampled for hydrocarbons and PCB and therefore care must be exercised in interpreting the PCB analyses of plankton. It is to be noted that the sampling sites (Nos 3-5) of plankton in the Turku archipelago, where the high PCB concentrations were obtained, are along a much-trafficked ship route (cf. Fig. 1). Direct discharge into the water, e.g. by dumping of hydraulic fluids and lubricants from ships may be a locally significant source of the PCB contamination (NELSON et al. 1972). These sampling sites are also close to a dumping area of dredge spoil from a nearby harbor and dock. When the temperature stratification of water disappears during September and October, the whole water column becomes homogeneous. This causes a remobilization of material accumulated near the bottom.

TABLE 1. PCB CONTENT IN PLANKTON FROM THE TURKU ARCHIPELAGO DURING 1974 (SAMPLING SITES, SEE FIG. 1.)

SITE No	DATE	SURFACE CATCHING PCB's PPM LIPID WEIGHT	SURFACE CATCHING PCB's PPM WET WEIGHT	DEPTH CATCHING PCB's PPM LIPID WEIGHT	DEPTH CATCHING PCB's PPM WET WEIGHT
1	74-05-16	15	0,17	-	-
	06-18	8,3	0,06	-	-
	08-19	15	0,14	-	-
	10-17	14	0,32	-	-
2	06-18	4,5	0,04	6,2	0,07
	07-12	8,8	0,10	8,6	0,08
	08-19	43	0,35	7,9	0,05
	10-17	47	0,37	97	0,58
3	05-15	N.D.[A]	N.D.	6,0	0,10
	06-18	6,3	0,04	5,3	0,06
	07-12	14	0,24	9,3	0,13
	08-19	340	3,3	64	0,44
	10-17	98	0,50	8200	57
4	05-15	4,1	0,23	9,2	0,29
	06-18	8,9	0,08	4,3	0,04
	07-12	39	0,42	19	0,29
	08-19	52	0,49	96	0,87
	10-17	1090	4,1	9000	47
5	05-16	N.D.	N.D.	280	3,1
	06-19	6,1	0,05	8,5	0,08
	08-19	28	0,17	97	0,72
	10-17	425	2,6	210	1,2
6	05-15	5,7	0,23	40	0,92
	06-19	22	0,14	16	0,14
	08-20	125	0,78	51	0,31
	09-16	63	0,87	16	0,13
	10-17	-	-	390	1,8
7	05-15	15	0,26	23	0,37
	06-17	4,8	0,05	18	0,22
	08-20	37	0,21	83	0,51
	10-17	16	0,09	74	0,74
8	05-15	31	0,22	57	0,40
	06-17	2,6	0,03	6,2	0,06
	08-20	41	0,26	50	0,33
	09-16	77	0,86	12	0,10
	10-17	21	0,11	150	1,4

[A] N.D. = NOT DETECTED

When the data presented in the Table I are summed up, not including the October values, the mean values in plankton are 38 ppm on a lipid basis and 0.37 ppm on a wet weight basis, the ranges of variation being rather high, 2.6 - 340 ppm and 0.03 - 3.3 ppm, respectively. Although the mean value is of about the same class of magnitude as was found earlier in this area (LINKO et al. 1974b), the variation ranges of the PCB concentrations are much larger in the present study.

The PCB concentrations in plankton found in the depth catching were usually somewhat greater than those in the surface catching, even when the variation of plankton biomass is taken into account.

To get a view of the local variation of the PCB level in plankton the mean values (excluding October values) obtained on a lipid basis in different sampling sites are presented as column diagrams in Fig. 1. The greatest PCB values were found in the central part of the studied area (Nos 3 - 6) while in the outer parts of the archipelago the PCB level is decreasing. Similar results were obtained in the PCB contents of plankton in the Stockholm archipelago by JENSEN et al. (1972b). However, in our study the obtained values were very low near the shore (Nos 1 and 2).

In Table II the PCB concentrations in plankton from two sampling sites (Nos 5 - 6) during 1975 and 1976 are presented. They varied greatly according to the time of collection like the values of 1974 in Table I. As in the last mentioned year also the plankton collected in 1975 shows remarkably high PCB values in early spring and autumn. This may be due to extraneous contamination of the plankton which has been pointed out earlier. However, there are considerable seasonal alterations in the plankton composition as found also by PURASJOKI and NIEMI (1978). High PCB values recorded by us in plankton in spring and autumn coincided with the time of diatom maxima. HARVEY et al. (1974) have also observed remarkable high PCB levels in the Atlantic Ocean in samples rich in phytoplankton. There is, however, much fluctuation in the PCB content of the plankton biomass, which limits together with the small number of samples studied the comparison of the seasonal variation.

In order to facilitate the comparison between the concentration levels of PCB´s in plankton from various marine regions, the available mean values and ranges of PCB´s are summarized in Table III. The results obtained in these studies resemble each other very much although they represent so different kinds of marine regions, from open oceans to archipelagoes, firths and estuarines. The data from the Atlantic Ocean show the greatest differences, which depends on the different sampling methods used (HARVEY et al. 1974). The plankton from the Lake Päijänne gave a PCB value which was only one tenth of that found in the Baltic Sea. The Baltic Sea values obtained from the

TABLE II. PCB CONTENT IN PLANKTON FROM THE TURKU ARCHIPELAGO DURING 1975-76 (SAMPLING SITES, SEE FIG. 1.)

SITE No	DATE	SURFACE CATCHING PCB's PPM LIPID WEIGHT	SURFACE CATCHING PCB's PPM WET WEIGHT	DEPTH CATCHING PCB's PPM LIPID WEIGHT	DEPTH CATCHING PCB's PPM WET WEIGHT
5	75-05-12	8.1	0.06	850	6.3
	06-25	12	0.17	6.3	0.07
	07-24	16	0.11	5.7	0.04
	08-22	24	0.17	26	0.09
	10-01	88	0.48	120	0.69
	10-23	130	0.70	47	0.25
	11-11	40	0.22	110	0.58
5	76-05-06	7.5	0.14	52	0.72
	07-23	4.1	0.04	15	0.14
	10-29	39	0.22	56	0.45
	12-15	10	0.09	35	0.29
6	75-05-12	126	0.53	350	1.8
	06-26	10	0.09	11	0.10
	07-24	21	0.19	17	0.14
	08-22	20	0.13	33	0.20
	10-01	15	0.08	33	0.18
	10-23	20	0.12	38	0.17
	11-11	9.9	0.08	680	3.8
6	76-05-06	11	0.10	41	0.31
	06-01	-	-	23	0.19
	07-23	4.1	0.04	47	0.39
	08-10	-	-	17	0.16
	09-16	-	-	66	0.52
	10-29	23	0.06	60	0.49
	12-14	18	0.11	44	0.26

Stockholm and Turku archipelagoes are quite similar. The data of the Turku area from 1972/73 to 1976 show that the PCB level in the plankton did not change during this period. This is in accordance with the OECD monitoring studies of Baltic herring during 1973-75. Furthermore the PCB residue level in fish varying from 14 to 23 ppm on a lipid basis, was reasonably close to that found in plankton (25 - 38 ppm) from the same area. Baltic herring feeds mainly on plankton in the pelagic zone of the sea. On the contrary HARVEY et al. (1974) found in mixed plankton a higher average concentration of PCB than in any gilled organism in the Atlantic. Their data reveal no evidence of biomagnification of PCB's on a wet or lipid weight basis. Our results are in agreement with the assumption of CLAYTON et al. (1977) that all biota within an ecosystem has similar PCB residue levels when normalized to lipids. Their results obtained by studies on marine plankton suggest that bioaccumulation is predominantly controlled by equilibrium partitioning of the polluting chemical between the internal lipid pools of the biota and ambient water.

TABLE III. MEAN VALUES AND RANGES[A] OF PCB CONCENTRATIONS IN PLANKTON FROM VARIOUS MARINE REGIONS

REGION	PCB's PPM LIPID WEIGHT	PCB's PPM WET WEIGHT	REF.
BALTIC SEA			
STOCKHOLM ARCHIPELAGO	18 (3-35)	-	JENSEN ET AL. 1972B
BALTIC SEA			
TURKU ARCHIPELAGO 1973	25 (4-77)	0,19 (0,04-0,75)	LINKO ET AL. 1974B
" " 1974[B]	38 (26-340)	0,37 (0,03-3,3)	THIS STUDY
" " 1976[C]	28 (4-66)	0,23 (0,04-0,72)	" "
NW ATLANTIC SHELF	40 (2,4-260)	0,15 (0,01-0,3)	RIESEBROUGH 1972
SOUTH ATLANTIC	48 (7-120)	0,20 (0,02-0,64)	-"-
NE ATLANTIC	2,3 -	- -	WILLIAMS AND HOLDEN 1973
" "	- (0,1-5,5)	- (0,01-0,12)	HOLDEN 1973
FIRTH OF CLYDE	- (0,1-17)	- (0,08-2,2)	-"-
NE PACIFIC ESTUARINE ZONES	2,2 (1-16)	- -	CLAYTON ET AL. 1977
LAKE PÄIJÄNNE[D]	-	0,03 (0,002-0,14)	SÄRKKÄ ET AL. 1978

[A]THE NUMBERS OF THE MINIMUM AND MAXIMUM VALUES ARE PRESENTED IN PARANTHESIS

[B]VALUES ARE TAKEN FROM TABLE I EXCLUDING THE DATA FROM OCTOBER

[C]VALUES ARE TAKEN FROM TABLE II

[D]FOR COMPARISON VALUES FROM A FINNISH FRESH-WATER AREA ARE PRESENTED. VALUES GIVEN AS DRY WEIGHT CONCENTRATION ARE TRANSFORMED HERE TO WET WEIGHT VALUES ON AN ASSUMPTION THAT DRY WEIGHT CONSTITUTES 10 % OF WET WEIGHT

The results of our plankton studies indicate that the PCB pollution in the Turku archipelago is still a problem of actual interest. It may affect the stability of the whole aquatic ecosystem of this area. Thus effective measures must be resorted to prevent this kind of pollution.

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