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ACCUMULATION OF HEAVY METALS IN THE SOFT TISSUES AND SHELLS OF *DREISSENA POLYMORPHA* (PALLAS) IN LAKE PEIPSI-PIHKVA

Abstract. Using the method of atomic adsorption spectrophotometry, the content of cadmium, copper, zinc, lead, and iron in soft tissues and shells of the fresh-water bivalve mollusk *Dreissena polymorpha* (Pallas) in Lake Peipsi-Pihkva has been determined. It has been found that the content of heavy metals in soft tissues exceeds that in shells 1.5 to 2 times. In the order of increasing content heavy metals form the following row: cadmium, copper, zinc, lead, and iron. The animals collected at river mouths, especially on peaty or silted bottoms, accumulate more heavy metals than those collected on rocky or sandy bottoms. It is concluded that human impact is not the same in different areas of Lake Peipsi.

Key words: heavy metals monitoring, atomic adsorption spectrophotometry, *Dreissena polymorpha* (Pallas).

Introduction

The constantly increasing human impact on the hydrosphere leads to higher and higher contents of toxic materials in aquatic ecosystems (Морозов et al., 1984; Никаноров et al., 1985; Salánki, Salama, 1987; Thomas, 1988; Брагинский et al., 1989). The especially high "metallic pressure" on water bodies makes it necessary to monitor heavy metals in aquatic animals involved in complex biological food chains. At earlier stages of contamination of fresh-water ecosystems with heavy metals, animals appear to be more sensitive than plants. The life span of animals is longer, and they constantly accumulate pollutants (Fischer, 1986). The fresh-water bivalve mollusk *Dreissena*, which is so wide-spread in L. Peipsi that it covers more than half of its bottom area (V. Timm, 1990), seems to be a suitable object for such monitoring. Large biomass of dreissenas, their attached position, and involvement in food chains make our goal — estimation of the content of heavy metals in the soft tissues and shells of dreissenas, still more important.

Material and Methods

The material originates from Lake Peipsi-Pihkva (L. Pskovsko-Chudskoye) situated on the border of Estonia and Russia. The lake consists of three separate basins: the northern and the largest is L. Peipsi (L. Chudskoye), the southern is L. Pihkva (L. Pskovskoye), and the connecting strait is called L. Lämmijärv (L. Tyoploye). Below L. Peipsi is used to designate the whole system.

The mollusks were collected in June 1987 during an expedition on RV *Prometheus* belonging to the University of Tartu, Estonia. Adult specimens with the shell length of 20—25 mm were collected on 13 stations at different depths (3—9 m) and from different bottoms (rocky, sandy, silted, clayey, and peaty). A bottom drag with the sampling area of 225 cm² was used for the collection of the material.

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Table 1

The content of heavy metals in soft tissues of dreissenas in L. Peipsi

Part of the lake	Site of collection	Type of bottom sediments	Content of metals, μg per g dry weight				
			cadmium	copper	zinc	lead	iron
Peipsi s. s.	1. Mustvee	Rocks	1.9±0.2	8.9±1.2	20.1±2.8	9.3±1.4	156.0±16.2
	2. Vasknarva	Rocks	2.4±0.4	11.7±1.3	19.8±2.0	6.7±0.9	190.1±19.7
	3. Piirissaar Island	Silted sand	2.9±0.6	26.2±2.9	32.0±2.9	7.0±0.8	214.9±22.6
	4. Mustvee	Silted clay	2.2±0.3	19.2±2.5	22.2±2.7	20.0±3.2	182.5±20.4
	5. Gdov	Silted clay	4.3±0.6	31.3±2.9	39.7±4.9	57.5±7.4	397.3±26.5
	6. Piirissaar Island	Silt	3.5±0.7	29.5±2.7	39.3±4.0	27.7±4.0	201.1±18.8
	7. Mouth of River Emajõgi	Peat	7.6±0.9	31.6±2.9	49.1±5.3	85.7±18.8	246.5±28.7
Lämmijärv	8. Northern area	Silted clay	1.6±0.2	12.7±1.6	33.6±3.6	33.3±5.1	146.9±12.1
	9. Southern area	Silted clay	2.9±0.4	25.6±2.4	63.0±5.0	41.1±4.7	221.4±23.5
Pihkva	10. Northeastern area	Fine-grained sand	2.1±0.3	15.0±1.7	19.4±2.3	70.0±13.6	91.7±5.4
	11. Mouth of River Velikaya	Silted sand	5.6±0.8	29.8±1.9	39.4±3.6	42.9±7.3	469.3±24.5
	12. Northern area	Silt	3.3±0.4	22.3±2.4	24.8±2.9	25.6±4.4	186.4±14.7
	13. Southeastern area	Silt	3.9±0.5	27.1±2.1	51.5±5.9	67.5±11.2	180.5±19.9

Table 2

The content of heavy metals in shells of dreissenas in L. Peipsi

Part of the lake	Site of collection	Type of bottom sediments	Content of metals, μg per g dry weight				
			cadmium	copper	zinc	lead	iron
Peipsi s. s.	1. Mustvee	Rocks	0.17±0.02	3.8±0.7	9.0±1.1	5.8±0.8	61.3±9.1
	2. Vasknarva	Rocks	0.21±0.02	2.9±0.6	6.2±0.8	6.1±0.7	78.6±9.2
	3. Piirissaar Island	Silted sand	0.30±0.06	7.2±1.1	8.4±0.7	7.0±1.0	107.7±12.9
	4. Mustvee	Silted clay	0.28±0.08	5.1±0.7	11.4±1.3	12.4±1.9	80.0±14.8
	5. Gdov	Silted clay	0.48±0.08	9.2±1.2	12.2±1.5	36.0±5.2	105.5±11.3
	6. Piirissaar Island	Silt	0.39±0.08	8.1±1.2	10.7±1.2	15.5±2.9	95.2±9.8
	7. Mouth of River Emajõgi	Peat	0.69±0.12	10.7±0.9	13.8±1.1	53.5±4.2	141.2±9.9
Lämmijärv	8. Northern area	Silted clay	0.19±0.02	3.1±0.4	5.9±0.8	17.3±2.2	51.4±3.9
	9. Southern area	Silted clay	0.61±0.05	8.0±0.9	9.3±1.2	28.9±4.1	91.3±5.1
Pihkva	10. Northeastern area	Fine-grained sand	0.33±0.08	4.8±0.5	10.1±2.8	57.2±8.2	56.6±7.0
	11. Mouth of River Velikaya	Silted sand	0.41±0.03	8.1±0.9	18.2±4.3	49.1±7.6	96.5±7.2
	12. Northern area	Silt	0.40±0.08	5.4±0.7	13.5±2.9	26.1±4.7	87.2±5.9
	13. Southeastern area	Silt	0.49±0.06	7.2±0.9	15.6±4.8	62.3±9.1	107.1±19.1

Table 3

Content of heavy metals in shells of dreissenas from different geographical zones

Water body	Content of metals, µg per g dry weight					Authors
	cadmium	copper	zinc	lead	iron	
1. L. Peipsi s. s.	0.17—0.69	2.9—10.7	6.8—13.8	6.1—53.5	61.3—141.2	Our own data
2. L. Lämmijärv	0.19—0.61	3.1—8.0	5.9—9.3	17.3—28.9	5.4—91.3	"
3. L. Pihkva	0.33—0.49	4.8—8.1	10.1—18.2	26.1—52.2	56.6—107.1	"
4. Dnieper-Donbas Canal	2.8—5.1	3.0—6.8	9.5—19.4	—	116.0—911.0	Khomik and Kharchenko (Хомик, Харченко, 1989)
5. Less contaminated water bodies in wilderness areas of southern Central Russia	—	21.3—70.4	28.5—90.6	3.4—18.7	530.0—1350.0	Nikanorov et al. (Никаноров et al., 1985)

The level of pollution in the lake was estimated by the content of heavy metals in soft tissues and shells of mollusks. The contents of cadmium, copper, zinc, lead, and iron were determined by the method of atomic adsorption spectrophotometry on AAS-3 ("Zeiss").

The shell surface was cleaned, washed and dried, then the shells were ground in a tephlon mortar and weighed. A sample of 0.5 g was dissolved in 5 ml of concentrated hydrochloric and nitric acid mixture (3:1). Soft tissues separated from the shells were dried at 105 °C for 24 h, weighed, reduced to constant weight, homogenized, and subjected to mineralization with concentrated nitric acid (5 ml per 0.5 g tissue weight). In 24 h the solutions obtained were vaporized to the state of wet salts on a sand bath, dissolved in 10 ml of deionized water, filtered through a dense filter (blue tape), and used for analysis on AAS-3.

At each of the 13 stations 5 samples were taken, each sample containing 1—3 specimens. The results of analysis were averaged and the standard error of mean was determined.

Results and Discussion

The content of heavy metals in soft tissues and shells of dreissenas is given in Tables 1 and 2. As Table 1 shows, soft tissues accumulate heavy metals quite actively. Iron ranks first in the series of the chemical elements examined. Its content in tissues varies more than five-fold depending on the site of collection, ranging from 92 to 469 μg per g tissue dry weight. Lead comes second. Its content in tissues varied 14-fold: from 7 to 86 μg per g tissue dry weight. Next come zinc and copper; their content varied 3—4 times: zinc 19 to 63, and copper 9 to 32 μg per g tissue dry weight. Cadmium content in soft tissues of mollusks collected at all sites was the lowest in the row. It varied five-fold and was from 1.6 to 7.6 μg per g. Thus, the variation was the highest in lead, which showed a 14-fold variation, and the lowest in zinc in which the variation was 3.3-fold.

The distribution of heavy metals in the shells of dreissenas was similar. As seen from Table 2, the first in the row is iron, and the last is cadmium. Zinc, lead, and copper are in between. The variation of their content in shells decreased from lead to zinc and iron. However, the content of heavy metals in shells was lower than in soft tissues. This difference was the highest for cadmium. Its content in shells was a whole order lower than in soft tissues. As to other metals, this difference was 2—3-fold.

Thus, in L. Peipsi the accumulation of heavy metals by soft tissues of dreissenas is more intensive than by shells; this may be due to their different rates of metabolism. In shells the metabolic processes are slower, and they do not accumulate heavy metals so rapidly as soft tissues (Fischer, 1986).

Also, the higher content of metals in soft tissues may testify to high current level of contamination in the lake, whereas high content of metals in shells would be indicative of long-term contamination processes (Морозов et al., 1984; Никаноров, Жулидов, 1986; Havlik, Marking, 1987; Кавун et al., 1989).

The level and type of contamination of lakes are usually judged by bottom sediments regarded as "memory" of human impact (Нахшина, 1985; Жулидов et al., 1980). When comparing the types of bottom sediments in the sites of collection it becomes evident that in animals inhabiting peaty or silted bottoms the content of heavy metals in soft tissues and shells of mollusks is higher than in those from sandy or rocky bottoms (Tables 1 and 2). These differences are typical both of biometals constantly present in the animal organism, and metals not participating in enzymatic processes, which are only indicative of human impact, such as cadmium and lead. An increase in the content of such metals is more often observed close to the mouths of rivers (Emajõgi, Velikaya, Gdovka) carrying into the lake municipal and industrial wastes and chemicals from fields. A strict relation between the type of bottom sediments and the content of heavy metals in the body of mollusks has been repeatedly reported in literature (Коновалов, Коренева, 1986; Никаноров et al., 1985). Besides, it should be pointed out that in the areas with higher content of organic matter the populations of mollusks are larger. As a consequence, heavy metals released from dead animals are also involved into the process (Чернышева, 1988; Хомик, Харченко, 1989).

Apparently, for constant monitoring of anthropogenic pollution of water bodies it wold be better to use areas with lower content of organic matter in the water to exclude the additional effects which cause elevated accumulation of heavy metals in animal organisms.

It was of interest to compare the data obtained on L. Peipsi with those obtained for the same species of mollusks and applying the same methods, but on water bodies from other geographical zones with different thermal regimes. As can be seen from Table 3, the copper and zinc contents in the shells of mollusks from L. Peipsi and the Dnieper-Donbas Canal were practically the same, whereas the contents of cadmium and iron were lower in the mollusks from L. Peipsi. In the mollusks collected in less contaminated wilderness areas in southern Central Russia (Никаноров et al., 1985), the contents of copper, zinc, and iron were much higher than in those from L. Peipsi. However, the content of lead, which is more characteristic of anthropogenic contamination, was 2—3 times lower than in L. Peipsi. The higher lead content in the dreissenas of L. Peipsi is in agreement with its content in the bottom sediments. Three-year studies of its content in the lake have revealed its gradual increase throughout this period (Lepane et al., 1990).

The higher content of some heavy metals in the shells of mollusks from southern areas with relatively lower human impact might be explained by the effect of higher temperature on the metabolic processes. This, in turn, can be accompanied by increased accumulation of metals taking an active part in enzymatic processes (Vicente at al., 1988; Цельмович, Гапеева, 1989). Thus, under equal human impact in southern and northern ecosystems, the animals would accumulate heavy metals more rapidly in the former, and, therefore, the toxic effect would be more significant there than in the north.

Thus, it can be concluded that L. Peipsi is under certain human pressure. This is evidenced, first, by the higher content of heavy metals in soft tissues of mollusks than in their shells; and secondly, higher content of cadmium and lead in soft tissues of animals from L. Peipsi as compared with those from ecologically pure wilderness areas. The human pressure is stronger at river mouths and on bottoms rich in organic matter. L. Pihkva which is the most eutrophic in the system, is in need of stricter pollution control.

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