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# THE DYNAMICS OF CADMIUM AND NICKEL ACCUMULATION IN COMMON CARP *CYPRINUS CARPIO* L.*

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Abstract

The aim of the study was to assess the dynamics of cadmium and nickel accumulation in the carp, *Cyprinius carpio* L., during the rapid growth period between 3rd and 6th month of life, including seasonal changes.

Chemical assays were performed on samples of gills, anterior and mid-posterior part of the alimentary tract, liver, kidneys, skin and muscles. Prior to the assay, 1-g tissue samples were digested with 3 ml of concentrated $HNO_3$ in a CEM MDS 2000 microwave oven. The samples prepared this way were assayed for Cd and Ni. Cadmium level was determined with flameless graphite furnace atomic absorption spectrometry (GF-AAS) in a ZL 4110 Perkin Elmer. Nickel was determined inductively coupling plasma atomic emission spectrometry (ICP-AES) in a JY-24 Jobin Yvon apparatus.

The results indicated that in the period of growth between 3rd and 6th month of life, cadmium and nickel concentrations in the examined carps fluctuated. Average cadmium content in examined organs ranged between $0.053 \div 0.004$ μg $g^{-1}$ wet weight. Average nickel content in examined organs ranged between $0.326 \div 0.023$ μg $g^{-1}$ wet weight. The observed fluctuations are supposed to be a result of intensive growth and accompanying accumulation of metals from water.

Key words: fish, *Cyprinus carpio* L., cadmium, nickel.

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**ZMIANY W KUMULACJI KADMU I NIKLU W ORGANIZMACH KARPI *CYPRINUS CARPIO* L.**

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Abstrakt

Oceniano dynamikę kumulacji kadmu i niklu w różnych narządach i tkankach karpi *(Cyprinus carpio* L.) w okresie intensywnego ich wzrostu, czyli między 3. a 6. miesiącem życia.

Badania przeprowadzono na 240 karpiach hodowanych w wodach pochłodniczych. Z każdej ryby do analiz chemicznych pobierano próbki: nerek, wątroby, przewodu pokarmowego, listków skrzelowych, mięśni grzbietowych i skóry. Próbki narządów o masie 1 g zmineralizowano na mokro, w obecności 3 $cm^3$ $HNO_3$, w piecu mikrofalowym CEM MDS 2000. Kadm oznaczono metodą bezpłomieniowej absorpcyjnej spektrometrii atomowej GF-AAS, nikiel z użyciem emisyjnej spektrometrii atomowej w plazmie indukcyjnie sprzężonej (ICP-AES).

Stwierdzono, że u przebadanych karpi między 3. a 6. miesiącem życia wystąpiły wahania zawartości Cd i Ni. Średnie zawartości kadmu w badanych narządach wynosiły 0.053 ÷ ÷ 0.004 µg $g^{-1}$ mokrej masy, natomiast średnie zawartości niklu – 0.326 ÷ 0.023 µg $g^{-1}$ mokrej masy. Zaobserwowane niewielkie zmiany poziomu kadmu i niklu są wynikiem intensywnego wzrostu karpi i towarzyszącej temu kumulacji metali ze środowiska wodnego.

Słowa kluczowe: ryby, *Cyprinus carpio* L., kadm, nikiel.

# INTRODUCTION

Harmful metals, such as cadmium, nickel, zinc, lead, cobalt and copper, are introduced to the environment as a result of various human activities. The elements cause ecosystems pollution, influencing the natural environment and inhabiting organisms. Heavy metal pollution of aquatic environment adversely affects ontogeny of both plants and animals (JEZIERSKA, WITESKA 2001). Many factors influence the concentrations of metals in fish bodies, like: species, age, body weight and length, sex, season or fishing ground (LIANG et al. 2000, 2004). All those factors simultaneously contribute to maintaining the fish's proper physiological condition. An increase of cadmium concentration above the permitted level and an excess or deficiency of nickel may cause serious disturbances of biochemical processes and internal homeostasis.

The aim of the study was to assess and compare the degree of cadmium and nickel accumulation in organs and tissues of common carp *Cyprinus carpio* L. during the period of intensive growth, including seasonal differences.

## MATERIALS AND METHODS

The study involved a total of 240 carp Cyprinus carpio L. individuals. The carp were 4 and 5 month-old. The fish had been reared at the research station of the Agricultural University of Szczecin, situated in the vicinity of the Dolna Odra Power Plant at Nowe Czarnowo. The carp were reared in the power plant's cooling water discharge at temperatures 20 ÷ 24°C. When in culture, the fish were fed an Aller Aqua pelleted feed containing 37% protein and 12% fat. The fish individual weight and length ranged within 118.3 – 138.7 g and 18.2 – – 20.2 cm, respectively. The carp were reared in the power plant's cooling water discharge canal. The daily feed ration was 3.4 ± 0.2 g/fish. Chemical assays were performed on samples of the liver, alimentary tract, kidneys, gill lamellae, skin, and dorsal muscles, collected from each individual. When dissecting the fish, anatomopathological observations of the organs and tissues were recorded. The samples were frozen and kept at –2°C until analysed.

Tissue samples, weighing 1 g each, were subjected to wet digestion with 3 ml concentrated $HNO_3$ in a CEM MDS 2000 microwave oven. The solution obtained was quantitatively transferred to polyethylene vials and brought to 30 g with deionised water. The samples obtained this way were analysed for content of cadmium, iron, nickel, zinc, copper, and magnesium.

Cadmium was assayed with flameless atomic absorption spectrometry (GF-AAS) in a ZL 4110 Perkin Elmer apparatus. A content of nickel was determined with inductively coupled plasma – atomic emission spectrometry (ICP-AES) in a JY-24 Jobin Yvon apparatus. Content of individual elements are reported in μg $g^{-1}$ wet weight (μg $g^{-1}$ w.w.).

The data obtained were subjected to statistical treatment involving analysis of variance (ANOVA) at significance levels of $p \leq 0.05$ and $p \leq 0.01$; the analysis was conducted using the Statistica 6.0 software.

## RESULTS AND DISCUSSION

Fish living in natural environment are constantly exposed to harmful chemicals including cadmium and nickel. Metals can penetrate into fish bodies through alimentary tract, skin and gills, being absorbed directly from water or from food (Protasowicki 1991, Sreedevi et al. 1992).

The average cadmium concentrations in the examined organs ranged from 0.004 to 0.053 μg $g^{-1}$ wet weight. The highest concentration of cadmium was observed in the liver, mid-posterior part of alimentary tract and gills, while the lowest concentration was found in the muscles (Table 1). Cadmium levels in examined carps in spring and autumn were very similar. statistically significant dif-

ferences between cadmium concentrations were found only in the liver and mid-posterior part of alimentary tract (Figure 1). Similar observations were made by PROTASOWICKI (1991), BRUCKA-JASTRZĘBSKA, PROTASOWICKI (2004a) and MARKIEWICZ et al. (1998) in their studies on cadmium accumulation.

The average nickel concentrations in the examined organs varied between 0.023 and 0.326 μg $g^{-1}$ wet weight. The highest nickel level was found in the kidney and liver, and the lowest in the anterior part of alimentary tract (Table 1). No statistically significant differences between spring and autumn in nickel concentrations in carp organs were observed. Nickel concentrations in examined carps were very similar in both seasons (Figure 2). This is in agreement with observations made in other studies on nickel accumulation by SOBECKA (1998) and BRUCKA-JASTRZĘBSKA, PROTASOWICKI (2004b).

Table 1
Tabela 1

Cadmium and nickel content in the organs of carps bred in cooling water
Zawartości kadmu i niklu w tkankach i narządach karpi z wód pochłodniczych

| Examined organ<br>Badany narząd | | Cd and Ni content (μg·$g^{-1}$ w.w.)<br>Zawartość Cd i Ni (μg·$g^{-1}$ m.m.) | | |
|---|---|---|---|---|
| | | $\bar{x}$±SD | min | max |
| Liver<br>Wątroba | Cd<br>Ni | 0.053±0.007<br>0.243±0.042 | 0.041<br>0.165 | 0.067<br>0.363 |
| Entire alimentary tract<br>Cały przewód pokarmowy | Cd<br>Ni | 0.030±0.004<br>0.032±0.006 | 0.026<br>0.020 | 0.035<br>0.045 |
| Anterior part of alimentary tract<br>Przednia część przewodu pok. | Cd<br>Ni | 0.019±0.003<br>0.023±0.004 | 0.014<br>0.017 | 0.031<br>0.035 |
| Mid-posterior part of alimentary tract<br>Środkowokońcowa część przewodu pok. | Cd<br>Ni | 0.040±0.009<br>0.041±0.009 | 0.026<br>0.023 | 0.035<br>0.056 |
| Kidney<br>Nerki | Cd<br>Ni | 0.031±0.006<br>0.326±0.030 | 0.021<br>0.219 | 0.046<br>0.370 |
| Gills<br>Skrzela | Cd<br>Ni | 0.039±0.006<br>0.175±0.020 | 0.025<br>0.138 | 0.053<br>0.219 |
| Skin<br>Skóra | Cd<br>Ni | 0.022±0.003<br>0.042±0.007 | 0.018<br>0.029 | 0.028<br>0.068 |
| Muscles<br>Mięśnie | Cd<br>Ni | 0.004±0.001<br>0.031±0.008 | 0.002<br>0.003 | 0.006<br>0.054 |

* w.w. – wet weight, $\bar{x}$ – mean, SD – standard deviation
* m.m. – mokra masa, $\bar{x}$ – średnia, SD – odchylenie standardowe

Trace concentrations of cadmium and nickel, found in intensively growing carps, are supposed to be a result of cooling water pollution caused by precipitation, sewage and waste dump drainage waters. The observed fluctuations of cadmium and nickel levels in examined organs and tissues were caused by the intensive growth of carps, accumulation of metals from water and elimination of metals

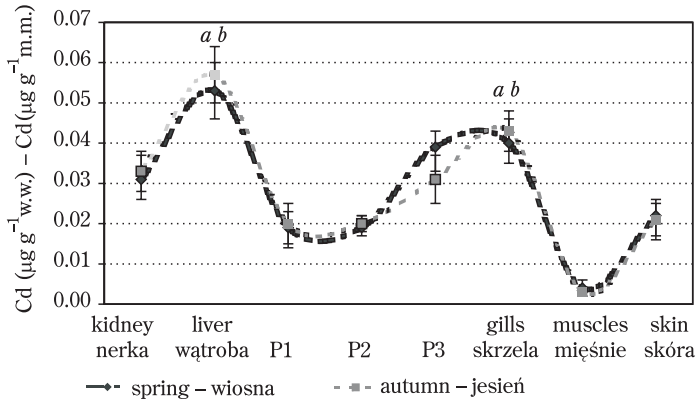


Fig. 1. Comparison between cadmium levels in organs of carp in spring and autumn: P1 – entire alimentary tract, P2 – anterior part of alimentary tract, P3 – mid-posterior part of alimentary tract, w.w. – wet weight, *a* – statistical significance of differences (spring – autumn) $p<0.05$, *b* – statistical significance of differences (spring – autumn) $p<0.01$

Rys. 1. Porównanie poziomu kadmu w narządach karpi z uwzględnieniem zmian sezonowych: P1 – cały przewód pokarmowy, P2 – przednia część przewodu pokarmowego, P3- środkowokońcowa część przewodu pokarmowego, m.m. – mokra masa, *a* – różnice statystycznie istotne między badanymi próbami z uwzględnieniem zmian sezonowych (wiosna – jesień) $p<0.05$, *b* – różnice statystycznie istotne z uwzględnieniem zmian sezonowych (wiosna – jesień) $p<0.01$

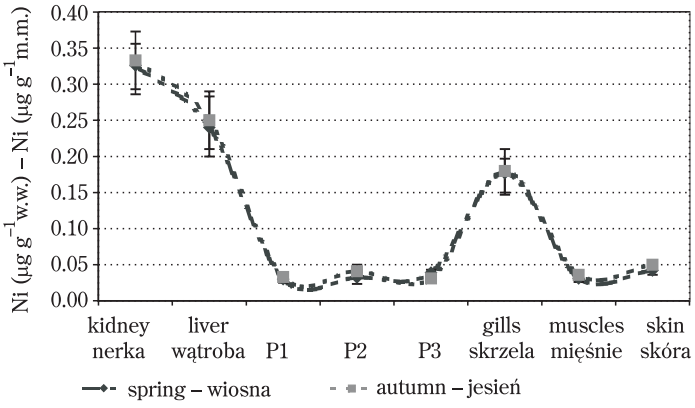


Fig. 2. Comparison between nickel levels in organs of carp in spring and autumn. Explanations see Fig. 1

Rys. 2. Porównanie poziomu niklu w narządach karpi z uwzględnieniem zmian sezonowych. Objaśnienia patrz rys. 1

from carp bodies to water. The elimination process enables maintaining the concentrations of harmful substances in fish bodies at the level safe for ontogeny and health.

Cooling waters, discharged from power plants, are often used for the cyprinids and the salmonids breeding, as they have nearly constant temperature all the year round. Such an activity have been conducted for many years in a channel collecting cooling waters from the Dolna Odra Power Plant in West Pomeranian Voivodeship. The cooling waters contain trace concentrations of toxic substances, including cadmium and nickel, although the concentrations are within limits (*Rozporządzenie...* 1991, *Raport WIOŚ* 2003, JEZIERSKA, WITESKA 2001, KNÖCHEL et al. 2002). In none of the rivers of West Pomeranian Voivodeship heavy metal concentrations exceed limits (PROTASOWICKI, CHODYNIECKI 1988, *Raport WIOŚ* 2003).

Data on concentrations of heavy metals and bio-elements in carps at various ontogeny stages are available in references (DOBRZAŃSKI et al. 1996, KOŁACZ et al. 1996, MOORE, RAMAMOOTHY 1984, VIRK, KAUR 1999). In contrast, analogous data referring to carps bred in cooling waters are still lacking.

## CONCLUSIONS

1. Average cadmium concentrations in the examined organs ranged from 0.004 to 0.053 μg $g^{-1}$ wet weight. The highest cadmium concentration was observed in the liver, mid-posterior part of alimentary tract and gills, while the lowest concentration was found in the muscles.

2. Average nickel concentrations in the examined organs varied between 0.023 and 0.326 μg $g^{-1}$ wet weight. The highest nickel level was found in the kidney and liver, and the lowest in the anterior part of alimentary tract.

3. Cadmium and nickel concentrations in the examined carps were within limits.

4. Cadmium concentrations in the liver and mid-posterior part of alimentary tract statistically significantly differed between spring and autumn. Nickel concentrations in the examined carps were very similar in both seasons.

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