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Қ. И. Сәтпаев атындағы Қазақ ұлттық техникалық зерттеу университеті

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ИЗВЕСТИЯ

НАЦИОНАЛЬНОЙ АКАДЕМИИ НАУК
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NEWS

OF THE ACADEMY OF SCIENCES
OF THE REPUBLIC OF KAZAKHSTAN
Kazakh national research technical university
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NAS RK is pleased to announce that News of NAS RK. Series of geology and technical sciences scientific journal has been accepted for indexing in the Emerging Sources Citation Index, a new edition of Web of Science. Content in this index is under consideration by Clarivate Analytics to be accepted in the Science Citation Index Expanded, the Social Sciences Citation Index, and the Arts & Humanities Citation Index. The quality and depth of content Web of Science offers to researchers, authors, publishers, and institutions sets it apart from other research databases. The inclusion of News of NAS RK. Series of geology and technical sciences in the Emerging Sources Citation Index demonstrates our dedication to providing the most relevant and influential content of geology and engineering sciences to our community.

Қазақстан Республикасы Ұлттық ғылым академиясы "ҚР ҰҒА Хабарлары. Геология және техникалық ғылымдар сериясы" ғылыми журналының Web of Science-тің жаңаланған нұсқасы Emerging Sources Citation Index-те индекстелуге қабылданғанын хабарлайды. Бұл индекстелу барысында Clarivate Analytics компаниясы журналды одан әрі the Science Citation Index Expanded, the Social Sciences Citation Index және the Arts & Humanities Citation Index-ке қабылдау мәселесін қарастыруда. Web of Science зерттеушілер, авторлар, баспашылар мен мекемелерге контент тереңдігі мен сапасын ұсынады. ҚР ҰҒА Хабарлары. Геология және техникалық ғылымдар сериясы Emerging Sources Citation Index-ке енуі біздің қоғамдастық үшін ең өзекті және беделді геология және техникалық ғылымдар бойынша контентке адалдығымызды білдіреді.

НАН РК сообщает, что научный журнал «Известия НАН РК. Серия геологии и технических наук» был принят для индексирования в Emerging Sources Citation Index, обновленной версии Web of Science. Содержание в этом индексировании находится в стадии рассмотрения компанией Clarivate Analytics для дальнейшего принятия журнала в the Science Citation Index Expanded, the Social Sciences Citation Index и the Arts & Humanities Citation Index. Web of Science предлагает качество и глубину контента для исследователей, авторов, издателей и учреждений. Включение Известия НАН РК. Серия геологии и технических наук в Emerging Sources Citation Index демонстрирует нашу приверженность к наиболее актуальному и влиятельному контенту по геологии и техническим наукам для нашего сообщества.

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**CHANGE OF FORMATION CONDITIONS OF GROUNDWATER
OF KAZAKHSTAN UNDER THE INFLUENCE
OF ANTHROPOGENIC CHANGES OF THE ENVIRONMENT**

Abstract. Anthropogenic environmental changes in Kazakhstan lead to changes in the formation of groundwater. The anthropogenic impact on the environment is expressed in the change of the relief and hydrographic network, the redistribution of water resources and the change in their qualitative and quantitative characteristics. An important consequence of anthropogenic influence is a change in the temperature regime of the territory and the nature of precipitation. The results of the analysis of the nature of changes in the formation of groundwater are given. The areas with the most strongly changed formation conditions, which include zones of ecological disaster in the Aral Sea region and the Semipalatinsk nuclear test site, as well as built-up areas of large industrial centers and urban agglomerations of cities, are identified. A comprehensive analysis of climatic, glaciological and hydrogeological materials on the territory of Kazakhstan was used as a research methodology to determine the influence of climatic and anthropogenic environmental changes on the formation conditions of groundwater. Comparison of the research results from different years with the materials of recent years identified that fundamental changes in the quantitative indicators of groundwater supply should not be expected and groundwater resources, unlike surface water resources, will not significantly decrease. The use of research results will allow justifying the expansion of water supply for the population at the expense of groundwater.

Key words: regularities of formation, groundwater, anthropogenic changes, water supply.

Introduction. The conditions of groundwater formation in Kazakhstan are determined by a combination of natural factors, the main of which are climatic conditions, the geological structure and the influence of human activity. The processes of changing geological conditions take so long periods of time that they can be considered as unchanged compared with the time of the civilization development. Climatic changes also take considerable time periods, however the parameters of changes can be well confident detected by long-term observations. The most rapidly changing factor in the formation of groundwater is human economic activity significantly changing the physiographic conditions of the groundwater formation.

The methods of researches. As a research methodology, we used a comprehensive analysis of climatic, glaciological and hydrogeological materials on the territory of Kazakhstan in order to determine the impact of climatic and anthropogenic environmental changes on the groundwater formation conditions.

The main changes in physiographic conditions that most strongly affect the conditions for the groundwater formation:

- changes in the terrain during the development of mineral resources (Karaganda and East Kazakhstan regions), during the construction of settlements and hydraulic structures on the rivers Zhaiyk, Ertis and Esil;

- changes in the hydrographic network as a result of the construction of hydropower facilities (the Zhaiyk river), the construction of irrigation systems (the Syrdarya, Ile and Karatal rivers), the redistribution of surface water between river basins during the construction of navigable and watering canals;

- changes in the composition of vegetation, the composition and conditions of soil moisture as a result of agricultural and forest management activities;

- changes in the composition of atmospheric air as a result of fuel combustion and violation of surface air circulation in built-up areas, as well as emissions of technological waste gases;

- change of the groundwater level conditions under the influence of:

- lowering the level of large bodies of water (Aral Sea);

- groundwater exploitation for water supply and irrigation;

- irrigation and drainage measures in agriculture;

- drainage measures in the extraction of minerals;

- changes in the conditions of supply and discharge of groundwater in built-up areas;

The main changes in climatic conditions that most strongly influence and determine the conditions for the formation of groundwater:

- a change in the temperature regime of the territory is an important factor in changing the conditions for the groundwater formation. In recent years, there has been an increase in the level of the average temperature in Kazakhstan - an average of about 1.8°C within 100 years, which is more than 2 times higher than the world values. An increase in air temperature causes an increase in evaporation and reduces the amount of groundwater supply, i.e. reduces the amount of groundwater resources;

- change in air temperature, expressed in global warming and the associated increase in extreme weather events such as storms, rainfalls, fog, floods, etc. Annual floods in certain areas of our country are a direct consequence of these anomalies. During the period from 1990 to 2016, the number of heavy snowfalls increased 2.5 times, the number of heavy rains increased 2.7 times, the number of heavy fogs increased more than 2 times, dust storms occur 3.4 times more often. Almost 2 times increased floods on mountain rivers. The number of mudflows increased by 2 times. According to the Kazgidromet observation network, the air temperature has increased throughout the territory of Kazakhstan in all months of the year for several decades. The average annual temperature in Almaty 100 years ago was about 7 °C, and in 2016 - 12 °C (an increase by 5 degrees);

- changing of the conditions of atmospheric air circulation;

- change in the distribution of precipitation by area and time. In the long-term section, the amount of precipitation on the territory of Kazakhstan for the year practically does not change, there is only a slight increase in the northern and mountainous regions. There is more rainfall because that falls in the form of showers;

- changing of the conditions of evaporation and transpiration.

The greatest changes in the conditions of groundwater formation under the influence of natural and anthropogenic factors are confined to industrial centers and urban agglomerations, as well as to zones of ecological disaster in the Aral Sea region and at the Semipalatinsk nuclear test site. Active, increasing from year to year, changes in air temperature, precipitation and evaporation, as well as human interaction with the natural environment, acquired in the new millennium features of a global change in the anthropogenic and climatic process.

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Active, increasing from year to year, changes in air temperature, precipitation and evaporation, as well as human interaction with the natural environment, acquired features of a planetary change in the anthropogenic and climatic process in the millennium that has come. Global anthropogenic warming of the climate, which began in the post-industrial period, poses a certain threat to the environmental habitat of modern human, because estimates of the World Meteorological Organization show that global temperature rise on Earth may reach 2.7-3.5°C by the end of the XXI century [1]. Possible climate changes in Kazakhstan by 2030, 2050 and 2085, relative to the base period of 1961-1990, can be as

follows: + 1.4°C, + 2.7°C and + 4.6°C, respectively, [2], although the amount of precipitation will increase slightly : at 2%, 4% and 5% per year, respectively.

The values of meteorological quantities for a long observation period are not a set of homogeneous statistical data, since over the years the conditions of observations have changed, as well as the influence of the main climate-forming factors, the influence of anthropogenic factors on the conditions of the weather station. For example, it is impossible to compare the conditions of the weather station of Karaganda or Almaty 30-40 years ago and now. At the moment, it is surrounded by numerous enterprises, including those with active transport movement around the meteorological station.

To clarify the trend of the average annual temperature on the territory of Kazakhstan, the meteorological data of six stations located in different regions of Kazakhstan were processed. For example, instrumental observations carried out for 30–60 years in the mountainous regions of South and Southeast Kazakhstan showed that the average annual air temperature here increased by 0.1–0.3°C every ten years. According to the developed scenarios [3], during the period up to 2050-2075a higher temperature is expected in the mountainous regions of these territories. At elevations above 1500 m, this increase may be 1.5-5.5°C.

It has been determined that the glaciation of the mountains of Central Asia from the middle of the 20th century was mainly in a state of degradation, accelerated since the early 1970s. A study of the dynamics of glaciation in the mountains of southeastern Kazakhstan in comparison with the results of the assessment of changes in glaciation in other mountainous regions shows that, like in most glacial regions of the world, until the early 1970s, glaciers remained here in a relatively stable state. However, this situation has changed in recent decades due to global warming, as evidenced by glaciological studies in the Central Asian region [4]. The rates of degradation of Central Asian glaciers are among the highest in the world: 0.8% of the area and 1% from volume per year. If the general trend of changes in the temperature regime of the territory in the coming decades continues, the melting of glaciers will continue. At the same time, despite the reduction of glacier resources with an average intensity of about 1% per year, the norms of river flow and its intra-annual distribution remained relatively stable during the last half-century, which gives grounds for Kazakhstan glaciologists to assume the existence of a compensation mechanism that ensures this stability under conditions of glaciation degradation. The role of such a mechanism is supposedly performed by the melt waters of underground ice, buried (moraine-covered) glaciers and rock glaciers. And since the ground ice reserves in the mountains of the region are comparable with the ground glaciation resources, the researchers believe that if the amounts of precipitation and maximum snow reserves in the zone of flow formation remain in stability that is characteristic for the last decades, the compensation mechanism may last for more than one century. This gives reason to hope for the relative stability of the norms of river flow and regional water resources for at least the coming decades.

As for groundwater, there was practically no special research on the upcoming changes in their resources, due to global warming. This is due to the existing opinion that groundwater is better protected from adverse climatic factors due to deep deposition. Even in the Sahara desert, the sandy massifs of Western and Southern Kazakhstan, where the air temperature is high and very little precipitation falls, there is fresh groundwater.

However, there are areas where the moisture cycle is intense, groundwater resources are being updated very actively. These areas include mountainous areas of South and South-Eastern Kazakhstan, which are distinguished by special conditions for the groundwater formation, depending on the orographic and climatic conditions. Here, permafrost has the greatest influence on the conditions of groundwater supply; its thickness increases with height: the gradient values of the increase in the thickness of the frozen zone per 100 m height are at least 10-20 m. The maximum thickness of the frozen zone at altitudes of 3100 m reaches 60 m, 3500 m - about 130-140 m, at 4000 m - more than 200 m, and at an altitude of 5000-6000 m - several hundred meters [5,6]. As can be seen from the above data, already at altitudes of 3200-3400 m, the thickness of frozen rocks becomes significant. In these conditions, the characteristics of groundwater recovery will be completely different than in areas where there is no permafrost. According to the data given in [7], in the high part of the mountains, solid permafrost acts as an aquitard. It prevents the infiltration of precipitation and snow melt water. For this reason, small groundwater resources are formed here mainly due to the melting of ice located in rock cracks, under the influence of deep heat co-

ming from the lower layers of the earth's crust. Groundwater in this area is very deep, as evidenced by the absence of natural water manifestations in the form of springs, as well as groundwater flow into rivers [7]. Below the permafrost zone, the conditions for groundwater recovery are more favorable, as evidenced by the numerous springs emerging in depressions of the relief, and the large size of the groundwater flow into the rivers. For example, at the latitude of the Tuyuksu tourist base in Zailiysky Ala Tau (abs. 2500 m), the underground flow into the M. Almatinka river reaches 35 l/s per 1 km² of its catchment basin. As the level of the mountain slope decreases, the magnitude of the formed groundwater becomes smaller. At altitudes of 1900-2100 m, it is 18-20 l/s per 1 km².

From the data presented, there is a clear increase in the module of the natural resources of groundwater as the height of the mountain slope increases. In the light of what has been noted, let us imagine the case when by the end of this century, in the mountainous regions of South and South-East Kazakhstan, the air temperature, as compared with the present, will increase by 3.5°C (the average between the forecasted 1.5-5.5°C). Such a change in the temperature conditions of a mountainous area can lead to a change in the snow line in the mountains, movement (raising) of the permafrost distribution boundary, and it is even possible that glaciers will degrade strongly until they disappear completely [3.8].

Of all the noted changes in the natural conditions of the mountainous area in the future, the movement of the high-altitude boundary of the distribution of permafrost can have the greatest impact on groundwater. The scale of this process can be judged on the basis of gradient indicators of permafrost development. According to research data [9, 10], for every 100 m of elevation of elevations in mountainous areas (above 1500 m), the temperature falls by 0.6°C, i.e. with an increase in air temperature of 3.5°C, the permafrost boundary may rise by 583 m. Such changes in general may have a favorable effect on the conditions of recovery of groundwater resources. First of all, by reducing the area occupied by permafrost, the area of intensive feeding of groundwater will increase. For example, in Zailiysky Alatau in the basin of the Bolshaya Almatinka river, such an increase will amount to 103 km², Malaya Almatinka - 28.2, Talgar -144, Issyk-71 and Turgeni -193 km². The amount of groundwater supply in the northern slope of the Zailiysky Alatau at altitudes of 2000–3000 m varies from 25–27 in the basin of Bolshaya Almatinka to 30–35 l/s per km² in the basin of Malaya Almatinka.

As the absolute elevations of the catchment area increase, it is legitimate to suppose an increase in the emerging groundwater resources, especially according to the research materials of I. S. Sosedov [9], in the range of 3000-4000 m in Zailiysky Alatau, the greatest amount of precipitation falls, amounting to 1300-1400 mm per year, or 40% more than in the area of modern supply. Considering the above, groundwater supply in the freeing part of the mountains from permafrost as a result of climate warming can be much larger. This is quite possible, since as a result of climate warming, an increase in evaporation from the ocean surface and, accordingly, of precipitation falling on land is expected. Thus, global warming can improve supply conditions and form additional groundwater flow. In the Kyrgyz Alatau, such movement of the permafrost boundary can take place only in the basins of the Aspara and Merke rivers. Unlike Zailiysky Alatau, the lower boundary of permafrost here is located at around 3400 m [11, 12]. When raising its border by 583 m, permafrost rocks almost completely disappear in the basins of these rivers, or the groundwater recharge area will increase by 176.4 km², including 115 km² in the Aspara river basin and 61.4 km² in Merke.

Results of works. On the whole, planetary climate warming will not cause significant changes in the magnitude of groundwater supply in the conditions of the Trans-Ili and Kyrgyz Alatau. However, its quantitative assessment at the present stage of the study of the hydrogeological conditions of the high-mountain zone remains unsolved.

The research results will be in demand in the research and production sphere, which deals with water resources, environmental problems, groundwater search and the agrarian sector of the republic.

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ҚОРШАҒАН ОРТАНЫҢ АНТРОПОГЕНДІК ӨЗГЕРІСТЕРІНІҢ ӘСЕРІНЕН ҚАЗАҚСТАННЫҢ ЖЕР АСТЫ СУЛАРЫНЫҢ ҚАРЫПТАСУ ЖАҒДАЙЛАРЫНЫҢ ӨЗГЕРУІ

Аннотация. Қоршаған ортаның антропогендік өзгерістері Қазақстандағы жер асты суларының қалыптасу жағдайларының өзгеруіне әкелді. Қоршаған ортаға антропогендік әсер, жер бедері мен гидрографиялық желілердің өзгеруімен, су ресурстарын қайта бөлу және олардың сапасы мен сандық көрсеткіштерінің өзгеруімен сипатталады. Аймақтың температуралық режимі мен атмосфералық жауын-шашын антропогендік әсердің маңызды салдары болып табылады. Жер асты суларының қалыптасу жағдайларының өзгеру сипаттамаларына қорытынды жасалды. Арал маңы мен Семей аудандарының экологиялық апатты белдемдеріне жататын, сонымен қатар ірі өнеркәсіптік орталықтар және қала агломерация аймақтары салынған қалыптасудың неғұрлым қатты өзгеріске ұшыраған аймақтары бөлінді. Қоршаған ортаның жер асты суларының қалыптасуына климаттық және антропогендік өзгерістердің әсерін анықтау мақсатында Қазақстан аймағының климаттық, гляциологиялық және гидрогеологиялық материалдарына толық талдау жасау зерттеудің әдістемесі ретінде қолданылды. Әр жылдардағы және қазіргі кездегі зерттелген жұмыстарды салыстырғанда, жер асты суларының қоректенуіндегі сандық көрсеткіштердің іргелі өзгерістерге ұшырамағаны, сонымен қатар жер асты суларының жер беті суларына қарағанда айтарлықтай азаймайтыны анықталды. Зерттеу нәтижелерін қолдану жер асты сулары есебінен елді-мекендерді сумен қамтамасыз етуді кеңейтуге мүмкіндік береді.

Түйін сөздер: қалыптасу жағдайлары, жер асты сулары, антропогендік өзгерістер, сумен қамтамасыз ету.

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ИЗМЕНЕНИЕ УСЛОВИЙ ФОРМИРОВАНИЯ ПОДЗЕМНЫХ ВОД КАЗАХСТАНА ПОД ВЛИЯНИЕМ АНТРОПОГЕННЫХ ИЗМЕНЕНИЙ ОКРУЖАЮЩЕЙ СРЕДЫ

Аннотация. Антропогенные изменения окружающей среды в Казахстане ведут к изменениям условий формирования подземных вод. Антропогенное воздействие на окружающую среду выражается в изменении рельефа и гидрографической сети, перераспределению водных ресурсов и изменению их качественных и количественных характеристик. Важным следствием антропогенного влияния является изменение температурного режима территории и характера выпадения атмосферных осадков. Приводятся результаты анализа характера изменения условий формирования подземных вод. Выделены районы, с наиболее сильно измененными условиями формирования, к которым отнесены зоны экологического бедствия в Приаралье и Семипалатинского ядерного полигона, а также застроенные территории крупных промышленных центров и городских агломераций городов. В качестве методологии исследований использовался комплексный анализ климатических, гляциологических и гидрогеологических материалов на территории Казахстана с целью определения влияния климатических и антропогенных изменений окружающей среды на условия формирования подземных вод. В результате сопоставления результатов исследований разных лет с материалами современного последних лет установлено, что кардинальных изменений в количественных показателях питания подземных вод не следует ожидать и ресурсы подземных вод в отличие от ресурсов поверхностных вод существенно не сократятся. Использование результатов исследований позволит обосновать расширение водоснабжения населения за счет подземных вод.

Ключевые слова: закономерности формирования, подземные воды, антропогенные изменения, водоснабжение.

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