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MERCURY CONTAMINATION OF TISSUES AND ORGANS OF PIKE

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Abstract

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The work aimed at determining in which predatory fish tissue mercury is cumulating to the highest degree. Mercury content was investigated in particular tissues and organs of pike. Fishes bought at random in Warsaw fish wholesale company in November 2005 comprised the experimental material.

Before sampling fishes were weighed and measured. The samples of the following tissues were collected for the investigations: scale, fins, liver, spleen, swim bladder, heart, frontal and dorsal kidney, spawn or milt, eyes, gills, skin, bones, brain and intestine. Mercury content in the collected samples was determined using the analyzer of mercury traces controlled by the computer programme AMA 254.

A correlation between the level of mercury concentration and the age and body weight of fish was observed as a result of the performed investigations. The tissue which cumulates mercury to the highest degree is the muscle tissue, significant amounts of this element were also noted in the intestine and liver which proves that the main way of mercury entering the fish organism is the alimentary tract.

Key words: mercury, pike, muscles

Introduction

The degree of environmental contamination is constantly increasing, and the emitted pollutants are more and more toxic for human beings as well as plant and animal organisms. The mechanism of a toxic action of compounds on the organism is greatly differentiated depending most of all on the traits and chemical structure of a compound. Compounds

exhibiting great chemical activity exert more intense harmful action, more quickly destroy tissues and organs of the organism. Especially dangerous are mercury compounds.

An important factor which is decisive about the toxic effect of mercury on the environment is its ability for cumulating in the organism and joining the alimentary chain. Mercury released from ore, fuel or earth crust becomes very mobile. It permanently stays in the environment circulating in various forms between water, air, deposits and soil.

With the development of civilization, mercury became to be used in many technological procedures. It results is the fact, that together with sewage and wastes it started to enter the environment. Thus a quick development of investigations on the mechanisms of toxic activity of mercury took place. It was established that it is a very dangerous element both in metallic form and inorganic compounds. However, the most hazardous are organic mercury compounds such as, e.g. methylmercury. It is a compound which originates as a result of the activity of aquatic microorganisms and thus can be easily cumulated by other aquatic organisms. Especially easy mercury is cumulated in the organisms of predatory fishes, where it is bound by the protein sulphydryl groups (90% of the consumed dose is absorbed) (Banaszczyk, 2002; Budzińska-Wrzesień, 1999). This binding causes the fact that half-life lasts about 2 years which causes accumulation of that compound at the successive levels of the trophic chain.

Bioaccumulation of mercury is particularly important for human beings and animals. Man, being the last link of the alimentary chain gets the biggest dose of that harmful metal which is accumulated in various tissues and organs of the organism. Pathological signs (disturbances of sight, hearing, speech and movement coordination) appear only after many months or even years.

Due to that, it is very important to perform systematic monitoring investigations aiming at determining the mercury level in food. Especially controlled should be all products for children and pregnant women because methyl-mercury causes the appearance of various developmental anomalies.

In Poland, laboratory examinations are carried out which aim at determining the level of mercury in food products. It is necessary for protecting the consumer life (Szprengier-Juśkiewicz, 1996). Especially important is the control of predatory fishes which are the biggest source of that element in the diet (Ożóg, 2006).

The aim of the present investigation was the determination of the amount of mercury accumulated in particular tissues and organs of fishes accessible for consumers. It was also important to establish the effect of the weight of fishes on the amount of accumulated mercury.

Material and methods

The experimental material comprised samples of tissues and organs of pikes. It is a fish that because of its great palatability and low fat content is among valuable fishes, willingly fished and consumed. Fishes for the investigation (10 fishes) were bought in Warsaw fish wholesale

company. Each fish was measured and weighed. Than organs were isolated from each fish and their weight was established exact to 10 mg. Then samples from the following organs and tissues were collected: scales, fans, liver, spleen, swim bladder, heart, frontal and dorsal kidneys, spawn or milt, eyes, gills, muscles, skin, bones, brain and intestine.

The determinations were performed in the Department of Biology of Animal Environment, Warsaw University of Life Sciences according to the methodology accepted by the State Veterinary Institute in Pulawy. Mercury content was determined with the help of an automatic mercury analyzer AMA 254 by ALTEC from the Czech Republic. Samples of known weight not exceeding 300 mg were placed in the analyzer combustion boat and put into the combustion chamber. There the sample was dried and subjected to thermal decomposition at the temperature of 850–900° C. Then products of decomposition were transferred to the outlet of the combustion chamber where halides, nitrogen and sulphur oxides were caught and mercury vapors are settled on a pipe covered with gold. Here an amalgam is produced. After warming, mercury accumulated in the amalgam is transferred to measurement trays where absorption is measured.

The method consists in determining the absorption spectrum of the lamp in which cathode is made of mercury. The result is calculated on the basis of the sample weight and calibration curves and presented on the computer screen in the chosen concentration units, in this case in $mg \cdot kg^{-1}$. Sensitivity of the apparatus amounts to 0.01 $\mu g \cdot kg^{-1}$, and the measuring range 0.05–600 μg. Calibration of the apparatus was done with the help of solution of the polygraphically pure mercury in 2% HNO_3.

Results and discussion

The mercury level in the investigated pikes varies. The highest concentration of this element amounted to 0.3040 mg in pike No. 3. A significant amount of mercury was observed in pike No. 7, amounting to 0.1917 mg. In the remaining pikes the content of mercury did not exceed the level 0.15 mg (Fig. 1).

While comparing the content of mercury in particular tissues and organs of the investigated fishes, it was noted that the highest mercury level occurred in the muscles (Fig. 2). The mean content of mercury in muscles amounts to 0.1021 mg. High mercury level is also observed in pike bones and also in the liver and intestines, however, it is much lower than in the muscles. In bones the mercury concentration is 13 fold lower, in the liver about 60 fold and 100 fold in the intestines as compared to the muscles. Brain is the organ with the least mercury content.

As it results from the investigations muscles are tissue that cumulates mercury to the highest level (87%) as compared to the remaining organs and tissues (Fig. 3). Bones take the second place as far as the accumulation of this element is concerned although in that case it is much lower amounting to 7%. A clearly lower level of mercury is observed in the intestines (2%) and in the liver (1%). Other tissues together cumulate about 3% of that element.

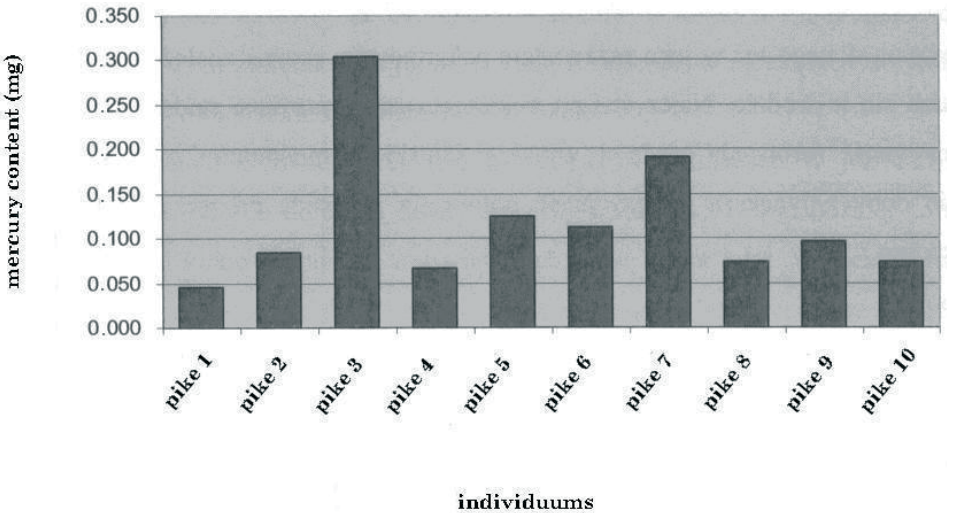

Fig. 1. Mercury content in the investigated fishes.

The cause of such mercury distribution in particular organs and tissues is their weight. While comparing the weight of a tissue or an organ and the level of their mercury content it can be stated that the amount of the cumulated element is directly proportional to the tissue or organ weight (Fig. 4).

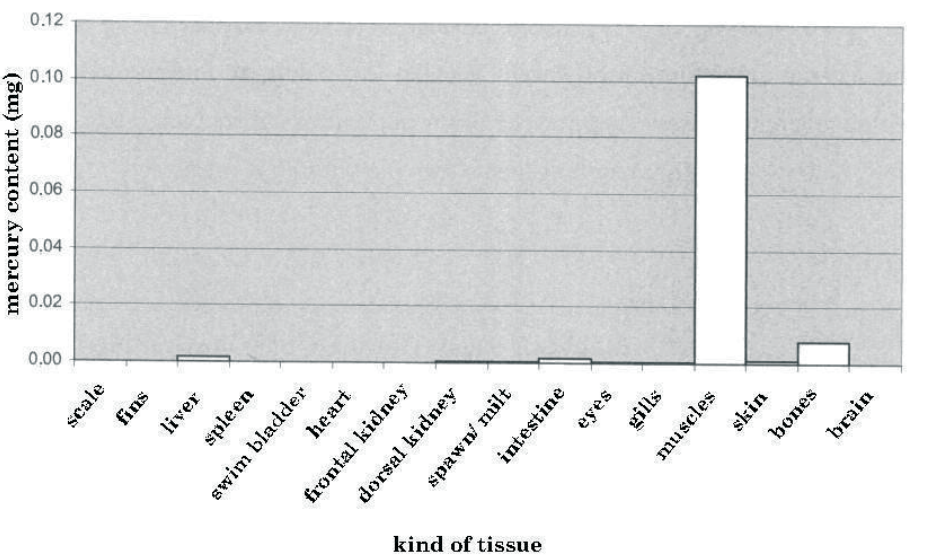

Fig. 2. Mean mercury content in the tissues and organs of pikes.

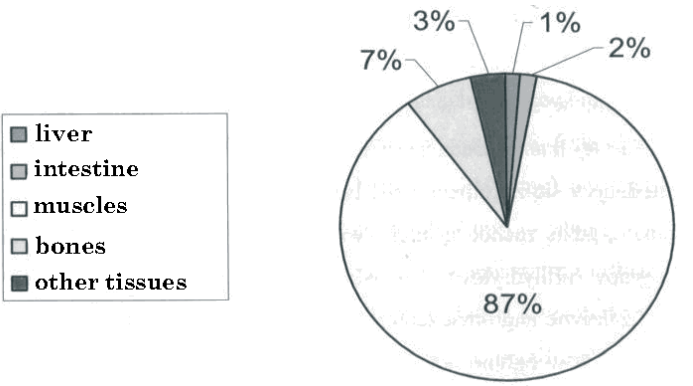

Fig. 3. The share of tissues in the total mercury content.

Muscles are the tissue which has the highest weight in the fish organism (Fig. 4) and thus they have the much higher mercury concentration amounting to 0.1436 $mg \cdot kg^{-1}$ (Fig. 5) than other tissues and organs. Such a high mercury accumulation in muscles results from the presence of great amounts of sulphur amino-acids whose sulphydryl groups easily and permanently bind mercury.

A comparison of the weight of particular organs and tissues shows that a significant weight in the fish organism is taken up by bones. It causes the accumulation of a high amount of mercury in that tissue, despite the fact that that the concentration of this element in bones is low amounting only to 0.2972 $mg \cdot kg^{-1}$ (Fig. 5).

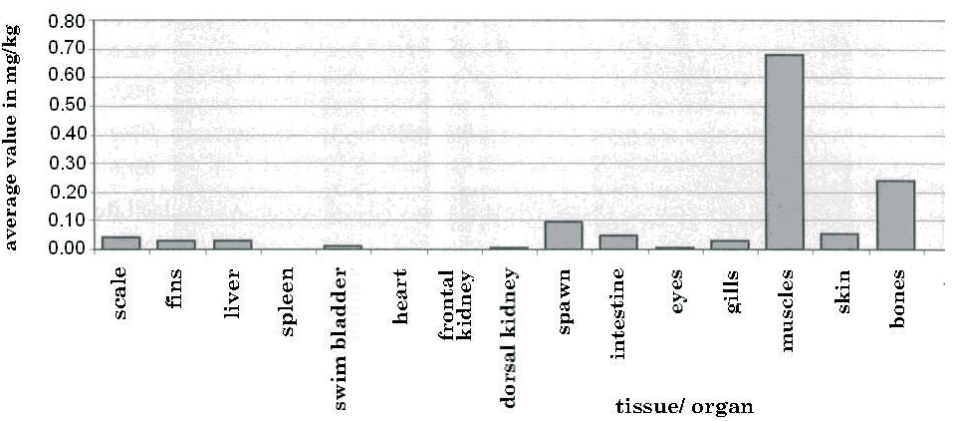

Fig. 4. Weight of tissues and organs of the investigated fishes.

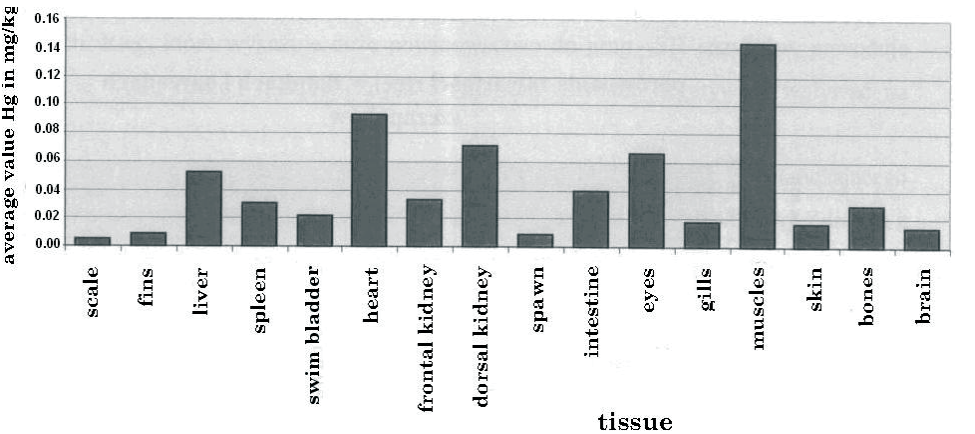

Fig. 5. Mercury concentration in the tissues and organs of pikes.

It results from the analysis of mercury concentration in particular organs that apart from muscles, the highest level of this element occurs in the hearth (Fig. 5). It points to a high affinity of mercury to that organ. It is connected with mercury binding with the –SH groups of proteins which are present in the heart muscle. Apart from that, the heart is an organ in which intensive metabolic processes take place with the participation of enzymes containing sulphydryl groups. On the other hand, the participation of the heart in the total accumulation of that metal in the fish organism is small which results from its low weight. In the investigated pikes the weight of heart was about 0.0016 kg.

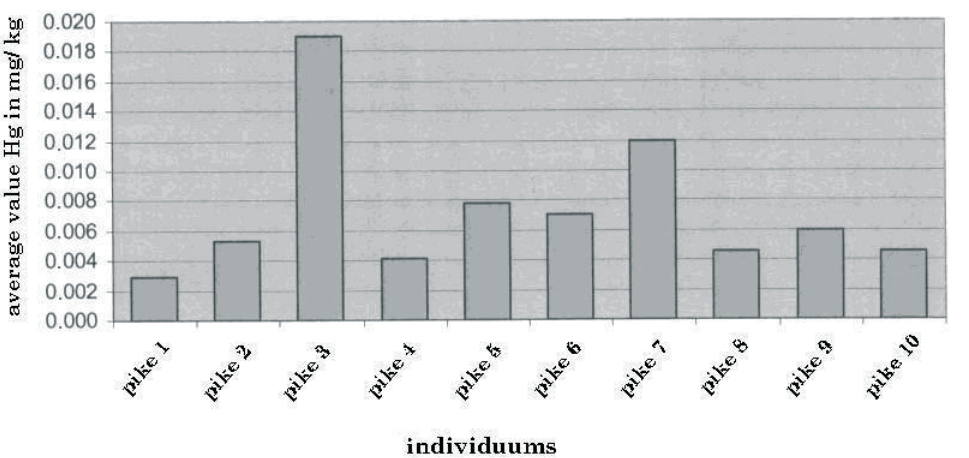

Fig. 6. The comparison of mercury content in the tissues and organs of the investigated fishes.

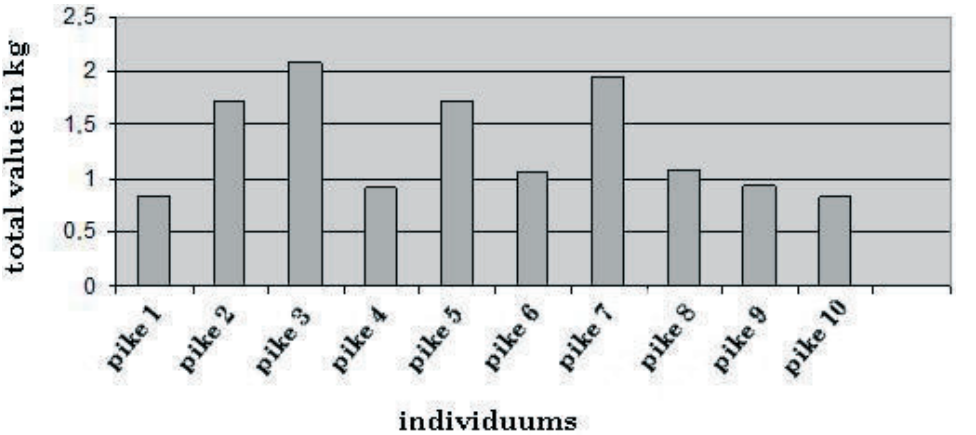

Fig. 7. The comparison of body weight of the investigated fishes.

It also results from Fig. 5 that a high concentration of mercury is observed in the dorsal kidney and eyes as well as in the liver, intestine and frontal kidney. However, it should be stressed that the share of those organs in the total accumulation of mercury is small due to their slight weight. A high concentration of mercury in the fish eyes (0.0657 $mg \cdot kg^{-1}$) may be connected with their direct contact with water contaminated with heavy metals. Mercury present in the environment passes into the sight organ and binds with proteins comprising its structures.

The investigations confirmed that mercury concentration in the tissues and thus the amount of that element cumulated in them and in the whole fish depends on its weight. The greatest mercury concentration recalculated per tissue (0.0190 mg) was noted in the pike No.3 which had the highest weight (2.074 kg) (Fig. 7). On the other hand the least amount of that element (0.0029 mg) was found in the fish of the lowest weight (0.832 kg) – fish No.1 (Fig. 7). The biggest fish, the probably older it is, and thus it longer stayed in the contaminated environment which could result with a bigger mercury accumulation in its organs and tissues.

The so far obtained results allow for a statement that the main way of mercury entering the organism of predatory fish is the alimentary tract. Intestine, apart from the muscles and bones, is the organ which cumulates mercury to a highest degree. Apart from that, some significant amounts of this element occurs in the liver which confirms the part of the alimentary tract in the process of mercury absorption by the fish organism. High mercury concentration is also noted in the dorsal kidney (0.0708 $mg \cdot kg^{-1}$). Correlations between mercury concentrations in the muscles and in the liver and kidney are positive. It points to the fact that mercury absorbed from the alimentary tract is uptaken in the liver which plays the role of a detoxicative filter. Then mercury goes to the kidneys and finally to the muscles.

It results from the calculated coefficients of mercury content in particular tissues and organs that there are correlations between some of them. Significantly correlated in respect to the amount of the investigated element are muscles and scales. Here the correlation coefficient amounts to 0.7038. Even stronger dependence occurs between such tissues as muscles and spawn/milt where the correlation coefficient is 0.9291. It may suggest the appearance of significant amounts of mercury in the reproductory cells of greatly contaminated fishes. It may negatively affect fish reproduction.

In none of the investigated pikes the mercury level exceeded the accepted sanitary standards which were established by the Ministry of Health order from 13 January 2003 at the level of 1 $mg \cdot kg^{-1}$.

Conclusion

The obtained results allow for the following conclusions:

1. Mercury distribution in the investigated tissues and organs of pikes is not even.
2. Muscles are the tissue which cumulates mercury to the greatest degree.
3. Mercury content in fish tissues is strongly connected with the fish body weight and age. Older fishes with bigger body weight are more contaminated with mercury than the young ones.
4. Alimentary tract is the main source of mercury contamination of predatory fishes which is confirmed by: the increased mercury content in the intestine and the liver as compared to other organs and positive correlations of these contents with muscles.
5. The degree of mercury contamination of the investigated fishes is slight and does not exceed the accepted standards.

Translated by the authors

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