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INVESTIGATIONS OF PESTICIDE RESIDUES IN FISH AND OTHER AQUATIC ORGANISMS OF LAKE BALATON AND SOME OTHER AQUATIC HABITATS

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In all parts of the world of intense agricultural production, diverse plant protection and insecticide materials have been applied at ever increasing rates during the last 15—20 years. The initially almost limitless use and spreading of the various kinds of pesticides were extremely encouraged by the heavy demands on marketable fruits and vegetables, as well as the recognization that the application of these easily administrable synthetic organic compounds considerably increases the quantity, and enhances the quality of the yield. Measures especially successful in agriculture and forestry had at first eclipsed the already apparent damages, and thus delayed restrictions in the use of pesticides.

Later, however, indications have increasingly multiplied, especially in the United States of America, calling attention, among others, to the fact that the diverse pesticides, transmitted by precipitation or some other means into the surface or subsurface waters, will deleteriously affect their quality and might thus be highly detrimental to life. The first conspicuous effects of this damaging phenomenon manifested themselves in the high-rate mortality of fish (HYNES 1960, TARZWELL 1965a). Subsequent and recent investigations have also shown that a number of invertebrate organisms (worms, crustaceans, various aquatic insect larvae), many of them important sources of fish-food, had also perished. In these days, attention focussed on the study of the indirect effects of the pesticides, prevailing by the means of biological accumulation and transmission through the food-chain (KLEIN 1962, TARZWELL 1965b, KEITH, MOHN and ISE 1965). Instigated by these findings, world-wide projects were framed for the solution of the pesticide problem, and provisions taken endeavouring to delimit within reasonable bounds the application of these toxic agents.

In Hungary, the attention of the research workers was drawn to the problem by the extensive destruction of fish in Lake Balaton in March—June, 1965. According to estimations, the loss of fish amounted to about 50 wagons, of which about 40% was pike-perch (RIMANÓCZY 1966). With respect to the considerable rate of destruction, a host of research workers of a number of institutions initiated investigations for the clarification of its course, causes, and future effects (Fisheries Enterprise of the Balaton, National Fishery Board, National Institute of Public Health, Water Economy Scientific Research

Institute, National Animal Health Research Institute, National Agricultural Quality Inspecting Institute, National Institute for Food and Nourishment Research, Danube Research Station of the Hungarian Academy of Sciences, Biological Research Institute of the Academy of Sciences, etc.).

On the basis of investigations, and excluding other possibilities (parasitic, bacterial, virus infections, radioactive or industrial pollutions, etc.), the probable cause of the fish destruction in Lake Balaton can be ascribed to the effects of pesticides (primarily DDT and its decomposed derivatives) arrived into the lake (V. Cieleszky and A. Dénes 1965 in MS.).

Our studies aimed at obtaining information, on the basis of ample materials, on the content of pesticide residues in the more important fish species and other aquatic organisms of Lake Balaton, and to compare them with similar conditions prevailing in other waters. The publication of the research results is deemed worth-while in view of the fact that they submit information on the present situation in a field but slightly studied in Hungary until recently, and thus establish a basis of comparison for future attainments.

Material and methods

1. Collection and preparation of materials

Our research material comprised first (August—November, 1966) the fish and other organisms of Lake Balaton. After the termination of two research series, it was found necessary to analyse samples deriving from other localities, for the sake of comparison. We have thus examined the fish samples of the Danube-reach in Comitat Tolna and two fish ponds in Comitat Somogy (Somogycsicsó and Mike), as well as the bivalve shells of the stagnant reach of the Danube-branch near Győr and the Old Lake of Tata. Fish were selected immediately after their having been netted, whereas the shell and Crustacean plankton samples were collected prior to the study. The formers were gathered by hand, the latter by a large-mesh No. 6 plankton net.

Investigations extended to ten (in details to four) fish and three mollusc species. The constituent members of the Crustacean plankton had not been separated as to species. The quantitative and qualitative distribution of the organisms studied were as indicated in the Table on p. 119.

Fish were dissected by the usual methods of "kitchen technology". Liver, fats, roe and milt were segregated, in larger fish also blood, spleen, kidney and gall. Smaller fish were worked up, depending on the quantity available, in their entirety, or their inner organs indiscriminately together. Meat was invariably examined. The data of smaller fish found in the stomach of predatory fish were listed separately. Shells were cut in two by a knife, and the entire animal analyzed. Plankton was left spread on a filter paper to facilitate the evaporation of the greater part of water.

Of the organs listed above, those which made it necessary had been minced by a meat-grinder. Frozen tuna fillets, used for negative control, had been prepared similarly.

Of the separated organs (also minced if necessary) 15—20 and 50—60 grams, respectively, were weighed according to the available quantities. The entire amount of gall, spleen, kidney, and blood were worked up. Of the other

Fish	Specimen	Live weight (kg)
Lucioperca lucioperca L. (pike-perch) (+ spawn)	80	68
Esox lucius L. (pike)	50	18
Cyprinus carpio L. (carp) (+ spawn)	120	25
Abramis brama L. (bream) (+ spawn)	150	20
Pelecus cultratus L. (razor-fish) (mainly spawn)	110	4
Aspius aspius L. (balin)	10	6
Amiurus nebulosus LE SUEUR (bullhead pout)	8	1
Carassius carassius L. (crucian-carp)	5	2
Perca fluviatilis L. (perch)	11	9
Ctenopharyngodon idella VALLENCIENNES (Amur)	1	4
Total	545	157
Bivalves		
Anodonta cygnea L. (mussel)	220	30
Unio tumidus zelebori (PAREYSS) ZELEBOR (river mussel)	150	22
Unio pictorum balatonicus KÜSTER (painter's mussel)	300	15
Total	670	67
Other		
Crustacean plankton (filtered)	—	5

materials, ample quantities (200—400 g) were minced and average samples taken. The quantity of the average samples had been determined by previous experiments.

2. Technique

To determine acid- (HCH isomeres, DDT and DDE) and lye-resistant (dieldrin and aldrin) pesticide residues, two parallel samples were taken from all investigated material. The weighed samples were broken, together with some anhydrous sodium sulphate, into powder in a porcelain mortar. The sodium sulphate powder mixture was transferred into an Erlenmayer flask (ground-stoppered), and pur. n-pentane added until it covered the material 2—3 cm high.

Development continued by repeated vigorous shaking for 2 hours, and dissolution by one night. Next day, the n-pentane extraction was filtered through an anhydrous sulphate layer (4—5 cm) placed on glass-wool in a funnel; the material collected in the funnel was also washed out two or three times by 100—150 ml n-pentane. Of the combined extraction, n-pentane was evaporated down to 5—10 ml, without heating, either outdoors or in a chemical box.

The purification of the acid-resistant pesticide residues derived from fats and other accompanying substances was executed through a diatomite column mixed with vitriol. In most cases, there was no need for aceto-nitrile shaking (CIELESZKY and DÉNES 1966).

In the purification of the lye-resistant pesticide residues, the potassium hydroxide saponification of the fats were first done (O'DONNEL 1954, 1955; CUETO 1960, CIELESZKY and DÉNES 1966). Subsequent to the aceto-nitrile shaking, the pesticide residues to be determined received final purification through an activated aluminiumoxyde column (BROCKMANN).

After the chromatographic column-clearing, the substances were condensed and collected in centrifugal tubes, completely evaporated down.

The pesticide residues transferred into the centrifugal tubes were dissolved in 0.1 ml distilled p.a. ethylacetate, and their separation was executed by thin-layer chromatography. Adsorbent: aluminiumoxyde G (after STAHL), developer: pss. n-hexane.

The developing of the chromatograms was made by ABBOTT's (1964) technique.

Evaluation was made semiquantitatively with reference to standards developed along with the substances to be determined.

Since, in our investigations, extremely small quantities of materials (1—10 γ) had to be identified, the technique discussed above was repeatedly controlled. In our experience, the possibility of error is primarily inherent in the course of fluid-to-fluid distributional purifications. Whenever possible, we had therefore abandoned this form of technique. By determining the suitable dimensions of the vitriol-diatomite column, we had been able to assure and maintain the desirable effectivity of purification.

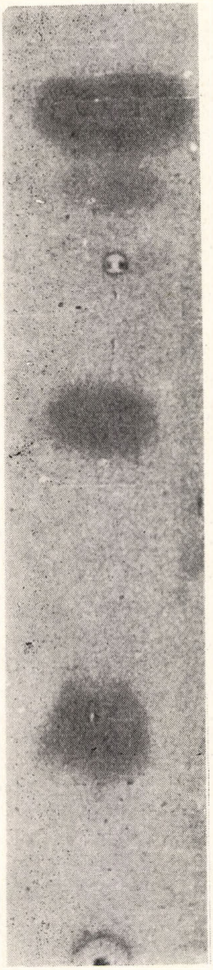
Results and conclusions

The numerical data of the results of investigations are summarized in *Tables 1—6*. Of the demonstrated residual components (α-, β-, γ-, δ-HCH; DDT; DDE, aldrin, dieldrin, and an unknown one), the greatest amounts were shown by DDT and its decomposition products, DDE, γ-HCH and an unknown component. On the basis of its Rf value, this latter somewhat resembles heptachlorine, but its chemical identification could not be made in want of a standard *(Figs. 1, 2)*. That fact also speaks against heptachlorine that, as far as we know, this substance is not used in applied technologies in Hungary. The high occurrence of DDT and its decomposing substances seems to be obvious in view of the amount of the pesticide applied (dusted) in the area of the Balaton and its drainage basin. In the Comitats Veszprém, Zala, and Somogy, for instance, about 441 metric centners of aldrin, dieldrin and DDT had been applied between 1st January, 1964 and 1st Juny, 1965, before and during the destruction of fish in Lake Balaton; of this sum, DDT amounted to 328.6 centners (compiled by DONÁSZY, in MS., on the basis of data submitted by the Agricultural Commerce Center).

The data given in the tables show considerable fluctuation. The deviation of values; beyond the subjective errors due to the semiquantitative evaluation, is to be sought for in mainly three other factors:

a) In the course of investigations, individuals belonging to the same age group within the species were not always available. As it is shown by the results *(Tables 1—6)*, this fact alone caused considerable deviations.

b) Presumably there arrived various amounts of spray-residues into the several water bodies of the Lake Balaton. This seems to be substantiated by the amounts of DDT used by the three comitats mentioned above: the quantities applied rather differ from one another (Comitat Veszprém: 51.4, Somogy: 123.6., Zala: 153.6 centners). The inference is reasonable, therefore, that the diverse organisms of fish-food received different amounts of spray-residues. Fish individuals belonging to the same species but to different populations (and areas) might thus have accumulated various amounts of pesticide residues.



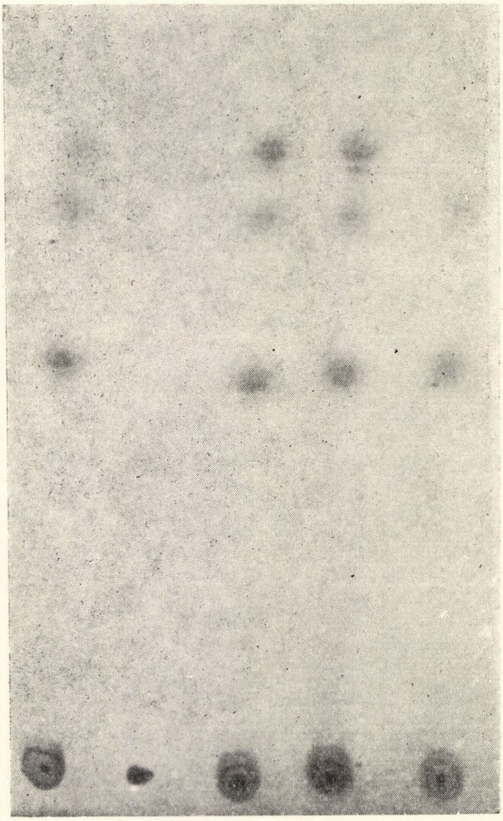


Fig. 2. a, c, d — a meat, a liver and a milt of pike perch fished fom Balaton *b* — a meat of young fish from fish pond *e* — a lever of carp from Balaton.

Fig. 1 A liver of 3 kg piked fished from Balaton

c) Insufficiency in research material with respect to fish species or organ might also have contributed to the deviation of values.

In the followings, we propose to discuss those investigated species only whose data were suitable for a statistical evaluation, too. In order to be able to point out certain differences or agreements and other connections, we have calculated the average standard error of pesticide residues found in higher quantities in fish and some other groups of organisms. These calculations may possibly have the conceptual error of commeasuring the values obtained from individuals of different age groups. In view of the fact, however, that we have aimed at an informative survey, we commit, in our opinion, a smaller mistake by this means than in describing some "extreme" individual cases.

Of the fish (pike-perch, pike, carp) originating from diverse localities, it is only the pike-perch which shows a certain amount of difference. Individuals deriving from fish ponds exhibit rather small values of, and slight fluctuations in, the components γ-HCH, DDT, DDE, and "?", but these differences

Table 6 — 6 táblázat

Mollusk and Crustacean Plankton Samples
Mollusca és crustacea plankton mintái

Period of study (month) Vizsgálat ideje (hónap)	Species investigated Vizsgált faj	Origin of sample Minta származása	Chlorined pesticide residue Klórozott pesticid maradékok (mg/kg) HCH α	β	γ	δ	DDT	?	DDE	Ald.	Dield.	Humidity content Nedvesség-tartalom, %
August	Tavi kagyló*	Balaton	0.00	0.00	0.30	0.00	0.38	0.22	0.30	0.00	0.00	
	Folyami kagyló**	Balaton	0.00	0.00	0.20	0.00	0.38	0.22	0.30	0.00	0.00	
	Festő kagyló***	Balaton	0.00	0.00	0.20	0.00	0.38	0.22	0.30	0.00	0.00	
September	Festő kagyló***	Balaton	ny	ny	0.12	ny	0.13	ny	ny	0.00	0.00	
	Tavi kagyló*	Balaton	ny	0.02	0.05	0.02	0.05	ny	ny	0.00	0.00	
	Tavi kagyló*	Győr	ny	ny	0.01	ny	0.03	0.01	ny	0.00	0.00	
	Crustacea-plankton (szűrt)	Balaton	ny	ny	0.01	ny	0.10	0.03	ny	0.00	0.00	
October	Tavi kagyló*	Tata, Öregtó	0.00	0.00	0.00	0.00	ny	0.00	0.00	0.00	0.00	
November	Tavi kagyló*	Balaton	0.00	0.00	0.07	0.00	0.07	0.00	0.00	0.00	0.00	
	Festő kagyló***	Balaton	0.00	0.00	0.03	0.00	0.08	0.00	0.00	0.00	0.00	
	Festő kagyló***	Balaton	0.00	0.00	ny	0.00	0.13	0.09	0.00	0.00	0.00	
	Folyami kagyló**	Balaton	0.00	0.00	ny	0.00	0.15	0.13	0.00	0.00	0.00	82.7
	Folyami kagyló**	Balaton	ny	ny	0.04	ny	0.11	0.11	0.00	0.00	0.00	82.7
	Crustacea plankton⁰ (szűrt)	Balaton	ny	ny	0.04	ny	0.12	0.13	0.00	0.00	0.00	
	Crustacea plankton⁰ (szűrt)	Balaton	ny	ny	0.05	ny	0.22	0.19	0.00	0.00	0.00	91.5
	Crustacea plankton⁰ (szűrt)	Balaton	ny	ny	0.05	ny	0.09	0.08	0.00	0.00	0.00	
	Planktonról leszűrt□ víz mg/l	Balaton	ny	ny	ny	ny	0.12	0.10	0.00	0.00	0.00	

* *Anodonta cygnea* = mussel
** *Unio tumidus zelebori* = river mussel
*** *Unio pictorum balatonicus* = painter's mussel
⁰ Crustacean plankton (filtered)
□ Water extracted from plankton in mg/l
ny = tr = traces-injom

are, with respect to the ± deviations, rather small as related to those originating from Lake Balaton and the Danube-reach in Comitat Tolna. More precisely, the difference lies in higher pesticide values occurring but sporadically in samples deriving from fish ponds, whereas they occur more frequently in the two latter ones. The toxicity of carps originating from diverse localities fluctuates within the same order of magnitude. The values of the pikes from Comitat Tolna and Lake Balaton also agree *(Table 7)*. These data seem to

Table 7 — 7. táblázat

Differences in pesticides, with respect to meat, liver, and roe, between fish species deriving from various localities (on the basis of *Tables I—IV)*

Különböző gyűjtőhelyekről származó halfajok közötti pesticidkülönbségek, hús, máj ikrára vonatkozóan *(I—IV. táblázatok alapján)*

Fish species Halfajok	Locality Gyűjtőhely	Pesticide residue mg/kg Pesticid-maradék mg/kg			
		γ-HCH	DDT	DDE	?
Pike-perch — süllő	Lake Balaton	0.15 ± 0.12	0.49 ± 0.18	0.44 ± 0.17	0.12 ± 0.09
In Tolna the Danube-reach	Tolnai Dunaág	0.16 ± 0.12	0.22 ± 0.11	0.12 ± 0.07	0.10 ± 0.05
Fish ponds	Halastavak	0.01 ± 0.005	0.09 ± 0.02	0.05 ± 0.025	0.00
Pike — csuka	Lake Balaton	0.37 ± 0.33	0.57 ± 0.40	0.90 ± 0.66	0.49 ± 0.23
In Tolna the Danube-reach	Tolnai-Dunaág	0.38 ± 0.22	0.40 ± 0.16	0.65 ± 0.28	0.17 ± 0.12
Bream — keszeg	Lake Balaton	0.20 ± 0.16	0.50 ± 0.03	0.34 ± 0.24	0.23 ± 0.21
Carp — ponty	Lake Balaton	0.03 ± 0.003	0.05 ± 0.03	0.03*	0.02 ± 0.02
In Tolna the Danube-reach	Tolnai-Dunaág	0.01 ± 0.006	0.07 ± 0.01	0.04 ± 0.01	0.02 ± 0.01
Fish ponds	Halastavak	0.02 ± 0.02	0.12 ± 0.06	0.09 ± 0.11	0.07 ± 0.13

* = mean of two data
* = két adat átlagértéke

corroborate the assumptions of CIELESZKY et al. (1965 in MS.), namely that there evolved an approximately identical level in fish deriving from other standing bodies of water beyond those of the Lake Balaton.

If it were examined, however, whether this level of toxicity is the same between raptorial and peaceful fish species within the same aquatic habitat, the answer would not be unequivocal. For the Balaton, the DDT level is about identical in the pike and the pike-perch (0.57 ±0.40 and 0.49 ± 0.18, respectively), whereas it is significantly different and very low in the carp (0.05 ± 0.03). It is also striking that the pesticide level of the bream falls within the order of magnitude of the raptorial species. Conditions are similar in the Danube-reach of Comitat Tolna. At the same time, there is no difference between the pike-perch and the carp deriving from fish ponds *(Table 7)*. The solution of the problem should obviously be looked for in the food-chain and the concomitant accumulation of the pesticides of the two aquatic habitats

Concerning the organs and tissues, respectively, of the fish species examined in details, spray-residues appear in the greatest quantity in fatty tissues, and least of all in meat *(Table 7)*. In the pike-perch, liver and roe show about identical levels of high toxicity, whereas in the pike this refers to the liver, followed by an essentially lower level in the roe.

The analysis of other invertebrate, aquatic organisms *(Table 6)* shows that they contain a noteworthy amount of pesticide residues, especially those inhabiting Lake Balaton. The values of the molluscs living in Lake Balaton are slightly higher than those of the Crustacean plankton.

Animal group	Pesticide residues in mg/kg			
	γ-HCH	DDT	DDE	?
Bivalve shells	0.13 ± 0.03	0.19 ± 0.04	0.11 ± 0.05	0.12 ± 0.03
Crustacean plankton	0.04 ± 0.01	0.13 ± 0.03	0.0	0.11 ± 0.03

Table 8 — *8. táblázat*
Pesticide residues found in diverse organs of some fish species
(on the basis of *Tables 1—4)*

Egyes halfajok különböző szerveiben talált pesticid-maradékok
(1—4. táblázat alapján)

Fish species halfaj	Organ szerv	Pesticide residue mg/kg pesticid maradék mg/kg			
		γ-HCH	DDT	DDE	?
Pike-perch — süllő	meat — hús	0.05 ± 0.02	0.22 ± 0.09	0.17 ± 0.07	0.08 ± 0.03
	liver — máj	0.17 ± 0.06	0.20 ± 0.15	0.32 ± 0.13	0.09 ± 0.03
	roe — ikra	0.15 ± 0.10	0.32 ± 0.13	0.14 ± 0.08	0.07 ± 0.03
	fat — zsír	0.48 ± 0.20	0.69 ± 0.37	0.81 ± 0.27	0.22 ± 0.22
Pike — csuka	meat — hús	0.12 ± 0.06	0.24 ± 0.09	0.24 ± 0.10	0.15 ± 0.11
	liver — máj	0.84 ± 0.22	0.95 ± 0.33	1.68 ± 0.66	0.76 ± 0.22
	roe — ikra	0.18 ± 0.06	0.20 ± 0.07	0.35 ± 0.11	0.09 ± 0.02
	fat — zsír	2.59 ± 0.93	1.93 ± 0.86	5.14 ± 0.97	0.96 ± 0.45
Carp — ponty	meat — hús	0.02 ± 0.01	0.08 ± 0.01	0.06 ± 0.01	0.04 ± 0.01
	liver — máj	0.02 ± 0.01	0.05 ± 0.01	0.03 ± 0.01	0.01 ± 0.01
	fat — zsír		0.20 ± 0.09	0.00	0.00
Bream — keszeg	fat — zsír	0.62 ± 0.11	0.80 ± 0.15	1.35 ± 0.53	0.63 ± 0.28

If the significance of the two groups of organisms in the life of the lake is considered, it is the plankton to which the greater importance should be ascribed (considerable biomass, important fishfood).

The results of our investigations also seem to bear out the fact that the destruction of fish in Lake Balaton was primarily caused, similarly to that of other lakes wherein even greater rates of perdition in the fish fauna had been observed (HUNT and BISHOFF 1960), by pesticide residues (primarily DDT) accumulated through the links of the food-chain. This is substantiated by the high DDT content (0.13 ± 0.03) of the Crustacean plankton, as well as the considerable pesticide content found in the stomach of the raptorial fish species and the specifically examined fish spawn *(Tables 1, 2, 4)*. Their accumulation, e.g. in the pike-perch and the perch attains the lower level of the amount toxic for the several species of fish (KLEIN 1962). It is worthwhile to enlarge on the feeding habits of the pike-perch. According to WOYNÁROVICH's (1959) investigations, the bream plays an important role in the winter feeding of the pike-perch (January—February, 33% of all ingested food). It changes to its

Table 9 — 9. táblázat

Combined occurrence (mg/kg) of DDT and its decomposition products in various fish species of Lake Balaton, in 1965 and 1966

DDT és bomlástermékeinek együttes előfordulása (mg/kg), különböző balatoni halakban 1965 és 1966-ban

Fish species — halfaj	Organ — szerv	DÉNES—CIELESZKY Jun. 1965	BARON—CSONTI—PONYI Aug.—Nov. 1966
Pike-perch — süllő	meat — hús	0.1 0.2	1.80 (Aug.) 1.01 (Sept.) 0.09 (Nov.) 0.21 (Nov.)
	liver — máj	0.4 8.4	1.40 (Aug.) 1.85 (Sept.) 0.15 (Nov.)
	inner organs — belső rész	1.1	1.3 (Aug.)
Carp — ponty	meat — hús	0.4 0.8	0.08 (Oct.) 0.13 (Nov.)
	liver — máj	0.4 0.4 0.2	0.05 (Oct.) 0.02 (Nov.)
	milt — tej	0.2	0.18 (Oct.)
Bream — keszeg	meat — hús	0.2 0.1 0.2	1.88 (Aug.) 1.07 (Sept.)
	liver — máj	0.1 0.1 0.2	0.34 (Sept.) 0.24 (Nov.)

staple diet *(Acerina)* in the spring. As was pointed out, the pesticide content of the bream is very high and thus a considerable amount of toxic material might accumulate in the pike-perch by spring. It is quite probable that, aside of other factors, also this one may effectively have contributed to the destruction of fish, commencing in the spring of 1965. In the feeding of the bream, the Crustacean plankton has a significant role (PONYI 1955, BERINKEY 1966), thus they, too, could have accumulated spray-residues.

By comparing data deriving from identical samples in 1965 and 1967 *(Table 9)*, it seems that the pesticide level of the bream had further increased, while, in the case of the pike-perch and the carp, the values received are within the order of magnitude of previous data.

Summary

The authors have determined by thin-layer chromatography the content of pesticide residues of fish originating from different bodies of water (Lake Balaton, the Danube-reach in Comitat Tolna, various fish ponds) as well as those of some other aquatic organisms.

Of the demonstrated residue components, the highest amounts are represented by DDT and its decomposition substances, DDE, γ-HCH, and an unknown factor.

Among the fish species originating from various localities, it was only the pike-perch which showed slight differences as to the quantity of spray-residues. It seems that there evolved an approximately identical level of spray-residues in fish deriving also from waters beyond those of Lake Balaton. On the other hand, there was a sharp difference found between the raptorial fish species (pike-perch, pike) and the carp of the same water area (with respect to Lake Balaton and the Danube-reach in Comitat Tolna). Fish-ponds represent an exception, insofar as corresponding and low values have been demonstrated in both the pike-perch and the carp.

Among the organs and tissues, respectively, of the several fish species, fatty tissues contain the highest amount of pesticide residues, followed by the liver — in some cases the roe — and meat.

The DDT content of the Crustacean plankton of the Lake Balaton is highly significant (0.13 mg/kg), especially in view of its role in the food-chain.

Data obtained from samples similar in composition of the years 1965 and 1967 show that the pesticide level of the bream had increased, while the values referring to the pike-perch and the carp remained within the order of magnitude of the previous data.

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PESTICID-MARADÉKOK VIZSGÁLATA A BALATON ÉS NÉHÁNY MÁS VÍZI ÉLETTÉR HALAIN, EGYÉB VÍZI SZERVEZETEIN

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Összefoglalás

Szerzők különböző vizekből (Balaton, Tolnai-Dunaág, Halastavak) származó halak és néhány egyéb vízi szervezet pesticid-maradék tartalmát határozták meg vékonyréteg kromatográfiával.

A kimutatott maradék-komponensek közül a legnagyobb mennyiségben a DDT és bomlásterméke a DDE, γ-HCH és egy ismeretlen komponens található.

A különböző gyűjtőhelyekről származó halfajok közül a permet-maradék mennyiségét illetően csak a fogas süllő mutatott kisebb fokú különbséget. Úgy látszik, hogy a balatoni halakon túlmenőleg más hazai vizekből származó halakban is megközelítőleg azonos permetmaradék-szint alakult ki. Ellenben az azonos vízterületről származó ragadozó halak (fogas, süllő, csuka) és a ponty között (Balaton és Tolnai-Dunaágra vonatkozóan) éles különbség adódott. Kivételt mutatnak a halastavak, ahol a süllőben és a pontyban egyaránt alacsony és megegyező értékeket mutattak ki.

Az egyes halfajok szervei, ill. szövetei közül a zsírszövet tartalmazza a legtöbb pesticid-maradékot, majd a máj — egyes esetben az ikra — és a hús következik.

Igen jelentős a Balaton Crustacea-plankton DDT tartalma (0,13 mg/kg), különösen akkor, ha figyelembe vesszük azok szerepét a táplálékláncban.

Az 1965. és 1967. évi azonos mintákból származó adatok azt mutatják, hogy a dévérkeszeg pesticid-szintje emelkedett, míg a fogas süllő és ponty értékek a korábbi adatok értékei körül mozognak.

АНАЛИЗ ОСТАТКА ПЕСТИЦИДОВ В РЫБАХ И ДРУГИХ ВОДНЫХ ОРГАНИЗМАХ В БАЛАТОНЕ И ИНЫХ ВОДНЫХ АРЕАЛАХ

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Посредством тонкослойной хроматографии был проведен анализ остатка пестицидов в рыбах и других водных организмах, собранных в Балатоне, Ветви Дуная у Толна и искусственных озерах.

В самом большом количестве обнаружили ДДТ и продукты его расспада, а именно γ-ДДЕ, ХЦХ и еще один точно неидентифицированный компонент.

В отношении содержания остатка яда у рыб, происходящих из разных мест обитания, незначительное отклонение обнаружилось только у судака. Примерно одинаковое количество пестицида накапливалось и у тех рыб, которые живут не в Балатоне. В отличие от этого между хищниками и карпом из одного и того же места (Балатон и ветвь Дуная) обнаруживается значительная разница. От этого отличаются искусственные рыбные озера, где содержание пестицидов и у карпа и у судака низкое.

Из органов и тканей разных рыб самое большое количество остатка пестицидов обнаруживается в жировой ткани, затем в печени и наконец в икрах и мышцах.

В планктоновых ракообразных Балатона обнаруживается значительное количество ДДТ (0,13 мг/кг), важность которого подчеркивается ролью этих организмов в питательной цепи водных животных.

Сравнивая данные, полученные при анализе образцов, собранных в 1965 и 1967 годах, выяснилось, что уровень пестицидов повышался в леще, и остался без изменения в карпе и судаке.