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Potentaility of utilising water for irrigation of the main Mil-Karabakh collector

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Abstract. *The article presents the results of assessing the composition and quality of water in order to determine the possibilities of using the water of the Main Mil-Karabakh collector for irrigating arable land. The purpose of the study was to determine the level of mineralization and chemical composition of the collector-drainage waters of the middle reaches of the Kura River and to assess the volume of the formed collector-drainage waters . It is determined that the mineralization of these waters is in the range of approximately* $0.4 - 3.6 g/l$*. According to the chemical composition, the collector-drainage waters are classified as chloride-sulphate type. The existing classification of the collector-drainage waters are analyzed in accordance with their chemical composition, possiblity of use for chrrigation taking into account the proposed mathematical formulas and recommendations. The results of the study show that about 800 million* m^3 *of collector-drainage water is a reserve water and can be used as an additional source of water for irrigation.*

Keywords. water resources · water deficit · volume and quality of collector-drainage waters · mineralization · Kura-Araz lowland · water salinity · volume of formed drainage waters.

Mathematics Subject Classification (2010): 76M25

1 Introduction

However, the use of water without taking into account its chemical composition and quality assessment can gradually lead to negative consequences for both plants and soil. The Mil-Karabakh Collector (MKC) was built in 1957-1965 to divert drainage water from the reclaimed and developed 155 thousand hectares of irrigated lands of the Mil-Karabakh lowland. The Mil-Karabakh collector with a total length of 152 km and an estimated discharge of 25 $m^3/sec.$ was reconstructed and connected with the Main Mil-Mugan Collector through settlings between the side-hills in the sloping plain along the Kura River.

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The years of natural drought observed in recent years, as well as anthropogenic changes in the flow of the Kura river, are causing serious damage to the national economy, including the agricultural sector. Because drought and lack of irrigation water, the villagers face great difficulties, losing their income from farming.

In times of fresh water shortage, it is often necessary to use unconventional water, i.e. water with excessive consumption of minerals, as an additional source to fill the shortage of irrigation water. Taking into account the use of collector and drainage waters (including well waters) for universal consumption and agriculture in dry years, the natural use of significant water resources is required to the limit. Basically, runoff and drainage waters are used spontaneously without any scientific equipment.

It is necessary to comply with the regulatory requirements for the quality and composition of collector and drainage water used in agriculture. However, in the world science and practice of there is a fairly large experience in the use of high-level drainage and waste water for irrigation of arable land [5, 7] . The are several works (of N.M. Reshetkina, E.I. Chembarisov, M.A. Yakubov, and others [10, 12–13]) devoted to drainage and reuse of waste water for irrigation.

In order to eliminate the water shortage in Azerbaijan, collector-drainage waters are mainly used for growing crops during the growing season.

The Kura-Araz lowland accounts for about 85-90% of the agricultural production of Azerbaijan. The main Mil-Karabakh, main Shirvan, main Mil-Mugan Collectors were built to remove the mineralized water from the fields.

Collector-drainage water accumulates mainly due to the seepage of mineralized water from the Mingachevir reservoir in irrigated fields through the Upper Shirvan and Upper Karabakh canals. Influence of inter-farm main and on-farm canals on the formation of a forming collectot drainage waters is also great Water losses from irrigation canals, mainly in soils, reach 35-40%. Filtered water from canals raises the water level, nourishing it, increasing the volume of water flowing into drains, reservoirs and collectors. At the same time, in Azerbaijan, mineralized waters, observed in the arid climatic zone, due to absorption, cause various degrees of surface degradation, coming to the surface through capillaries. In a number of cases, due to non-compliance with irrigation standards, river waters are discharged into reservoirs, and this is one of the reasons that the water flowing from the Main Mil-Karabakh collector has the low mineral content. The maximum water consumption in collectors, as a rule, is observed during the growing season, during spring and autumn rains.

2 Analysis and discussion

When analyzing and assessing the quality of irrigation water, the amount of salts, pH, anions and cations, microelements, that have special values for plants should be determined. When evaluating irrigation water, five conditions must be taken into account:
- chemical composition of water;
- characteristics of the irrigated product;
- characteristics of soil;
- climate;
- Existing agricultural technology.

It should be noted that the toxic effect of various salts on agricultural products is different. Therefore, the quality of water available for irrigation is assessed in two ways. First, irrigation water should not harm the growth and yield of crops. . Secondly, with irrigation of any degree of mineralization and salinity, there should not be resalizing or soil resalinization

Changes in properties of soil during irrigation with slightly saline water depend on the amount of salts and their physical properties. The mechanical composition of the soil reflects the adsorption of salts and ions in the absorbing complex, which in turn changes the water-physical properties of the soil. Furtheremore the initial chemical composition of the soil also has a great influence on the character of exchange reaction between the salt water and soil. Irrigation of unsalted soil with salted water causes soil salinization. On the other hand, when irrigating salted soils with salted water with good drainage, its salinity can be decreased.

When assessing water consumption for irrigation, it is necessary to take into account total evaporation and precipitation, that are two main characteristics of the climate. The rate of evaporation reaches the maximum amount of salt water that can be given to a given crop in a given soil during the growing season. The intensity of the precipitation is also one of the factors influencing the change in the number of salts when irrigated with salt water. Against the background of heavy short rains, salts are washed out from the surface. For example, if mineralized water has a relatively small detrimental effect on plant development when irrigated in furrows, then plant productivity may decrease when respond irrigated with the same composition and the amount of same rain water [9].

There are a number of methods for determining the quality of water used or intended for irrgation. In our research following the indicators are the largest widespread implementationsion:

I Classification. Irrigation water quality assessment by the degree of mineralization (M) [4];

If according to the accepted gradation

$M \leq 0,5 g/l$ l -the water is completely suitable for irrigation,

$M=0,5\div 2,0$ g/l - is suitable,

$M=2,0\div 5,0$ g/l - is sless suitable

$M>5$ g/l - is not suitable and dangerous for irrigation.

II Classification. Suitability of water for irrigation was studied by N. Stebler and O.A. Otsenka (K) according to the irrigation coefficient proposed by Alekin [1].

In this case, it is recommended to use the formula for determining irrigation coefficient.

If $Na^{+} - CI^{-} \leq 0$, to determine the irrigation coefficient it is rational to use the following formula:

$$K = \frac{288}{5CI^{-}}, \tag{2.1}$$

if $Na' - CI' > 0$, then to determine the irigation coefficient, we offer :

$$K = \frac{288}{Na^{+} + 4CI^{-}}, \tag{2.2}$$

if$K > 18$, the water is completely suitable for irrigation ,

$K = 6 \div 18$- is suitable,

$K = 1,2 \div 6$ -is less suitable

$K < 1,2$- is unsuitable.

III Classification. proposed by A. M. Mozheiko and T.K. Vorotnikov for assessing the quality of irrigation water "in percent of sodium" $(Na\%)$is given by the following formula [6]:

$$(Na\%) = \frac{Na \cdot 100}{Ca^{2+} + Mg^{2+} + Na^{+}}, \tag{2.3}$$

If $Na\% \leq 60\%$, the water is completely suitable for irrigation;

$Na\% = (60 \div 80)\%$ - is less suitable;

$Na\% \geq 80\%$ - is unsuitable .

Thus, high sodium content leads to a large number of soda and salinity in the soil. Depending on the amount of sodium, water can be classified as a fully suitable or unsuitable for use.

IV Classification. Assessment by potential sodium absorption factor (SAR) [3]; In the USA, to assess water by the potential sodium absorption factor, Richards-Gapon ofters:

$$SAR = \frac{Na^+}{\sqrt{\frac{Ca^{2+}+Mg^{2+}}{2}}}, \tag{2.4}$$

If $SAR<10$, there is no chance of soltness formation
$SAR=10\div18$- medium degree, $SAR=10\div18-$ highest degree,
$SAR>26$ m - the danger of the formation of highly saline soils.
V Classification. To assess the quality of water by the percentage of magnesium (Mg%), the following formula is used [10];

$$Mg\% = \frac{Mg^{2+}\cdot 100}{Ca^{2+}+Mg^{2+}}, \tag{2.5}$$

If $Mg\% \leq 50\%$ - the water is suitable for irrigation,
$Mg\% \geq 50\%$, i.e. presence in % in water Mg $_{(Ca^{2+}+Mg^{2+})}$ is more than 50% from the amount, in this case, has negative impact to the soil .
VI Classification. Estimated water quality by estimated salinity (PD) was calculated using the formula proposed by Donsen [14];

$$PD = CI^- + \frac{SO_4{}^{2-}}{2} \tag{2.6}$$

If $PD=3\div15$mg-eq / l , - the water is completely suitable for irrigation;
$PD = (15 \div 20)$ mg-eq / l –is suitable,
$PD > 20$ mg-eq / l – is un suitable.
VII Classification. Another risk factor causing sodium salinity is the amount if *CO* $_3$ *and* HCO $_3$. The presence of bicarbonates in irrigation water plays a major role in calcium deposition and, to a lesser extent, of magnesium in the form of carbonates. It increases the change in the ratio of sodium to total amount of cations in irrigation that leads to sodium danger. In connection with this, a group of weakly alkaline irrigation waters was identified by the Soviet scientists (Kovda, 1946). Eaton uses the term "sodium carbonate residue" (Eaton, 1950) [3, 8, 15]:

$$NaHCO_3 = (CO_3^{2-} + HCO_3^-) - (Ca^{2+} + Mg^{2+}) \tag{2.7}$$

Wilcox (Wilcox, 1958) came to the conclusion if in water
$NaHCO_3 < 1,25$ *mg-eq/l* , the water is completely suitable for irrigation;
$NaHCO_3 = (1,25 \div 2,5)$ *mg-eq/l* – is suitable;
$NaHCO_3 > 2,5$*mg-eq/l* – is unsuitable
Arany (1956) showed that when assessing the effect of sodium carbonate, the type of soil should also be taken into account (the author called it soda equivalent). That is, if the water contains the same amount of sodium carbonate, then for soils with the reaction of medium pH < 7 will improve the soil.

According to Szabolch and Darab, alkalinity equal to 10 mg/l of soda, determined by phenophthalein, indicates the upper limit of soda content in irrigation water.

VIII Classification. To assess water quality by the ratio of salt cations$Na^+/(Ca^{2+} + M^{2+})$ [2];
If
$Na^+/(Ca^{2+} + Mg^{2+}) \leq 1$ - the water is completely suitable for irrigation,
$Na^+/(Ca^{2+} + Mg^{2+}) = (1 \div 4)$ - is suitable
$Na^+/(Ca^{2+} + Mg^{2+}) > 4$ - is unsuitable for irrigation.

A complete water gravity analysis of water 134 samples from the Main Mil-Karabakh collector was carried out and calculated in the form of tables for each classification. Taking into account the volume of the paper, the data are given only in one table.

Table. Water quality assessment of the Main Mil-Karabakh collector according to different classification

Assessment method	Requirements	Suitability of KDS for irrigation by classification	Quantity in %
I classification by mineralization	$M \leq 0,5c/l$ $M=0,5\div2,0c/l$ $M=2,0\div5,0c/l$ $M>5c/l$	Full . Suitable Suitable Less suitable Unsuitable	4.63 56.48 33.33 5.56
II classification : according to the coefficient of irrigation.	$K > 18$ $K = 6 \div 18$ $K = 1,2 \div 6$ $K < 1,2$	Full . Suitable Suitable Less suitable Unsuitable	66.67 30.6 0.93 1.85
III Classification by: Na , in %	$Na\% \leq 60\%$ - $Na\% = (60 \div 80)\%$ $Na\% \geq 80\%$	Full . Suitable Suitable Less suitable Unsuitable	45.45 - 46.36 7.27
IV SAR classification	$SAR<10$ $SAR=10\div18$ $SAR=10\div18$ -	Full . Suitable Suitable Less suitable Unsuitable	67.0 27.84 5.16 -
V In classification by Mg , in %	- $Mg\% \leq 50\%$ - $Mg\% \geq 50\%$	Full . Suitable Suitable Less suitable Unsuitable	14.29 - 85.71 -
VI Classification, according to PD	$PD=3\div15$ $PD = (15 \div 20)$ - $PD > 20$	Full . Suitable Suitable Less suitable Unsuitable	75.0 15.74 - 9.26
VII Classification by alkalinity of water	$NaHCO_3 < 1,25$ $NaHCO_3 =$ $= (1,25 \div 2,5)$ - $NaHCO_3 > 2,5$	Full . Suitable Suitable Less suitable Unsuitable	- one hundred - -
VIII Classification: According to the ratio of salt cations	$Na^+/(Ca^{2+}+Mg^{2+}) \leq 1$ $Na^+/(Ca^{2+}+Mg^{2+}) = (1 \div 4)$ - $Na^+/(Ca^{2+}+Mg^{2+}) > 4$	Full . Suitable Suitable Less suitable Unsuitable	31.78 67.29 - 0.93

The percentage of water suitable for irrigation is presented below as a bar graph.

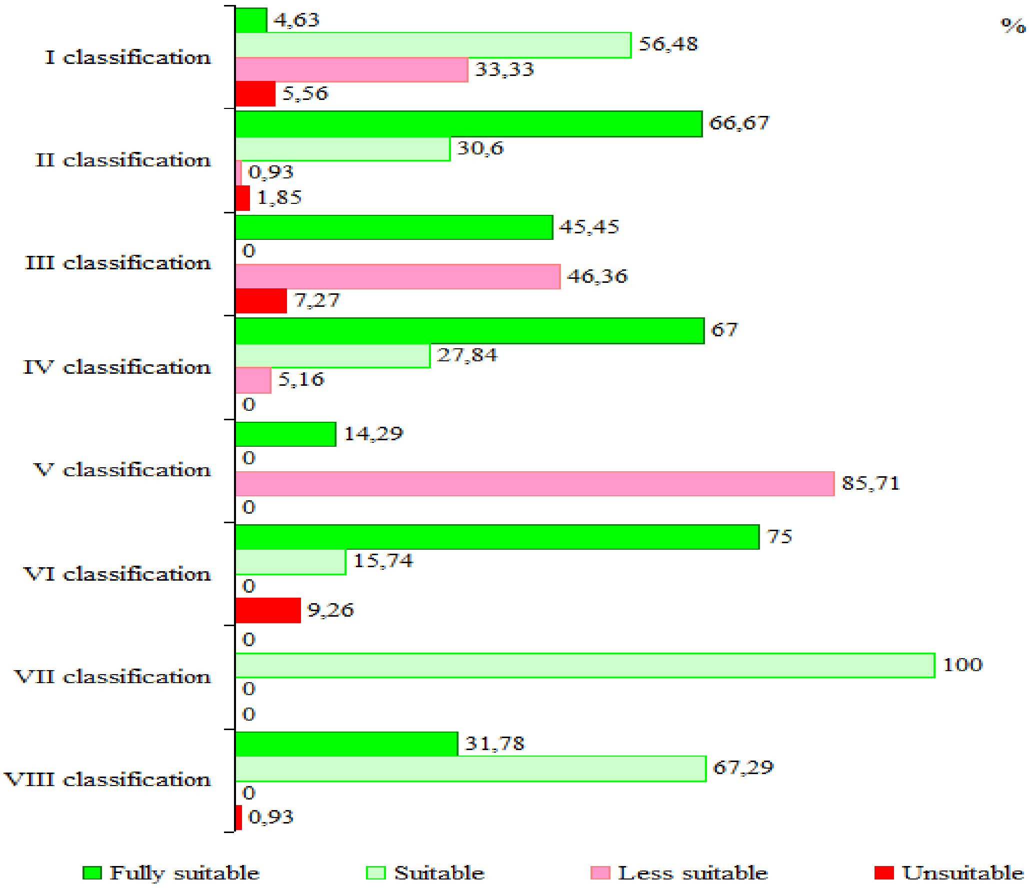

Fig 1. Description of the irrigation water assessment histogram.

As can be seen from the table and figure, the water of the Main Mil-Karabakh collector is completely suitable and suitable for irrigation according to all classifications.

3 Conclusions

- Non-compliance with design indicators due to the lack of treatment, repair and restoration work in the KDS, resulting in a rise in the level of groundwater and soil salinization.
- It has been established that the mineralization of the water of the Main Mil-Karabakh collector is very low. The reason is that as a result of non-compliance with irrigation norms and rules, river waters feed open drains, reservoirs and collectors.
- Studies have shown that about 800 million m^3 of water of the main Mil-Karabakh collector can be used as an additional source to replenish the river water, shortage since its mineralization is in the range (0.4-3.6) g/l.
- If the topographical situation allows, the collector water can be stored in a temporary reservoir (mineralization can be reduced by adding fresh water) and used for land irrigation by gravity or mechanically.

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