

OPERATIONAL DYNAMICS AND ENVIRONMENTAL CONDITIONS OF RESERVOIR-IMPACTED REGION

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Abstract- The article highlights current issues of the period, starting from the second half of the 19th century, projects implemented by the government of tsarist Russia in the field of land reclamation and water management in order to effectively use arable land on the Kura-Araz plain, cotton production, expansion of acreage using the water resources of the Kura River. Data on the project implementation goals has been collected” Construction of the Mingachevir hydroelectric complex and irrigation of the Kura-Araz plain”, about the main design indicators of the dam and reservoir at the Mingachevir reservoir. After the completion of the construction of the Mingachevir reservoir dam in 1953, starting in 1954, the level and volume of water accumulated in front of the dam were recorded. Electricity production began in the building of the hydroelectric power station, which was commissioned in 1955. From the water reserves accumulated in the Mingachevir reservoir, the Karabakh canal has been put into operation since 1958, through which irrigation water is transported to the Karabakh and Milevskaya plains along the right bank of the Kura River, and since 1959, the Shirvan Canal, through which irrigation water is transported to the Shirvan Plain along the left bank of the Kura River. During the operation of the reservoir in the period from 1954 to 2023, the indicators collected by the Azerbaijan State Agency for Water Resources on the annual maximum water levels in front of the dam and the corresponding volumes of water were studied, and it turned out that over 69 years of operation, the reservoir had worked for a total of 9 years, corresponding to the design indicators. The Mingachevir reservoir was operated for 60 years at a level below the design parameters, that is, the efficiency of this facility was low. The income, expressed in large numbers, was refused. During the operation of the Mingachevir reservoir, the average annual water consumption on the Kura River was lower than in previous years due to regulation at the reservoir. In 2003-2010, there was no threat of flooding on the coast around Kura. In the years following the commissioning of the Mingachevir reservoir, serious environmental changes took place in the Kura-Araz plain, starting with the Mingachevir reservoir and ending with the Caspian Sea on the banks of the Kura

and Araz rivers. The article extensively covers the classification of soil salinity on arable lands, the impact of the degree of salinity on crop yields, and the work to be carried out to ensure the effective use of land and water resources available on the Kura-Araz plain.

Keywords: Irrigation System, Drainage, Collector, Collector-Drainage System, Artificial Reservoir, Hydroelectric Power Station, Hydroelectric Power Station Building, Reservoir Operating Mode, Flow Regulation, Saline Soils.

1. INTRODUCTION

Since the main purpose of the article is to analyze the operating mode of the Mingechaur reservoir and assess the environmental situation in the area of its impact, in terms of discussion, these goals are related to technical indicators, mathematical results and analysis of hydraulic engineering systems. As engineering aspects, the risks of dam collapse are indicated (areas with a population of 1.3 million people, the likelihood of flooding 16 cities and 500 villages), the construction time and capacity of canal networks, minimum level modes for stable dam operation, and the final part notes engineering recommendations and reconstruction needs.

In order to rationalize the use of land on the Kura-Araz plain, representatives of the tsarist government working in the field of agriculture regularly came to Azerbaijan starting in 1813. Although research has been carried out on the Kura-Araz plain for this purpose over the years, no work has been carried out on the implementation of the planned projects. About 80 percent of the agricultural products produced in Azerbaijan over the past 125 years, and cotton, which is a technical crop, is grown on the Kura-Araz plain as a whole. The Kura-Araz plain has favorable natural conditions for the development of the agricultural sector. The upper 1.0 m vegetation layer of the earth's surface contained nutrients, heat and air conditions in volumes sufficient for the growing season.

Without carrying out irrigation and land reclamation measures on the plain, it was impossible to harvest crops from arable lands. The history of the search for a source of

irrigation water and research on the efficient use of the water resources of the Kura River in this region began in ancient times. In 1861, the outbreak of the civil war on the North American continent led to the fact that in a short period of time the selling price of cotton in the world increased by 4-5 times. During this period, 62.4 tons of cotton were produced in Transcaucasia. 48 tons of produced cotton were grown in the Irevan province. The increase in the selling price of cotton on the world market created historical conditions for increasing cotton production in tsarist Russia. Design and survey work has begun on the Kura-Araz plain in order to provide cotton products to the weaving industry. In 1860, engineers Belli and Gabbe, invited from England, who participated in the construction of the Baku-Poti railway, were given new tasks.

They were instructed to study the following issues in order to develop the direction of melioration and water management in the Kura-Araz Plain.

1. Study of the state of existing irrigation systems in the Kura-Araz Plain and proposal of projects for the construction of new irrigation systems
2. Determining the volume of water remaining after use in various sections of the rivers flowing in the Kura-Araz Plain and identifying areas where the designated volume of water can be used in newly built irrigation systems
3. Developing recommendations on the possibility of building new irrigation systems on arable land areas with efficient use of the water resources of the region's rivers.

2. PROBLEM STATEMENT AND ITS SOLUTION

Belli and Gabba conducted research in the Kura and Araz river basins for 8 years in accordance with the assignment received. Schematic plans were drawn up in the initial versions of numerous projects. The construction of a main canal near the mouth of the Ganykh River, which would receive water from the left bank of the Kura River, was very interesting in its relevance. The route of the proposed main canal runs along the slopes of the left bank of the Kura River on the territory of the current Mingachevir reservoir and provides irrigation water to agricultural fields located in the influence zone of the current Upper Shirvan Canal. Unfavorable relief conditions for the construction of the canal and the large financial costs required did not allow this project to be implemented at that time.

In 1927, the idea arose to build a dam and create a reservoir at the place where the Kura Bozdagh River cuts through. In the original version, it was assumed that the height of the dam would be 28.0 m. In 1930, the height of the dam was planned to be 38.0 m, and in 1931 - 64.0 m. Although famous scientists and specialists of the USSR were involved in the preparation of the design documentation necessary for the construction of the Mingachevir Reservoir, the main design documents were developed at the Azerbaijan State Institute for the Design of Water Management Facilities. In 1940, the preparation of the design documentation for the reservoir was fully completed. Construction work began in 1941.

However, construction work was suspended due to the attack of the German fascists on the USSR. By the Decree of the Government of the USSR dated October 20, 1945 number 2664, which ended the war with a victory, the implementation of the project "Construction of the Mingachevir Hydroelectric Complex and Irrigation of the Kura-Araz Plain" was launched.

The construction of the 80.0 m high earth dam with a simple design that has no analogues in the world was completed in 1953. The definition of the characteristic volumes of the reservoir was calculated for long-term flow regulation. The artificially created Mingachevir reservoir was created in the historical Samukh depression, located between the Akhbarbahar ridge in the north, Bozdag in the south and Palantokhen in the west. It is supposed to use the water reserves of the Kura River accumulated in the reservoir for complex purposes. A hydroelectric power station building was built on the body of the dam to generate electricity due to the pressure created in front of the dam. Thanks to the construction of the Upper Karabakh and Upper Shirvan canals, the existing agricultural areas on the Karabakh, Mil, Shirvan and partly Mugan plains were provided with irrigation water in accordance with the need for water and it became possible to build new irrigation systems.

One of the main goals in creating the reservoir was to accumulate and regulate floodwaters that regularly occur on the Kura River in the spring months in the area from Mingachevir to the Caspian Sea. The width of the dam in the upper part of the Mingechaur reservoir is 16 m, the length is 1550 m, the unused dead volume is 7679 million m³, the water level corresponding to the dead volume is 68.0 m. The useful volume is 8051 million m³, and when this volume is completely filled, it will be 15730 million m³, the height of the water level is 83.0 m, the area of the water surface is 605.0 km², the length of the reservoir along the river is 70.0 km, the average width of the reservoir is 18 km, the maximum depth is 75 m, the average depth of the reservoir is 26 m, and the length of the coastline along the perimeter of the reservoir is 247 km. A schematic view of the Mingechaur dam is shown in Figure 1. When the reservoir is completely filled, that is, at a level of 83.0 m, there are hydraulic devices that will ensure the discharge of water accumulated in front of the dam into the lower part in an emergency:

- 1) 1600 m³/sec flow into the lower outlet with a length of 1350 m;
- 2) 2000 m³/sec flow into the left-bank outlet with a length of 600 m;
- 3) 780 m³/sec flow into the hydroelectric power station;
- 4) 113 m³/sec flow into the Upper Karabakh Canal and 78 m³/sec flow into the Upper Shirvan Canal

During the operation of the Mingachevir reservoir (1953÷2024), the maximum value of the total water flow into the reservoir from the Kura, Gabirri and Ganykh rivers was observed on April 22, 1968 and amounted to 3100 m³/sec.



Figure 1. Plan view of the Mingachevir Dam [1]

When the reservoir is completely filled, i.e. according to the design indicators at the level of 83.0 m, the volume of a certain part of the flood waters intended for regulation in the reservoir is 340 million m³. The water level corresponding to this volume is 83.56 m. The Mingachevir HPP has been the most powerful source of hydropower in the Transcaucasian region for many years. It is planned that with the operation of 6 hydroelectric units installed at the HPP, 371 thousand kW of electricity will be generated per year. Currently, this figure is 400 thousand kW. The capacity of one unit according to technical characteristics is 130 m³ / sec, and the water flow with the simultaneous operation of all units is 780 m³ / sec. The water stored in the reservoir was used to generate electricity in the first years, i.e. until 1958 and 1959 (Figure 2).

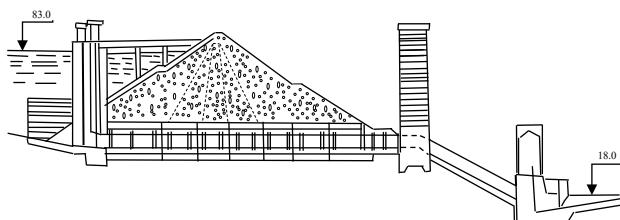


Figure 2. Cross-section view of the Mingachevir Dam from the hydroelectric power station [1]

In order to provide the fields with irrigation water from the water collected in the Mingachevir reservoir, the Upper Karabakh Canal with a flow rate of 113.0 m³/sec was put into operation in 1958, and the Upper Shirvan Canal with a flow rate of 78.0 m³/sec was put into operation in 1959. The bottom height at the water intake of the Upper Karabakh Canal is 59.0 m, and the bottom height at the water intake of the Upper Shirvan Canal is 65.33 m. In order to provide the canals with irrigation water during the vegetation period in accordance with the water needs of plants and to ensure the efficient use of the hydroelectric power station, the water level in the reservoir should be at the required height in accordance with the design capacity. After the construction of the Mingachevir reservoir, the area of the territory that was abandoned by people was 252 thousand hectares. The area of the reservoir's impact zone on the Kura-Araz plain is 1,270 thousand hectares. Over

the years of operation, the Kura River washed about 900 thousand m³ of solid particles away into the reservoir annually. In the first year of water accumulation in the reservoir, the maximum water level was 69.21 m, recorded on July 12, 1954. The volume of water in the reservoir corresponding to this level was 8,581 million m³.

During the operation of the Mingachevir reservoir, that is, in 1954-2022, the relevant institution of the Azerbaijan State Water Resources Agency collected data on the characteristic water levels and corresponding water volumes in the reservoir. When studying these indicators, it was found that during the operation of the reservoir in 1954-2023, the Mingachevir reservoir was operated in accordance with the design indicators for 9 years. That is, the water level in the reservoir was 83.0 m or slightly higher.

- On July 4, 1959, the water level was 83.28 m;
- On August 7, 1963, the water level was 83.28 m;
- On July 10, 1968, the water level was 83.38 m;
- On June 22, 1973, the water level was 83.84 m;
- On June 22, 1975, the water level was 83.09 m;
- On June 7, 1976, the water level was 83.34 m;
- On June 28, 1978, the water level was 83.84 m;
- On June 13, 1988, the water level was 83.28 m;
- On June 2-4, 2010, the water level was 83.20 m.

Over 70 years of operation of the Mingachevir reservoir, the required volume of water was accumulated in the reservoir for 9 years. Consequently, over 61 years of operation of this structure, the efficiency coefficient was low. That is, a loss of funds was allowed, expressed in large figures [2, 3]. During the investigation of this identified issue, it was revealed that before the transfer of the Mingachevir reservoir to the subordination of the Ministry of Emergency Situations of Azerbaijan in 2011, the reservoir dam was subordinated to the Azerenergy Joint-Stock Company of Azerbaijan. That is, this organization also monitored the volume of water accumulated in front of the dam.

The hydraulic structures regulating the intake of water from the reservoir to the Karabakh and Shirvan canals were subordinated to the Open Joint-Stock Company "Azerbaijan Melioration and Water Management". There was no organization responsible for the coastal areas along the perimeter of the reservoir, the length of which is 245 km. One of the many causes of the floods that occurred on the Kura and Araz rivers in 2010 was the improper regulation of the flow in the Mingachevir reservoir [4]. Positive changes were observed in subsequent years. All subordination of the Mingachevir reservoir was transferred to the Ministry of Emergency Situations of Azerbaijan. Therefore, the operation of the reservoir in accordance with the design parameters currently depends on specialists working in the Ministry of Emergency Situations. There is a dam on the Mingachevir reservoir, which will annually collect the required volume of water to a height of 83.0 m.

The Mingachevir reservoir has not remained untouched by the influence of fabricated and anthropogenic factors. In 1999, a landslide occurred on the right bank of the Mingachevir reservoir dam. Due to the

danger it posed to the main water intake structures that provide irrigation water to the Upper Karabakh Canal, the area where the landslide occurred was divided into 3 zones and the necessary restoration measures were taken. The collapse of the earth dam built at the Mingachevir hydroelectric complex due to the influence of man-made events can be very dangerous. Thus, within 24 hours, the Kura-Araz plain can be flooded with water at a depth of 0.5 m to 10 m. Depending on various factors, such a situation can last from 4 hours to several days. It is expected that the speed of floodwaters will be approximately 3-25 km per hour. This process will cover the entire territory in the affected area in a short time. Flooding will affect 16 cities with a population of about 1.3 million people, up to 500 settlements, as well as 1.27 million hectares of agricultural land equipped with material and technical resources [4].

The study of the above-mentioned problems is one of the current topics. After the commissioning of the Mingachevir hydroelectric power station in 1955, the hydroelectric power station produced electricity. Plants cultivated on more than 220 thousand hectares of arable land in the zone of influence of the Upper Karabakh and Upper Shirvan canals were provided with irrigation water corresponding to their full water needs. The expected yield was obtained from agricultural crops. Cotton production areas were developed. The role of the Mingechaur reservoir project in the country's economy and the rise of the social sphere was very large and decisive. Much has been written about the project and its significance in recent years.

As can be seen from Figure 3, the zone of influence of the Mingechaur reservoir includes flat areas from the upper reaches of the Kura and Araz rivers to the Caspian Sea. Numerous scientists have studied the hydrogeological conditions of the Kura-Araz plain in Azerbaijan. A.K. Alimov wrote that on the Kura-Araz plain, a layer of impenetrable clay has the shape of a slab. After the formation of the Mingechaur reservoir, the groundwater level approached the Earth's surface due to the influence of filtration of water from accumulated in the reservoir into deep layers of water flowing from the Verkhne-Karabakh and Verkhne-Shirvan channels built in the groundwater channel, and irrigation water supplied in furrows, strips and burials of surface irrigation equipment in excess of the norm (800- 1400 m³/ha) during the growing season.

This will be written about in a positive way in the coming years. In the areas affected by the Mingechaur reservoir, the average depth of groundwater in May in the 1930s was approximately 5-6 m, while in 2010 this figure was 1.0-1.5 m. Salinization processes of varying degrees are observed on 70-80 percent of the land in the sown areas. Considering that the yield of individual crops grown on slightly saline soils decreases by 15-25 percent, the volume of crop losses in the region in recent years can be expressed in large figures. The service life of the existing melioration and water management systems in the territories has expired and requires reconstruction. Capital flushing projects that need to be implemented to flush out

the salts accumulated in the plant layer require funds that will be expressed in large figures.

One of the global problems of the 21st century is the efficient use of arable land resources. The basis of the proverb that if labor is the father of an abundant harvest, then the soil is its mother is the labor of people in the field of melioration. The history of melioration activities is very ancient. Thus, "melioration" works are coeval with the history of human culture. For several millennia, people have been building irrigation systems and consistently expanding the area of arable land to create an abundant harvest. In 1909, the area of cotton crops in Mugam on the Kura-Araz Plain was 14.2 hectares (average yield 7.6 cents / ha), and in 1914, the area of cotton crops was 112.2 thousand hectares. In Azerbaijan in 1920 - 400 thousand hectares, in 1940 - 726 thousand hectares, in 1962 - 1.0 million hectares. Area, and in 1970 1.129 million hectares of area were irrigated. Currently, there are about 1.450 thousand hectares of irrigated land, from which more than 90% of agricultural products produced in the country are taken. By receiving water from the Upper Karabakh and Upper Shirvan canals, which were put into operation after the completion of the construction of the Mingachevir reservoir (Figure 3), irrigation systems were built on 220 thousand hectares of arable land on the Karabakh, Mil and Shirvan plains.

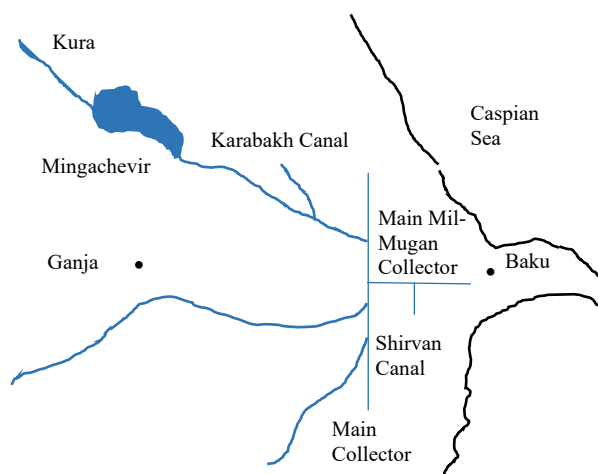


Figure 2. Schematic plan of main canals and collectors built after 1955 in the Kura-Araz plain [1]

Starting from 1900, the process of salt accumulation in the upper plant layer of the soil in the irrigated areas of the Kur-Araz plain began due to the influence of groundwater. This began to have a serious impact on the productivity of plants and the quality of the product. Therefore, in order to investigate the state of land reclamation in Northern Mugham, regulate the level of groundwater, and test collector-drainage systems, a project called "Jafarkhan drainage system" was implemented in the territory of the present Saatly district, which is constantly used as initial data in scientific literature. Here, 6 closed drains with an average depth of 2.44-4 m, a distance between drains of 328-814 m, a total length of 5620 m, one open drain with an average depth of 2.15 m and a length of 3077 m, and a collector with a length of 7800 m and an average depth of

4 m that drains drain water in an area of 700 hectares were constructed. Because of scientific research conducted on the construction of the collector, it became clear that in order to maintain the groundwater level at the required depth, collector-drainage systems should also be built along with irrigation systems. In this zone, large-scale construction of collector-drainage systems in open construction has begun.

Drainage waters built until 1953 were discharged from the areas where thorough washing was carried out to other neighboring areas. This process continued until the Mugan-Salyan collector was put into operation in the Mugan and Salyan plains. In order to prevent the salinization process of the soils in the Shirvan plain and to carry out thorough washing, the Shirvan drainage experimental area was created in 1956 on an area of 900 hectares. The construction of collector-drainage systems began in the Karabakh zone in 1958.

Since the construction of collector-drainage systems in the Kur-Araz plain was not carried out together with irrigation systems, it was found that the impermeable layers resembled plates, water losses from irrigation systems increased, and due to improper irrigation techniques, the groundwater level approached the surface of the earth over the years. The dynamics of groundwater level changes in the plain were as follows:

The average depth of groundwater from the Earth's surface in the Shirvan Plain was 6.04 m in 1930, 5.08 m in 1950, 3.99 m in 1960, 2.59 m in 1970, 2.02 m in 1990, and 1.8 m in 2000 [5].

The average depth of groundwater from the Earth's surface in the Karabakh Plain was 3.45 m in 1930, 2.78 m in 1950, 2.40 m in 1960, 1.79 m in 1970, 1.57 m in 1980, 1.28 m in 1990, and 1.0 m in 2000 [7].

The average depth of groundwater in the Mughan Plain from the Earth's surface was 4.23 m in 1930, 3.89 m in 1950, 2.84 m in 1960, 2.38 m in 1970, 1.99 m in 1980, 1.65 m in 1990, and 1.5 m in 2000 [7].

The average depth of groundwater in the Mil Plain from the Earth's surface was 5.34 m in 1930, 5.10 m in 1950, 3.09 m in 1960, 2.42 m in 1970, 2.12 m in 1980, 2.01 m in 1990, and 1.65 m in 2000 [6].

The first collector that collected drainage waters from the Kura-Araz plain and discharged them into the Caspian Sea was the Mugan-Salyan collector. In subsequent years, the main Shirvan collector, the Mil-Karabakh collector and the main Mil-Mugan collector were built.

From the above indicators, it became clear that, despite the construction of reservoirs in certain areas of the Kura-Araz plain, the process of groundwater convergence to the earth's surface continues. To stop the process, first of all it is necessary to regulate water losses in irrigation systems in accordance with the norm. Water loss in cultivated areas should be avoided. That is, the volume of water entering the plate, which we mentioned above, should be less than the volume of water leaving this plate. The approach of the groundwater level to the Earth's surface stimulates the process of soil salinization on arable land. According to official data, 60 percent of the soils in the area of the Mingechaur reservoir have varying degrees of salinity.

Considering that in slightly saline soils, yields initially decrease by 10-25 percent, depending on the type of plant.

The mineral content of groundwater in the Kura-Araz Plain increased year by year from 1930 to 1950. In subsequent years, with the commissioning of inter-farm collectors and the Mughan-Salyan, Bash Shirvan, Mil-Karabakh main collectors, the mineral content of groundwater began to decrease. The average mineral content in 1980 was approximately 2 times lower than in 1950. It should be noted that the Bash Mil-Mugan collector, which drains the drainage waters of the cultivated fields on the right bank of the Kura River into the Caspian Sea, was built in a timely manner to prevent groundwater from approaching the surface of the earth in the Kura-Araz plain and thus stop the process of re-salinization of the soil [7].

3. ENGINEERING DISCUSSION

The Mingachevir Reservoir was put into operation in 1953. Its normal filling level is 83 meters, and the total water volume is about 15.73 cubic kilometers (15.730 million m³). According to historical data, the reservoir was completely filled only in certain years - 1959, 1963, 1968, 1973, 1975, 1976, 1978, 1988 and 2010. The maximum water level in these periods is associated with climatic conditions and an increase in water resources.

Table 1. Dynamics of water level changes in Mingachevir reservoir by year

Period / Year	Level (m)	Note	Analysis
1953-1980	83 m (full filling)	Fast filling, sufficient water supply	In the first years, the stability of the Kura River flow and hydrometeorological conditions ensured rapid filling of the reservoir
1980-2000	80-83 m	Stable level	Water consumption increased, but no significant decrease was observed
2010	83 m	Last full filling	It is due to a favorable year from a hydrological point of view
2018	70.78 m	Starting to decrease	The reduction of water resources in the Kura basin is due to climatic factors
2019	68.54 m	Decrease by 2.24 m	One of the lowest indicators in recent decades
2021	69.6 m	Increase by 1.06 m	Temporary recovery due to large amounts of precipitation
2022-2023	~69 m	Water inflow decreased by 50%	The decrease in the inflow into the reservoir from 823 million m ³ to 455 million m ³ in 2018-2022 reflects a critical situation

In subsequent periods, especially in October 2019, a significant decrease in the water level was observed. Thus, this month the water level was 68.54 meters, which is 33 centimeters less than in the same period last year (70.78 meters). A positive trend was also observed in 2021. In the corresponding period of the same year, the water level was 1.06 meters higher than in the previous year, and this increase is estimated to be equivalent to about 500 million cubic meters of water reserves. Statistics for 2023 show a gradual decrease in water reserves. Thus, if in 2018 the volume of water entering the reservoir was 823 million cubic meters, then in 2022 this figure dropped to 455 million cubic meters. This indicates that the water inflow over the past 4 years has decreased by about 50%.

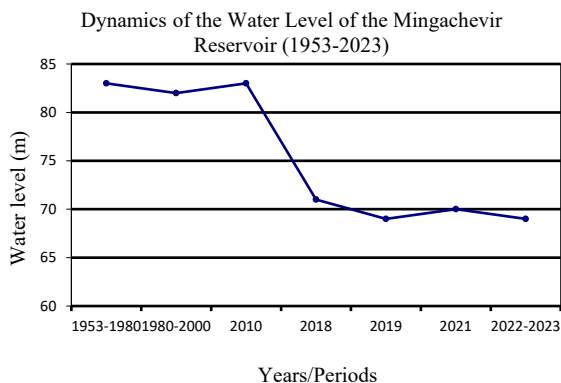


Figure 3. Graph of changes in the water level in the Mingachevir reservoir (1953-2023)

If in 2018 the volume of water entering the reservoir was 823 million m³, then in 2022 this figure dropped to 455 million m³. This is a decrease of approximately 50% in just 4 years. This trend is associated with both global climate change and intensive water withdrawal in the Kura River basin.

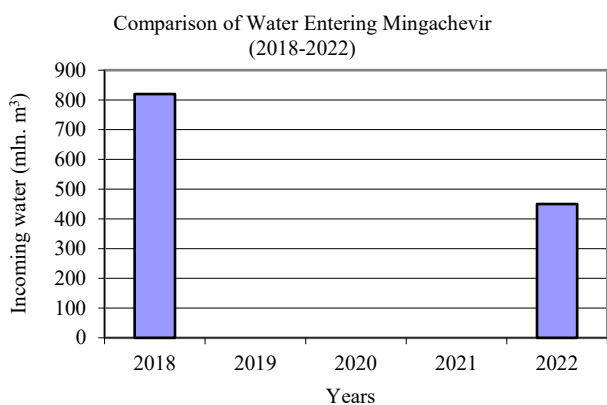


Figure 4. Comparison of water inflow volumes into the Mingachevir reservoir (2018-2022)

Table 2. Water withdrawal indicators from the Karabakh and Shirvan canals

Channel name	Length (km)	Average water intake (m ³ /s)	Maximum water intake (m ³ /s)	Role and importance
Karabakh	172-172.4	113	138	Irrigation of the Karabakh and Mil-Mugan zones
Shirvan	122-123	78	-	Land melioration of the Shirvan plain

Although the filling level of the Mingachevir reservoir was stable in 1953-2010, a significant decrease has been observed in recent decades due to climate change and increased pressure on the water sector. The 50% decrease in water volume in 2018-2022 demonstrates the seriousness of this problem. This situation also prevents the canals from being fully loaded and necessitates new approaches to water management in the future.

4. CONCLUSIONS

1. In countries around the world, drinking water resources and arable land areas are decreasing over the years as a result of observed natural and anthropogenic impacts. The construction of the Mingachevir reservoir in 1953, which ensures the use of the water resources of the Kura River for complex purposes, was the right decision.
2. With the construction of the Mingachevir reservoir, cheap electricity was produced for the first time among the Transcaucasian of the land. At that time, the energy needs of the three neighboring lands were met.
3. After the Mingachevir hydropower station was put into operation in 1955, the Upper Karabakh canal in 1958, and the Upper Shirvan canal in 1959, the water needs of plants cultivated on more than 210 thousand hectares of arable land in the Kura-Araz plain were met, and the agricultural sector developed significantly.
4. In the years following the construction of the Mingachevir reservoir, serious ecological changes occurred in the areas within its impact zone. Due to the influence of the water volumes leaking from the Upper Shirvan and Upper Karabakh main canals built in the soil bed, numerous canals in the irrigation systems, and the irrigation water supplied to the cultivated plants in the fields in excess of the norm, the depth of the groundwater, whose mineral content varied between 5÷100 g/l, was approximately 1.6 m. In the Shirvan, Karabakh and Mil plains, compared to 1953, the depth of the groundwater increased by approximately 4.0 meters during the 10 years of operation of the Mingachevir reservoir.
5. In order to stop the process of groundwater approaching the surface of the earth, prevent the re-salinity of the soil and carry out major washing works on the soils in the fields, the construction of collector-drainage systems began in 1956 in the Shirvan plain, in 1956 in the Karabakh plain, and in 1953 in the Mil plain.
6. The operational life of the land reclamation construction systems implemented in the Shirvan, Karabakh and Mil plains in the impact zone of the Mingachevir reservoir has almost come to an end.
7. Approximately 8-12 billion m³ of water is supplied to the arable lands in the Kur-Araz plain per year. Progressive irrigation techniques should be applied to reduce the volume of irrigation water. In order to minimize water losses in irrigation systems, field canals and temporary ditches should be replaced with polyethylene pipes.
8. The article provides a comparative approach to the open mode of water discharge, accumulation of water in front of the dam and mixed modes. In the open mode, even if floods are prevented, energy losses increase. In the accumulation mode, energy production increases, but soil salinization and groundwater rise to the Earth's surface are observed. A mixed regime creates a compromise between the water balance and environmental risks. Each of these models has been analyzed in terms of efficiency, energy generation, environmental impact, and agricultural land maintenance, and presented in an appropriate tabular form. Because of this comparison, a scientific justification for the transition to optimal regimes was presented.

9. The article presents the dynamics of water level changes over the years, exceeding the design level of the dam 9 times during its operation and the intervals of its repetition based on specific tables and data.

Based on these data, the creation of an inequality between the irrigation needs in the Kura River basin and the actual reservoir regime was added to the discussion. In addition, he scientifically justified the need to raise the groundwater level to 1.5 m, monitor soil salinity by up to 80%, reduce yields on arable land by up to 25%, as a result, reduce water losses and reconstruct collector and drainage systems.

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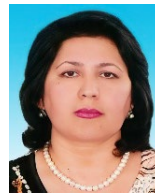
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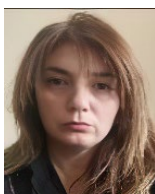
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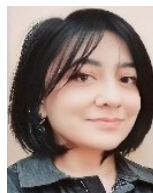
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