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Cadmium bioaccumulation in kidneys of freshwater fishes from Kardzhali and Studen kladenets dams

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Human interference upon or within water ecosystems has negative effect upon the quality of the water and brings considerable contamination which in turn damages the aquatic animals and organisms in general.

The present study has the aim to investigate the accumulation level of the heavy metal cadmium in the kidneys of the freshwater fishes from river Arda belonging dams.

The cadmium levels within tissue kidney samples from fishes common rudd (Scardinius erythrophthalmus), common bleak (Alburnus alburnus) and European perch (Perca fluviatilis) have been monitored by atomabsorpbing and spectrophotometric methods.

Increased levels of the cadmium in kidney tissue samples have been estimated which are upper than the acceptable limits in foods. Scardinius erythrophthalmus from Studen Kladnets dam and Perca fluviatilis from Kardzhali dam have the highest contamination indexes. This may be due to the fact that these fish species are highly adaptive and resistant against the changes and influences of the environmental sources even if they are severe and deadly.

A process of biomagnification of cadmium level has been accrued into fishes from Kardzhali dam compared to the ones in Studen Kladenets dam where biomagnification index (BMI) is above a unit.

Key words: kidney, fishes, accumulation, heavy metals

Introduction

Cadmium is consider as one of the most toxic heavy metals. Over recent decades, its content has considerably increased in areas affected by the refuse of a number of industrial enterprises.

The cadmium content in the water environment leads to its accumulation in the tissues and organs of various kinds of animals along the food chain [1]. As early as 1975, Ribelin and Migaki establish the fact of cadmium's causing the histopathological changes occurring on the kidney nephrons; later that was confirmed by other investigators [6]. In research done on the European bass (*Dicentrarchus labrax*) when heavily poisoned by cadmium showed the basic spots of toxicity are the lamellas of the gills and the kidney tubules, and in the case of subchronic poisoning, mainly the kidneys and the liver get affected [7]. When sublethal concentrations of cadmium are administered to rainbow trout (*Salmo gairdneri*) chiefly the parenchyma tissue is affected and acute toxicity is caused [3].

The kidney is a basic organ with a hematopoietic function and in it the differentiation of all blood cells takes place [12]. In the case of chronic intoxication with heavy metals over the acceptable concentration limits, destructive alterations may be occur in the parenchyma organs of fishes and also anemia and exhaustion [10, 11].

Proceeding from these data, the aim of this research has been to trace the content of the heavy metal cadmium in the kidneys of three kinds of freshwater fish inhabiting the valley of the Arda River. The task was set to establish the bioaccumulation coefficient (BC) and the biomagnification index (BMI).

Materials and methods

The tests were done in the area of the Arda River, including stations in the two water basins – the Kardzhali and Studen Kladenets dams.

The chemical analysis for cadmium content in the water of the Kardzhali and Studen Kladenets dams was done using the method of flame atom-absorbent spectrophotometry air-acetylene (2100-2300° C) with a Perkin Elmer 3030 B apparatus. As test animals, three kinds of freshwater fish were used: common bleak (*Alburnus alburnus L.*), common rudd *(Scardinius erythrophtalmus L.)* and European perch (*Perca fluviatilis L.*), inhabiting the Kardzhali and Studen Kladenets dams.

The cadmium content in the organ samples of the freshwater fish investigated was determined via the method of atom-absorbent spectrophotometry (AAS „PERKIN-ELMER 3030 B") at the CLGE of the Bulgarian Academy of Sciences. The results were calculated in of air-dry sample and conform to the Regulation of Acceptable Concentration Limits (ACL) on the content of harmful chemical substances in foodstuffs [14, 15, 16].

The three kinds of fish belong to different trophic levels in the food chain, which enables one to trace the process of biomagnification by determining the biomagnification index (BMI) as set forth by Amiard and Amiard-Triquet, 1977. BMI boils down to a process of bioaccumulation on the higher tiers of the food-chain pyramid and is arrived at through the formula:

BMI = concentration of the metal at the trophic level X/ concentration of the metal at the trophic level X-1

The degree of bioaccumulation was determined via the bioaccumulation coefficient (BC) and arrived at through a formula representing the ratio of cadmium content in the organism to the cadmium content of water [9].

Results and discussion

The quantitative data established of cadmium content in the water of the Kardzhali and Studen Kladenets dams are shown in the enclosed tab. 1.

The data of cadmium content in the water of both dams indicate that the metal's content has not increased, its values being below ACL.

The research results of the cadmium content in the fish kidneys from the Kardzhali and Studen Kladenets dams are shown in tab. 2.

The analysis and dynamics of cadmium content in the kidneys of the three kinds of freshwater fishes from the Kardzhali and Studen Kladenets dams reveal data whose values are above ACL. As regards the hygienic norms for freshwater fish, the research at the Kardzhali Dam indicates that the metal's bioaccumulation in the kidneys of common bleak is 42.42 times over the norm, the number for rudd being 50.64, and the one for perch 81.2. Comparing the cadmium content in the kidneys of, respectively, common bleak, rudd, and perch, the metal's content is highest in the kidneys of perch, followed by rudd and common bleak.

As regards the hygienic norms for freshwater fish, the research at the Studen Kladenets dam indicates that the metal's bioaccumulation in the kidneys of common bleak is 255.58 times over the norm, the number for rudd being 120.34, and the one for perch 118.9. Comparing the cadmium content in the kidneys of, respectively, common bleak, rudd, and perch, the metal's content is highest in the kidneys of rudd, followed by common bleak and perch (Tab. 2). The accumulation of cadmium in the organism of fish may lead to concentrations causing morphological changes in the kidneys.

The high affinity of organs with parenchymal structure towards cadmium is confirmed by other authors. It is consider that cadmium and copper are mainly accumulated in the liver and the kidneys [2, 4]. That may be explained by the individual adaptive stability of the fish species organism.

As regards the trophic level, the perch is considered as an unpretentious predator [13]. It feeds on small fishes and invertebrate, displacing, in some basins, most kinds of valuable fish. Its economic value is but insignificant while it is chiefly the object of sport fishing practice. The perch survives in waters poor of oxygen, too, where many other fishes would perish.

The rudd carry out a sedentary way of life. Young fish feed on plankton, and the adult ones on insects, larvae, small worms etc [13]. As regards the trophic level, the rudd is deemed a benthophage. Probably due to its sedentary way of life, in the Studen Kladenets dam rudd's kidneys high values of cadmium have been found.

Despite it being a plankton-eating species, the cadmium content in the kidneys of the common bleak is above ACL. Compared to ACL, the values of cadmium in the kidneys of the three fish species are above the acceptable concentration limits in both dams.

The results of analysis show that BMI for the Studen Kladenets dam is below 1. BMI for the Kardzhali dam is above value 1, for which reason we can point out that as regards cadmium there is a clearly defined process of biomagnification in the organism of the predatory species perch which is on a higher level in the food-chain pyramid (Tab. 3).

The bioaccumulation coefficient (BC) was calculated based on the average cadmium content in the three kinds of fish under research. According to the value of the bioaccumulation coefficient, the water inhabitants are defined as macroconcentrators ($BC > 2$), microconcentrators ($BC = 1$ to 2), and deconcentrators ($BC < 2$) [9]. The results of the bioaccumulation coefficient show that all three kinds of fish under research have a proven bioaccumulative capability and may be defined as macroconcentrators of cadmium (Tab. 4).

Of particular negative importance from the point of view of cadmium's ecological/toxicological influence is its accumulation on all levels of the food chains in those ecosystems, which creates a health hazard for humans, too.

It must be pointed out that that research serves as a basis for bio-monitoring and help towards improving the quality of waters in dams, the development of commercial fishing and fishing as a sport as well as for improving the safety of people using fish for consumption. When viewed as bio-monitoring, determining of the content and distribution of specific contaminants of an anthropogenic origin, as heavy metals in animal organisms, is a significant stage of the overall evaluation of the ecological state of the environment they inhabit [8].

T a b l e 1. Average content of cadmium (mg/l) in the water of the dams Kardzhali and Studen Kladenets

№	Place of taking sample	ACL	Cadmium content
1.	the Kardzhali Dam	0.01	0.0003
2.	the Studen Kladenets Dam	0.02	0.0157

T a b l e 2. Cadmium content (mg/kg) in the kidneys of common bleak, rudd, and perch from the Kardzhali and Studen Kladenets dams

№	Kind of fish	ACL	Place of taking sample	
			the Kardzhali Dam	the Studen Kladenets Dam
1.	*Scardinius erythrophtalmus*	0.05	2.121	12.779
2.	*Alburnus alburnus*	0.05	2.532	6.017
3.	*Perca fluviatilis*	0.05	4.060	5.945

T a b l e 3. Biomagnification index (BMI) distributed among *Perca fluviatilis, Alburnus alburnus,* and *Scardinius erythrophtalmus*

Biomagnification index (BMI)	Kardzhali dam	Studen Kladenets dam
BMI_1 *Perca fluviatilis / Alburnus alburnus*	1.603	0.988
BMI_2 *Perca fluviatilis / Scardinius erythrophtalmus*	1.914	0.465

T a b l e 4. Bioaccumulation coefficient (BC) of cadmium of *Scardinius erythrophtalmus, Alburnus alburnus,* and *Perca fluviatilis*

Kind of fish	Bioaccumulation coefficient	
	Kardzhali dam	Studen Kladenets dam
Scardinius erythrophtalmus	7070	813.949
Alburnus alburnus	8440	383.248
Perca fluviatilis	13533.333	378.662

Conclusions

1. The water values of the cadmium in Kardzhali and Studen Kladenets dams are below ACL.
2. Cadmium is accumulated in the kidneys of the investigated fishes and values are higher than ACL.
3. The cadmium bioaccumulation manifests a species-wise differentiation in the kidneys of the different investigated fishes and it is highest in perch from the Kardzhali dam and rudd from the Studen Kladenets dam.
4. The cadmium biomagnification is above value 1 in the kidneys of the three investigated fishes from the Kardzhali dam.
5. Cadmium BC above value 2 has been proved for the investigated rudd, common bleak and perch fishes, which qualifies them as macroconcentrators for this heavy metal.

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