RADIOECOLOGICAL RESEARCHES USING DIFFERENT ANALYTICAL TECHNIQUES

РАДИОЭКОЛОГИЧЕСКИЕ ИССЛЕДОВАНИЯ С ИСПОЛЬЗОВАНИЕМ РАЗЛИЧНЫХ АНАЛИТИЧЕСКИХ МЕТОДОВ

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The aim of the present work is to give comprehensive studies in terms of ecological situation in two countries of different geological features (Egypt and Belarus). 89 samples of soil and 84 sediment were collected from Egypt [1]. While 63 samples were collected from Belarus. The samples were analyzed using Neutron activation analysis and gamma spectrometry. In Belarus, the maximum activity of ^{137}Cs was observed in the Gomel region near Mozyr (6830 Bq/kg) and the minimum activity in the Vitebskiy Region near Luzhki-Yazno (5 Bq/kg) [2]. The average activity concentrations of ^{40}K, ^{232}Th, and ^{238}U equal to 15.3±6.6, 15.6±11.1 and 220±31 Bq/kg, respectively, are significantly lower than those reported for the upper continental crust, world average sediments as well as world average soils, suggesting the presence of a considerable portion of mafic material, most probably originating from the Ethiopian High Plateau [1].

Целью настоящей работы является комплексное изучение экологической ситуации в двух странах с различными геологическими особенностями (Египет и Беларусь). Всего из Египта было собрано 89 образцов почвы и 84 отложений [1]. При этом в общей сложности было отобрано 63 образца из Беларуси. Образцы анализировали с использованием нейтронно-активационного анализа и гамма-спектрометрии. В Беларуси максимальная активность ^{137}Cs наблюдалась в Гомельской обл. около Мозыря (6830 Бк / кг) и минимальная активность в Витебской области около Лужки-Язно (5 Бк / кг) [2]. Средние значения удельной активности ^{40}K, ^{232}Th и ^{238}U, равные 15,3±6,6, 15,6±11,1 и 220±31 Бк / кг соответственно, значительно ниже, чем те, которые были зарегистрированы для верхней континентальной коры, среднемировых отложений, а также среднемировых значений. Почвы, свидетельствующие о наличии значительной части мафической породы, вероятнее всего, происходящей из Эфиопского Высокого Плато [1].

Keywords: NAA, gamma spectrometry, ecology, radioecology, environmental monitoring, ionizing radiation.

Ключевые слова: НАА, гамма-спектрометрия, экология, радиоэкология, мониторинг окружающей среды, ионизирующее излучение.

Neutron activation analysis (NAA) is one of the most accurate methods for determining elements in samples of different origin. It has high sensitivity, selectivity, does not destroy the sample under study. It allows the simultaneous determination of many elements in one sample and does not require complex chemical separation methods [3].

NAA has been widely used not only in radioecological research, but also is actively involved in geology for the search of oil and minerals; in environmental monitoring to assess the quality of air, water and soil; in ecology, for example, in assessing the migration of various pesticides from soil to groundwater and in many other studies.

The action of the NAA is based on the neutron bombardment of the analyzed sample with duration of several nanoseconds to hours. It is known that a neutron has no electric charge, so it does not interact with the electron shells of atoms and is not repelled by the Coulomb field of the nucleus. Due to these properties for the penetration of a neutron into the nucleus there is no potential barrier, and the neutron can cross the boundary of the nucleus, even if it moves at a very low speed [4].

When exposed to neutrons, radioactive isotopes with a certain half-life and radioactive radiation in the form of gamma quanta with different wavelength begin to form from the sample atoms. Then gamma quanta with different wavelengths pass through the gamma spectrometer, which allows determining the content of any atoms in the sample under study. Thus, thanks to this information, it is possible to determine the presence of certain elements in the sample and its concentration.

Among the disadvantages of this method is that the sample remains radioactive even for many years, and therefore requires the disposal of radioactive material. Also, the NAA as a method gradually disappears due to the reduction of

suitable nuclear reactors for irradiation, which is associated with a decrease in the popularity of this method and with the increasing cost of the reactors themselves [3].

Due to the strong anthropogenic impact on the ecosystem of various sources of radioactive and technogenic pollution, NAA is actively used to detect radioactive and abnormal elements found in abnormal concentrations in the soil, water, air and biological material. Thus, environmental protection is vital for modern society and the purpose of these studies is to identify sources of pollution and control the spread of various elements [5].

Ecology, and in particular radioecology as a science, became most relevant during the Second World War, when numerous nuclear weapons tests took place. Now this science also plays an important role in connection with the development of nuclear energy and medicine. Concentration of artificial radionuclides in the biosphere is constantly increasing due to the accumulation of nuclear waste or improper nuclear processing. Some highly toxic radionuclides have a long half-life (millions of years), which indicates a huge radiation load on the environment and requires constant development and improvement of radioecological monitoring methods [5].

In radioecology, NAA and gamma spectrometry are used to assess the natural radiation background, its effect on living and nonliving objects, as well as in assessing the contamination of a certain territory with various technogenic factors (industry, nuclear power stations).

NAA, together with gamma-spectrometry, is an excellent method for assessing the radioecological situation in various areas, both of man-made contamination and normal environmental conditions. It is actively involved in a huge number of international projects and is still a relevant tool of modern radioecology and environmental monitoring [3].

Thanks to the NAA, studies are conducted on the presence of cosmic dust in various plant species around the world, with a subsequent assessment of the viability of these species in which cosmic dust was detected. Also after the accident at the Chernobyl nuclear power station and other man-made disasters, it became important to monitor radioactively contaminated sites and territories for research on the presence of radionuclides in soil, water and air, and its migration. These studies are also important because the excessive accumulation of radionuclides in the ecosystem contributes to its accumulation in the human body with the subsequent development of various pathologies, the most dangerous of which is oncology [3; 6].

The accident at the Chernobyl nuclear power station in 1986 led to irreparable contamination of the vast territories of Belarus with various radionuclides for millions of years. Due to this man-made disaster, radioecology and environmental monitoring, both in this country and around the world, have caused the greatest relevance. Over the past 33 years after the accident, an enormous amount of research has been conducted with various methods on the effect and distribution of radionuclides in the ecosystem and on the further forecast of their spread to other territories. Among such methods can be identified NAA and gamma spectrometry.

For example, studies were carried out in 2006–2007 of the elemental composition of the territories of Belarus and the presence of ^{137}Cs and ^{210}Pb radionuclides in Belarus 30 years after the accident at the Chernobyl nuclear power station in an article by *Yu.V. Aleksiayenak et al.* The objects of the study were mosses *Hylocomium splendens* and *Pleurozium schreberi*, and NAA and gamma spectrometry were used as the method for determining the presence and concentration of elements in the object. Based on the results of a study obtained using a gamma spectrometer, Figure 1 shows the concentration of ^{137}Cs and ^{210}Pb in various regions of Belarus [2].

Thus, NAA and gamma spectrometry give researchers and scientists in the field of radioecology and other scientific disciplines a fairly accurate determination of the presence of radionuclides in objects of animate and inanimate nature. This information is very important in assessing the migration of radionuclides in the atmosphere and the future determination of the effectiveness of various measures to eliminate the negative effects of not only the Chernobyl nuclear power station, but also other man-made accidents and disasters of various sizes [2; 3].

Another example of the use of NAA and gamma spectrometry in radioecology is the study of the environmental radioactivity of soil and bottom sediments of the deltas and the Nile River basin by *W. Badawy et al.* In the course of these studies, the natural radiation background of the Nile River was estimated by the presence of natural ^{40}K, ^{232}Th, and ^{238}U and determination of their concentration under the influence of various natural factors, and in particular the movement of various rocks along the Nile River [1].

To study the natural background radiation, it was necessary to take samples of soil and bottom sediments from the delta and along the entire Nile River within the territorial boundaries of Egypt (Fig. 2). This approach made it possible to accurately determine the presence of ^{40}K, ^{232}Th, and ^{238}U in various areas of the Nile River using NAA [1].

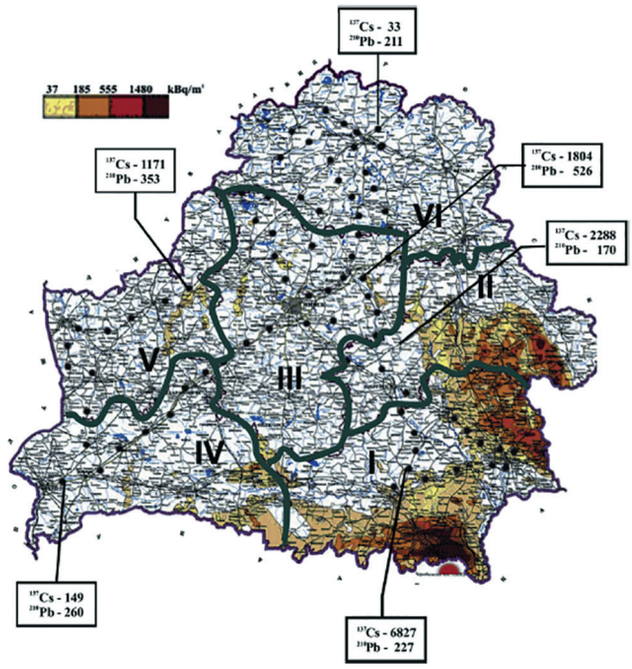

Figure 1 – Map of ^{137}Cs and ^{210}Pb contamination in Belarus in 2004 with sampling points with the maximum concentration (Bq / kg of dry moss) in different regions from the study of Yu. V. Aleksiayenak et al. [2]

Figure 2 – General map of Egypt showing the locations of the collecting points along the Nile valley according to W. Badawy et al. [1]

The results obtained in the study of the Nile River by *W. Badawy et al.* were then compared with results from other countries (Table 1), which indicates the relevance of using NAA and gamma spectrometry in world science [1]. NAA and gamma spectrometry allow an assessment of the elemental composition and natural background radiation in various regions of the planet, and the variability of background radiation under the influence of various biotic and abiotic environmental factors [3].

Table 1 – Comparison of average values of activity concentrations (Bq / kg) between countries according to W. Badawy et al. [1]

Activity concentration (Bq / kg)			
Country	^{232}Th	^{238}U	^{40}K
Finland	62	78	962
Australia	89	4	681
Hungary	32.1	33.3	418
Jordan	26.7	49.9	291
Egypt	15.3	15.6	220
Nigeria	20	20	180
Ghana	24.2	13.6	162
Libya	4.5	7.5	28.5
Worldwide	30.0	35.0	400

NAA is currently one of the most reliable methods for determining elements in the sample under study. Despite its economic value and demands in specially trained personnel, this method is still actively used for radioecological assessment of the state of the environment and in many other areas of scientific research.

Constant improvement of reliability and operability of sources of radiation pollution of the environment is required in order to avoid the risk of a man-made disaster. Also, a large role is assigned to the regular monitoring of the state of the environment in order to quickly prevent and save the population and other living organisms from the deadly effects of radiation, and one of the leading roles in this area belongs to the NAA and gamma spectrometry.

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МОДИФИЦИРУЮЩЕЕ ДЕЙСТВИЕ ЗАСОЛЕНИЯ СРЕДЫ НА ПРОРАСТАНИЕ ГАММА-ОБЛУЧЕННЫХ СЕМЯН

SALTING AS A MODIFICATOR OF THE PROCESS OF GROWTH OF GAMMA-IRRADIATED SEEDS

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Наличие эффекта радиостимуляции у растений связано с поливалентностью эффекта облучения и факторами окружающей среды, которые могут быть модификаторами радиобиологических эффектов. В представленной работе критериями оценки эффектов раздельного и последовательного действия гамма-облучения (доза 2,5 и 5,0 Гр) и засоления (1,0 и 2,5 % NaCl) были выбраны скорость набухания семян озимой ржи, их всхожесть и накопление биомассы осевыми органами прорастающих растений. Установлено, что облучение семян активирует процесс прорастания с «физического набухания» и до формирования проростка