Radiation Monitoring of Agricultural Products as One of The Factors of Ecological Security of Population

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Abstract—The Chernobyl disaster, which knows no analogies in the world in the scope of radioactive emission and duration, radionuclide composition and physical and chemical discharge forms, led to the large-scale pollution of agricultural lands and products, including animal production. After the Chernobyl disaster in Penza region the following figures in radioactive fallout were recorded ^{137}Cs and ^{90}Sr . The aim of this research is to study and analyze the common factors of a radiation situation in agricultural production sphere in Penza and in its region.

Keywords— ^{137}Cs , ^{90}Sr , ^{40}K , ^{226}Ra , volumic activity, monitoring radiation security, radionuclide.

I. INTRODUCTION

After having conducted a set of actions aimed at radioactive pollution damage assessment and post-accident recovery and clean up in agriculture, some issues arose, which underlined the necessity to specify data on: the level of radioactive impurity with some radionuclides containing in feed-stuff, ration and animal products on the territory of the Russian Federation; the common factors and regularities in radionuclides migration along the chain – feeding – animal – animal products; the normalization principles identifying radioactive substances in feed stuff; the criteria on controlling radioactive substances in agricultural products; the principals towards the development of reliable and eligible system for veterinary radiological monitoring based on some new techniques and methods dealing with radioactive control, analysis and prediction of a radioactive situation [1, 2].

As the main objectives of the research we point out: studying the content of radioactive pollution, containing in objects under veterinary inspection, caused by global and local radionuclides emissions and by a decline rate of concentration of such substances as ^{40}K , ^{226}Ra , ^{232}Th and ^{137}Cs that contain in emissions; studying the peculiarities of polluting feed stuff and products for animals raising ^{40}K , ^{226}Ra , ^{232}Th and ^{137}Cs ;

identifying the risk assessment when radionuclides can be supplied in animals with feed stuff and ration, specifying the transmission ratios ^{40}K , ^{226}Ra , ^{232}Th and ^{137}Cs from feed stuff into animal products within the period when these animals were used; studying and specifying some methodological and normalization aspects that feature a permissible level of radionuclides in feed stuff; rationale and development of State-based veterinary radiological control and monitoring system in the Russian Federation; development and improvements towards the veterinary rules and regulations, radiological control methods, veterinary-sanitary expertise and samples taking from the objects appearing in veterinary monitoring zone.

II. METHODS AND MATERIALS

In order to conduct some experimental studies addressed finding the basic radionuclides in the agricultural products samples under experiment we applied the gamma ray spectroscopy (Green Star (GS) “SKS-07P”) that is intended to testing radionuclide specific activity in samples on three forms of radiation.

III. RESULTS

Close examination of the agricultural product samples – feed stuff and pasturing soil intended for animal grazing (grown in Penza region) – taken for the analysis has shown that there is the necessity in carrying out more detailed examination of animal products.

Numerous tests, carried out on high-sensitivity spectroscopy equipment during 4 years by a group of Penza physicists, and targeted at radionuclide concentration in food products, animal products and feed stuff have shown in the objects under study the concentration of following radionuclides: Cs^{137} , Ra^{226} , Th^{232} , Am^{241} , Rn^{222} . There were some cases with overconcentration (MPCs – maximum

permissible concentrations) [4, 5, 6]. MPCs are introduced in table I.

TABLE I. PERMISSIBLE CONCENTRATIONS OF RADIONUCLIDES IN PRODUCTS AND WATER

Product	Specific activity, Bq/kg
Drinking water	18.5
Milk, fermented milk products, sour cream, curd cheese, cheese	50
Butter, condensed and canned milk	100
Powdered milk	100
Meat (pork, lamb), poultry, fish, eggs, meat and fish products	500
Beef meat and beef meat products	400
Fats and oils, margarine	40
Potato, vegetables, greens, fruit and berries	80
Bread, cereals, flour, sugar	40
Canned vegetables, fruit, berries, honey	74
Baby food	37
Dried garden fruit	70
Forest food products	370

TABLE II. MILK PRODUCTS MONITORING (PENZA MANUFACTURERS).

Product	Weight kg	Measured by	²²⁶ Ra		¹³⁷ Cs	
			Bq/kg	Bq/l	Bq/kg	Bq/l
Danish cows milk 2,5%	0.310	GS				
Danish cows milk 3,2 %	0.300	GS				
Yogurt	0.30	GS	6.11	1.656		
Ryazhenka	0.250	GS	27.33	6.123		
Serum	0.350	GS	27.89	9.42		
Bio-milk products	0.250	GS	53.72	3.4		
Brynza cheese	0.200	GS	23.38	3.31		
Curd cheese	0.200	GS	46.32	3.2	5.321	0.62
Curd cheese products with greens	0.150	GS	32.85	4.7		
Melty cheese	0.150	GS	8.25	1.21	9.08	0.89
Smoked cheese	0.200	GS	21.66	0.85	9.12	0.78

Product	Weight kg	Measured by	²³² Th		⁴⁰ K	
			Bq/kg	Bq/l	Bq/kg	Bq/l
Danish cows milk 2,5%	0.310	GS			157.2	46.16
Danish cows milk 3,2 %	0.300	GS			176.8	33.25
Yogurt	0.30	GS	1.841	0.487	86.55	23.31
Ryazhenka	0.250	GS			51.67	11.57
Malted milk	0.250	GS				
Serum	0.350	GS				
Bio-milk products	0.250	GS			42.73	3.89
Brynza cheese	0.200	GS			56.75	14.67
Curd cheese	0.200	GS			67.77	9.23
Curd cheese products with greens	0.150	GS			60.25	11.33
Melty cheese	0.150	GS			152.4	25.7
Smoked cheese	0.200	GS			57.7	33.2

TABLE III. MEAT PRODUCTS MONITORING (PENZA MANUFACTURERS).

Product	Weight kg	Measured by	²²⁶ Ra		¹³⁷ Cs	
			Bq/kg	Bq/l	Bq/kg	Bq/l
Chicken	0.345	GS	10.93	5.26		
Duck	0.320	GS	175.2	33.75		
Turkey	0.356	GS	67.96	4.86		
Beef	0.367	GS	37.96	7.2		
Pork	0.326	GS	23.98	7.42		
Lamb	0.405	GS	19.2	1.34		

Product	Weight kg	Measured by	²³² Th		⁴⁰ K	
			Bq/kg	Bq/l	Bq/kg	Bq/l
Chicken	0.345	GS			124.5	54.1
Duck	0.320	GS				
Turkey	0.356	GS	5.3	0.78	54.69	8.09
Beef	0.367	GS	3.78	1.4	67.45	8.05
Pork	0.326	GS	8.42	3.1		
Lamb	0.405	GS			176.1	28,71

TABLE IV. MONITORING ON FOOD PRODUCTS FOR FARM ANIMALS.

Product	Weight kg	Measured by	²²⁶ Ra		⁴⁰ K	
			Bq/kg	Bq/l	Bq/kg	Bq/l
Mixed feed for chicken	0.098	GS	11.4	1.117	747.6	73.26
Mixed feed for Danish cows	0.142	GS	18.36	2.6	404.3	57.41
Mixed feed for local domestic cows	0.136	GS	40.9	5.56	138.7	18.86
Nutritional supplements for cows	0.100	GS			569.5	56.95
Nutritional supplements for pregnant cows	0.142	GS	81.25	10.48	215.4	27.78
Silage	0.142	GS			249.8	35.47
Hay	0.105	GS	26.17	2.75	352.8	35.28
Straw	0.120	GS	33.15	5.47	278.3	28.13

Based on the measurements carried out in most cases we can conclude that such dangerous substances ²²⁶Ra, ²³²Th, ¹³⁷Cs in the objects under examination have been in MPCs. Most products are rich with ⁴⁰K that is necessary for human organism and health.

The important factor for preventing accumulation of radionuclides in people's organism, who live or work near or in the territories polluted with emergency emissions, is using particular food products and their components. Specifically it relates to long-living radionuclides (for example, ⁹⁰Sr), which are able to migrate along the food chains, being accumulated in organism and tissues, expose bone marrow and bone tissue to chronic radiation, increasing by it the risk to malignancies formation.

It turns out that food fortification with fish, calcium, bone flour, fluorine, and seaweeds contribute to reducing a cancer diseases risk.

A big interest in this context is introduced by indigestible carbohydrates, which are used in nutrition purposes particularly for food products prescribed in treatment and prophylactic aims.

Considerable importance in prophylactic radioactive impact has beta-carotene and food products with high concentration of this pro-vitamin.

To reduce the radiation dose on population can be achieved by the target optimization of agricultural production structure, using the factor that in farm products the radionuclide concentration is 2-4 times less than in products of crop production. The basic part of radionuclides supplied into organisms with food ration occurs through intaking of vegetables products, such as cabbage and potato.

IV. CONCLUSION

The results obtained within studying the issues set up in this research allowed us to make the following conclusions:

1) the material that was reviewed showed that in changes in natural radiation level of environment a great role plays atomic power stations, nuclear explosions and radioactive waste. The adverse security situation in Penza region is caused by high concentration of artificial radionuclides (¹³⁷Cs, ⁹⁰Sr, ⁴⁰K, ²²⁶Ra и ²⁴¹Am). The Chernobyl disaster conditioned the environmental pollution mainly with ¹³⁷Cs [3].

2) the products produced in Penza region that were under examination showed a high concentration of ⁴⁰K. It is observed in such products as: cabbage, domestic carrot, cheese, and bread; ¹³⁷Cs is found in cabbage, smoked sausage and in bread; ²²⁶Ra is found in bread. Less concentration of ⁴⁰K is found in buck wheat, cucumbers, and smoked sausage; ¹³⁷Cs is observed in macaroons and buck wheat; ²²⁶Ra is in carrot, tomato, potato, and cucumbers.

In products from Danish cows the concentration of substances under examination is significantly low because the feed stuff for them is grown separately, when the pastures are planted with grass imported to Russia together with the cow-cattle.

For 20 years that passed since the Chernobyl disaster the value of the average activity of ¹³⁷Cs in Penza lands (soils) has decreased from 1.5 Cu/km² till 0.121 Cu/km² that means 10 times less. It is not surprisingly and mostly connected with the fact that the half-life period of ¹³⁷Cs equals to 30 years, but the decrease in activity is going exponentially.

Detection in soils ²⁴¹Am is mainly connected with nuclear tests that were taken place in Semipalatinsk, in Novaya Zemlya and etc. but not directly related to the Chernobyl case. By the reason that neutron capture at nuclear tests is happening during a very short time and it results in transuranium elements formation with a very big atomic weight (americium, berkelium, curium and etc.). Another case is with radionuclides formation, when they are in a reactor, the neutrons are captured occasionally and the product obtained can dissociate before additional neutrons are captured. The half-life period of ²⁴¹Am is about 500 years. Therefore, in the nearest centuries ²⁴¹Am will be in soils. Moreover, ²⁴¹Am is a radioactive product of plutonium - ²⁴¹(²⁴¹Pu), whose radioactive decay is 14.4 years, but ²⁴¹Pu – a radioactive product of curium - ²⁴⁵(²⁴⁵Cm), whose half-time period is 8 500 years. The ²⁴¹Am dissociates up to neptunium - ²³⁷(²³⁷Np), and its radioactive decay period is 2,14 · 10⁶ years; its finding is also possible in the nearest time after the additional calibration of a spectrometer.

The artificial radioactive elements in soils are significant supplementation to the natural radiation background to which living organisms have some time difficulties to adapt. When one radionuclides are dissociated, the others are formed and we have the chain reaction that is going quicker than evolution. A human organism does not manage to adapt and this entails the negative impacts on people's health because apart from radiation background rise there is happening the

internal exposure. This can lead to malignant tumours formation.

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