**Abstract**

**PhD Dissertation for the Degree of Doctor of Philosophy (PhD) in the specialty "6D060800 – Ecology" by Yespolayeva Aikerim Ryskulovna on the topic:" Assessment of the contribution of oil and gas production complex to the formation of the ecological state of Mangystau region"**

**General Characteristics of the Work.**This scientific study utilizes the "Atlas of Mangystau Region" from the Institute of Geography, Ministry of Education Science of the Republic of Kazakhstan as its primary input material. The study aims to provide a comprehensive analysis of the natural, economic, and social conditions of the area, focusing on the assessment of environmental impacts. The research incorporates system-wide and eco-geographical laws to understand the relationships between natural components and to transform cartographic information into quantitative data for mathematical models. One of the key objectives of the study is to develop a method for solving the inverse problem related to environmental impact assessment. Expert estimates map of human impact on environmental components in the Mangystau region are used as a basis for this research. The study aims to address new theoretical challenges related to environmental issues in the region.

**Relevance of the research topic**. Management decisions aimed at reducing environmental stress in regions are typically based on the principle of "the polluter pays," which involves imposing fees or penalties on those who are responsible for environmental damage. However, in the field of waste management, this principle is often undermined by the practice of outsourcing waste removal and recycling to specialized companies on a contractual basis.

To truly assess the environmental impact of different industries and companies in a region, an independent evaluation of environmental data is necessary. This evaluation should consider the overall impact of all enterprises in all sectors of the economy, as well as the specific contributions of individual industries or companies to overall pollution levels.

In the case of the oil and gas extraction industry in the Mangystau region, addressing environmental challenges requires innovative solutions that take into account the complex interplay of factors affecting the local environment. This may involve conducting comprehensive environmental assessments and developing strategies to mitigate the industry's impact on the region's ecosystem.

**Purpose of Research:** The purpose of this research is to evaluate the impact of oil and gas extraction on the environment in the Mangystau region. The goal is to assess the overall anthropogenic disturbance in the area and determine the extent to which the oil and gas industry contributes to this disturbance. The research aims to provide an independent evaluation that can be used to implement the "polluter pays" principle, requiring those responsible for environmental damage to bear the costs. This evaluation will be based on existing peer-reviewed maps that assess the level of human impact on various environmental components.

**To achieve this purpose the following tasks were identified and solved:**

Assess the impact of oil and gas production on the natural and economic characteristics of the Mangystau region, including the effects on biodiversity, water resources, and local communities.

Study the current environmental situation in the region, including air, water and soil quality, waste management, and the overall ecological footprint of industrial activities.

Develop a comprehensive methodology for conducting integrated environmental assessments in the region, considering the results of previous assessments and the specific challenges of anthropogenic transformation.

Quantify the contribution of the oil and gas industry to the environmental degradation in the region using advanced analytical methods and tools.

Provide recommendations for sustainable development practices and mitigation measures to address the environmental impact of oil and gas activities in Mangystau.

**The object and subject of study.** Additionally, field research will be conducted to collect data on the current ecological state of the region. Interviews with local residents, government officials, and experts in the field will also be conducted to gather information on the factors influencing the environment in Mangystau region.

**Methods of research.** The data collected through these various methods will be analyzed using statistical and qualitative research techniques to identify trends, patterns, and correlations in the data. The results of the research will be used to assess the current ecological state of the region, identify the main factors contributing to anthropogenic transformation, and make recommendations for sustainable development and environmental conservation in Mangystau region.

**Scientific novelty of research**. The novelty of the research is determined by the development of new methods for solving theoretical problems - “inverse” problems traditionally used in complex environmental assessment. The fundamental difference between the ideas for studying existing methods of integrated environmental assessment is the use of multidimensional models (the objective function as a linear multiple regression equation).The capabilities of these models are significantly superior to those traditionally used in GIS overlay operations, since areas of intersection can be identified by no more than three parameters, while environmental engineering methods show that to achieve acceptable accuracy of estimates, there must be at least five important parameters

**The theoretical significance of the work** lies in the development of methods for quantitatively determining the contribution of the oil and gas production complex to the transformation of anthropogenic components of the environment of the Mangistau region as a concrete result of a new solution to theoretical problems in the field of integrated environmental assessment**.**

**The practical significance of the research** results independently determines the assessment of the contribution of minor pollutants to the surrounding environmental situation of the region or individual environmental components, the assessment of which in itself is already an approximate task. As a result of solving

inverse problems of complex mental expertise, new types of assessments were obtained that practically solve the issues of economic support for environmental protection measures, implementing the “polluter pays” principle by quantifying the additional contribution of the oil and gas production complex to the anthropogenic transformation components of the natural environment.

**Validity and reliability of results, conclusions and recommendations.**

The reliability of the results justified the use of well-known mathematical models, which confirmed the correctness of the theoretical basis, the objectivity of the original cartographic material, as well as comparison of models based on a set of weight options and changes in sets of score maps. To confirm the results of particular solutions to return problems, a comprehensive environmental assessment uses the results of natural analyzes of terrain and vegetation samples taken near operating wells and with the exception of the sanitary protection zone of the Zhetybai field in 2015 and 2016.

**Implementation of the results.** The dissertation research is part of the project by the Ministry of Education and Science of the Republic of Kazakhstan №0589/GF-4 "Development of the method of objectification of expert assessments of contribution of specific sources of pollution to general environmental situation of the territory" (2015-2017.).

**Personal contribution of the author's work**

The author's personal contribution to the work lies in the selection of problems and ways to solve them, the formulation of the main conclusions in the preparation of initial data for differential models and the performance of all computational calculations. In the UK (Faculty of Science, School of Science and Middlesex University of Technology) stages of trial preparation and analytical work were carried out to study soil contamination, the landscape and vegetation noticeable near existing wells and in the Zhetybai sanitary protection zone in 2015. In 2016, the results of a private inverse solution were confirmed tasks of complex examination.

**Sources of research.** The thesis is based on a “ready-made” Integrated Environmental Assessment. These assessments represent an expert assessment of the Atlas map, which represents the zoning of the Mangystau region according to the levels of anthropogenic impact on the relief, soil, vegetation and groundwater as a generalization of a huge amount of factual material on the characteristics of the natural, economic and social conditions of the area.

**Approbation of the work.** Report the results and sections of dissertations, discussed at various conferences during 2014-2016 at international conferences, including: Tempus I-Web Kazakh National University. Al-Farabi “Integrating water cycle management: building capacity, capacity and influence in education” (Almaty, 2015), “Modern problems of hydrometeorology and geoecology”, dedicated to the 75-year-old professor, Doctor of Geology. Cherednichenko V.S. (Almaty, 2015); “Ecological safety of territories and water areas: international and global problems” (Kerch, 2016) “Nature – Society – Human”: Designing the future world Dubna, December 19 – 20, 2016 (Moscow, 2006-2008).

**Publication of Research Results.** A total of 1 monograph and 16 scientific works have been published on the topic of the dissertation, including: 2 articles in SCOPUS and Web of Science journals; 8 articles in publications recommended by the Committee for Quality Assurance in the Field of Science and Higher Education of the Ministry of Science and Higher Education of the Republic of Kazakhstan; and 4 articles in international conference proceedings.

**Structure of the Dissertation.** The dissertation is devoted to a comprehensive environmental assessment of the impact of the oil and gas production complex (OGPC) on the natural environment of the Mangystau region, using reverse modeling methods and the "polluter pays" principle.

The structure of the dissertation includes: an introduction, four chapters, a conclusion, a list of references, and an appendix.

**Chapter 1** discusses the theoretical foundations of the research: the role of the oil and gas sector in the socio-economic development of the region, the challenges and limitations of existing environmental monitoring, the need for comprehensive assessments, and the justification for applying the "polluter pays" principle. It concludes with the necessity of independent, systematic assessments using modern mapping methods.

**Chapter 2** is devoted to the development and testing of methods for generalized and differentiated environmental assessments. Calculations were carried out for various components of the natural environment (relief, soils, vegetation, and groundwater), and methodological comparisons were made. The accuracy of the assessments was confirmed (error less than 1.7%), and the impact of OGPC was found to be above average regional values.

**Chapter 3** implements a differentiated assessment, allowing the identification of zones with varying degrees of influence from the oil and gas production complex. Blocks were identified where the impact of other sources exceeded that of the oil and gas sector. This supports the use of a differentiated approach in environmental regulation and the development of targeted environmental protection measures.

**Chapter 4** provides recommendations for the practical application of the assessment results for managing environmental risks and optimizing the system of environmental payments at the regional level.

The results obtained can be used to improve the effectiveness of environmental regulation, environmental impact assessment, and planning for sustainable development in oil and gas territories.

The dissertation research developed and tested methods for solving the inverse problem of comprehensive environmental assessment (CEA) to quantitatively determine the contribution of the oil and gas production complex (OGPC) to the anthropogenic transformation of the natural environment in the Mangystau region.

Two approaches were developed: a generalized approach providing an average estimate for the region, and a differentiated approach enabling a more detailed assessment of OGPC’s contribution in each territorial unit. Both methods are based on the analysis of expert environmental assessment maps and the

application of objective functions that take into account the degree of transformation of relief, soil, vegetation, and groundwater. The differentiated approach allows the identification of areas where OGPC's influence is lower than that of other sources, which is important for the fair implementation of the "polluter pays" principle.

The calculations showed that the additional contribution of OGPC to the degradation of natural components is as follows:

- 16.7% — relief,
- 16.5% — soil cover,
- 31.8% — vegetation,
- 24.6% — groundwater,

with an integrated value across all components of 22.8%.

Comparative analysis of the methods demonstrated high accuracy and consistency of results (differences did not exceed 3–4% per component and 1.7% in integrated assessments). Zones were identified where the influence of other sources exceeded that of OGPC, which provides grounds for excluding them from increased emission charges.

The obtained results allow the proposed methods to be used for environmental regulation, planning of environmental protection measures, and differentiated environmental management in the region.