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INVESTIGATIONS BY GAS CHROMATOGRAPH ON THE CHLORINATED HYDROCARBON POLLUTION IN TWO AREAS OF LAKE BALATON

ZSUZSA PÁSZTOR, JENŐ E. PONYI*, ATTILA HOLLÓ and LILY GÖNCZY

National Institute of Public Health, Budapest,
**Biological Research Institute of the Hungarian Academy of Sciences, Tihany, Hungary*

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The first studies on the chlorinated hydrocarbon pollution in Lake Balaton (BARON et al., 1967; PONYI et al., 1968) were based on thin-layer chromatographic measurements summarizing the results of so many analyses that, even today, the great fish kill in 1965 can be ascribed to chlorinated hydrocarbon pollution. The results are supported by the probability of these pesticides being accumulated in the food-chain. The authors mentioned above found γ-HCH, DDT and their decomposition products in fishes, plankton crustaceans and molluscs.

Investigations with gas chromatograph have been carried out at the first by FELFÖLDY and TÓTH (1967), when γ-HCH, aldrin, dieldrin and DDT could be located in fishes. PINKOLA and TÓTH (1971) stated their presence in the water and water weeds. In their exploratory study CZEGLÉDI-JANKÓ et al. (1973) reported on the occurrence of 2.4-D (Dikonirt), in addition to the γ-HCH, DDT and their metabolites, in Lake Balaton.

When collating the literary data the followings become evident:

1. Despite the fact that DDT and its decomposition products have been decreasing since the fish kill in 1965, they are still present in the lake.

2. γ-HCH was also found in significant quantity.

The aim of our studies was to gain further informations on the concentration of γ-HCH, DDT and their decomposition products in the lake and in aquatic organisms. We were going to find explanation to the followings:

1. The degree of chlorinated hydrocarbon pollution in different members of the food-chain (algae, zooplankton, non-predatory and predatory fishes).

2. Whether or not the two water areas of diverging quality differ in the chlorinated hydrocarbon content.

3. The degree of chlorinated hydrocarbon pollution of River Zala and its effect on the lake.

Dates and localities of collecting, materials and methods

Samples were taken along two standard transversal sections of Lake Balaton (A and M), at the inlet of River Zala and 10 km upwards in the river itself *(Fig. 1)*. The selection of these sites was indicated by previous investiga-

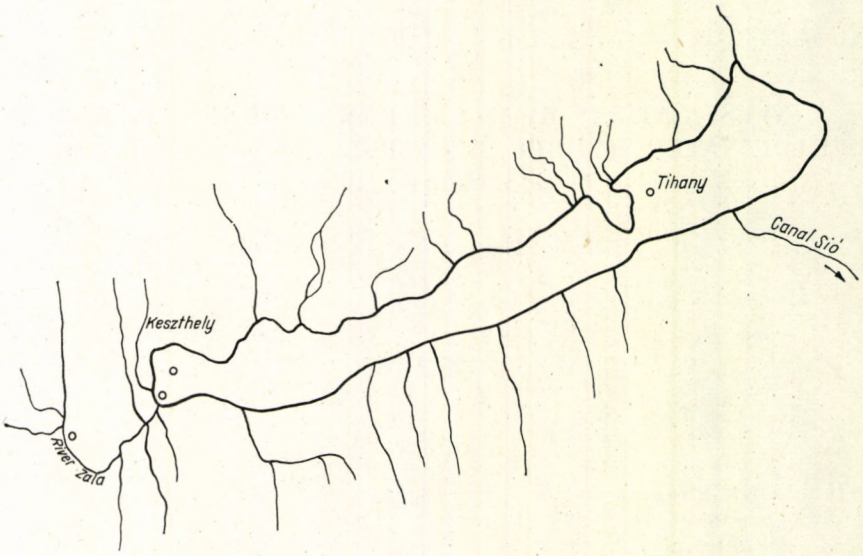

Fig. 1. Sampling places in Lake Balaton

tions (PONYI et al., 1972; PONYI and P.-ZÁNKAI, 1972; PONYI, 1975). Owing to the fact that section M is influenced by the inflowing waters in a remarkable degree and section A only to some extent, the quality of the two water areas differs very much. At the same date of the investigations the two sections were characterized by the following differences:

	section M	section A
Organic carbon content (mg/l)	6.42	5.36
Chemical O_2 consumption (mg/l)	4.94	3.80
Total P (mg/m^3)	86.60	51.50
Bacterium (cells$\times 10^5$/ml)	4.70	3.50
Algae (individual number$\times 10^5$/l)	4.90	1.40
Rotatoria (μg wet weight/l)	24.00	42.00
Planctonic Crustacea (μg dry weight biomass/l)	99.00	69.00

At the sampling places water, phytoplankton, plankton Crustacea, white grass-carp *(Hypophtalamichthys molitrix)*, carp *(Cyprinus carpio)* and pike-perch *(Stizostedion lucioperca)* were collected in the following months:

Date of sampling	water	fish	plankton
April 1973	+	−	−
June	−	+	−
July	−	+	+
October	+	−	+

The phytoplankton and the planktonic crustaceans were filtered with sampling nets No. 25 and 6.

The degree of γ-HCH, DDT, DDE and DDD pollution was examined in all samples.

Water sample of 4000 ml was extracted in petroleum ether of 2×150 ml (Carlo Erba, boiling point of 30—40°C) with shaking. The petroleum etheric phases were brought together and evaporated with anhydrous sodium sulphate of max. 5 g (Merck). After decantation the extracts were condensed in rotary vacuum concentrator of Rotadest type at 40°C. The concentrate was purified on Davidow column in the appliance of CZEGLÉDI-JANKÓ and CIELESZKY (1968). The purification lasted for 1.5 hours. The purified extracts were evaporated almost dry and taken up in hexane of gas chromatographic purity. In the fish samples the degree of pollution was determined in the flesh, brain, liver, eggs and milt. The whole quantity of the brain and liver samples was homogenized with distilled water in the ratio of 1 : 1. 10—10 g flesh of each fish was homogenized with distilled water of the same quantity. The homogenizates of the organs and plankton samples were liofilizated in a final vacuum of 10^{-2} torr, at a sublimation temperature between —25 and —30°C applying an after heating of 35°C.

Since the rest of organs to be determined were compounds diluting easily in lipids, the fat content of the samples was extracted in petroleum ether after liofilization. Of the fat obtained and measured, 0.1—0.15 g was studied on. The analyses resulted three parallel mean values.

The examinations were carried out with an instrument of Packard type. The conditions of the chromatographic experiment were as follows:

Column: made of pyrex glass of 180×0.4 cm; OV 17 and QF-1 partitive liquid of 1.5 per cent layered on solid carrier; temperature: 190°C.
detector: electron capture; tritium foil content (activity of 150 mC); temperature: 196°C
carrier gas: nitrogen of high purity, flow rate 55 ml/minute; vaporizer temperature: 220°C.

The identification and quantitative determination was carried out by means of a stock-solution compounded of reference materials. The solution also contained α-, β-, and δ-HCH. We failed, however, to evaluate the quantity of these substances.

Results

1. *Chlorinated hydrocarbon content of water samples*

The gas-chromatographic investigations showed the γ-HCH pollution of Lake Balaton to be identical at Tihany and in the Keszthely Bay in spring (35 ng/l) *(Table I)*.

In autumn the γ-HCH values decreased at the sampling sites. In the Keszthely Bay and River Zala only 7–14 per cent, while at Tihany 37 per cent of the spring values were found.

In spring the DDT pollution of the water could be denoted in figures only at Tihany. Owing to its low quantity, it could not be worthily measured at other sampling places. In autumn it showed an increase reaching a concentration of 9 ng/l in the Keszthely Bay.

TABLE I

Chlorinated hydrocarbon pollution of Balaton and River Zala, 1973 (μg pesticide/1000 ml water)

Site of sampling	Date of sampling	γ-HCH	DDE	DDD	DDT
Tihany	April	0.035	Ny	0.001	0.002
	Oct.	0.013	Ny	Ny	Ny
Keszthely	April	0.035	Ny	0.002	Ny
	Oct.	0.005	Ny	Ny	0.009
Inlet of River Zala	April	0.037	Ny	0.002	Ny
	Oct.	0.002	Ny	Ny	0.003
10 km upwards in River Zala	April	0.039	Ny	0.003	Ny
	Oct.	0.003	Ny	Ny	0.003

Ny = less than 0001 μg/1,000 ml water

In spring the DDD was of almost identical concentration all over the lake and in the River Zala.

2. *Chlorinated hydrocarbon content of plankton samples*

Phytoplankton could be analysed only once, in October, when the water-bloom was followed by heaps of algae floating on the surface. In this period the alga concentration was as much as 4.2 mg wet weight/litres (HERODEK and TAMÁS, 1974; 1975). In the phytoplankton samples DDT and DDD were found in the largest quantity *(Table II)*. Compared to the values of planktonic Crustacea the quantity of γ-HCH also seemed to be significant.

TABLE II

Pesticide content of the phytoplankton and plankton crustacean samples in two different regions of Lake Balaton, 1973 (mg pesticide/1000 g dry plankton)

Month	Region	γ-HCH	DDE	DDD	DDT	Fat content %
VII.	Tihany, section A Crustacea-plankton	0.129	0.126	0.115	0.025	5.72
VII.	Keszthely, section M Crustacea-plankton	0.171	0.135	0.089	0.042	5.06
X.	Keszthely, section M Crustacea-plankton	0.229	0.165	0.166	0.679	11.69
X.	Keszthely, section M Phyto-plankton	0.635	0.327	3.507	4.086	4.09

The following species of crustaceans were found in the samples: *Eudiaptomus gracilis* (10 individuals/litre), *Cyclops vicinus* (13 individuals/litre), *Mesocyclops leuckarti* (3 individuals/litre), *Daphnia cucullata* (1 individual/litre) and *Cyclops nauplii* (5 individuals/litre).

The γ-HCH and DDT content of planktonic Crustacea collected along the transversal section M in summer and autumn is different *(Table II)*. In the autumn the γ-HCH pollution was 1—2 times, while the DDT pollution 16—17 times as high as it was in the spring.

The comparison of the summer samples taken along sections A and M shows that the degree of pesticide pollution of the two areas differs to some extent. Reducing into water value and regarding the inequality in the plankton density, this difference even grows *(Tables III* and *IV)*.

TABLE III

Estimated quantity of plankton in the period of the investigation (in µg dry weight/litre)
(WINBERG, 1971; HERODEK and TAMÁS, 1973; 1975; PONYI, 1975)

Month	Section	Planktonic Crustacea	Phytoplankton
July	A	122	280
	M	161	1240
October	A	69	420
	M	185	840

TABLE IV

Pesticide pollution of plankton at two sampling areas of Lake Balaton (µg pesticide/m^3 water)

Month	Section	Plankton	γ-HCH	DDE	DDD	DDT
VII.	A	Crustacea-	0.016	0.015	0.014	0.003
VII.	M	Crustacea-	0.028	0.027	0.014	0.007
X.	M	Crustacea-	0.042	0.031	0.031	0.126
X.	M	Phyto-	0.533	0.275	2.946	3.432

3. *Pesticide content of fish samples*

Analyses of the different organs of white grass-carp *(Table V)* showed that chlorinated hydrocarbon is present in larger quantity in the 3 + year-old specimens than in the 2 + year-old ones. The γ-HCH, content of fles was found to be 9 times higher and of brain of 3+ year-old 4 times higher than in case of 2 + old specimens. The difference in the concentration of DDT was 2.5-fold in the flesh. The increased pesticide content of the 3+ year-old specimens is connected with the changed fat-content.

The pesticides found in the different organs of the pike-perch and carp differ in quantity at the two sampling sites *(Table VI)*. The γ-HCH content of the liver, eggs, milt and brain of pike-perches collected in the north-eastern basin is higher than that of the specimens from the Keszthely Bay. The γ-HCH content of these organs of carp is the opposite of these values, found to be higher just in the Keszthely Bay. The distribution of DDT and its decomposition products shows other picture like the γ-HCH did. The degree of pollution of the organs of fish collected at the two areas is nearly the same.

TABLE V

Pesticide content of the organs of white grass-carp (Hypophthalmichthys molitrix) at Keszthely, June 1973 (mg pesticide/1000 g organ, wet weight)

Age	Organ	γ-HCH	DDE	DDD	DDT	Fat content %
3+	Flesh	0.136	0.162	0.179	0.165	24.49
3+	Liver	0.038	0.056	0.051	0.086	13.25
3+	Brain	0.117	0.042	0.026	0.099	6.46
2+	Flesh	0.015	0.012	0.037	0.064	6.87
2+	Liver	0.026	0.060	0.058	0.094	8.52
2+	Brain	0.031	0.061	0.034	0.106	7.20

TABLE VI

Pesticide content of the organs of pike-perch and carp in two regions of Lake Balaton, July 1973 (mg pesticide/1000 g organ, wet weight)

Species	Organ	Site of sampling	γ-HCH	DDE	DDD	DDT	Fat-content %
Pike-perch	Flesh	Tihany	0.0120	0.0074	0.0022	0.0214	0.37
		Keszthely	0.0133	0.0058	0.0029	0.0174	0.35
	Liver	Tihany	0.0266	0.0828	0.0208	0.0232	1.11
		Keszthely	0.0157	0.0672	0.0400	0.0346	1.56
	Milt and eggs	Tihany	0.0131	0.0076	0.0033	0.0260	1.60
		Keszthely	0.0072	0.0104	0.0039	0.0608	1.71
	Brain	Tihany	0.0244	0.1071	0.0137	0.0235	7.87
		Keszthely	0.0078	0.0775	0.0207	0.0292	6.73
Carp	Flesh	Tihany	0.0173	0.0162	0.0073	0.0226	1.10
		Keszthely	0.0129	0.0319	0.0218	0.0213	1.70
	Liver	Tihany	0.0329	0.0360	0.0160	0.0186	3.68
		Keszthely	0.0819	0.0656	0.0440	0.0320	5.63
	Milt and eggs	Tihany	0.0113	0.0101	0.0049	0.0146	1.04
		Keszthely	0.0165	0.0256	0.0192	0.0088	2.34
	Brain	Tihany	0.0057	0.0076	0.0016	0.0078	4.30
		Keszthely	0.0228	0.0196	0.0093	0.0180	5.05

When determining the ratio of DDT and its decomposition products (DDE + +DDD), significant differences were found in three cases *(Table VII)*. A difference in the ratio of DDT/DDE + DDD pollution in the examined organs of pike-perches collected in the two areas was shown only by the eggs and milt. At Tihany it was found to be 2.4 and at Keszthely 4.3. In addition to the eggs and milt, the flesh of carp shows a shift like this in ration, but in an inverse manner. While at Tihany the ratio of DDT/DDE + DDD equals 1, this shifts to the advantage of the decomposition products at Keszthely.

Discussion

Our gas- chromatographic results can be compared to other data on Lake Balaton only restrictedly because, on the one hand, there are only three publications describing similar methods (comp. the introduction); on the other

TABLE VII

Ratio of DDT and its decomposition products found in the organs of pike-perch and carp at the two collecting areas

Collecting station	Pike-perch DDT/ DDE+DDD	Carp DDT/DDE+DDD	Organ
Tihany	2.2	1.0	flesh
Keszthely	2.0	0.4	flesh
Tihany	0.2	0.4	liver
Keszthely	0.3	0.3	liver
Tihany	2.4	1.0	eggs and milt
Keszthely	4.3	0.2	eggs and milt
Tihany	0.2	0.8	brain
Keszthely	0.3	0.6	brain

hand, the comparison is hindered by the way of publishing or the diverging matter of the investigations. Compared to PINKOLA's and TÓTH's (1971) data on 1968—69, now the quantity of γ-HCH found in the water proved to be significantly lower *(Table VIII)*.

TABLE VIII

The quantity of γ-HCH (ng/1000 ml water) measured in Lake Balaton and River Zala in different years

Sampling site	PINKOLA and TÓTH, 1971			PÁSZTOR et al. 1973
	1967	1968	1969	
River Zala	64	130—170	84	3—39
Keszthely Bay	86	30—165	150	5—35
At Tihany	12	50—170	76	13—35

Comparing the data it seems that the quantity of γ-HCH markedly varied from year to year. The values are higher in spring than in autumn. This seasonal fluctuation is strictly connected to the period when γ-HCH is used and is washed by rain into the lake (October 1973 was pretty dry). This is supported by the data of PINKOLA and TÓTH (1971) stating that the high γ-HCH content measured in October 1968 was caused by the rather rainy weather.

DDT and its decomposition products were measured in all samples. Of course, the values were low, varying between 2 and 9 ng/litre. It means that DDT can be still found at present. Owing to the few data at our disposal, its origin cann ot be determined. As a matter of fact in the Keszthely Bay the quantity of DDT was found to be three times highes than in River Zala at the same time in autumn.

Analysing the plankton samples, the same chlorinated hydrocarbons were found similarly in the water. In October the water, phytoplankton and plankton crustaceans were sampled simultaneously. On this basis the distribution of γ-HCH and DDT in the water and in the plankters could be estimated *(Table IX)*. Our results showed that most of the pesticides could be found in the water and the γ-HCH and DDT content of algae was 10 to 28 times higher than that of the plankton crustaceans.

TABLE IX

Percentual distribution of chlorinated hydrocarbon between the water and the plankters in the Keszthely Bay, in October 1973

	γ-HCH	DTD
Water	89.3	70.5
Phytoplankton	9.9	28.5
Planktonic Crustacea	0.8	1.0

Comparing the pesticide content of two plankton Crustacea samples taken in the Keszthely Bay it is visible that it was higher in autumn than in summer *(Tables II* and *IV)*. It may be caused by the phenomenon that in October the macrophytoplankton breaks up into pieces of 10—15 μ size, thus becoming good for serving as food. In this period most of the water weeds of high pesticide content (PINKOLA and TÓTH, 1971) do the same and are fed on by the cladocerans. There was no rain before the samplings giving reason for the increased pesticide level in the crustaceans.

Comparing our data to those on the planktonic Crustacea in 1967 obtained by using the thin-layer chromatographic method (PONYI et al., 1968), it is seen that at the same time and localities place — e.g. along section M —the pesticide content increased with one order of magnitude *(Table X)*.

TABLE X

Comparison of the pesticide content of planktonic Crustacea in Lake Balaton (mg pesticide/1000 g dry plankton)

Month	Site of sampling	γ-HCH		Total DDT	
		* PONYI et al. (1968)	PÁSZTOR et al. 1973	*PONYI at al. (1968)	PÁSZTOR et al. 1973
VII.	A	0.200	0.129	0.730	0.266
VII.	M	0.010	0.171	0.050	0.266
X.	M	0.001	0.229	0.001	1.010

Note: * = Data on wet weight are calculated after WINBERG (1971)

Of the three fish species examined, the greatest pollution of white grass-carp may be ascribed to the relatively high pesticide content of the plankton organisms *(Table XI)*. It is known that the white grass-carp feeds on phyto- and zooplankton, consequently, its pesticide uptake is the highest. Comparing the maximal and minimal quantity of DDT and its decomposition products found in the organs of white grass-carp to earlier literary data *(Table XII)*, it becomes evident that it does not decrease with one order of magnitude as the pike-perch does *(Table XIII)*.

Compared to that in 1966, the γ-HCH pollution level of carp liver increased *(Table XIV)*. On the other hand, the γ-HCH content of pike-perch was lower than it was in 1966 *(Table XV)*. The difference between the degree of pesticide pollution of the carp and pike-perch is explained by food biology. To answer all questions, e.g. what is caused by the different ratio of DDT and

TABLE XI

Comparison of the pesticide level in the fishes collected in the Keszthely Bay in June, 1973 (mg pesticide/1000 g organ, wet weight)

Organ	Species	γ-HCH	Total DDT
Flesh	2+ white grass-carp	0.0150	0.2222
	3+ white grass-carp	0.1360	0.506
	Carp	0.0129	0.1416
	Pike-perch	0.0133	0.1418
Liver	2+ white grass-carp	0.0260	0.2114
	3+ white grass-carp	0.0375	0.1930
	Carp	0.0819	0.1416
	Pike-perch	0.0157	0.1418
Brain	2+ white grass-carp	0.0309	0.2002
	3+ white grass-carp	0.1172	0.1665
	Carp	0.0228	0.0469
	Pike-perch	0.0078	0.1274

TABLE XII

Maximum and minimum value of DDT and its decomposition products found in the organs of white grass-carp and some other species in Lake Balaton (numbers rounded)

Year	Species	Authors	mg/1000 organ wet weight
1965	Pike-perch, carp, bream	DÉNES and CIELESZKY (cit. ap. BARON et al.)	0.1 —8.4
1966	Pike-perch, carp, bream	BARON et al.	0.02—1.88
1967	Volga pike-perch, Mirror carp, Razor fish	FELFÖLDY and TÓTH*	0.01—0.42
1973	White grass-carp	PÁSZTOR et al.	0.17—0.51

Note: * = Unkown whether or not total DDT had been determined

TABLE XIII

Level of DDT and its decomposition products in pike-perch in different years (mg/1000 g organ, wet weight)

Organ	DÉNES and CIELESZKY 1965	BARON et al. 1966	PÁSZTOR et al. 1973
Flesh	0.1—0.2	0.09—1.80	0.026—0.031
Liver	0.4—8.4	0.15—1.85	0.127—0.142

its decomposition products in the eggs and milt of the two species, should be clarified by further investigations.

TABLE XIV

Quantity of γ-HCH in the carp in different years (mg/1000 g organ, wet weight)

Organ	BARON et al. 1966	PÁSZTOR et al. 1973
Flesh	0.01—0.03	0.013—0.017
Liver	0.01—0.03	0.033—0.082

TABLE XV

Quantity of γ-HCH in the organs of pike-perch (mg/1000 g organ, wet weight)

Organ	BARTON et al. 1966	PÁSZTOR et al. 1973
Flesh	0.03—0.07	0.012—0.013
Liver	0.11—0.23	0.016—0.027
Eggs and milt	0.05—0.25	0.007—0.013

Relying the above findings the three questions raised in the introduction can be answered as follows:

1. The organisms playing an important role in the food-chain of Lake Balaton are characterized by different levels of, pesticide pollution. Contrary to the plankton crustaceans the pesticide accumulates in larger quantity in the phytoplankton. Consequently, the pollution level of white grass-carp feeding directly on algae is significantly higher than that of the carp or pike-perch. Since the sixties the pesticide content of carps (γ-HCH) increased to some extent. It is explained by the accumulation of pesticides in the alga-detritus → *Chironomus-Dreissena* → carp food-chain. The lowest pollution level was found in pike-perch.

2. There is a difference in the pollution level between the Keszthely Bay and the open water at Tihany, although this is not significant. This is due to the River Zala directly polluting the water in the Keszthely Bay. On the other hand, even the alga concentration is higher in the bay. The quantity of pesticides fixed in the plankton may increase the chlorinated hydrocarbon pollution of water with its 10—30 per cent.

3. Our data do not point out whether the γ-HCH pollution of the lake originates from River Zala alone or from the other tributaries, as well. This latter suggestion may be supported by the fact that DDT was found in larger quantity in the lake than in River Zala.

Summary

In 1973 the authors studied the chlorinated hydrocarbon pollution in two regions of different water quality of Lake Balaton with gas-chromatographic method. At the collection sites water, samples of phytoplankton and plankton crustaceans were taken, and white grass-carp *(Hypophthalmichthys molitrix)*, carp *(Cyprinus carpio)* and pike-perch *(Stizostedion lucioperca)* were collected. The quantity of γ-HCH, DDT, DDE and DDD chlorinate

hydrocarbons were examined in all samples. After the gas-chromatographic analyses the followings could be established:

1. The γ-HCH pollution of the Keszthely Bay and the open water at Tihany was identical in spring (35 ng/l). At the inlet of River Zala and in the river itself this value was somewhat higher (37 and 39 ng/l). In autumn their quantity decreased at each of the sampling sites.

2. In spring the DDD concentration was distributed evenly in the lake (1.4—1.7 ng/l), however, it was higher in River Zala (3.2 ng/l). In this season, except the surroundings of Tihany (2.1 ng/l), DDT was found only in very low values (less than 1 ng/l) with some increase in autumn and amounting to 8.5 ng/l in the Keszthely Bay.

3. In the Keszthely Bay the autumn phytoplankton samples containing DDT (4.086 mg/kg dry weight) and DDD (3.507 mg/kg dry weight) were in the largest quantity. Regarding the actual alga concentrations at the sampling sites this equals to 7.2 $\mu g/m^3$ pesticide fixed in the plankton.

4. The chlorinated hydrocarbon content of plankton crustaceans shows differences especially in the summer and autumn samples (0.437 and 1.239 mg/kg dry weight). In the autumn samples the value of γ-HCH was found to be 1.3—1.8 times higher than that of DDT being 16—27 times higher than in summer. Regarding the actual concentration of plankton crustaceans at the sampling sites, this equals to 0.05—0.23 $\mu g/m^3$ pesticide fixed in them.

5. In the specimens of the 3+ year-old white grass-carps the chlorinated hydrocarbon was found in significantly larger quantities than in the 2+ year-old ones. Examining the pollution of white grass-carp it was noted that the flesh of the 3+ year-old specimens contained 9 times (0.136 mg/kg), and their brain 4 times (0.117 mg/kg) as much γ-HCH as the 2+ year-old ones. As regards DDT, it was present in 2.5 times larger quantity (0.506 mg/kg) in the flesh of the 3+ year-old specimens.

6. The pesticide pollution (mg/kg organ, wet weight) of the organs of pike-perch and carp is lower than that of the wite grass-carp. In the case of pike-perch collected at Tihany the γ-HCH content of liver (0.027), eggs and milt (0.013) and brain (0.024) was higher than in the Keszthely Bay (0.0161; 0.007; 0.008 respectively). The carps showed higher pollution levels in the Keszthely Bay. As regards DDT and its decomposition products, a significant difference was found between the eggs and milt of pike-perch and that of the carp at the two areas. In the case of carps, even the difference in the flesh pollution is worth mentioning.

REFERENCES

Baron, F., F. Csonti, J. E. Ponyi (1967): Investigations of pesticide residues in fish and other aquatic organisms of Lake Balaton and some other aquatic habitats. — *Annal. Biol. Tihany* **34**, 117—128.

Czeglédi-Jankó, G. V. Cieleszky (1968): *Analyst* **93**, 445—452.

Czeglédi-Jankó, G., J. Ponyi, F. Csonti (1973): A Balaton peszticid szennyezettségi dinamikájának néhány kérdése. — *Halászat* XIX. (66), 74—75.

Felföldy, L., L. Tóth (1967): A mezőgazdaság kemizálásának hatása a vízgazdálkodásra. I. Peszticidek. — *Vízügyi szakmai világszintbeszámolók* **18.** VITUKI, *Vízügyi Műszaki Tájékoztató Iroda, Budapest (rotaprint eljárás)*, p. 184.

Herodek, S., G. Tamás (1973): The primary production of phytoplankton in Lake Balaton, April—September 1972. — *Annal. Biol. Tihany* **40**, 207—218.

Herodek, S., G. Tamás (1975): A fitoplankton elsődleges termelése a Balaton Keszthelyi-medencejében 1973—1974 években. — *Annal. Biol. Tihany* **42**, 175—190.

Pinkola, L., L. Tóth (1971): A Balaton peszticid-viszonyainak feltárása. — *Beszámoló a VITUKI 1968. évi munkájáról, Budapest*, 227—244.
Ponyi, J. E., F. Csonti, F. Baron (1968): An investigation of the content of the chlorinated hydrocarbon residues of the crustacean plankton in the Balaton. — *Annal. Biol. Tihany* **35**, 183—189.
Ponyi, J. E., J. Oláh, A. Frankó (1972): Distribution of organic matter and bacteria in the upper layer of bottom deposit in the open water of Lake Balaton. — *Annal. Biol. Tihany* **39**, 141—148.
Ponyi, J. E., N. P.-Zánkai (1972): Investigations on planktonic Crustacea in Lake Balaton V. Horizontally occurring quantitative changes in the different areas of the lake in 1965—1966. — *Annal. Biol. Tihany* **39**, 131—139.
Ponyi, J. E. (1975): The biomass of zooplankton in Lake Balaton. — *Symp. Biol. Hung.* **15**, 215—224.
Winberg, G. G. (1971): Symbols, units and conversions factors in studies of fresh water productivity. — *IBP Center Office, London*, p. 23.

A KLÓROZOTT SZÉNHIDROGÉN SZENNYEZETTSÉG GÁZKROMATOGRÁFIÁS VIZSGÁLATA A BALATON KÉT KÜLÖNBÖZŐ VÍZTERÜLETÉN

Pásztor Zsuzsa, Ponyi Jenő, Holló Attila és *Gönczy Lily*

Összefoglalás

A szerzők 1973-ban a klórozott szénhidrogén szennyezettségre vonatkozóan gázkromatográfiás módszerrel vizsgálták a Balaton két, vízminőségben eltérő vízterületét. A vizsgálati helyekről víz, fito- és Crustacea-plankton, fehér busa, *(Hypophthalmichthys molitrix)*, ponty *(Cyprinus carpio)* és süllő *(Lucioperca sandra)* került begyűjtésre. Az összes mintára vonatkozóan vizsgálták a gamma-HCH, DDT, DDE és DDD klórozott szénhidrogének mennyiségét. A gázkromatográfiás elemzések során a következőket állapították meg:

1. A tihanyi és keszthelyi víztérség gamma-HCH szennyezettsége tavasszal azonos (35 ng/lit). A Zala-folyó beömlésénél, valamint magában a folyóban ez az érték magasabb (37 és 39 ng/lit). Ősszel az összes vizsgált helyen mennyiségük lecsökkent.

2. A DDD koncentráció tavasszal a tó vizében közel azonos (1,4—1,7 ng/lit.) csupán a Zala-folyóban magasabb (3,2 ng/lit.). A DDT tavasszal a tihanyi vizeket kivéve (2,1 ng/lit.), csak nyomokban (1 ng/lit. alatt) található. Ősszel valamelyest megemelkedik és a Keszthelyi-öbölben elérte a 8,5 nannogramot literenként.

3. A Keszthelyi-öböl őszi fitoplankton mintájában a legnagyobb mennyiségben a DDT (4,086 mg/kg száraz súly) és a DDD (3,507 mg/kg száraz súly) fordult elő. Figyelembe véve az algák tényleges koncentrációját a gyűjtőhelyeken, ez 7,2 $\mu g/m^3$ planktonhoz kötött peszticidnek felel meg.

4. A Crustacea-plankton klórozott szénhidrogén tartalma különösen a nyári és az őszi minták között mutat eltérést (0,437 ill. 1,239 mg/kg szárított súly). Míg a lindán esetében 1,3—1,8-szor, addig a DDT-re vonatkozóan 16—27-szer nagyobb értékeket figyeltek meg az őszi minták javára. Figyelembevéve a Crustacea-plankton tényleges koncentrációját a gyűjtőhelyeken, ez 0,05—0,23 $\mu g/m^3$ rákplanktonhoz kötött peszticidnek felel meg.

5. A 3 nyaras fehérbusa példányokban számottevően nagyobb mennyiségekben található klórozott szénhidrogén, mint a 2 nyarasokban. A γ-HCH-ra vonatkozóan a 3 nyaras busa húsában kilencszer (0,136 mg/kg), az agyában négyszer (0,117 mg/kg több van mint a 2 nyarasban. A DDT esetében a húsban két és félszeres a különbség (0,506 mg/kg) az idősebb példányok javára.

6. A süllő és a ponty különböző szerveiben található peszticidek mennyisége (mg/kg szerv nedves súly) alacsonyabb, mint a fehér busáé. A Tihany előtti vizekből származó süllőknél a máj (0,027), ivartermék (0,013) és az agy (0,024) γ-HCH tartalma magasabb, mint a keszthelyi példányoké (0,0161; 0,007; 0,008). A ponty esetében ugyanazon szervekre vonatkozóan éppen fordítva igaz, a keszthelyi minták γ-HCH tartalma a magasabb. A DDT és bomlástermékeinek aránya a süllő és ponty esetében a két gyűjtőhelyre vonatkozóan az ivartermékben, a pontynál ezenkívül még a húsban is jelentősen eltér egymástól.