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Biochemical features of the influence of distribution and accumulation of heavy metals in the system "soil – plant food – poultry droppings" on the organism of broilers

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Abstract. The direct consequences of a complex of structural changes in the form of intensification, industrialization and geographic conditioning of heavy metals that can be utilized through soil destruction often lead to environmental problems and cyclically affect the food chain. In this regard, one of the most important areas of research in the field of poultry farming with the identification of chemical waste is the protection of environmental objects, namely the soil as an object characterized by the accumulative properties of heavy metals, which entail a number of consequences. The normal vital activity of a living organism requires an optimal amount of minerals with trace elements and heavy metals, which creates the need to monitor this cyclic system. The paper presents the results of a study of heavy metals from soil samples, samples of plant food, as well as poultry dung and the effect of their excess or deficiency on the biochemical parameters of the body of chickens. Pursuing the relevance of the content of heavy metals in objects eliminated by the body in the form of excrement, containing substances permeable to the entire body, today it is undergoing intensive study, since plant zones are an integral part of the food chain, accompanied by immuno-biochemical significance for the healthy state and development of birds.

1. Introduction

Today man extracts billions of tons of all kinds of ores, building materials and fuel from the earth; a certain share of the produced raw materials of which goes to waste, amenable to water and wind erosion, as a result of spraying in the atmosphere. The development of industrial enterprises, their intensity and concentration have led to a number of environmental problems [1]. In the process of poultry farming a large number of wastes is also reproduced, a significant part of which is of a metabolic character and contains various substances, including heavy metals. Domestic and foreign authors, such as L. Bondarenko, O. Maslow and B. Oleinikov, found that basically in all possible cases radionuclides come with food and enter the trophic chains "soil-plant food-organism", thereby penetrating into living organisms. About 5% of the radionuclides penetration into the body occurs due to aqueous solutions and only about 1% with oxygen passing through the respiratory tract [2].

Compound feeds that have a plant origin can accumulate heavy metals and be a transitional stage in the cycle of the trophic pyramid - soil - vegetation - poultry organism - droppings. Compound feeds



used as food show themselves as a basic source of import of heavy metals into the body of birds [3]. Analyzing various sources, it was noted that 40%-80% of heavy metals comes from plant sources, and only 20%-40% comes from the air-capillary pathway. Scientists have proven that there is a certain need for certain chemical elements for the body to function optimally. Deficiency of a number of elements, abundance or imbalance can cause microelement diseases, as well as cause natural or man-made biogeochemical endemia [4]. However, it should be noted that in addition to the industrial sector, a number of natural influences, such as climate, relief features of the area, the consistency of soil-forming rocks and characteristics of vegetation, have an effect on the level of heavy metals in soil samples [5].

2. Materials and methods

Bird droppings contain chemical compounds, including heavy metals that make up the structure of compound feed, which penetrate the body as a result of the intake of plant material directly obtained from the subsoil [6]. Therefore, the object of the study was poultry droppings, compound feed in the form of forage and soil fields located near the poultry enterprises of the city of Kostanay, as well as in areas remote from the main source of pollution in the form of industrial facilities, namely production and poultry farming. Since the soil is a sensitive monitoring indicator of the ecological state of the environment, which directly affects the biochemical state of the organism, the article discusses the concentration of heavy metals in the system "soil – plant food – poultry droppings". The proper soil sampling was carried out by the generally recognized envelope method at a depth of 10-20 cm in studies areas at a distance of 150, 500 and 1000 meters from the source of pollution production, "Zhas Kanat" broiler poultry farm in the city of Kostanay, from which samples of vegetable food and poultry droppings were taken. The quantitative and qualitative study of heavy metals such as Cu, As, Co, Pb, Cd, Hg, Cs and Sr in plant feed, poultry droppings and soils near the poultry farm was carried out. The analysis of the concentration of the mobile form of heavy metals in the composition of the samples under study was carried out at the air temperature of 220C and a relative atmospheric humidity of 65% according to GOST methods, for each object respectively [7]. In order to calculate the level of deficiency or excess, which causes contamination of the objects of study with mobile forms of heavy metals, the generally recognized normalized values of indicators close to neutral were used according to the determined indicators of samples, respectively [8].

3. Results

When analyzing the chemical composition of the studied objects, it was identified that the samples contain a certain amount of heavy metals. The dynamics of the concentration of heavy metals in plant food, soil and poultry droppings are shown in figure 1.

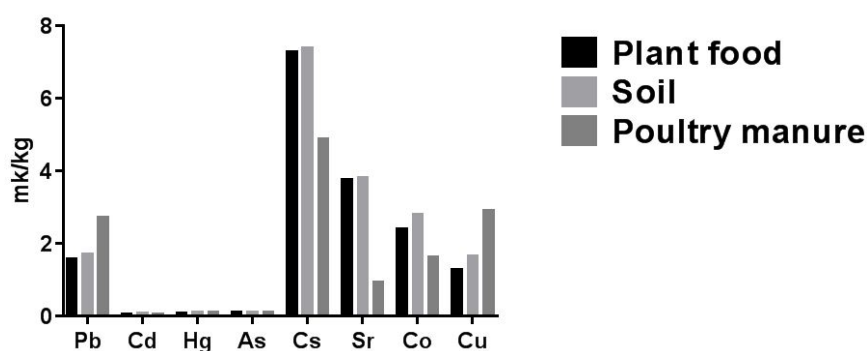


Figure 1.
Comparative analysis of heavy metals in soil, plant food and poultry droppings.

The comparative analysis (figure 1) of the data obtained on the indicators of the concentration of heavy metals in soil samples of plant food and poultry droppings revealed that a greater amount of the compounds of Cu, As, Pb, Co, Hg and Cs dominate in the soil composition, while the concentration

of Cd is higher in poultry droppings and Sr is higher in vegetable food. The dynamics of indicators of heavy metals in the soil with the reference concentrations of heavy metals in soils showed a decrease of cadmium and cobalt in the vegetation (figure 1). It should be emphasized that it is not a conglomerate of heavy metals which regulates a number of processes in the body, but an individually isolated heavy metal that carries out a certain system of activity typical for it [9].

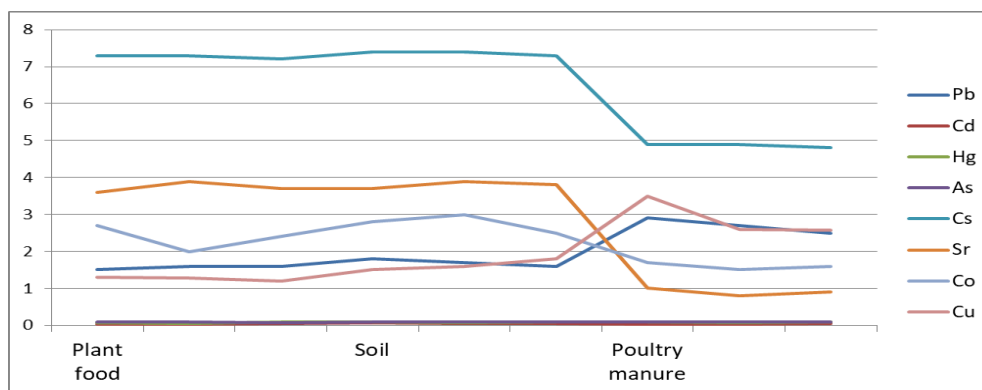


Figure 2. Dynamics of indicators of heavy metals in soil, plant food and poultry droppings.

Analyzing the dynamics of heavy metals accumulation (figure 2), it was found that the concentration of lead and strontium suffers a significant decrease in the composition of poultry droppings, and the level of cesium and copper, on the contrary, increases, while the highest dynamics of the level of cobalt is observed in the composition of the soil.

The saturated component of the study, removed by the body in the form of poultry droppings, is a permeable indicator through the entire body of chickens, capable of determining the excess or deficiency of minerals containing heavy metals, accompanied by immuno-biochemical significance for the normal state of vital activity of the whole organism [10].

Redox processes affecting the prolongation of the organism's vital activity, such as heat exchange, metabolism, bone formation, reproduction, respiration through tissues, growth and other biochemical features, which are characterized by the joint participation of microelements, are the processes under study [11]. For example, the functions of the gonads, as well as the metabolism of fats, proteins, carbohydrates and minerals, are directly affected by zinc [12]. The normal state of the thyroid gland and the activity of the pituitary gland are determined by the normative level of bromine. It should be noted that nickel deficiency causes a long period of bird growth, damage to the hematopoietic system, and deformed metabolism of zinc, iron and copper. Abnormal generation of enchondral ossification and collagen results from insufficient nickel levels in the body [13].

4. Discussion

Analyzing the concentration of the mobile form of heavy metals in the soil, it was found that the concentration of salts of heavy metals such as cobalt, cesium, strontium and cadmium in the soil samples were superior to other analyzed samples. Consequently, the content of Co, Cs, Sr and Cd was recorded, where their concentration was 2.76 ± 0.144 mg / kg, 7.36 ± 0.032 mg/kg, 3.8 ± 0.057 mg/kg and 0.05 ± 0.003 mg/kg, respectively (table 1), which does not exceed the levels of maximum permissible concentration.

Thus, the level of lead (table 1) in soil samples, plant food and poultry droppings was 1.7 ± 0.057 mg/kg, 1.56 ± 0.032 mg/kg and 2.7 ± 0.115 mg / kg, respectively, and it is at the bottom the turn of the optimal level for plant feed. Lead has the ability to accumulate on bone materials, thereby accelerating their gradual deformation, accumulate in the kidneys and liver, causing chronic brain pathologies and memory impairment, which slows down the functions of the processes necessary for the activity of a healthy organism [14].

Table 1. The content of heavy elements in the samples of compound feed, poultry droppings and soil near the poultry enterprises of the city of Kostanay (mg/kg; n = 3).

| No | Indicators | Plant feed (compound feed) | Soil | Poultry droppings |
|----|---------------|----------------------------|-------------|-------------------|
| 1 | Pb | 1.56±0.032 | 1.7±0.057 | 2.7±0.115 |
| 2 | Cd | 0.03±0.003 | 0.05±0.003 | 0.03±0.003 |
| 3 | Hg | 0.066±0.008 | 0.08±0.005 | 0.08±0.005 |
| 4 | As | 0.08±0.0009 | 0.085±0.002 | 0.082±0.0009 |
| 5 | Cs-137. bq/kg | 7.26±0.032 | 7.36±0.032 | 4.86±0.032 |
| 6 | Sr-90. bq/kg | 3.8±0.057 | 3.8±0.057 | 3.8±0.057 |
| 7 | Co | 2.36±0.132 | 2.76±0.144 | 1.6±0.057 |
| 8 | Cu | 1.26±0.132 | 1.63±0.087 | 2.89±0.304 |

The accumulation of arsenic in the samples of plant food and soils was 25 times and 23.5 times lower than the optimal indicators, thereby making up -4% and -4.25% of the optimal indicators, respectively, for the samples (table 1). It should be taken into account that arsenic deficiency in the body of birds inhibits the growth of young chickens, deforming the process that synthesizes proteins, and increases the level of uric acid in the plasma of the animal body.

In the studied samples of plant food, soil and poultry droppings, it was recorded that the concentration of cadmium is below the optimal values by -6%, -10% and -1.5%, while the level of cobalt is -47.2%, 55.2% and 32%, respectively, for samples. It should be noted that the optimal content of cadmium ensures the normal biochemical state of the body, avoiding diseases such as anemia, impaired lung function, liver deformity, osteoporosis, skeletal disorders, hypertension and others. It is known that cobalt plays an important role in the activity of systemic hemodynamics and blood pressure, which undoubtedly emphasizes the importance of compliance of its level indicators in the body with the reference norms [15].

The concentration of mercury in samples of plant food, soil and poultry droppings was 0.066 ± 0.008 mg/kg, 0.08 ± 0.005 mg/kg and 0.08 ± 0.005 mg/kg, respectively, according to the samples, and is at a significantly lower boundary of the optimal value for the organism levels by -66%, -3.8% and -3.9%. It is known that mercury is involved in the activation of certain enzymes, such as carboxypeptidase, carbonic anhydrase, and alkaline phosphatase.

The copper concentration (table 1) on all three objects of study is uneven, 1.26 ± 0.132 mg/kg in samples of plant food, which is lower than the optimal value by -42%, 1.63 ± 0.087 mg/kg (-54.3%) and 2.89 ± 0.304 mg/kg (-2.1%) in soil samples and poultry droppings, respectively. It should be noted that an integral part of the body's activity is redox reactions, directly dependent on the level of iron and copper, which also predetermine the process of hematopoiesis.

5. Conclusion

The above analysis of the research data and their comparison with the acceptable levels of heavy metals in poultry droppings has shown that there is a decrease in the permeability of cesium and strontium. Thus, the concentration of cesium and strontium is 4.86 ± 0.032 bq/kg and 0.9 ± 0.057 bq/kg, respectively, being on the minimum side of the level which is optimal for the body of birds.

In the course of the study, in the cycle soil - plant food - poultry droppings inhibition of arsenic 0.085 ± 0.002 mg/kg, 0.08 ± 0.0009 mg/kg and 0.082 ± 0.0009 mg/kg, cesium 7.36 ± 0.032 mg/kg, 7.26 ± 0.032 mg/kg and 4.86 ± 0.032 mg / kg, strontium 3.8 ± 0.057 mg / kg, 3.8 ± 0.057 mg / kg and 3.8 ± 0.057 mg/kg, as well as cobalt 2.36 ± 0.132 mg/kg, 2.76 ± 0.144 mg/kg and 1.6 ± 0.057 mg/kg, respectively, which indicates the distribution of a certain amount of heavy metals in plant materials and in the body that uses plant feed as food, which ensures the natural functioning of physiological activities metabolism in the body of birds.

Ecological and economic monitoring of the selected areas near the broiler poultry farm "Zhas Kanat" in the city of Kostanay confirms that in the system "soil – plant food - bird droppings" there is

a minimum impact of anthropogenic and technogenic nature on natural objects where there is a presence of various species insects, microorganisms, as well as other types of natural self-healing, contributing to the maintenance of environmental safety. However, there is a need to take into account the conditions of mineral metabolism, since a significant amount of mineral compounds, including compounds of heavy metals, in proper proportions take part in membrane permeabilities, enzymatic activation, energy supply of the body, while the loss of balance equilibrium of these elements leads to pathology in metabolic processes. Heavy metals contribute to the process of photosynthesis, support the synthesis of proteins, carbohydrates, vitamins and starch, and also promote the absorption of trace elements, such as nitrogen, as well as being present in biochemical processes, they are a vital component for the normal functioning of the living organism of animals, including birds.

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