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BIOACCUMULATION OF CADMIUM IN SOME ORGANS OF CARP, *Cyprinus carpio* L., IN CASE OF PER OS ADMINISTRATION

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A b s t r a c t. Studies on cadmium bioaccumulation in carp internal organs showed that cadmium ingestion resulted in an increase of Cd content most of all in the organs taking part in the processes of absorption and excretion. The increase was not proportional to cadmium doses. Fish muscles had the lowest ability to accumulate cadmium and there was no definite trend of the observed changes.

Key words: CADMIUM, ACCUMULATION, CARP

INTRODUCTION

Freshwater as well as marine organisms are able to accumulate heavy metals in the amounts considerably exceeding those found in the environment. These microelements are uptaken directly from water or are ingested with food (Ferard et al. 1983, Kumada et al. 1972).

Earlier studies showed that there was a relationship between cadmium content in fish and water, as well as that when this element was uptaken directly from water its distribution in particular carp organs followed a definite pattern (Protasowicki and Chodyniecki 1988).

The objective of this study was to determine the relationship between cadmium doses administered orally and cadmium levels in the fish organs.

MATERIALS AND METHODS

Studies were performed on 39 carps (*Cyprinus carpio* L.) weighing 50-135 g ($\bar{x} \pm s_x = 87 \pm 22$ g), of total length from 15.5 to 19.5 cm (17.3 ± 1.0 cm).

The fish were acclimated for two weeks and then divided into 3 groups, 12 fish in each group. They were placed in glass aquaria of 80 dm^{-3} each. Three fish represented an initial sample. Fish in group 1 and 2 were given $Cd(NO_3)_2$ orally, during a 28-day experiment, at the doses of 4 and 40 µg Cd/fish respectively. Cadmium was administered in gelatine pills, every day with the exception of Saturday and Sunday. Control group was given pills with no cadmium. 200 mg pills were made using 20% gellatine solution stained with cochineal red in amount

4 mg/dm^{-3}. Pellets were fed to the fish throughout the experiment, at a rate of 3% of body weight. Cadmium content in the pellets amounted to 0.343 μg.g^{-1}. Water temperature in the aquaria ranged between 20 and 21°C, average pH was about 8. The aquaria were areated all the time to maintain oxygen levels at 8-9.76 mg $O_2 \cdot$ dm^{-3}. Water was changed every day.

Fish were collected on the first day (initial sample), and on 7th, 14th, 21st and 28th day of the experiment. They were tightly packed in polyethylene bags, frozen, and stored until the analysis. Samples of muscles, hepatopancreas, kidneys, spleen, gills, skin, digestive tract and spine bones were collected from partly thawed fish and analysed to determine bioaccumulation of cadmium. Samples were digested in a 4:1 mixture of HNO_3 and $HClO_4$ according to the method described elsewhere (8). All determinations were made with the method of flame absorption atomic spectrometry, in Varian Techtron A 1200 apparatus. Cadmium content was calculated using a callibration curve, with attention given to the parallel blind sample.

RESULTS

Initial cadmium content was different in particular fish organs. Low cadmium levels were found in musles, skin, heart, spleen and gills; they were within the range 0.045-0.093 μg.g^{-1} wet weight. Higher levels of 0.202-0.400 μg.g^{-1} were found in liver, bones, digestive tract and kidneys. Cadmium content in carp organs changed during the experiment (Fig. 1). With the exception of a few cases, changes were observed in all fish groups, in the control group as well.

Range and time of these changes depended on the dose. Maximal absolute increase of cadmium content took place mostly in the fish given 40 μg/fish daily. Intoxication with cadmium did not change the pattern of its distribution in particular fish organs. Only spleen accumulated more cadmium, so that it moved to the group of organs with the highest cadmium content.

Average cadmium content in the fish muscles did not exceed 0.100 μg.g^{-1} in all groups. Changes in cadmium content in the muscles showed no definite trend.

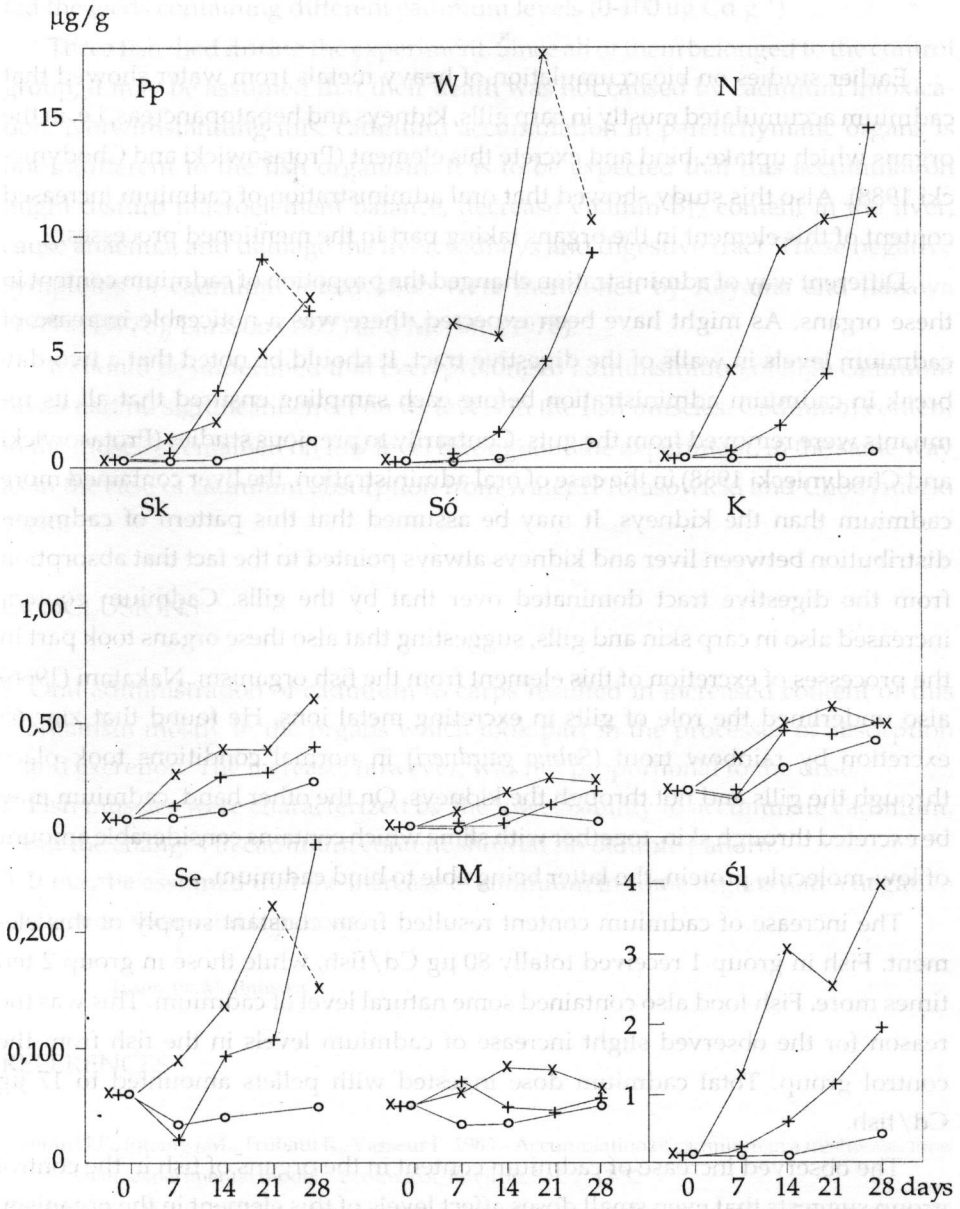

Fig. 1. Changes of cadmium content (μg^{-1} wet weight) in selected carp (*Cyprinus carpio*) organs at different daily doses administered orally. o - control sample, + - daily dose 4 µg, x - daily dose 40 µg, Pp - digestive tract, W - hepatopancreas, N - kidneys, Sk - gills, Só - skin, K - vertebrae, Se - heart, M - muscles, Śl - spleen (points in the figure represent mean values for 3 fish)

DISCUSSION

Earlier studies on bioaccumulation of heavy metals from water showed that cadmium accumulated mostly in carp gills, kidneys and hepatopancreas, i.e. in the organs which uptake, bind and excrete this element (Protasowicki and Chodyniecki 1988). Also this study showed that oral administration of cadmium increased content of this element in the organs taking part in the mentioned processes.

Different way of administration changed the propotion of cadmium content in these organs. As might have been expected, there was a noticeable increase of cadmium levels in walls of the digestive tract. It should be noted that a two-day break in cadmium administration before each sampling ensured that all its remnants were removed from the guts. Contrarily to previous studies (Protasowicki and Chodyniecki 1988) in the case of oral administration, the liver contained more cadmium than the kidneys. It may be assumed that this pattern of cadmium distribution between liver and kidneys always pointed to the fact that absorption from the digestive tract dominated over that by the gills. Cadmium content increased also in carp skin and gills, suggesting that also these organs took part in the processes of excretion of this element from the fish organism. Nakatani (1966) also underlined the role of gills in excreting metal ions. He found that zinc-65 excretion by rainbow trout (*Salmo gairdneri*) in normal conditions took place through the gills and not through the kidneys. On the other hand, cadmium may be excreted through skin, together with slime which contains considerable amount of low-molecule protein, the latter being able to bind cadmium.

The increase of cadmium content resulted from constant supply of this element. Fish in group 1 received totally 80 µg Cd/fish, while those in group 2 ten times more. Fish food also contained some natural level of cadmium. This was the reason for the observed slight increase of cadmium levels in the fish from the control group. Total cadmium dose ingested with pellets amounted to 17 µg Cd/fish.

The observed increase of cadmium content in the organs of fish in the control group suggests that even small doses affect levels of this element in the organism. However, it should be noted that increased bioaccumulation of cadmium in the fish organs did not depend lineary on the dose. This result is in agreement with the findings by Ferard et al. (1983) who observed similar phenomenon in the studies on cadmium bioaccumulation in *Leucaspius delineatus*. These authors used for 4 days natural food containing 260 and 560 $\mu gCd.g^{-1}$. Also Kumada et al. (1972) observed curvilinear increase of cadmium content in rainbow trout (*S. gairdneri*)

fed the feeds containing different cadmium levels (0-100 μg $Cd.g^{-1}$).

Three fish died during the experiment. Since all of them belonged to the control group, it may be assumed that their death was not caused by cadmium intoxication. Notwithstanding this, cadmium accumulation in parenchymatic organs is not indifferent to the fish organism. It is to be expected that this accumulation might disturb macroelement balance, decrease vitamin B_{12} content in the liver, cause anaemia, and damage the liver, kidneys and digestive tract. These negative symptoms of cadmium intoxication were mentioned by Koyama and Itazawa (1977a, 1977b), Larsson (1977) and Merlini (1978).

It should be underlined that even prolonged administration,of high cadmium doses had no significant effect on its levels in the fish muscles. Cadmium content in the muscles remained on low level throughout the experiment, in the same way as in the case of cadmium absorption from water (Protasowicki and Chodyniecki 1988).

CONCLUSIONS

1. Oral administration of cadmium to carps resulted in increased content of this organism mostly in the organs which took part in the processes of absorption and excretion. The increase, however, was not proportional to the dose.
2. Fish muscles were characterized by the lowest ability to accumulate cadmium, but the changes in cadmium content showed no definite pattern.
3. It may be assumed that the increase of cadmium in some organs had a negative effect on their vital functions.

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STRESZCZENIE

BIOAKUMULACJA KADMU W WYBRANYCH NARZĄDACH KARPIA - Cyprinus carpio L. PRZY POBRANIU PER OS

Badano bioakumulację kadmu z przewodu pokarmowego. Rybom o masie od 50 do 135 g ($\bar{x} \pm S_x$ - 87 ± 22 g) podzielonym na dwie grupy, podawano kadm w ilości 4 i 40 µg na osobnika dziennie. Równolegle prowadzono próbę kontrolną. W czasie 28-dniowego doświadczenia wszystkie ryby karmiono granulatem w ilości około 3% w stosunku do masy ciała. Naturalna zawartość Cd w paszy wynosiła 0,343 $\mu g.g^{-1}$. Ryby do badań pobierano na początku doświadczenia, a następnie co 7 dni. Oznaczenia kadmu wykonano metodą płomieniowej AAS po spaleniu prób na mokro w mieszaninie HNO_3:$HClO_4$.

Badano dynamikę zmian poziomu kadmu w przewodzie pokarmowym, wątrobotrzustce, nerkach, skrzelach, skórze, sercu, śledzionie, kościach kręgosłupa i mięśniach. Wykazano, że znaczny wzrost zawartości kadmu następował w narządach związanych z procesami wchłaniania i wydalania. Głównie miało to miejsce w przewodzie pokarmowym, wątrobotrzustce i nerkach. Obserwowany wzrost nie był jednak proporcjonalny do dawki podanej karpiom. Stwierdzono, że mięśnie wykazywały najmniejszą zdolność kumulacji kadmu, przy równoczesnym braku jakiegokolwiek trendu zmian. Autorzy przypuszczają, że znaczny wzrost zawartości kadmu w niektórych narządach mógł upośledzić ich funkcje życiowe.

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