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Satbayev University

ХАБАРЛАРЫ

ИЗВЕСТИЯ

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ASSESSMENT OF THE IMPACT OF HUMAN ACTIVITY ON GROUNDWATER STATUS OF SOUTH KAZAKHSTAN

Abstract. The main reserves of fresh groundwater in South Kazakhstan are confined to aquifers of Quaternary, Neogene, Paleogene, Cretaceous deposits of Artesian basins. They play a major role in the water supply of the population with drinking water, especially large water consumers. Fractured water basins are characterized by significantly smaller reserves of fresh groundwater, but their widespread distribution in the region is of practical interest for the water supply of smaller water consumers.

The anthropogenic impact on groundwater has become especially noticeable in the current century due to the development and intensification of industry and agriculture, the growth of large cities and the expansion of urbanized territories. Intensification of the anthropogenic load on the resource potential of groundwater and associated ecosystems leads to a progressive deterioration of ecological and hydrogeological conditions in South Kazakhstan. This is primarily due to the depletion of groundwater resources, the formation of depression craters and water retention zones, groundwater pollution, which significantly affects the natural environment and human habitat. These negative changes occur especially intensively in areas of mining, oil and gas production and chemical industry development, characterized by significant changes in the existing water exchange, which is caused by violations of the water balance in the subsurface caused by the drainage of mineral deposits during their extraction, the exploitation of groundwater for domestic and industrial water supply and drainage systems, and also presence of industrial and household untreated effluents.

Key words: groundwater contamination, anthropogenic changes, groundwater resources, anthropocentrism, South Kazakhstan.

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ОҢТҮСТІК ҚАЗАҚСТАН ЖЕРАСТЫ СУЛАРЫНЫҢ ЖАҒДАЙЫНА АНТРОПОГЕНДІК ФАКТОРЛАРДЫҢ ӘСЕРІН БАҒАЛАУ

Аннотация. Оңтүстік Қазақстандағы тұщы жерасты суларының негізгі қоры артезиан алаптарының төрттік, неоген, палеоген, бор шөгінділерінің сулы горизонттарымен шектелген. Олар халықты, әсіресе ірі су тұтынушыларын ауыз сумен қамтамасыз етуде үлкен рөл атқарады. Жарықшақ су бассейндері тұщы жерасты суларының айтарлықтай аз қорымен сипатталады, бірақ олардың аймақта кең таралуы кішігірім су тұтынушыларын сумен қамтамасыз ету үшін практикалық қызығушылық тудырады. Өнеркәсіп пен ауыл шаруашылығының дамуы мен қарқындауына, ірі қалалардың өсуіне және урбанизацияланған аумақтардың кеңеюіне байланысты жерасты суларына антропогендік әсер қазіргі ғасырда ерекше байқалды. Жерасты суларының және онымен байланысты экожүйелердің ресурстық әлеуетіне техногендік жүктеменің күшеюі Оңтүстік Қазақстанның экологиялық және гидрогеологиялық жағдайларының үдемелі нашарлауына алып келеді. Бұл ең алдымен жерасты сулары ресурстарының сарқылуымен, ойпат шұңқырлары мен судың кері аймақтарының қалыптасуымен, жерасты суларының ластануымен байланысты, бұл табиғи орта мен адамның тіршілік ету ортасына айтарлықтай әсер етеді. Бұл жағымсыз өзгерістер әсіресе таукен мұнай-газ және химия өнеркәсібі салаларын дамыту салаларында қарқынды болып табылады, жер қойнауындағы су балансының бұзылуына байланысты қолданыстағы су алмасуындағы елеулі өзгерістермен, пайдалы қазбаларды өндіру кезінде оларды құрғату, жерасты суларын шаруашылық-тұрмыстық және өнеркәсіптік сумен жабдықтау және су бұру жүйелері үшін пайдалану нәтижесінде туындаған, сондай-ақ өндірістік және тұрмыстық тазартылмаған ағынды сулардың болуымен сипатталады.

Түйін сөздер: жерасты суларының ластануы, антропогендік өзгерістер, жерасты суларының қорлары, антропоцентризм, Оңтүстік Қазақстан

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ОЦЕНКА ВЛИЯНИЯ АНТРОПОГЕННЫХ ФАКТОРОВ НА СОСТОЯНИЕ ПОДЗЕМНЫХ ВОД ЮЖНОГО КАЗАХСТАНА

Аннотация. Основные запасы пресных подземных вод Южного Казахстана приурочены к водоносным горизонтам четвертичных, неогеновых, палеогеновых, меловых отложений артезианских бассейнов. Они играют основную роль при водообеспечении населения питьевой водой, особенно крупных водопотребителей. Бассейны трещинных вод характеризуются значительно меньшими запасами пресных подземных вод, но их широкое распространение на территории региона представляет практически интерес для водообеспечения более мелких водопотребителей. Антропогенное влияние на подземные воды стало особенно ощутимым в текущем столетии в связи с развитием и интенсификацией промышленности и сельского хозяйства, ростом крупных городов и расширением урбанизированных территорий. Интенсификация техногенной нагрузки на ресурсный потенциал подземных вод и связанные с ними экосистемы ведут к прогрессирующему ухудшению эколого-гидрогеологических условий в Южного Казахстана. Это связано прежде всего с истощением ресурсов подземных вод, образованием депрессионных воронок и зон подпора вод, загрязнением подземных вод, существенно влияющим на окружающую природную среду и среду обитания человека. Особенно интенсивно эти негативные изменения происходят в районах развития горнодобывающей, нефтегазодобывающей и химической промышленности, характеризующихся значительными изменениями сложившегося водообмена, что обусловлено нарушениями водного баланса в недрах, вызываемого осушением месторождений полезных ископаемых при их добыче, эксплуатацией подземных вод для хозяйственного и промышленного водоснабжения и систем отведения дренажных вод, а также наличием промышленных и хозяйственно-бытовых неочищенных стоков.

Ключевые слова: загрязнение подземных вод, антропогенные изменения, ресурсы подземных вод, антропоцентризм, Южный Казахстан.

Introduction. The main groundwater resources of the Republic with mineralization up to 10 g/l (55%) are concentrated in South Kazakhstan. At the same time, the share of groundwater with mineralization up to 1 g/l is 59% of the total projected fresh water resources of Kazakhstan (Smolyar V.A. et.al 2012).

The total value of the forecast groundwater resources with mineralization up to 10 g/l is 87.5 million m3/day, including those with mineralization up to 1.0 g/l - 54.8 (62.6%); 1-3 g/l – 22.5 (25.7%); 3-10 g/l – 10.2 (11.7%). The main groundwater resources are confined to the foothill plains of Zhetysu, Zailiysky, Kirghiz Alatau, Karatau, Talas Mountains, as well as artesian basins. A smaller part of them is concentrated in the massifs of fractured rocks. At the same time, groundwater resources are unevenly distributed throughout the territory of Southern Kazakhstan due to the prevailing geological, hydrogeological and natural conditions. The largest modules of forecast groundwater resources are observed in the territories of Almaty and Turkestan regions, where the main groundwater reserves of Southern Kazakhstan with mineralization up to 1 g/l are concentrated (Smolyar V.A. et.al, 2011).

146 groundwater deposits with total proven reserves of 25.6 million m^3/day have been explored in Southern Kazakhstan, including: for household and drinking water supply - 8,7; industrial and technical water supply - 0.9; irrigation of land – 15.9; balneological purposes (mineral waters) - 0.016.

Most of the explored deposits are located within the artesian basins - 43 and the removal cones of foothill plumes and intermountain depressions - 43. 34 deposits are associated with deposits of river valleys, 26 groundwater deposits are associated with limited structures of fractured-karst water massifs and zones of tectonic disturbances. The largest number of underground water deposits (52) have been explored in the Almaty region, to which the largest amounts are associated of proven groundwater reserves (17.0 million m^3/day). The distribution of forecast groundwater resources by administrative regions of the Southern region is presented in Table 1 (Absametov M.K. et.al, 2019).

Table 1 - Distribution of forecast groundwater resources of Southern Kazakhstan

Administrative areas	Forecast groundwater resources, million m^3/day			
	Total	Including with mineralization, g/l		
		up to 1	1-3	3-10
Almaty	49,8	39,1	8,4	2,3
Zhambyl	22,5	14,9	7,5	0,01
Kyzylorda	15,9	3,2	7,6	5,1
Turkestan	11,4	8,4	3,0	-

Significant changes in natural hydrogeological conditions occur during the exploitation of groundwater for water supply, irrigation, irrigation of pastures:

- there is a depletion of aquifers, that is, groundwater reserves of overlying and adjacent horizons are depleted and extensive depression funnels are formed;

- hydrogeological conditions in oil and gas aquifers change during development with formation pressure maintenance, which contributes to the penetration of aggressive oil and gas fluids into the upper aquifers, pollutes ground and surface waters, and changes the chemical composition of groundwater deposits;

- hydrogeological conditions on the areas of irrigated lands change significantly: the water-salt balance of the irrigation zone changes, the level of groundwater rises, which contributes to flooding, groundwater is polluted with toxic substances of fertilizers and pesticides, that is, their hydrochemical regime changes; there is (wide) salinization of lands, which is the main scourge of irrigated agriculture and one of the important negative factors influencing the geological environment;

- a significant impact on the hydrogeological situation is also exerted by uncontrolled self-discharging of wells in certain areas, leading to the formation of depression funnels that are extensive in area, resulting in a decrease in groundwater levels.

Another type of anthropogenesis of the natural regime of groundwater is the increase in their levels, accompanied by flooding of various structures and, at the same time, having a more extensive distribution area. Flooding is associated, as a rule, with floods and high waters and is of a short-term nature, its impact entails a change in landscapes: waterlogging of lands, waterlogging, suppression of natural vegetation (Mustafayev S.T. et.al, 2011).

From the standpoint of anthropocentrism, a number of degrees of territorial disturbance of landscapes, ecosystems and their corresponding zones should be distinguished (Belousova A.P. et.al, 2006):

- ecological well-being - in this case, the state of natural complexes is close to their natural functioning;

- environmental risk - there is a fixed change in the natural properties of natural complexes, leading to negative consequences;

- ecological crisis - changes in the properties of natural complexes pose a threat to economic activity and human health;

- ecological disaster - in this case, negative changes lead to disruption of economic activity and morbidity of people;

- environmental catastrophe - negative changes lead to the impossibility of conducting economic activities and human habitation;

In all regionally expressed categories of anthropogenesis of the lands of Southern Kazakhstan, there are local areas of various micro-, meso- and

macro-anthropogenic scales in terms of area and intensity of technogenic impact on natural ecosystems, accompanied by violations of the water-salt and hydrochemical regime of the underground hydrosphere.

Materials and methods. During the field work, samples were taken at 106 observation points for a complete chemical analysis and for the determination of technogenic chemical pollutants and the so-called pesticides, herbicides, polychlorinated befinyls, which do not occur in nature, but are created by man. All selected samples were handed over to the chemical-analytical laboratory of the Institute for the determination of drinking groundwater pollutants of a technogenic nature. This analysis was carried out on a computerized instrument - a chemical analyzer (GC-MS, serial №GSQA1312F07). It should be emphasized that the sampling of drinking groundwater during field work requires adherence to special rules. First, samples taken at the water intake (well) must be preserved by adding the organic matter hexane, which, due to the very low concentration of pollutants, must absorb these substances. After that, the taken sample should be kept in a special cooler with ice at a temperature not higher than + 50°C.

Groundwater in the territory of Kazakhstan is in a wide variety of hydrogeological conditions and is subject to powerful anthropogenic impact. First of all, this is manifested in their contamination. The main sources of groundwater pollution are gaseous, liquid and solid substances and production waste from industrial enterprises of mining and oil and gas complexes, agricultural facilities, cities and large settlements, large dumps of industrial, household and radioactive waste. The ecological situation in South Kazakhstan remains unfavorable, and environmental pollution is high.

The largest sources of contamination are observed near enterprises that discharge industrial waste and wastewater onto the earth's surface or into the river network without prior treatment - in 2016, the total volume of wastewater discharge into the river network amounted to 5,9 km³/year, including 0,131 km³/ year (2,25%) – untreated. The existing technologies for processing raw materials in Kazakhstan in terms of waste output (per unit of production) are inferior to advanced foreign analogues.

In recent years, the number of identified and potential sources of pollution has remained virtually unchanged, which is due to the economic recession in the republic, a decrease in the growth of industrial and agricultural production, and the associated decrease in the discharge of mass pollutants and wastewater volumes associated with these processes. The basis of the modern industry of the country is the most environmentally hazardous enterprises of the metallurgical, fuel and energy and mining industries (Kabdtakhmanoba S.K. et.al, 2016). They account for 88.5% of all emissions into the environment. In South Kazakhstan, largest centers of groundwater pollution have formed within the Karatau (South

Kazakhstan) mining complexes, as well as in the Almaty region.

According to the results of monitoring in the area of large cities, areas of groundwater pollution were identified in the zone of influence of individual deposits. Near such pollutants, large halos of groundwater pollution are observed, leading to the failure of entire groundwater intakes or their sections. The main criteria for the quality of natural waters in terms of hydrochemical indicators are the values of maximum allowable concentrations (MPC) of pollutants for sources of drinking, household and fishery water use (Oskotskaya E.R. et.al, 2016), (Mukhamedzhanov M.A. et.al, 2018).

Depending on the size of the source of pollution and the amount of toxic substances entering the aquifer, the scale of pollution varies over a very wide range. In recent years, there has been a tendency to reduce the sanitary reliability of underground sources of centralized drinking water supply. According to groundwater monitoring data, 162 potential sources of pollution have been identified in the territory of South Kazakhstan, 133 of them directly affect the hydrogeochemical state of groundwater. The largest number was found in Almaty (103) and Turkestan (29) regions (Table 2). They are the most ecologically unfavorable regions of Kazakhstan in terms of pollution (Mukhamedzhanov M.A. et.al, 2019).

Table 2 - Distribution of sources and sites of groundwater contamination and availability of their observational network in South Kazakhstan

Administrative areas	Number of potential sources of groundwater contamination	Number of identified sites of groundwater contamination		
		Total	surveyed	having an observation network
Almaty	103	10	10	10
Zhambyl	19	16	15	16
Kyzylorda	11	3	2	2
Turkestan	29	17	3	17
Total by SK:	162	46	30	45

In Kazakhstan, there is also areal pollution of groundwater with oil products in the territories of almost all oil and gas producing complexes. In addition, contamination of groundwater with radionuclides has been established at oil production sites. The main areas of technogenic radioactive contamination of groundwater are noted at the Semey nuclear test site and in the zone of its influence, at the sites of peaceful nuclear explosions (including the so-called «Azgir trace» in the Northern Caspian region), at the sites of burial and storage of radioactive waste (especially in the territories Kokshetau, Kengir-Akbakai and Chiganak-Aksuek mining complexes), in areas of developed uranium deposits, especially by in-situ leaching (on the territory of the Shu-Sarysu mining complex

- developed uranium deposits Uvanas, Kanzhugan, Mynkuduk and Moinkum). Most of the pollution centers are formed in industrial areas - 181, at agricultural and municipal facilities - 47 and 26, respectively. This research is funded by the Science Committee of the Ministry of Education and Science of the Republic of Kazakhstan Grant No. BR10965134: Assessment of fresh groundwater resources as the main source and long-term reserve of sustainable drinking water supply for the population of the Republic of Kazakhstan.

Results and discussion. Let us now consider the ecological state of groundwater in the context of the regions of South Kazakhstan (Smolyar V.A. et.al, 2011). The following is the current state and level of groundwater contamination in South Kazakhstan.

Almaty region. There are 103 potential sources of pollution and 10 identified sites of groundwater pollution on the territory of the region. Groundwater contamination in the region is characterized as dangerous, moderately dangerous and permissible. The most intense technogenic impact on the geological environment is exerted by the largest Almaty industrial district in the region with the largest city in Kazakhstan – Almaty (about 1.8 million inhabitants) with numerous industrial enterprises, municipal landfills of household and industrial waste, ash dumps, sewage accumulators, filtration fields (Thevs N. et.al, 2017; Pueppke S.G. et.al, 2018).

There are 24 underground water deposits in operation in the Almaty region. Of these, 11 are subject to a dangerous (7) and moderately dangerous (4) degree of pollution. Hazardous pollutants contain groundwater of the Almaty deposit (removal cone) used for domestic drinking water supply in Almaty: cadmium - up to 10 MPC, manganese - 7-14 MPC, mercury - 1-2 MPC, phenols - 6 MPC, bromine - 2-5 MPC, petroleum products - 3-5 MPC, nitrates - up to 4 MPC. Within the field, the greatest danger is posed by industrial enterprises located in CHP-1, CHP-2, Pervomaiskaya oil depot, sedimentation tanks and waste water storage, Avatskaya and Almaty poultry farms. Most of the sources of pollution are concentrated in the northwestern part of the field, where contamination with heavy metals, phenols, nitrates, fluorine, bromine, and petroleum products is found in the groundwater (Zhang Z et.al, 2015). At the Almaty field, the upper aquifers are polluted - up to a depth of 100 m or more.

The established sources contamination of groundwater deposits, first of all, filtration fields of the cities of Almaty, Taldykorgan, Ushtobe, Zharkent, Kapshagai, Kaskelen, Talgar, urban-type settlements Fabrichny, Shemolgan, Uzunagash, Shilik, Chunja, Malovodnoye, Turgen, Karakemir, Mirny, Alekseevka, Avat, Energeticheskiy, Taran. In addition, groundwaters of the deposits pollute the tailings of the processing plants of the Koksu and Tekeli mines, the filtration fields and sedimentation tanks of the Ushtobe meat processing plant, Sarkand

cheese factory, Kapal butter factory, the Taldykorgan and Kirov sugar factories, and the Razvilnen butter factory (Isupova M.V. 2019).

Zhambyl region. 32 groundwater deposits have been explored in the region for economic, drinking and complex purposes, 6 of which are subject to pollution. The most noticeable pollution of groundwater is observed on the territory of the Talas-Assy interfluve, where the main industrial enterprises are concentrated and the largest groundwater deposits have been explored and exploited (Talas-Assy – southern part, North-Talas-Assy, Zhualy, Predeskov and Bijlikol), large concentrated water intakes have been created. In the underground waters of these deposits, fluorine with a maximum content of 3-8,2 MPC was registered, in addition, a number of components were found in high concentrations: sulfates – 1,5-3 MPC, ammonium - 3-5 MPC, hardness - 3-4 MPC, mineralization - 2-2,5 MPC. In some places, groundwater contains nitrates and nitrites up to 1.7 MPC,

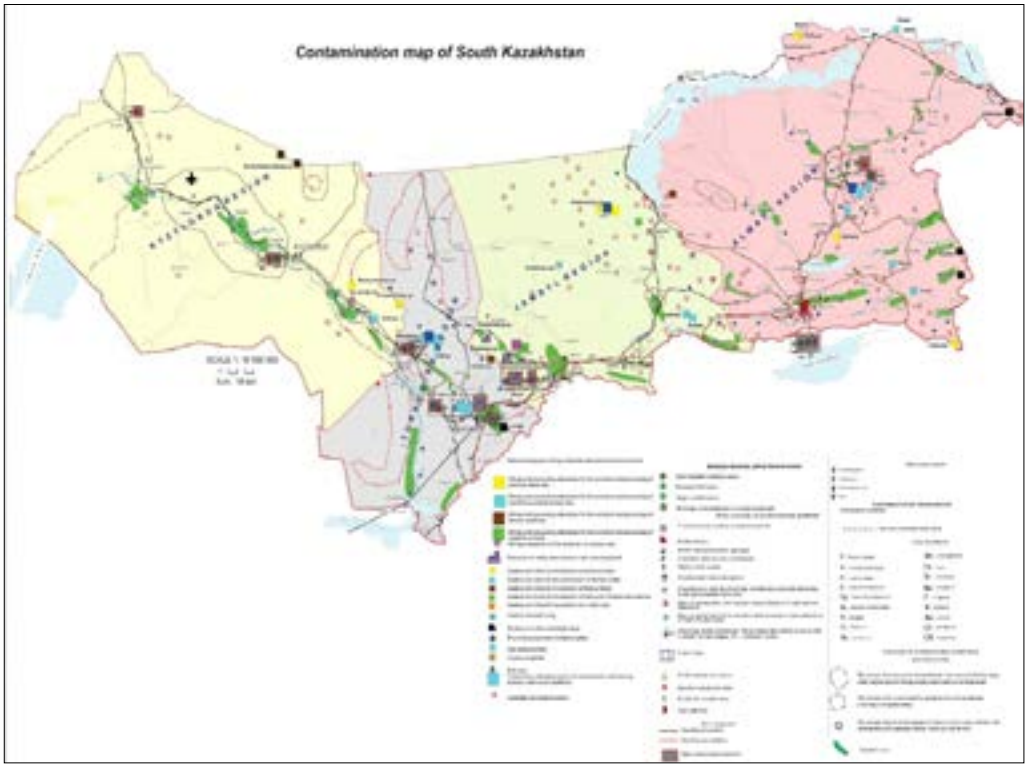

Figure 1 - Map of groundwater contamination in South Kazakhstan

and chlorides appear near filtration fields and sugar factories – up to 2 MPC and Synthetic surfactants - up to 4 MPC. The degree of danger of groundwater contamination of these deposits is moderately dangerous and, in places, dangerous. In addition to the Talas-Assy interfluve, polluted industrial drains

pose a threat of contamination to the downstream Assy, Bijlikol and Shu-Novotroitsk groundwater deposits, which are the main source of economic and drinking water supply of the Assy district center and the city of Karatau. The degree of danger of groundwater contamination of these deposits is moderately dangerous, and the Shu-Novotroitsk is permissible.

Kyzylorda region. In the Kyzylorda region, 18 groundwater deposits have been explored for economic and drinking purposes, 14 of which have been put into commercial operation. According to regime observations, there is an increase in water mineralization at seven exploited deposits. Thus, at the Terenozek groundwater deposit, the mineralization of groundwater has increased to date from 1,3 to 1,43 g/l, at the Kyzylorda – from 1,1 to 1,5 g/l, at the Karmakch – from 1,53-1,6 to 1,65-1,8 g/l, at the Rice – from 1,3-1,6 to 1,65-1,8 g/l, at the Shalkiya groundwater deposit – from 0,6-1 to 0,7-1,1 g/l, at the Sarybulak – from 1,5-3 to 2-3,3 g/l, at Kuvandarya – from 1,2-1,4 to 1,45-1,6 g/l. The degree of contamination of the groundwater of these deposits is moderately dangerous. Contamination of the groundwater of the upper aquifer within the limits of the Torangylysay field (not exploited) and the developed Kyzylorda was noted. For the first, groundwater pollution occurs from irrigated massifs located near the deposit, for the second - due to the pulling up of substandard waters of the Syrdarya River.

Turkestan region. 29 potential groundwater pollutants have been identified in the region. These are solid waste accumulators: sludge accumulators of JSC «Phosphorus», ash dumps of CHPP-1 and CHPP-2 of Shymkent, tailings of concentrating factories of the Baizhansai and Achisai mines; liquid waste accumulators: evaporation ponds of the Shymkent lead, phosphorus, oil refining, chemical and pharmaceutical plants; filtration fields of Shymkent, Kentau, Shymkent Poultry farm of the village of Zhelanda, Sastyubinsky cement works, oil depots of Shymkent, Belye Vody village, Mankent village.

In the Turkestan region, 25 groundwater deposits have been explored for economic and drinking and complex purposes, 21 of which have been put into industrial development for economic and drinking water supply. Groundwater contamination was detected only at 3 deposits. Within the Abai deposit, the mineralization of groundwater varies widely – from 0,4-0,5 to 1,93-2,16 g/l, which is 1,9-2,1 times higher than the MPC. Large sources of groundwater pollution have been installed on the area of the Badam-Sairam field - JSC «Phosphorus», the regional oil depot. Thus, in the area of JSC «Phosphorus», the growth of groundwater mineralization averages 0,14 g/l per year (from 0,5 g/l in 1988 to 1,2 g/l in 1992), the hardness reaches 1,8 MPC, permanganate oxidability is 17 times higher than the background. Smaller identified sources of pollution are hydrolysis plant, meat processing plant, cement plant. The water intakes of

the Badam-Sayram deposit are contaminated with the following components: nitrates – 1,1-1,3 MPC, iron – 4,2 MPC, mercury - 3 MPC, phosphates – 2,5 MPC. Possible (potential) sources of groundwater pollution of the main water intake are CHP-3, asbestos-buffer plant, cannery, flour mill, karakul plant, electrical products plant, livestock complexes. The main polluting components of the groundwater of the main intake exceeding the MPC are iron (6-20 MPC), nitrates, oxidizability (1-1.8 MPC) and hardness (2-2.2 MPC). When processing the uranium deposits of Uvanas, Kanzhugan, Mynkuduk in Betpak-Dala by underground leaching, groundwater is contaminated with both radionuclides and heavy metals within a radius of several kilometers from the deposits. There is an increased content of lead, polonium, radon.

The most environmentally unfavorable regions of Kazakhstan in terms of pollution are Zhambyl, Kyzylorda, Turkestan and Almaty regions, which make up 52,2% of the Republic's area (Figure 1).

Conclusion. The greatest changes in the conditions for the formation of groundwater in South Kazakhstan are associated with anthropogenic impact on the regime of surface runoff due to its regulation in the river basins of their smaller tributaries. The ratio of increase and decrease in groundwater resources depends on the geomorphological conditions of a particular area and can vary significantly. Important factors in changing the conditions for the formation of groundwater in South Kazakhstan are changes in the temperature regime of the territory and anthropogenic pollution of groundwater.

Versatile anthropogenic impact on nature leads to significant changes in the appearance of natural areas. Agricultural production is the main type of impact on the natural and territorial complexes of Kazakhstan, which significantly affects the landscape and ecological state of the land, covering 85,3% of the country's land. The main types of agricultural impact on landscapes are agrogenic, reclamation and pasture. Steppe landscapes are disappearing, natural forest landscapes are being replaced by derivatives, swamps are being drained, deserts are being irrigated, and so on. At the same time, types of impacts and the response of geosystems to them in each natural zone have their own specifics. Thus, zonal patterns of changes in geosystems have been established and studied during pasture digression under the influence of agriculture, during restorative successions.

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