European Journal of Molecular & Clinical Medicine
ISSN 2515-8260 Volume 7, Issue 11, 2020

RADIOMETRIC DETERMINATION OF THE PRESENCE OF CAESIUM-137 AND STRONTIUM-90 RADIONUCLIDES IN PRODUCTS OF THE FODDER INDUSTRY

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Abstract: ***The article studies the determination of the presence of Cs-137 and Sr-90 radionuclides in the products of the feed industry using the radiometric method. The presence of cesium-137 and strontium-90 radionuclides in compound feed, haylage, silage, and the meal was experimentally determined. An increased amount of Cs-137 in the compound feed was revealed.***

Keywords: radionuclide, radiometer, becquerel, Marinelli vessel.

INTRODUCTION

Today in the world, huge research work is being carried out on radiometric monitoring of agricultural products. According to scientists, the share of natural sources of radiation in the total dose accumulated by an average person throughout his life is 87%, the remaining 13% are from sources created by humans. Developed countries spend billions of dollars annually on the disposal of radioactive waste. For this reason, radiometric monitoring of agricultural products is of great importance today.

In the world, large-scale research work is being carried out to develop methods for determining the presence of radionuclides in various products, which makes it possible to reduce their detection limit, eliminate or significantly reduce the effect of macro and micro-components on human health, and increase the accuracy and sensitivity of the analysis. Usually, when analyzing the presence of radionuclides in agricultural products, the methods of low background radiometry, beta spectrometry, and mass spectrometry are used. But these methods have several drawbacks, that is, low sensitivity and high error. Therefore, the use of new radiometric methods for determining the presence of radionuclides in various samples is of particular scientific importance. In our studies, we used a radiometric-spectrometric method for determining the presence of radionuclides in agricultural products [1, 8].

The main pollutants of the feed industry are potassium-40, cesium-137, and strontium-90 (Fig. 1). First, these radionuclides enter plants through the soil, and then into the body of animals and cause various oncological diseases in animal husbandry. And through dairy, meat, and other agricultural products, it enters the human body [2, 5]. Secondly, in plants, radionuclides accumulate from phosphorus fertilizers, which contain radioactive elements. If the plants are grown on the soil containing the most phosphorus fertilizers, especially superphosphates, then the compound feed made from this plant also contains radionuclides. With long-term use of large doses of phosphorus fertilizers in the soil, small amounts of heavy metals contained in them can accumulate uranium, thorium, and their daughter products of radioactive decay. There are especially many such impurities in superphosphate. Therefore, to avoid the possibility of involving toxic and radioactive elements in the biological cycle, the use of phosphorus fertilizers should be under the constant control of agrochemists.

Soil radioactivity is mainly due to human activity, i.e., technogenic radionuclides (Sr-90, Cs-137, etc.). However, it is now absolutely clear that the radioactivity of soils is mainly associated with the presence of natural radionuclides, namely, members of the radioactive series U-238 and Th-232, as well as K-40 [2, 4].

At present, the technogenic radiation background is caused by such highly active radionuclides as Cs^{137}, Sr^{90}, plutonium isotopes Pu^{239}, Am^{241}. These and many other so-called "artificial" radionuclides exist in the lithosphere without human participation, being formed as a result of natural nuclear reactions.

Factors affecting soil radioactivity:

- Type of natural environment;
- Climatic and landscape zone;
- Composition of rocks;
- Tectonic structure of sedimentary cover and crystalline basement;
- Interconnection of horizons with each other;
- Intensity and composition of atmospheric precipitation (filtration in the aeration zone);
- Salt composition of the soil;
- Seasonal variations in the level of radioactivity and abrupt changes during tectonic movements;
- The level of anthropogenic impact.

From radiation monitoring, the soil is an extremely complex object due to the following circumstances:

- a wide range of mineralization and composition of salts;
- a huge range of natural variations inactivity, the absence of the concept of background;
- the almost complete absence of radioactive equilibrium;
- different levels of activity even within the same horizon;
- seasonal variations in activity levels;
- variations in activity associated with tectonic movements;
- variety of radionuclide composition of soil [3].

The reason for the sharp violation of radioactive equilibrium in natural soils: differences in the geochemical properties of different elements and the rule of isotopic shift (of several radioactive isotopes of one element, short-lived ones are more mobile).

Routes of entry of radioactivity into soils:

1. Groundwater
2. Radon
3. Leaching from rocks
4. Flushing from the territories
5. Loss

According to researcher Vasilenko I. Ya., Radioactive cesium is one of the main dose-forming radionuclides of the fission products of uranium and plutonium. The nuclide is characterized by a high migration capacity in the external environment, including food chains. The main source of radiocaesium intake for humans is food products of animal and plant origin. Radioactive cesium supplied to animals with contaminated feed accumulates mainly in muscle tissue (up to 80%) and the skeleton (10%). Contaminated feed receives a dose from the soil, the radioactivity of the soil is mainly due to human activity, i.e., technogenic radionuclides (Sr-90, Cs-137, etc.). However, it is now absolutely clear that the radioactivity of soils is mainly associated with the presence of natural radionuclides, namely, members of the radioactive series U-238 and Th-232, as well as K-40 [6].

At present, the technogenic radiation background is caused by such highly active radionuclides as Cs^{137}, Sr^{90}, plutonium isotopes Pu^{239}, Am^{241}. These and many other so-called "artificial" radionuclides exist in the lithosphere without human participation, being formed as a result of natural nuclear reactions.

Over the past 100 years, there has been a sharp increase in the natural radiation background of natural environments by many orders of magnitude and bringing it in many cases to a level dangerous for humans. Factors affecting soil radioactivity (Fig. 1).

Figure 1 Factors affecting soil radioactivity

From radiation monitoring, the soil is an extremely complex object due to the following circumstances (Fig. 2):

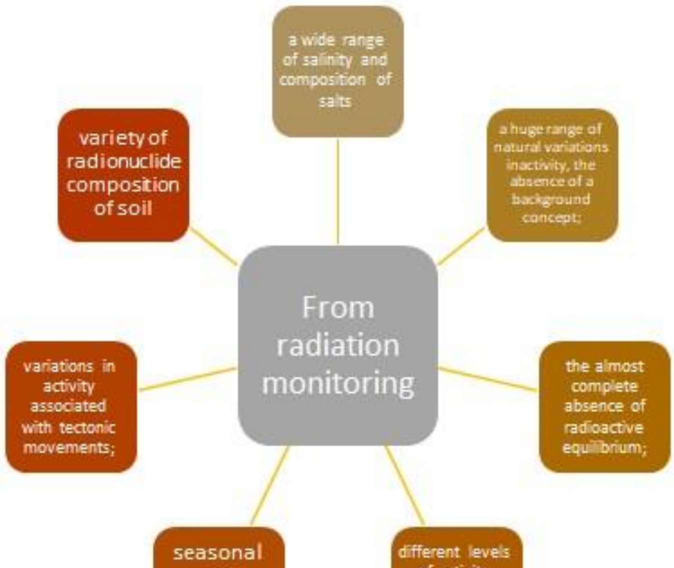

Figure 2 From radiation monitoring

The reason for the sharp violation of the radioactive equilibrium in natural soils: differences in the geochemical properties of different elements and the rule of isotopic shift (of several radioactive isotopes of one element, short-lived ones are more mobile) [7]. Routes of entry of radioactivity into soils (Fig. 3).

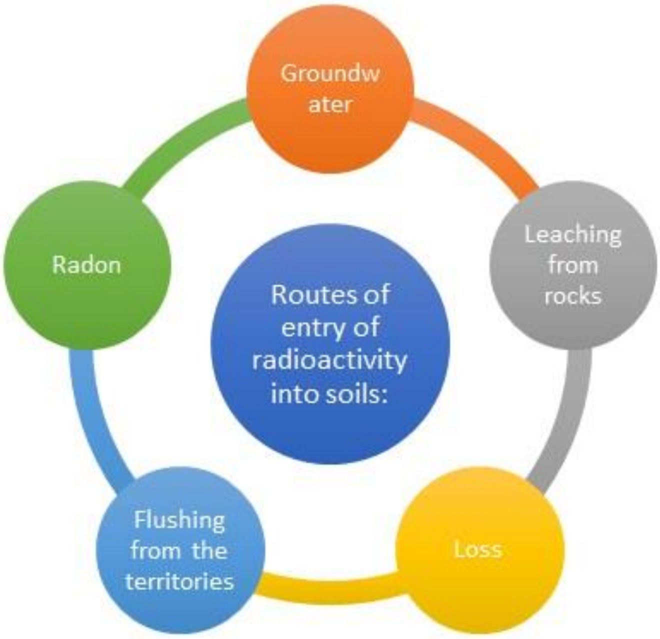

Figure 3 Routes of entry of radioactivity into soils

The main sources of external and internal radiation are radioactive cesium and strontium (Fig. 4).

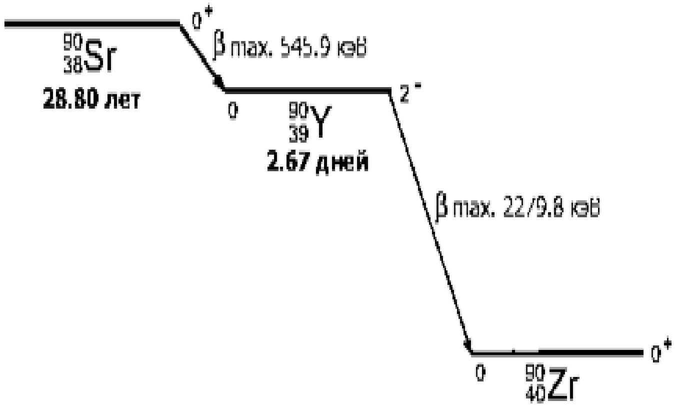

Figure 4 Scheme of the decay chain $^{90}Sr \rightarrow {}^{90}Y \rightarrow {}^{90}Zr$

Of the radioisotopes of cesium, ^{137}Cs is of the greatest importance, which is characterized by a high yield in fission reactions and a lifetime ($T_{1/2}$ = 30.2 years) and toxicity. It is considered to be one of the most significant radionuclides of nuclear fission products. Cesium-137 is a beta emitter with an average beta energy of 170.8 keV. Its daughter radionuclide 137mBa has a half-life of 2.55 min and emits gamma quanta with an energy of 661.6 keV during decay. Natural strontium belongs to trace elements and consists of a mixture of four stable isotopes ^{84}Sr (0.56%), ^{86}Sr (9.96%), ^{87}Sr (7.02%), ^{88}Sr (82.0%). In terms of physical and chemical properties, it is analogous to calcium. Strontium is found in all plant and animal organisms.

MATERIALS AND METHODS

Experimental part

To determine the presence of radionuclides in the feed industry products, an MKGB-01 "RADEK" radiometer-spectrometer (Russia) was used.

Figure: 3. Radiometer-spectrometer MKGB-01 "RADEK"

The radiometer measures the energy distribution of beta radiation in the energy range from 65 to 4000 keV. The study was carried out under static conditions from samples of the products of the feed industry (compound feed, silage, haylage, meal, and husk), which were selected at the warehouse of the "Yuksalish" farm in the Termez district of the Surkhandarya region of the Republic of Uzbekistan. Product samples were taken and cleaned with cold water according to the O'zDSt ISO / IEC 17025: 2017 standard. Pure products were crushed in a crusher and passed through a sieve with a diameter of 5-10 mm. The crushed samples were dried for 1 hour in a SNOL-80-01 drying cabinet at a temperature of 1000C. After cooling, the sample was placed in containers, filling the containers with the sample up to the mark on the container body.

The containers were weighed and the weight of the container with the sample was determined in grams and the weight of the sample was determined by the formula:

$$m_{so} = m_{knr} - m_{x} \quad g. \tag{1}$$

Then the bulk density of the sample was determined by the formula:

$$P_{so} = m_{so} / 1000 \quad g / cm3. \tag{2.}$$

The bulk density of each sample did not exceed 2 g / cm3. A label was filled on each counting sample, which indicated the sample number, sample weight.

RESULTS

The prepared containers were placed in a radiometer and the beta-radiation activity of cesium-137 and strontium-90 of each sample was measured for 40 minutes. The determination results are shown in Tables 1 and 2.

No	The name of the feed industry products	The value of the β- radiation activity Cs-137, Bq / kg *(HC=0,5)
1	Compound feed	0,55
2	Haylage, corn	0,24
3	Husk, cotton	0,32
4	Silo, reed	0,31
5	Small meal from cotton seeds	0,25

Table 1 Results of determinations of the presence of Cesium-137 radionuclide in products of the fodder industry.

(t_{meas} = 40 min, E_{max} = 624 keV, CW = 0.64 imp / s * Bq, BDEG-80, Marinelli vessel)

* (HC = 0.5) - the level of intervention of caesium-137 in agricultural products.

Table 1 shows that in most agricultural products, the level of interference of cesium-137 is lower, except for compound feed. Here the main role is played by temperature and humidity, because for the preparation of haylage, husks, silage, and meal you need a closed system for fermentation and the temperature of the system will be high (about 950C), and the compound feed are prepared in the usual dry mechanical way, that is, all the ingredients of the compound feed are crushed and mix thoroughly. For this reason, in other feeds, besides compound feed, cesium and strontium dissolve in water (they are readily soluble in water) and their concentration in the feed will below.

No	Name of food	The value of the β- radiation activity Sr-90, Bq / kg *(HC=2,5)
1	Compound feed	0,73
2	Haylage, corn	0,81
3	Husk, cotton	0,71
4	Silo, reed	0,95
5	Small meal from cotton seeds	0,87

Table 2 Results of determining the presence of radionuclide Strontium-90 food.

(t_{meas} = 40 min, E_{max} = 624 keV, CW = 0.64 imp / s * Bq, BDEG-80, Marinelli vessel)

* (HC = 2.5) - the level of strontium-90 interference in agricultural products.

Table 2 shows that in all products the amount of strontium-90 is lower above the intervention level.

CONCLUSIONS

Thus, we investigated different products of the feed industry and came to the following conclusion:

Radioactive cesium and strontium are biologically hazardous radionuclides. As a beta emitter, they pose the main danger when ingested. According to our research, an increased amount of cesium-137 radionuclide was found in the compound feed. In other feeds, the amount of cesium-137 and strontium-90 radionuclides is normal. The cesium-137 radionuclide enters the body with contaminated products of the feed industry and accumulates in the body of animals, and then in the human body, exposing it to constant radiation. In the end, it causes various cancers in the human body. Therefore, monitoring the presence of radionuclides in the feed industry is a necessary process.

CONFLICTS OF INTEREST

The authors declare that there is no conflict of interest.

DECLARATION OF INTERESTS

The authors declare that they have no known competing financial interests or personal relationships that could have appeared to influence the work reported in this paper.

FINANCING

The authors said there were no sources of funding.

ACKNOWLEDGMENTS

The authors gratefully acknowledge the great help and cooperation provided by all the respondents of this study. The authors would also like to thank Ph.D. Associate Professor Turaev Bakhodir Ergashevich, and Ulugov Bazar Dzhumaevich for his assistance and insights on an earlier draft of this article.

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