Monitoring heavy metals and their impact on animal health

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Abstract: The article is devoted to the analysis of the results of ten scientific studies conducted in separate biogeocenoses of the Chui zone of the Kyrgyz Republic. The research is aimed at monitoring the content of toxic metals in the chain "soil - plant - animal" and assessing their impact on animal health. The paper monitored the content of heavy metals such as lead (Pb), mercury (Hg), cadmium (Cd), arsenic (As), nickel (Ni), copper (Cu), zinc (Zn), cobalt (Co) along the biochemical food chain. The paper details the process of studying heavy metal content in mountain soils, forage plants and animal blood using inductively coupled plasma atomic emission spectrophotometer. Studies have shown that the accumulation of heavy metals in animal organisms exceeds their concentration in soil and plants by tens and hundreds of times, which leads to various biogeocenotic pathologies of animals in the Chui zone. Based on the results of the studies, conclusions about the imbalance of toxic metal content and its consequences for biogeocenoses of the Chui zone were made.

1 Introduction

In connection with climate change and urbanization of mountain regions, as well as increasing environmental pollution, the study of the content of toxic metals and their effect on animal health in the system: - soil - plant-animal [1, 2] becomes a priority. Kyrgyzstan is a mountainous country, with a sharply continental climate; especially, the Chui zone is considered industrial, since large enterprises, tailings dumps, and industrial cities such as Tokmok, Bishkek, Kant, Kara-Balta are concentrated there, and the South-North international highway passes through this zone. The main pollutants of these industrial enterprises are toxic emissions (heavy metals), nitrogen oxides, sulfur dioxide, carbon monoxide, etc. They constantly pollute the natural environment (ecosystem), which negatively affects human and animal health. Therefore, several scientists working on this problem [2, 3] believe that studying the content of heavy (toxic) metals in environmentally unfavorable areas, as well as their effect on animal health, is a very urgent task.

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2 Materials and methods

Scientific and production experiments were carried out on different farms in the Chui region. These farms were located at a distance of 1.5-3 km from industrial cities such as Bishkek, Tokmok, Kant, Kara-Balta, and the main South-North highway of the country. In all samples (soil, plant (feed), blood), the content of heavy metals was studied in comparison with the values of their threshold limit value (TLV), according to Sanitary rules and regulations 42-128-4433-87 and GOST 17.4.3.01 - 2017 using atomic -emission spectrophotometer with inductively coupled plasma ICP-ATS OPTIMAL5300 DVU-ICP-MS Elan DRC. The blood of experimental animals was examined in the scientific laboratory of the Department of Internal Animal Diseases, KNAU named after. K.I. Skryabin, according to the methodology proposed in veterinary medicine by I.P. Kondrakhin, N.V. Kurilov, A.G. Malakhov et al. (1985) [4, 5]. Blood was taken from 10 cows of the Alatau (local) breed (experimental and controlled), where the following was determined: the amount of total protein using a URL refractometer; sugar level according to the Somogyi method; reserve alkalinity using double flasks according to Kondrakhin; total calcium according to Vichev and Karashev with the complexometric method; inorganic phosphorus with vanadate-molybdenum reagent according to Pulse in the modification of Koromyslov and Kudryavtseva; lymphocytes were determined by I.P. Kondrakhin et al[6, 7]. Controlled (healthy) animals were taken from safe areas of the republic. The obtained data were processed using the MS Excel program on the IRUCRED- ($P \leq 0.05$; $P \leq 0.5$) computer according to the Student distribution.

3 Results

According to individual scientists, ecological zones near large industrial enterprises, transport hubs, and cities are always polluted with various chemicals [7, 8]., especially heavy (toxic) metals such as lead, mercury, cadmium, arsenic, nickel, copper, etc. [9, 10],. In this regard, we set ourselves the goal and objectives of conducting scientific research on the system: - soil-plant (feed) - animal in those farms of the Chui zone where they have located 1.5-3 km from industrial cities and the main highway "South-North", and also found out the effects of these toxic elements on animal health. The results of highly toxic elements (class I) according to the classical chain are shown in Table 1.

Table 1. Indicators of highly toxic elements (class I) in experimental and control samples in the Chui zone

Types of samples	Soil, mg/kg				Plant, mg/kg				Blood, mg/l			
	Pb	Hg	Col	As	Pb	Hg	Col	As	Pb	Hg	Ca	As
Experimental sample	0,1	0,05	0,01	0,20	1,07	0,08	0,25	0,25	0,03	0,0005	0,0006	0,40
Control sample	0,3	0,1	1,0	0,15	3,0	0,05	0,30	0,23	0,1	0,005	0,03	0,05

Note: Indicators of the control sample, according to TLV

Comparative indicators of first-class pollutants (see Table 1) show that lead, mercury, cadmium, and arsenic, as toxic elements with an atomic weight of more than 50 units, entering a living organism and interacting with the body's biocatalysts, suppress them the main functions and contribute to the occurrence of one or another animal pathology. These toxicants are especially dangerous due to their ability to bioaccumulate, i.e. they accumulate in the body of animals, creating an increased concentration. However, as the results of the study show, the content of all heavy metals in the system: - soil - forage plant - organism (blood) in the Chui zone was within the permissible norm, except arsenic. Its amount in the soil exceeded by 25.0%, in forage plants by 80%, and in the blood by almost 86.0%. Data for other toxic elements belonging to the second class, such as nickel, copper, zinc, and cobalt, are presented in Table 2.

Table 2. Indicators of toxic elements (class II) in experimental and control samples in the Chui zone

Types of samples	**Soil, mg/kg**				**Plant, mg/kg**				**Blood, mg/l**			
	Ni	Cu	Zn	Co	Ni	Cu	Zn	Co	Ni	Cu	Zn	Co
Experimental sample	0,05	0,68	1,05	0,02	0,99	7,1	26,5	5,1	0,05	58,2	314,2	4,0
Control sample	4,0	6,8	5,0	1,3	2,0	8,5	30,0	7,7	0,12	95,3	400,0	4,5

Note: Nickel levels in blood are mg/l.

Based on the results of the studies (see Table 2), it can be assumed that in all components of the food chain (soil, food plant, blood), the content of toxic elements of the second class was significantly low in the basic indicators, for example, the amount of nickel in the soil - 98.7%, in fodder plants - 50.5%, in blood - 58.3% less than the control sample. The amount of copper, respectively (90.0% -16.4% -38.9%), the amount of zinc, respectively (79.0% - 11.0% - 21.4%), and the amount of cobalt in the soil decreased to 1. 2%, in fodder plants up to 33.7%, and in blood, the difference compared to the basic indicators is 11.1%. This imbalance of highly toxic (first hazard class) and toxic (second hazard class) heavy metals significantly affected the health of animals (see Table 3).

Table 3. Indicators of biochemical blood tests in experimental cows n=10

№	**Indicators**	**Experimental group**	**Control group**	**P≤**
1.	Total protein, g%	3,90 ± 0,29	8,6 ± 0,03	0,05
2.	Sugar, mg %	38,2 ± 1,44	60,0 ±0,31	0,01
3.	Phosphorus, mg %	2,9 ± 0,05	6,0 ±0,22	0,05
4.	Calcium, mg %	11,0 ± 0,77	12,5 ± 0,41	0,05
5.	Reserve alkalinity, total % CO_2	37,0 ± 4,30	66,0 ± 0,45	0,01
6.	Lymphocytes, %	48,5 ± 0,24	64,0 ± 1,03	0,05

As the data in Table 3 shows, in cows of the experimental groups, the main indicators of metabolism undergo significant changes, namely, the protein content in the blood significantly decreases to 3.90±0.29 versus 8.6±0.03g% in healthy animals (P≤ 0.05), the amount of sugar up to 38.2±1.44 versus 60.0±0.31 mg% (P≤0.01), phosphorus and calcium, respectively (up to 2.9±0.05 – 11, 0 ± 0.77 mg%), reserve alkalinity decreases to 37.0 ± 4.3 vol% CO2 versus 66.0 ± 0.45 vol% CO2 in control animals (P≤ 0.01); the same change was found in the immune system i.e. the number of lymphocytes decreases to 48.5 ± 0.24% versus 64.0 ± 1.03% in healthy animals (P≤ 0.05) [11, 12],.

4 Discussion

Many scientists [13, 14], studied the effects of individual heavy metals on the environment, especially in those zones where large industrial enterprises are concentrated, such as the Southern Ural, Altai Territory, Bashkir Zauralye, South-East Belarus, etc., but special monitoring in certain high-mountainous territories (zones), such as the Chui zone of Kyrgyzstan for the content of toxic metals along the food chain: - soil – forage plant – animal, as well as their influence on changes in the metabolism and immune system of the body in cows of the Alatau breed has not been carried out. Therefore, studying and determining the content of heavy metals in the environmentally polluted Chui zone and elucidating their effect on animal health was the main task of our scientific research. Based on the results of scientific research, we found that highly toxic elements of the first class (Pb, Hg, Cd) in the classical chain were within the permissible limits, except arsenic (As). The amount of arsenic exceeded the TLV from 25.0% to 86.0%, and toxic elements of the second class (Ni, Cu, Zn, Co,) in the trophic chain were significantly low from 11.0% to 90%, except for cobalt, its content decreased slightly to 1.2% in soil. It should be noted that prolonged exposure to heavy (toxic) elements on the body, even at maximum permissible concentrations, always leads to disruption of the vital functions of the body in animals. This is evidenced by scientific research by other scientists [15, 16],.

5 Conclusions

Based on the scientific research obtained, we can draw the following conclusions that the Chui zone of Kyrgyzstan in terms of the content of highly toxic elements of the first class in the system: - soil - forage plant - -blood was within the permissible norm, except arsenic, and the amount of arsenic in the soil exceeded by 25.0%, in food plants by 8.0%, and in blood by almost 86.0%. The content of toxic elements of the second class was significantly low among the basic indicators. Such an imbalance of heavy metals caused a violation of the metabolism and immune system of the body of Alatau cows.

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