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Fish toxicology

DYNAMICS OF THE PCBs DECLINE IN SELECTED ORGANS OF CARP (*CYPRINUS CARPIO* L.) DURING DEPURATION IN CLEAN WATER

DYNAMIKA ZANIKU PCB W WYBRANYCH NARZĄDACH KARPIA (*CYPRINUS CARPIO* L.) PODCZAS ODPIJANIA W CZYSTEJ WODZIE

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The aim of this study was to determine the dynamics of PCB content decline in three selected organs and tissues (gill filaments, muscle tissue, perintestinal adipose tissue, liver, and alimentary tract) of cultured carp, previously exposed to Clophen A50 via oral route, in the course of their 40-day stay in PCB-free environment.

The samples were analysed using gas chromatography. The highest decrease in PCB concentration, related to wet weight was noted for the perintestinal adipose tissue and the alimentary tract. The lowest PCB decrease in lipids was recorded in the liver (10.0%) and the highest one—in the alimentary tract. In decrease related to the total weight of the organs and tissue studied was the highest for the gill filaments (61.6%), while the values compared for perintestinal adipose tissues showed a 6.6% increase.

INTRODUCTION

Polychlorinated biphenyls (PCBs) are mixture of homologs and isomers of different physical state—from fluids of low viscosity and density to resins and solids. PCBs are one of the most durable synthetic compounds resistant even to mineral acids and bases. PCBs practically are not soluble in water but solve well in organic solvents, oils, and natural lipids; do not conduct electricity, have low vapour pressure and high durability in natural environment (Fishbein 1972; Södergren and Gelin 1983). Such physico-chemical properties decided on broad usage of PCBs in many industrial branches since 1929. PCBs had become components of many daily used products, which favoured their easy access into environment (Lichtenstein et al. 1969; Herrel 1971; Reynolds 1971; Waish 1972; Cundel 1974; Harvey et al. 1974).

The global production of PCBs since 1980 has reached, approximately, ~2 mln tonnes (Anonymous 1979), 60% of which entered seas and oceans and was deposited within the continental shelf area. For many years, the problem of polychlorinated biphenyls and their presence in natural environment and ecological threat they pose were out of sight. In 1966 Jensen (1966) identified PCBs in the Baltic sea fishes. Effluents of industrial and municipal sewage dumped into water basins and rivers as well as solid industrial and municipal by-products collected at dumping grounds penetrate easily into soil and surface waters and get into atmosphere as vapores.

While in water basins, lipophilic by nature, PCBs enter easily the trophic chain and show high bioaccumulation coefficient. PCBs enter fish body through the gills and alimentary tract in a diet and cumulate mainly in reserve adipose tissue and other organs and tissues rich in lipids (Lichtenstein et al. 1969; Tutsakova 1973; Cundel 1974; Harvey et al. 1974; Dexter and Field 1989).

It is generally believed, that polychlorinated biphenyls are metabolised by fishes only slightly and they persist within particular organs and tissues for a long time. The main excretion routes of the PCBs from fishes being liver, gall-bladder, and alimentary tract.

The objective of this study was to determine dynamics of the polychlorinated biphenyls decline within the selected carp organs and tissues during depuration in clean water.

MATERIAL AND METHODS

The subject of present study were cultured carp (*Cyprinus carpio* L.) weighing 263.8 to 271.2 g, contaminated previously with Clophen A50. The experiment was carried out under laboratory conditions in glass aquaria—100 dm^3 in volume—in tap water with forced aeration. In order to dechlorinate the water and adjust the water temperature, aquaria were filled up with tap water and aerated for 24 hours prior to fish introduction. During the experiment the water temperature ranged from 18 to 24°C, oxygen content oscillated between 7.6 and 10.2 mg/dm^3, and pH was 6.4–7.4. Every day carp were transferred to aquaria with clean water and were fed with granulated feed free of PCBs, containing 40% of total protein and 6% of lipids, 6 times a day, in 2-hour intervals. To measure the fish weight adequately, carp were divided into groups of five, at random, and marked.

PCB concentrations in tested fish were determined after 1, 2, 3, 5, 10, 20, 30, and 40 days of fish detoxication process. The procedure stated with collection of samples of muscle tissue (filets), liver, perintestinal adipose tissue, alimentary tract and gill filaments from 5 fish. Each sample type was weighed and homogenized separately. Subsequently, 10 g of blended muscle tissue, 3 g of liver and alimentary tract, 2 g of gill filaments and 1 g of perintestinal adipose tissue subsamples were collected for analysis. Analyses were carried out in 5 repetitions according to Jensen et al. (1983) method. Analytical procedure included extraction of lipids together with associated compounds with acetone-hexane mixture (2.5 : 1), then with hexane-ethyl ether (9 : 1) followed by purification of the extracts with 7% SO_3 in H_2SO_4 and 5% KOH in 96% C_2H_5OH. Qualitative and quantitative readings of the PCBs were carried out with a "Pye-Unicam" gas chromatograph equipped with ^{63}Ni electron capture detector (ECD).

RESULTS

For fish subjected to previous intoxication with Clophen A50 *via* oral route, followed by 40-day stay in environment free of PCBs a further essential increase in the total body weight, of tested organs and tissues, as well as changes in lipids content were observed (Tables 1 and 2). Changes in the levels of PCB residues in wet weight of the tested organs and tissues, in relation to the depuration time, are presented in a form of regression curves at Fig. 1, while Table 3, shows relevant data related to lipids.

Table 1

Mean increment of fish body weight and the weight of tested organs and tissues (%) during carp stay in PCB-free environment

Subject of analysis	Initial weight (g)	Duration of experiment (days)						
		1	3	5	10	20	30	40
		weight increment (%)						
Gill filaments	3.6 ±0.9	0.16	0.65	1.84	4.52	11.44	16.11	24.90
Muscle tissue	104.7 ±3.1	0.14	0.42	2.76	5.64	10.37	18.43	25.23
Perintestinal adipose tissue	2.9 ±0.1	1.24	2.96	4.14	17.42	34.31	51.74	80.61
Alimentary tract	4.3 ±0.1	1.41	2.35	9.42	17.63	26.11	34.28	45.90
Liver	3.7 ±0.1	0.00	1.08	3.19	5.35	7.16	11.27	16.03
Whole fish	263.8 ±4.2	0.84	1.92	3.52	6.47	12.41	18.96	26.63

Table 2

Changes in lipids content (%) within the tested organs and tissues during carp stay in PCB-free environment

Organs and tissues	Duration of experiment (days)							
	0	1	3	5	10	20	30	40
	lipids content (%)							
Gill filaments	1.11	1.14	1.29	1.27	1.19	1.14	1.16	1.23
Muscle tissue	5.15	5.17	5.43	5.86	6.14	6.23	6.41	6.37
Perintestinal adipose tissue	87.29	87.26	86.26	86.91	86.11	86.21	86.18	86.23
Alimentary tract	5.03	5.34	5.43	5.61	5.73	6.04	5.68	5.54
Liver	11.69	11.71	11.26	10.93	10.15	8.32	7.43	5.84

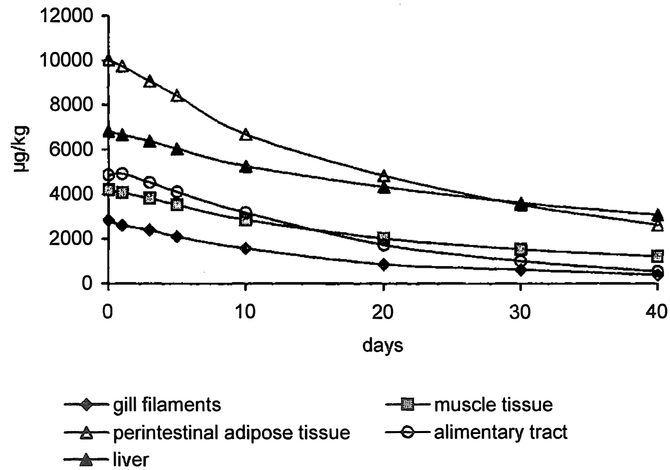

Fig. 1. Decline of PCB levels in the studied organs and tissues of carp kept in PCB-free environment

The highest decrease in relative values of PCB (Clophen A50) concentrations, in wet weight, was observed for the perintestinal adipose tissue and alimentary tract, particularly during first 10–20 days of depuration. A decrease in PCB content in other organs and the muscle tissue was significantly less pronounced (Fig. 2) As for the PCB concentration in lipids, after 40-day stay of fish in water free of PCBs, the lowest decrease was noted for the liver—10% and the highest one for the alimentary tract—90% (Table 3). When converted into total weight of particular organs and tissues, the highest decline in PCB content was noted for gill filaments—61.6%; with a 6.6% increase, when compared to the initial PCBs level, noted for the perintestinal adipose tissue (Fig. 2).

Table 3

Changes in PCB content in lipids of the tested organs and tissues of carp kept in PCB-free environment

Samples	Duration of experiment (days)							
	0	1	3	5	10	20	30	40
	PCB content (µg/kg)							
Gill filaments	255675.9	229473.7	186252.0	165897.6	131722.7	75894.7	53991.4	30666.7
Muscle tissue	81425.2	78564.8	70324.1	60023.9	46351.8	32539.3	23948.5	18891.7
Perintestinal adipose tissue	11499.9	11176.2	10455.7	9709.5	7761.5	5608.7	4102.2	3031.1
Alimentary tract	96560.4	92209.7	83361.0	73222.8	55335.1	28771.5	17980.6	9593.9
Liver	58396.1	56971.9	56651.9	55269.9	51687.7	52049.3	48764.7	52530.8

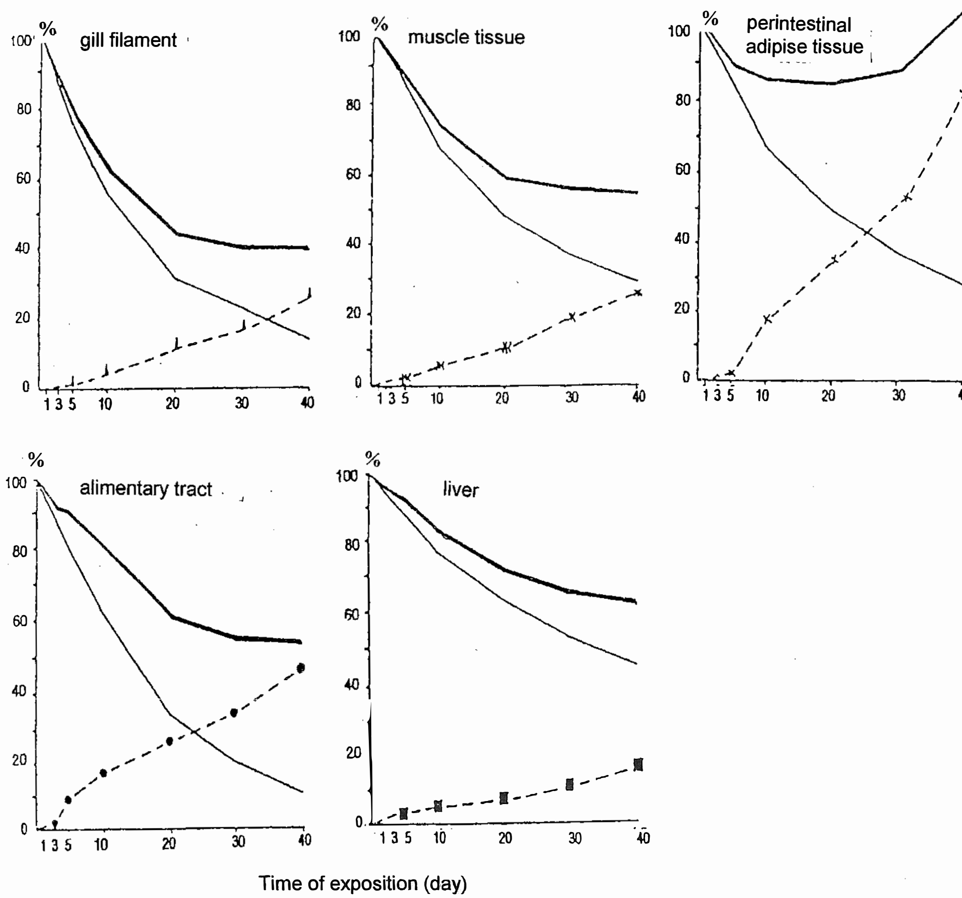

Fig. 2. Relative (%) and absolute decline of the content of the analysed PCBs and weight increment of the studied organs and tissues of carp kept in PCB-free environment;
(—), concentration; (▬), absolute value, related to the total weight of organs;
(---), weight increment

DISCUSSION

In the PCB-free environment, an essential decline of PCB residues was noted in all organs and tissues of carp, previously exposed via oral route to Clophen A50. The changes were in direct proportion to the time of depuration. Half-life of the PCB (Clophen A50) concentration within the tested organs and tissues was as follows: gill filaments—13, alimentary tract—14, muscle tissue and perintestinal adipose tissue—19, and liver—34 days of stay in PCB-free water.

The above-mentioned data do not evidence PCBs excretion from fish but indicate, a decline in PCB concentration levels (a relative value), only. Due to essential growth in weight of the tested organs and tissues, a real decline in PCBs residues, after 40-day stay of carp in PCB-free water, was much lower. Yet, when compared to the initial level a 6.6% increase in PCBs content for perintestinal adipose tissue was noted. A similar phenomenon was observed by Knickmeyer and Steinhart (1989).

According to the obtained results, the decrease in PCB concentrations in individual fish organs and tissues was affected by the depuration time in PCBs-free under environment and, particularly, by the weight increment rate. It is consistent with previous surveys of Boon and Duinker (1985), Larson et al. (1991), and O'Conor and Pizza (1987). They considend the liver, gall-bladder, alimentary tract and the gonad's products excreted at spawning as the main excretion routes of PCBs from fish. It is generally acknowledged, for the PCBs to be metabolised by fishes at low rate and, under natural conditions, to be deposited within organs and tissues for a long time (Narboune 1979; Tervo et al. 1982; Solbakken et al. 1984; Boon and Duinker 1985; Hesselberg et al. 1990; Larsson et al. 1991).

CONCLUSIONS

1. A significant decline in PCB levels was noted in the previously exposed carp, kept in PCB-free environment.
2. The highest decrease in PCBs concentration (a relative value), per wet weight and when converted to lipids, was noted for the gill filaments and alimentary tract while the lowest one was noted for the liver.
3. Weight increments of the tested organs and tissues of carp distinctly contributed to the decline in the relative PCB content levels which was in direct proportion to the time of stay of fish in PCB-free environment.
4. The absolute values of decline in PCB levels, related to the total weight of organs and tissues of carp were distinctly smaller, though in perintestinal adipose tissue the exceeded the initial level by 6.6%.

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DYNAMIKA ZANIKU PCB W WYBRANYCH NARZADACH KARPIA (*CYPRINUS CARPIO* L.) PODCZAS ODPIJANIA W CZYSTEJ WODZIE

STRESZCZENIE

Za główne źródło skażenia środowiska wodnego PCBs uważa się ścieki przemysłowe i komunalne, odprowadzane do zbiorników wodnych, oraz odpady stałe poprodukcyjne i komunalne gromadzone na składowiskach, z których łatwo przenikają do gleby i wód powierzchniowych oraz ulatniają się z parą wodną do atmosfery.

W zbiornikach wodnych polichlorowane bifenyle, jako lipofilne szybko włączają się w obieg troficzny i charakteryzują się wysokimi współczynnikami biokumulacji. Z wody do organizmu ryb PCB wnikają głównie przez skrzela oraz wraz z pokarmem i kumulują się głównie w zapasowej okołojelitowej tkance tłuszczowej oraz innych organach i tkankach bogatych w lipidy.

Celem badań jest określenie dynamiki zaniku PCB w 5 wybranych narządach i tkankach (listki skrzelowe, tkanka mięśniowa, okołojelitowa tkanka tłuszczowa, wątroba i przewód pokarmowy) karpia hodowlanego, uprzednio skażonego drogą pokarmową Clophenem A50, podczas 40-dniowego przetrzymywania w wodzie wolnej od polichlorowanych bifenyli. Badania analityczne wykonano metodą chromatografii gazowej. Wykazano, że największy spadek PCB w wartościach względnych (stężenie) w mokrej masie obserwowano w okołojelitowej tkance tłuszczowej i w przewodzie pokarmowym. W lipidach po 40 dniach ekspozycji najmniejszy spadek zawartości notowano w wątrobie (10,0%), a najmniejszy w przewodzie pokarmowym (90,0%). W wartościach bezwzględnych w przeliczeniu na masę całych narządów i tkanek, największym spadkiem zawartości charakteryzowały się listki skrzelowe – 61,6%, natomiast w okołojelitowej tkance tłuszczowej stwierdzono 6,6% jej wzrost w stosunku do poziomu wyjściowego Wyliczony półokres spadku stężenia w analizowanych narządach i tkankach kształtował się następująco: listki skrzelowe – 13, przewód pokarmowy – 14, tkanka mięśniowa i okołojelitowa tkanka tłuszczowa – 19, a wątroba – 34 dni ekspozycji w środowisku wolnym od PCB.

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