AZERBAIJAN REPUBLIC

On the rights of manuscript

ABSTRACT

Of the dissertation for the degree of Doctor of Science

ASSESSMENT OF RECLAMATION-ECOLOGICAL CONDITION OF IRRIGATED LANDS IN MUGHAN-SALYAN MASSIF AND SCIENTIFIC-PRACTICAL BASIS FOR THEIR STABILIZATION

Specialty: 3103.02-**Amelioration, reclamation and soil protection**

Field of science: **Agrarian sciences**

Applicant: Mirza Firudin Gurbanov

Baku - 2022

The dissertation work was carried out in the Azerbaijan Scientific Production Association Hydrotechnics and Amelioration

Scientific consultant: Doctor of agrarian science, professor
Agamir Calal oglu Hashimov

Official opponents: Doctor of technical science, professor
Fuad Mahmud oglu Hajizadeh

Doctor of texnika science, professor
Feyruz Bashir oğlu Bashirov

Doctor of texnika science
Ahmed Shirin oglu Mammadov

Doctor of agrarian science, associate professor
Mustafa Gilman oglu Mustafayev

Azerbaijan National Academy of Sciences of Higher Attestation Commission at the President of the Republic of Azerbaijan, one time BED 1.32 Dissertation board attached to the Institute of Soil Science and Agrochemistry

Chairman of the Dissertation Council: Corresponding member of ANAS, Doctor of Agrarian sciences, professor
__________ **Alovsat Gulush oglu Guliyev**

Scientific secretary of the Dissertation council: Doctor of agrarian science, associate prof.
__________ **Naila Hidayat gizi Orujova**

Chairman of the scientific seminar: Doctor of texnika science, associate prof.
__________ **Sabir Tehrankhan oglu Hasanov**

İNTRODUCTİON

Topic urgency and degree of elaboration. Considerably serious reforms have been carried out and are still being carried out under conditions of new economic relations and market economy for improving the welfare of the population, creating the abundance of products and ensuring the development of all these factors. At present 664600 he or 46.6% out of 1.426 million he irrigated lands that is currently suitable for agriculture, is saline to varying degrees. 479600 he or 33.0% of total area is alkaline to some extent. Mugan-Salyan irrigation massif is one of the most favorable areas for irrigation in the republic. The total area of irrigated land suitable for agriculture is 273594 hectares. As per data of 2015, the soils in 180183 he (65.9%) of the massif at the depth of one meter were salinized to varying degrees. The depth of occurrence of the ground water is distributed in the area as following: in 4612 he less than 1,0 m, in 31707 he at the intervals 1,0 – 1,5 m, in 136175 he at the intervals 1,5 - 2,0 m, in 82677 he at the intervals 2,0 – 3,0 m, in 18423 he more than 3,0 m. The analysis conclude that, despite the facts of covering the lands of the Mugan-Salyan irrigation area by collector-drainage network, implementation of complex land-reclamation measures and intensive use of the area for long-term agricultural crops, the current reclamation condition of the massif lands cannot be considered satisfactory.

The collector-drainage systems built in the Mugan-Salyan irrigation area are mostly open type. In spite of certain advantages, it is necessary to build the water headers and collectors at greater depths at the areas with less inclination (<0.001) or without inclination, in the mouth of horizontal drains to avoid the regimes of overflooding the areas. As per calculations, the minimum depth of such water headers should be 5-6 m, and the depth of collectors 8-9 m. As per operating experiences, the cross-sections of the water headers and collectors built at such depths are deformed over a certain period of time (slopes destruction, slides, grass, reeds and etc.). This will eventually lead to the disruption of the initial drainages operating conditions and the deterioration of land reclamation. On the other hand, the rise of the Caspian Sea level recently has led to deterioration of the environmental situation in the Caspian region and the rise of groundwater levels. Under these conditions, the construction of open water headers and collectors at the indicated depths is efficient neither from hydraulic nor from ameliorative viewpoints. The analysis of geomorphological features of irrigated lands in Kur-Araz plain shows that the soils with less inclination of relief or without any inclination are mainly spread in Mugan-Salyan massif.

According to the calculations, such lands in the Mugan-Salyan area are spread over 268000 ha. Thus, it is necessary to increase the efficiency of horizontal drainages in areas with less inclination or without inclination of relief, and to elaborate suitable drainage systems for regulating the ecological reclamation balance in those areas. Assessment of the current state of land use shows that land users' attitude to land is different and sometimes they do not use the land properly.

As a result of these and other anthropogenic impacts on soil, degradation of soils occurs in the ecological and land reclamation condition. Apparently, the existing problem in the massif is one of the issues that are chosen by its complexity and difficulty in solution. Interrelated and interdependent problems solution depends on a number of factors.

The possibility of solving such problems is related to the elaboration and implementation of a comprehensive system of measures which is expected to be of great scientific and practical importance.

The purpose and tasks of research is to assess the ecological and land reclamation condition of Mugan-Salyan irrigation massif, to forecast water-salt regime of the massif, to identify ecological and reclamation violations, to develop scientific and practical basis of new engineering ways and methods for their removing. The following tasks must be fulfilled in order to achieve the goals:

1. Analysis and generalization of perennial materials of funds, experimental and production researches for the purpose of assessment of ecological and reclamation condition of irrigated lands.

2. Forecasting salinization and desalinization processes on irrigated lands.

3. Analysis of current state of collector-drainage systems operating in the massif.

4. İnvestigation the operation of siphon-vacuum drainage system that has a new working principle and structure in the areas with less inclination (<0,001) of relief or without any inclination.

5. Studying the possibility of using groundwater for irrigation against the background of siphon-vacuum drainage systems.

6. Development of scientific-practical bases for regulation of ecological-reclamation balance in irrigated lands of the massif.

The studied object. The lands of Mugan-Salyan irrigation massif is the object of study. The investigations were conducted in 1982-2015 in the experimental plots in Salyan, Saatlı, Sabirabad, Neftchala districts. The experiments for the study of the siphon-vacuum drainage system operation were performed in Marishli village of Salyan district and the studies related change of groundwater levels in the surrounding areas of the Caspian Sea were carried out in selected sites in Garalar village of Sabirabad and Garabaghli village of Salyan district.

The purpose of the study. Theoretical and methodical basis of dissertation work consist of agrarian problems, development of land reclamation, state programs on perfection of service mechanisms, long-term studies of the author and other scientific works of the scientists and specialists. Different methods and ways have been used for researches in this area:

Comparative analysis; multi-graphical grouping; multidimensional taxonomy; correlation and regression communication; systematic approach and others.

As a result, on the basis of theoretical and scientific classification adopted on the methodology, the completeness and proper use of reclamation systems for restoring ecologic-reclamation balance in irrigated lands of the studied area was provided. Information on the processes of investigation and evaluation of the results is widely presented in separate chapters, depending on the physical nature of issues under study.

Thesis for defense. Defended:

1. Effectiveness of complex reclamation measures in Mugan-Salyan irrigation massif.

2. Investigation of factors affecting the environmental and land reclamation condition of the irrigated lands of the massif, development of a complex system of reclamation measures to improve the water-salt regime.

3. Theoretical and experimental justification of application of a siphon-vacuum drainage system that can be used in various soil and geomorphological conditions.

4. Substantiation availability of groundwater irrigation against the background of a managed drainage system.

5. Determination of efficient schemes of appropriating irrigated lands under new economic condition.

Scientific innovation of the research.

1. Based on the analysis and generalization of the perennial fund, experimental and production studies, salinization and desalinization processes were predicted in irrigated soils, and control and regulation measures were developed against reiterative salinization of the soils.

2. For the first time a siphon-vacuum drainage system with new principles of operation at the areas without inclination or with less inclination of relief (<0,001) has been tested and recommended for large-scale use in production.

3. A comprehensive system of measures was developed to regulate the water-salt regime in the aerial zone by investigating the impact of water levels changes in the river Kur and the Caspian Sea on the groundwater level in the surrounding areas.

4. Factors promoting the development of lands under the new economic conditions were evaluated and new schemes of appropriation were proposed.

The theoretical and practical significance of the study is the creation of favorable environmental-reclamation conditions in the soils at the result of forecasting of alkalinity-salinization processes, prevention of secondary salinization in the irrigated soils of the massif by lowering the groundwater level, withhold deep water headers and collectors by applying siphon-vacuum drainage system at the areas without inclination or less inclination of relief.

Approbation and application. Methodological recommenddations based on the results of the studies have been applied and used in farmlands operating in Mugan-Salyan irrigation massif. Recommendations and proposals on the fundamentals of the work were submitted to the relevant organizations for use in the design, construction and operation.

The main regulations and separate parts of the dissertation have been aprobated at international scientific and practical conferences held in our country and abroad.

"Amelioration in XXI century, views, scientific researches, problems, scientific and practical conference" (Baku, 2002); materials of scientific and practical conference "Water, problems, investigations" (Baku, 2001); International scientific conference titled "Azerbaijan lands: genesis, geography, amelioration, rational use and ecology" (Gabala, 2012)"; Scientific and practical conference devoted to 90th years anniversary of National Leader Heydar Aliyev "H.Aliyev's land reforms are assurance of food safety" (Baku, 2013); conference "Khazar International Water Technologies" (Baku, 2013)"; "Water, energy and food safety in the countries of the Eastern Europe, Caucasus and Central Asia: problems and solutions" (Tashkent, 2013); International scientific and practical conference titled "Water farm, modern problems of engineering communication system and ecology" (Baku, 2014); International scientific and practical conference "Improvement of hydrotechnical systems and water farm technologies" (Herson, 2017).

International scientific and practical conference "Modern technologies and achievement of engineering sciences in the field of hydraulic engineering and water engineering" (Kherson, 2019).

The dissertation work was carried out in 1982-2015 on the basis of scientific-research works carried out basing on scientific and technical problems of state importance in accordance with the subject plan of Azerbaijan Hydrotechnics and Amelioration Scientific-Production Union.

Published works. 34 scientific articles and 6 theses were published on the dissertation work, including 16 articles in foreign countries.

Volume and structure of the thesis. The thesis consists of 303 pages printed on a computer, introduction, 7 chapters, conclusions and 222 references. The work includes 27 figures, 77 tables and 15 Annexes, including 426831 signs (table of contents -8136, introduction -11413, chapter I -50449, chapter II -69682, chapter III -115593, chapter IV -18608, chapter V -56520, chapter VI -46845, chapter VII -37247, conclusion -12338).

Research object, physical and geographical conditions of the researchobject, geomorphology, climatic conditions, vegetation, soils, geology and hydrogeology, hydrography, and modern state of its study are explained in **the first chapter.** Ecological and ameliorative condition of the research object was assessed according to soil salinization, alkalinization, groundwater mineralization degree, depth of occurrence of groundwater, soil erosion rate, drainage rate, agricultural plant productivity, intensity of desalination-salinization in the irrigated networks of the massif are studied in **the second chapter.**

The third chapter is dedicated to the study of the factors affecting amelioration condition of Mugan-Salyan irrigation massif lands.

Role of drainage in irrigated lands, methods of intensification of drainage work, vacuuming of drainage systems and its physico-mathematical nature, report schemes, and issues concerning regularity of depression curve formation in these systems are explained in **the fourth chapter.**

Assignment, constructions and working principles of siphon-vacuum drainage systems, constructive solution of developed new generation vacuum-drainage system, its functional capabilities, its application and results of conducted experimental works, used and proposed suction cups for creating a vacuum in the drainage system, results of the studies related construction and working principle of siphon-vacuum drainage system radial type are given in **the fifth chapter.**

The sixth chapter deals with the factors determining the regulation of water and land relations under modern farming conditions, water resources and their use in irrigation, main principles of efficient land use, role of siphon-vacuum drainage systems in the use of internal water resources and possibilities of using alternative water resources in the event of water shortage.

The seventh chapter is dedicated to the development of a system of differentiated engineering and agro-ameliorative measures to improve the ecological-ameliorative condition of the lands in Mugan-Salyan irrigation massif and determination of economic benefit obtained from implementation of recommended measures.

OF THE WORK

CHAPTER I. The object of the research, natural and economic conditions, current state of the study

The irrigated lands of Salyan, Neftchala, Sabirabad, Saatlı, Imishli and Bilasuvar districts were included in the study area. The lands of the massif are lands that have been reclaimed and intensively used under agricultural crops for a long time. The total area of the surveyed area is 89599 thousand he, and irrigated land is 2736 thousand he. Relief of the area consists mainly of the plains, slope is weakly observed in the south-east direction of the massif.

The altitudes of Mugan-Salyan irrigation area range between negative 22-28 m, which is relatively to the sea level. Close location of groundwater to the surface where the relief is below the sea level has caused the salinity of most of the lands. The climate of the massif is mainly subtropical with the desert type. The average annual air temperature rises in the East, decreasing towards the Caspian Sea, in the West.

Air relative humidity is high. Relative humidity raises to 79% in the spring and falls to 65% in summer. The coldest month is January, the hottest months are July and August. The amount of precipitation is small.

The average annual rainfall is 68 mm. The average annual amount of atmospheric precipitation is 246-320 mm, and the average annual air temperature varies between 14.1 and 14.8 degrees.

The evaporation in Mugan-Salyan massif is uneven throughout the year. The lowest evaporation is observed in winter – 59 mm. In spring evaporation rises gradually and reaches its maximum value in summer - 457 mm. In the fall, evaporation value is strongly reduces, reaching about 187 mm. Since the climate is semi-desert, the vegetation cover of the massif refers to the semi-desert type. The main vegetation period cover coincides with the summer, when rainfall falls more. The annual plants, which vegetation period expires in April, begin to dry in early May.

The vegetation of the area is subdivided into the following groups: halophytic vegetation is salt-loving and presents the main plant cover. In the growing season they are present in the virgin land and the lands that are not using under sowing. Xerophytic plants - these are drought-resistant plants that do not occupy a wide area and do not have a significant impact on the process of soil formation. Ephemeral plants - they germinate early in spring and quickly vanish and occupy a small area.

Hygrophilous plants - these groups are green all the year round and grow under extreme moisture, mainly nearby rivers, streams and lakes (cane, couch grass etc.). Currently, such cereals as wheat, barley and corn; such technical crops as cotton, sunflower; such fodder crops as alfalfa, such vegetable plants as tomatoes, cucumber, cabbage, onion; watermelon, melon, etc. grow in the area and are widely used.

In 1904 soil scientist M.R. Kalinin and agronomist B.A. Kamensky had a scientific mission to Mugan with a special research work related the lands[1].

Soil surveys started by a group that included soil scientist M.R. Kalinin and agronomist B.A.Kamensky. In Mugan, soil surveys have

expanded since 1925. In 1925, two major expeditions in the field of land surveys worked in Mugan. The first expedition was headed by S.I.Tyuremnov and the second expedition was led by L.L.Nojin.

---

[1]Каменский Г.И. Сообщение по вопросу об осоленение Муганских почв./ Г.И.Каменский. - Тифлис: -1904.- 120 с.

In 1929 under the leadership of A.S.Preobrajenski land surveys were continued in Salyan plain[2]. Subsequently, large-scale research issues in Mugan-Salyan massif were studied by N.A. Besednov, V.R. Volobuyev, A.K. Behbudov, M.K. Rahimov, Y.G.Sultanov, M.P. Babayev, G.M.Mustafayev and others[3,4,5,6,7,8,9].

Gray soil is mainly characteristic for Mugan-Salyan irrigation massif. Gray-meadow soil type is one of characteristic soil types of the massif. The massif also includes chestnut, saline with low and medium humus, meadow-boggy and alkaline lands. The mechanical composition of these soil types varies from light sand to loams and clays. In the soils with less humus the amount of humus is 1.5-2.5% and in medium humus soils - 2.5-3.2%.

The amount of carbonates in all soil types varies from 3% to 10%. In 0-60 cm soil layer, the absorption is 20-30 mg/Eq for every 100 gr of soil. Calcium ion prevails in absorption (40-50% of the total absorption) while the amount of other ions is as following: 30-40% magnesium ion and 5-15% sodium ion. As per hydrogeological features the investigated massif is characterized by the presence of

---

[2]Преображенский А.С. Лесная растительность Азербайджана/ А.С.Преображенский.- Баку: Изд. АН АзССР, - 1954.- с. 10-18

[3]Беседнов Н.А. Дренаж, как мелиоративная мера на территории Северной Мугани/ Н.А.Беседнов -Баку: Азернешр,- 1939.- 120с.

[4]Волобуев В.Р. Мугань и Сальянская степь/ В.Р.Волобуев: Баку: Элм,- 1951.- 129 с.

[5]Бехбудов А.К. Мелиорация засоленных земель/А.К.Бехбудов, Х.Ф. Джафаров - Москва:- Колос, -1980.- 240с.

[6] Mustafayev M.Q. Muğan-Salyan massivində torpaqların meliorativ vəziyyəti və onların yaxşılaşdırılması yolları //Az. Coğrafiya Cəmiyyətinin əsərləri- Bakı:- 2008.-s.120-124

[7] Babayev M.P. Azərbaycanın antropogen torpaqlarının nümunəvi biomorfogenetik təsnifatı və diaqnostikası/ M.P. Babayev - Bakı: Elm, -2006.- 165 s.

[8] Рагимов М.К. Неравномерность опреснения почвогрунтов и грунтовых вод при промывок. //Труды АзНИИГиМ, Т.VII, Баку: - 1968, - с. 40-45

[9] Султанов Ю.Г. Динамика минерализации коллекторно-дренажных систем в зоне обслуживания Мугано-Сальянского србоса / Ю.Г.Султанов, М.Г. Мустафаев //Известия АН АзССР (сер. биолог.наук),- Баку: -1988,- № 3,- с. 48-53.

groundwater and pressure water. Groundwater levels vary. Groundwater with low depth of occurrence spread in the surrounding area of the river Kur and the Caspian Sea in the form of the stripes.

Change of the depth of occurrence of seasonal groundwater varies between 1.0-1.5 m. Ground water mineralization ranges from 1.0 g/1 to 50,0 g/l. Chlorine and sulphate-chlorine salts, prevailing in the chemical composition possess a danger for the soils secondary salinization.

CHAPTER II. Ecological and land-reclamation assessment of the current state of Mugan-Salyan irrigation massif lands

Assessment of land reclamation and ecological condition of land has been included in land reclamation and soil science in recent years. Assessment of land reclamation and ecological condition of the lands has been included in amelioration and soil science in recent years.

The modern ecological and land reclamation state of the soils can be assessed with the help of a number of criterias such as the development of amelioration measures[10]. However, it is considered more appropriate and reliable to use the following criteria to reveal common patterns within these criteria.

Soil salinization degree and type; soil alkalinity degree; depth of occurrence and mineralization degree of groundwater; degree of land drainage; crop yields; amount of humus in soil; rate of soil erosion.

The data obtained from long-term observations (1983-2015), as well as from research, design and survey organizations and directly conducted by the individual farms of the massif were systematized, investigated and analyzed. Subsequently, ecological and land reclamation state of irrigated lands of the districts includedmatized, investigated and analyzed.

Subsequently, ecological and land reclamation state of irrigated lands of the districts included into Mugan - Salyan massif was

[10] Məmmədov Q.Ş. Şorlaşmış və şorakətləşmiş torpaqların ekomeliorativ qiymətləndirilməsi/ Q.Ş.Məmmədov, A.C.Həşimov, X.F.Cəfərov - Bakı: -MBA mət. -2005.- 180s.

evaluated[11,12,13]. 180183 he (65.9% of the total irrigated area) are salinized. 59,8% (107,686 he) out of salinized soils are weakly salinized, 22.6% (40,826 he) are averagely salinized, 17.6% (31,671 he) are highly salinized. One of the factors influencing the production of high and rich agricultural products in suitable irrigated areas is alkalinity. The largest area of non-alkalinized lands in the irrigated areas of the massif is noted in 1997. In 1977 the area of non-alkalinized lands was 124280 he, but in 2015 this figure was reduced to 91113 he. Weakly, averagely and highly alkalinized lands areas have increased significantly. Thus, during 1993-2015, the area of weakly alkalinized soils increased from 133353 he to 148180 he, and the area of averagely and highly alkalinized soils increased from 31249 he to 34301 he. As per analysis of the materials for the period 1993-2015, though alkalinized land areas has declined considerably over the years, the area of weakly, averagely and highly alkalinized soils have increased significantly. One of the indicators that characterize the land reclamation state is the groundwater level and degree of mineralization. The hydrogeological condition of the irrigated lands affects the reclamation of the soil. It occurs rapidly if groundwater level is much closer to the earth surface. The results of long-term researches and experiments show that in irrigated soils, if the level of mineralized (more than 3 g/l) groundwater is higher than the critical depth (2.0-2.5 m), the lands are subjected to salinization. The most dangerous condition of groundwater on irrigated soils is its location at a depth of 1.0-1.5m below the earth surface.

The most dangerous condition of groundwater on irrigated soils is its location at a depth of 1.0-1.5m below the earth surface.

---

[11] Gurbanov M.F. Assessment of amelioration state of Mugan-Salyan irrigation massif as per salinization //Azerbaijan Agrarian Scientific Journal, № 5-6, Baku, 2006, p.166-168.

[12] Gurbanov M.F. Assessment of amelioration condition of Mugan-Salyan irrigation massif as per alkalinity // Azerbaijan Agrarian Scientific Journal, № 7-8, Baku, 2006, p.81-82.

[13] Gurbanov M.F. Groundwater regime in irrigated lands of Mugan-Salyan massif // AzET Scientific works of the Institute of Agriculture and Economy, №2, Baku, 2006, p.172-176.

In general, groundwater with mineralization less than 1.0 g/l in the studied area increased almost for 2,5 times, from 7400 he to 18794 he during the studied period. In all the regions and in the massif, in general, the area of groundwater with mineralization more than 3.0 g/l is significantly reduced. The area of groundwater with mineralization more than 3.0 g/l reduced from 113600 he to 93459 he. As it is seen, ground water with mineralization 1,0-3,0 g/l makes 68% of the total irrigated area in massif. Groundwater with mineralization over 3,0 g/l accounts 32% of the irrigated area. The process of soil formation varies depending on the ground water location, its mineralization and composition. Due to these features, it is determined that there are automorphic, hydromorphic and semi-hydromorphic regimes in soil formation. The depth of occurrence of ground water is 1.0-1.5 m depth at 31617 he area. This represents 11.6% out of the total irrigated area. The most dangerous situation for this indicator is found in Sabirabad, Saatlı and Imishli districts. In Sabirabad, this indicator was 8926 hectares in 2015, 7028 hectares in Saatlı and 7733 hectares in Imishli. The area covered by groundwater depth of 1.5-2.0 m is 136265 he, which is 50.0% of the total irrigated area. In general, areas with groundwater depth of occurrence ranging from 1,5-2,0 m covered 136265 he in 2015, which constitutes 50% of total irrigated area. In general, depth of occurrence at the interval 1-2 m covers 172059 he (62,8%). If to add of 4612 he where the depth of occurrence is less than 1,0 m, thus, in 176671 he (64.5%) groundwater occurs at 0-2 m. In other words, 64.5% of the total irrigated area of the massif contains hydromorphic soils and the groundwater is above the critical depth (2.0-2.5m).

The areas of the semi-hydromorphic conditions are spread over an area of 96923 he (25.5%), which is a very small indicator for the massif. Hydromorphic conditions are not desirable. One of the factors that has a significant impact on the reduction of the natural fertility of agricultural lands is the erosion processes occurring on land resources. 23.8% or 212,906 he out of 895992 he of Mugan-Salyan massif have been eroded to varying degrees. 41815 he (19.6%) is weakly eroded, 9885 he (4.7%) is averagely eroded, 161206 he (75.7%) is highly eroded. Highly eroded areas: 26795 he in Sabirabad district, 21720 he in Saatli, 26,660 he in Imishli, 43891 he in Salyan district, 24760 he in Neftchala district and 17200 he in Bilasuvar district. In other words, 68.8-82.0% areas are highly eroded. Averagely eroded lands are not observed in Sabirabad, Bilasuvar and Saatli regions. 3820 he (10.9%) in Imishli, 4715 he (7.4%) in Salyan and 1350 he (4.1%) in Neftchala districts are averagely eroded. The area is averagely eroded. In total, 9885 he (4.7%) of the soils is averagely eroded. In addition to water erosion, strong wind erosion is occurring here as the region's major land resources are formed in semi-desert conditions.

Desalinization or salinity intensity of irrigated soils was estimated using the method proposed by V.R.Volobuyev.

As per the reports, during the study period (1993–2015) only salinization was observed in Saatlı and Bilasuvar districts with very little value β=-0.001 and β=-0.0027), resalinization process took place in Sabirabad (β= 0.001), Salyan (β= 0.027), Neftchala (β=-0.024) and Imishli (β= 0.009) districts[14]. As it is seen from the table of desalinization and salinization intensity, the rate of β is very low. As per total water balance table, the profitability (income) is greater than its expenditure. Water delivery prevails in the profitability (58,7%), while drainage flow (39.4%) and total evaporation (37%) prevail in the expenditure. Excessive evaporation in the expenditure of the balance leads to the accumulation of salts in upper layer of the irrigated lands and, eventually, salinization.

Despite the operation of the collector-drainage network in the massif, the water from various sources is not discharged on time. The level of natural drainage of the area is low, i.e. $Q_{out} < Q_{in}$

The results of our analyzes and assessments on various criteria show that ecological and land reclamation state of the irrigated lands in the studied area cannot be considered satisfactory. There is a need to develop the system of a complex of engineering and agro-ameliorative measures system to improve ecological and land reclamation condition of the irrigated lands.

[14] Qurbanov M.F. Muğan-Salyan massivi torpaqlarının duz rejiminin proqnozlaşdırılması // -Bakı: Azərbaycan aqrar elmi, - 2007, - № 4-5, - s.98-100

Table 1

Prices of calculated βs for 0-100 cm soil layer for typical periods

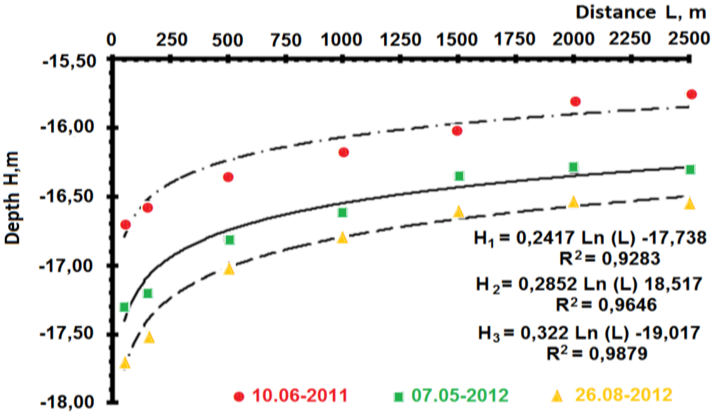
Typical periods	t, year	Sabirabad			Saatlı			Salyan			Neftchala			İmishli			Biləsuvar		
		S_n	S_t	β	S_n	S_t	β	S_n	S_t	β	S_n	S_t	β	S_n	S_t	β	S_n	S_t	β
1984-1989	5	0,63	0,45	-0,071	0,42	0,42		0,53	0,45	-0,032	0,86	0,67	-0,05	061	0,50	-0,040			
1989-2005	16	0,45	0,35	-0,016	0,42	0,40	-0,001	0,45	0,71	0,030	0,67	0,90	0,018	0,50	0,54	0,005			
2005-2015	10	0,35	0,35	-	0,40	0,40	-	0,71	0,72	-	0,90	0,89	-0,004	0,54	0,54	-			
1984-1993	9	0,63	0,34	-0,066	0,42	0,41	-0,002	0,53	0,44	-0,020	0,86	0,65	-0,027	0,61	0,44	-0,030			
1993-2015	22	0,34	0,35	0,001	0,41	0,40	-0,001	0,44	0,72	0,027	0,65	0,89	0,024	0,44	0,54	0,009	0,34	0,32	-0,0027
1984-2015	31	0,63	0,35	-0,019	0,42	0,40	-0,001	0,53	0,72	0,012	0,86	0,89	0,001	0,61	0,54	-0,004			

CHAPTER III. Investigation of the factors affecting the reclamation condition of Mugan-Salyan irrigation massif

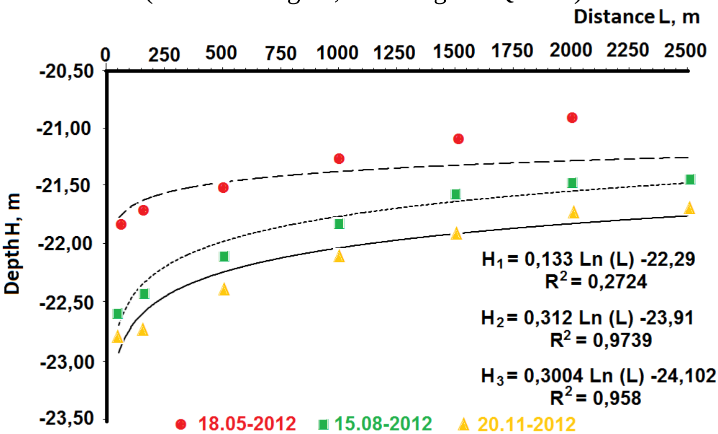
The factors affecting the deterioration of the ecological and reclamation condition of the irrigated lands in the massif are different. Periodic drastic changes in the hydrological regime of the river Kur and the Caspian Sea feed the mineralized groundwater near the surface of the plains, raise their levels, repeatedly salinizes the soils, and create excessive tension in drainage systems operation. The role of the collector-drainage network in improving the ecological and land reclamation state of the soils is indispensable. However, when the collector-drainage network fails to perform its functions at a normal rate, this and other reasons allow the groundwater levels to rise above the critical depth and, eventually, the soils are repeatedly salinized. The factors affecting the change of groundwater levels in the surrounding areas of the river Kur, the working conditions of collector-drainage and irrigation systems in the impact zone of the river Kur, and processes in the aerial zone of the soils were studied[15]. In order to address these issues, planning works were carried out along the river Kur (along Sabirabad-Caspian Sea), salt-water regime posts were selected in Garalar village of Sabirabad district (near Surra hydrological station) and in Garabagly village of Salyan district.

The selected salt-water posts were provided with observation wells. Systematic measurements were made for determining the depth of occurrence of groundwater with the help of observation wells, and groundwater samples were taken at certain times to study the mineralization and chemical composition of groundwater. As the area we investigate covers help of observation wells, and groundwater samples were taken

[15] Гурбанов М.Ф. Assessment of ecological and land reclamation state of the lands and groundwater regime at the coastal territory of the river Kur.//Herald APK Stavropol, Stavropol, 2016, №1 (21), p.217-220.



Fiqure 1. Dynamics of changes in the groundwater level in accordance with the water level in the Kur river (Sabirabad region, the village of Qaralar)



Fiqure 2. Dynamics of changes in the groundwater level in accordance with the water level in the Kur river (Salyan region, the village of Karabagly)

at certain times to study the mineralization and chemical composition of groundwater. As the area we investigate covers Sabirabad-Caspian Sea part of the river Kur, the river Kur feeds groundwater in the surrounding areas. An analysis of the collected data shows that the changes in water levels in the river Kur are reflected very quickly in the groundwater levels change. Variation of groundwater levels in the surrounding areas of the river Kur varies according to the water level in the river. In such areas, the groundwater dynamics almost reiterates the regime of river water. As the distance away from the river route, change amplitude of groundwater level change gradually decreases. Beginning from 400 m distance of the river Kur, the groundwater is located above the critical depth (h_c=2,0-2,5).

The distance of groundwater from the earth surface in Sabirabad district is 108-165 cm at a distance of 1500 m from the river course, 92-140 cm at a distance of 2000 m, and 90-132 cm at a distance of 2500 m, according to different values of the water level in the river Kur. Analogously, in Salyan district, these indicators are equal to 105-180 cm at a distance of 1500 m, 90-170 cm at a distance of 2000 m, and 88-165 cm at a distance of 2500 m. Data from observation wells for both research objects was collected in order to determine the distance at which the groundwater level stabilizes. Data related the soils at different distances L=500 m, L=1000 m, L=1500 m, L=2000 m and L=2500 m from the route of the river Kur is studied.Experimental dependences H=f(Q) were found between the distance of groundwater from the earth surface and the discharge of the river Kur. The values of the approximation coefficient (R^2) found according to the received dependencies show that after L=1500 m (R^2=0.5862) the amplitude of groundwater changes graduallyç decreases and almost stabilizes at distances L=2000-2500 m (R^2=0.38 and R^2=0.29). Therefore, the influence radius of the river Kur in Sabirabad - Caspian Sea areas can be assumed to be 2200 m.

Depth of occurrence of groundwater in surrounding areas of the river Kur depends on the water level in the river Kur and directly depends on operation of collector-drainage networks built in those areas.

In this regard, study of collector-drainage network operation allows for a more detailed study of the problem. The issues related to the technical condition of collector-drainage network were studied in the built area of 280 ha in Garabagli village of Salyan district. The collector-drainage network is of an open type and is located 2000 m from the route of the river Kur. The initial distances between drains are equal to 300-400 m. The lengths of the drains are different depending on the arrangement schemes.

According to the results of the researches conducted on technical condition of 21 primary drains, 3 water collectors and 1 collector, no water flow was observed in 7 primary drains. Water flow was very weak in 9 primary drains, and water flow was weak in 5 primary drains. Siltation of most of the primary drains and growth of reeds and other wild plants are observed in the drains. It makes difficult flow of drainage water and drainage cannot fully perform its function. In 70-80% of the parts where the drain, water collector and collector meet, there is no difference in levels, and in very few parts, difference in levels is relatively noticeable. Most drains and water collectors operate under pressure. The water level in the drain, water collector and collector is 1.5-2.0 m from the earth surface.

As per the results of 25 studied drains, water collectors and collectors, the activity of 11 of them was assessed as sufficient, activity of 6 - as insufficient, and activity of 8 - as useless. As the Caspian Sea is a closed water basin, global climate, tectonic and anthropogenic changes in the Earth disrupts its level stability. When the amplitude of the level change is sometimes high, this process possesses a number of large-scale problems for coastal areas and states. In 1977, sea-level declined to the lowest level (28.92 m) observed in the XX century. Sea water level raised for 2.79 m during the short historical period (1977-1999) and reached 26.13 m. Since 1999, there has been observed a decline in sea level. During the period 1999-2014, the level of the Caspian Sea decreased for 1.30 m and in 2014 the average annual sea level was -27,43 m.

The influence of changes of the Caspian Sea level in the coastal strip on the groundwater regime was studied. Calculations indicate that at different sea levels between -28,9 m (minimum level) and -26.13 m (maximum level), ΔH values vary from -0.5 m to 1.93 m. These values are considerably smaller than the accepted massif values $h_{cr=}$2.2 m.

Taking into account the radius of impact of the pressure as 25 km caused by sea level rise in the Caspian Sea, this factor affects not only the Caspian Sea areas, but also the groundwater level in Mugan -Salyan massif[16].

Table № 2 shows the dynamics of groundwater changes in the massif.

Table 2

Dynamics of distribution depth of occurrence of groundwater in Mughan-Salyan massif by areas, in %

1930					2015				
0-1m	1-2 m	2-3 m	3-5 m	>5 m	0-1m	1-2 m	2-3 m	3-5 m	>5 m
4,8	39,3	24,8	22,6	8,5	0,69	43,42	49,2	6,69	-

In 1930 water level in the Caspian Sea was -26.22 m, and in 2015 -27.43 m. Apparently, in the studied area, groundwater at the depth of more than 5 m (8.5%) was observed in 1930. Groundwater at the depth of 3-5 m was 22.6 %. However, in 015 (after 85 years), groundwater at the depth of 3-5 m decreased from 22.6% to 6.69 % and groundwater at the depth of more than

[16] Gurbanov M.F. Impact of the Caspian Sea level fluctuation on groundwater regime and functioning of the hydro-reclamation network in the Caspian side zones.//International Journal of Advanced Engineering Research and Science (ISARFS), Volume 5, issue-5, May-2018, p.272-276.

5 m was not observed. The massif is mainly dominated by the areas where groundwater is distributed at the depth of 1-3 m. Analysis of change dynamics of the depth of occurrence of groundwater depending on time shows that the process of groundwater approaching the earth surface has taken place. On one hand, it is connected with the activity of collector-drainage and irrigation systems, and the other reason is related to level fluctuations in the Caspian Sea.

As per analysis, the fluctuations at the level of the Caspian Sea, especially in connection with the rise of the Caspian Sea, violated operating mode of reclamation network (collector and drainage network, various canals and rivers) in Mugan-Salyan irrigation massif, as well as in the regions of the Caspian Sea. Analysis of available materials shows that the rate of groundwater discharge to the sea decreases at the result of rising sea level. This leads to decrease of inter-drainage pressure and a decrease of the flow rate of collector-drainage network. The water level in collector is at 1.5-2.0 m depth below the earth surface. This affects the speed and water discharge and flow velocity in the collector. Comparison of the design and actual cost of flow velocity and discharge in Main Mil-Mugan Collector's 110 km section, located between the river Araz and the Caspian Sea, proves that there is a difference between these values. If the reservoir's design capacity is 107 m^3/s in the section flowing into the Caspian Sea, this is 30% less than the project value, which is actually 74,0 m^3/s. In that section, the design speed of water in the collector is 0.52 m/sec, and the actual value is 0.41 m/sec. Actual speed is 21.0% less than design speed. 6 collectors join the Main Mil-Mugan Collector within 110 km. It affects both the collectors and the primary drains. As a result, the normal operation conditions of collector and drainage network in general have been violated. The groundwater level in the affected areas is closer to the surface and it causes the secondary salinization in those areas.

Most of the rivers in the republic, including the country's largest river Kur flow into the Caspian Sea. The rise of the Caspian Sea level has had a significant impact on the occurrence of dynamic processes and the hydrological regime of the rivers around rivers mouth and the coastal zone. The sea-level effect and the decrease in river velocity have led to the south-east arm sedimentation. The generalization of the research materials allows us to conclude that a number of comprehensive training measures are needed to be implemented for solving a number of problems related rising sea levels and the future development of coastal farms. The measures will include: construction of high-speed drainage systems in all zones; establishment of stable observation networks; strengthening of the coastal zone; implementation of appropriate measures to improve ecological and land reclamation condition of the soils; considering the level of Caspian Sea variations as an important factor when establishing new settlements and facilities.

As in many regions around the world, recurrent droughts in Azerbaijan have been causing huge damage to agriculture. Drought is observed in spring and summer, when precipitation is much lower than normal and temperatures are much higher than normal, and humidity is much lower. During this period, deposit of moisture in the soil is reduced to the minimum moisture content, consumed by physical evaporation and transpiration (vegetation evaporation). It causes to unfavorable conditions for the normal development of plants, disruption the normal photosynthesis process and reduction of fertility. It is necessary to develop a system of measures to address the nature of the drought factor, to reduce or mitigate its impacts and possible damage, and to manage scientifically the faced problems associated with drought in order to ensure sustainable agricul-ural development in areas affected by drought. Therefore, development of the system of measures is of great scientific and practical importance. As the territory of our republic has different climatic features, it cannot affect the degree of anoalies of individual processes occurring in this area. Anomalous processes refer to drought, floods and other processes. Thereore, the damage caused by anomalous processes to different spheres of economy in different regions of the country is of great concern. Analysis of temperature and precipitation anomalities shows that recurrence rates of dry seasons have increased since the second half of the period 1891-2000 (1940).

According to recent assessments, droughts took place from 1940 to 2000 constitute 65-70% out of total droughts. These results provide an important basis for forecasting issues. The above-mentioned results allow us to conclude that drought could be managed partly and minimized by its adverse effects. For this purpose, it is necessary to: carry out agrotechnical measures, create forest shelter belts, cultivate drought-resistant plants according to local conditions, use advanced irrigation methods and other means. Artificial reservoirs (water reservoirs, ponds, pools) should be established in the plains and foothill areas to struggle against drought.

In case of heavy rains, flood waters should be collected in such reservoirs to prevent flooding and at the same time to provide water resources and should be used to irrigate agricultural crops during drought period. Irrigation canals of the massif are mainly lined in the earth embankment, that’s why technological water losses occur at almost all stages during water transportation, which in addition leads to water losses. Increased groundwater levels due to irrigation water losses causes to deterioration of soil reclamation.

As it is seen, the factors affecting the existing ecological and amelioration conditions of the irrigated lands of massif are different, and solutions depend on many factors. Therefore, a system of measures has been developed in accordance with the results of comprehensive studies to address existing problems.

IV CHAPTER. Methods of intensification of drainage systems operation in irrigated lands

On irrigated lands, salinity control is mainly carried out at the background of intensive drainage systems. Until recently, the design and construction of open horizontal drainage systems in saline lands reclamation has been given more attention. Perennial operation experiences of open horizontal drainage systems have shown that the construction of such drainage systems is not costly, but less efficient in terms of technical specifications. Open horizontal drainage systems do not work in accordance with required hydraulic and geometric parameters. In order to keep open horizontal drains in the required budgeted depth, maintenance and cleaning activities must be carried out regularly, which requires significant investment.

In view of these shortcomings, in recent decades, attention has been paid to the construction of blind horizontal drainage systems. Hydraulic operation of blind horizontal drains depends entirely on the condition of water catchments and collectors. Despite some advantages, there are met certain difficulties while operating blind horizontal drains in areas with low inclination. Thus, to prevent siltation of blind horizontal drains, as well as the cost-effectiveness of diameters, these drains should be constructed with the specified inclination (0.0015 - 0.002). At the areas of low relief (<0.001) it is required to construct water catchments and collectors at larger depths for avoiding submerged mode at the drains inlet.

According to approximate calculations, the depth of such water headers should be 5-6 m, and the depth of collectors 8-9 m. As per operation experiences, cross sections of open water headers and collectors at such depths are deformed at small intervals (destruction of slopes, slides, siltation, grass, reeds and etc.).

This will eventually lead to violation of the blind horizontal drains operating conditions and deterioration of the soil reclamation. All the above mentioned necessitates the development of new drainage systems at the areas with less inclination (<0.001) or without inclination to increase the effectiveness of blind horizontal drains and eliminate negative events. The design of such a drainage system can be accomlished by intensifying the drainage operation. One of the main ways to intensify drainage is to vacuum drainage. Vacuuming the surface of the drainage system may create additional pressure. In other words, it is possible to increase the impact pressure by keeping the depth of construction regular. All of these will increase the rate of ground water entering the drain. Initial experiments with the aim of improving reclamation condition of the soils by using vacuum were made in 1961 by V.A. Kalantayev[17].

As per studies, the drainage increases several times with the creation of a vacuum. In 1964 a vacuum horizontal drainage system was built to carry out experimental investigations in the Ilyich kolkhoz of the Jarco district of the Turkmen SSR. Researches on this system show that vacuum horizontal drainage systems have more ameliorative effects than ordinary horizontal drains. The amount of drainage water and groundwater rate of fall exceeds that of ordinary horizontal drains. In normal horizontal drains, the impact pressure over the drains was 0.5 m. With the creation of a vacuum, the impact pressure increased by 0.7 m, resulting in a pressure of 1.2 m on a vacuum drain.

Unlike ordinary drains, groundwater rate of fall is more for 3-4 times. By creating vacuum on the surface of the drain will increase the impact pressure, the amount of water that enters the drain, and it will cause to quick reduction of groundwater level. The aboveentioned drainage system basically operates in an uncontrolled mode. In 1964 V.A.Kalantayev, V.I.Klimko proposed a new draiage system to study

---

[17] Калантаев В.А. Дренаж орошаемых земель и методы его интенсификации/ В.А.Калантаев.- Ашхабад: Ылым,- 1984.- 282с.

the operation of vacuum horizontal drains in sandy and heavy loamy soils[18].

Two pumps were used for vacuum generation and exhausting water from vacuum horizontal drain. One of these pumps was used for air suction and the other one for water suction. In 1963-1966 V.I.Bobchenko and G.A.Bulayev conducted fundamental washing experiments in Adj Chol against a drainage system built from horizontal plastic pipes, providing vacuum generation on the surface of the pipe[19]. As per the studies, additional pressure is generated together with vacuum generation which considerably increases the soil's filtration capacity. The cost of the drain module increases to 50%. In 1971 V.A. Kalantayev proposed a new drainage system - a debit-adjusted vacuum vertical drainage system. Both horizontal and vertical vacuum drains, as opposed to ordinary ones, can operate both in their own flow and in the forced mode, i.e. by forced discharge of water through pumps.

CHAPTER V. Siphon vacuum drainage systems

As it was noted, open or blind horizontal drains built in areas with no inclination or less inclination ($i < 0.001$) are not economically or technically efficient. That’s why new drainage systems have been developed to improve the efficiency of horizontal blind drains at the areas with no inclination or with less inclination[20].

The siphon vacuum drainage system is structurally composed of the following elements.

---

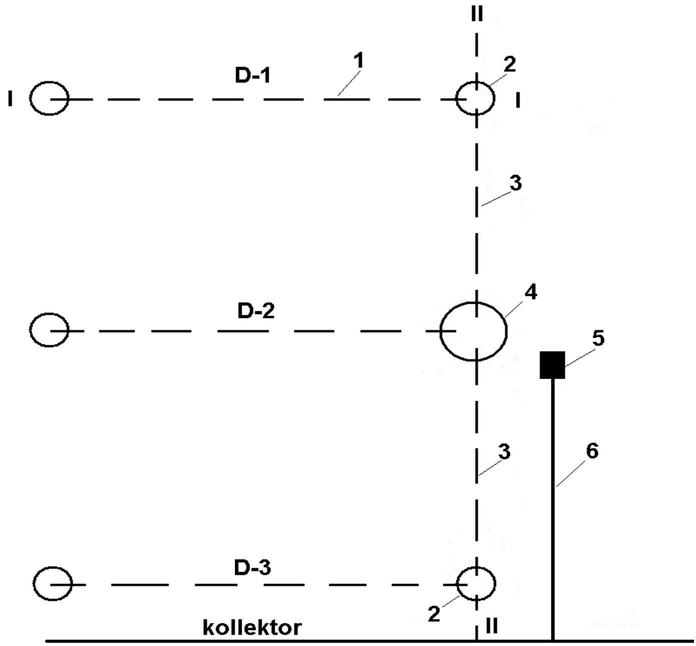
[18] Климко А.И. Об использовании вакуума при осушении сельскохозяйственных земель // Москва: Гидротехника и Мелиорация,- 1964,- №12.- с.57-62

[19] Бобченко В.И., Булаева Г.А. Вакуумирование дренажа и капитальные промывки тяжелых сильнозасоленных земель //-Москва: Хлопководство, 1975, №1- с.24-26

[20] Салахов Ф.С. Система закрытого дренажа сифонного действия. // Труды АзНИИГиМ, т.2, Баку: -1974.- с.172-178

Horizontal drainage siphons (1) with holes having walls with adverse slope through bends at the end (2) are connected into distant wells. Distant wells are connected to the central wells (4) by means of collecting siphon (3) without any holes.

Pumps (5) are installed near the central wells - on the earth surface. These pumps pump out the mineralized drainage water from the central wells and pass it to the surface concrete ducts (6) and is removed from the irrigated areas by these canals.



1 – siphon-drain; 2 – distant wells ; 3 – siphon water header;
4 – central well; 5 – pump; 6 – water collecting canal

Fiqure 3. Plan of vacuum siphon-drain

There is a low pressure in the siphon-drains. This pressure occurs due to with the difference in water levels in the wells at the beginning and at the end of the drain. This feature allows constructing the siphon-drains with certain adverse slope. In order to ensure the normal operation of the siphon-drains, it is necessary to remove the air that enters to the surface of the water. For this purpose, special instruments – air eliminators are installed on the bends of siphon-drains, as well as collecting siphons.

The principle of operation of the proposed siphon-vacuum drainage system is as follows. Groundwater level rise gradually during washing or during vegetation irrigation.

The groundwater in the siphon-drains compresses the air between pipe and water surface in the direction of water collecting wells. Since the air eliminators are located on the bends, the air in the pipes starts to come out of those air eliminators. When the air in the drains is fully discharged, the ball is lowered (absorbed) and closes the lid. Thus, the pressure in the siphon-drains is lower than the atmospheric pressure, in other words, vacuum forms in siphon-drain. Siphon-drains are activated and the drainage water begins to flow into the collecting wells. When the water level in the central and distant wells is leveled, the pumps start to pump the water from the central wells to the surface channels and, thus, water is removed from the area. At the same time, due to the difference in water levels in the central and distant wells, collecting siphons which coordinate distant and central wells start to operate and begin to transfer water from the distant wells to the central wells. In this case, the whole system is working. This process continues until air enters the drains together with groundwater and breaks down vacuum. From the moment the vacuum is broken, the process of flowing water from the drains to the wells stops, then the next cycle for the system operation starts to work. For studying the effectiveness of the proposed drainage system, an experimental-drainage object was built in the area of 42 he in Marishly village of Salyan district, and experimental research works were performed on that site. The main hydrodynamic indicators of drainage (as well as siphon drainage) is drainage discharge and drainage modules, groundwater regimes and rates of fall. During the perennial assimilation, the field of practice was assimilated under different crops (mainly cotton and cereals). Surface irrigation was applied. Irrigation rates for crop plants made 3050 m^3/he and 4900 m^3/ha for cotton crops.

The maximum daily consumption of the drain during vegetation irrigation is 11.3 1/sec and the minimum daily consumption is 2.01/sec and varies depending on the pressure in the middle of the inter-drainage area. Drainage module is one of the key factors in determining the effectiveness of drainage operation. In a siphon-vacuum drainage system, the drainage module changes in a large range, depending on the pressure[21].

Table 3

The prices of the drainage module dependinq

Pressure, H, m	1,0	1,1	1,2	1,3	1,4	1,5	1,6	1,8	2,0	2,2	2,3	2,5
Drainage module, q, 1/s.ha	0,105	0,130	0,160	0,190	0,220	0,260	0,270	0,285	0,300	0,370	0,430	0,550

Thus, when H = 1,0 m, the drainage modulus is q= 0.105 l/sec.ha and H = 2.5 m q = 0.55 1/sec.ha. This indicates that the siphon-vacuum drainage system's capacity to drain is much higher than that of conventional ones. In the siphon-vacuum drainage system, the groundwater rate of fall is 3-4 times higher than that of conventional drainage.

Table 4

Rate of gall of qroundwater dependinq on pressure

Pressure,cm	100	110	120	130	140	150	160	170	180	190	200	210	220
V, cm/day	2,4	3,5	3,8	4,0	4,3	4,7	5,0	5,9	6,9	8,0	9,4	10,4	12,0

Groundwater rate of fall varies from 2.4 cm/day up to 12.0 cm/day depending on the pressure.

[21] Gurbanov M.F. Efficiency of a siphon drainage system under conditions in a low gradient area // Russian Agricultural Sciences, Volume 43, issue 6, November-2017, p.490-493.

This will reduce the level of mineralized groundwater which raised during the vegetation irrigation period, thus preventing secondary salinization. Initial salinization of the soils is characterized by significant diversity

However, mostly non-salinized soils and weakly salinized soils prevail at one meter depth of the soil. Medium and highly salinized soils were also observed in the form of certain spots. At a depth of 3 meters, degree of salinity in the soil increases in all cases from average to high salinity.

The type of salinity is chloride-sulfate. Sodium out of cations prevails. The amount of gypsum is less than 1%. The amount of Ca cation prevails in the absorption complex. Prior to the construction of a siphon-vacuum drainage system, groundwater was located at the depth of 2.0 m from the surface. Ground water mineralization ranged from weak mineral (8,8 g/1) to medium (17,3 g/1). By its chemical composition, groundwater refers to the type of chloride-sulfate. Sodium sulfate (54-60%) prevails. The experimental area was used under cotton plants, and in 1983 - under grain crops. Surface irrigation was applied at the area.

The amount of irrigation water per 1 he constituted 3050-4900 m^3/he. Irrigation water is completely suitable for irrigation due to its minerality.

The irrigation water minerality ranges from 0.7 to 1.0 g/l. During the assimilation of the experimental area there has been no significant change in the exchange of salts in the soil, but in some cases, there have been cases of desalinization.

The dry residue at the depth of 0-3-meter soil layer dropped almost 0.30% over a four-year assimilation period[22].

---

[22] Gurbanov M.F. Salty regime of the irrigated lands on a background of siphon-vaccum drainage at the area with less inclination // Bulletin of the institutions of higher education in the North Caucasian region. Series “Natural sciences”, №4, Rostov-na-Donu, 2017, p.104-109.

Thus, the dry residue at the depth of 0-1-meter soil layer ranges from 0.50% to 0.34%, at the depth of 1-2-meter soil layer from 0.57% to 0.32%, and at the depth of 2-3-meter soil layer - from 0.54% to 0.40%.

As per analyses, reduction of the salts amount also leads to change of their hypothetical composition. Decrease of the amount of sodium and magnesium salts in the soil solution is observed. This is the result of substitution reactions in the soil-absorbing complex.

As a result, the amount of gypsum in the soil solution increased, which is typical for one meter depth of soil.

Analogous condition is also observed in chloride salts. Significant reduction of NaCl amount in soil solution was observed, while formation of new salt-magnesium chloride ($MgCl_2$) in soil solution was observed. In the soil profile, the amount of bicarbonates $NaHC0_3$ and $Ca(HC0_3)_2$ remained relatively stable.

$CaCI_2$ was observed in the first year of acquisition, but disappeared in subsequent years. Ground water refers to the chloride-sulfate type by its chemical composition.

It has been observed that the mineralization of groundwater during the long-term development is also sufficiently low. Drainage water mineralization is reduced from 30g/l to 21.57 g/l, and this trend continues every year.

As noted, areas with low inclination (<0.001) and the areas without any inclination possess horizontal siphon-vacuum drainage systems of various designs. In such siphon drainage systems, the initial siphon-drains are parallel to each other, and each of them is eventually coordinated with a drain well. For further simplifying the design of this system, we have proposed a siphon drainage system consisting of new radial drains[23].

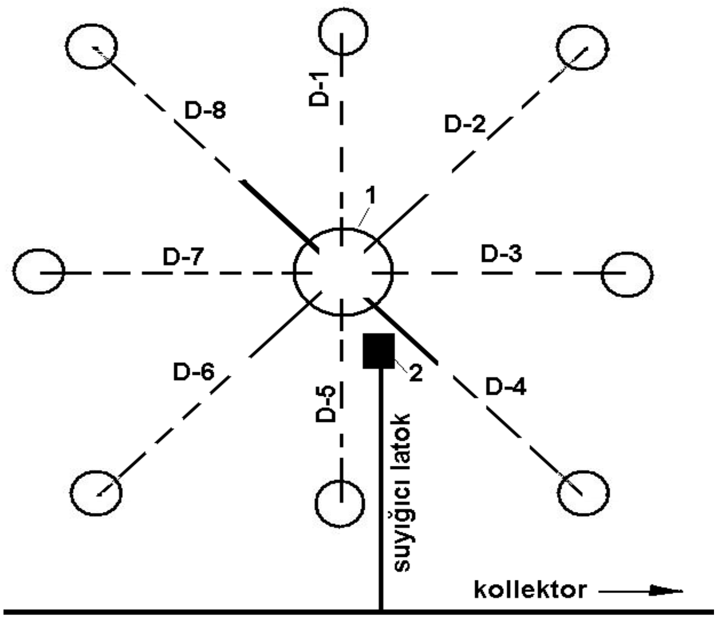
[23] Гурбанов М.Ф. Вакуумная дренажная система радиального типа //Мелиорация и водное хозяйство. г. Москва, 2016, № 6, с.47-49

The main feature that differentiates the proposed radial siphon drainage system from the mentioned siphon drainage system is their layout chart in plan.

In radial siphon-drainage systems, all drainage siphons are linked directly to the central well. The proposed radial siphon-drainage system has the following advantages.

1) Since all drainage siphons are linked directly to the central well in the form of radial drains, there is no need for the wells adopted in the previous scheme and for each drain-siphon.

2) In the scheme we investigated, the wells are connected to each other by means of water headers made of pipes without holes.



1 – central water collecting canal: 2 – pump station
---- siphon-drains with holes along length
___ section of siphon-drains without holes

Fiqure 4. Siphon drainage system consisting of radial drains

Depending on the size of the area served by the siphon drainages, the number of these wells is at least 4-6. Consequently, as the number of wells increases, the number of siphon-drains connecting these wells increases as well. And the newly proposed radial siphon drainages do not need such water catchers.

3) For the normal operation of the siphon-drains, as well as siphon water headers, the air eliminators are placed at the end of them for normal operation. These air eliminators serve to release air entered the siphons. As the number of water headers increases, the number of air eliminators also increases. Since radial siphons do not have binders, there is no need for such air eliminators. On the other hand, failure of one of the air eliminators in collecting wells for any reason can stop the whole system's operation. In radial siphons, this danger is eliminated.

4) Since all radial siphon drains are only connected in the central well, it is easier to control and operate the system.

5) The wells which coordinate the siphon-drains, water headers that coordinate these wells are not envisaged in new radial siphon drains which allow them to save enough material.

CHAPTER VI. Some problems related the use of water and land resources under market economy conditions

At present, agricultural production in Azerbaijan is represented by small farms. Different irrigation and reclamation networks in each administrative district are managed by the relevant district irrigation systems and collector operation departments. The use of irrigation and land reclamation networks in the former kolkhozes and sovkhozes is currently being carried out by the Water Users Association (WUA), which was established to organize irrigation in those areas. The main task of the WUA is to ensure equal and fair distribution of irrigation water among the water users and proper operation of the system. However, transportation of irrigation water to irrigated areas at the right time and in the required amount is due to a large amount of means. Thus, taking into account the fact that previous irrigation in Azerbaijan had an impact on soil reclamation, it should be carried out with technological precision so as not to cause salinization and negatively affect soil fertility while meeting the crop demand. Despite the work fulfilled and the experience gained in recent years, there is a need to develop and implement ongoing measures to improve water and land use both at farms and at the district level. Since the solutions to these issues are multifaceted, the following basic steps are required for step-by-step and interconnected actions: replacing high-water plants used in agricultural systems with less water-intensive plants, creating new drought-resistant and less water-intensive varieties; improving water use at farms, minimizing water losses in irrigation systems, including on-site irrigation; selection and application of rational irrigation methods, technologies and modern irrigation techniques; development of optimal irrigation regimes of agricultural crops and their application in irrigation agriculture; studying the ways and effectiveness of using non-traditional water for irrigation purposes under conditions of water scarcity. Unlike conventional horizontal drainages, vacuum drainage systems are controlled. Thus, it is possible to increase or decrease the amount of water entering the drain at any time. Increasing the level of groundwater to a certain height by stopping drainage flow (turning off the pumps) in vacuum drainage systems moisturizes the tillage and feeds the root. The water entering the tillage allows reducing the number of surface irrigation (periodic irrigation rates) during the vegetation period and the overall vegetation irrigation rate. In the proposed drainage system depending on the depth of the ground water and the root system of the plants, the capillary feeding of the plants due to the groundwater was calculated[24].

[24] Gurbanov M.F. Role of the drainage and groundwater regime in water-soil regulation // Bulletin of APK Stavropol, Stavropol, 2016, №3(23), p.244-248.

Table 5

Report on capillary nutriton of plants in the Mugan-Salyan massiv at the expense of groundwater, m^3/ha

Depth of root system, m	Depth of groundwater, m				
	0,5	1,0	1,5	2,0	2,5
Cotton					
up to 0,6 meters deep	4165	1960	735	245	-
up to 1 meters deep	4900	2695	1225	735	-
İs greather than (>) when 1,0 m	4900	4900	3430	1960	245
Autumn cereal					
up to 0,6 meters deep	2592	1220	457	153	-
up to 1 meters deep	3050	1677	762	457	-
İs greather than (>) when 1,0 m	3050	3050	2135	1220	153
Cover clover					
up to 0,6 meters deep	4080	1960	720	240	-
up to 1 meters deep	4800	2640	1220	720	-
İs greather than (>) when 1,0 m	4800	4800	3360	1920	240
Two-year clover					
up to 0,6 meters deep	5780	2720	1020	340	-
up to 1 meters deep	6800	3750	1700	1020	-
İs greather than (>) when 1,0 m	6800	6800	4750	2720	340

For a cotton plant with vegetation irrigation rate of 4900 m^3/ha, depth of the root system is 0.6 m. While depth of occurrence of groundwater is 1.0 m, 1.5 m, 2.0 m, and 2.5 m feeding with groundwater constitutes correspondingly 1960 m^3/ha (40%), 735 m^3/ha (15%) and 245 m^3/ha (5%).

When depth of the root system is 1.0 m, these values are respectively 2695 m^3/ha (55%), 1225 m^3/ha (25%), and 735 m^3/ha (15%). When depth of the root system is 2.0 m the values are respectively 4900 m^3/ha (100%), 3430 m^3/ha (70%), 1960 m^3/ha (40%). The analogous situation applies to other plants as well.

According to the program of meliorative measures, which will ensure the development of agriculture (mainly grains, cotton and livestock production) in the country in 2013-2020, it is planned to use winter pastures in Sabirabad, Saatli, Salyan and

Neftchala districts.

Application of this principle against the background of vacuum drainage systems has great practical importance in effective use of water resources under current condition of irrigation water scarcity, as well as in regulation of water-soil relations.

Numerous experiments related using of salty water were conducted over the last 25-30 years. At the result of these experiments use of salty water, reserve of salty water, suitability of large collectors and sea water for irrigation purposes was assessed. Productivity of various agricultural plants irrigated with salty water and efficiency of cleaning the soil from salts were determined in washing experiments with salty water as well. According to the reports of the relevant departments of Azerbaijan Amelioration and Water Farm Open Joint-Stock Company, 1089 million cubic meters of irrigated areas in Mughan-Salyan massif are irrigated every year through Main Mil-Mughan Collector (MMMC), and 439 million cubic meters through Mughan-Salyan Spillway (MSS). In general, about 1,735 million cubic meters of collector-drainage water with a mineral content of 4-6 g/l is annually discharged into the sea through large collectors. Considering that the average vegetation irrigation rate is 5500 m^3/ha, it is possible to irrigate an area of 315,000 hectares in Mughan-Salyan massif, where are spread chloride-sulphate type salinized soils with a filtration coefficient of 1.5 m/day.

CHAPTER VII. Differential engineering and land reclamation system of measures and its economic efficiency for improving the ecological and land reclamation condition of Mugan-Salyan irrigation massif

This chapter is devoted to the development of a system of differentiated engineering-agro-ameliorative measures for improvement of ecological and reclamation state of the lands of Mugan-Salyan irrigation massif and determination of economic benefits from implementation of proposed measures. Evaluations by various criteria show that ecological and reclamation condition of irrigated lands of the studied area cannot be considered satisfactory. Different engineering-agro-ameliorative measures has been developed for each area included in the massif, taking into account the fact that the irrigated lands are characterized by various agricultural-ameliorative and agrophysical indicators. Engineering-agro-ameliorative measures include: ensuring efficient operation of irrigation canals and collector-drainage network; establishment of short-term sown areas; employment of organic and mineral fertilizer systems; proper and timely cultivation of soil; selection of irrigation methods and techniques that protect the soil structure and provide the efficient use of irrigation water; employment of desalinization irrigation regimes on saline soils and conducting preventive washing irrigation; groundwater level regulation. Mathematical and statistical reports and analysis show that the water-physical characteristics of the soils leakage and parameters of convective diffusion of salts in the regions included in the study area differ from each other. The lands of Bilasuvar and Imishli districts are characterized by heavy granu-lometric composition, low rates of salt and water (D * = 0.027 m^2/day and D * = 0.045 m^2/day, α = 2,517 and α = 1,753), the soils of Saatly, Sabirabad, Salyan and Neftchala districts are mainly characterized by light and medium-sized loams granulometric composition, high salinity and water supply. D * = 0.110 m/day, α = 1,274 in Saatlı and Sabirabad districts; D * = 0.055 m^2/day, respectively α = 1,42 and α = 623 in Salyan and Neftchala districts. At the same time, the geographical location of Salyan and Neftchala districts (the location in the mouth of Main Mil-Mugan Collector, Mugan-Salyan irrigation massif and the river Kur, changes in the Caspian Sea) aggravates the environmental and reclamation state of these areas in comparison woth other regions. In view of the above, a differentiated engineering-agro-ameliorative measures system was developed and recommended for production to improve ecological reclamation condition of the lands in the irrigated areas[25]. Analysis of the results of many years researchers shows that applying fundamental washing, current washing, spraying, rice paddy sowing and etc. are recommended for bringing salinized soils to useful state depending on the type of salinity, degree of salinity, water-physical properties of the soil, water supply of the area and so on. In the course of the agrarian reforms, mainly sown areas with good reclamation conditions were privatized, which mainly consisted of not salinized, weakly or averagely salinized soils. As per the studies, in the areas of private property, severe and highly salinized soils are also met in the form of "spots". At present, the weakening of farms, their inadequate organization, the lack of funding and technical resources do not allow employing a number of technological measures. On the other hand, according to the statistics, cultivated areas of the farms are often less than 20 hectares. Therefore, measures aimed at improving land reclamation by land users on privately owned lands should be agrotechnical and agromeliorative. Weakly and averagely salinized soils under crops in private property are prevailing. If to take into account the distribution of saline soils in the form of the spots, one of the following measures must be taken to make these lands suitable for sowing:

- implementation of effective washing vegetation irrigation by increasing the rates by 5-30%;
- current washing in autumn-winter and early spring, when the fields are free from plants and watering ploughed soil before sowing;

[25] Gurbanov M.F. Differentiated engineering and agro-ameliorative measures for improving ecological and land reclamation state of irrigated lands of Mugan-Salyan massif //Azerbaijan Agrarian Scientific Journal, №2, Baku, 2017, p.62-71.

- reduction of salinization intensity with the use of saline-resistant agricultural crops along with reclamation measures in weakly and averagely salinized soils. Since 28854 he of irrigated lands are severe and very saline soils, it is important to undertake fundamental washing measures to make these lands suitable. Such lands are most prevail in Imishli (10605 he), Salyan (7387 he) and Neftchala (7387 he) districts. The soils with area of 1375 he in Sabirabad, 584 he in Saatlı and 1516 he in Bilasuvar districts are severely and highly salinized. On the basis of the recommended classification and limits of harmfulness, the washing rates required for making the soils suitable are calculated.

The economic benefits of the proposed system of measures are achieved by the following factors. Due to cleaning saline soils from harmful salts and, as a result, increasing crop productivity; economic benefit from the employment of new engineering structures; at the expense of elimination of shortage of irrigation water; at the expense of environment protection and preservation of ecological balance. According to the calculations, economic benefits were as follows:

at the expense of increasing crop yields - 344 man/he, due to reducing the cost of building new engineering structures construction 97 man/he, due to elimination lack of irrigation water 120 man/he, at the expense of environmental protection in severe and highly saline soils, and preservation of ecological balance 67.8 million manat.

Conclusions

1. 180183 he (65.9% out of the total irrigated area) in the massif is subjected to salinity to some extent. 59,9 % (107,686 he) of the soils are weakly salinized, 22.6% (40826 he) averagely salinized, and 17.5% (31,671 he) highly salinized soils. In general, alkalinity of the soils in Mugan-Salyan massif, as well as in all the districts included in the massif, is not favorable. As per the materials for the period 1993-2015, free-

alkaline lands have been significantly reduced in all districts, but both the areas of weakly, averagely and highly alkaline soils have increased significantly. As of 2015, alkaline soils in the irrigated area constituted 91113 he, weakly alkaline soils - 148180 he, averagely and highly alkaline soils area constituted 34301 he.

2. Underground water with mineralization 1.0-3.0 g/l constituted 61% out of total irrigated area (166499 he) and underground water with mineralization above 3.0 g/l - 32% of total irrigated area (93459 ha). 65.5% (176671 he) out of total irrigated area of the massif contains hydromorphic soils, and the groundwater is above the critical depth (2.0-2.5 m). Areas belonging to the semi- hydromorphic regime are spread across an area of 96923 hectares (25.5%), which is a very small indicator for the massif. Hydromorphic mode is not desirable, because active evaporation from the groundwater surface creates favorable conditions for the soils re-salinization. It is practically impossible to create an automorphic regime under the current conditions. Because the construction depth of the drains is mainly 3.0-3.5m, it is not able to lower the groundwater level to 4.0m. Therefore, the acceptable regime may be half hydromorphic regime. Under this regime it is possible to ensure the desalinization process in soils.

3. According to the total water balance compiled, the profitable (income) portion of the balance exceeds its expenditure. Irrigation water (58.7%) and feeding with pressure water (10.5%) are predominant in the income portion of the balance. Drainage flow (39.4%) and total evaporation (37%) prevail in the expenditure section. Excessive evaporation in the balance expenditure section leads to the accumulation of harmful salts in the upper layer of the irrigated soils and, eventually, salinization. Despite the operation of the collector-drainage network in the massif, the water of different origin that enters it is not depleted in due time. The level of natural

drainage of the area is low.

4. Changes in water levels in the river Kur are reflected in groundwater levels at a rapid rate. Groundwater level regime in the surrounding areas of the river Kur almost reiterates the river water regime. In the Sabirabad Caspian Sea section of the river Kur, the river feeds groundwater in the surrounding areas. As per studies, starting from the 400 km part of the Kur river route, the groundwater distances from the earth surface locate above the critical depth (h_c = 2.0-2.5 m). It is one of the factors that create favorable conditions for re-salinization of the soils as a result of groundwater evaporation. Planting forest shelter belts with deep root systems and high water evaporation in areas with difficult terrain conditions is one of the most effective means of reducing groundwater level.

5. On the basis of comparative analysis of perennial data and the results of our mathematical reports, the causes of disturbance of hydrogeological, ameliorative and environmental balance in the surrounding area due to changes in water levels in the Caspian Sea were investigated. It has been determined that changes in the Caspian regime have completely changed the underground water regime (groundwater) in the Caspian Basin, resulting in increased soil salinity and disturbance of the collector-drainage network operating conditions. Resistance caused by sea pressure reduced the ability of the collector-drainage systems for 15-20%, which led to an increase of perpendicular pressure on the groundwater flow, a decrease in the depth of occurrence of groundwater, and an increase of the evaporation process. If the flow rate of falling of Main Mil-Mugan Collector into the Caspian Sea is projected to be 107 m^3/s, the actual value is 74 m^3/s, for 30% less than of the design value. In that section, the design rate of water in the collector is 0.52 m/sec, and the actual value is 0.41 m/sec. Actual speed is 21.0% less than project speed.

6. Using advanced irrigation methods and other means it is

also possible to manage and minimize the negative effects of such anomalous natural phenomenon as drought at the result of agrotechnical measures carried out in the soils. Establishment of wind forest strip as one of the main means of climate reclamation, cultivation of drought-resistant plants in accordance with local conditions are among these measures. Artificial water reservoirs (reservoirs, ponds, pools) should be created to control drought. In case of heavy rains, flood waters should be collected in such tanks in order to prevent flooding and at the same time to create water reserve and should be used to irrigate agricultural crops during drought period.

7. The length of the various drainage ditches constructed in the irrigated massif is 5284 km. As a result of the researches, it was found that the water losses in the earth canals constitute 30-35 % out of irrigation water. Increasing groundwater levels due to the losses of irrigation water contributes to the deterioration of soil reclamation, as well as some technological difficulties appear in the delivery of irrigation water, depending on the farming structure of individual farmers. Thus, at different times irrigation water is delivered through canals to meet the water demand of the areas. After its distribution the excess water is spilled, which reduces the efficiency of the use of irrigation water.

8. The analysis of the principles of automatic and optimal control of salt-water regimes allows us to conclude that one of the main disadvantages of conventional horizontal drains is their inability to operate. Against the background of such drainage systems, it is not possible to increase or decrease the amount of water entering the drain at any time. Against the background of the proposed siphon-vacuum drainage system, it is possible to increase or decrease the amount of water entering the drain at any time and, ultimately, to create favorable water, salt, delivery and heat regimes in the soil.

9. As per studies, in the siphon-vacuum drainage system,

the drainage module changes in a large range, depending on the pressure. Thus, when the drainage module is H = 1.0 m, it changes to q = 0.105 1/sec.he, and correspondingly when the drainage module is H = 2.5 m, it changes to q = 0.55 1/sec.he. The drain capacity of the siphon-vacuum drainage system is much higher than that of conventional ones. At the same time, the rate of groundwater fall in the siphon-vacuum drainage system is 3-4 times higher than that of conventional drains. Groundwater rates of fall vary from 2.4 cm/day to 12.0 cm/day, depending on the pressure. This allows in a small interval to lower the level of mineral groundwater, which rose to a certain height during the vegetation irrigation period, thus, preventing secondary salinization. 10. In siphon-vacuum drainage systems it is possible to automate the system operation by placing relays at the optimum (maximum and minimum) levels in the central well. On the other hand, since these drainage systems are controlled, it is possible to apply sub-irrigation by adjusting the groundwater level. In siphon-vacuum drainage systems, open concrete canals (or flumes) play the role of water headers. This allows the use of less mineralized groundwater for irrigation. The application of this principle is very important in the efficient use of water resources under current conditions of irrigation water shortages, as well as in regulation of water-land relations.

11. About 1735 million m^3 of collector-drainage water is pumped into the sea each year through the large collectors of Mugan-Salyan area. 315000 he area could be irrigated with such amount of water.

12. According to mathematical and statistical reports and analysis, water-physical characteristics of the soil-water leaching environment of the areas under study, the parameters that characterize the salts convective diffusion, are different. If the lands of Bilasuvar and Imishli districts are characterized by heavy granulometric composition, low salt and water rates (D * = 0.027 m^2/day and D*= 0.045 m^2/day, α = 2,517 and α = l,

753). Mainly light and medium loams are spread in the lands of Saatlı, Sabirabad, Salyan and Neftchala districts, the soils are characterized by high salinity and water. D*= 0.110 m^2/day, α=1,274 in Saatly and Sabirabad districts; D*= 0.055 m^2/day, α=1,42 and α=1,623 in Salyan and Neftchala districts. At the same time, the geographical conditions of Salyan and Neftchala districts (location at the mouth of the Main Mil-Mugan collector and Mugan-Salyan spillway and the river Kur, the level changes in the Caspian Sea) aggravates ecological and land reclamation condition of these areas.

In view of the above, differentiated engineering and agro-ameliorative system of measures has been developed and recommended for production for improving ecological and land reclamation condition of the soils at the area of irrigation massif.

Recommendations for production

1. It is recommended to improve water-physical properties of light clay soils through deep plowing (20-30 cm), loosening (50-60 cm) and spreading manure and, accordingly, to increase its water absorption capacity.

2. Soils salinization should be gradually eliminated by applying irrigation with 10-15% washing mode by giving arable water at the rate of 1500-2000 m^3/ha in weakly salinized soils, and 20% washing mode by giving arable water at the rate of 2000-2500 m^3/ha in medium salinized soils.

3. It is advisable to reduce the intensity of salinization by using salt tolerant agricultural plants along with melioration measures in weakly salinized soils.

4. It is recommended to lower salinity by carrying out basic washing at the rate of 10,400-12,700 m^3/ha, depending on degree of salinization in severely and very severely salinized soils.

5. It is advisable to use salt-tolerant and water-demanding plants to continue the post-washing process and further reduce salinization in severely saline soils.

6. Gypsum should be applied to the soil at the rate of 3-5 t/ha before sowing as a preventive measure to fight against alkalinization.

7. It is necessary to carry out smoothing of the ground surface in all types of land, regardless of its melioration status.

8. In order to fight against drought more effectively, it is necessary to ensure that more water is absorbed into the soil during winter by using agrotechnical methods. For this purpose, in order to prevent the moisture collected in the soil from evaporation from the soil surface, the movement of water through capillaries towards the soil surface should be prevented by using special agrotechnical methods, and a protective layer against drought should be created on the soil surface.

9. Considering the local conditions, it is recommended to change the planting structure. It is possible by replacing plants that require a lot of water in the planting structure with plants that are resistant to drought and have less water demand.

10. It is appropriate to apply closed irrigation systems due to the current soil structure of infarm networks in order to prevent water losses from the earth canals.

11. It is recommended to use progressive irrigation methods (rainfall, drip, etc.) in areas where groundwater is very close to the earth surface (1-2 m).

12. It is recommended to establish forest strips consisting of plants with high sub-evaporation capacity in the surrounding areas of the river Kur in order to lower the level of groundwater.

13. It is advisable to reduce the amount of water taken from fresh water sources by using collector-drainage water for irrigation of agricultural plants in order to eliminate the tension in the soil-water balance.

14. As since the change of level regime in the Caspian Sea disrupts oeration mode of the hydromelioration network (primarily the collector-drainage network) in the sea's influence zone, the normal operation mode of the hydromelioration network must be restored firstly. For this purpose, it is recommended to carry out current and major repair and restoration works in the existing collector-drainage network, to reduce the created pressure by mechanical means, to replace the reconstructed collector-drainage networks with controlled siphon-vacuum drainage systems.

15. Siphon-vacuum drainage systems, which are recommended to be built in areas with low or no relief, are a controlled system. For this reason, it is appropriate to use them during sub-irrigation irrigation by adjusting the groundwater level. At the same time, in these systems, open type concrete canals located on the earth surface have replaced the role of water collector. So, there are opportunities to use drainage water with low mineral content for irrigation purposes.

Published scientific researches

1. Development of washed soils under agricultural crops and rehabilitation of fertility of the soils // bulletin of coordinating group of WUA. Baku-2001, p.37-40.

2. Washing salinized soils under various plants. For farmers: informational reference book // Baku, 2001, p.64-68.

3. The role of siphon-drainage system in the rational use of internal water resources // Az.Water problems ETI materials of the scientific and practical conference titled "Water, problems, researches". Baku, 2001, p.179-181.

4. Possibilities of using underground water on a background of siphon-drainage systems / Amelioration in XXI century, opinions, scientific researches, problems, scientific and practical conference, Baku, 2002, p.124-127 (Hasanov H.Y.).

5. Some problems of rational use of the lands under

market economy // Azerbaijan Agrarian Scientific Journal, № 3-4, Baku, 2006, p.120-123 (Hasanov H.Y.).

6. Groundwater regime in irrigated lands of Mugan-Salyan massif // AzET Scientific works of the Institute of Agriculture and Economy, №2, Baku, 2006, p.172-176.

7. Assessment of amelioration state of Mugan-Salyan irrigation massif as per salinization //Azerbaijan Agrarian Scientific Journal, № 5-6, Baku, 2006, p.166-168.

8. Assessment of amelioration condition of Mugan-Salyan irrigation massif as per alkalinity // Azerbaijan Agrarian Scientific Journal, № 7-8, Baku, 2006, p.81-82.

9. Drought, its features and reasons of formation // Collected scientific articles of AzSRI of HA, XXVII volume, Baku, 2007, p.109-114.

10. Assessment of present ameliorative and ecological state of the lands in Neftchala district // Journal ”Ecology and Water Farm”, №5, Baku-2007, p.9-12 (Hasanov H.Y.).

11. possibilities of planting drought-resistant plants for reducing the negative effects of drought // Collected scientific articles of AzSRI of HA, XXVIII volume, Baku, 2008, p.138-142.

12. Finding and using additional water sources to reduce the adverse effects of drought under water shortage // Collected scientific articles of AzSRI of HA, XXIX volume, Baku, 2009, p.96-103.

13. The role of root systems in the drought resistance of plants // Azerbaijan Agrarian Scientific Journal, № 5, Baku, 2009, p.87-88.

14. The role of temperature and average annual precipitation anomalies in the occurrence of drought // Collected scientific articles of AzSRI of HA, XXX volume, Baku, 2010, p.35-39.

15. Current ameliorative state of the lands of Mugan Amelioration Experimental Station // Journal “Soil science and

agrochemistry”, XX volume, №1, Baku, 2011, p.335-360.

16. Drought management and mitigation measures // Collected scientific articles of AzSRI of HA, XXXI volume, Baku, 2011, p.24-25.

17. Assessment of environmental and land reclamation state of agricultural lands retained in state property and measures to improve them // Collected scientific articles of AzSRI of HA, XXXI volume, Baku, 2011, p.48-54 (Nasibov S.M.).

18. Mitigation of flood effects from the rivers Araz and Kur // Scientific and practical conference on the theme “H.Aliyev’s land reforms is food security”devoted to the National Leader Heydar Aliyev’s 90th anniversary, “Soil Science and Agrochemistry” volume 21, №1, Baku, 2013, p.379-383.

19. Investigation of collector-drainage systems operation // Collected scientific articles of AzSRI of HA, XXXIII volume, Baku, 2013, p.191-195.

20. Assessment of irrigation water quality impact on ecological and land reclamation state of the soils in the southern Mughan plain.//The materials of the 2nd Khazar International Water Technologies conference. Azerbaijan, Baku, April 11, 2014, p.191-195 (Rufullayev E.I., Ismayilov C.M.).

21. Impact of water losses in the earth embankments on land reclamation state of the soils and measures to prevent them // Collected scientific articles of AzSRI of HA, XXXV volume, Baku, 2016, p.49-53.

22. Regulation and management of water-soil relations under modern farming // Collected scientific articles of AzSRI of HA, XXXVI volume, Baku, 2016, p.127-135 (Co-authors Rufullayev E.I., “Akbarov M.A.).

23. Differentiated engineering and agro-ameliorative measures for improving ecological and land reclamation state of irrigated lands of Mugan-Salyan massif //Azerbaijan Agrarian Scientific Journal, №2, Baku, 2017, p.62-71.

24. Forecasting salt regimes of irrigated lands of Mughan-Salyan massif // Kishovarz farmer, Dushanbe, 2013, №2, p.44-46.

25. of changing of the Caspian Sea level on ecological and land reclamation state of the lands of Mugan-Salyan massif // Russian agricultural science (Reports of the Russian Academy of Agricultural Sciences), Moscow, 2016, №2-3, p.60-62.

26. Assessment of ecological and land reclamation state of the lands and groundwater regime at the coastal territory of the river Kur.//Herald APK Stavropol, Stavropol, 2016, №1 (21), p.217-220.

27. Impact of changing of the Caspian Sea level on ecological and ameliorative state of the lands of Mugan-Salyan Massif // Russian Agricultural Sciences, may 2016, Volume 42, issue 3, p.285-287.

28. Ecological and land reclamation state of irrigated lands in mughan-Salyan massif of the Republic of Azerbaijan // Agrarian scientific journal, Saratov, 2016, №10, p.3-5.

29. Role of the drainage and groundwater regime in water-soil regulation // Bulletin of APK Stavropol, Stavropol, 2016, №3(23), p.244-248.

30. Radial vacuum drainage system // Amelioration and water farm, Moscow, 2016, №6, p.47-49.

31. Impact of irrigation water quality on the soils salty regime // The materials of International Scientific and Practical Conference “Perfection of hydraulic systems and water farm technologies”. Chersonia State Agrarian University, Chersonia, 2017, p.104-108.

32. Assessment of management and mitigation of drought effects for the Republic of Azerbaijan // Зрошуване землеробство. Институт Зрошуваного землеробства Национальной академии аграрных наук Украини. Міжвідомчий темитичний науковий збірник, г.Херсон:Грінь Д.С.,вип.67, 2017, p.10-12.

33. Operating efficiency of siphon-drainage at the area with less inclination // Russian agricultural science (The lectures of the Russian Academy of Agriculture), Moscow, 2017, №5, p.35-38.

34. Salty regime of the irrigated lands on a background of siphon-vaccum drainage at the area with less inclination // Bulletin of the institutions of higher education in the North Caucasian region. Series “Natural sciences”, №4, Rostov-na-Donu, 2017, p.104-109.

35. Ecological and reclamation condition and scientific and practical basis of regulation of the irrigated lands in Mugan-Salyan massif // Collected scientific articles of AzSRI of HA, XXXII volume, Baku, 2017, p.31-56.

36. Efficiency of a siphon drainage system under conditions in a low gradient area // Russian Agricultural Sciences, Volume 43, issue 6, November-2017, p.490-493.

37. Impact of the Caspian Sea level fluctuation on groundwater regime and functioning of the hydro-reclamation network in the Caspian side zones.//International Journal of Advanced Engineering Research and Science (ISARFS), Volume 5, issue-5, May-2018, p.272-276.

38. Main indicators of the soils fertility in Mugan steppe during long-term use in agriculture // Agrarian science, №5, Moscow, 2018, p.50-52.

39. Alternative water sources for irrigating the lands in Mugan-Salyan massif // International scientific and practical conference “Current technologies and engineering achievements in the field of hydraulic engineering construction” collection of scientific proceedings. Herson, 2019, p.30-34.

40. Water feed and its impact on reclamation condition of the irrigated lands in Mugan-Salyan massif in the Republic of Azerbaijan // Science and World. International scientific journal, №8 (72), Volgograd, 2019, p.45-47 (in co-authorship).

The defense of the dissertation will be held at the meeting of the Dissertation Council BED 1.32 operating under the Institute of Soil of Azerbaijan National Academy of Sciences, on "23 September" 2022 at 11⁰⁰ o'clock.

Address AZ 1073, Baku, Mammad Rahim Street 5,
e-mail: tai/amea@mail/ru

The dissertation can be found in the library of the Institute of Soil of Science and Agrochemistry of ANAS.

Elecrtonic versions of the dissertation and synopsis posted on the official website of defterxana@tai.science.az.

The synopsis was sent to the necessary addresses on "12" august 2022

Signed for print: 18.07.2022
Paper format: 60×84 1/16
Volume: 80516
Number of harrd copies: 30

Published by “MSV NASHR” MMC.
Tel: 012 539 54 69
Mob: 070 555 99 07