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Climate change in Kyrgyzstan and its impact on the emergence of biogeocoenotic pathologies in animals

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Abstract. Biogeocoenotic pathology refers to the widespread occurrence of disease not only in animals but also in humans and plants. Such conditions arise as a result of adverse changes in the environment. In this context, the timely investigation of the ecosystem of the Chüy Region of Kyrgyzstan as an aetiological factor, along with early detection of pathologies in cattle resulting from these changes, has become particularly important. This study aimed to examine biogeocoenotic pathology in Alatau breed cows in the Chüy Region, to carry out monitoring based on the "soil plant animal" system concerning the content of biogenic macro- and micronutrients as well as toxic metals, and to develop recommendations for establishing an innovative ecological centre to support ecosystem optimisation in Kyrgyzstan The experimental study involved Alatau cows in the second half of gestation, with soil and plants used as key environmental components. The soil, plants and animal blood samples were analysed using an atomic emission spectrophotometer. At the same time, key metabolic indicators in the experimental and control groups of cows were assessed using standardised and unified methods. Analysis of soil, forage plants and blood from cows kept in environmentally disadvantaged areas of the Chüy Region revealed a

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significant imbalance in the levels of macronutrients, micronutrients and heavy (toxic) metals. This imbalance in the biochemical trophic chain has disrupted the circulation of substances within the specific biogeocoenosis of the Chüy zone, a phenomenon linked to ecological degradation – particularly in areas where major industrial enterprises are concentrated. To support timely ecosystem monitoring in Kyrgyzstan, the authors have proposed the establishment of an innovative scientific and educational ecological centre focused on protecting the health of humans and animals. The findings of this study may be applied in medicine, agriculture, veterinary science, ecology, and within both academic and research institutions

Keywords: cow; soil; plant; blood; innovative scientific and educational ecological centre; toxic metals

Introduction

Kyrgyzstan is a developing mountainous country, with mountains covering up to 95% of its total territory. The country stretches approximately 900 km from east to west and 410 km from north to south, lying between 39° and 43° N latitude. Its total area is nearly 200,000 square kilometres. The climate is sharply continental, with extreme temperature fluctuations – from as low as -53.6°C in winter to as high as +44°C in summer. Annual precipitation ranges from 150 to 650 mm. Snow cover can vary from 4 to 200 cm, while permafrost occupies around 34% of the country's territory. Solar radiation levels reach between 136 and 161 kcal/cm^2. Kyrgyzstan possesses extensive natural pastures – around 9.2 million hectares, or 86% of all agricultural land. However, over 60% of these pastures have experienced various forms of degradation (Oruzbayeva, 1982). At the 29th Conference of the Parties to the United Nations Framework Convention on Climate Change, attended by around 100 heads of state and government, the President of the Kyrgyz Republic, S. Japarov, stated that glaciers in Kyrgyzstan are melting at an unprecedented rate. Over the past 50 to 70 years, the total glacier area has decreased by 16% due to climate change within the country (United Nations Climate Change Conference, 2024). Speaking at the international conference Global Mountain Dialogue for Sustainable Development: Towards the Bishkek +25 Summit on 24 April 2025, President S. Japarov once again drew the international community's attention to climate change, extreme weather events, natural disasters, accelerated ecosystem degradation, and glacier melt in mountainous regions (S. Japarov spoke..., 2025).

The main causes of these changes include global warming, loss of biodiversity, ozone layer depletion, air and water pollution, accumulation of industrial and domestic waste, and greenhouse gas emissions, among others (Essack, 2018; Eskew *et al.*, 2020). In Kyrgyzstan, these issues ultimately lead to climate change and the emergence of new pathologies affecting not only plants and animals but also humans. Biogeocoenotic pathology is a field that studies mass diseases in animals arising from adverse environmental changes within ecosystems (biogeocoenoses). It views animal diseases as closely linked to shifts in environmental conditions – such as climate change, ecotoxicants, radioactive metals, and toxic gases – in ecosystems altered by human activity. These diseases, along with the resulting decline in the quality of livestock products, pose a threat not only to animal health but also to human health (Elenshleger, 2016; Moskalchuk, 2021).

In this context, Kyrgyzstan endorsed the agreement on the seventeen Sustainable Development Goals (SDGs) to be achieved by 2030, adopted in Paris in 2015 (The 17 Goals, 2015). This document was signed by nearly 200 countries, including Kyrgyzstan. Industrial cities such as Bishkek, Kant, Tokmok, and Kara-Balta have particularly polluted atmospheres, contaminated by emissions of heavy metals and toxic mixtures of smoke, fog and dust (smog). According to reputable international organisations, air quality in Bishkek is among the most hazardous, with an Air Quality Index (AQI) rating of 229. The average annual concentration of PM 2.5 is approximately 153.5 μg/m^3, significantly exceeding both national and international hygienic standards by as much as 3.6 times (United Nations, 2022; IQAir, n.d.). Certain heavy metals, such as lead, mercury and arsenic, are classified as highly hazardous substances. Once deposited in the bones, they lead to gradual degeneration and accumulate in parenchymal organs such as the liver, kidneys and heart. These toxicants can reduce the immune system's responsiveness, contribute to chronic neurological disorders and, in some cases, cause cancer (Skugoreva *et al.*, 2016; Pourret & Hursthouse, 2019).

The ecological issue of biogeocoenotic pathology in animals should be addressed through a comprehensive approach aimed at improving environmental conditions, involving experts from a range of fields, including ecology, toxicology, technology, agrochemistry, land reclamation, medicine and veterinary science. To investigate this problem in Kyrgyzstan in a holistic manner, the authors of this article set the aim of studying climate change in the Chüy zone – an area with high levels of atmospheric pollution caused by transport and industrial emissions. The study involved monitoring the "soil-plant-animal" system for macronutrients, micronutrients and heavy metals; identifying biogeocoenotic pathologies in Alatau breed cows; and developing proposals for the establishment of an innovative ecological centre dedicated to safeguarding the health of both humans and animals.

Materials and Methods

The experimental studies were conducted between October 2018 and July 2022 within a specific biogeocoenosis – the Chüy zone of Kyrgyzstan – at farms most affected by anthropogenic influences: Vetka AC, Chabrets Farm, and Kyrgyz IFIBS. These sites are located within 3 kilometres of the country's main North-South highway, as well as near major industrial cities such as Bishkek, Kant and Kara-Balta The experiment involved Alatau breed cows in the second half of gestation (10 animals in total), divided into experimental (5 cows) and control (5 cows) groups. The animals were selected based on average body weight and external conformation measurements. They were kept in open feeding and exercise areas under identical feeding conditions. During the autumn and winter months, the live weight of the cows ranged on average from 361 to 368 kg.

The content of macronutrients, micronutrients and heavy metals in the "soil-plant (forage)animal (blood)" system was analysed using atomic emission spectrophotometry (ICP-AES OPTIMA 5300 DV and ICP-MS Elan DRS). Sampling of experimental and control specimens, including soil and forage plants, was carried out following GOST 17.4.1.02-83 (1985), GOST 17.4.3.01-2017 (2017), and SanPiN 42-123-4089-86 (1986). Blood samples were collected following the recommendations of the I. Kondrakhin *et al.* (1985). For morphobiochemical analysis, blood from both experimental and control cows was drawn in the morning before feeding. The parameters measured included erythrocyte and leukocyte counts, haemoglobin, glucose, lymphocytes, total protein, carotene, phosphorus and calcium levels, using standardised and unified methodologies (Kondrakhin *et al.*, 1985). All results were meticulously recorded and documented in a specially bound laboratory journal. The data were processed using MS Excel software on a TRUCRED computer, and statistical analysis was conducted using Student's t-test, with significance thresholds of $P \leqslant 0.05$ and $P \leqslant 0.5$. The experiment was conducted following the ethical standards outlined in the Code of Practice for the Housing and Care of Animals Bred, Supplied or Used for Scientific Purposes (2014).

Results and Discussion

The results of the experimental study indicated that the primary cause of biogeocoenotic pathologies in cows is an imbalance of specific biogenic macro- and micronutrients, as well as heavy metals, in soil and forage. Similar conclusions have been drawn by other researchers, including V. Baturin *et al.* (1998) and M. Wrzecińska *et al.* (2021), who reported that environmental contamination by toxic waste is one of the key factors contributing to the development of biogeocoenotic pathologies in animals. S. Mukhacheva & V. Bezel (2015) further asserted that ecotoxicants (particularly heavy metals) affect not only the mother but also the foetus, within the "mother-placenta-foetus-offspring" system. This finding is supported by the research of R. Nogoibaeva *et al.* (2020). The results of the comparative analysis of macro- and micronutrient content in soil, forage and the blood of experimental cows are presented in Figures 1, 2, and 3.

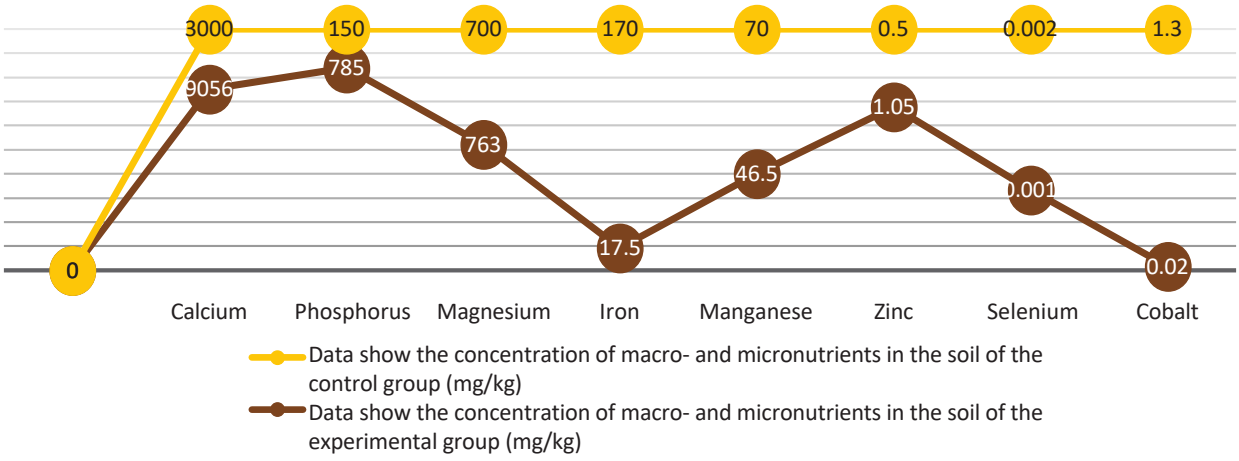

Figure 1. Content of macro- and micronutrients in the soil from the environment of experimental cows
Source: developed by the authors based on original research

Based on the data in Figure 1, it can be assumed that the levels of certain macro- and micronutrients in the soil of the environmentally compromised biogeocoenosis differ significantly from baseline values. For example, the concentrations of manganese, iron, cobalt, and selenium are considerably lower, whereas the levels of calcium, phosphorus, and magnesium are higher than the threshold concentrations. Figure 2 presents data on the macro- and micronutrient content in forage.

The concentrations of calcium and magnesium in the forage increased by 24.2% and 39.3%, respectively, compared with standard levels. However, other essential elements – phosphorus, iron, manganese, zinc, selenium,

and cobalt – were significantly lower than those found in the control samples within this biogeocoenosis.

Figure 3 presents data on the macro- and micronutrient content in the blood of the experimental cows.

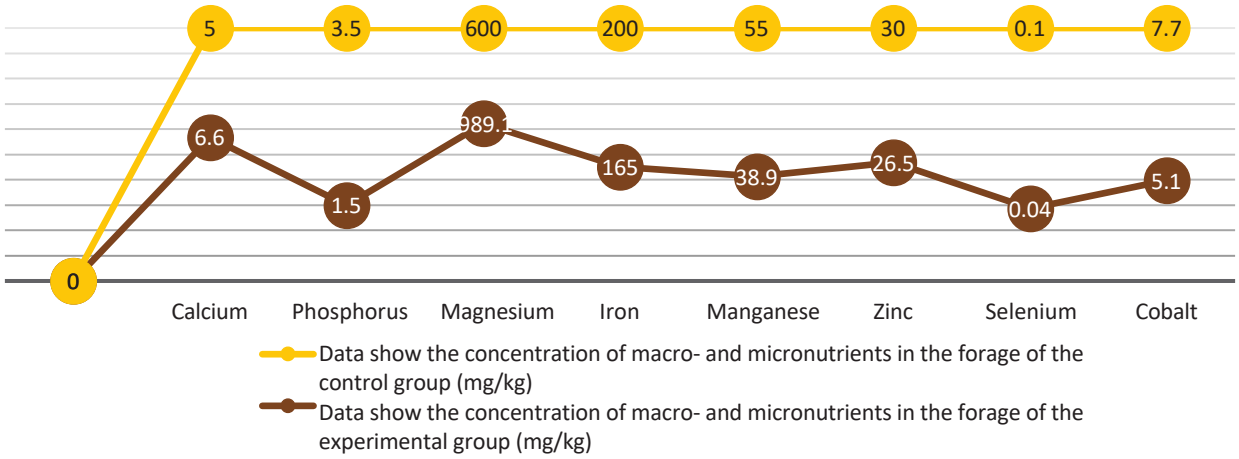

Figure 2. Content of macro- and micronutrients in the forage consumed by experimental cows
Source: developed by the authors based on original research

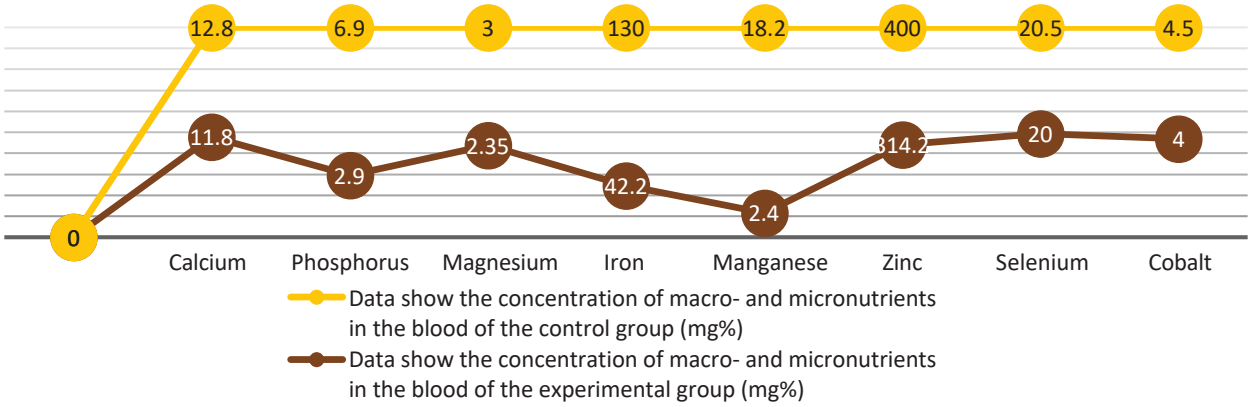

Figure 3. Content of macro- and micronutrients in the blood of the experimental cows
Source: developed by the authors based on original research

In the blood of the experimental cows, the total calcium level was at the lower limit of the physiological norm, while the phosphorus concentration decreased to 2.9 mg% compared with 6.9 mg% in the control group. This suggests a potential disruption in the calcium-to-phosphorus ratio (optimal ratio: 2:1). Furthermore, analysis of micronutrient levels in the blood indicates that nearly all values were significantly lower than those in the control group, pointing to impaired metabolism in the experimental cows (Urazaev, 2000; Elenshleger, 2003).

As noted by A. Sindreva (2012), E. Skorykh (2014), and G. Samoilenko *et al.* (2018), an imbalance of certain essential micronutrients in the "soil-plant-animal" system can lead to metabolic disorders in animals. Within the framework of this study, the authors examined the presence of toxic elements such as lead, mercury, cadmium, nickel, and arsenic in the soil, forage, and blood of the experimental cows. Similar studies were conducted in Kazakhstan by A. Farmer & A. Farmer (2000). According to the present findings, the average concentrations of heavy metals in the soil and forage did not exceed the maximum permissible levels. Only the concentration of arsenic in the soil exceeded the MPL by 0.1 mg/kg, while in plants it reached a peak value of 0.3 mg/kg compared to 0.25 mg/kg in the control samples. In the blood, no exceedance of the maximum permissible concentrations was observed for lead, mercury, cadmium, or nickel. However, the concentration of arsenic was found to be eight times higher, at 0.40 mg/L versus 0.05 mg/L in the control animals. The harmful effects of arsenic on both human and animal health have been reported by T. Abdulmutalimova *et al.* (2019).

Thus, the imbalance of macro- and micronutrients and heavy metals acts as an ecological factor in the "soil-forage-animal" system, affecting animal health (Gortázar *et al.*, 2007; Duskaev *et al.*, 2014; Gertman *et al.*, 2020). The results of the comparative analysis of the morphobiochemical composition of the blood in the experimental cows are presented in Figure 4.

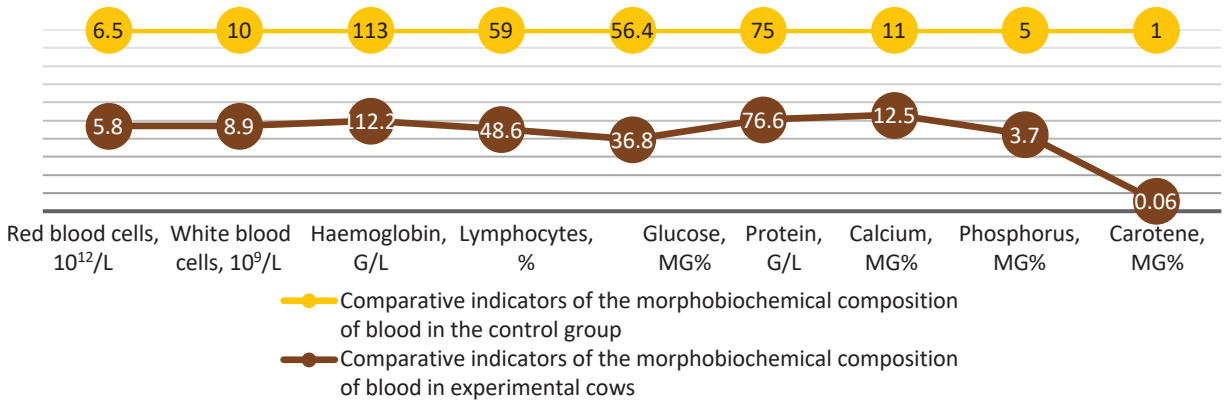

Figure 4. Comparative indicators of the morphobiochemical composition of blood in experimental cows
Source: developed by the authors based on original research

Based on the data presented in Figure 4, the number of erythrocytes decreased by 10.7%, white blood cells by 21.3%, haemoglobin by 12.0%, and lymphocytes by 17.6% ($P \leqslant 0.05$). Significant changes were also observed in glucose concentration (a decrease of 13.3%). Conversely, the level of calcium increased by 12.0%, while the levels of phosphorus, total protein, and carotene decreased by 19.2%, 6.5%, and 4.4%, respectively ($P \leqslant 0.05$). These findings are consistent with the results of previous studies by I. Shkuratova (2000), I. Donnik *et al.* (2012), and M. Nogoibaev *et al.* (2023).

The authors of this study concluded that, in order to optimise the ecosystem in Kyrgyzstan, it is essential to establish an innovative scientific-educational ecological centre for the protection of human and animal health. This centre should integrate existing, independently operating institutions into a unified, modern research and training hub capable of addressing key issues related to ecosystem optimisation in Kyrgyzstan. Its core mission would be the timely assessment of climatic and biogeocenotic (ecosystem) conditions, as well as the early detection of climate change. The centre is envisioned as a creative community of highly qualified specialists and researchers, founded on shared professional interests and committed to the humanistic values of education and science. In the long term, the effective operation of this innovative centre will require the training and involvement of highly skilled biogeocenologists.

Conclusions

In the environmentally compromised areas of the Chüy Region of Kyrgyzstan, an imbalance in the levels of macro- and micronutrients, as well as toxic elements, has been identified in the soil, forage plants, and the blood of Alatau breed cows used in the study. It was established that the quantities of essential macro- and micronutrients within the biogeochemical trophic food chain in the Chüy area differ significantly from baseline values, particularly in the calcium-to-phosphorus ratio. The average concentrations of toxic elements such as lead, mercury, cadmium, and nickel in the "soil-forageblood" system did not exceed the maximum permissible levels, except arsenic, which reached 0.40 mg/L compared to 0.05 mg/L in the control animals.

To ensure appropriate responses and early warning of ecosystem changes, it is necessary to establish an innovative scientific-educational ecological centre in Kyrgyzstan dedicated to the protection of human and animal health. Looking ahead, the authors of this study aim to continue indepth research on this issue across the country and on other animal species. As Kyrgyzstan is a highland country, climate change has become one of the most significant and persistent factors contributing to the emergence of various biogeocenotic pathologies in animals. While the climatic conditions of lowland regions have been thoroughly studied, the effects of climate change in other areas – such as Naryn, Issyk-Kul, Osh and Talas – remain insufficiently explored. In this regard, comprehensive climate research (including air and water conditions, temperature changes, wind speed, and other variables) is planned in the aforementioned regions of Kyrgyzstan. The authors also intend to carry out integrated monitoring of greenhouse gases, radionuclides, and other toxic substances within the "soil-water-air-plants-animals" system, and to investigate the decline in the quality of livestock and crop production. Experimental studies will include the manifestation of biogeocenotic pathologies in other animal species, such as sheep, goats, and their young. The practical value of this study lies in its status as the first comprehensive investigation into climate change in Kyrgyzstan and the levels of macro- and micronutrients and heavy (toxic) metals within the "soilplants (forage)-animals" system under conditions of environmental contamination in the Chüy Region. It also marks the first development and proposed implementation of the INUEC.

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Conflict of Interest
The authors declare no conflict of interest.

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Кыргызстандагы климаттын өзгөрүшү жана анын малдын биогеоценотикалык патологиясынын пайда болушуна тийгизген таасири

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Аннотация. Биогеоценоздук патология – бул жапырт түрдө жаныбарлардын гана эмес, адам менен өсүмдүктөрдүн да оорушу. Бул оорунун пайда болушу айлана-чөйрөдөгү жагымсыз өзгөрүүлөрдүн натыйжасында байкалат. Ушуга байланыштуу Кыргызстандын Чүй зонасынын экосистемасын өз убагында иликтөө, аны этиологиялык фактор катары карап чыгуу, ошондой эле ушул өзгөрүүлөрдүн натыйжасында пайда болгон ири мүйүздүү малдын патологияларын эрте аныктап, алдын алуу өзгөчө актуалдуулукка ээ болууда. Изилдөөнүн максаты – Чүй зонасындагы алатау породасындагы уйлардын биогеоценоздук патологиясын изилдөө, “топурак-өсүмдүк-жаныбар” системасы боюнча алардын курамындагы биогендик макро- жана микроэлементтердин, ошондой эле уулуу металдардын деңгээлин мониторинг кылуу жана Кыргызстандын экосистемасын оптималдаштыруу үчүн инновациялык экологиялык борборду түзүү боюнча сунуштарды иштеп чыгуу болду. Эксперименталдык тажрыйба үчүн стелдин экинчи жарымындагы алатау породасындагы уйлар колдонулду, ал эми айлана-чөйрөнүн негизги компоненти катары топурак менен өсүмдүктөр алынган. Топурак, өсүмдүк жана жаныбарлардын каны атомдук-эмиссиялык спектрофотометр аркылуу изилденди, ал эми тажрыйба жана көзөмөлдөгү уйлардын негизги метаболизм көрсөткүчтөрү бирдиктүү унификацияланган методдор боюнча аныкталды. Чүй облусунун жагымсыз зоналарында жайгашкан тажрыйбадагы уйлардын топурагынын, тоют өсүмдүктөрүнүн жана кандарынын анализинин натыйжасында макро-, микроэлементтер менен оор (уулуу) металлдардын мазмуну боюнча олуттуу дисбаланс аныкталды. Бул биохимиялык трофикалык чынжырдагы дисбаланс белгилүү бир биогеоценоздо – тактап айтканда, Кыргызстандын Чүй зонасында зат алмашуу процессинин бузулушуна алып келген, бул айрыкча ири өнөр жай ишканалары топтолгон райондордогу экологиялык абалдын бузулушу менен байланыштуу. Кыргызстанда экосистеманы өз убагында изилдөө максатында авторлор адам менен жаныбарлардын саламаттыгын коргоо боюнча инновациялык илимий-окуу экологиялык борборду түзүү сунушун иштеп чыгышкан. Бул изилдөөнүн жыйынтыктары медицинада, айыл чарбасында, ветеринардык медицинада, ошондой эле экология тармагында, окуу жана илимий мекемелерде пайдаланылышы мүмкүн

Негизги сөздөр: уй; топурак; өсүмдүк; кан; инновациялык илимий-окуу экологиялык борбор; уулуу металлдар

Изменение климата в Кыргызстане и его влияние на возникновение биогеоценотических патологий у животных

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Аннотация. Биогеоценотическая патология – это массовое заболевание не только животных, но и человека и растений. Данное заболевание проявляется вследствие неблагоприятных изменений в окружающей среде. В этой связи своевременное изучение экосистемы Чуйской зоны Кыргызстана как этиологический фактор, а также раннее предупреждение патологий у крупного рогатого скота, возникающих в результате этих изменений, приобрело особую актуальность. Целью исследования было изучение биогеоценотической патологии коров алатауский породы в Чуйской зоне, проведение мониторинга по системе «почва-растение-животное» на содержание в них биогенных макро- и микроэлементов, а также токсичных металлов, и разработка рекомендаций по созданию инновационного экологического центра для оптимизации экосистемы в Кыргызстане. Для экспериментального опыта использовали коров алатауской породы во второй половине стельности, а как основной компонент окружающей среды брали почву и растения. Почву, растения и кровь животных исследовали с помощью атомно-эмиссионного спектрофотометра, а исследование основных показателей метаболизма у опытных и контрольных коров проводилось по единым унифицированным методикам. В результате анализа почвы, кормовых растений и крови у подопытных коров, которые находились в неблагоприятных зонах Чуйской области, установлен серьезный дисбаланс по содержанию макро-, микроэлементов и тяжелых (токсичных) металлов. Такой дисбаланс в биохимической трофической цепи привел к изменению круговорота веществ в определенном биогеоценозе, т.е. в Чуйской зоне Кыргызстана, что связано с нарушением экологической обстановки, особенно в тех районах, где сосредоточены крупные промышленные предприятия. С целью своевременного изучения экосистемы в Кыргызстане авторами разработаны рекомендации по созданию инновационного научно-учебного экологического центра по охране здоровья человека и животных. Результаты данного исследования могут быть использованы в медицине, сельском хозяйстве, ветеринарной медицине, а также в сфере экологии, в учебных и научных учреждениях

Ключевые слова: корова; почва; растение; кровь; инновационный научно-учебный экологический центр; токсичные металлы