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Fish physiology

BIOACCUMULATION OF PCB's (AROCLOR 1242) AND ITS EFFECTS ON THE ELECTROCARDIOGRAM OF THE EEL *ANGUILLA ANGUILLA* L.

BIOAKUMULACJA POLICHLOROWANYCH DWUFENYLI (AROCHLOR 1242) I ICH WPŁYW NA ELEKTROKARDIOGRAM WĘGORZA (*ANGUILLA ANGUILLA* L.)

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Fish exposed to 200 and 300 µg/l PCB's (Aroclor 1242) for 24 hr demonstrates negative chronotropic effect; increase in the duration of segments and intervals as well as the waves amplitude. A tachycardia was also observed during the experiments. On the other hand, bioaccumulation of PCB's in the eel fish was depended upon the concentration and time, the level of PCB's in the liver was significantly higher than the level observed in the other tissues. Also, the descending order of PCB's accumulated after 24 hr was found in the gills, blood, kidney, liver and muscle, respectively.

INTRODUCTION

The polychlorinated biphenyl mixtures (PCB's) are synthetic compounds that have been used for various industrial purposes. These compounds are extremely stable, not hydrolyzed by water, acid or alkali and are able to withstand high temperature without disintegrating. As expected from these properties, the PCB's undergo extremely slow biodegradation.

The widespread occurence of PCB's has been well documented for a number of marine organisms (Risebrough et al. 1968; Jensen et al. 1969; Zitko, 1971, Stalling and Mayer, 1972; Hansen et al. 1974). However, the actual mode of action and ecological effects of these compounds are poorly understand (Walker, 1976). It was evidented the need for further research and information on the physiological effects of PCB's to aquatic organisms. The aim of this work is to assess bioaccumulation of PCB's (Aroclor 1242) and its effects on the bioelectrical activity of the eel heart.

Table 1

Changes in the bioelectrical activity of eel exposed 200 and 300 µg/1 PCB's (Aroclor 1242)

Time hr.	Dose µg/1	Waves "mV"		P	Segments "sec."		Intervals "sec."		Heart rate beats/min.
		QRS	T		S–T	T–P	P–Q	Q–T	
0	00	2.70 ± 0.55	0.61 ± 0.52	0.09 ± 0.02	0.41 ± 0.06	0.31 ± 0.05	0.21 ± 0.05	0.74 ± 0.14	49.70 ± 8.46
1	200	2.80 ± 0.81	0.66 ± 0.75	0.50 ± 0.19	0.42 ± 0.23	0.37 ± 0.04	0.26 ± 0.03	0.92 ± 0.41	43.63 ± 14.67
	300	3.44 ± 1.17	0.67 ± 0.61	0.18 ± 0.07	0.52 ± 0.03	0.71 ± 0.61	0.28 ± 0.03	0.96 ± 0.04	33.53 ± 12.87
2	200	1.16 ± 0.46	0.60 ± 0.58	0.30 ± 0.14	0.30 ± 0.14	0.20 ± 0.09	0.18 ± 0.02	0.62 ± 0.25	68.69 ± 16.47
	300	2.51 ± 0.60	0.42 ± 0.28	0.12 ± 0.07	0.32 ± 0.05	0.28 ± 0.04	0.22 ± 0.05	0.67 ± 0.02	53.66 ± 9.33
6	200	2.96 ± 0.70	1.16 ± 1.58	0.16 ± 0.09	0.35 ± 0.18	0.26 ± 0.08	0.24 ± 0.02	0.78 ± 0.61	57.99 ± 18.50
	300	3.45 ± 1.43	0.66 ± 0.37	0.26 ± 0.14	0.46 ± 0.06	0.38 ± 0.08	0.24 ± 0.04	0.86 ± 0.05	42.49 ± 4.20
24	200	3.79 ± 1.24	1.18 ± 0.80	0.30 ± 0.12	0.42 ± 0.10	0.52 ± 0.29	0.28 ± 0.03	0.98 ± 0.38	38.80 ± 9.78
	300	3.77 ± 1.18	0.97 ± 0.40	0.26 ± 0.12	0.47 ± 0.06	0.46 ± 0.12	0.25 ± 0.03	0.92 ± 0.03	40.79 ± 1.17

Average of three observations.

MATERIALS AND METHODS

Individuals of eel, *Anguilla anguilla* L. weighing 210±73.3 gm were brought to the laboratory and acclimated for one week under appropriate experimental conditions. Fish electrocardiogram (ECG) were obtained with the method of Labat (1966) using a single channel CGK-301 electrocardiographic apparatus and CMK-405 cardiomonitor. According to this method, the exploring electrodes were inserted in the abdominal surface over the position of the heart transversely to the longitudinal axis of the body and tangentially to the pericardial sack. The earthed electrode was usually placed on the tail of the fish. Recording of the ECG began after returning the fish with the electrodes to normal condition at paper speed 25 mm/sec. The heart rate per minute was calculated directly from the obtained ECG.

Fish were individually subjected to 200 and 300 µg/l PCB's (Aroclor 1242) in a glass aquarium containing 20 liters of aerated dechlorinated tap-water and changes in the ECG was recorded. The values of temperature, dissolved oxygen and pH during the experiments were 18.0± 0.5°C; 8.6 ±0.6 mg/l and 7.5± 0.3, respectively.

Bioaccumulation of PCB's in the liver, gills, muscle, blood and kidney were also determined. The tissues were blended with anhydrous sodium sulphate (50 gm) and n-hexane (150 ml) for 10 minutes. The extracts were concentrated to 10 ml. 5 ml was used to determine fat tissue percentage. The other was concentrated to 3 ml and purified with 7% SO_3 in H_2SO_4 and with 5% KOH in 96% C_2H_5OH. The content of PCB's in different organs was determined according to the method of gas chromatography using Chromatron GCHF 18.3 apparatus.

Statistical test (t-test) was made to evaluate the significant changes caused by PCB's.

RESULTS AND DISCUSSION

Changes in the bioelectrical activity of the eel heart exposed to different concentrations of PCB's (Aroclor 1242) are shown in Table (1). It is evident that, at 0 time the ECG appears normal and the heart rate was 49.70 beata/min. Fish exposed to 200 and 300 µg/l PCB's for 24 hr resulted in decreasing of the heart rate to 38.80 and 40.79 beats/min., respectively which is explained as being caused by the depressing action of the vagal nerve (Siato, 1973).

This is in agreement with the results of Bruckner et al. (1973) who found that PCB's had a depressing action of the Central Nervous System. A tachycardia was also recoded after 2hr of exposure to different concentration of PCB's (68.69, 53.66 beats/min.) respectively, which may be resulted from inhibition of the parasympathetic fiber and reduction in the vagal tone. On the other hand, changes in the heart rate was found to be associated with an increase in the duration of S–T, T–P segments and P–Q, Q–T intervals from 0.41, 0.31, 0.21, 0.74 sec. to 0.42, 0.52, 0.28, 0.98 sec. at 200 µg/l and to 0.47, 0.46, 0.25, 0.92 sec. at 300 µg/l, respectively.

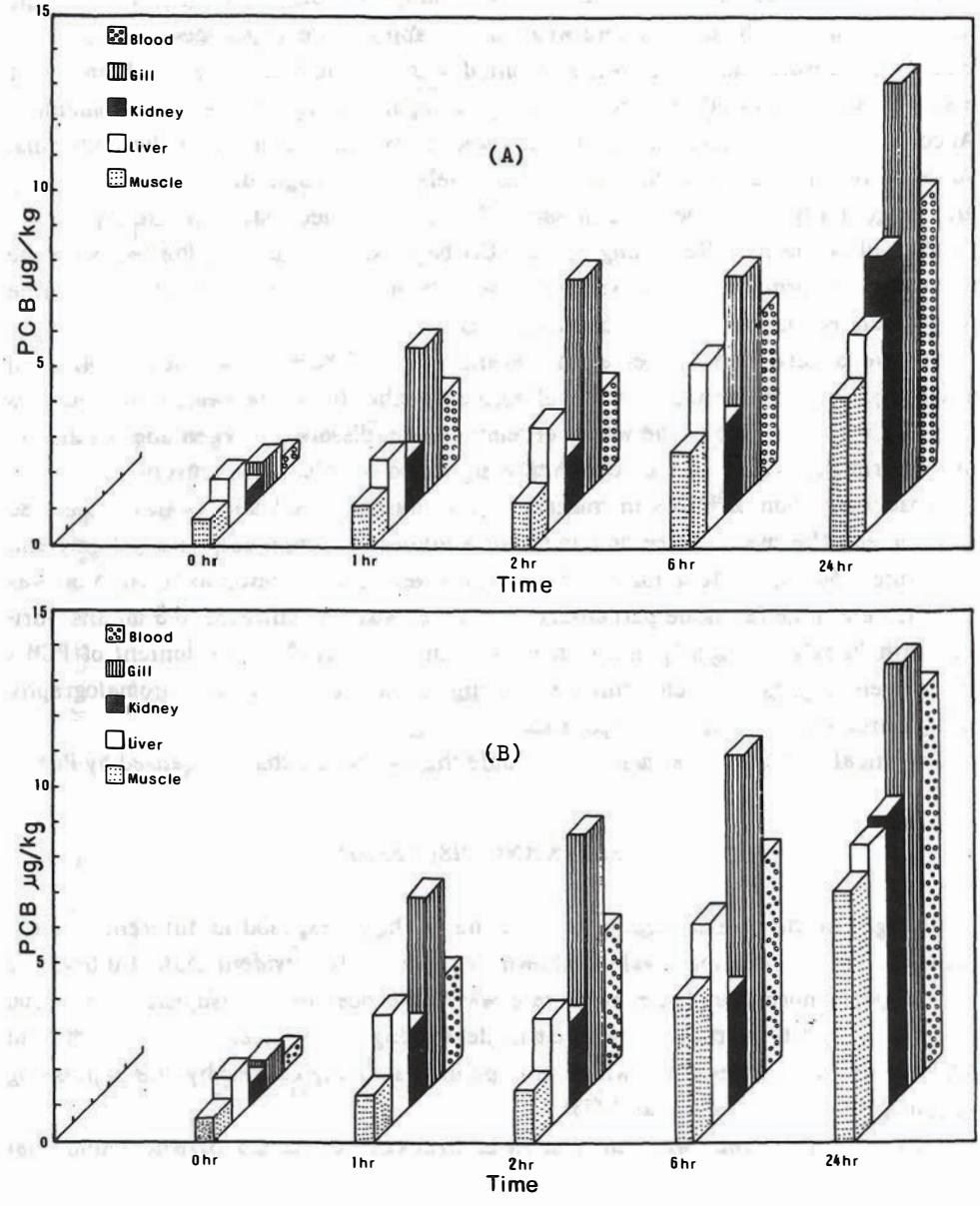

Fig. 1. Bioaccumulation of PCB's (Aroclor 1242) in different organs of eel exposed to: A. 200 µg/l. B. 300 µg/l.

In this study, fish exposed to different concentrations of PCB's exhibited an increase in the waves amplitude. As shown in Table (1), the amplitude of the QRS, T, P waves increased from 2.70, 0.61, 0.03 mV. at 200 µg/1 and to 3.77, 0.97, 0.26 mV. at 300 µg/1, respectively which reflects a disturbance in the electrical potential of the cardiac muscle membrane. It is likely that the positive inotropic effect in the eel heart showed during the experiments resulted from changes in Ca^{2+} metabolism (Andrew, 1989). Statistically, changes in the bioelectrical activity was non-significant ($P > 0.05$) which means that these concentrations of PCB's had a limited effects on the eel heart.

Bioaccumulation of PCB's (Aroclor 1242) in the eel fish at different concentrations and time of exposure are shown in Fig. (1). The basic finding are, at 0 time the liver tissue generally had concentration of PCB's 2 to 4 times higher than the levels observed in the other tissues analyzed with statistically significant difference ($P < 0.05$). This is probably due to its high lipid content. The obtained results is in agreement with Stalling and Mayer (1972); McDermott et al. (1976). As shown in Fig. (1), the highest concentration of PCB's accumulated in the eel fish after 24hr of exposure to 200 and 300 µg/1 was found in the gills (11.7; 12.1 µg/Kg), respectively. Suteau et al. (1987) reported that the level of ^{14}C activity measures in gills appeared related to the PCB's water concentration. The blood concentration of PCB's showed also a rapid initial distributive phase and slow terminal elimination phase with average concentration of 7.9; 10.7 µg/Kg.

The obtained results is in accordance with Kulkarni and Karara (1990). On the other hand, a significant concentrations ($P < 0.05$) of PCB' was also found in the kidney (8.3; 9.2 µg/Kg) and in the liver (7.2; 7.9 µg/Kg) of the eel fish. In this study, the lowest concentration of PCB's was found in the muscle (4.3; 7.1 µg/Kg). This is in agreement with the results of Hansen (1976).

From the above results, it has become clear that fish exposed to different concentrations of PCB's demonstrated that they can accumulate it directly from the water and leads to much higher accumulation in the tissues with highly significant differences ($P < 0.05$). Also, the mean values of PCB's accumulated in the eel fish were correlated to its concentration in the water and the duration of exposure.

CONCLUSIONS

1. PCB'shad a limited effects on the bioelectrical activity of the eel heart.
2. At 0 time, the liver appeared to function the major site of PCB's storage.
3. The values of PCB's accumulated depended upon the concentration and time of exposure.
4. The highest concentration of PCB's accumulated in the eel fish after 24hr was found in the gills followed by the blood, kidney, liver and muscle.

REFERENCES

Andrew J.E., 1989: Polychlorinated biphenyl (Aroclor 1254) – induced changes in femur morphometry, calcium metabolism and nephrotoxicity. Toxicology, **57**, 1: 83–96.

Bruckner J., K. Khanna, H. Cornish, 1973: Biological response of the rat to polychlorinated biphenyl. Toxicol. Appl. Pharma., **24**: 434–448.

Hansen D.J., 1976: PCB's: Effects on and accumulation by estuarine organisms. In.: National Conference on Polychlorinated Biphenyls. Chicago: 282–283.

Hansen D., P. Parrish, J. Forester, 1974: Aroclor 1016: Toxicity to and uptake by estuarine animals. Environ. Res., **7**: 363–373.

Jensen S., A. Johnels, M. Olsson, G. Otterlin, 1969: DDT and PCB in marine animals from Swedish water. Nature, **224** (5216), **247**.

Kulkarni M.G., A.H. Karara, 1990: A pharmacokinetic model for the disposition of polychlorinated biphenyls (PCBS) in channel catfish. Aquat. Toxicol., **16**, 2: 141–150.

Labat R., 1966: Electrocardiologie chez les poisons teleosteen: Influence de quelques facteurs ecologiques. Toulouse Edouard Private, Libraire-Editeur, 255.

McDermott D., D. Young, T. Heesen, 1976: PCB contamination of southern California marine organism. In: National Conference on Polychlorinated Biphenyls. Chicago, 155–160.

Risebrough R., P. Reiche, D. Peakall, S. Herman, M. Kirven, 1968: Polychlorinated biphenyls in the global ecosystem. Nature: **220** (5172), 1098.

Siato T., 1973: Effects of vagal stimulation on the pacemaker action potentials of carp heart. Comp. Biochem. Physiol. **44A** 1: 191–199.

Stalling D., F. Mayer, 1972: Toxicities of PCB's to fish and environmental residues. Environ. Health Perspectives, No. 1, DHEW, Nat. Inst. Environ. Health Sci.: 159–164.

Suteau P., M. Migaud, J. Narbonne, 1987: Absorption and tissue distribution of radioactivity in mussels (Mytilus galloprovincialis) exposed to low concentrations of ^{14}C-polychlorinated biphenyl. Sci. Total. Environ., **67**: 187–193.

Walker C.R., 1976: PRE-1972 knowledge of nonhuman effects of polychlorinated biphenyls. In: National Conference on Polychlorinated Biphenyls. Chicago, 268–281.

Zitko Y., 1971: Polychlorinated biphenyls and organochlorine pesticides in some freshwater and marine fishes. Bull. Environ. Contam. Toxicol., **6**, 464.

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BIOAKUMULACJA POLICHLOROWATYCH DWUFENYLI (AROCHLOR 1242) I ICH WPŁYW NA ELEKTROKARDIOGRAM WĘGORZA (*ANGUILLA, ANGUILLA* L.)

STRESZCZENIE

Ryby poddane działaniu dawki 200 i 300 µg PCB/l (Arochlor 1242) przez 24 h, charakteryzuje ujemna chronotropowa reakcja, wydłużony czas trwania odcinków i odstępów oraz większa amplituda fal. Podczas trwania doświadczeń obserwowano także zjawisko tachykardii.

Stwierdzono, że bioakumulacja związków PCB u węgorza zależy od stężenia związku i czasu działania. Wyjściowo, zawartość związków PCB w wątrobie jest wyraźnie wyższa od tej stwierdzanych w innych tkan-

kach. Po 24 h ekspozycji na działanie PCB ilości akumulowanych polichlorowanych dwufenyli były najwyższe w skrzelach i coraz niższe, odpowiednio, w krwi, nerkach, wątrobie i mięśniach.

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