Received 07.02.2025 Revised 12.05.2025 Accepted 26.06.2025

Vol. 21, No. 3
2025

Scientific Reports of the National University of Life and Environmental Sciences of Ukraine

Journal homepage: https://scireports.com.ua/en

UDC 639.311; 539.163; 614.876; 613.648;

DOI: 10.31548/dopovidi/3.2025.49

The dependence of ^{137}Cs absorption by carp fish feed on the content of various types of Prussian Blue

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Suggested Citation:

Kashparov, V., Levchuk, S., Shvardak, A., Kondratyuk, D., & Zhurba, M. (2025). The dependence of ^{137}Cs absorption by carp fish feed on the content of various types of Prussian Blue. *Scientific Reports of the National University of Life and Environmental Sciences of Ukraine*, 21(3), 49-61. doi: 10.31548/dopovidi/3.2025.49.

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Abstract. In the context of increased radioactive contamination of aquatic ecosystems following the Chornobyl accident, there is a clear need for a scientifically sound selection of feed additives to reduce ^{137}Cs accumulation in fish. This study aimed to determine the optimal concentrations and types of Prussian Blue (PB)/hexacyanoferrates in feed, considering both their radiological effectiveness and economic viability. The research employed a wet granulation method for feeds, with the addition of ferrocin, potassium ferric hexacyanoferrate (KFCF), and ammonium ferric hexacyanoferrate (AFCF) at concentrations of 0.1% and 1%. This was followed by a series of batch experiments to measure the activity concentration of ^{137}Cs and calculate the distribution coefficients over time. The results indicated that moistening the feed in an aqueous medium led to a three-fold increase in its mass within the first hour of contact, after which a steady state was achieved. For all types of PB, the ^{137}Cs distribution coefficients consistently increased during the first 120 minutes, reaching 3.5-4.5 L/kg at 0.1% PB content and 5.6-6.2 L/kg at 1%. No statistically significant difference was recorded between the types of hexacyanoferrates, suggesting similar effectiveness for ferrocin, KFCF, and AFCF at the same concentration. However, it was established that increasing the concentration from 0.1% to 1% only doubled the effectiveness, which raises questions about the economic viability of such a step. The practical significance of the data obtained lies in the potential for using feeds supplemented with the most accessible forms of Prussian Blue to reduce the radioactive burden in fish farming, particularly in radioactively contaminated water bodies

Keywords: radiocaesium; hexacyanoferrate; countermeasure; radioactive contamination; freshwater fish; reduction factor

Introduction

Various types of Prussian Blue (PB)/hexacyanoferrates very effectively absorb caesium from solutions, which allowed their use as a primary countermeasure in animal husbandry after the Chornobyl accident. A report by the expert group of the Chornobyl Forum of the International Atomic Energy Agency (IAEA) (Anspaugh & Balonov, 2006) states that in some settlements, fish are the main source of radiocaesium intake into the body and internal radiation dose for the population. In this regard, it is relevant to assess the radiological effectiveness of using PB to reduce radioactive contamination in fish based on the dynamics of ^{137}Cs absorption by fish feed depending on the content of different types of hexacyanoferrates.

The IAEA recommendations conclude that the use of protective measures/countermeasures is the most effective way to protect the population from radiation after the Chornobyl NPP accident. The national report of Ukraine compiled by I.V. Abramenko *et al*. (2022) states that the main part of $^{134, 137}$Cs enters the human body through livestock products. Numerous experimental studies by A. Karpenko *et al*. (2023) and O.N. Antipenko (2023) showed that the most effective and inexpensive countermeasures aimed at reducing radiocaesium intake into the human body and livestock products are the use of various types of Prussian Blue as feed additives. Based on the summarised data, A. Nisbet & J. Sherwood (2024) concluded that the radiological effectiveness of using PB to reduce $^{134, 137}$Cs content in the meat and milk of cattle, as well as the meat of sheep, deer, and pigs, is 80-90%.

In European countries, including Austria, Germany, Norway, France and the United Kingdom, ammonium ferric hexacyanoferrate (AFCF) – $NH_4Fe\ [Fe\ (CN)_6]$) was used as an animal feed additive after the Chernobyl accident, the price of which currently reaches 1 Euro per 1 g. Due to the high cost of AFCF in Ukraine after the Chornobyl accident, ferrocin (a mixture of 95%

ferric hexacyanoferrate (FCF – $Fe_4[Fe(CN)_6]_3$) and 5% potassium ferric hexacyanoferrate (KFCF – $KFe[Fe(CN)_6]$)), was used, the price of which is significantly lower (0.05 Euro per 1 g) (Thermo Scientific Chemicals, 2025).

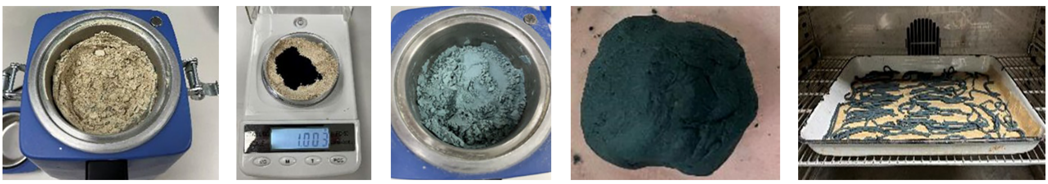
PB has found wide application not only in radiation protection as an antidote for internal intake of thallium and caesium radioisotopes due to its exceptional adsorption properties, but also in nanomedicine, chemical sensing, catalysis, spectroscopy, food production, and ion batteries. C. Rodwihok *et al.* (2024) showed that hexacyanoferrate forms insoluble colloids and its ability to adsorb Cs^+ reaches 200 g/g, which is more than 1000 times more effective compared to other alkali metals, such as potassium and sodium ions. Therefore, PB prevents caesium from being absorbed in the gastrointestinal tract (GIT) of animals and entering the blood, as a result of which caesium radioisotopes are transited out of the body with faeces. N. Chakraborty *et al.* (2024) investigated nanoscale forms of Prussian Blue as promising materials for medical applications, particularly for combating infections, controlling wound processes, and drug delivery. The authors emphasise that the ability for selective adsorption of cations, including caesium, opens up prospects for interdisciplinary use of these compounds. The work by D. Parajuli *et al.* (2025) is devoted to developing a protocol for the long-term storage of radioactive caesium in the form of stable complexes with metal hexacyanoferrates. The research results confirmed the exceptional stability of such compounds, allowing them to be considered a safe form of radionuclide isolation in industry and ecology. Researchers S. Khandaker *et al.* (2025) created an innovative adsorbent in which potassium hexacyanoferrate is embedded in the structure of layered hydroxides, ensuring high efficiency of ^{137}Cs extraction from seawater. The authors demonstrated that the obtained material retains sorption properties even in complex conditions with a high content of competing ions.

Employees of NULES (National University of Life and Environmental Sciences) of Ukraine, P. Pavlenko *et al.* (2023), in natural conditions of the Chornobyl exclusion zone, and V. Kashparov *et al.* (2024), in controlled laboratory experiments, showed the high radiological effectiveness of using one type of PB, namely potassium ferric hexacyanoferrate (KFCF), to reduce radiocaesium activity in fish. In the study by P. Pavlenko *et al.* (2023), the activity concentration of ^{137}Cs in silver carp was reduced by 7-16 times and 12-27 times when the feed contained 0.1% and 1% KFCF, respectively. At the same time, the dynamics of ^{137}Cs sorption from water by feed containing 1% and 0.1% KFCF, which was manufactured under industrial conditions by extrusion – dry granulation – was studied. In farm animals, KFCF additives in feed affected ^{137}Cs absorption in the GIT, but did not affect the rate of excretion of caesium already deposited in the body. For fish, in the work of V. Kashparov *et al.* (2024), the effect of KFCF on the rate of radiocaesium excretion from the body of silver carp was statistically significantly established for the first time, which was almost twice the excretion rate when only pure feed without KFCF was used. Based on the results obtained, it can be concluded that the use of KFCF in fish feed is a highly effective and inexpensive countermeasure. The use of other types of PB (hexacyanoferrates), such as AFCF or ferrocin, may also be effective, but requires further study. The aim of this work was to evaluate the dynamics of ^{137}Cs sorption by feed containing 0%, 0.1%, and 1% AFCF, KFCF, and ferrocin from water under controlled laboratory conditions, to provide a scientific basis for using optimal concentrations of various types of PB in feeds, in terms of radiological effectiveness and price, to reduce ^{137}Cs radioactive contamination in fish.

Materials and Methods

The experiment was conducted at the Ukrainian Institute of Agricultural Radiology of the National University of Life and Environmental Sciences of Ukraine in 2024. Industrial feed for carp fish produced by "Skalaria" (Ukraine) with a pellet size of 3 mm, containing 30% protein, 10% fat, 3% fibre and vitamins A, D_3, E and C, was used as a control and basis for the preparation of feed with different contents of various types of Prussian blue (PB). Feed with different PB contents was produced in laboratory conditions using the wet granulation method. For this purpose, industrial feed for carp fish from the company "Skalaria" (Ukraine) was ground for 100 seconds in an IKA Model M 20 S000 crusher (Germany) to obtain a control batch of feed that did not contain PB and a base for preparing feed with a content of 0. 1% and 1% PB (Fig. 1): ferrocin – a mixture of 95% ferric hexacyanoferrate (FCF) – $Fe_4[Fe(CN)_6]_3$ and 5% (KFCF) (Ukraine), potassium ferric hexacyanoferrate (KFCF) – $KFe[Fe(CN)_6]$ and ammonium ferric hexacyanoferrate (AFCF, Giese salt) – $NH_4Fe[Fe(CN)_6$ (Thermo Scientific Chemicals, 2025). To prepare feed with a 1% PB content, 1 g of PB (Fig. 1a) was added to 99 g of crushed basic feed (Fig. 1b) and thoroughly mixed again for 100 seconds in an IKA Model M 20 S000 crusher (Fig. 1c). After that, 10 g of feed containing 1% PB was added to 90 g of mixed basic feed and thoroughly mixed again for 100 seconds in a crusher to prepare feed with a concentration of 0.1% PB. All equipment was thoroughly cleaned after each stage of feed preparation to prevent cross-contamination of hexacyanoferrate in the feed. For wet granulation, 60% distilled water was added to a 100 g mixture of feed with different PB contents and thoroughly mixed until a homogeneous plastic mass was obtained (Fig. 1d). Wet granulation of the feed was carried out using a manual meat grinder. The feed was then dried in an oven at 105°C for 1 hour (Fig. 1d).

As a result of the work done, feed containing 0%, 0.1% and 1% ferrocin, KFCF and AFCF was prepared (Fig. 2).

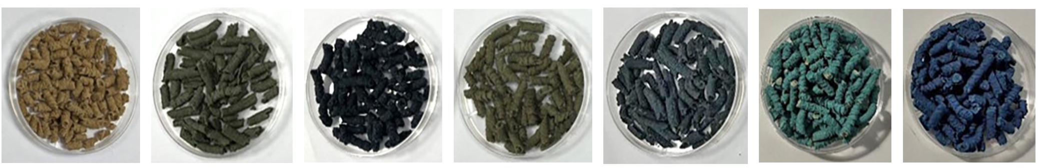


a b c d e

Figure 1. *Stages of feed preparation with different PB content: grinding of the main feed*

Note: a – does not contain PB; b – addition of 1 g of PB to the main feed; c – homogenisation of feed with 1% PB; d – moistening of feed for wet granulation; e – drying of feed at 105 °C

Source: developed by the authors



0% PB 0.1% of ferrocin 1% of ferrocin 0.1% KFCF 1% KFCF 0.1% AFCF 1% AFCF

Figure 2. *Feed containing 0%, 0.1% and 1% ferrocin, KFCF and AFCF*

Source: developed by the authors

The dynamics of ^{137}Cs sorption from water by feed with different contents and types of selective cesium sorbent containing 0%, 0.1% and 1% ferrocin, KFCF and AFCF after wet granulation were determined in 33 ml plastic vessels with holes in the bottom. The tare weight (wet beaker with holes and Petri dish lining) was 9 g. Feed samples weighing 5.0 ± 0.1 g (DM) with different hexacyanoferrate contents were used. The feed samples were kept for different periods of time (1 minute, 5 minutes, 15 minutes, 30 minutes, 60 minutes and 120 minutes) in 800 ml glasses with distilled H_2O, to which a solution of ^{137}Cs (3 ml with activity concentration of 0.62 ± 0.05 kBq ml^{-1}) was added (Fig. 3).

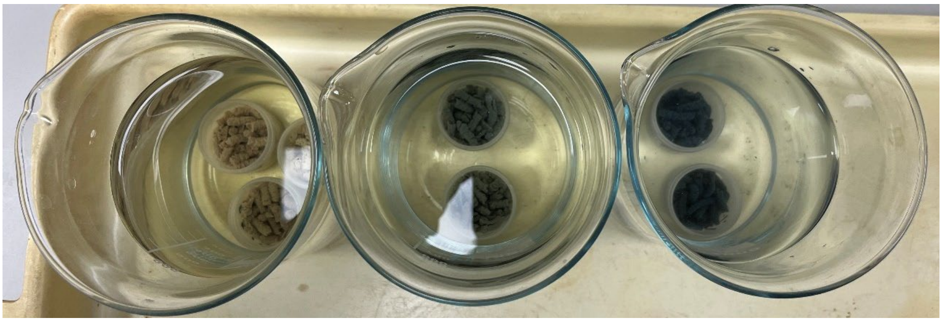


Figure 3. *Study of ^{137}Cs sorption by feed with different hexacyanoferrate contents from an aqueous solution*
Source: developed by the authors

After each soaking stage in the solution, the wet mass (WM) was measured using a KERN balance (Germany) with an accuracy of 0.01 g. The ^{137}Cs activity in the feed was measured in a weighing bottle for 300 seconds using a scintillation gamma spectrometer (SEG-05, Ukraine; LSRP software) with a 63 × 63 mm NaI(Tl) detector within a passive shield (5 cm) (Fig. 4). As the sample volumes often didn't match the calibration geometry, correction factors were applied. Geometric correction was based on determining the mass/volume of the sample in each container. The correction factors were calculated using the relationship between efficiency and sample volume for each container with known solution activity. The correction factors (CF) for the 15 ml H_2O weighing bottle geometry were 0.6 (Fig. 4a). After each stage of ^{137}Cs absorption by the feed from the solution, its activity concentration was monitored in 120 ml plastic containers. The correction factors (CF) for the "100 ml H_2O powder" geometry were 0.8 (Fig. 4).

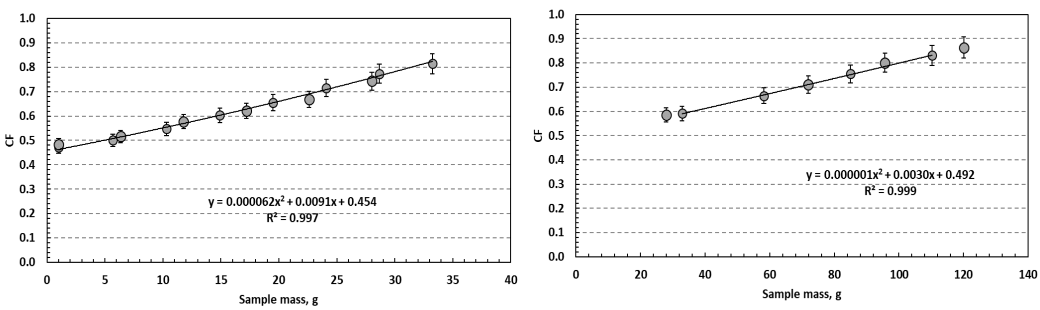


Figure 4. *Correction factors (CF) for measuring ^{137}Cs activity in water in plastic vessels*
Note: a – 33 ml beakers, b – 120 ml "powder"
Source: developed by the authors

A standard set of MS Excel tools was used to analyse the experimental data, namely to obtain mean values and standard deviations. The reliability of the differences between samples was analysed using the non-parametric Kruskal-Wallis test. Statistical significance was set at $p < 0.05$.

Results and Discussion

The results obtained show the change in feed weight and ^{137}Cs distribution coefficients (solid-liquid distribution coefficient (K_d) – the ratio of the activity concentration of ^{137}Cs in the feed (C_f, Bq/kg) to the activity concentration of ^{137}Cs in the solution (C_w, Bq/L)) depending on the contact time with water (Fig. 5). From the results, it's clear that the activity concentration of ^{137}Cs was highest in the feed prepared by wet granulation that contained 1% ferrocin, KFCF, or AFCF, after 120 minutes of contact with the solution (Table 1). At this point, the activity concentration of ^{137}Cs in the feed at natural moisture content (WM, wet mass) was K_d = 5.6-6.2 times higher than its activity concentration in water (2.3 ± 0.2 kBq/L), and 3.7–4.2 times higher compared to feed that did not contain hexacyanoferrates (Fig. 5). When the feed contained 0.1% of different PB types, radiocaesium was absorbed only 1.4–1.6 times less effectively compared to feed containing 1% hexacyanoferrates (Table 1). No statistically significant differences ($p > 0.05$) were observed in the absorption of ^{137}Cs from water by feed with different types of caesium-selective sorbent, whether it contained 0.1% or 1% of ferrocin, KFCF, or AFCF (Fig. 5, Table 1).

The activity concentration of ^{137}Cs in feed with 1% and 0.1% hexacyanoferrates, after 120 minutes of contact with the solution, was approximately 4 times higher compared to feed that contained no hexacyanoferrates at all (Table 1). This was partly due to its wetting by the solution (the mass increased threefold from 5 g to 15 g after being kept in water (Fig. 5a, 5b, and 5c)). In feed with 1% KFCF, which was prepared by dry granulation and used in the work of P. Pavlenko *et al.* (2023) and V. Kashparov *et al.* (2024), the ^{137}Cs distribution coefficients were lower (K_d = 3.6 ± 0.2 (Bq/kg)/(Bq/L)) compared to feed prepared by wet granulation (K_d = 5.9 ± 0.2 (Bq/kg)/(Bq/L), Fig. 5b). This is attributed to its higher density and less wetting by the solution (mass increased only twofold when kept in water).

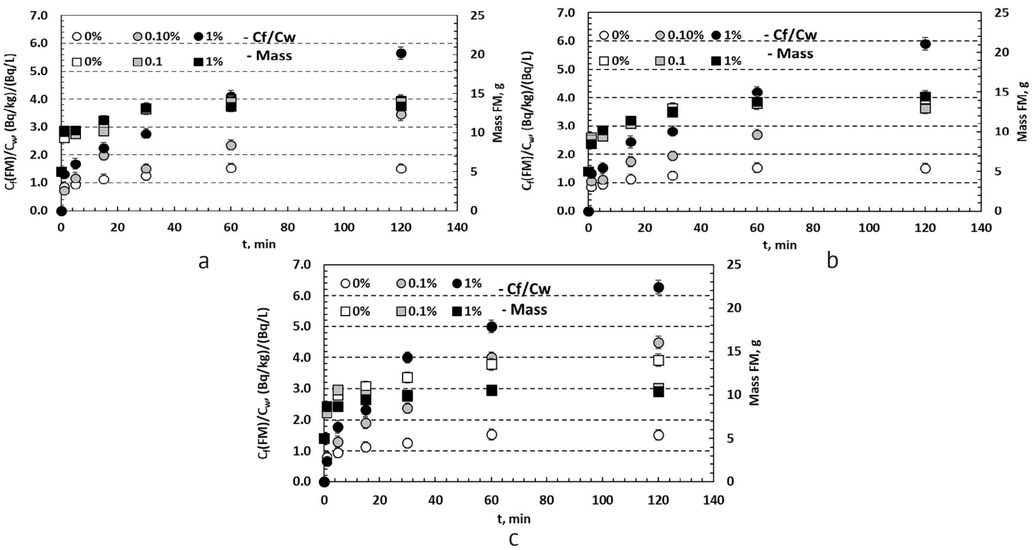


Figure 5. *Dynamics of feed weight (Mass FM, g) and ^{137}Cs distribution coefficients at different iron hexacyanoferrate contents*

Note: K_d – ratio of activity concentration of ^{137}Cs in feed (C_f, Bq/kg) to the activity concentration of ^{137}Cs in solution (C_w, Bq/L); a – Ferrocin, a mixture of 95% ferric hexacyanoferrate (FCF) – $Fe_4[Fe(CN)_6]_3$ and 5% (KFCF) – $KFe[Fe(CN)_6]$; b – potassium ferric hexacyanoferrate (KFCF) – $KFe[Fe(CN)_6]$; c – ammonium ferric hexacyanoferrate (AFCF) – ($NH_4Fe[Fe(CN)_6]$)

Source: developed by the authors

Table 1. *Activity concentration of ^{137}Cs in feed (C_f, Bq/kg WM) at different iron ferric hexacyanoferrate contents*

Feed composition, %	Hexacyanoferrate	Activity concentration of ^{137}Cs in feed, Bq/kg		
		After 30 minutes of contact with the solution	After 60 minutes of contact with the solution	After 120 minutes of contact with the solution
1	Ferrocin, a mixture of 95% FCF and 5% KFCF	6.4 ± 0.6	9.6 ± 1.0	13.1 ± 1.3
	Potassium ferric hexacyanoferrate (KFCF)	6.6 ± 0.7	9.8 ± 1.0	13.7 ± 1.4
	Ammonium ferric hexacyanoferrate (AFCF)	9.3 ± 0.9	11.6 ± 1.2	14.6 ± 1.5
0.1	Ferrocin, a mixture of 95% FCF and 5% KFCF	3.5 ± 0.4	5.5 ± 0.6	8.0 ± 0.8
	Potassium ferric hexacyanoferrate (KFCF)	4.6 ± 0.5	6.3 ± 0.6	9.4 ± 0.9
	Ammonium ferric hexacyanoferrate (AFCF)	5.5 ± 0.6	9.3 ± 0.9	10.4 ± 1.0
0	FCF, KFCF i AFCF	2.9 ± 0.5	3.6 ± 0.5	3.5 ± 0.5

Source: developed by the authors

Based on the experimental results (Fig. 5), the parameters of approximation of the kinetics of cesium sorption by feed with different hexacyanoferrate contents upon contact with the solution t = 0.25-2 hours were obtained by a linear dependence of the type $K_d(t) = a + bt$ (Table 2). The results show that the rate of increase in the distribution coefficient of 137Cs in feed containing 1% PB (2.0 ± 0.1 L/kg/hour) was 1. 3-2 (1-1.5 L/kg/hour) and 10 (0.2 ± 0.1 L/kg/hour) times higher compared to feed containing 0.1% and 0% hexacyanoferrates, respectively.

Table 2. *Time dependencies of ^{137}Cs distribution coefficients in feed ($K_d(t) = a + bt$), L/kg*

Feed composition, %	Hexacyanoferrate	a, (Bq/kg)/(Bq/l)	b, L/kg/ hour	R^2
1	Ferrocin, a mixture of 95% FCF and 5% KFCF	1.9 ± 0.2	2.0 ± 0.1	0.98
	Potassium ferric hexacyanoferrate (KFCF)	1.9 ± 0.2	2.0 ± 0.1	0.99
	Ammonium ferric hexacyanoferrate (AFCF)	2.5 ± 0.3	2.0 ± 0.1	0.88
0.1	Ferrocin, a mixture of 95% FCF and 5% KFCF	1.4 ± 0.2	1.0 ± 0.2	0.87
	Potassium ferric hexacyanoferrate (KFCF)	1.4 ± 0.2	1.3 ± 0.1	0.998
	Ammonium ferric hexacyanoferrate (AFCF)	1.8 ± 0.3	1.5 ± 0.2	0.85
0	FCF, KFCF i AFCF	1.2 ± 0.2	0.2 ± 0.1	0.70

Source: developed by the authors

K. Niizeki *et al.* (2020) in experiments with the cultivation of Japanese dace (*Tribolodon hakonensis*) and K. Matsuda *et al.* (2020) in five species of salmonids showed that the main activity of ^{137}Cs enters fish orally along with radioactively contaminated feed (over 99%) and a small part (less than 1%), mainly in winter, enters directly from water. The rate of ^{137}Cs entering fish directly from water is k_w = 0.03-0.07 1/day, which was obtained in experiments at different temperatures and for different fish species in experiments by V. Kashparov *et al.* (2024) and T. Wada *et al.* (2023). Thus, with a ^{137}Cs content in water (C_w) at the level of units Bq/l and an excretion rate k_b = 0.007 1/day, the equilibrium activity concentration of ^{137}Cs in fish ($C_{fish} = C_w*k_w/k_b$, Bq/kg) due to water contamination alone will not exceed tens of Bq/kg. At the same time, due to the contamination of natural fish feed in real natural conditions, the activity concentration of ^{137}Cs in fish is hundreds of times higher and reaches thousands of Bq/kg when the content of radiocaesium in water is at the level of units Bq/l (Man & Kwok, 2000; Kaglyan *et al.*, 2024). Considering that fish usually consume artificial feed in less than 1 hour, the contamination of feed with ^{137}Cs from hexacyanoferrate due to sorption will be insignificant and less than 4 times different from traditional fish feed without PB (Fig. 5). Therefore, the activity concentration of ^{137}Cs in artificial feed with PB will slightly exceed the radioactive contamination of water in the reservoir.

Depending on the size of the fish and the water temperature, no more than 5-8% of artificial feed per live weight of carp fish is used daily (Shipton, 2021; CARP 2022-2023, 2023; Huang *et al.*, 2025). With a radio-caesium content in water at a level of units Bq/l, the intake of firmly fixed ^{137}Cs per 1 kg of live weight of fish per day will be less than 1 Bq/day together with artificial feed with PB. This will lead to a steady-state activity concentration in fish of less than 100 Bq/kg, which is an order of magnitude lower than the contamination of fish in similar natural conditions (Man & Kwok, 2000; Wada *et al.*, 2023).

Since the sorption properties of feed with different types of Prussian blue did not differ statistically significantly, it can be concluded that their radiological effectiveness will be the same and will correspond to the radiological effectiveness of using similar feed for cyprinid fish with KFCF additives. As shown in the works of P. Pavlenko *et al.* (2023) and V. Kashparov *et al.* (2024), the radiological effectiveness (reduction factor) of using similar feed for cyprinid fish from the "Skalaria" company, both in laboratory and real conditions in the Chernobyl exclusion zone, was 7-16 and 12-27 times higher with a feed content of 0.1% and 1% KFCF. Thus, when the concentration of KFCF in the feed was increased 10 times from 0.1% to 1%, the radiological effectiveness increased only 2 times, which is consistent with the results of changes in the sorption capacity of various types of hexacyanoferrates obtained in this work (Tables 1 and 2). Even with a feed content of 0.1% PB, its radiological effectiveness remains extremely high (about 10 times) and exceeds the effectiveness of countermeasures previously proposed to reduce cesium radioisotope contamination of fish in freshwater reservoirs many times over. Researchers J.T. Smith *et al.* (2003) proposed increasing the concentration of the chemical analogue of caesium, potassium, in water by adding large amounts of KCl to reservoirs. In real conditions, when 15 tonnes of potassium chloride fertiliser were added to Lake Svyatoe (0.05 kg per m^2 of water surface), the resulting desorption of previously fixed caesium from bottom sediments resulted in short-term and insignificant radiological effectiveness (less than 40%). A.Ye. Kaglyan *et al.* (2018) patented a method for cleaning crucian carp from ^{137}Cs by transferring the fish to clean water and using clean feed. This method requires labour-intensive fishing and keeping the fish in "clean" conditions, which only reduces the activity of ^{137}Cs in fish by half after 100 days. In contrast, as shown by V. Kashparov *et al.* (2024), the use of feed containing 0.1% KFCF allows the activity concentration of ^{137}Cs in crucian carp to be reduced by half in just 30 days without catching fish in "dirty water".

The results obtained indicate that the radiological effectiveness of using different types of Prussian blue in feed for carp fish will be the same, and the main factor determining the feasibility of using one type of hexacyanoferrate or another will be its price and availability. It has been established that with the cost of feed for carp fish in Ukraine at around 1-2 euros per kilogram, adding 0.1% ferrocin or KFCF (0.05 euros per 1 g) to it will increase the cost of feed with radioprotective properties by less than 5%. A similar application of AFCF can double the cost of feed (Thermo Scientific Chemicals, 2025). The results of the study indicate the potential for creating inexpensive and effective feed additives to reduce radioactive contamination of fish, which may be of practical importance in restoring safe fish farming in post-radiation regions.

Summarising the results obtained, it should be noted that all the studied types of Prussian blue – ferrocin, potassium ferric hexacyanoferrate (KFCF) and ammonium ferric hexacyanoferrate (AFCF) -demonstrate similar sorption capacity for ^{137}Cs at the same concentrations in feed. Although increasing the content of hexacyanoferrates in feed from 0.1% to 1% increases radiological efficiency, this increase is not proportional and is accompanied by a significant increase in the cost of the product. Given the lack of statistically significant differences in sorption properties between types of hexacyanoferrates, the choice of a specific compound is determined primarily by its cost and availability. Therefore, it is advisable to continue the practical implementation of the most cost-effective forms of PB in fish feed in post-radiation regions.

Conclusions

As a result of the wet granulation process, feed for carp fish was produced with 0%, 0.1% and 1% ferrocin (a mixture of 95% ferric hexacyanoferrate) – $Fe_4[Fe(CN)_6]_3$ and 5% potassium ferric hexacyanoferrate – $KFe[Fe(CN)_6]$; potassium ferric hexacyanoferrate – $KFe[Fe(CN)_6]$ and ammonium ferric hexacyanoferrate – $(NH_4Fe[Fe(CN)_6])$. In laboratory batch experiments, the dynamics of changes in feed mass in water and the distribution coefficients of ^{137}Cs in feed with different contents and types of Prussian Blue (PB) were measured. For this purpose, 5 g of each type of feed was placed in 800 mg of a solution with a activity concentration of ^{137}Cs of 2.3 Bq/ml.

The results showed that the weight of the feed increased due to wetting with water. The distribution coefficients of ^{137}Cs in the feed also increased with increasing contact time of the feed with the solution and reached a maximum value after 120 minutes. At the same time, no statistically significant differences were observed in the sorption of ^{137}Cs by feed containing 0.1% or 1% ferrocin, KFCF or AFCF. The absorption of radiocaesium by feed from water containing various types of PB was insignificant compared to feed without hexacyanoferrate additives. Therefore, given the strong fixation of ^{137}Cs by various types of Prussian Blue, it can be concluded that this will not lead to an increase in the intake of radiocaesium into the fish organism.

The results obtained earlier and in this work may indicate the high radiological efficiency and low cost of using fish feed with additives of various types of hexacyanoferrates, which requires direct verification of the use of these feeds in experiments with fish in laboratory and real production conditions.

Acknowledgements

The study was supported by the National University of Life and Environmental Sciences of Ukraine, the Ministry of Education and Science of Ukraine (Project 110/6-pr-2024 and No. 110/7-pr-2024).

Funding

None.

Conflict of Interest

None.

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Залежність абсорбції ^{137}Cs кормом для коропових риб в залежності від вмісту в ньому різних видів Берлінської лазурі

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Анотація. У контексті підвищеного радіоактивного забруднення водних екосистем після Чорнобильської аварії постає необхідність у науково обґрунтованому виборі кормових добавок для зменшення накопичення ^{137}Cs у рибі. Метою дослідження було визначення оптимальних концентрацій та видів гексаціаноферратів/Берлінської лазурі (БЛ) в кормах з огляду на їхню радіологічну ефективність і економічну доцільність. У дослідженні застосовано метод мокрого гранулювання кормів з додаванням фероцину, залізо-гексаціаноферату калію (KFCF) та амонію (AFCF) у концентраціях 0.1 % та 1 %, з подальшим проведенням серії batch-дослідів із заміром питомої активності ^{137}Cs та обчисленням коефіцієнтів розподілу у часі. Результати показали, що зволоження корму у водному середовищі призводило до трикратного збільшення його маси протягом першої години контакту, після чого досягався стаціонарний рівень. Для всіх типів БЛ коефіцієнти розподілу ^{137}Cs стабільно зростали протягом перших 120 хвилин і досягали 3.5-4.5 л/кг при вмісті 0.1 % БЛ та 5.6-6.2 л/кг при 1 %. Статистично достовірної різниці між типами гексаціаноферратів не зафіксовано, що свідчить про подібну ефективність фероцину, KFCF і AFCF при однаковій концентрації. Водночас встановлено, що підвищення концентрації з 0.1 % до 1 % збільшує ефективність лише вдвічі, що ставить питання про економічну доцільність такого кроку. Практичне значення отриманих даних полягає у можливості використання кормів із додаванням найдоступніших форм Берлінської лазурі для зниження радіоактивного навантаження у рибництві, зокрема в умовах радіаційно забруднених водойм

Ключові слова: радіоцезій; гексаціаноферат; контрзахід; радіоактивне забруднення; прісноводна риба; фактор зменшення