ANNOTATION

Dissertation for the degree of Doctor of Philosophy (PhD) in the educational program "8D05203-Hydrology"

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"Assessment and zoning the potential risks in the river basins of the Ile Alatau during the outburst of moraine lakes"

Relevance of the research topic. Mudflows are a dangerous hydrological phenomenon, especially relevant for the mountainous regions of the eastern, southeastern and southern parts of Kazakhstan. As proof of the mudflow hazard, one can cite the detrimental consequences that they bring to these territories. Based on the information presented in the Anthology of Mudflow Phenomena in Kazakhstan, one can find information about damage to economic facilities and even loss of life during mudflows. In addition, the area of formation of the mudflow and its impact in the republic is about 164 thousand km², of which 11 thousand km² are in the Almaty region, which increases the level of mudflow danger in places suitable for human life and economic activity.

In conditions of climate change in mountainous areas as a result of the retreat of glaciers and the release from under the ice of modern moraines, which are the scene of intensive formation of lakes of various genesis, sizes and configurations. This led to an increase in the risk of outburst of mora-glacial lakes in the study area. Thus, settlements, economic facilities and types of infrastructure in the central part of Ile Alatau have become direct recipients of a potentially dangerous zone.

Therefore, due to the intensive development of mountainous areas, the speed and area of influence of human economic activity is increasing, as well as the wear and tear of buildings built to protect against mudflows or the danger that they will not be able to withstand the expected mudflows in the future, there is a need to assess the risk of outbursts moraine-glacial lakes, mudflow hazard and mudflow risk, vulnerability of the territory to mudflows, creation on their basis of new versions of maps of mudflow hazard and vulnerability of the territory to mudflows.

Currently, to assess potential mudflow hazards, the use of geographic information systems (GIS) and Earth remote sensing (ERS) technologies is expanding in order to make quick and timely decisions. In particular, the results of a study of the zoning of a mudflow-prone area by assessing the mudflow hazard and vulnerability of territories are necessary when making decisions on managing mudflow risks of the territory and predicting mudflow-hazardous zones. Also, the results achieved will undoubtedly make it possible to make optimal and rational decisions when designing and planning activities that need to be implemented in the flooded area and protective structures that can be built. And this, in turn, is the basis for the correct and timely implementation of protective and preventive work to save the population from the catastrophic consequences of a mudflow.

The purpose of the work is hydrodynamic modeling of a debris flow formed during the outburst of moraine-glacial lakes in the Ile Alatau river basins, as well as assessment of the potential outburst hazard of moraine-glacial lakes and zoning of hazardous areas. **Research objectives.** To achieve this goal, a number of tasks were considered in the dissertation work:

- Clarification of the morphometric and hydrological characteristics of moraine-glacial lakes in the central part of Ile Alatau;

- Assessment of the dynamics of development of moraine-glacial lakes in the central part of Ile Alatau;

- Determination of factors and criteria influencing the outburst hazard of moraine-glacial lakes in the central part of Ile Alatau;

- Assessment of the current state of moraine-glacial lakes in the central part of Ile Alatau;

- Assessment of ongoing measures aimed at preventing the outburst of moraine-glacial lakes in the central part of Ile Alatau;

- Modeling of mudflows formed during the breakthrough of moraine-glacial lakes in the Ile Alatau river basins and determining the degree and level of danger during their passage;

- Assessment and zoning of potential hazards in river basins during the outburst of moraine-glacial lakes in the central part of Ile Alatau.

Object of study. The basins of the Ulken and Kishi Almaty rivers, located in the central part of the northern slope of Ile Alatau.

Subject of research: classification of moraine-glacial lakes, dynamics of their changes in time and space, assessment of the potential danger in river basins during the outburst of moraine-glacial lakes.

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Research methods: to assess and zone the potential hazard from the outburst of moraine-glacial lakes in the Ile Alatau river basins, it is necessary to use a set of combined and specialized methods used in the field of Earth sciences. Among them are system analysis, synthesis, cartographic, comparative analysis, logical modeling and other methods. In addition, statistical methods and GIS technologies and remote sensing data were used to analyze the dynamics of moraine-glacial lakes in time and space. Assessment and zoning of potential hazards in river basins was carried out using a multi-criteria decision-making method.

Main provisions submitted for defense:

I. The morphometric characteristics and spatial distribution of moraine-glacial lakes were determined based on an assessment of the dynamics of development for 1970-2020. and the current state of moraine-glacial lakes located in the central part of Ile Alatau.

II. The mudflow hazard criteria were selected based on an analysis of factors influencing the outburst hazard of moraine-glacial lakes by assessing measures aimed at preventing the outburst hazard of moraine-glacial lakes. Using a multi-criteria decision-making method, large-scale maps (1:25,000) of mudflow hazard and vulnerability of territories to mudflows of the study area were created.

III. The accuracy of large-scale maps of mudflow hazard and vulnerability of the territory to mudflows of the study area has been increased based on hydrodynamic modeling using the RAMMS program.

Scientific and practical significance of the work: The scientific and practical value of the research work includes the research results achieved using GIS technologies and Earth remote sensing data, which are effective for assessing the danger of dangerous exogenous processes and their prevention, as well as managing mudflow risk.

The results of the study of the potential danger of river basins and hydrometeorological characteristics of moraine-glacial lakes can be used to determine the degree of danger of mudflow-hazardous objects in the study area, create preliminary warning systems and timely and effective implementation of evacuation work in the event of mudflows, and assess mudflow hazard. The results of zoning of territories prone to mudflows in the study area can serve as the basis for planning water services, calculating economic and social costs, as well as informing the population and assessing mudflow risk.

The results of the dissertation work received practical application in the operational work of the State Institution "Kazselezaschita" to develop and implement measures to prevent the danger of icing of moraine-glacial lakes on the northern slope of Ile Alatau and to prevent the consequences of mudflows. Also, the results of the study can be used in the work of the Ministry of Emergency Situations of the Republic of Kazakhstan, district and regional departments, and scientific organizations.

Scientific novelty of the work:

> Clarification of the number of moraine-glacial lakes, classification of moraine-glacial lakes by area, determination of the dynamics of the distribution of moraine-glacial lakes by elevation using the water index (NDWI) to assess the current state and dynamics of development of moraine-glacial lakes;

> Determination of the morphometric characteristics of moraine-glacial lakes based on processing of satellite images and creation of maps (1:25,000) of the spatiotemporal distribution of moraine-glacial lakes;

> Determination of the main criteria influencing mudflow hazard and vulnerability of the territory to mudflows based on an assessment of hydrometeorological, geomorphological, geobotanical factors influencing the formation, development and passage of mudflows;

➤ Updated map (1:25,000) of mudflow hazard in the Ulken and Kishi Almaty river basins, located in the central part of Ile Alatau using a multi-criteria decision-making method by processing indicators describing current changes in the natural environment in the GIS environment;

 \succ Creation of a map of the territory's vulnerability to mudflows in the Ulken and Kishi Almaty river basins, located in the central part of Ile Alatau, based on data on objects that may be subject to flooding;

> Modeling of a mudflow formed during the outburst of moraine-glacial lakes located in the central part of Ile Alatau using RAMMS (RApid Mass Movements Simulation), based on the modeling results, the accuracy of the map of the territory's vulnerability to mudflows was increased and the hazard levels along the river bed were clarified mudflow paths.

Author's contribution to scientific work. In order to achieve the goals and objectives of the research work, a complete review of the research work was carried out and the information necessary for the research was collected. The hazard criteria were processed using GIS technologies and new maps were created to assess the potential hazards in the study area. The writing of the dissertation and the design of the manuscript were carried out with the personal participation of the author.

Approbation of work. The basic principles and results of the dissertation research were presented and discussed at international conferences held in Kazakhstan and abroad:

-Abdullaeva Ə.S., Musina A.K. Ile Alatauynyң soltүstik betkeji ortalyқ boligindegi mұzdyқtyқ-morenalyқ kolderdiң қalyptasu sharttary. «Farabi əlemi» atty studentter men zhas ғalymdardyң halyқaralyқ ғylymi konferenciya materialdary. Қazaқ universiteti, Almaty, Қazaқstan. 2021. 52 b.

-Abdullaeva Ə.S., Musina A.K. Ile Alatauynyң soltүstik betkeji ortalyқ boligindegi morenalyқ kolderdiң қazirgi zhaғdajy. «Farabi əlemi» atty studentter men zhas ғalymdardyң halyқaralyқ ғylymi konferenciya materialdary. Қаzaқ universiteti, Almaty, Қazaқstan. 2022. 88 b.

- Abdullaeva Ə.S. Ile Alatauynyң ortalyқ bөligindegi morenalyқ kөlderdiң aқtarylu қauiptiligine əser etushi faktorlar. «Zhasyl kөpir ұграқtan-ұграққа» IX Halyқaralyқ studentter forumy. Қаzaқ universiteti, Almaty, Қazaқstan. 2022. 489-496 b.

- A.K. Mussina, A.S. Abdullayeva, M. Barandun, The importance of conducting research methods to assess the state of glacial-moraine lakes. NEWS of the National Academy of Sciences of the Republic of Kazakhstan. Series of Geology and Technical sciences. NAS RK, Almaty, Kazakhstan. 2022. pp. 147-155. DOI:10.32014/2518-170X.245

- Mussina, A., Raimbekova, Zh., Shahgedanova, M., Barandun, M., Narbayeva, K., Abdullayeva A., Nyssanbayeva A. Mountain Resilience: A Tool for Mudflow Risk Management in the Ile Alatau Mountains, Kazakhstan. Mountain Research and Development (MRD), 43(1), 2023. DOI:10.1659/MRD-JOURNAL-D-22-00004

- А.К. Мусина, Ә.С. Абдуллаева Іле Алатауының орталық бөлігіндегі өзен алаптарының сел қауіптілігін бағалау және зоналау // Гидрометеорология и экология. 2023. №4 (111), б. 34-60. doi:10.54668/2789-6323-2023-111-4-34-60.

Scope and structure of the dissertation. The dissertation consists of 143 pages, 11 tables, 33 figures. The structure of the work consists of an introduction, 5 chapters, a conclusion and 168 lists of references.