A NEW CONCEPT FOR THE BIOACCUMULATION OF LEAD AND CADMIUM ALONG A FOOD CHAIN WITH FARM ANIMALS

Bayko Baykov, Kiril Kirov, Milena Guguva, Botyo Zaharinov, Irina Popova Andrzej Krynski[1], Abdul Karim[2], Dimo Penkov[3],, Hristo Hristev[3]

New Bulgarian University, Science Research Institute of Ecology and Sustainable Development, 21 Montevideo Str., Sofia1618, Bulgaria
1 Warsaw Agricultural University, Dydision of Animal nd Environment Hygiene, 02-787 Warszawa, Ciszewkiego str. 8, Poland
2 University of Forestry, Faculty of Veterinary Medicine, Department "Agricultural Sciences", Kliment Ohridski Blvd. 10, Sofia 1756, Bulgaria
3 Agrarian University, 12 Mendeleev Str., Plovdiv 4000, Bulgaria

Key words: lead, cadmium, bioaccumulation, food chain, secondary production

Introduction

The term bioaccumulation defines the selective accumulation of toxic substances/chemical elements and compounds/ along the food chain. During the period after the 60's the bioaccumulation of some pesticides was researched. Hebel & Wrigt /1996/ indicate that if the content of DDT in lakes is 1 unit then it reaches 10 million units in predatory fish. This phenomenon, for some unknown reasons, is mechanically transferred to the accumulation of toxic chemical elements. In scientific literature it is admitted that the degree of bioaccumulation of toxic chemical elements is comparable with that of xenobiotics.

In this research we set our aim to study the degree of bioaccumulation of lead and cadmium and to formulate a concept for the bioaccumulation of these elements, which have an increased technogenic klarck in many regions of Bulgaria. The reason we carried out the research in this direction is our first study/together with Krynski/, which indicated that in ecotopes with increased klarck of lead and cadmium, the content of the two toxic elements is higher in liver and kidneys of rabbits, but the degree of bioaccumulation is considerably lower in comparison with pesticides.

Material and methods

Research was carried out with kids/Capra hircus/ of equal age, sex and race, bred in ecotopes with different klarck of lead and cadmium from their birth to 70 days old/first technological phase/. A typical for the region plant community is formed for studying the chemical heterogeneity at the first trophic level (the autotrophs). The kids have been studied for: biomass, forage consumption, health condition, and slaughter indices.

Soil from the surface soil layer, pasture grass and hay, muscular tissues, liver and kidneys have been studied for the content of lead and cadmium applying the method of Jorchrem/1993/ with AAS Perkin-Elmer 4100 type.

The chemical heterogeneity of soil has been estimated by using the klarck /K/ unit which is determined as a correlation of the quantity of the examined chemical element in 1 kg dry soil to the average quantity of the element in Bulgarian soils. For autotrophic organisms the chemical heterogeneity has been determined using the criterion - Bioconcentration factor (BCF), which is determined as a correlation of the quantity of the chemical element in 1 kg dry plant biomass to the quantity of the chemical element in 1 kg dry soil. At the first heterotrophic level we applied differentiated approach as BCF is determined at two levels: BCF_1 = quantity of the chemical element (in mg) in 1 kg dry biomass from the secondary production / quantity (in mg) in 1 kg soil.

Results

Data is presented in Table 1 for the chemical heterogeneity of lead and cadmium in the two ecotopes, where the research has been carried out, as well as for both trophic levels. Experiments are carried out in two ecotopes: a region anthropogenically polluted with lead and cadmium (First ecotope) and a region without anthropogenic changes of the chemical content of the surface soil layer (Second ecotope).

Data in Table 1 shows that at the autotrophic level there is a dispersal of cadmium and lead. Dispersal of the two studied elements is determined at the first heterotrophic level as well. Dispersal is calculated using BCF_1, regarding the chemical elements' quantity in the ecotope.

Analyzing the bioaccumulation of lead and cadmium in the organisms of kids, bred in ecotopes with different klarck of the two chemical elements, we register that the typical for the xenobiotics bioconcentration - progressive increase of their concentration at each trophic level - is not present. Using the criterion BCF_1, it is seen that in the examined organs and tissues of kids a considerable dispersal of both toxic elements exists compared to their

quantity in soil. It is determined that in the group of animals bred in ecotope I (with anthropogenically increased klarck of lead) the degree of concentration is considerably lower in comparison with that of animals bred in an environment with normal quantity of lead in soil (ecotope II). This characteristic is expressed better when assessing the bioaccumulation of cadmium.

Discussion

The conducted research indicates that differences regarding the movement of xenobiotics and toxic chemical elements along the food chain exist. Whereas for xenobiotics the degree of bioaccumulation is proportional to its quantity in the ecotope, we determined that the increase of lead and cadmium in the ecotope stimulates mechanisms, which are the reason BCF in the first group to be considerably lower in comparison with the control group 2, bred in an ecotope with normal klarcks of lead and cadmium for Bulgaria. This effect is known as substrate induction and it is determined about other factors as well /Baykov, 1968/. Substrate inducement changes the metabolism and processes of catabolism are activated. Data in Table 1, which correspond to our previous research /Baykov, 1994; Baykov et al., 1995, 1996/, gives us reason to claim that high lead and cadmium doses are a systematic stressor and the response of the organism is characterized by the typical stress reactions: increased energy expenditure, expressed by the degree of accumulation of energy in the secondary production, decrease in growth due to the activation of the catabolic reactions, low resistance of the organism leading to the increase of mortality. The stress effect, caused by the increased content of lead and cadmium in soil, activates mechanisms we think are evolutionary formed. They significantly decrease the degree of accumulation of lead and cadmium in the examined tissues. It should be underlined that a range exists where the increase of lead and cadmium in the ration does not exceed the MRL/Maximum Residue Level/ values of the two toxic elements in secondary production, which is used as food by people. The reason for this statement is the data in bold in Table 1, which show the quantity of lead and cadmium in fresh biomass. Since the existing norms for the content of the toxic elements and compounds are stated for fresh biomass, a conclusion could be made that even in regions with an increased technogenic klarck of the toxic elements it is possible to obtain secondary production with quantities of lead and cadmium below the MRL.

The conducted research in natural ecosystems and at modeled conditions give us ground to presume that regarding xenobiotics, which are relatively new pollutants, there are no evolutionary formed mechanisms for restricting their accumulation in the organism,

whereas for lead and cadmium there are mechanisms, which restrict their bioaccumulation, but they are accompanied with stress effects on the organism.

Acknowledgements

This research is entirely financed by NBU, "Development of Science Research" fund; project "Application of new criteria in bioecological monitoring with a view to assess the lead and cadmium technogenic pollution on biocenosis and human health" (Contract 43/20.05.03).

References

1. *Baykov, B., Doctors thesis. S., VMI, Sofia, 1968.*
2. *Baykov, B., Toxicol. Environ. Chem., 42, 227-233, 1994.*
3. *Baykov, B., et al., Toxicol. Environ. Chem., 49, 119-121, 1995.*
4. *Baykov, B., et al., Toxicol. Environ. Chem., 54, 155-159, 1996.*
5. *Dobrovolskiy, V.V., Introduction to biogeochemistry, M., Visshaya shkola, 1998.*
6. *Dobrovolskiy, V.V., Geochemical problems in physical geography, M., Prosveshtenie, 1984.*
7. *Hebel, B., R.Wrigt, Environmental Science, 5/e, NY., Prentice Hall, 1996.*
8. *Jorchem, L., J of AOAC Intrernational, 76 /4/, 798-813, 1993.*
9. *Kabata-Pendias, A. & H. Pendias, Trace elements in Soil and Plants, CPC Press Inc. Florida, 28, 1984.*

Table1 Chemical heterogeneity in an anthropogenic ecosystem for the production of meat with different klarck of lead and cadmium in the ecotope

No	Contents mg/kg	Lead		Cadmium	
		I group	II group	I group	II group
1.	Soil of pasture Average contents for Bulgaria K	118 ± 9,0 25 4,27	25,3 ± 1,2 25 1,01	3,44 ± 0,3 0,07 49,14	0,42 ± 0,1 0,07 6,0
2.1.	Hay BCF	6,63 ± 0,21 0,06	2,0 ± 0,05 0,08	0,72 ± 0,02 0,21	0,30 ± 0,08 0,71
3.	Phytophages Kids				
3.1.	Liver BCF_1	5,42 ± 0,42 0,05 **1,59 ± 0,10** [a]	0,98 ± 0,24 0,04 **0,28 ± 0,06** [a]	0,49 ± 0,11 0,14 **0,14 ± 0,06** [a]	0,17 ± 0,08 0,40 **0,05 ± 0,01** [a]
3.2.	Kidney BCF_1	5,61 ± 0,63 0,05 **1,10 ± 0,11** [a]	2,98 ± 0,25 0,12 **0,58 ± 0,07** [a]	0,51 ± 0,08 0,15 **0,10 ± 0,02** [a]	0,30 ± 0,09 0,71 **0,06 ± 0,01** [a]
3.3.	Muscles BCF_1	3,00 ± 0,32 0,03 **0,83 ± 0,11** [a]	1,03 ± 0,18 0,04 **0,28 ± 0,11** [a]	0,09 ± 0,02 0,03 **0,03 ± 0,02** [a]	0,06 ± 0,01 0,14 **0,02 ± 0,01** [a]

[a] fresh tissue (mg/kg)