MOVEMENT OF CADMIUM AND LEAD IN ANTHROPOGENICALLY FORMED TROPHIC CHAINS OF A PASTURE TYPE

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РЕЗЮМЕ

Проведено е изследване за движението на олово (Pb) и кадмий (Cd) в трофична верига в две села (промишлено замърсено и незамърсено). Установено е съдържанието на двата тежки метала в почвата, храната и различните органи на млади ярета и трансферът им в трите трофични нива, използвайки различни статични и динамични методи на изчисление.

Авторите доказват, че е възможно количественото определяне на химичната хетерогенност на хетеротрофните нива, използвайки два критерия: наред с динамичния критерий "Кларк на концентрация" (Cc), използван досега, се включва и "Фактор на биоакумулация" (FB), който показва реалната стойност на натрупване или разсейване на химичния елемент според съдържанието му в почвата или на трофично ниво в автотрофния организъм. Повишеният Cc на олово /4,72/ и кадмий /49,14/ в почвата не е причина за концентрацията им в хранителната верига на нивото на автотрофните организми и на нивото на организмите-фитофаги /ярета/. Изследванията на FB показват, че техногенно високият кларк на олово и кадмий в екотопа е причина за някои промени в метаболизма, способстващи за разпръскване на оловото по трофичната верига и спада на стойностите до 0,05 – 0,02 в сравнение със съдържанието му в екотопа, и на кадмия – до 0,03 – 0,15 в изследваните органи и тъкани.

КЛЮЧОВИ ДУМИ: олово, кадмий, екотрофична верига, почва, фуражи, ярета

ABSTRACT

An investigation on the movement of Lead (Pb) and cadmium (Cd) in a trophic chain in 2 villages (industrial polluted and non polluted) has been conducted. The contents of the 2 heavy metals in the soil, food and in different organs of young kids, so as their transfer in the 3 trophic levels (using different static and dynamic methods of recalculation) have been established.

The authors show, that it is expedient to determine quantitatively the chemical heterogeneity at the heterotrophic levels applying two criteria: along with the dynamic criterion "Clarc of concentration"(Cc), used up to know, to include also "Factor of bioaccumulation" (FB), which shows the real value of accumulation or dispersal of the chemical element according to its content in soil or at the trophic level of the autotrophic organisms. The increased Cc of lead /4,72/ and cadmium /49,14/ in soil is not the reason for the concentration in the nutrition chain at the level of the autotrophic organisms and at the level of the organisms phytophages /kids/. The studies of the FB show that the technogenically high Clarc of lead and cadmium in the ecotope is the reason for some changes in the metabolism, enabling the dispersal of lead along the trophic chain, the values falling down to 0,05 – 0,02 compared to its content in the ecotope, and, of cadmium – down to 0,03 – 0,15 in the tested organs and tissues.

KEY WORDS: Lead, Cadmium, Ecotrophic chain, Soil, Forages, Kids

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DETAILED ABSTRACT

An investigation on the contents of lead (Pb) and cadmium (Cd) in soil, forages and different organs (liver, kidneys and abdominal muscles) of young kids (Capra ovis), so as their movement in the different ecological levels has been conducted. Due to the fact, that the coefficient of biological intake /CBI/ proposed by Perelman in 1979 is static, the authors suggest to determine the Clarc of concentration /Cc/-concentration of the studied chemical element in 1000 g of the secondary biological produce /concentration of the chemical element in the water and forage necessary for obtaining 1000 g of the tested produce, which shows the movement dynamics of the chemical elements in synthesizing the secondary biological produce. Parallel with the dynamic factor Cc, it was determined the static Factor of Bioaccumulation FB_1 – the content of the studied chemical element in the sample of 1000 g of secondary biological produce / the content of the same element in 1000 g of dried soil and FB_2 – the content of the chemical element in 1000 g of secondary biological produce / the content of the same element in 1000 g of primary biological produce from the autotrophic level of the same ecotope.

The experiments have been conducted in two ecotopes: under technogenic pollution with cadmium and lead /first ecotope/ and in a region without anthropogenic changes of the chemical content /second ecotope/. After studying 24 soil samples of the horizon 0-20 cm, the established mean content of lead in the first ecotope was 118 mg/kg and of cadmium – 3,44 mg/kg, while in the second the values were 25,3 and 0,42 mg/kg, respectively. The mean content of lead in the Bulgarian soils is 25 mg/kg and the mean cadmium content is 0,07 mg/kg (data in 2002). The Clarc of concentration for lead in the first ecotope was 4,72 and in the second – 1,01 (the same as the mean value for Bulgaria). As for cadmium, the values of the Cc were 49,14 and 6,0, respectively. The literature review shows that the cadmium amount in many regions of Bulgaria is increased, however the increase is not resulting from anthropopressure and technogenic changes in the distribution of the chemical elements. Studies of the soil-forming rocks give a reason to state that the increased cadmium Clarc in the second ecotope has a natural origin.

The following results have been established- Pb – content (mg/kg)- polluted- 118, non polluted- 25.3; Cd – content (mg/kg)- polluted- 3.44, non polluted- 0.12; Pb in meadow grass (hay)- mg/kg DM- polluted- 6.63, non polluted- 2.0; Cd in meadow grass (hay)- mg/kg DM- polluted- 0.72, non pollutted-0.30; Pb in cereals- mg/kg DM- polluted- 0.68, non pollutted-0.10; ; Cd in cereals- mg/kg DM- polluted- 0.46, non pollutted-0.07; Pb in kids liver – mg/kgDM- polluted- 5.42, non polluted- 0.98; Cd in kids liver – mg/kgDM- polluted- 0.49, non polluted- 0.17; Pb in kids kidneys – mg/kgDM- polluted- 5.61, non polluted- 2.98; Cd in kids kidneys – mg/kgDM- polluted- 0.51, non polluted- 0.30; Pb in kids muscles (M. abdominis) – mg/kgDM- polluted- 3.50, non polluted- 1.03; Cd in kids muscles – mg/kgDM- polluted- 0.09, non polluted- 0.06. The following transfer factors between different parts of the ecological chain have been established: FB"meadow grass/pasture soil"- Pb (polluted)- 0.06, non polluted- 0.08, Cd (polluted)- 0.21, Cd(non polluted)- 0.71; FB"cereals/soil- Pb (polluted)- 0.006, non polluted- 0.003, Cd (polluted)- 0.13, Cd(non polluted)- 0.17; Cc"liver/forage + drinking water (mean)"- Pb (polluted)- 0.07, non polluted- 0.015, Cd (polluted)- 0.03, non polluted- 0.09; Cc"kidney/forage + drinking water (mean)"- Pb (polluted)- 0.05, non polluted- 0.13, Cd (polluted)- 0.02, non polluted- 0.09, Cc"muscle/forage + drinking water (mean)"- Pb (polluted)- 0.04, non polluted- 0.04, Cd (polluted)- 0.01, non polluted- 0.02.

It was concluded, that the dynamic criterion "Clarc of concentration" provides the reason to state that metabolism changes depending on the lead and cadmium Clarc of concentration in the ecotope, and, at higher Cc, lower values of the Cc were established. That suggests the available capacities of the studied organisms-phytophages to maintain the chemical homeostasis. There were possibilities of limiting the unfavorable effect of the technogenically increased lead and cadmium Clarc on the biocenosis by forming a plant society consisting of suitable plant species and choosing animals- phytophages displaying specifically decreased level of bioaccumulation of those toxic elements.

INTRODUCTION

The chemical heterogeneity of the lithosphere was established by Clark at the end of 19 century and in 20 century Vernadskiy formed a doctrine about the chemical heterogeneity in the rest of the biospheric components including in live substance /Dobrovolskiy, 1998/. The investigations were mainly conducted with the aim of establishing the degree of concentration or dispersal of the chemical elements in the autotrophes, taking as a comparison their content in soil /Reylly, 1980; Kabata-Pendias and Pendias, 1984; Dobrovolskiy, 1984, 1998 etc./. The studies on the bioaccumulation at the heterotrophic levels of the trophic chain later became numerous, however the stress has always been laid on the xenobiotics including on organochlorine and organophosphorous chemicals where concentrations of $10^6 – 10^7$ have been detected compared to soil and water medium /Hebel and Wrigt, 1996/.

The study of the chemical heterogeneity of lead and cadmium at the trophic level of the heterotrophic organisms was an object of a number of publications, including by Bulgarian authors, the investigations comprising fowl /Baykov, 1994, Baykov et al., 1995,1996,1996-a, Stantchev,1988, etc./ as well as hydrobionts /Baykov, 1999/. Most of the experiments with fowl have been conducted under modeled conditions by enriching the ration with different amounts of cadmium and lead salts.

For assessing the chemical heterogeneity at the level of autotrophic organisms the criteria applied was the coefficient of biological intake /CBI/ proposed by Perelman in 1979.

CBI is the amount of the studied element in the ash of a plant biomass unit / the amount in a dried soil unit.

Due to the fact that the quantity is static, /Baykov, 1994/ suggest to determine the Clarc of concentration /Cc/, which shows the movement dynamics of the chemical elements in synthesizing the secondary biological produce.

In the present investigation, the following objectives were set:

1. To analyze the criteria of assessing the chemical heterogeneity of the chemical elements in the autotrophic and heterotrophic organisms.
2. To study the technogenic Clark of lead and cadmium of the surface soil layer in an ecotope of industrial pollution and in a region without an increased anthropogenic Clark.
3. To study the effect of cadmium and lead Clark in soil on the dynamics of bioaccumulation in the goat organism during the first technological phase of their raising.
4. To form an anthropogenic trophic chain of a pasture type comprising species of low degree of cadmium and lead concentrations.

MATERIAL AND METHODS

The studies have been conducted with two groups of kids /*Capra hircus*/ of one and the same sex, age and race, of the first technological age /from their birth to 70 days old/. With the aim of studying the chemical heterogeneity at the autotrophic level, a plant society has been established consisting of typical for the region plants: 30 % of grain crops with prevailing species *Andropogon ischaemum*, *Poa bulbosa*, *Festuka ovina*; 5 % of leguminous of the species *Genista tincoria*, *Onibrychis arenaria*, *Sanguisorba minor*; 55 % of various grasses, including the species *Euphorbia cyparisias*, *Tecrium chamaedris*, *Thymus montana*, *Filagi germanica*, *Sclerantus annus*, *Vwerbascum thapsiformae*, *Eringuim campestre*, *Sempervivum patens*; 5 % of the bushes *Juniperus communis*, *Rubus idaeus*, *Caprinus orientalis* and 5 % of trees *Pinus silvestris*.

Samples have been collected from the plant society each ten days, each sample including grain, leguminous and grassy species.

For the kids /n = 10/ the biomass, forage rations, health status and slaughtering indices have been studied.

Soil from the surface layer, forages, drinking water, muscles, liver and kidneys have been tested for the lead and cadmium content following the method of Jorchrem /1993/ by I AAS, type Perkin-Elmer 4100.

The chemical heterogeneity of soil has been quantitatively assessed according to the Clarc of concentration /Cc/ by Vernadskiy and the bioaccumulation at the autotrophic and the first heterotrophic levels – by criteria developed by ourselves.

Clarc of concentration – content of the studied element in the soil sample /mean Clarc of the soil or the lithosphere.

RESULTS AND DISCUSSIONS

Criteria for assessing the chemical heterogeneity

The experiments have been conducted in two ecotopes: under technogenic pollution with cadmium and lead /first ecotope/ and in a region without anthropogenic changes of the chemical content /second ecotope/. After studying 24 soil samples of the horizon 0-20 cm, the established mean content of lead in the first ecotope was 118 mg/kg and of cadmium – 3,44 mg/kg, while in the second the values were 25,3 and 0,42 mg/kg, respectively. The mean content of lead in the Bulgarian soils is 25 mg/kg and the mean cadmium content is 0,07 mg/kg (data in 2002). The Clarc of concentration for lead in the first ecotope was 4,72 and in the second – 1,01 (the same as the mean value for Bulgaria). As for cadmium, the values of the Cc were 49,14 and 6,0, respectively. The literature review shows that the cadmium amount in many regions of Bulgaria is increased, however the increase is not resulting from anthropopressure and technogenic changes in the distribution of the chemical elements. Studies of the soil-forming rocks give a reason to state that the increased cadmium Clarc in the second ecotope has a natural origin.

Perelman /1979/ suggested that the chemical heterogeneity between the lithosphere and the autotrophic organisms could be determined quantitatively using the criterion coefficient of biological intake, which is calculated according to the content of the studied element in the ash of the plant sample to its content in the respective part of the lithosphere. We think that criterion does not comply with the modern notion of soil as a biocoss body (a transit structure by Vedansky), i.e. containing from 10 to 60 % of organic matter. The proposed method has been mechanically borrowed from the methods applied in geochemistry. Keeping in mind that peculiarity, we suggest two criteria for assessing the chemical heterogeneity:

Static

Factor of Bioaccumulation /FB/ - the content of the studied chemical element in 1000 g of dry primary or secondary biological produce / the content of the element in 1000 g of soil from the ecotope. With the aim of assessing the effect of the separate trophic levels on the chemical heterogeneity, it is advisable that the FB includes two quantitative criteria: FB_1 – the content of the studied chemical element in the sample of 1000 g of secondary biological produce / the content of the same element in 1000 g of dried soil. That criterion corresponds to the one used in studying the water ecosystems, i.e. BCF /bioconcentration factor/ - the content of the chemical element in the investigated sample / its content in the water. For assessing the role of the separate trophic levels on the concentration or dispersal of the studied chemical elements, it is expedient to determine FB_2 – the content of the chemical element in 1000 g of secondary biological produce / the content of the same element in 1000 g of primary biological produce from the autotrophic level of the same ecotope.

Dynamic

For assessing the chemical heterogeneity it is important to detect the dynamics of the processes following the criterion developed by us, Clarc of concentration /Cc/.

Cc – Concentration of the studied chemical element in 1000 g of the secondary biological produce /concentration of the chemical element in the water and forage necessary for obtaining 1000 g of the tested produce.

Evaluation of the importance of the technogenic Clarc for the chemical heterogeneity of cadmium and lead in the trophic chain of a pasture type

The anthropogenically formed trophic chain of a pasture type, which is an object of the present investigations, includes the described plant society and the different biological matrix of kids. That heterotrophic species, a source of secondary biological produce, has been selected on the basis of previous investigations that had shown significant differences in the bioconcentration of cadmium and lead in the organisms of lambs and kids raised in regions of increased technogenic Clarc /Hristev et al., 2002/.

Table 1 shows the data about the lead and cadmium amounts in the ecotopes of anthropogenically formed trophic chains of a pasture type. The FB has been analyzed at the level of the autotrophic organisms, an object of studies being the meadow grasses, and, the hay and grain obtained from them, respectively. Significant dispersal of lead was detected, varying about 0,01 n, while the cadmium dispersal varied about 0,1 n. The results obtained about the cadmium dispersal coincided with the data of Dobrovolskiy /1984/, however, as far as lead is concerned, significant differences were reported. According to the author cited, that toxic element accumulated in the autotrophic organisms in the mathematical order of n, i.e. from 1 to 9,99 times, while our investigations showed a dispersal of 0,06 and 0,08 for the first and the second ecotopes, respectively.

The content of the studied chemical elements in the grain forages was approximately 10 times lower for lead compared to the meadow grasses and from 2 to 4 times lower for cadmium. The ecological sense of those differences is limiting the content of the toxic factor in those plant parts related to the reproduction of the plant population. That factor was already established in tree species /by Dobrovolskiy, 1983/.

The investigation on Cc showed that the intensive metabolic processes were the reason for the high degree dispersal of lead in the grain: in the order of 0,001 n, i.e. by one mathematical order higher in comparison with the meadow grasses. In cadmium the same mathematical order of dispersal was reported: 0,1 n, however the values were lower especially in the plants from the second ecotope.

Table 1: Chemical heterogeneity in an anthropogenic ecosystem for meat production

№	**Content mg/kg**	Lead **First group**	Lead **Second group**	Cadmium **First group**	Cadmium **Second group**
1.	Pasture soil	**118**	**25,3**	**3,44**	**0,12**
	Mean content for Bulgaria	25	25	0,07	0,07
	Cc	4,27	1,01	49,14	6,0
2.1.	**Meadow grass** /hay/	**6,63**	**2,0**	**0,72**	**0,30**
	FB	0,06	0,08	0,21	0,71
2.2.	**Cereals**	**0,68**	**0,10**	**0,46**	**0,07**
	FB	0,006	0,003	0,13	0,17
3.	Phytophages Kids				
3.1.	Liver	5,42	0,98	0,49	0,17
	FB_1	0,05	0,04	0,14	0,40
	FB_2	0,81	0,49	0,68	0,57
3.2.	**Kidney**	5,61	2,98	0,51	0,30
	FB_1	0,05	0,12	0,15	0,71
	FB_2	0,85	1,49	1,04	1,00
3.3.	**Muscles**	**3,50**	**1,03**	**0,09**	**0,06**
	FB_1	0,02	0,04	0,03	0,14
	FB_2	0,45	0,51	0,125	0,20

At the first heterotrophic level where an object of analysis were typical of the country small animals /kids/, a lower content of lead was established compared to the aututrophic organisms, with an exception of the lead concentration in the kidneys of the kids from the second ecotope where FB_2 was 1,149 while for ecotope one it was 0,85. As for the cadmium the degree of accumulation in the kidney was about 1. Significant differences were established in the other studied tissues. In liver FB_2 of the animals raised in the first ecotope was 0,82 and in the second – 0,49. For cadmium the values were 0,51 and 0,30, respectively, or the cadmium content was lower in that extremely important for the vital functions organ by 32 % and 43 %, respectively. The lowest was the cadmium and lead content in the muscles of kids. As for lead, for both groups the lead content was established to be twice lower. For cadmium the differences were within two mathematical orders. When interpreting the data obtained, it must be pointed out that in that case the meadow grasses, despite as a plant society, represent a classical example at the aututrophic level and it is expedient to use them as a comparison. The animals had been fed with other foods, too, and the source of the studied elements was also drinking water, due to which the data obtained for FB_2 only suggest an orientation about the chemical heterogeneity between the two trophic levels: the autotrophic and the first heterotrophic one /of the phytophages/. An objective information about the lead and cadmium bioaccumulation is going to be obtained from the interpretation of FB_1 because all the components of the flow incoming into the ecosystem, come from the respective ecotope. In all the studied organs – liver, kidneys and muscles – a significant dispersal of cadmium and lead has been detected in comparison with their content in the soil of both ecotopes – one and two. In most of the studied tissues it was established that the lead and cadmium dispersal was more obviously expressed in the organisms of the animals raised in the ecotope of technogenically increased Clarc of the two toxic elements.

For establishing the dynamics of the mobility process of lead and cadmium as toxic elements along the trophic chain, we used the criterion Clarc of concentration /Cc/, which shows the sources of the respective elements in the incoming flow and the degree of bioaccumulation at the first heterotrophic level. Due to the fact that it is the first time an information is given about the input amounts of lead and cadmium, showing the amounts not only in forages and drinking water, also the amounts of the two toxic elements contained in air, in our previous investigations /Hristev et al., in print/, we set the task of detecting the objectiveness of the doctrine that the basic source of toxic chemical elements is the lithosphere. In experiments conducted in a region of increased lead and cadmium Clarc, it was established that the major source of lead for the kids was the forage – 98,99 % of the whole amount introduced, followed by drinking water – 0,94 % and air – 0,07 %. There were differences for the cadmium: the major source of that element was the forage /99,84 % for the kids/, while the intake with the drinking water was only 0,15 %. From air, the animals received 0,001 % of cadmium. The investigations carried out give the reason to eliminate air when assessing the lead and cadmium amounts in the incoming flow of the anthropogenic ecosystem for obtaining secondary biological produce, and, the studies comprised only the two major sources related to lithosphere or soil: forages and drinking water.

Data in Table 2 show that for obtaining 1 kg of secondary biological produce /mean torso weight + liver + kidney/, nutritive elements were taken containing lead: for the first group the amounts were 21,39 mg/kg of weight gain and, for the second group – 6,40 mg. Concerning cadmium the values were 5,29 and 0,64, respectively. Table 3 presents the results of the biometric investigations and the lead and cadmium amounts in the muscles, liver and kidneys of lambs and kids raised in a region of increased technogenic Clarc of the mentioned toxic elements. The numerator shows the content of the studied element in the fresh weight and the denominator – in a kg of dry weight. The highest lead and cadmium content is in the liver and the lowest in the muscles. The hygienic assessment according to the EU norms – Regulation 466/2001, on the basis of which Regulation №12/2002 was adopted by the Bulgarian Ministry of Health, shows that the high technogenic Clarc of lead affects the quality of the secondary biological produce obtained. The ultimate permissible level for lead in liver and kidneys is 0,5 mg per a kg of biomass, while the detected amount of 1,59 mg/kg of liver in kids was 3,18 times higher than the permissible level. High content of lead was also established in kidneys – 2,2 times higher than the ultimate permissible level for the kids. The highest values compared to the EU norms, were detected in the muscles. At a permissible level of 0,1 mg/kg of muscles, the established amounts of 0,83 mg in the kids was 8,3 times higher than the ultimate permissible level. In the animals from the second group considerably lower lead concentrations were detected in the tissues and organs recommended for testing by the World Health Organization. In all the studied samples from animals belonging to the second group, the lead content was below the set ultimate permissible levels. Considerably lower content of the toxic element was found in the kidneys of the kids, too - at a permissible level of 1,0 the established value was 0,10. In the muscles the permissible content is up to 0,05 mg/kg and the established amount was 0,03 mg/kg. In the animals raised under the conditions of technogenically unpolluted ecotope /second group/, the cadmium content was considerably lower compared to the first group and far below the ultimate permissible concentration.

Table 2: Incoming flow of substances at heterotrophic level of phytophages

№	Index	Tested Group Content	Pb	Cd	Control Group Content	Pb	Cd
1.	Drinking water l / life	274,50	1,51	0,059	225	0,45	0,045

2.	Food						
2.1.	Milk	72,83	10,34	0,36	70,56	6,35	0,21
2.2.	Green grass	1,83	1,21	0,13	12,6	0,38	0,06
2.3.	Meadow hay	20,0	138,03	34,07	15,45	51,0	4,85
2.4.	Cereals	14,08	8,72	4,93	13,56	1,22	0,83
	Total: forage + water	108,74	159,80	39,55	112,17	59,41	6,00
	Mean weight torso + liver + kidney	14.50	21,39	5,29	12,05	6,40	0,64

Table 3: Biometric indices and Cd and Pb content in secondary biological produce

№	Index	**Tested Group** Weight	**Pb**	**Cd**	**Control Group Weight**	**Pb**	**Cd**
1.	Biomass after slaughtering	15,25			16,90		
2.	Torso	7,21			9,00		
2.1.	Liver	0,227	1,59/5,42	0,14/0,49	0,270	0,98/3,27	0,058/0,17
	Cc		0,07	0,03		0,15	0,09
2.2.	Kidney	0,032	1,10/5,61	0,10/0,51	0,037	0,87/2,68	0,06/0,30
	Cc		0,05	0,02		0,13	0,09
2.3.	Muscles	4,33	0,83/3,00	0,03/0,09	5,40	0,29/1,03	0,016/0,056
	Cc		0,04	0,01		0,04	0,02

The assessment by the dynamic criterion Clarc of concentration showed that despite the great amount of substance passing through the cells of the heterotrophic organisms used in the experiment, the Cc of lead in the liver of the kids from the first group was 0,07, and, from the second group – 0,15; in the kidneys – 0,05 and 0,13, respectively; in the muscles of the animals from the second group – 0,04. It is worth mentioning the significantly higher degree of lead dispersal in the studied organs and tissues of the animals from the first group. The assessment of the cadmium Cc showed the same relationship – a considerably higher degree of dispersal in the studied secondary biological produce of kids from the first group: in liver – 0,03 for the first group and 0,09 for the second one; in kidneys – 0,02 and 0,09 and in the muscles – 0,01 and 0,02, respectively. The results obtained give the reason to conclude that the investigated heterotrophic species possess regulatory mechanisms for limiting the unfavourable effect of the increased cadmium and lead concentrations, resulting from the technogenically increased Clarc in soil. The indicator for that was the dynamic Cc criterion, proving undoubtedly the dispersal in liver, kidneys and muscles. Comparing BF_1 and Cc, the conclusion can be drawn that there is a dispersal of the two toxic elements – lead and cadmium – along the ecological nutritive chain. Cc shows that the organism has reacted to the increased lead and cadmium contents in food and water. At higher Clarc of concentration, it was detected that the regulatory mechanisms were activated proportionally to the amounts of the chemical elements in the ambient environment. The conducted studies in two ecotopes of different lead and cadmium Clarc and the significantly lower established values of BF_1 give a reason to suggest that the present case refers to a substrate induction of the regulating mechanisms, a fact established in our previous investigations for activating the tryptophan pyrolase and other enzymes at increased introduction of the substrate quantities into the organism. While conducting the experiments, no symptoms of acute or chronic poisoning of the animals from the first group were established. The results presented in Table 3 show significant differences in the cadmium and lead contents in liver, kidneys and muscles of the animals from the two groups, however, those differences do not provide the basis to suggest an existing toxic effect in the animals from the first group. Cc and BF_1 factor are indicative about the tendency of the organism towards preserving the chemical homeostasis despite the Clarc of concentration of lead /4,72/ and of cadmium /49,14/ in the ecotope. The biometric indices give the reason to state that the maintenance of the homeostasis is related to activating the catabolic processes, which is confirmed by the increased forage ration for 1 kg of weight gain /by 20,3 % for the animals from the first group/, the decreased weight gain /torso biomass by 19,9 % lower for the first group/ and increased water consumption /by 22 %/ for the animals from that group. The results obtained show that the heterotrophic organisms /primary bioconsumers/ react in a different way to the introduction of toxic elements in the nutrition chain. Lead and cadmium are a part of the living environment during the evolution of the species and due to that, there are mechanisms developed for limiting their accumulation in the organs and tissues. The xenobiotics synthesized by humans are a new component of the living environment /DDT has been applied for about 60 years/. Obviously, along the nutrition chain the organisms have not developed mechanisms for limiting their accumulation and the values reached are about $10^6 – 10^7$ compared to their concentration in the ecotope /soil or water/. In those cases, a toxic effect is observed, which in some instances, becomes the reason for dying of fowl populations.

An attempt of forming a trophic chain with the aim of decreasing the cadmium and lead bioaccumulation in the section of phytophages, the source of secondary biological produce used for human food.

The conducted preliminary investigations showed that it was possible to form a plant society of traditional for the country and widely spread grassy species, having cadmium and lead Clarc of concentration below 1. With the aim of obtaining a positive effect, 10 % of the plant society included trees and bushes that according to literature data /Dobrovolskiy, 1998/ concentrated toxic elements, including cadmium and lead, to a high degree. In our previous studies /Hristev et al., 2002/ specific differences were established between traditional for Bulgaria small ruminants: lambs and kids, the former concentrating the studied chemical elements to a higher degree. Out of that reason, the section of the phytophages providing a source of secondary biological produce used as human food, was represented by those animals.

CONCLUSIONS

- It is expedient to determine quantitatively the chemical heterogeneity at the heterotrophic levels applying two criteria: along with the dynamic criterion Cc, used up to know, to include also FB, which shows the real value of accumulation or dispersal of the chemical element according to its content in soil or at the trophic level of the autotrophic organisms.
- The increased Clarc of concentration of lead /4,72/ and cadmium /49,14/ in soil is not the reason for the concentration in the nutrition chain at the level of the autotrophic organisms and at the level of the organisms phytophages /kids/.
- The studies of the FB show that the technogenically high Clarc of lead and cadmium in the ecotope is the reason for some changes in the metabolism, enabling the dispersal of lead along the trophic chain, the values falling down to 0,05 – 0,02 compared to its content in the ecotope, and, of cadmium – down to 0,03 – 0,15 in the tested organs and tissues.

The dynamic criterion “Clarc of concentration” provides the reason to state that metabolism changes depending on the lead and cadmium Clarc of concentration in the ecotope, and, at higher Cc, lower values of the Cc were established. That suggests the available capacities of the studied organisms-phytophages to maintain the chemical homeostasis.
There are possibilities of limiting the unfavourable effect of the technogenically increased lead and cadmium Clarc on the biocenosis by forming a plant society consisting of suitable plant species and choosing animals-phytophages displaying specifically decreased level of bioaccumulation of those toxic elements.

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