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Satbayev University

Х А Б А Р Л А Р Ы

ИЗВЕСТИЯ

НАЦИОНАЛЬНОЙ АКАДЕМИИ
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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.

НАНПК сообщает, что научный журнал «Известия НАНПК. 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 НАНПК. 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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**ASSESSMENT OF THE POTENTIAL OF SELF-DISCHARGING
HYDROGEOLOGICAL WELLS FOR SUSTAINABLE
DEVELOPMENT OF RURAL AREAS OF ZHAMBYL REGION**

Abstract. In Zhambyl region there is a significant number of self-discharging artesian wells, large majority of which are not equipped with regulating devices. As a result of spouting, a considerable amount of groundwater is lost every year, and fertile land is swamped and salinized, causing considerable damage to agriculture in the region. Assessment of the potential for flowing well operation of pressure groundwater in Merke district has been carried out based on the analysis of the results of the expedition surveys. The capacity of perspective self-discharging wells is 0.536 m³/s and for the growing season is estimated at 6.947 million m³, which, taking into account the average irrigation of 4515 m³/ha allows to provide irrigation of agricultural crops on additional 220 ha. At development of self-discharging wells the main method of irrigation is sprinkling, under which water consumption during irrigation is reduced, there is no discharge, optimal soil water regime is provided and microclimatic indicators in plant development environment are improved.

Key words: self-discharging hydrogeological well, pressure artesian groundwater, flowing well operation, Merke district.

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ЖАМБЫЛ ОБЛЫСЫНЫҢ АУЫЛДЫҚ АУМАҚТАРЫН ТҰРАҚТЫ ДАМУҒА ҮШІН ӨЗДІГІНЕН АҒАТЫН ГИДРОГЕОЛОГИЯЛЫҚ ҰҢҒЫМАЛАРДЫҢ ӘЛЕУЕТІН БАҒАЛАУ

Аннотация. Жамбыл облысының аумағында өздігінен ағатын артезиан ұңғымаларының саны көп, олардың басым көпшілігі бақылау құрылғыларымен жабдықталмаған. Атқылаудың салдарынан жыл сайын жерасты суларының едәуір мөлшері жоғалып, құнарлы жерлер батпақтанып, сортаңданады, бұл облыстың ауыл шаруашылығына айтарлықтай зиян келтіруде. Экспедициялық барлаулардың нәтижелерін талдау негізінде Меркі ауданындағы қысымды жерасты суларының фонтандық пайдалану мүмкіндігіне баға берілді. Перспективалы өздігінен ағатын ұңғымалардың өнімділігі 0,536 м³/с, ал вегетациялық кезеңде 6,947 млн м³ дейін бағаланады, бұл орташа суаруды 4515 м³/га есепке алғанда ауыл шаруашылығы дақылдарын қосымша 220 гектар суаруға мүмкіндік береді. Өздігінен ағатын ұңғымаларды игеру кезінде суарудың негізгі әдісі жаңбырлатып суару болып табылады, бұл суару кезінде су шығынын азайтады, ағызу болмайды, топырақтың оңтайлы су режимі қамтамасыз етіледі, өсімдіктердің дамуы үшін қоршаған ортадағы микроклиматтық көрсеткіштер жақсарды.

Түйін сөздер: өздігінен ағатын гидрогеологиялық ұңғыма, қысымды артезиан жерасты сулары, фонтанды пайдалану, Мерке ауданы.

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ОЦЕНКА ПОТЕНЦИАЛА САМОИЗЛИВАЮЩИХСЯ ГИДРОГЕОЛОГИЧЕСКИХ СКВАЖИН ДЛЯ УСТОЙЧИВОГО РАЗВИТИЯ СЕЛЬСКИХ ТЕРРИТОРИЙ ЖАМБЫЛСКОЙ ОБЛАСТИ

Аннотация. На территории Жамбылской области насчитывается большое количество самоизливающихся артезианских скважин, подавляющее большинство которых не оборудовано регулируемыми устройствами. В результате фонтанирования ежегодно теряется значительное количество подземных вод, заболачиваются и засоляются плодородные земли, что наносит значительный ущерб сельскому хозяйству области. На основе анализа результатов экспедиционных обследований проведена оценка потенциала фонтанной эксплуатации напорных подземных вод Меркенского района. Производительность перспективных самоизливающихся скважин составляет 0,536 м³/с, и за вегетационный период оценивается в 6,947 млн.м³, что с учетом средней оросительной в 4515 м³/га позволяет обеспечить полив сельскохозяйственных культур дополнительно на 220 га. При освоении самоизливающихся скважин основным способом полива является дождевание, при котором сокращаются затраты воды при поливе, отсутствует сброс, обеспечивается оптимальный водный режим почвы и улучшаются микроклиматические показатели в среде развития растений.

Ключевые слова: самоизливающаяся гидрогеологическая скважина, напорные артезианские подземные воды, фонтанная эксплуатация, Меркенский район.

Introduction. The need to ensure conditions that contribute to the preservation of life and health of the population in the country is emphasized in the “Main Provisions of the General Scheme of Organization of the Territory of the Republic of Kazakhstan”, approved by the Resolution of the Government of the Republic of Kazakhstan No. 1434 (Approved by Resolution of the Government of the RK, 2013) dated December 30, 2013. In addition to the main directions of development of the country’s regions, agriculture development is provided for Zhambyl region as a priority for the agricultural sector until 2050. The local

bodies of the region are implementing a number of practical measures aimed at increasing the volume of irrigated land and the area of flooded pasturelands. And development of self-discharging hydrogeological wells is one of the promising areas.

The territory of Zhambyl region is characterized by extremely uneven distribution of fresh water resources, including administrative districts (Smolyar et al., 2002; Mukhamedzhanov, 2014; Murtazin et al., 2019). Almost all resources of quality drinking water are confined to piedmont and intermountain areas, while inland, northern, north-eastern and north-western areas of the region are almost deprived of significant fresh water resources. A clear example of this is the industrial and economic development of the Pribalkhash zone, against the background of total absence of drinking water resources, which remains relevant up to the present day. If we take into account that the feeding areas for all the artesian basins of the area are mountainous, piedmont and intermountain latitudinal zones, the ecological and economic balance of groundwater resources in these areas in the long term is a strategic objective for state planning.

Under the conditions of growing water resources deficit during the growing season, the issues of rational and efficient use of irrigated land should become a priority of water policy (Tolepbayeva et al., 2020; Sagin et al., 2017; Shagarova et al., 2018; Absametov et al., 2019). During the period of economic reforms from planned to market economy, investments in water sector were almost absent, which resulted in intensive deterioration of irrigation and drainage systems and deterioration of ecological and reclamation state of lands. The low cost of surface water discourages agricultural producers from introducing water-saving technologies and from reconstructing irrigation systems to prevent filtration losses. Primitive irrigation technologies on more than 90% of the area lead to the development of irrigation erosion, soil salinization and other negative processes. Low tariffs hinder the inflow of new investment.

The Ministry of Agriculture of the Republic of Kazakhstan plans to increase the area of land by 2040 through rehabilitation of unused irrigated land from 1.4 to 2.1 million ha with regular irrigation. Based on the analysis of crops grown on the additional area, agricultural water consumption will increase up to 21.1 km³ by 2040 (on average by 1.7% per year). With development of self-irrigation wells the main method of irrigation is sprinkling, which reduces water consumption during irrigation, eliminates discharge, provides an optimal soil water regime and improves microclimatic indicators in the environment of plant development.

The scientific justification and geo-information support for management decisions on the use of pressurized groundwater potential in flowing well (self-discharge) operation for sustainable development of rural areas in Zhambyl region seems to be relevant and practically meaningful.

Materials and basic methods. Visual observations, collection and analysis of specialized information were carried out to identify and assess the status of self-discharging hydrogeological wells in Zhambyl region. Its sources include published reference books, atlases and monographs, information and statistical reports of line ministries, their institutions and agencies, scientific, thematic and geological reports, published topographic and other specialized maps of various purposes. The research is based on primary materials obtained through the collection of published and archive materials. A list of them is given in the list of sources used (Hydrogeology of the USSR, 1970; Dzhakelov, 1993; Sydykov et al., 1999; Medeu et al., 2015). During the work, special attention was paid to technical characteristics of wells, location and availability of water users. Field surveys were carried out to establish the geographical location of self-discharging hydrogeological wells and to assess the impact of self-discharging on the environment. The work was carried out in accordance with the current methodological recommendations and other subsoil use regulations of the Republic of Kazakhstan. Based on the results of the survey, the Survey Acts for self-discharging hydrogeological wells were prepared and signed by the specialist who conducted the survey and representatives of the regional Akimat. Following the survey and sampling of self-discharging wells, water samples were taken to assess the possibility of their use for domestic and drinking water supply and land irrigation. As a result of all surveys, analyses of materials were provided to develop predictive scenarios for the operation of self-discharging wells using the geographical information system.

Research area. Zhambyl region is located in the south of the Republic of Kazakhstan (Figure 1). The boundaries of Zhambyl region are Karaganda region in the north, Turkestan region in the west, Almaty region in the east, and the Republic of Kyrgyzstan in the south. The total area of region territory is 145.4 thousand sq.km. There are 10 administrative districts with population of about 1.1 million people within the region. The territory of the region is very unevenly populated, the population density in the south reaches up to 100 people per km², at the same time in the central (Moiynkum sands) and northern (Betpakdala plateau) parts of the region there are almost no settlements.

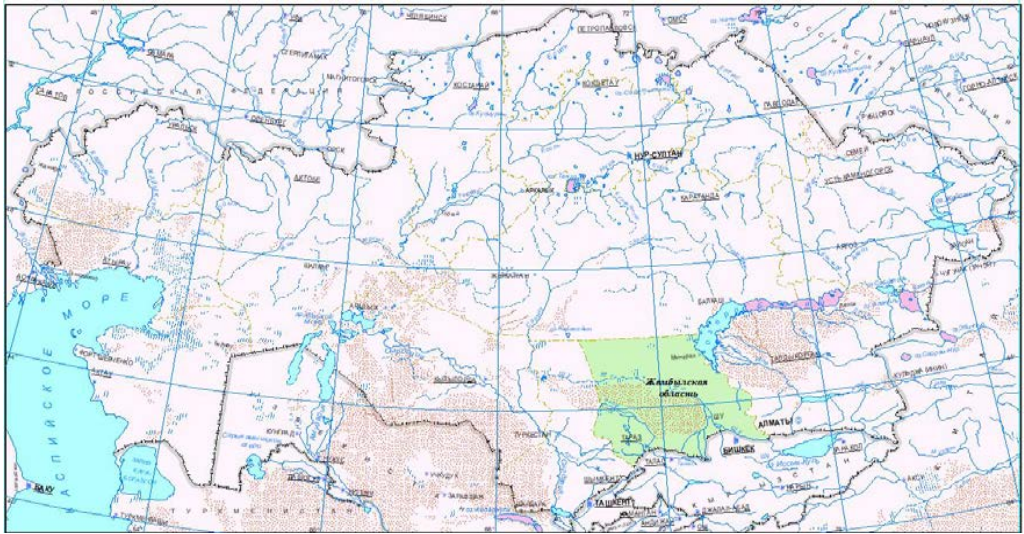


Figure 1 - Map of Zhambyl region

The water supply of cities and large villages is provided by groundwater from explored deposits. Rural settlements - mainly due to artesian wells operating groundwater of alluvial, alluvial-proluvial deposits of quaternary period. Within the thick cones of withdrawal in the foothills of the Kyrgyz range, high pressure groundwater deposits in alluvial-proluvial and Neogene sediments were once explored as sources of water supply to rural settlements as well as for land irrigation. Self-discharging wells, traversed at various stages of hydrogeological investigations, were partially transferred in due time for the use of rural water users.

The Shu River, disappearing in the Muyunkum sands in the north-east (average annual flow of 57.2 m³/s, Georgievka station) and the Talas River, passing through the south-western part (average annual flow of 22.4 m³/s, Zhambyl station) flow through the territory of the region. Numerous low-flow rivers and temporary watercourses flow down from the northern slope of the Kyrgyz range, which are lost in the alluvial cones when they leave the mountain gorges and take part in groundwater recharge.

Groundwater in Zhambyl region is confined to the following hydrogeological areas: mountainous areas; foothill plain of the northern slope of Kyrgyz Alatau; foothill plain of the north-eastern slope of Maliy Karatau; foothill plain of the south-western slope of Shu-Ili mountains; hilly-ridgy plain of Moiyunkum; south-eastern part of Betpakdala.

Mountainous areas including Kyrgyz Alatau, Maliy Karatau, Kendiktas and Shu-Ili mountains are characterized by diverse hydro-geological conditions.

Here, non-pressure waters of fracture and fracture-karst types are mainly developed, with mineralization up to 1 g/l, predominantly hydrocarbonate calcium composition. The flow rate of some springs reaches 860 m³/day (Ostrovskiy, 1976; Veselov et al., 1999).

Foothill plain of the northern slope of Kyrgyz Alatau. Pore unconfined and confined waters are common in the area under consideration. Non-pressure waters form underground streams, connected at the foot of mountains with boulder and pebble rocks with thickness from 200 to 300 m. The depth of groundwater occurrence varies from 5-10 to 100 m. The productivity of wells, opening the pore water of pebbles and sands, usually is 260-2,500 m³/day. Flow rates of wells and wells drilled in sandy loam and clay sands do not exceed 43 m³/day. Pressurized waters of the foothill plain, sometimes self-discharging, are associated with the Quaternary deposits of the proluvial plain. Hydrophilic sediments are represented by sands with gravel, interlaid with loams, clays. The thickness of aquiferous complexes ranges from 40 to 150-300 m. Waters are fresh, with salinity less than 1 g/l, calcium hydrocarbonate, rarely sodium sulphate.

Foothill plain of the north-eastern slope of the Maliy Karatau. There are widely developed groundwater of predominantly pore type - unconfined and confined in the described territory. Non-pressure waters are confined to areas where plains are composed of thin quaternary sediments or Neogene and Chalk rocks come to the day surface. Hydrophilic sediments are mostly clayey sands, loose sandstones and conglomerates. The depth of levels varies from 3 to 10 m. Groundwater is fed by winter-spring precipitation. Mineralization of water usually does not exceed 1-3 g/l, composition is sulphate or mixed sodium-calcium.

Groundwater confined to alluvial-proluvial sediments of the Talas River alluvial cone. In the southern part the hydrophilic sediments are represented by gravel and pebble formations, and in the northern part they are uncovered by sands, deposited at depths of 3 to 10 m. The thickness of aquifers is 30-90 m in the south and 10-30 m in the north. Groundwater is formed due to filtration of surface water from the Talas River, atmospheric precipitation and partly water from irrigation canals. They are discharged in the Talas River valley and partially penetrate into the sands of Moynkum as underground flow.

Below non-pressure waters in alluvial-proluvial gravel-pebble and sandy rocks, interlacing with loams and clays, pressure waters are developed, occurring at depths from 30 to 100 m. Flow rates uncovering pressure water wells vary from 860-2,580 m³/d in the south to 258-1,032 m³/d in the north.

Foothill plain of the south-western slope of the Shu-Ili mountains. Non-pressure pore waters associated with proluvial-alluvial gravel and sandy-clay

Quaternary sediments, up to 10-50 m thick, are common between the Shu-Ili mountain uplands and the Shu River valley. Levels vary in depth from 5 to 10 m. The waters are fresh and slightly saline. In the north-western part of the plain, groundwater occurs mainly in alluvial small- and fine-grained sands at depths of 3 to 10 m. Water quality is various. Brackish waters with mineralization of 1-3 g/l sulphate prevail. The productivity of groundwater wells varies from 8 to 172 m³/day. Groundwater, with exception of the extreme north-western part, is of practical interest for pasture watering by means of mine wells and shallow wells of 5 to 30 m depth.

The hilly-ridgy plain of the Moiyunkum sand massif. The hilly-ridgy plain of the Moiyunkum sand massif contains the largest desert pasture areas in South Kazakhstan. They cover about 4 million hectares in Zhambyl region. The sandy hilly-ridgy plain extends in the latitudinal direction for more than 500 km. In the northern part it is replaced by an undulating plain of saxauls. Porous unconfined and confined waters are exceptionally widespread in the Moiyunkum. The thickness of sands containing pore water is 150-200 m in the central and eastern parts of Moiyunkum, and up to 100 m in the Shu valley. In modern alluvial valleys of the Shu and Talas Rivers, groundwater is deposited in multigrained sands. Depth of the groundwater occurrence varies from 20 to 30 m, and on the hillocks and ridges from 40 to 60 m. A similar picture is observed in the axial elevated western part of Moiyunkum with large ridge relief. Here in the swale features the water depth is up to 30-50 m and on the ridges up to 50-100 m. In the central part of the eastern half of the sands, the depths range from 3 to 5 m and under the hillocks and ridges from 5-10 to 15-20 m. Their total area is about 700 km² and they extend north-westward. During the period of high water levels, they blow out to the surface in some places, forming small lakes, some of which dry up by the autumn (e.g. Baskul, Dalankuduk, Baschingil, Astaukul, Maikuduk, Akkan, Ayayukul, Shcherbakty, etc.). In the peripheral parts of Moiyunkum, adjacent to the modern valleys of the Shu and Talas Rivers, sands (mostly small- and fine-grained) have a flat relief. The depth of groundwater occurrence is from 10 to 20 m, and in the valleys of the Shu and Talas Rivers does not exceed 3-5 m (Veselov, 2002; Absametov et al., 2017).

The south-eastern part of the Betpakdala Plateau. It is a flat, in some places gently undulating desert pasture area. In the eastern rocky part, groundwater of fracture and fracture-karst type is developed, and in the western part - of pore type. The depth of fissure water occurrence varies from 5 to 15 m, and only in the uplands it reaches 20-30 m. Mineralization from 3 to 5 g/l, sulphate-chloride-sodium to sodium chloride composition. Flow rates of fracture water wells are 0.8-8.6 m³/d, reaching 43 m³/d in granitoids. In the Bashtaktau mountains some sources show flow rates up to 86-130 m³/day. In the fracture zones the flow rates

of wells increase up to 172-258 m³/day. Fracture-karst waters are developed in carbonate rocks, forming closed molds. Their occurrence depth is from 5 to 30 m. The quality of water is brackish and salty. The mineralization of fissure karst water in the peripheral parts of structures, in places of water exchange is usually 3-10 g/l, in the central parts of closed structures with impaired water exchange up to 10-50 g/l. The water composition is usually sodium chloride (Ostrovskiy, 1976).

The object of research. In 2021, expedition surveys of hydrogeological wells were conducted in Merke, Shu and Korday districts of Zhambyl region. A total of 204 hydrogeological wells were surveyed and tested. 137 wells among them are self-discharging. Flow rates of these hydrogeological wells reach 3,500 m³/day. Pumps are installed in 20 hydrogeological wells.

Most of the self-discharging wells are located in Merke district (Figure 2), for which the analysis and assessment of the potential of flowing well operation of pressurized groundwater, its status and prospects for sustainable development of rural areas are provided. Calculations of the average irrigation rate for the whole growing season for all agricultural crops in Merke district for additional irrigation of lands were made.

Results and discussion. The research carried out shows that in the research area the following things are of important practical relevance:

- Groundwater from alluvial-proluvial and alluvial deposits of the Kyrgyz and Talas Alatau foothills with a depth of up to 100 m, well flow rates of 430-5,200 m³/day;
- groundwater of Chalk, Palaeogene and Neogene deposits, occurring at depths of 100 to 800-1000 m. Well flow rates do not usually exceed 690-860 m³/day at 5-10 m lowering of the level.

Within the research area, two groundwater deposits have been explored for agricultural purposes in the cones of the alluvial bench and intermountain basins: Asparin and Merke.

There are 182 hydrogeological wells surveyed in Merke district, 132 thereof are self-discharging wells. These wells are confined to 12 rural areas out of 14. Wells with productivity above 860 m³/day are of the greatest practical interest. Forty prospective wells have been identified and their distribution in the rural areas is shown in the table 1.



Figure 2 - Physical map of the Merke district with location of hydrogeological wells

Distribution of prospective self-discharging wells in the Merke district

No.	Number of wells	Confinedness of wells (rural area)	Total flow rate, l/s
1	12	Oital	176
2	1	Surat	30
3	1	Sarymolda	10
4	1	Zhanatogan	10
5	10	Andas Batyr	138
6	5	Kenes	60
7	2	Aktogan	20
8	1	T. Ryskulov	10
9	4	Akermen	82
Total	37		536
Self-discharging wells with warm water			
1	2	Andas Batyr	24
2	1	Kenes	10
Total	3		34
GRAND TOTAL	40		570

The total capacity of 37 self-discharging cold water wells is estimated at 0.536 m³/s (46.31 thousand m³/day; 0.0169 km³/year). The capacity of 3 wells with warm water (above 30°C) is estimated at 0.034 m³/s (2.94 thousand m³/day). Total capacity of prospective self-discharging wells of Merke district for practical use is estimated at 0.57 m³/s.

Based on the analysis of the results of the field surveys, an assessment of the potential for flowing well operation of pressure groundwater has been made for Merke district.

According to the regional department of agriculture of Zhambyl region in Merke district in 2021 103,540 ha were sown, including: cereals and pulses (wheat, barley, maize for grain) - 59,038 ha; oil crops (safflower and other oil crops) - 5,743 ha; sugar beet - 2,021 ha; potatoes - 1,051 ha; vegetables and melons - 2,811 ha; forage and silage (maize for silage, perennial grasses) - 32,839 ha; raspberry, strawberries - 37 ha.

Also according to the Department of Agriculture of Zhambyl region the following irrigation rates for the whole growing season, which is 5 months, have been agreed for the territory for 2021 in Merke district (150 days): perennial grass - 6300 m³/ha; horticultural crops- 5,800 m³/ha; sugar beet- 5,350 m³/ha; vegetable- 5,300 m³/ha; onion- 8,500 m³/ha; maize for grain- 4,300 m³/ha; potato- 4,250 m³/ha; sunflower- 3,600 m³/ha; soybean- 3,800 m³/ha; maize for silage – 3,400 m³/ha; cucurbits – 2,950 m³/ha; spring grain crop-2,800 m³/ha; winter wheat – 2,350 m³/ha. The average irrigation rate for the whole growing season for all agricultural crops in Merke district is estimated at 4,515 m³/ha, with the number of irrigations for the whole growing season reaching 7.

The capacity of 37 prospective self-discharging wells in the Merke district is 0.536 m³/s, which is 6.5% of the calculated value of annually replenished groundwater resources of the productive aquiferous complex. Thus no depletion of groundwater resources is expected.

During the growing season under flowing well operation, the total volume of groundwater brought to the surface from 37 self-discharging wells is estimated at 6.947 million m³. Taking into account the average irrigation norm of 4,515 m³/ha, with the number of irrigations during the whole vegetation period of 7 at the expense of 37 self-discharging wells there is a possibility to provide irrigation of agricultural crops on additional 220 ha.

When developing self-discharge wells, the main irrigation method is sprinkling, which reduces water consumption during irrigation, eliminates discharge, ensures an optimum soil water regime and improves microclimatic indicators in the plant development environment.

Conclusion. The potential of self-discharging artesian groundwater resources for sustainable development of rural areas and increase of irrigated land fund of Merke district of Zhambyl region has been analyzed and assessed. Prospective self-discharging wells have been identified. Capacity of 37 self-discharging wells is estimated as 0,536 m³/s (46,31 thousand m³/day, 0,0169 km³/year). The average irrigation rate for the whole growing season for all crops in Merke district is calculated, which is estimated at 4,515 m³/ha, with the number of irrigations for the whole growing season reaching 7.

The survey revealed that almost all of the self-discharging wells used by the local population for various purposes do not have special water use permits.

Subject to the issuance of special water use permits, the wells can be used in the future. The restoration of 25 clogged hydrogeological wells is of practical interest to the region.

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