Advances in Biology & Earth Sciences
Vol.10, No.1, 2025, pp.135-147
https://doi.org/10.62476/abes.101135

ASSESSMENT OF THE TECHNICAL CONDITION OF COLLECTORS AND DETERMINING THE SUITABILITY OF COLLECTOR WATERS FOR REUSE

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Abstract. The article's main objective is to assess the geotechnical and technical condition of the drainage and collector system constructed to improve the melioration condition of agricultural lands and maintain their suitability for use, as well as to determine the suitability for reuse of water collected in the collector. One of the most important tasks of the present time and for the future in terms of the planet's need for water is to overcome the shortage of water caused by unpredictable and unexpected climate changes, including global warming, drought and other negative natural phenomena. For this reason, by the principle of "every drop of water is valuable", conducting appropriate monitoring and assessment of the engineering-geological and technical condition of collectors for efficient use of water collected from drainage networks and discharged into the Caspian Sea by these collectors, the level of which is decreasing from year to year and complete prevention or minimization of losses during transportation of these waters is an important necessity. The inclusion of such measures as "purification and reuse of collector-drainage and wastewater" and "reconstruction of irrigation canals and collectors" in the Action Plan for the implementation of the "National Strategy for the Efficient Use of Water Resources" in the Republic of Azerbaijan for 2024-2027 further increases the relevance of the scientific, technical and practical research reflected in the article.

Keywords: *Collector, water, monitoring, geotechnics, erosion.*

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Received: *19 December 2024;* ***Accepted:*** *25 March 2025;* ***Published:*** *15 April 2025.*

1. Introduction

In the conditions of water shortage observed in the conditions of recent climate change, such issues as efficient use of available water resources, loss-free delivery of water taken from water sources to consumers, assessment of the technical condition of drainage and collector systems created for irrigation of agricultural lands and improvement of the ameliorative conditions of lands, prevention of water losses by restoring the operability of these systems, reuse of water used or generated during any technological process, have become some of the most pressing problems of our time.

Conducting technical and geotechnical surveys to assess the technical condition of drainage systems, including the collector and drainage network and determining the degree of their operational suitability (study of defects, erosion processes, landslides, deformations, siltation, overgrowing with grass, etc.) is of great importance.

How to cite (APA):
Shiraliyev, N., Nabiyeva, J., Abbasova, G., Aliyeva, F. & Khalilova, A. (2025). Assessment of the technical condition of collectors and determining the suitability of collector waters for reuse. *Advances in Biology & Earth Sciences, 10*(1), 135-147 https://doi.org/10.62476/abes.101135

Monitoring of the technical condition of reclamation structures is carried out for the following purposes:

- maintaining the established operating mode;
- ensuring continuous monitoring of technical condition indicators and safe operation;
- timely identification of elements of a reclamation structure that require an unscheduled inspection of their technical condition;
- determining the degree and rate of change in the technical condition of reclamation structures;
- developing, based on the information received, measures to ensure conditions for the safe operation of reclamation facilities and preventing their transition to a limited operational or emergency state (GOST R 70566, 2022).

The study of vertical movements occurring in the soil mass along the collector route for various reasons, including deformation processes such as subsidence, subsidence, heaving, formation of shrinkage cracks, washouts, landslides and collapses, as well as other natural and anthropogenic factors complicating the operation of collectors, is the most important factor in eliminating risks arising from the said processes.

The work carried out to identify the abovementioned cases was based on many years of experience, linear observations, the use of some technical measuring devices, photogrammetry, assessment of the observed changes in relief, violations of the integrity of the collector nomenclature elements and visual inspection of all the abovementioned cases.

All identified negative cases were appropriately recorded and documented with photographs and determination of the coordinates of their locations.

To determine the chemical composition and other indicators of water, a water sample was taken from the Boladi collector and the corresponding analyses were carried out in the soil and water analysis laboratory of the Water and Amelioration Scientific Research Institute PLE.

2. Research object and research methodology

The Boladi and Cil collectors we are considering are an integral part of the drainage and collector system of the research region.

The Boladi and Cil collectors, located in the Lankaran Lowland, were chosen as the object of study (Figure 1).

The research methodology was selected based on the requirements of relevant regulatory documents, standards and guidelines.

1. Law of the Republic of Azerbaijan on Land Reclamation and Irrigation. 1996.
2. AzDTN 2.10-2. 2022. Amelioration systems and structures. Design standards.
3. GOST R 70566-2022. Amelioration systems and structures. Survey and monitoring rules.
4. GOST R53778-2010 “Buildings and structures. Survey and monitoring rules for technical conditions.
5. Guidelines for monitoring deformations of foundations and foundations of buildings and structures. Moscow - 1975.

Figure 1. Research area

The Boladi collector originates from the village of Kharkhatan in the Lenkoran district and extends to the Caspian Sea. The collector is 18.0 km long and has a capacity of 10 s/m^3.

The Cil collector originates from the village of Cil in the Lenkoran district and extends to the Caspian Sea. The collector is 14.0 km long and has a capacity of 10 s/m^3.

3. Research results, an analysis and a discussion

Although the width of the Boladi collector according to the design parameters is 8.0 meters (Figure 2), according to the results of our measurements, the actual width corresponding to the upper surface of the existing water level in the surveyed section of the collector fluctuates between 4.0 and 23.0 meters (Figures 3 and 4).

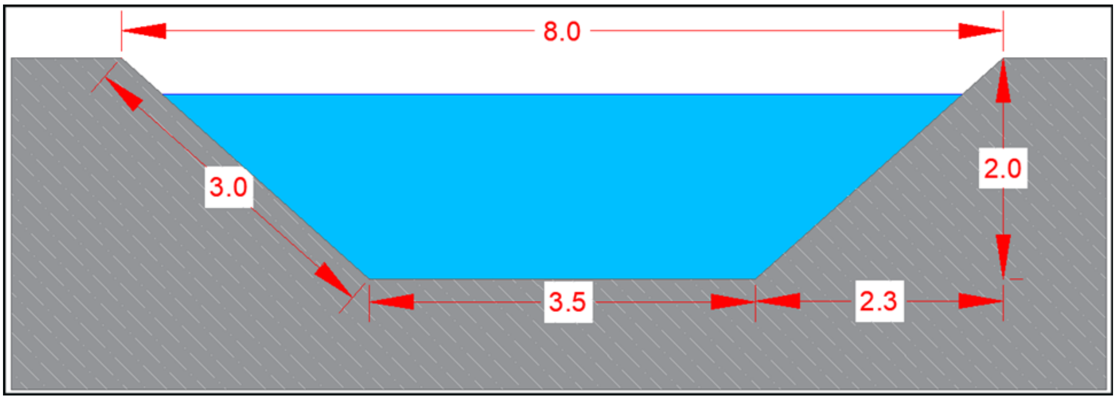

Figure 2. Design dimensions of the Boladi collector

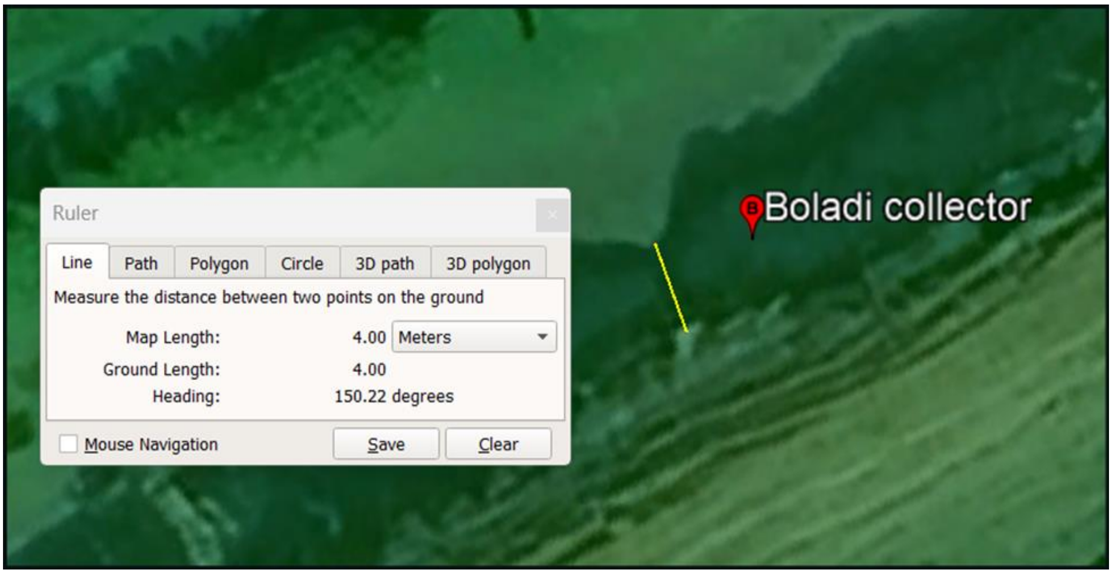

Figure 3. The actual minimum length of the Boladi collector

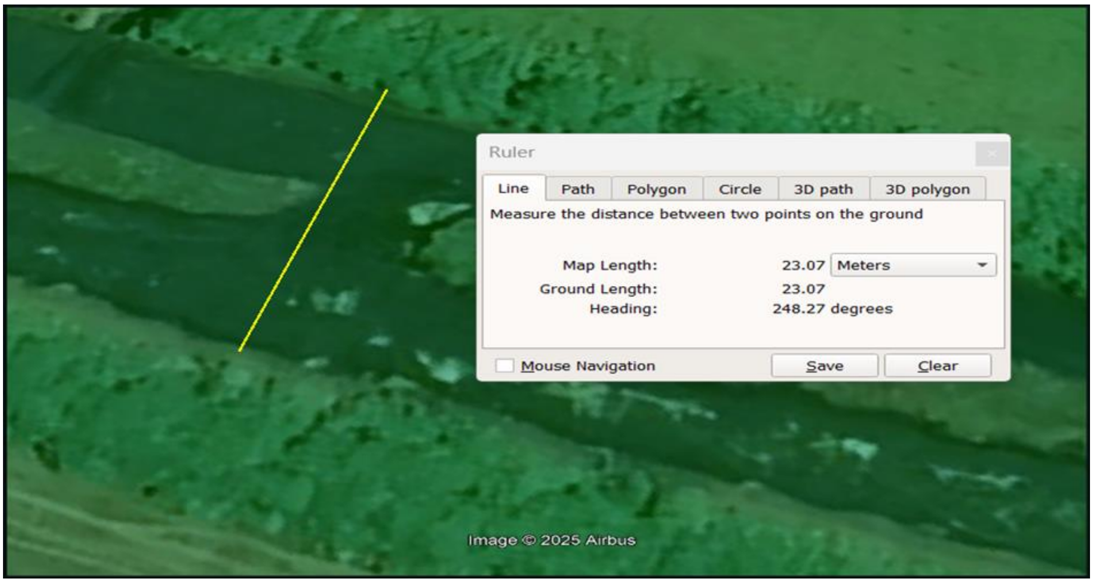

Figure 4. The actual maximum length of the Boladi collector

During geotechnical monitoring, a discrepancy was recorded between the actual parameters of the Cil collector, which is exposed to certain physical-geological, physical-geographical, technogenic and anthropogenic factors during operation and the design parameters. The width of the Cil collector in the studied area varies between 4.85-25.7 meters (Figures 5, 6 and 7).

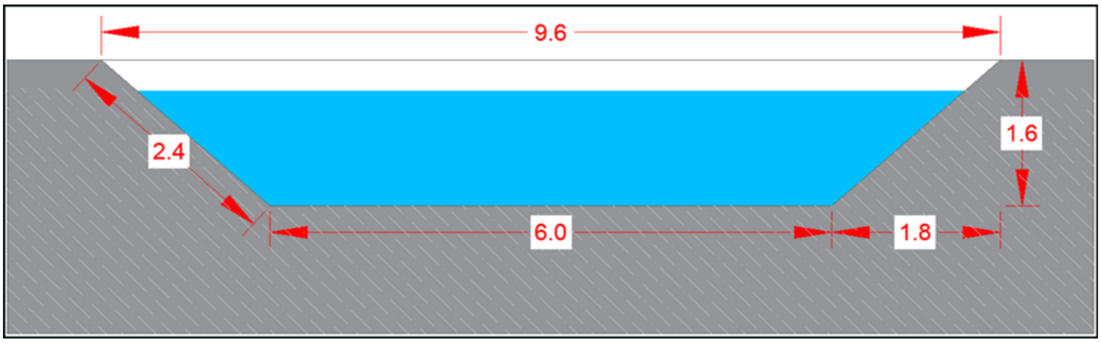

Figure 5. Design dimensions of the Cil collector

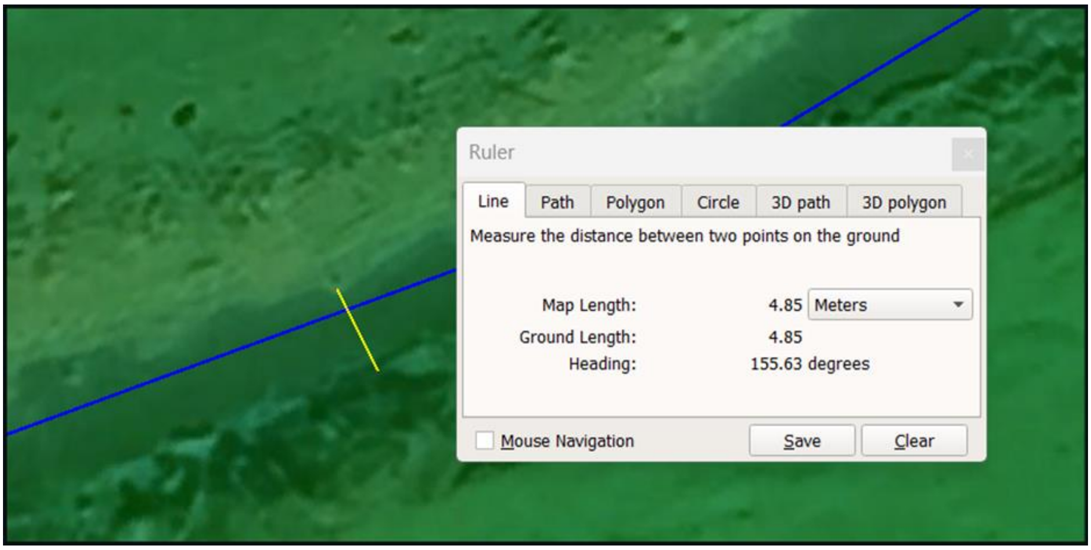

Figure 6. The actual minimum length of the Cil collector

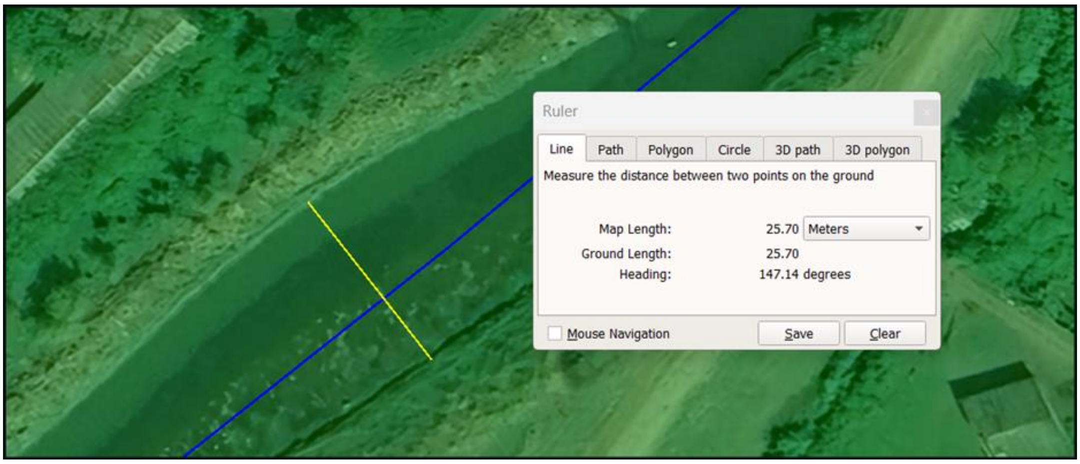

Figure 7. The actual maximum length of the Cil collector

When conducting geotechnical monitoring to determine the technical condition of collectors, the following defects were most often encountered:

1. Changes in the dimensions of the collector along its width and length as a result of settlement and erosion processes occurring in the soil massif on the slopes of the collectors (Figure 8);

2. Scour, erosion, landslides and collapse of collector slopes under the influence of atmospheric precipitation and surface water runoff (Figure 9);
3. Development of grasses, aquatic plants, shrubs and various types of trees on the water surface and slopes of the collector (Figure 10);
4. Complete or partial coverage of the water surface of the collector with aquatic plants (Figure 11);

Figure 8. Processes of erosion and settlement of the soil massif of the collector slope

Figure 9. Washout, erosion, landslides and collapse of collector slopes

Figure 10. Development of grasses, aquatic plants, shrubs and various types of trees on the water surface and slopes of the collector

Figure 11. Full or partial coverage of the water surface of the collector

Interpreting the preliminary data obtained during monitoring, it was concluded that the main factor negatively affecting the ability of the collector to perform its function is the siltation of the collector bottom, which significantly reduces the speed of water movement, creating favorable conditions for the development of various types of plants, shrubs and trees.

Research has shown that other reasons causing a decrease in the speed of water movement in a collector are the filling of the base or bottom of the collector with various deposits formed as a result of erosion and destruction of the slope under the influence of physical-geological and physical-geographical processes and wastewater of various origins, as well as anthropogenic impacts.

The percentage expression of the collector's operability or unsuitability was calculated using the following formula (Karuchina, 2009):

$$Dki = \frac{\mathrm{Lki}}{\mathrm{Lk}} \times 100\ \%$$

Here Lki is the length of the section of the collector where the i-th defect is noted (siltation of the channel, collapse, undermining, erosion of the collector slope, overgrowing of the slope with grass, vegetation, bushes and various types of trees, etc.), Lk is the length of the collector.

Using the above formula, it was determined that the collector's serviceability was 29.5% or its unusability was 70.5%.

If the degree of unsuitability of the collector for the selected damaged element exceeds 20% by the requirements of the relevant regulatory documents, it is necessary to carry out urgent cleaning and restoration measures to ensure the design parameters of the collector, including strengthening the collector slope (Karuchina, 2009).

Frequently recurring factors complicating the operation of the collector are erosion processes in the soils of the coastal part and the slope of the collector, artificial formation of landslide-prone soil massif on the banks and slopes, frequent erosion and collapse of this massif, the presence of heaving, subsidence and subsidence, as well as partial or continuous coverage of the collector with plants, shrubs and various types of trees practically along the entire route of the collector.

Based on the interpretation of the results of monitoring data and the conducted studies, it can be stated that the main reasons for the technical condition of the Boladi and Cil collectors are:

- failure to perform maintenance work on the collectors;
- erosion processes on both banks of the collectors;
- deformation processes in the soil massif that forms the coastal slope of the collector;
- development and spread of various plant species on the water surface and slopes of the collector along its entire length;
- failure to perform work to prevent landslides, collapses and other exogenous processes and negative phenomena in the collector structures.

To eliminate the above-mentioned negative phenomena, it is necessary to carry out appropriate measures to prevent water losses in drainage and collector systems, restore functional activity and improve the technical condition of collectors.

The purpose of these measures should be to restore the design indicators for the technical level of existing systems, to ensure their water drainage, to apply optimal technological changes for high-quality irrigation of agricultural products, to improve the melioration state of lands and to minimize negative anthropogenic and technogenic impacts on melioration systems through the use of new and innovative approaches in compliance with environmental protection requirements.

The speed of water flow in the Boladi and Cil collectors was not determined during the monitoring. Visually, it was determined that the water flow rate in both collectors is very low and significantly less than the requirements of the relevant standards (SP 421.1325800, 2018).

It is known that the minimum speed of water flow in collectors (siltation speed) should be at least 0.3 m/s and the maximum (flushing speed) no more than 1.5 m/s (SP 421.1325800.2018b).

To maintain the working condition of the elements of drainage systems and in our case open collectors, first of all, it is necessary to systematically conduct visual inspections according to a certain calendar schedule and provide technical maintenance and repair.

During the technical maintenance of collectors, the following work should be performed: cleaning the bottom of the collector from elements that negatively affect the flow of water in the collector, including sediment soils coming with water of various origins; cleaning the surface of the water in the collector from algae; cleaning the slopes and berms of collectors from plants, shrubs and trees; restoring sections of the collector that have been subjected to exogenous, geological and anthropogenic impacts; carrying out engineering measures to prevent erosion of coastal parts of the collector.

After eliminating the consequences of deformation and erosion processes in the soil massifs that make up the coastal slopes of the collectors, clearing the collector bed from silting and eliminating grasses and shrubs, work should be carried out to strengthen the banks of the collectors.

The slopes of the ditches and collectors must be strengthened by 100-150 mm above the design level, which is done by sowing grass or applying turf (SP 425.1325800, 2018).

For timely strengthening of the slopes of collectors, it is necessary to carry out work on planting plants on the surface of the slope or laying turf on it, taking into account the condition of such a factor that the speed of water flow should not exceed the speed of siltation (Figures 12 and 13).

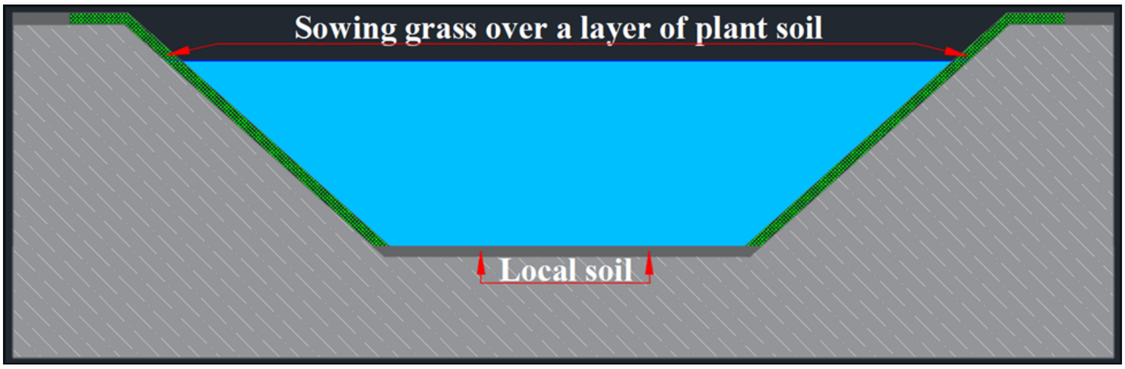

Figure 12. Planting plants on the surface of the collector slope

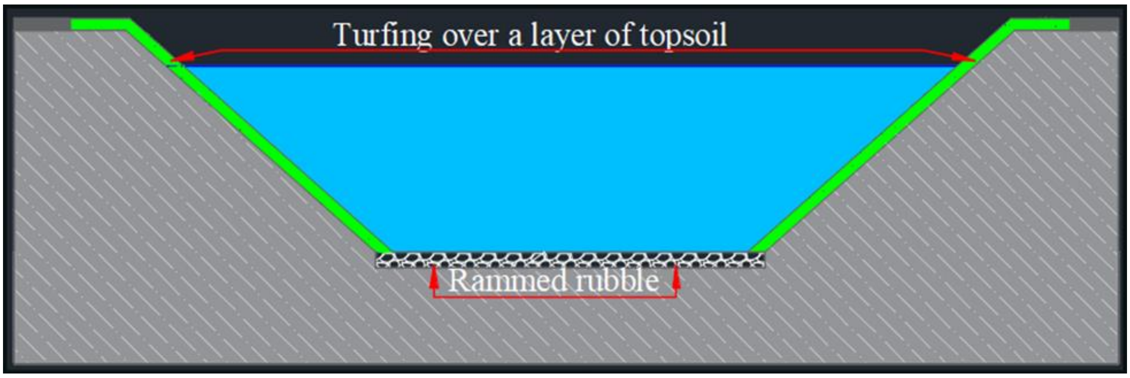

Figure 13. Laying turf on the surface of the collector slope

Water is the most important resource for all life on the planet. Of all the water resources on Earth, only 2.5 percent is fresh. Two-thirds of fresh water is trapped in ice caps and glaciers. Of the remaining one percent, a fifth is located in remote, hard-to-reach areas and a large amount of seasonal precipitation during floods cannot be easily used

(Khojiyev *et al*., 2019). Over time, water is becoming less and less; access to clean and safe drinking water is becoming limited in different countries (Usmanov *et al*., 2023).

To check the suitability of the collector water for providing the region's population with drinking water and irrigation of crops, a water sample was taken from the collector and submitted to the “Soil and Water Analysis” laboratory of the “Water and Amelioration Scientific Research Institute” PLE.

The results of the analyses to determine the chemical composition of water are presented in Table 1.

Table 1. The results of the analyses to determine the chemical composition of water

No	Names of indicators	Measurement unit	Indicators	Acceptable limit of indicators
1	pH	pH	7,7	6,5-9,5
2	The blur	NTU	8,7	<3,0
3	Electrical conductivity	μs/cm	799	<2500
4	Hydrocarbonate, (HC_3)	mg/1	305,1	1000
5	Sulfate, (SO_4^2)	mg/1	20,7	500
6	Chloride (Cl^-)	mg/1	191,4	350
7	Calsium (Ca^{2+})	mg/1	70,1	<130
8	Magnesium (Mg^{2+})	mg/1	36,2	<65
9	Sodium+Potassium, (Na^++K^+)	mg-ekv/1	108,3	212
10	Overall stiffness	mg/1	6,5	7
11	Total mineral content	mg/1	731,7	1000
12	Dry residue	mg/1	760,0	1000
13	Ammonium ion, (N-NH_4^+)	mg/1	0,18	0,5
14	Nitrite ion (N-NO_2^-)	mg/1	0,8	3
15	Nitrate, (N-NO_3^-)	mg/1	0,6	50

Water quality is an important factor that plays a major role in people's lives. Clean water is necessary for health protection, agriculture and industry.

The results of laboratory water analysis and assessment of physical and chemical indicators affecting water quality and compliance of this water with drinking water standards are presented below (GOST 2874-82, 2021):

- The pH value of the provided water sample is 7.7, which indicates that the water is normal, neutral or very slightly alkaline. The pH value of drinking water should be between 6.5 and 9.5. This indicator indicates that the water is suitable for biological and chemical processes and the pH of the water here is fully compliant with the standards.
- Turbidity in the presented sample of water is 8.7 NTU. High turbidity indicates that this water requires filtration and purification processes for drinking purposes.
- The electrical conductivity of the presented water sample is 799 μS/cm and meets the requirements of current regulations. This indicates that the water has the appropriate composition and is safe as drinking water.
- The amount of hydrocarbonates in the water sample shown is 305.1 mg/l. According to the requirements of regulatory documents, the content of hydrocarbonates in drinking water should be less than 1000 mg/l and accordingly, the value of carbonates corresponds to the standards.
- The sulfate content in the submitted water sample is 20.7 mg/l, which is below the regulatory limit of 500 mg/l. This indicator indicates that the water meets drinking water standards.

- The amount of chloride ion in the submitted sample is 191.4 mg/l, which does not exceed the maximum permissible level for drinking water of 350 mg/l.
- The calcium content is 70.1 mg/l, magnesium - 36.2 mg/l. For drinking water, the calcium content should be less than 130 mg/l and the magnesium content - less than 65 mg/l. These indicators indicate that the water hardness is at an average level.
- The sodium and potassium content in the supplied water is 108.3 mg/l, below the regulatory limit of 212 mg/l, indicating that the water is safe for consumption.
- The total hardness of the water is 6.5 mg-eq/l, the total mineralization is 731.7 mg/l. The given values confirm that the water does not have high mineralization and is therefore suitable for consumption.
- The dry residue in the submitted sample is 760.0 mg/l. The dry residue content should be less than 1000 mg/l and this indicator also meets the requirements of regulatory documents.

An analysis of the chemical and other properties of water taken from the Boladi collector gives grounds to conclude that this water is not suitable for use as drinking water for only one indicator out of 15 - water turbidity.

It can be noted with confidence that although the water of the Boladi collector is not suitable as drinking water due to its turbidity, it can be reused for irrigation of crops or as industrial water in some relevant industries with the creation of melioration systems and water supply systems.

Taking into account the capacity of the Boladi collectors and the chemical composition of the water, which is almost suitable for drinking and taking into account the fact that in some settlements located near the named collector, underground waters of not very high quality are used, we consider it advisable to conduct a feasibility study on the desalination of the collector water and create the necessary infrastructure for water purification and provide the population of this region with additional sources of fresh water.

Recycled water provides a consistent and dependable water source while reducing the extraction of water from the environment. Measures to reduce drainage volumes in agricultural irrigation should be implemented at both the farm and plot levels, considering their impact on crop yields, according to international experience (Dyuisenkhan *et al*., 2024; Sharma & Tyagi, 2004). Drainage systems effectively restore and maintain soil quality on irrigated lands, with drainage water serving as a crucial water source in agriculture. Proposals for recycling drainage water and for capturing and storing water from fields are recommended for crop irrigation during soil moisture deficits. The practice of recycling drainage water and storing it for reuse as irrigation water is gaining traction to meet production and environmental objectives (Dyuisenkhan *et al*., 2024; Reinhart *et al*., 2019).

The reuse of drainage water receives government support in arid climate countries, with long-term plans being developed to preserve soil and water quality. Agricultural drainage water can be recycled and reused for irrigating fields at lower elevations without requiring treatment or pumping. Additionally, wastewater can be collected and stored in specialized reservoirs for subsequent reuse because water with high chemical contamination should not infiltrate groundwater aquifers (Dyuisenkhan *et al*., 2024; Hay & Helmers, 2017).

Ensuring groundwater sustainability is imperative to meet the Sustainable Development Goals (SDGs) amidst varying climate change scenarios and escalating water demands in the region. The overall sustainability of aquifers in irrigated lands requires consideration, as increased use can result in groundwater depletion (Dyuisenkhan *et al*., 2024; Samani *et al*., 2021).

The interpretation of the results of the scientific works of the above-mentioned researchers gives grounds to state that the reuse of drainage and collector waters of the studied region is appropriate and necessary for the irrigation of agricultural crops and for the needs of the population for drinking water.

4. Conclusion

Although the width of the Boladi collector according to the design parameters is 8.0 meters, according to the results of our measurements, the actual width corresponding to the upper surface of the existing water level in the surveyed section of the collector fluctuates between 4.0 and 23.0 meters.

During geotechnical monitoring, a discrepancy was recorded between the actual parameters of the Cil collector, which is exposed to certain physical-geological, physical-geographical, technogenic and anthropogenic factors during operation and the design parameters. The width of the Cil collector in the studied area varies between 4.85-25.7 meters.

It was determined that the main factor negatively affecting the ability of the collector to perform its function is the siltation of the collector bottom, which significantly reduces the speed of water movement, creating favorable conditions for the development of various types of plants, shrubs and trees.

Research has shown that other reasons causing a decrease in the speed of water movement in a collector are the filling of the base or bottom of the collector with various deposits formed as a result of erosion and destruction of the slope under the influence of physical-geological and physical-geographical processes and wastewater of various origins, as well as anthropogenic factors of varying degrees.

Frequently recurring factors complicating the operation of the collector are erosion processes in the soils of the coastal part and the slope of the collector, artificial formation of landslide-prone soil massif on the banks and slopes, frequent erosion and collapse of this massif, the presence of heaving, subsidence and subsidence, as well as partial or continuous coverage of the collector with plants, shrubs and various types of trees practically along the entire route of the collector.

After eliminating the consequences of deformation and erosion processes in the soil massifs that make up the coastal slopes of the collectors, clearing the collector bed from silt and eliminating grass and shrubs, work should be carried out to strengthen the banks of the collectors.

To eliminate negative phenomena, it is necessary to carry out timely appropriate measures to prevent water loss in drainage and collector systems and to carry out work to improve the technical condition and restore the functional activity of collectors.

Analysis of chemical and other water properties shows that the water from the Boladi collector is not suitable for use as drinking water due to its turbidity, but it can be used for irrigation of agricultural crops or as industrial water in some relevant industries with the creation of appropriate technological processes.

Taking into account the capacity of the Boladi collectors and the chemical composition of the water, which is almost suitable for drinking and taking into account the fact that in some settlements located near the named collector, underground waters of not very high quality are used, we consider it advisable to conduct a feasibility study on desalination of the collector water and create the necessary infrastructure for water purification and provide the population of this region with additional sources of fresh water.

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