Chemistry for Sustainable Development **16** (2008) 419–423

Metals in Tissues and Organs of the Baikal Seal

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(Received August 29, 2006; revised May 15, 2008)

Abstract

The content of metals (Fe, Mn, Cu, Zn, Cd, Co, Cr, and Ni) in the liver, kidneys and muscles of the Baikal seals *Phoca (Pusa) Sibirica* Gmel has been studied for the animals caught in the autumn of 2002–2003 in the Chivyrkuy gulf and in the spring of 2004 within the area of the Proval gulf of the Baikal Lake. The data obtained were processed using a multivariational method of main components. It is established that the heavy metal contamination level of the lake water area is low, the level of heavy metals in the ecosystem is comparable with the background one inherent in non- polluted areas of the World Ocean.

Key words: the Baikal seal, metals, multicomponent analysis, bioindicator

INTRODUCTION

Chemical contamination of the environment plays an important role in the biological circulation; therefore the biomonitoring of the natural environment quality assumes nowadays a special significance. In this connection the first and foremost interest is represented by heavy metals since they take an active part in the biochemical cycle suppressing the processes of metabolism in superfluous amounts [1].

The toxicity of metals is mainly determined by their ability to form complex compounds in organisms and to take part in the oxidation-reduction reactions resulting in changing the valency of a metal. As the result of these processes in the tissues of hydrobionts the functioning of biologically active substances is impaired, the capability of microelements to overcome biological barriers increases. Besides, there are other phenomena manifested worsening the viability of hydrobionts. It is just this property of heavy metals that has determined the need for the organization of global service for monitoring the level of heavy metal content in the natural media of the Earth's biosphere [2, 3].

The Baikal seal represents the major object of the biomonitoring carried out at the Baikal Lake since this animal serves as a closing member in the trophic chain of an aquatic basin.

The information concerning content of metals in the organs and tissues of the Baikal seal is of a great scientific and practical significance in connection with organizing the complex monitoring of the ecological condition of the reservoir [4]. The present work is aimed at the investigation of metal content in the organs and tissues of the Baikal seal as a bioindicator of the Baikal Lake ecosystem.

EXPERIMENTAL

As the subject of inquiry we have chosen the organs and tissues (kidneys, liver, and muscles) of the Baikal seal *Phoca (Pusa) Sibirica* Gmel. The sampling was carried out in 2002 from 30 adult individuals (8 males and 22 females), in 2003 from 15 animals (10 adult individuals and 5 embryos), in 2004 from 10 cubs (5 females and 5 males). The place for catching the animals was chosen at the Chivyrkuy gulf and the area of the Proval gulf of the Baikal Lake. The age of adult animals varied within the range from 1 year old to 23 years old, for cubs being from 1.5 to 2 months. The organs and tissues were kept at the temperature of −30 °C.

TABLE 1

Content of metals in organs and tissues of the Baikal seal, μg/g ± σ

Organ	Mn	Cu	Pb	Zn	Cd	Co	Fe	Ni	Cr
Adult individuals (males) – 2002									
Muscles (n = 7)	0.18±0.42	1.30±0.69	0.002±0.005	23±5	0.56±1.43	0.02±0.02	208±38	0.02±0.04	0.09±0.01
Liver (n = 4)	0.73±0.85	2.31±1.58	0.01±0.02	23±5	2.49±4.93	0.03±0.04	186±116	0	0.09±0.04
Kidneys (n = 5)	0.37±0.28	2.78±0.55	0.34±0.80	14±4	0.54±0.41	0.04±0.04	107±24	0.07±0.09	0.06±0.06
Adult individuals (females) – 2002									
Muscles (n = 17)	0.19±0.27	1.47±0.87	0.03±0.05	23±6	0.02±0.04	0.02±0.03	244±100	0.02±0.04	0.10±0.03
Liver (n = 11)	1.38±0.86	3.42±1.35	0	25±10	0.19±0.12	0.02±0.03	209±101	0	0.13±0.06
Kidneys (n = 10)	0.50±0.41	2.70±0.63	0.01±0.01	17±7	1.87±2.78	0.05±0.05	182±89	0.01±0.03	0.11±0.05
Adult individuals – 2003									
Liver (n = 10)	0.88±0.13	3.46±1.40	0.17±0.14	12±2	0.06±0.05	0.07±0.03	93±30	0.02±0.02	0.01±0.01
Kidneys (n = 7)	0.47±0.17	2.47±0.82	1.49±1.08	9±3	1.22±0.89	0.07±0.05	72±17	0.07±0.05	0.04±0.03
Embryos – 2003									
Muscles (n = 5)	0.39±0.27	0.58±0.13	0.43±0.10	12±4	0.03±0.01	0.03±0.05	14±3	0.01±0.02	0.07±0.02
Liver (n = 5)	0.28±0.04	7.38±1.34	2.15±1.21	34±9	0.03±0.02	0.04±0.06	141±37	0.06±0.07	0.05±0.01
Kidneys (n = 5)	0.21±0.11	2.16±0.12	1.31±0.89	32±18	0.04±0.02	0.26±0.13	38±7	0.01±0.01	0.11±0.05
Cubs (males) – 2004									
Muscles (n = 1)	0.09	0.94	0.13	18	0	0.01	32	0.11	–
Liver (n = 5)	0.93±0.45	1.76±0.57	0.30±0.12	40±24	0.001±0.002	0.01±0.01	354±259	0.07±0.05	0.02±0.01
Kidneys (n = 4)	0.36±0.05	3.18±0.53	0.16±0.03	24±13	0	0.02±0.01	37±13	0.07± 0.05	0.002±0.002
Cubs (females) – 2004									
Muscles (n = 2)	0.09±0.001	0.88±0.04	0.18±0.09	18±2	0	0.01±0.01	48±2	0.08±0.02	0
Liver (n = 5)	0.91±0.35	2.02±0.70	0.23±0.06	46±42	0.01±0.01	0.01±0.01	282±256	0.07±0.02	0.02±0.02
Kidneys (n = 5)	0.36±0.04	3.46±0.50	0.26±0.27	20±9	0.003±0.003	0.01±0.01	52±28	0.09±0.03	0.003±0.004

Note. σ is the standard deviation.

The preparation of samples for the estimation of the metal content (Fe, Mn, Cu, Zn, Cd, Pb, Co, Cr, and Ni) was carried out using the technique described in [5].

The determination of the concentration of metals in the samples was carried out using an atomic absorption spectrophotometry method with the help of an AAS Solaar M6 device. The data obtained (Table 1) were processed using a multivariation method of main components (PC analysis) basing on a Sirius 7.0 software package [6]. This method of the statistical analysis allows one to integrate the information with respect to all the objects and parameters and to construct a PC plot on its basis.

RESULTS AND DISCUSSION

Basing on the analysis of the data obtained it is established that the content of metals in liver and kidneys of the Baikal seal is higher as compared to their content in the muscular tissue (Fig. 1). This is in a good agreement with the data from the literature [7] being connected with the fact that the organs those play an important role in the processes of secretion, excretion and deposition in the organisms of hydrobionts (liver, kidneys) are characterized by an increased content of metals. In turn, kidneys and a liver differ from each other in the accumulation level of metals, too.

As far as the level of metal accumulation is concerned, the tissues and organs could be presented by the following series: muscles < kidneys < liver.

According to the level of metal accumulation in the tissues and organs of the Baikal seal the metals could be ranged in the following order: muscular tissue – Fe > Zn > Cu > Mn > Cd > Cr > Pb ≅ Co ≅ Ni; liver – Fe > Zn > Cu > Mn > Cr > Pb > Cd ≅ Co ≅ Ni; kidneys – Fe > Zn > Cu > Mn > Pb ≅ Cd > Cr > Co ≅ Ni.

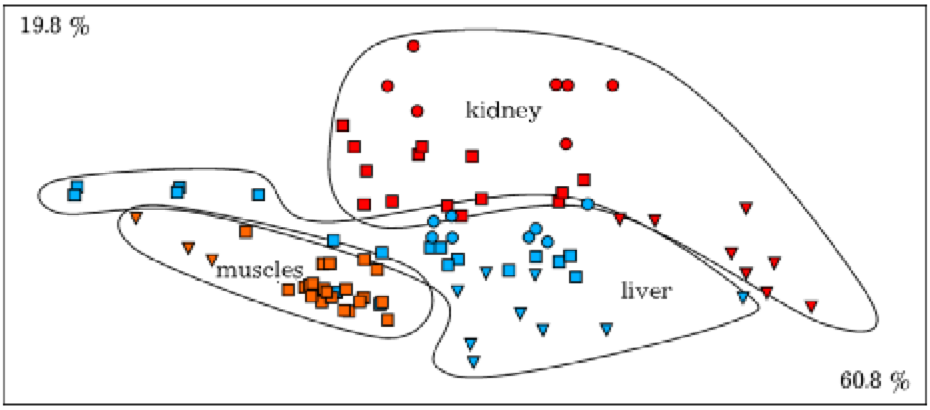

Fig. 1. Method of main components. Distribution of samples throughout the organs of the Baikal seal depending on the content of metals: □ 2002, ○ 2003, ▽ 2004.

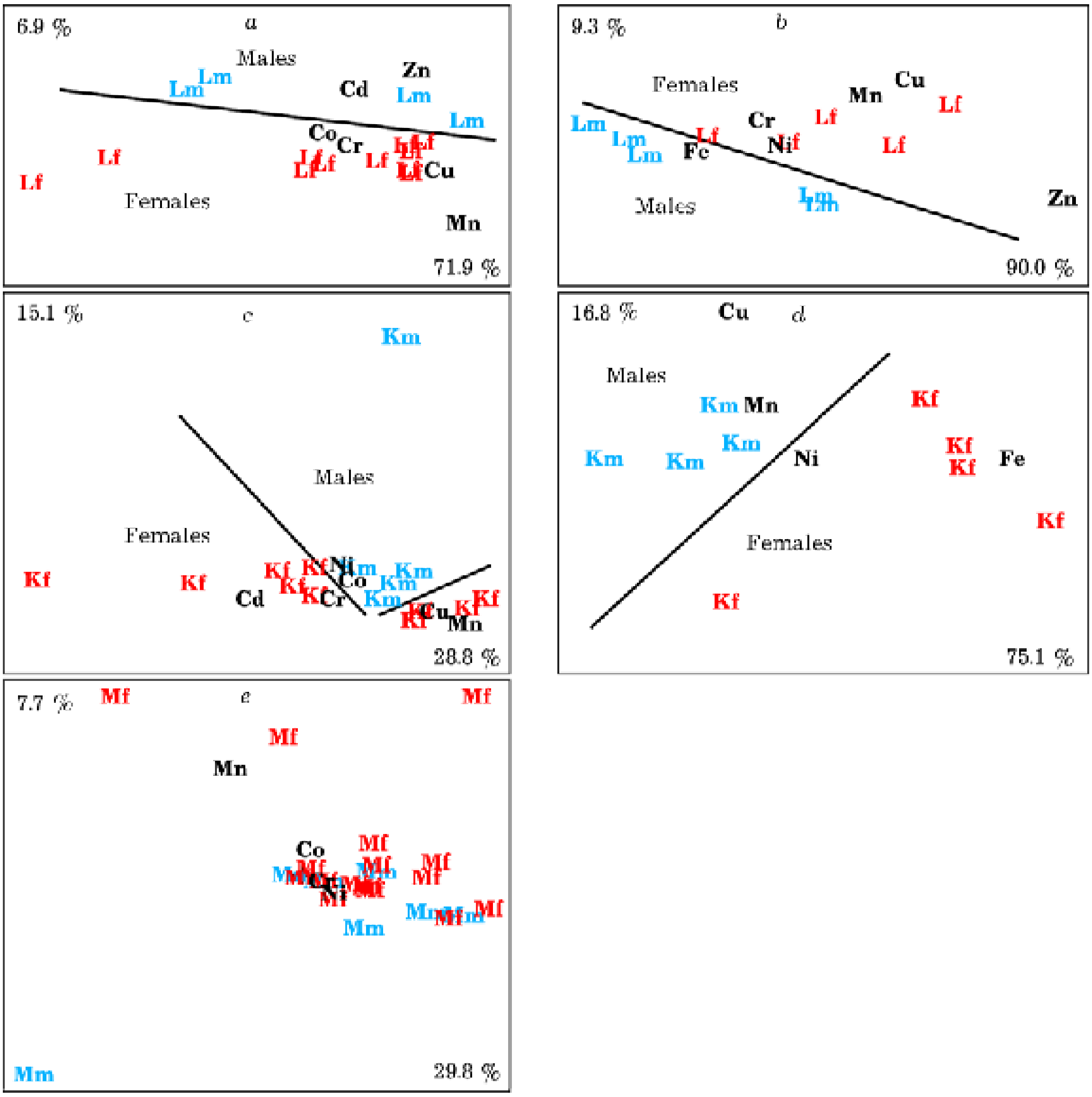

Fig. 2. Method of main components. Distribution of metals in the samples of liver (*a*, *b*), kidneys (*c*, *d*) and muscles (*e*) of the Baikal seal, taken in 2002 (*a*, *c*, *e*) and 2004 (*b*, *d*), depending on sex. Lm, Lf – liver of male and of female, respectively; Km, Kf – kidneys of male and of female, respectively; Mm, Mf – muscles of male and of female, respectively.

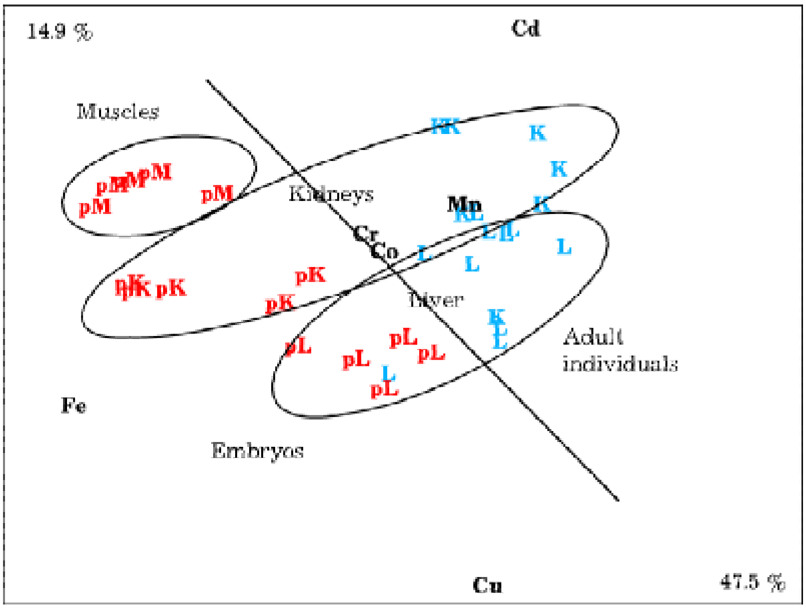

Fig. 3. Method of main components. The differences between adult individuals and embryos of the Baikal seal (2003). pM – muscles of embryos; pK, K – kidneys of embryos and of adult individuals, respectively; pL, L – liver of embryos and adult individuals, respectively.

The maximum concentrations of Zn, Cu and Mn are observed for liver of adult seals. For the accumulation level of some metals a difference is revealed between the organs of cubs and embryos of the Baikal seal and the organs of adult individuals. So, the content of copper in kidneys of cubs is higher as compared to its content in liver, whereas in kidneys of embryos the copper is even lower. For adult individuals the maximum content of iron is observed in muscles, and for cubs and embryos the maximum is observed in liver. The concentration of chromium for adult individuals and cubs of the Baikal seal is higher in liver, whereas for embryos it is higher in kidneys.

There are sex-and-age differences in the content of metals observed in organs and tissues of the seal. From the data presented in Fig. 2 one can see that there is a difference between females and males in the level of metals accumulation in liver and kidneys, whereas no sex-and-age differences were observed for muscles. The content of Fe, Cr, Cu and Mn in organs of females is higher in comparison with those of males. For cubs no pronounced distinctions were revealed in the level of metal accumulation in the organs of the individuals of different sexes.

One could note an obvious tendency for increasing the accumulation level of Fe, Zn, Mn and Cr depending on age. So, the content of metals in males increases with the age and tends to flatten out plateau for adult individuals. For females, on the contrary, the content of heavy metals in organs decreases with the age increased, since the metals transfer from female to her brood during the pregnancy and lactation period.

The breast milk of sea mammals is an essential source of toxic metals consumed by their brood. For five couples (female–embryo) of the Baikal seals caught in the Chivyrkuy gulf the content of metals in liver, kidneys and muscles (Fig. 3) has been determined. It has been established that the content of heavy metals in liver of cubs is higher in comparison with the content of these metals in liver of their mothers: copper (7.38±1.34) and (3.46±1.40) μg/g, respectively; iron – (141±37) and (93±30) μg/g of damp mass, respectively; zinc (34±9) and (12±2) μg/g of damp mass, respectively. The content of lead in the organs of embryos is higher as compared to those for adult individuals and cubs.

In the aspect of time (2002–2004) no increase in the concentration of lead, cadmium, nickel and chromium was registered.

As a whole, the obtained data on the content of microelements and the character of their distribution in the organs and tissues of the Baikal seal are not contradictory with respect to general laws observed for seals living in other aquatic basins, including seawater.

CONCLUSION

The analysis of obtained data concerning the accumulation of metals in organs and tissues of the Baikal seal has demonstrated that the metals are registered in an organism already at the early stages of the development and their content increases with the age of hydrobionts.

As a whole, for the three-year period a decrease is observed for the accumulation of the main heavy metals in the organs of the Baikal seal. However, a wider (in the aspect of time) monitoring is required for reliable estimation.

It is established, that the accumulation level of heavy metals in an organism of the Baikal seal is lower, than in the organisms sea mammals living in such polluted areas as Antarctic Region and Baltic Sea. The comparative analysis of the data we obtained and the results of [7] demonstrated that the content of metals in the samples of 2002–2004 has decreased. To all appearance, this fact indicates that there is a decrease in the Baikal Lake pollution observed as compared to the last years.

The Baikal seal plays the role of the indicator for the Baikal Lake ecosystem, therefore basing on the data obtained one could conclude that there is a low level of the lake waters contamination with heavy metals. The concentrations of the latter are close to background values, inherent in non-polluted areas of the World Ocean.

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