REVIEW
of the official reviewer for dissertation work
Nursapina Nurgul Armankyzy on the theme «Entering of natural radionuclides in soil and root crops with fertilizers and their distribution in "soil-plant" system» presented for the degree of Doctor of Philosophy (PhD) for educational programm «8D05301-Chemistry».

№	Criteria	Eligibility (one of the options must be checked)	Justification of the position of the official reviewer
1.	The topic of the thesis (as of the date of its approval) corresponds to the directions of development of science and/or state programs	1.1 Compliance with priority areas of science development or government programs: 1) The thesis was completed within the framework of a project or target program financed from the state budget (indicate the name and number of the project or program) 2) The thesis was completed within the framework of another state program (indicate the name of the program) 3) The dissertation corresponds to the priority direction of the development of science, approved by the Higher Scientific and Technical Commission under the Government of the Republic of Kazakhstan (indicate the direction)	1. The dissertation was completed within the framework of the state budget-funded scientific project of the Ministry of Education and Science of the Republic of Kazakhstan: "Influence of application of mineral fertilizers on accumulation ability of radionuclides and heavy metals in root vegetables" (Grant No. AP08052224, 2020–2022). 2. No, the thesis was not completed within the framework of another state program. 3. The dissertation corresponds to the priority area of science development: "Ecology, environment, and rational use of natural resources" as defined by the Higher Scientific and Technical Commission under the Government of the Republic of Kazakhstan. The research examines the distribution and transfer of natural radionuclides in the "soil–plant" system under the influence of fertilizers, which directly pertains to issues of environmental safety, soil contamination, and the

			ecological impact of agricultural practices.
2.	Importance for science	The work makes/does not make a significant contribution to science, and its importance is well disclosed/not disclosed	The dissertation makes a significant contribution to the scientific understanding of radionuclide behavior in the soil–plant system under the influence of various types of fertilizers. The importance of the research is clearly articulated in the introduction and supported throughout the thesis by well-formulated objectives, comprehensive analysis of experimental data, and relevant conclusions. Given the global relevance of environmental safety and food security, the findings of this work contribute to both fundamental knowledge in radioecology and its practical application in sustainable agriculture.
3.	The principle of independence	Self-reliance level: 1) High; 2) Medium; 3) Low; 4) No independence	The author's personal contribution includes the analysis of scientific literature, conducting the vegetation experiment, preparing samples for analysis, performing radiochemical separation for the simultaneous determination of natural radionuclide isotopes in the studied samples, followed by measurements using an alpha-spectrometer (Alpha Analyst, Canberra, USA), as well as processing and interpreting the obtained results.
4.	The principle of inner unity	4.1 Justification of the relevance of the thesis: 1) Justified; 2) Partially justified; 3) Not justified.	The relevance of the thesis is fully justified and clearly supported by current scientific, environmental, and agricultural challenges.
		4.2 The content of the thesis reflects the topic of the thesis:	The content of the thesis fully reflects its

		1) <u>Reflects;</u> 2) Partially reflects; 3) Does not reflect	stated topic and consistently addresses the stated research objectives.
		4.3. The purpose and objectives correspond to the topic of the thesis: 1) <u>correspond</u>; 2) partially correspond; 3) do not correspond	The purpose of the thesis — to establish the influence of application of fertilizers on the accumulation ability of radionuclides in root vegetables *D. carrota* and *R. sativus* — is clearly formulated and fully corresponds to the topic under investigation. The research objectives are logically derived from this goal and are consistently addressed throughout the dissertation.
		4.4 All sections and provisions of the thesis are logically interconnected: <u>1) completely interconnected;</u> 2) the interconnection is partial; 3) there is no interconnection	All sections and key provisions of the thesis are logically interconnected and follow a clear and consistent scientific structure. The literature review, methodology, experimental part, and conclusions are coherently aligned with the research objectives.
		4.5 The new solutions (principles, methods) proposed by the author are reasoned and evaluated in comparison with the known solutions: <u>1) there is a critical analysis;</u> 2) partial analysis; 3) the analysis does not represent one's own opinions, but quotes from other authors	For the first time, the influence of nine types of fertilizers available on the Kazakhstani market on the mobility and bioavailability of natural radionuclides in soils of the Almaty and Turkestan regions was investigated. The assessment was carried out using the method of sequential selective extraction, enabling comparison with established approaches and providing a justified rationale for the methods applied in the study.
5.	Scientific novelty principle	5.1 Are the scientific results and provisions new? <u>1) completely new;</u> 2) partially new (25-75% are new); 3) not new (less than 25% are new)	The scientific results and provisions of the thesis are completely new. For the first time, the effect of nine types of fertilizers used in Kazakhstan on the mobility and

			bioavailability of natural radionuclides in soils of Almaty and Turkestan regions was comprehensively studied. The work introduces new data on soil–plant transfer factors and isotope ratios for uranium and thorium series under fertilized conditions.
		5.2 Are the dissertation findings new? 1) completely new; 2) partially new (25-75% are new); 3) not new (less than 25% are new)	The findings are completely new and present original data on radionuclide transfer in fertilized soils of Kazakhstan, not previously reported in the literature.
		5.3 Technical, technological, economic or management decisions are new and reasonable: 1) completely new; 2) partially new (25-75% are new); 3) not new (less than 25% are new)	The dissertation introduces new technical approaches in assessing radionuclide transfer and bioavailability using sequential selective extraction methods. While the general principles of environmental radioactivity assessment are known, their specific application to Kazakhstani soils and fertilizer types, as well as the recommendations for safer fertilizer use in agriculture, represent partially new and practically relevant solutions.
6.	The validity of the main findings	All main conclusions are/are not based on scientifically significant evidence or well-grounded (for qualitative research and areas of training in the arts and humanities)	All main conclusions are based on scientifically significant evidence. The conclusions are supported by comprehensive experimental data obtained through validated analytical methods, including alpha-spectrometry and k_0-INAA. The findings are systematically interpreted and aligned with the research objectives, ensuring their scientific credibility and relevance.
7.	The main provisions for the defense	It is necessary to answer the following questions for each provision separately: 7.1 Is the provition proven?	Provision 1: The total activity concentration of U-234, U-238, Th-230, Th-232, and Ra-

		1) proven; 2) rather proven; 3) rather not proven; 4) not proven 7.2 Is it trivial? 1) yes; 2) no 7.3 Is it new? 1) yes; 2) no 7.4 Application level: 1) narrow; 2) medium; 3) wide 7.5 Is it proven in the article? 1) yes; 2) no	226 in monopotassium phosphate, ammonium nitrate, superphosphate, double superphosphate, phosphoric, organo-mineral mixture, NPK fertilizer, microfertilizer, peat fertilizer did not exceed limit value of 1000 Bq/kg according to the Technical Regulations of the Eurasian Economic Union "On requirements for mineral fertilizers." 7.1 – 1) Proven 7.2 - 2) No 7.3 - 1) Yes 7.4 - 3) Wide 7.5 - 1) Yes Provision 2: The application of monopotassium phosphate to soil samples from Baiterek village (Almaty region) increases the proportion of mobile uranium and leads to increase in the accumulation of uranium in the edible root of *R.sativus*. 7.1 – 1) Proven 7.2 - 2) No 7.3 - 1) Yes 7.4 - 2) Medium 7.5 - 1) Yes Provision 3: The application of double superphosphate to soil samples from Kyzemshek village (Turkestan region) significantly increases the transfer and accumulation of uranium isotopes (U-234, U-238) and Ra-226 in the edible root of *D.carrota*, compared to unfertilized soils.

			7.1 – 1) Proven 7.2 - 2) No 7.3 - 1) Yes 7.4 - 2) Medium 7.5 - 1) Yes
8.	The principle of reliability Reliability of sources and information provided	8.1 Choice of methodology - is justified or the methodology is described in sufficient detail 1) yes; 2) no	The choice of research methodology is fully justified. Analytical methods such as alpha spectrometry, k_0-INAA, and sequential extraction are described in sufficient detail and are appropriate for the research objectives. The procedures are validated, and quality control measures are clearly outlined.
		8.2 The results of the thesis were obtained using modern methods of scientific research and methods of processing and interpreting data using computer technologies: 1) yes; 2) no	The results were obtained using up-to-date scientific methods, including alpha spectrometry and k_0-INAA, as well as modern data processing techniques. Computer software was used for statistical evaluation and graphical presentation of the findings, ensuring accuracy and clarity of interpretation.
		8.3 Theoretical conclusions, models, identified relationships and patterns have been proven and confirmed by experimental research (for areas of training in pedagogical sciences, the results have been proven on the basis of a pedagogical experiment): 1) yes; 2) no	The theoretical conclusions and identified relationships between fertilizer type and radionuclide accumulation in root vegetables are supported by well-structured experimental research. The consistency of results across different soil types and plant species confirms the reliability of the established patterns.
		8.4 Important statements are confirmed / partially confirmed / not confirmed by references to current and reliable scientific literature	The key statements and theoretical foundations in the thesis are confirmed by references to up-to-date and credible scientific sources, including peer-reviewed

			articles, IAEA reports, and international methodological guidelines. The literature review is comprehensive and relevant to the research topic.
		8.5 Used literature sources are <u>sufficient</u>/not sufficient for a literature review	The dissertation cites 176 sources, including recent international publications. This number is sufficient for a comprehensive and relevant literature review.
9	Practical value principle	9.1 The thesis has theoretical value: <u>1) yes;</u> 2) no	The results of the dissertation expand scientific understanding of the behavior of natural radionuclides in the soil–plant system, significantly contributing to the formation of theoretical knowledge about the mobility and bioavailability of radionuclides under the influence of various types of fertilizers. The work makes a valuable contribution to the fields of radioecology and environmental geochemistry by providing deeper insights into radionuclide transfer mechanisms in agroecosystems. The obtained data are important for developing scientifically grounded approaches to fertilizer application in areas with elevated levels of natural radionuclides and serve as a basis for preparing regulatory documents and recommendations to ensure radiological safety.
		9.2 The thesis is of practical importance and there is a high probability of applying the results obtained in practice: <u>1) yes;</u> 2) no	The results of the dissertation have clear practical significance, as they can be used in the development of regulatory documents governing the use of fertilizers in areas with elevated levels of natural radionuclides. The

			findings provide a scientific basis for selecting fertilizers that minimize the transfer of radionuclides into edible plant parts, thereby contributing to improved environmental and food safety. This ensures a high probability of applying the results in agricultural and environmental management practices.
		9.3 Are the practice suggestions new? 1) completely new; 2) partially new (25-75% are new); 3) not new (less than 25% are new)	The practical suggestions made in the dissertation — such as the identification of specific fertilizers that increase or reduce the mobility and bioavailability of natural radionuclides — represent new contributions in the context of Kazakhstani agricultural conditions. While the general issue of radionuclide transfer is known, the region-specific recommendations and application of sequential extraction techniques provide partially new and applicable solutions for agricultural and environmental safety.
10.	The quality of writing and design	Academic writing quality: 1) high; 2) average; 3) below average; 4) low.	The academic writing quality of the dissertation is high. The text is well-structured, logically organized, and written in clear scientific language. Terminology is used correctly, and the style is appropriate for a scholarly work.

11.	Notes on a thesis	The following comments can be noted: 1. Typographical error in the table of contents: On page 2, the section is titled "EXPERIMENATL PART", which is a typographical error. It should be corrected to "EXPERIMENTAL PART". 2. Incorrect use of a scientific term: The word "concertation" is mistakenly used in several places instead of the correct term "concentration". These errors should be corrected. 3. Use of Latin names for crops is inconsistent throughout the text. 4. Figures and tables do not always include fertilizer codes (e.g., SP, AN, OMM) alongside full names. For easier cross-referencing and consistency, it is advisable that figures and tables consistently include both the fertilizer codes (e.g., SP, AN) and their full names (e.g., superphosphate, ammonium nitrate). This would help readers unfamiliar with the abbreviations.
12.	Scientific level of the doctoral student's articles on the topic of research (in case of defense of the dissertation in the form of a series of articles, the official reviewers comment on the scientific level of each article of the doctoral student on the topic of research)	The main results of the dissertation are reflected in 11 publications, which include: - One article in an international peer-reviewed journal with a non-zero impact factor (IF = 1.9, Q3, SJR 0.621, *Journal of Environmental Radioactivity*). This publication presents original experimental results on the transfer of radionuclides from soil to plants and meets international standards of scientific quality. The doctoral student contributed to experiment execution, data analysis, drafting, and revision of the manuscript. - Three articles in journals recommended by the Committee for Quality Assurance in Education and Science of the Ministry of Education and Science of the Republic of Kazakhstan. These publications cover elemental analysis of fertilizers, metal mobility in soils, and impurity determination. The doctoral student was actively involved in sample preparation, result interpretation, manuscript drafting, and responses to reviewers. - Six abstracts presented at international conferences. They reflect experimental progress and the doctoral student's ability to communicate scientific findings to the academic community. - One monograph (co-authored), which summarizes experimental and analytical work on radionuclide and heavy metal accumulation in root vegetables. The doctoral student contributed to the literature review, experimental part, and data interpretation.
13.	Decision of the official reviewer (pursuant to paragraph 28 of the present Model Regulations)	In general, the dissertation of Nurgul Nursapina titled "Entering of natural radionuclides in soil and root crops with fertilizers and their distribution in the 'soil–plant' system," submitted for the degree of Doctor of Philosophy (PhD) in the educational program "8D05301 – Chemistry" has been completed at a high scientific level. The dissertation contains a set of new, well-substantiated scientific results, demonstrates internal consistency, and meets the priority areas of scientific development as well as the regulatory requirements

		for PhD dissertations. It is recommended to petition the Committee to award Nurgul Nursapina the degree of Doctor of Philosophy (PhD) in the educational program "8D05301 – Chemistry".

Official Reviewer:
Senior Researcher at the Center for Integrated Environmental Research,
RSE on REM Institute of Nuclear Physics,
PhD.

(signature)

Krasnopyorova M.V.

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