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## Monitoring of Heavy Metals in Fodder and Animal Husbandry Products of the Polissia Zone of Ukraine

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**Abstract.** With a significant concentration of pollutants in the environment, they accumulate in plants, the feeding of which will lead to the transfer of toxic elements to the animal's body. Even a small concentration of heavy metals or radionuclides adversely affects both the animal and human bodies. Therefore, the monitoring of Pb and Cd in feed, milk, and meat during their production in the territory of the Polissia zone of Ukraine is relevant and requires further comprehensive study. The purpose of this study was to investigate the content of heavy metals in feed and slaughter products of animals raised in the Polissia zone with various levels of radioactive contamination. The research was carried out on young pigs and steers, which were put to fattening. The paper used the atomic absorption method for determining the content of toxicants in samples and the method of variation statistics for processing the results of the study. The results of studies of the content of Pb and Cd in the samples indicate the presence of substantial fluctuations in heavy metals within individual farms. As the level of <sup>137</sup>Cs soil contamination increases, the concentration of toxicants in feed, milk, and the longest back muscle of the animals under study increases. Exceeding of the maximum permissible concentration of Pb in milk (33.8%) and Cd (41.2%) was established. The concentration of Cd exceeded the established level in 72.2% of the examined samples of the longest back muscle of cattle and 80.0% of the samples of the longest back muscle of pigs. The Cd content in all feed samples under study was considerably higher than the established norm. The greatest excess of the toxicant was found in samples of hay, straw (41.9%), cake and meal (60%). Thus, indicators of the quality of feed and livestock products produced in the farms of the Polissia zone of Zhytomyr Oblast, affected by the accident at the Chernobyl Nuclear Power Plant, indicate that the concentration of Pb and Cd in the milk of dairy cows, muscle tissue of young cattle and pigs in most of the analysed sample exceeds sanitary and hygienic requirements. Therefore, to obtain milk and meat within the limits of current regulatory requirements, reducing the accumulation of heavy metals in feed for feeding animals and poultry stays a topical issue

**Keywords:** Lead, Cadmium, concentration, pollution, milk, the longest back muscle



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## INTRODUCTION

Ukraine still feels the consequences of the explosion at the Chernobyl Nuclear Power Plant to this day. In the 36 years that have passed since this terrible accident, many studies have been conducted to find the level of radiation pollution in the affected areas and to establish ways to reduce the impact of radiation on the body of animals and people. Minimisation of the consequences of an accident in the agricultural sphere on territories contaminated with radionuclides, which includes the implementation of radioprotective measures in crop and animal husbandry, is one of the main elements of the radiation safety system (Hudkov & Lazariev, 2018; Landin *et al.*, 2017; Romanchuk *et al.*, 2019). Therefore, one of the priority tasks of modern radioecological science is the systematic control of  $^{137}\text{Cs}$  and  $^{90}\text{Sr}$  contamination of plant and animal products and the study of the specific features of their migration in agricultural ecosystems.

Even today, a significant area of the Ukrainian Polissia zone is contaminated with radionuclides after the Chernobyl Nuclear Power Plant explosion. There are still cases of prominent levels of contamination with  $^{137}\text{Cs}$  and  $^{90}\text{Sr}$  isotopes of soil samples, feed crops, agricultural products, products of animal origin, etc. At the same time, in this zone, the development of industrial and intensive agricultural production led to an increase in the concentration of heavy metals in the agricultural landscape, which led to a disturbance in the ecosystem balance (Razanov *et al.*, 2022; Peng *et al.*, 2015a). An increase in the number of sick, weakened animals is an indicator of a violation of metabolic processes in the body. Upon feeding farm animals with feed contaminated with heavy metals, increasingly more harmful components gradually accumulate in their bodies, leading to a decrease in productivity and product quality (Peng *et al.*, 2015b; Martyshuk *et al.*, 2019; Zinko, 2017).

According to the authors' reports (Wang *et al.*, 2018), heavy metals of high toxicity – Pb, Cd, Hg, As, Se, F, Zn – pose a special danger to farm animals and humans. Referring to the results of research by WHO experts, including other international organisations, Pb is the largest environmental toxicant. Due to its high biological activity, lead can accumulate in all internal organs and tissues of animals and poultry (Trakhtenberg *et al.*, 2015). The reason for such distribution of this metal in the natural environment is the rather wide scope of its application and use. At its blood concentration of 200-400  $\mu\text{g}/\text{l}$ , people may develop signs of poisoning (Yabe *et al.*, 2015).

Cadmium is a natural heavy metal, one of the most toxic elements, it belongs to class II hazardous substances (Chen *et al.*, 2019; Lavryshyn *et al.*, 2018). Cd enters the body of animals mainly with feed and water, accumulates in tubular bones, pancreas, spleen and, above all, in the liver and especially in the kidneys, while the half-life of Cd from the body is from 10 to 30 years (Lavryshyn *et al.*, 2018). Upon reaching a significant

concentration in the body, Cd can affect the nervous system, as well as cause pathological changes in the tissues of organs (kidneys, lungs, bone tissue, organs of the reproductive and endocrine systems), suppressing the erythropoiesis (Peng *et al.*, 2015a; Ostapyuk & Gutyj, 2019). Namely, under the action of Cd, a decrease in functional activity was observed in bone marrow blood cells (CFU-E). Upon long-term cadmium feeding, an increase in the number of micronuclei in the bone marrow cells of animals was observed. This is what causes damage to DNA molecules. Cadmium, due to its high coefficient of biological accumulation, adversely affects the health and condition of animals (Ostapyuk & Gutyj, 2020; Knoell & Wyatt, 2021). The main danger of Cd is determined by long-term exposure to animal health, since it has a high coefficient of biological accumulation (up to 40 years) (Lavryshyn & Gutyj, 2019).

Recently, the accumulation of heavy metals and their hazardous compounds in the Ukrainian environment has increased several times, especially after the Chernobyl accident (Razanov & Kabachenko, 2018; Savchenko *et al.*, 2017). Environmental consequences of the use of mineral fertilisers and pesticides in violation of regulatory requirements adversely affect agroecosystems. The intensification of conventional agriculture not only in Ukraine, but also in the countries of the European Union, the development of industry in large cities increase the anthropogenic burden on the environment (Bigalke *et al.*, 2017). The entry of heavy metals into the soil, even in small concentrations, leads to their accumulation in feed in considerable quantities, feeding which to farm animals can lead to the production of livestock products with an increased content of dangerous pollutants, and therefore raw materials for food production (Mamenko & Portiannyk, 2019; Aloud *et al.*, 2022).

According to the results of research by international authors, it was found that when using feed for feeding animals that were grown in industrially developed areas, the concentration of Pb and Cd in muscle tissue and by-products turned out to be much higher compared to similar indicators of animals from ecologically clean zones (Caldasa *et al.*, 2016; Pilarczyk, 2014; Hashemi, 2018). Furthermore, it is known from literature sources that contaminated feed is the main source of heavy metals entering the animal body, and therefore in 99% of cases it is feed that is the source of danger (Satarug *et al.*, 2017; Heina *et al.*, 2019). Heavy metals decompose in the environment and accumulate in the tissues and organs of living organisms. Their main danger lies in the ability to accumulate in human food products, including products of animal origin (Wang *et al.*, 2018).

Since heavy metals are characterised by significant stability, pronounced cumulative properties, and a negative effect on the internal organs and systems of animals, the need to monitor them in feed and livestock products deserves attention. *The purpose of this*

study was to identify the content of Pb and Cd in feed, milk, and muscle tissue of cattle and pigs, which are produced in farms of the Polissia zone at various levels of radioactive contamination of the territory as a result of the accident at the Chernobyl Nuclear Power Plant.

### MATERIALS AND METHODS

Heavy metal contamination of feed and milk of dairy cows during stall keeping was monitored in agricultural

enterprises of the Zhytomyr Oblast with a level of contamination of the territory with radioactive caesium from 0.1 to 15 Ki/km<sup>2</sup>: up to 1 Ki/km<sup>2</sup> – DPDG “Nova Peremoha” of Liubarskyi and PAF “Yerchyky” of Popilnianskyi districts; 1-5 Ki/km<sup>2</sup> – experimental field and physiological yard of the PIRE of the NAAS of Ukraine, Korostenskyi district; above 5 Ki/km<sup>2</sup> – WWTP “Vidrodzhennia” of Korostenskyi and FG “Kavetskoho” of Narodytskyi districts (Table 1).

**Table 1.** Scheme of sampling of feed and whole milk in farms of Zhytomyr Oblast

Group No.	Agricultural land contamination density ( <sup>137</sup> Cs)	Farm name	Location	Number of samples taken, pcs.	
				Feed	Milk
1	Up to 1 Ki/km <sup>2</sup>	SE EF “Nova Peremoha” of the PIRE of the NAAS	Liubarskyi district, village of St. Chortoryia	41	12
		PAF “Yerchyky”	Popilnianskyi district, village of Yerchyky	30	12
2	1-5 Ki/km <sup>2</sup>	physiological yard of the PIRE of the NAAS of Ukraine	Korostenskyi district, village of Hrozyne	60	18
3	Over 5 Ki/km <sup>2</sup>	Vidrodzhennia ALLC	Korostenskyi district, village of Kupech	19	8
		Kavetskoho Farming	Narodytskyi district, village of Noryntsi	19	18

Experimental studies on full-aged dairy cows were conducted in the winter-stable period of 2020-2021. The experimental cows were fed three times a day, the rations included cereal hay and alfalfa, barley straw, forage and alfalfa hay, corn and forage silage, grain mixture, sunflower cake and meal. The animals' feeding diets were balanced in terms of basic nutrients.

Pb and Cd contamination of pig and steer meat was also monitored in the territories with different levels

of <sup>137</sup>Cs contamination according to the following scheme (Table 2). Feeding of animals in private farms was provided at the expense of feed grown on household plots and the territory of the community. Young pigs were fed various grain mixtures, wheat bran, boiled potatoes, fodder beets, pumpkins. The diet of steers included cereal hay, oat straw, cereal grain, fodder beet was used as juicy feed. Feeding of experimental animals in private sector farms was twofold – in the morning and in the evening.

**Table 2.** Scheme of sampling of the longest back muscle of experimental animals in private subsidiary farms of Zhytomyr Oblast

No. groups	Agricultural land contamination density ( <sup>137</sup> Cs)	Locality	District	Number of samples taken of the longest back muscle, pcs.	
				Steers	Young pigs
1	Up to 1 Ki/km <sup>2</sup>	Village of Mala Derevychka	Liubarskyi	4	3
		Urban-type settlement of Liubar	Liubarskyi	5	4
		Village of Yerchyky	Popilnianskyi	4	4
		Village of Pochuiky	Popilnianskyi	5	3
2	1-5 Ki/km <sup>2</sup>	Village of Nemyrivka	Korostenskyi	3	3
		Village of Synhai	Korostenskyi	3	3
		Village of Hrozyne	Korostenskyi	6	3
		Physiological courtyard of the Institute	Korostenskyi	6	3
3	Over 5 Ki/km <sup>2</sup>	Urban-type settlement of Narodychi	Narodytskyi	–	2
		Village of Lasky	Narodytskyi	–	2
		Village of Hrystynivka	Narodytskyi	–	3
		Village of Kupech	Korostenskyi	–	2

Feed sampling was carried out according to DSTU ISO 6497:2005 (2005), milk – DSTU ISO 707:2002 (2003), muscle tissue – according to DSTU 7992:2015 (2015).

Samples of the longest back muscle of pigs at the age of 10-12 months were taken for laboratory analyses. The age of steers upon slaughtering and selecting the longest back muscle of steers for further studies was 18-20 months, the weight of the selected meat samples was 1 kg. The samples were packed in thick plastic bags with a zip. The bags were tagged, indicating the place of sampling, the code of the sample, and the age of the animals. Milk from dairy cows was taken after morning milking in sterile glass jars with labels. The volume of milk samples taken for the study was 1 litre. Each container was labelled, indicating the place of selection, time of selection, and sample number.

Feed samples from farms were taken in plastic bags with labels with the name of the farm, the name of the feed, and the date of selection. The average weight of the feed sample for the studies was 1.5 kg. The selected samples were delivered to the site of further research on the day of selection.

Laboratory studies of milk, animal muscle tissue and fodder for Pb and Cd content were carried out in the laboratory of ecological safety of land, environment, and product quality of the Zhytomyr branch of the state institution “Institute of Soil Protection of Ukraine”. The content of heavy metals was determined according to the atomic absorption method per DSTU 7670:2014 (2015), the analysis was carried out on the atomic absorption spectrophotometer “Kvant – 2A”.

The method of variational statistics was applied based on the calculation of the arithmetic mean (M), the root-mean-square error (m) and the reliability of the difference between comparative indicators (P) and the materials of the conducted studies were processed (Ruban *et al.*, 2020).

All manipulations with animals were carried out according to the European Convention for the Protection of Vertebrate Animals Used for Experimental and Scientific Purposes, as well as the Law of Ukraine “On the Protection of Animals from Cruelty and the Procedure for Conducting Experiments and Experiments on Animals by Scientific Institutions” (European Convention for the Protection..., 1986; Law of Ukraine No. 3447-I..., 2006; Order of the Ministry of Education..., 2012).

## RESULTS AND DISCUSSION

Studies of the content of heavy metals in the feed-animal-livestock products trophic chain in different biogeochemical provinces of Ukraine are relevant and necessary in view of clarifying their distribution in the environment, investigating the biogenic migration of pollutants and accumulation in livestock products.

The content of heavy metals in feed included in the animal feeding diet can cause chronic intoxication of the body, accumulation of pollutants in organs and tissues, migration to milk and meat (Tóth *et al.*, 2016). Studies conducted in farms of the Polissia zone of Ukraine indicate that the content of Pb and Cd in feed substantially depends on their type (Table 3).

**Table 3.** Concentration of heavy metals in feed, mg per 1 kg of natural feed

Feed	Heavy metals					
	Pb			Cd		
	n	M ± m	% of samples above MPC	n	M±m	% of samples above MPC
Grain and legume hay, winter straw	43	2.462±0.134	0	43	0.323±0.023	41.9
Alfalfa and mixed grass haylage	24	1.201±0.075	0	24	0.179±0.017	8.3
Corn and mixed grass silage	31	0.768±0.077	0	31	0.091±0.014	6.4
Grain mix	46	1.084±0.086	0	40	0.186±0.016	10.0
Sunflower cake and meal	25	1.639±0.134	0	25	0.478±0.053	60.0
Maximum permissible concentration (MPC)	x	5.0	x	x	0.3	x

**Source:** results of the authors' research

For the most part, the highest concentration of Pb is determined in soils located along highways. Within a radius of 200 m from the roadway, the level of contamination reaches 100-1000 mg/kg. Considering the above data, it is safe to say that plants grown on soils near highways contain a considerable amount of heavy metal. According to

the conducted studies, it was found that of all the surveyed feeds, coarse feed accumulates the most Pb – hay of cereals and legumes and straw of winter crops (2,462 mg/kg). Sunflower cake and meal imported to the farms of the Polissia zone also contain a significant amount of this element – 1,639 mg/kg. In other feeds, the Pb content

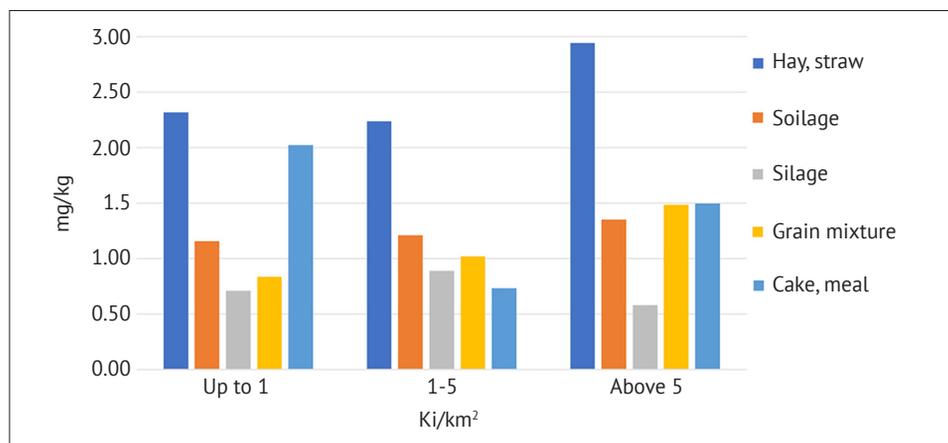
varies from 0.768 mg/kg (corn silage and mixed grasses) to 1.201 mg/kg (alfalfa hay and mixed grasses). Notably, none of the analysed feed types exceeds the maximum permissible concentration (5.0 mg/kg) for this element.

Sources of cadmium ingress into the soil are products of diesel fuel combustion, ore smelting, and various fertilisers. The accumulation of Cd in products of plant origin, in geochemical provinces, is from ones to tens of mg/kg, more often this indicator does not exceed 100-180 mg/kg (Shevchuk *et al.*, 2021).

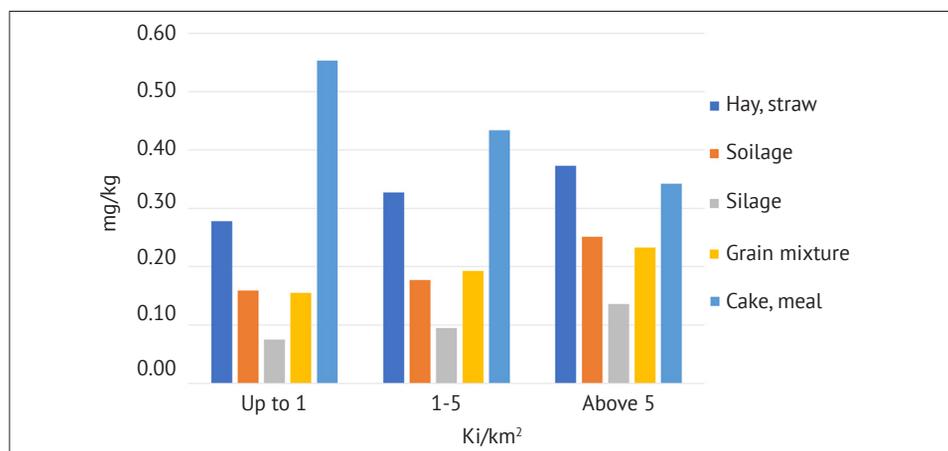
The highest Cd concentration was found in sunflower cake and meal – 0.478 mg/kg. Furthermore, 60% of samples of this type of feed exceeded the maximum permissible concentration for this metal. A substantial accumulation of Cd in hay and straw was found – 0.323 mg/kg. Moreover, 41.9% of the analysed coarse feed samples in terms of Cd content were higher than

the regulatory requirements (0.3 mg/kg). The average concentration of Cd in silage, hay, and grain mixture was 0.091 mg/kg, 0.179 mg/kg, and 0.186 mg/kg, respectively. Currently, these feeds also contain samples that exceed the maximum permissible concentration for this heavy metal: 6.4% in corn and mixed grass silage, 8.3% in alfalfa and mixed grass hay, and 10.0% in grain mixes. The high Cd content in feed can be explained by the considerable introduction of phosphate and potash fertilisers into the soil. Thus, according to Bondareva *et al.* (2012), with phosphate fertilisers, 3-4 g/ha of Cd is applied to the soil annually.

To establish the accumulation of heavy metals (Pb, Cd) in feed, they were researched in farms of the Polissia zone of Ukraine depending on the level of radioactive contamination of the territory by  $^{137}\text{Cs}$ : up to 1 Ki/km<sup>2</sup>, 1-5 Ki/km<sup>2</sup> and above 5 Ki/km<sup>2</sup> (Figs. 1; 2).



**Figure 1.** The Pb content in feed depending on the density of radioactive contamination of the territory with  $^{137}\text{Cs}$



**Figure 2.** The Cd content in feed depending on the density of radioactive contamination of the territory with  $^{137}\text{Cs}$

A clear pattern was established between the content of Pb in feed and the density of radioactive contamination of the territory – with an increase in the level of soil contamination by  $^{137}\text{Cs}$ , the concentration of the heavy metal increases in roughage from 2.317

to 2.942 mg/kg (by 27.0%,  $P>0.95$ ), hay – from 1.155 to 1.351 mg/kg (by 17.0%,  $P<0.95$ ), grain mixtures – from 0.834 to 1.484 mg/kg (by 77.9%,  $P>0.95$ ). At the same time, the lowest Pb content in silage was found in farms with the maximum level of radioactive contamination of

the territory with  $^{137}\text{Cs}$  (0.579 mg/kg), and the highest (0.889 mg/kg) in farms with a soil contamination level of 1-5 Ki/km<sup>2</sup>. The concentration of Pb in sunflower cake and meal varied from 0.733 to 2.023 mg/kg and did not depend on the density of radioactive  $^{137}\text{Cs}$  contamination of the territory.

An even more direct relationship was established between the content of Cd in feed and the density of radioactive contamination of the territory with  $^{137}\text{Cs}$  (Fig. 2). Thus, with an increase in the level of soil contamination with radioactive caesium from 1 to 5 Ki/km<sup>2</sup> and more, the concentration of the element in feed increases (except for sunflower cake and meal): in hay and straw – from 0.278 to 0.373 mg/kg, or by 34.2%, hay – from 0.159 to 0.251 mg/kg, or by 57.9%, silage – from 0.075 to 0.136 mg/kg, or by 81.3%, in grain mixture – from 0.155 to 0.233 mg/kg, or by 50.3% with a statistically significant difference ( $P>0.95$ ). An inverse linear relationship

was established for the content of Cd in sunflower cake and meal and the level of  $^{137}\text{Cs}$  soil contamination – the concentration of the element decreases from 0.553 to 0.342 mg/kg, or by 38.2%. This is probably due to the import of these high-protein feeds to the farms of Zhytomyr Oblast from processing enterprises of Ukraine using various technologies of their preparation.

Thus, to obtain environmentally safe livestock products, it is urgent to control the content of harmful substances in crop products and feed. With a high content of pollutants in feed rations, the risk of their accumulation in the body of animals and milk and meat above sanitary and hygienic requirements increases (Order of the Ministry of Health of Ukraine No. 368, 2013).

According to the conducted studies, it was established that livestock products produced in Zhytomyr Oblast farms are also heavily contaminated with heavy metals (Table 4).

**Table 4.** Pb and Cd content in animal milk and muscle tissue, mg/kg

Products	Heavy metals					
	Pb			Cd		
	n	M±m	% of samples above MPC	n	M±m	% of samples above MPC
Milk	68	0.145±0.008	33.8	68	0.027±0.001	41.2
Maximum permissible concentration	x	0.10	x	x	0.03	x
The longest back muscle of steers	36	0.239±0.011	0	36	0.074±0.007	72.2
Longest back muscle of pigs	35	0.232±0.008	0	35	0.061±0.002	80.0
Maximum permissible concentration (MPC)	x	0.5	x	x	0.05	x

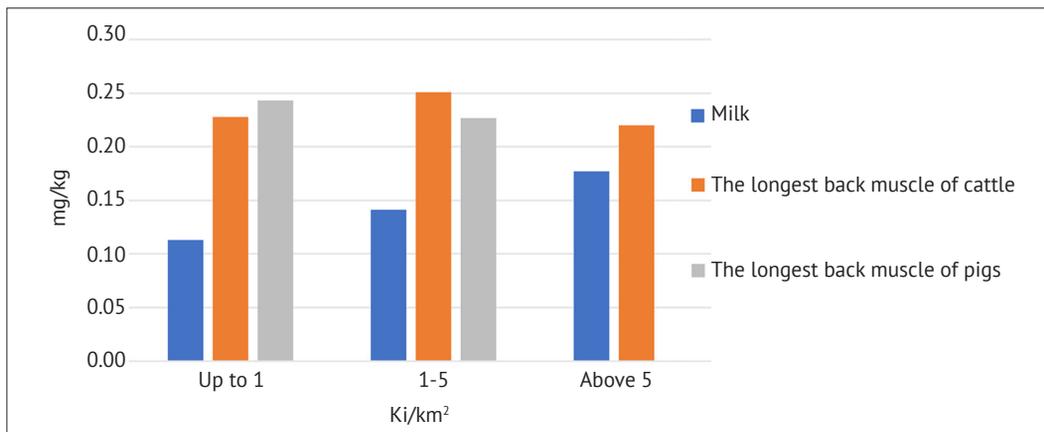
Thus, when examining 68 samples of cow's milk, it was found that the maximum permissible concentration of Pb in milk exceeded 1.45 times, as a result of which 33.8% of products for this element were higher than sanitary and hygienic requirements. On average, the Cd content in cow's milk was 0.027 mg/kg, which is lower than the maximum permissible concentration, but 41.2% of milk samples were higher than this indicator.

The longest back muscle of steers and pigs, compared to milk, is slightly less polluted with Pb – 0.239 mg/kg and 0.232 mg/kg, respectively, which does not exceed the maximum permissible concentration. At the same time, Cd accumulation in the muscle tissue of steers and pigs is quite high – 0.074 mg/kg and 0.061 mg/kg, respectively, which is 1.48 and 1.22 times

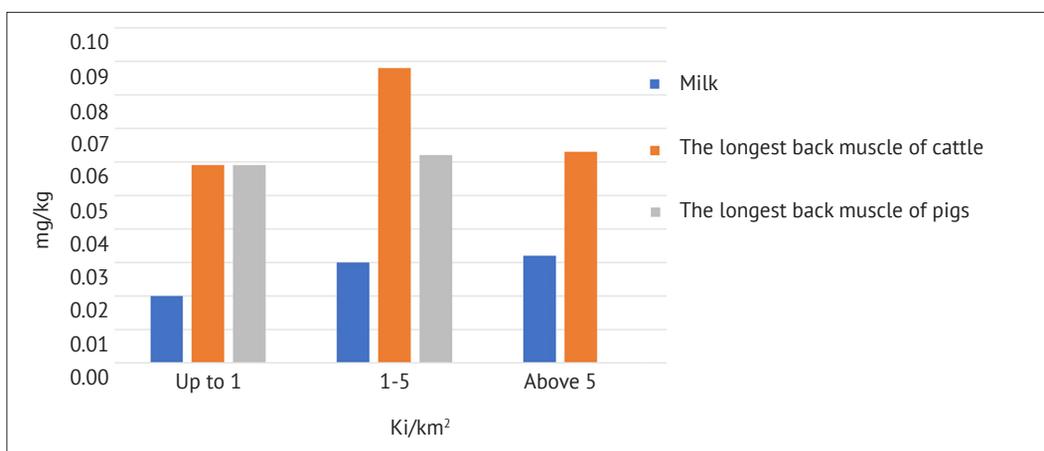
higher than the maximum permissible concentration. Furthermore, 72.2% and 80.0% of samples of the longest back muscle in cattle and pigs exceeded the regulatory requirements for Cd content in products.

According to the data obtained, cow's milk produced in the farms of Polissia of Ukraine contains a considerable amount of both Pb and Cd, and the muscle tissue of cattle and pigs is characterised by a high concentration of Cd.

The content of heavy metals in the milk of cows in the winter-stalling period, beef, and pork during their production in the farms of Zhytomyr Oblast at various levels of radioactive contamination of the territory with  $^{137}\text{Cs}$  was analysed: up to 1 Ki/km<sup>2</sup>, 1-5 and above 5 Ki/km<sup>2</sup> (Figs. 3; 4).



**Figure 3.** Accumulation of Pb in livestock products, depending on the density of radioactive contamination of the territory with <sup>137</sup>Cs



**Figure 4.** Accumulation of Cd in livestock products, depending on the density of radioactive contamination of the territory with <sup>137</sup>Cs

According to the given data, the highest content of Pb was noted in the milk of dairy cows kept in farms with the highest level of radioactive contamination of the territory with <sup>137</sup>Cs (above 5 Ki/km<sup>2</sup>) – 0.177 mg/kg. According to this indicator, they predominate animals from other groups by 0.036-0.064 mg/kg, or by 1.25-1.57 times with a highly reliable difference ( $P > 0.999$ ). Furthermore, 96.1% of milk samples from cows in this group exceeded the maximum permissible concentration for Pb content.

With an increase in the level of soil contamination with radioactive caesium, the concentration of Pb in the longest back muscle of steers also increases – from 0.228 to 0.251 mg/kg, or by 10.1% ( $p < 0.95$ ), while in the muscle tissue of pigs, the content of the element decreases from 0.243 to 0.220 mg/kg, or by 9.5%. This can be explained by different technologies of feeding young pigs in the farms of the forest-steppe and Polissia zones of Zhytomyr Oblast.

As the density of radioactive <sup>137</sup>Cs contamination of the territory increases from 1 to 5 Ki/km<sup>2</sup> and more, the content of Cd in livestock products also increases: in milk – from 0.020 to 0.032 mg/kg, or 1.60 times ( $P > 0.999$ );

in the longest back muscle of steers – from 0.059 to 0.088 mg/kg, or 1.49 times ( $P > 0.95$ ); in the longest back muscle of pigs – from 0.059 to 0.063 mg/kg, or 1.07 times ( $P < 0.95$ ) (Figure 4).

Thus, the analysis of the ecological quality of livestock products produced in the farms of the Polissia zone of Zhytomyr Oblast, affected by the accident at the Chernobyl Nuclear Power Plant, proved that the concentration of Pb and Cd in the milk of dairy cows, muscle tissue of young cattle and pigs in most of the analysed samples exceeds sanitary and hygienic requirements. Therefore, for the production of milk and meat within the current regulatory requirements, reducing the accumulation of heavy metals in animal feed remains an urgent issue.

The results obtained are consistent with the data of other researchers who have investigated the ability of heavy metals to accumulate in pig organs and tissues (Zhukorskyi et al., 2018; Savchuk et al., 2021). According to their data, the presence of heavy metals in feed rations 10 times higher than the maximum allowable level leads to the accumulation of Pb and Cd mainly in the bones, liver, kidneys, and meat of animals. According to other authors, the Cd content in the liver of geese

exceeded the maximum permissible concentration by 8 times (Razanov & Voitko, 2017). Other studies found that upon fattening steers for meat within the territory belonging to Zone III of radioactive contamination, the accumulation of Pb in muscle tissue did not exceed regulatory requirements and amounted to 0.067-0.112 mg/kg, while the concentration of Cd was much higher than sanitary and hygienic requirements (Savchuk *et al.*, 2021). International researchers are also concerned about the content of heavy metals in animal products. Thus, according to J.L. Han *et al.* (2022), analysis of 1,066 samples of fresh meat (pork, beef, lamb, and poultry) revealed average levels of heavy metal concentrations: Pb – 0.029 mg/kg, Cd – 0.002 mg/kg of raw weight.

### CONCLUSIONS

More than 36 years after the Chernobyl accident, the environmental situation in the Polissia zone of Ukraine stays difficult, which is confirmed by the elevated content of heavy metals in feed, milk, beef, and pork. A high concentration of Pb was found in coarse feed and sunflower

cake and meal (2,462 mg/kg and 1,639 mg/kg), 41.9% and 60.0% of samples of these types of feed, respectively, exceeded the maximum permissible concentration in Cd content. With an increase in the density of <sup>137</sup>Cs soil pollution, the content of heavy metals in fodder also increases: in hay and straw – 1.27-1.34 times; hay – 1.17-1.58; silage – 1.25-1.81; grain mixtures – 1.50-1.78 times. According to the results of the analysis of livestock products for the content of heavy metals, it was found that the maximum permissible concentrations of Pb in milk were exceeded by 1.45 times, Cd – in the longest back muscle of cattle and pigs – by 1.48 and 1.22 times, respectively. The Cd content in milk was within the regulatory requirements, while 41.2% of the analysed milk samples exceeded the maximum permissible concentration for this element. With the increase in the level of radioactive contamination of the territory by <sup>137</sup>Cs from 1 to 5 Ki/km<sup>2</sup> and more, the content of Pb and Cd in livestock products also increases: in milk – by 1.57-1.60 times, in the longest back muscle of cattle – by 1.10-1.49, the longest back muscle of pigs (excluding Pb) – 1.07 times.

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### Моніторинг важких металів у кормах і продукції тваринництва зони Полісся України

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**Анотація.** При значній концентрації забруднювачів у навколишньому середовищі відбувається їх нагромадження у рослинах, згодуювання яких у подальшому призведе до переходу токсичних елементів до організму тварини. Навіть невелика концентрація важких металів чи радіонуклідів має негативний вплив як на організм тварини, так і на організм людини. Тому моніторинг Pb і Cd у кормах, молоці та м'ясі за їх виробництва на території зони Полісся України є актуальним і потребує подальшого всебічного вивчення. Метою роботи було дослідити вміст важких металів у кормах і продуктах забою тварин, що вирощуються на території зони Полісся з різним рівнем радіоактивного забруднення. Дослідження проводили на молодняку свиней та на бугайцях, які поставлені на відгодівлю. У роботі були використані атомно-абсорбційний метод визначення вмісту токсикантів у зразках та метод варіаційної статистики для обробки результатів дослідження. Результати досліджень вмісту Pb і Cd у зразках свідчать про наявність істотних коливань важких металів у межах окремих господарств. Зі збільшенням рівня забруднення ґрунту  $^{137}\text{Cs}$  підвищується концентрація токсикантів у кормах, молоці, найдовшому м'язі спини досліджуваних тварин. Встановлено перевищення гранично допустимої концентрації Pb у молоці (33,8%) і Cd (41,2%). Концентрація Cd перевищувала встановлений рівень у 72,2% досліджуваних зразків найдовшого м'язу спини великої рогатої худоби та 80,0% зразків найдовшого м'язу спини свиней. Вміст Cd у всіх досліджуваних зразках кормів був значно вищим встановленого нормативу. Найбільше перевищення токсикантом встановлено у зразках сіна, соломи (41,9%), макухи та шроту (60%). Таким чином показники якості кормів та тваринницької продукції, яка виробляється у господарствах поліської зони Житомирщини, постраждалих внаслідок аварії на ЧАЕС, свідчать про те, що концентрація Pb і Cd у молоці дійних корів, м'язовій тканині молодняку великої рогатої худоби і свиней у більшості проаналізованих проб перевищує санітарно-гігієнічні вимоги. Тому для одержання молока і м'яса у межах діючих нормативних вимог нагальною проблемою залишається зменшення накопичення важких металів у кормах для годівлі тварин та птиці

**Ключові слова:** Плюмбум, Кадмій, концентрація, забруднення, молоко, найдовший м'яз спини