AP19678770 "Radioecological aspects of power coals and ash and slag waste radioactivity in the context of their impact on the environment" – p.m. Pak Yu.N.

Relevance

The relevance of the results is associated with studying radioecological aspects of natural radioactivity of power coals and ash and slag waste in the context of their negative impact on the environment.

The radiation hazard associated with natural radioactive elements contained in coal is one of the important problems of coal power engineering, which is underestimated in Kazakhstan. Systematic monitoring of radioecological safety is needed to reduce the radiation exposure of personnel and the population living in the areas where coal-fired thermal power plants are located. The existing radiation safety standards are limited to the content of radionuclides only in ash and slag waste when used for construction purposes.

Project objective

The objective of the project is to assess the impact of using coal containing natural radioactive elements in fuel energy on the radioecological situation of the environment.

Achieved results

In the coming decades, the share of coal in electricity generation will be even more significant. This exacerbates environmental problems due to radiation contamination of the environment with radionuclides concentrated in ash and slag waste and fly ash. In Kazakhstan, natural radioactivity of coals was poorly studied. Increased concentrations of radionuclides were found in a number of deposits (Karazhyra, Maikube). The average uranium and thorium contents in coals of Kazakhstan are 1.8 and 2.2 g/t, and in ash 8.7 and 10.6 g/t. Ash and slag dumps become a man-made deposit of radionuclides. When coal is burned at thermal power plants, some of the radionuclides are carried into the atmosphere by flue gases.

The innovative nature of this project lies in studying the distribution and forms of presence of NRE in coals to model the behavior of radionuclides during combustion and predict their potential emission into the environment.

In 2023, the features of the distribution of natural radionuclides of uranium, thorium and potassium in power-generating coals, their specific activity and forms of their presence depending on the coal grade and its quality (ash content) were studied. Specific radioactivity (concentrations of uranium (radium), thorium and potassium-40) was determined using power-generating coals as an example. Specific radioactivity of natural radioactive elements was determined in ash and slag waste obtained from burning power-generating coals. Preliminary conclusions were made in the process of processing the analysis results about a significant concentration of natural heavy radionuclides in ash and slag waste.

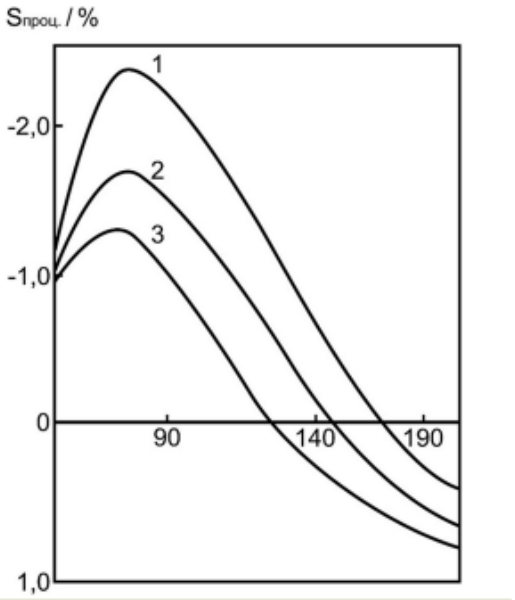
A sufficient number of selected representative samples and specimens, data on the specific activity of each radionuclide obtained on the basis of their analysis by modern nuclear radiometric, radiochemical and X-ray methods were determined. Primary representative samples and specimens of energy coals of Kazakhstan (using the Ekibastuz and Karaganda deposits as examples) were selected. The selected samples were prepared in accordance with GOST for analyzing uranium, thorium and potassium-40. 30 coal samples and 30 ash and slag waste samples were submitted for determining specific radioactivity of natural radioactive elements in them by a certified gamma-spectrometric method. Partial studies were performed to verify the correctness of the analysis and to assess random errors. Analytical studies were conducted to develop a model of the natural radionuclides behavior during coal combustion at thermal power plants and to predict the potential emission of these radionuclides into the environment.

An article was in a domestic publication recommended by the CQASHE.

In 2024, the distribution patterns of natural radioactive elements in fossils were studied. It was found that there is a lot of data on the forms of uranium, thorium and potassium-40 in fossil coals. Coals with a below-clarke uranium content are mainly characterized by the mineral form of occurrence, and coals enriched in uranium are characterized by the organic form. Estimation of the uranium balance by the forms of occurrence in different types of coal at different concentrations remains problematic. There is no clarity on the role of diagenesis and coal metamorphism on the form of uranium. The accumulation of uranium in coal depends on the formation of coal seams. As a result of sorption, uranium accumulates in organic matter or in clastogenic material. Sometimes a significant amount of uranium is associated with soluble aluminosilicate compounds. In coals with an abnormal uranium content, the dispersed form predominates. In the early stages of coal formation, the bulk accumulates in organic matter. In the process of coalification (changing the structure of organic matter), the ratio of uranium species changes. The role of mineral species increases. The geochemistry of thorium was also studied. An idea of the mineral species of thorium in coals was formed. The main carriers are monazite, rare-earth phosphates, silicates and aluminosilicates. There is also information about the possibility of Th concentration in organic matter. In general, thorium in coals is characterized by a high significant positive relationship with the ash content of coal. Medium-ash coals are characterized by Th in organic matter. In the process of coal metamorphism, species change with the formation of their own minerals. Radionuclide K40 is mainly contained in clay minerals, its concentration is closely related to the ash content of coal.

Generalization of the world experience on natural radioactivity of coals indicates that coal deposits of Kazakhstan are poorly studied for the presence of natural radioactive elements (uranium, thorium, potassium-40). Coals of Kazakhstan are generally characterized as weakly radioactive. Clarke contents of uranium and thorium in hard coals are 1.9 g/t and 3.1 g/t, respectively. The content of these natural radionuclides in the main coal deposits (Ekibastuz, Karaganda) is close to the clarke. However, in the ridge of deposits (Shubarkol, Maikube, individual layers of oxidized coals), elevated concentrations of uranium are observed. During combustion of coals even with low concentrations of radionuclides in combustion waste (solid ash, slag, fly ash), the content of radionuclides (uranium-238 and its decay products, thorium-232 and its decay products and potassium-40) increases by 3-8 times compared to the original coal. Using the example of Ekibastuz and Karaganda coals with different ash contents, the specific activities of the main radionuclides (U^{238} (Ra), Th^{232} and K^{40}) were determined by instrumental analysis of 25 coal samples from the Ekibastuz deposit using the gamma spectrometric method based on a semiconductor detector. The concentrations (specific activities of radionuclides) were determined: uranium-238 (radium-226) - 11.2-14.9 Bq/kg; thorium-232 - 11.7-13 Bq/kg; potassium-40 – 28-63 Bq/kg. In the ash and slag waste of the state district power plant burning Ekibastuz coal, the specific activities were U (Ra) – 53-70 Bq/kg; Th – 50-67 Bq/kg; K – 220-270 Bq/kg.

The concentration factors of radionuclides (the ratio of the concentration of a radionuclide in the ash and the original coal) vary within the range of 4.2-8.6. In the ash and slag waste of the Topar GRES, which burns Karaganda coals, the concentration factors of radionuclides vary within the range of 2.5-10.9. The results obtained indicate that when burning low-radioactive coals, radionuclides are concentrated in the ash and slag waste. The degree of concentration depends on many factors: the quality and brand of the coal burned, the concentration of radionuclides and their form of occurrence, combustion technologies and conditions, etc. Ash dumps, where ash and slag are stored, occupy vast territories and, in fact, turn into quasi-technogenic deposits of natural radioactive nuclides and many toxic, rare and rare earth elements. An article was published in a domestic edition recommended by the CQASHE; 2 Eurasian patents were received. The research results were presented at 3 international conferences (KazNiTU, Almaty, S. Ordzhonikidze RSUH, Moscow, branch of Lomonosov Moscow State University, Dushanbe), a textbook, a tutorial.



1, 2, 3 – H = 2; 4; 7 см

Рисунок 2 – Зависимость относительной чувствительности к железу от энергии регистрируемых гамма-квантов

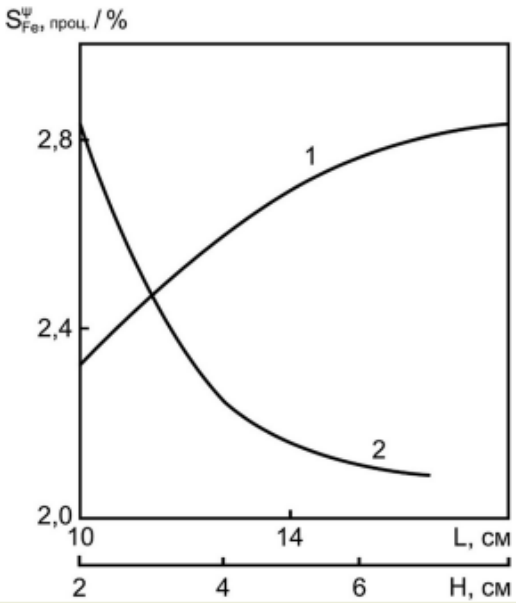


Рисунок 3 – Зависимость относительной чувствительности метода к железу: 1 – от длины зонда (H = 2 см), 2 – от высоты H (L = 18 см)

Figure 2 – Relative sensitivity to iron dependence on the energy of registered gamma-quanta

Figure 2 – Relative sensitivity to iron dependence on the: 1 – probe length; 2 – on the height

List of publications

in 2023:

1. Pak D., Tebayeva A., Pak Yu. Instrumental express analysis of ferromanganese ores by nuclear-geophysical method. University Proceedings. A. Saginov KTU. Karaganda, 2023. Iss. 4, P. 104-108.

in 2024:

1. Pak D.Yu., Tebayeva A.Yu., Pak Yu.N. Geological and geophysical testing of iron ores by the gamma-albedo method. University Proceedings. A. Saginov KTU. Karaganda, Issue. 2, 2024. P. 100-107.

2. Pak Yu.N., Pak D.Yu., Tutanov S.K., Bulatbayev F.N., Begimbetova A.S., Kenetayeva A.A., Tebaeva A.Yu., Yessendossova A.N. Gamma-albedo method of monitoring the effective atomic number of a complex substance. Eurasian Patent No. 046032, 2024.

3. Pak Yu.N., Pak D.Yu., Tutanov S. K., Ponomareva M. V., Ponomareva E. V., Tebayeva A. Yu., Matonin Vl. V. Radiometric method of assessing the content of natural radioactive elements in coals. Eurasian Patent No. 046319, 2024.

4. Pak D.Yu., Tebayeva A.Yu., Pak Yu.N. Laboratory practical training on nuclear technologies in geological and geophysical research (Part III): Titorial. Publishing House of A. Saginov KTU. 2024, 74 p.

5. Pak Yu.N., Ibatov M. K., Pak Yu.N., Tebayeva A. Yu. Fundamentals of Scientific Research and Inventive Creativity. Textbook with the stamp of the RK MES. Karaganda. KTU Publ. House, 2024, 151 p.

6. Pak D.Yu., Tebayeva A.Yu., Pak Yu.N. Nuclear-physical method of monitoring the ash content of coal. International Scientific Conference "Geology in Space and Time", branch of M.V. Lomonosov Moscow State University, Dushanbe, 2024, pp. 100-1012.

7. Tebayeva A.Yu., Pak D.Yu., Pak Yu.N. Analyzing ferromanganese ores using the nuclear-geophysical method. Proceedings of the XI International Scientific Conference of Young Scientists "Young People for Earth Sciences", Moscow, RSUH named after Ordzhonikidze, 2024.

8. Pak D.Yu., Tebayeva A.Yu., Pak Yu.N. Methodological studies of nuclear-geophysical control of the calorific value of coarse fuel. Proceedings of the International Scientific and Practical Conference "SATBAYEV INTERNATIONAL CONFERENCE 2024 (Satpayev Readings - 2024). Integration of Science and Technology: The Path to Sustainable Development, pp. 100-1012.

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Information for potential consumers

Studying natural radioactivity of coals and ash and slag waste generated during their combustion in coal power engineering is needed for fuel energy enterprises and state environmental control services

Scope: Earth and environmental sciences

Date of information updating: 08/11/2024