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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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V. V. Kulagin[1], D. B. Umbetaliyev[1], V. M. Mirlas[2], M. R. Zapparov[3], A. T. Makyzhanova[3], V. S. Rakhimova[3], S. Z. Zhigitova[4]

[1]RSE Zonal hydrogeological-meliorative center of the Ministry of Agriculture of the Republic of Kazakhstan,
[2]Eastern Israel R&D Center, Israel,
[3]KazNRTU named after Satpayev, Almaty, Kazakhstan,
[4]Taraz state university, Kazakhstan.
E-mail: vitali_kulagin@mail.ru, doc_dauren@mail.ru, vladimirmster@gmail.com, zapparov_m50@mail.ru, asyl_m_74@mail.ru, salybekova_v@mail.ru, saule_zatibekovna@mail.ru

GROUNDWATER HYDRO CHEMICAL REGIME AND SOIL SALINITY UNDER LONG-TERM OPERATION ON TASOTKEL IRRIGATED AND DRAINED LANDS OF ZHAMBYL REGION

Abstract. The article describes hydrochemical regime and dynamics in soil salinity in conditions of long-term operation at Tasotkel irrigated and drained lands located in Shudistrict, Zhambyl region.

The results of agro-meliorative surveys, stationary hydrogeological and hydrological observations, soil-meliorative works and laboratory studies performed by the RSE Zonal hydrogeological-meliorative center of the Ministry of Agriculture of the Republic of Kazakhstan, as well as information of regional water, agriculture and statistics bodies used to conduct studies on the following theme.

Meliorative state assessment of irrigated lands according to hydrogeological indicators, as well as soil-meliorative conditions in combination with agricultural conditions was made.

Key words: groundwater, hydro chemical regime, hydrogeological and meliorative conditions, soil-meliorative conditions.

Introduction. Shu district is located on the north-eastern part of Zhambyl region. There are Shu, Aksu, and Koragata Rivers used for irrigation of crops and livestock watering. Tasotkel water reservoir was constructed on Shu River for irrigation on the territory of the region. Today, Tasotkel irrigation lands occupy central part of the interfluve of Shu and Koragata Rivers, right-bank part of the Shu River above-flooded terrace and a part of the foothill plain [1, 11].

Total area of the irrigated lands is equal to 21,469.2 hectares, including 20,212.2 hectares of arable lands.

Climatic conditions in 2017 were characterized by a large amount of precipitation in the spring-summer period. The amount of precipitation for the following hydrological year is 438.5 mm [2].

Fodder crops, vegetables, melons, potatoes, grains, sugar beet, and oilseeds are mainly cultivated on irrigated lands. An increase in the average yield of such crops as sugar beet, sunflower and vegetables observed for 2017.

Irrigation was carried out from the Tasotkel reservoir by gravity due to topography. In 2017, the total amount of water abstraction estimated by 164.3 million m^3, and for water supply - 94.7 million m^3. Volume of collector-drainage water increased to 6.166 million m^3 in comparison with 2016.

1. Geographical setting and climatic conditions. Tasotkel irrigation areas located in the middle reaches of Shu River and occupies floodplain terraces and a part of the foothill plain. Absolute surface landmarks decrease from the foothill part to river valleys varies from 500 to 420 m.

Climatic conditions for the growing season were characterized by a humid and hot summer. Weather conditions were favorable for the growth and development of crops. According to the data of "Tole-bi" meteorological station, the minimum average monthly air temperature was -5.4 °C recorded in February, the maximum in July 26.8°C (table 1.1, figure 1.1).

Table 1.1 – Meteorological characteristics of Tasotkel irrigation area for the 2016-2017 hydrological year

Month												Total
2016		2017										
XI	XII	I	II	III	IV	V	VI	VII	VIII	IX	X	
Average air temperature by month, °C												
-1.9	-1.9	-5.2	-5.4	2.5	11.9	19.9	23.7	26.8	23.6	18.3	10.3	
Precipitation, mm												
36.0	65.0	22.0	61.0	14.0	86.0	44.0	41.0	0.5	6.6	14.0	48.4	438.5

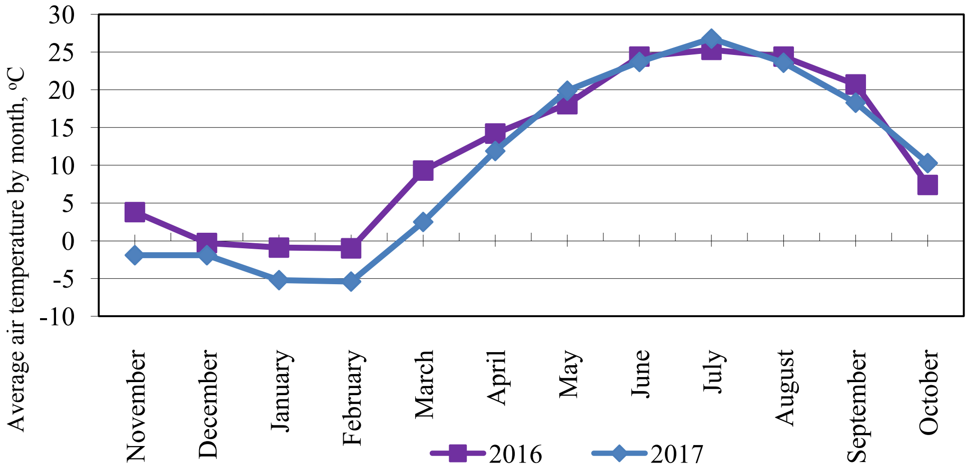


Figure 1.1 – Dynamics of average air temperature by month

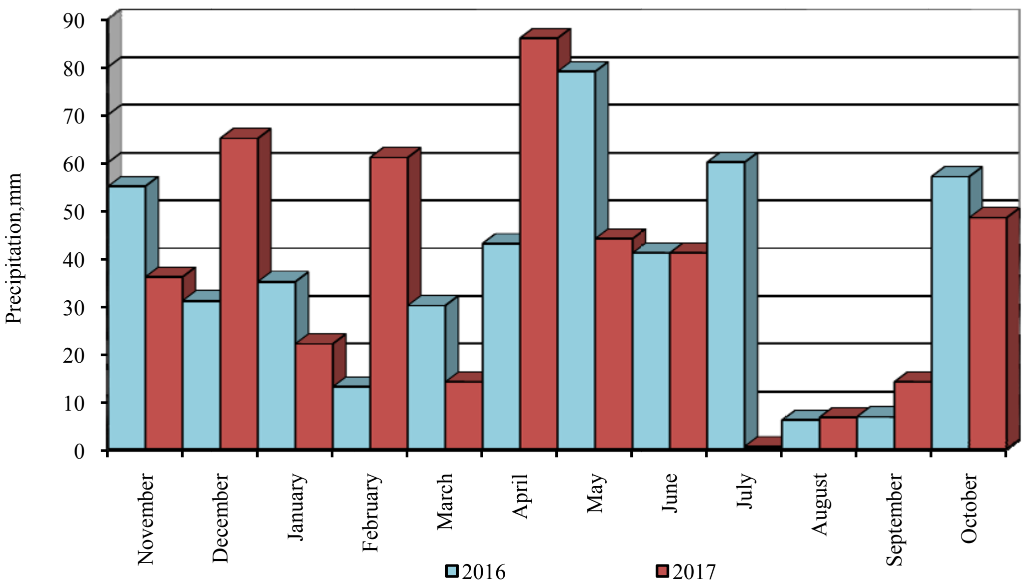


Figure 1.2 – Precipitation dynamics of Shu district for 2016-2017 hydrological years

It follows from the diagram that the maximum temperature for 2017 is slightly higher than last year's indicators and noted in July, but on average, it was at the level of long-term values.

The amount of precipitation for the hydrological year is equal to 438.5 mm, which is less by 18.2 mm than in previous years, but more than the average annual values. Of these, during the vegetation period, 192.1 mm precipitated (figure 1.2). The rainiest months are April-May (130 mm).

2. Technical condition of water management systems and water use. The right-bank main channel (RMC) and the left-bank main channel (LMC), through which water conducted to irrigated lands and for settlements completed of the earth-bed and the Tasotkel main channel (TMC) itself is made of concrete bed [3, 4].

According to the RSE "Kazvodkhoz" and the SME "Tasotkel", the total amount of water abstraction is 164.3 million m^3, water supply - 94.7 million m^3, of which 84.3 million m^3 were delivered to the Tasotkel irrigation array. The efficiency of the main channels estimated to 0.58.

Compared to 2016, the volume of water supply increased by 31,890.4 thousand m^3 (62,786 thousand m^3 in 2016). This was due to discharges of irrigation water into the collectors K-1 and Kokozek during the sewage treatment on the main channels.

The volume of collector-drainage waters reached 6.16mln.m^3 or only 6.5% of the volume of water supply, while in 2016 it did not exceed 3.649 mln.m^3. The increase in the volume of drainage flow is associated with an increase in water supply.

During the vegetation period, main channels made of earth-bed are going to silt. In November-December 2016SME "Tasotkel" carried out mechanical cleaning on the Aktobe channel with the length of 14.6 km, Aktogan channel - 3.7 km and Kirov channel - 1.5 km.

During the past 15 years, there was no repair and restoration works to improve the state of the collector-drainage network (CDN). Thus it’s overgrown with weed vegetation and createda backwater drainage (photos 1.2–3.2). On-farm (tray) irrigation networks are in an emergency condition. Main water losses occur during the transportation of water from the head structures to water discharge points. The efficiency of these channels varies from 0.40 to 0.55.

Photo 1.2 – Siltation of the collector K-1Photo 2.2 Silt and clogged collector K-1-1

To improve the current situation and ensure the optimal operation of drainage systems (NOK-1, NOK-2 do not provide drainage from irrigated lands suspended to them) mechanical cleaning is required.

Particularly, in need of clearing the site on the territory of Tolebirural district, with the extension of these collectors to a length of about 8 km to Koragata River and the deepening of the laid pipe under the Tolebi rural district road to the Abay village [4, 14].

Photo 3.2 – Silted and overgrown with reeds collector K-1-2

3. Quality of irrigation and collector-drainage waters. Mineralization and chemical compound of surface and collector-drainage wateron the irrigated lands ofShu district were studied by samples taken from three main channels, and also from Shu andKoragata rivers [5].

The mineralization of water in TMC varied from 0.49 to 0.58 g/L, and the chemical compound by its anion-cation presence varied from bicarbonate-sulfate magnesium-calcium to sulfate-hydrocarbonate magnesium-sodium. The SAR value was 1.1, i.e. the probability of soil alkalinization during irrigation with such water is absent.

Mineralization of water in PMC varied from 1.07 to 1.35 g/L, with sulfate-hydrocarbonate calcium-magnesium and sodium-calcium chemical compound mainly. The SAR did not exceed 2.1.

Mineralization of water in the K-1 collector during the vegetation decreased from 2.18 to 2.07 g/L, with a sulfate-hydrocarbonate calcium-magnesium chemical compound. The SAR index at the end of vegetation was equal to 1.0. Thus, in terms of mineralization, salt content and SAR index- the K-1 collector characterized with satisfactory quality and suitable for irrigation (figure 1.3).

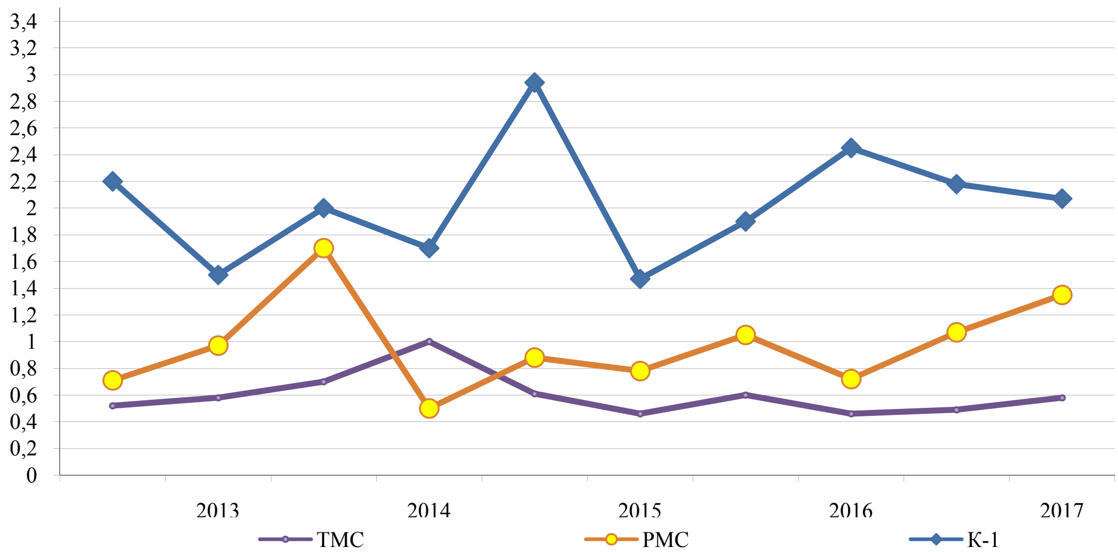


Figure 1.3 – Mineralization of irrigation and collector-drainage waters at Tasotkelirrigated lands for 2013-2017, g/L

It follows from the diagram that mineralization of water for irrigation varies depending on the season and water content of the year. During the reporting year, mineralization in PMC has increased significantly, in TMC has remained at the level of long-term values, and in the collector-drainage water, there has been a slight decrease.

4.Hydrogeological and meliorative conditions. Groundwater table formation on Tasotkel area significantly was influenced by irrigation type. During the growing season with the beginning of water supply, groundwater levels rise, and in the non-vegetation period, form dome of irrigation-groundwater drawn-off due to the drainage system operation and natural drainage of the territory. For seasonal and long-term dynamics, groundwater fluctuations are directly influenced by irrigation regime, irrigation norms, type of cultivated agricultural crops and technical conditions of the drainage system.

Groundwater level in April varied from 3.05 to 5.36 m. In May, after the water supplied to the fields, there was an increase in groundwater level with the greatest intensity in the first month. The amplitude of the rise in this period was equal to 0.11-0.35 m. During the entire irrigation period, the elevation of groundwater level continued and peaked in August, groundwater at that time detected at a depth of 2.20-4.53 m. With the termination of water supply, there was atendency to decrease in groundwater level. In the middle of September, groundwater level markedonadepth 2.28-4.66 m. Groundwater levels with a depth of more than 5 m observed only in winter and spring periods wells No. 523, 547, located in the floodplain of Shu River.

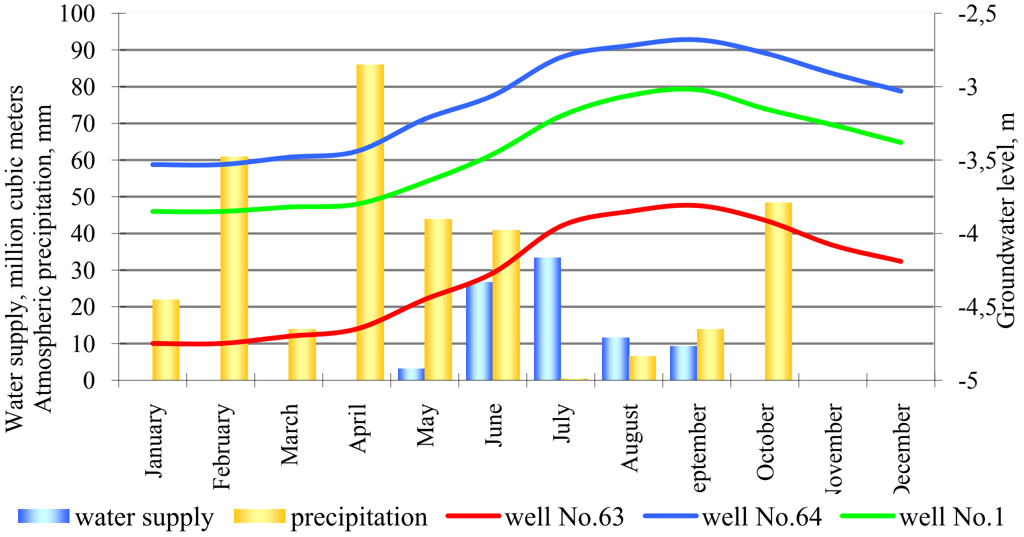
Irrigation lands according to hydrogeological conditionsare divided into the foothill plain on the right bank of Shu River, the flood plain of Shu River and the interfluve of Shu and Koragaty Rivers. Foothill plain characterized by natural drainage of the territory, elevated slopes of groundwater table, which provide intensive outflow from this area [6]. This creates a favorable level-salt regime of groundwater. For example, for a well No. 64 located on the right bank of Shuriver, groundwater in winterperiod marked at a maximum depth of 3.53 m (figure 1.4). With the beginning of the melting inspringperiod, a slight rise ofgroundwater level on 9 cmis noticed. After that, irrigation water flows down to the fields; a general rise in groundwater level is observed especially intensively in the first month of irrigation period - up to 22cm.Maximum increase in groundwater table observed in September up to 0.85m and was marked on a depth 2.68m. With the end of the irrigation period, there is a general decrease in groundwater. Near-well location of the well, elevated slope of the groundwater table, and natural drainage of the territory contributed to the leveling off the groundwater surface, which continues during the non-vegetation period.

The floodplain part of the right bank of Shuriver characterized by the occurrence of groundwater at a depth to 3-5 m. For example, in a well No. 165 groundwater level before the beginning of irrigation was equal to 3.76 m. Peak rise ofgroundwater level was observed in August, when level reached 2.91 m. With the termination of irrigation, there is a gradual decrease in groundwater. Therefore, in September level dropped to 3.05m. Groundwater restoration after the irrigation season continues throughout the non-vegetation period and the baseline values reach the spring level marks.

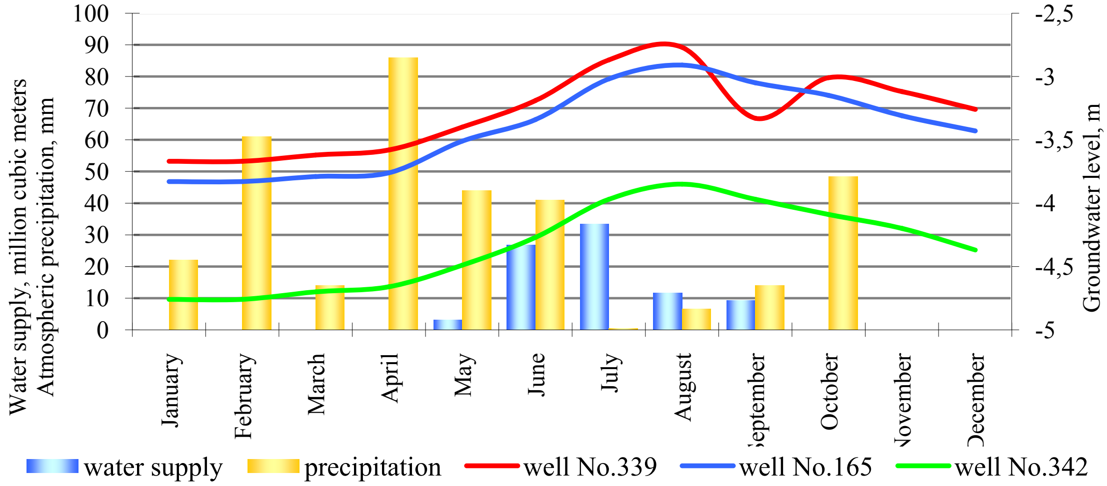
At the watershed areas, in the interfluve of Shu and Koragata Rivers, groundwater level marked on a depth of 2.5-5.5 m. Thus, for the borehole No.78, located in Tolebi district, groundwater level in April marked at a depth of 3.02 m. With the beginning of irrigation period, the rise in levels indicated, which continues until August. The amplitude of rising was equal to 0.81m up to the depthof2.21m. After the termination of irrigation markedgeneral decline in groundwater level. Revealed that interfluve area characterized by difficult conditions of groundwater outflow, with the aeration zone low filtration properties [7]. Therefore, after the completion of irrigation, levels during the month decreased only by 0.07 m and in September marked drawdown at a depth of 2.28 m.

After the termination of irrigation in September, local sites with groundwater level occurrence from 2 to 3 m on an area of 2332.9 hectares (7% from irrigated lands) observed on the studied area. Significant changes in the position of groundwater levels are not observed in comparison with the previous irrigation year (figure 2.4).

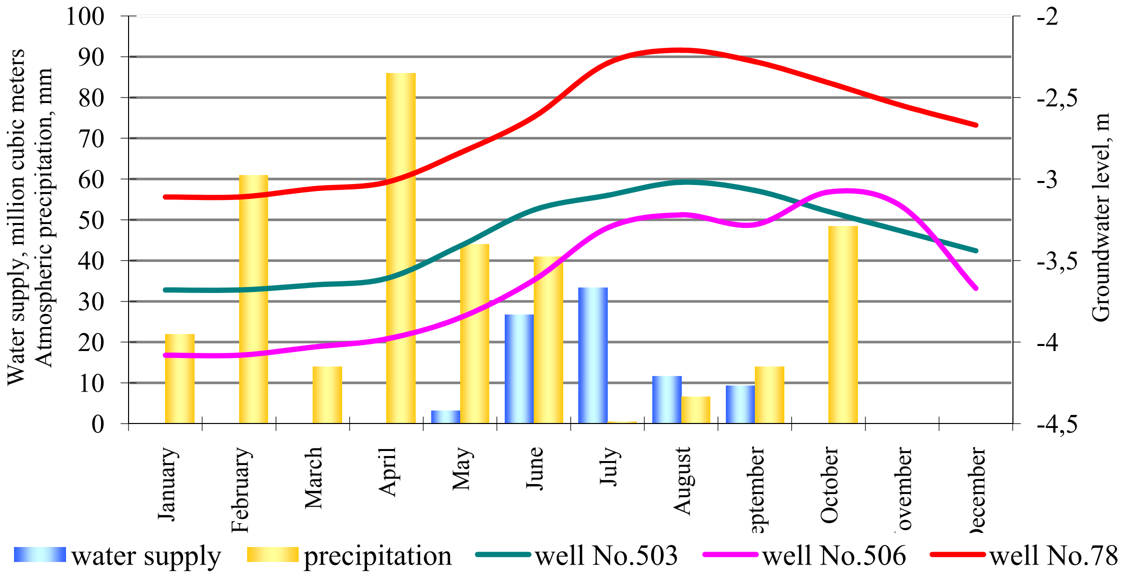
Fresh and slightly saline groundwater quality is common for the studied area. Fresh groundwater located mainly on the flood plain of Shu River with a salinity in April up to 0.27-0.91 g/L. Hydrogen carbonates and sulfates prevailed among the anions in the chemical composition, sodium and magnesium from the cations. On the rest of the territory, slightly saline groundwater with mineralization of 1.00-2.90g/L. In terms of chemical compound, these are sulfate or sulphate-hydrocarbonate sodium-magnesium or sodium-calcium waters.



Piedmont Plain. Right bank of Shu River



Floodplain part of Shu River



Interfluve of Shu and Koragaty Rivers

Figure 1.4 – Groundwater level variation on Tasotkel irrigated lands for 2017

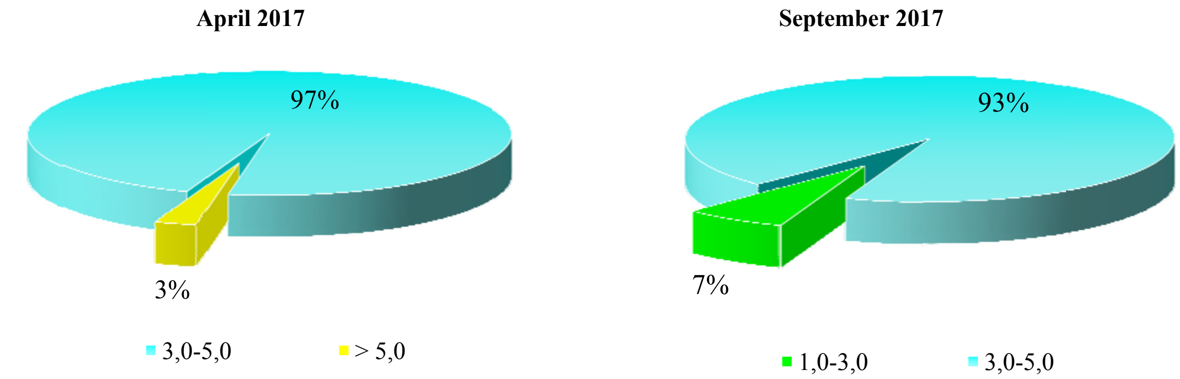


Figure 2.4 – Distribution of irrigated lands areas according to the depth of groundwater level at the Tasotkel area in 2017

At the end of the irrigation period in the interfluve of Shu and Koragata Rivers, as well as in the floodplains of Shu and Kokozek Rivers groundwater salinity reduced by 0.02-1.60 g/L due to dilution with more fresh surface water. Thus, well No. 79 located in Tolebi district, shown groundwater salinity decreased from 2.90g/L in May to 1.37g/L in September, chemical compound changed from sulfate-chloride sodium to chloride-hydrogen carbonate sodium magnesium.For the well No. 160, located in the Berlikustemsky rural district, salinity changed from 1.91g/L in May to 0.75g/L in September. Chemical compound changed from sulfate calcium-magnesium to bicarbonate calcium-magnesium.

The rest territory is characterized byaccumulation of salts in groundwater up to 0.02-2.39 g/L. Thus, well No. 8a, located in the Eskisu rural district, near TMC, shown the rise of groundwater mineralization from 0.65 g/L in May to 1.30 g/L in September. Chemicalcompound anion-cation presence varied from bicarbonate sodium to sulfate-hydrocarbonate magnesium sodium [10, 13]. Well No.4, located on the foothill plain of the right bank of Shu River, in the Zhanakagam rural district. Here mineralization increased from 0.50 g/L in May to 2.89 g/L in September due to the enrichment of groundwater with salt from soils and evaporation. Chemical compound anion-cation presence changed from hydrocarbonate-sulfate magnesium-sodium to sulfate-hydrocarbonate magnesium-calcium. With the rise of mineralization, bicarbonates are replaced by sulfates for the vast majority of wells. In September, mineralization of groundwater varied from 0.33 to 2.89 g/L, by the chemical compound among the anions predominated sulfates and hydrogen carbonates, and among the cations, prevailed sodium. Well No. 80, located on the interfluve of Shu and Koragata Rivers, on the western part of Tolebi rural district and wells No. 158, 523, located on the foothill plain, with groundwater salinity respectively 3.10, 3.14 and 3.37g/L, during the non-vegetation period, mineralization is usually restored to its original values.

The share of fresh groundwater is about 25% of regional usedfor irrigation in all rural districts.

Distribution of irrigated lands by the degree of groundwater mineralization in Tasotkel area shown in figure 3.4. During the growing seasonnumbers of areas with fresh groundwater decreased by 1147.5 hectares. On a long-term period, significant changes in redistribution of areas with different groundwater mineralization do not occur, which indicates stabilization inhydrochemicalregime [2].

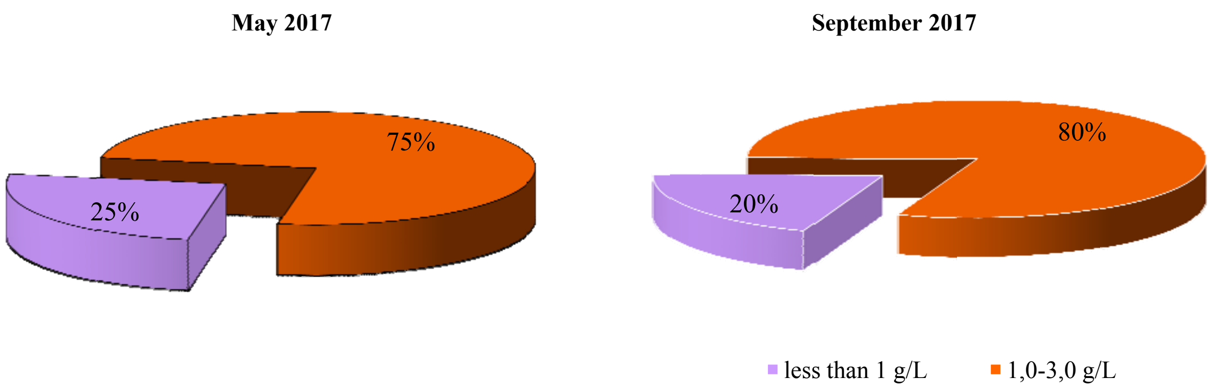


Figure 3.4 – Distribution of irrigated land areas by the degree of groundwater mineralization at Tasotkel irrigation land in 2017

5. Soil-meliorative conditions. Irrigated lands of Shu district located within two landscape zones - the foothill Plain of Kedykta Mountains and the Valley of Shu River. The foothill plain characterized by light sierozems. On the valley of Shu River definedmainly semi-hydromorphic and hydromorphic soils.

Soil salinity depends on close occurrence of mineralized groundwater, the presence of saline underlying rocks, non-compliance with the irrigation regime, unsatisfactory condition of irrigation and collector-drainage networks.

The presence of salinity facilitated by improperly applied agricultural technology. In particular, a poorly planned irrigation field with a close occurrence of mineralized groundwater is one of the causes for saline swamps appearance. The stronger the excessive moistening of the soil and the higher the level of saline groundwater, the more preconditions for secondary salinization occurrence. On the elevations and hills of the irrigated lands, defined an increase in a volume of evaporation. By virtue of this, along capillaries salts rise together with water. Withthe evaporation of water salts precipitates and accumulates in soil. Failure to comply with agrotechnical measures and water use regulations on soils prone to salinity, contributes to the emergence of so-called spotted salinization.

It should be noted that salinity is not an inevitable and mandatory consequence of irrigation. Proper planned irrigation system often contributes to desalinization of saline soils. However, excess irrigation and the absence of groundwater outflow causes salinization and even swamping. Incorrect irrigation, in addition to salinization, can have many other negative consequences as a soil structure break down, leaching, waterlogging and alkalinization even total loss of their territory.

Secondary salinization is one of the main degradation processes that determine ecological status of lands [8, 12]. Soil salinity is estimated by the depth of upper boundary salt horizon; chemical type of salts; by degree of salinity; on the percentage of saline soils participation. In this casesoil fertility and high yields on saline soils-the basis of fertility-humus are lost, mineralized, soil moisture binds, the physical properties of the soil become unfavorable for plants, and the activity of soil organisms is inhibited.

In figures 1.5–2.5 are shown are as of saline soils with sparse vegetation. Picture 3.5 shows the profile of saline soil.

Figure 1.5 – Highly saline surface of sierozem soils

Figure 2.5 – Salt spots on the surface of Shu River valley

Figure 3.5 – Cross-section of highly saline soils

If we consider the development of salinization processes on the Tasotkelirrigated lands, it should be noted, that present water-salt regime of irrigated lands on the area remains stable. By the results of surveys conducted in 2014 and in 2017, as well as by reconnaissance and agro-meliorative surveys data on the irrigated lands confirmed stable water-salt regime.

The largest saline soil spots weredefined on the northeastern and western parts of the area, in particular, on the 2nd and 3rd terraces above the flood plain of Shu River. Significantly, less saline areaswere allocated on the central and southern parts of the irrigation lands. If we consider the areas of saline soil formations in the context of rural districts, the worst situation for salinization was observed in Koragaty, Tolebi and Konaev districts.

Distribution of irrigated lands by the degree of salinity in 2017 is shownin figure 4.5. Slightly saline soils accounted for 3473 hectares, medium saline soils - 830 hectares, strongly and very strongly saline-14 hectares.

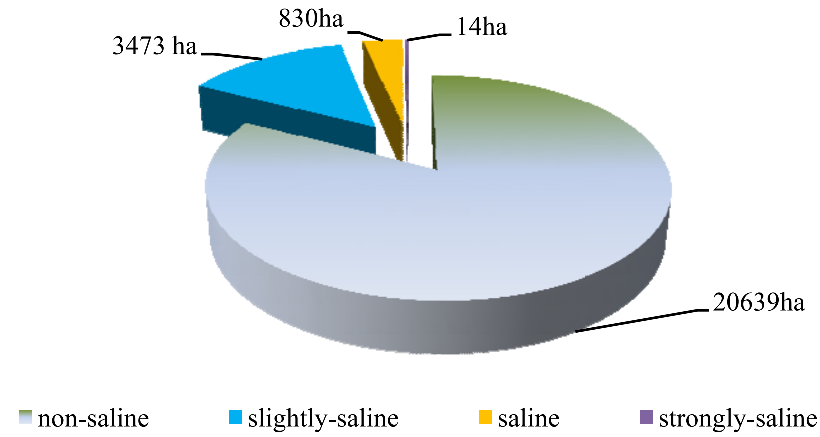


Figure 4.5 – Distribution of irrigated lands at Tasotkel irrigation array in terms of salinity for 2017

Relative stabilization for salinity on irrigated lands largely is related to the implementation of a number of meliorative measures in recent years. Dynamics for the areas of salinity formation on the Tasotkelirrigated lands for the period from 2013 to 2017 shown in figure 5.5.

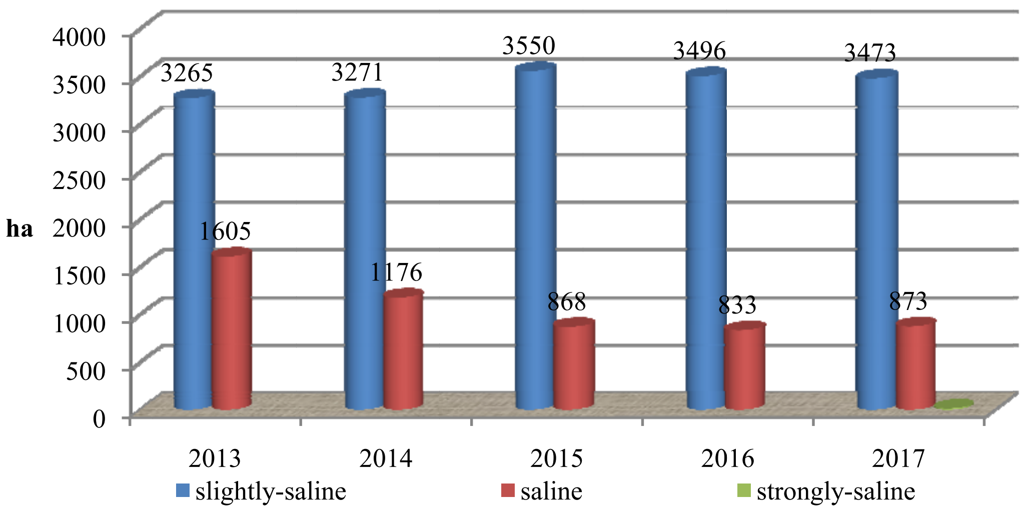


Figure 5.5 – Dynamics for the areas of salinity formation on the Tasotkelirrigated lands for the period from 2013 to 2017

Conclusions. According to the hydrogeological conditions for the pre-vegetation period, groundwater level was defined on a depth of more than 3m for the whole area of the irrigated land. Of these, for 598.4 hectares groundwater level marked on a depth of more than 5.0 m. There are no areas with a depth of groundwater less than 3.0 m.

By the chemical compound revealed fresh and slightly saline groundwater, on the whole territory of the irrigation with a salinity in April 0.30-2.90 g/L. In terms of cation-anion presence, it is sulfate or sulfate-hydrocarbonate sodium-magnesium or sodium-calcium water types. Revealed area with groundwater mineralization up to 1.0 g /L equal to 5400.0 hectares and 16069.2 hectares with mineralization 1.0-3.0 g/L.

Consideringthe development of salinization processes on Tasotkelirrigated lands we can make a conclusion that at present time water-salt regime of studied area remains stable.

Over the period from 2013 to 2017 it was shown a decrease and redistribution of irrigated lands by categories of their meliorative state. The reason for the reduction of land with an unsatisfactory reclamation state is the transfer of part of the low-productive irrigated arable lands to other categories of land use.

According to the accepted criteria [6,7] as the depth of occurrence, groundwater saline ty and the degree of soil salinity, on the area of 26 490.0 ha (77%) meliorative state of irrigated lands estimated as normal. Lands classified ascategoryof a satisfactory condition allocated on an area of 7256.0 hectares (21%). Irrigated lands are classified as unsatisfactory by reclamation state amounted to 789.0 ha (2%).

By the results of conducted studies, we believe that it is necessary to carry out a comprehensive reconstruction of Tasotkelirrigated lands with a complete modernization of irrigation system for modern technologies and equipped with automation and water measurement.

В. В. Кулагин[1], Д. Б. Умбеталиев[1], В. М. Мирлас[2],
М. Р. Заппаров[3], А. Т. Макыжанова[3], В. С. Рахимова[3], С. З. Жигитова[4]

[1]ҚР Ауылшаруашылығы министрлігі
Су ресурстары комитеті Аймақтық гидрогеологиялық-мелиоративтік орталық
республикалық мемлекеттік мекемесі,
[2]Ариэль университеті, Израиль,
[3]Қ. И. Сәтбаев атындағы ҚазҰТЗУ,
[4]Тараз мемлекеттік университеті, Қазақстан

ЖАМБЫЛ ОБЛЫСЫ ШУ АУДАНЫ ТАСӨТКЕЛ МАССИВІНДЕГІ ГИДРОМЕЛИОРАТИВТІ ЖҮЙЕНІ КӨПЖЫЛДЫҚ ПАЙДАЛАНУ ЖАҒДАЙЫНДА ГРУНТ СУЛАРЫНЫҢ ГИДРОХИМИЯЛЫҚ РЕЖИМІНІҢ ЖӘНЕ ТОПЫРАҚТЫҢ ТҰЗДАНУ ПРОЦЕСІНІҢ ҚАЛЫПТАСУЫ

Аннотация. Мақалада Жамбыл облысы Шу ауданы Тасөткел массивіндегі гидромелиоративті жүйені көпжылдық пайдалану жағдайында грунт суларының гидрохимиялық режимінің және топырақтың тұздану процесінің қалыптасу ерекшеліктері келтірілген.

Сонымен қатар, массивте ҚР Ауылшаруашылығы министрлігі Су ресурстары комитеті Аймақтық гидрогеологиялық-мелиоративтік орталық республикалық мемлекеттік мекемесімен орындалған агромелиоративтік зерттеулер, тұрақты гидрогеологиялық және гидрологиялық бақылаулар, топырақтық-мелиоративтік жұмыстар, лабораториялық зерттеулер нәтижелері пайдаланылды.

Суарылатын жердің мелиоративтік күйін бағалау гидрогеологиялық көрсеткіштер, сондай-ақ топырақтық-мелиоративтік жағдайлар мәліметтері бойыншасушаруашылық және ауылшаруашылық жағдайларымен бірге келтіріледі.

Түйін сөздер: грунт сулары, гидрогеохимиялық режим, гидрогеологиялық-мелиоративтік жағдайлар, топырақтық-мелиоративтік жағдайлар.

В. В. Кулагин[1], Д. Б. Умбеталиев[1], В. М. Мирлас[2], М. Р. Заппаров[3], А. Т. Макыжанова[3], В. С. Рахимова[3], С. З. Жигитова[4]

[1]РГУ Зональный гидрогеолого-мелиоративный центр Министерства сельского хозяйства РК,
[2]Ариэльский университет, Израиль,
[3]КазНИТУ им. Сатпаева, Алматы, Казахстан,
[4]Таразский государственный университет, Казахстан

ФОРМИРОВАНИЕ ГИДРОХИМИЧЕСКОГО РЕЖИМА ГРУНТОВЫХ ВОД И ДИНАМИКИ ЗАСОЛЕНИЯ ПОЧВ В УСЛОВИЯХ МНОГОЛЕТНЕЙ ЭКСПЛУАТАЦИИ ГИДРОМЕЛИОРАТИВНЫХ СИСТЕМ НА ТАСОТКЕЛЬСКОМ МАССИВЕ ЖАМБЫЛСКОЙ ОБЛАСТИ

Аннотация. В статье приведены особенности формирования гидрохимического режима грунтовых вод и динамики засоления почв в условиях многолетней эксплуатации гидромелиоративных систем на Тасоткельском массиве, расположенном в Шуском районе Жамбылской области.

При этом, использованы результаты агромелиоративного обследования, стационарных гидрогеологических и гидрологических наблюдений, почвенно-мелиоративных работ, лабораторных исследований, выполняемых на массиве РГУ Зональный гидрогеолого-мелиоративный центр Министерства сельского хозяйства РК, а также информации районных органов водного, сельского хозяйства и статистики.

Оценка мелиоративного состояния орошаемых земель приведена по данным гидрогеологических показателей, а также почвенно-мелиоративных условий в совокупности с водохозяйственными и сельскохозяйственными условиями.

Ключевые слова: грунтовые воды, гидрогеохимический режим, гидрогеолого-мелиоративные условия, почвенно-мелиоративные условия.

Information about authors:

Kulagin Vitali, RSE Zonal hydrogeological-meliorative center of the Ministry of Agriculture of the Republic of Kazakhstan**;** vitali_kulagin@mail.ru; https://orcid.org/0000-0002-5686-5674

Umbetaliyev Dauren, Deputy Director, RSE Zonal hydrogeological-meliorative center of the Ministry of Agriculture of the Republic of Kazakhstan**;** doc_dauren@mail.ru; https://orcid.org/0000-0002-4389-9189

Mirlas Vladimir, professor, Ariel University, Israel; vladimirmster@gmail.com; https://orcid.org/0000-0002-3117-0331

Zapparov Medethan, professor, KazNRTU named after Satpayev**;** zapparov_m50@mail.ru; https://orcid.org/0000-0002-7779-668X

Makyzhanova Assyl, doctor PhD, KazNRTU named after Satpayev**;** asyl_m_74@mail.ru; https://orcid.org/0000-0001-7704-9679

Rakhimova Valentina, doctor PhD, KazNRTU named after Satpayev; salybekova_v@mail.ru; https://orcid.org/0000-0002-5193-3375

Zhigitova Saule, doctoral student, Taraz state university; saule_zatibekovna@mail.ru; https://orcid.org/0000-0002-7997-4304

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