Annals of R.S.C.B., ISSN:1583-6258, Vol. 25, Issue 3, 2021, Pages. 2972 - 2980
Received 16 February 2021; Accepted 08 March 2021.

Effective Use of Irrigation Water in Case of Interfarm Canal

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Abstract: This article deals with the problems of large water losses in the "Ak-Yab" canal (Khorezm province, Uzbekistan) for filtration, as well as the factors that prevent this circumstance. At a time when the value of each drop of water is high and there is a shortage of water, the efficient use of irrigation canals to supply the water needed for crops is relevant. As a matter of this study, the assessment of the current state of the canal and the technical condition of the hydraulic structures in it was carried out using the observation methodology and long-term analysis of the collected data on this canal (in-situ). From a scientific point of view, specific proposals and conclusions were given for the repair and construction of the canal and its hydraulic structures. From a practical point of view, on the basis of data on the study of the state of the canal in the field, together with specialists in this field, the priorities for repair, rehabilitation and construction have been determined along the length of the Ak-Yab canal.

Key words. Canal, irrigation, filtration, reconstruction, water metering facility (hydrounit), water flow.

Introduction

In today's contemporary society, 2,800 km^3 of fresh water is annually utilized for agriculture. This is roughly 70% of the world's freshwater consumption, or seven times more than the water used by the world industry. Almost all of this water is used to irrigate crops. According to the International Commission on Irrigation and Drainage, there are 299,488,000 hectares of irrigated land in the world which consume this amount of water [1, 20].

Consumption of water resources at today's pace is leading to its global deficit. The development of new water resources requires large investments in the maintenance of water management systems. The price of each cubic meter of water is nowadays rising, causing problems in the water supply of developing aridic countries. As long as the current water use

model is maintained and water consumption per capita increases, the deficit of water resources will also increase proportionally [2, 21].

One of the approaches to contribute to the solution for the problem of saving water resources in irrigated agriculture is to ensure the efficient operation of irrigation networks in the efficient use of available water resources, by means of the introduction of water-saving irrigation technologies [3, 11, 12, 19]. In the effective use of irrigation networks, as noted above, this work is of great importance at a time when water shortages are increasing. One of the urgent tasks is to mechanize and automate water distribution processes, improve the reclamation of irrigated lands, mechanize production processes, increase the productivity of sustainable agricultural crops from reclaimed lands through the implementation of complex water management measures, and ensure the functioning of irrigation networks.

At the same time, many international and national scientists in Uzbekistan have focused on improving the reclamation of irrigated lands, the rational use of available water resources and the use of biological treatment of collector-drainage water mineralization in times of water shortage, as well as methods of saving irrigation water [4, 5, 7, 8, 9, 10]. A number of scientists have conducted research and achieved high results in monitoring water wastage in irrigation networks in the country, as well as monitoring and repair of hydraulic structures in the canal, the application of water-saving technologies in the field, optimization of hydraulic parameters of canals [8, 12, 13, 14, 17, 22, 23, 24].

Taking into account the views of the above-mentioned scientists, currently exceptionally limited number of investigations and studies have been conducted to study the condition of the canal “Ak-Yab” in Khiva, Khorezm province of Uzbekistan and its hydraulic structures, as well as the effective use of the canal. To ensure the efficient operation of the canal by monitoring, specific measurements and data analyses on the length of the canal, maintenance and restoration, concrete foundation or construction of new subordinary irrigation canals, as well as control and design of hydraulic structures were studied in the analytical field.

Due to the results of limited studies, the technical condition of the Ak-Yab canal and the non-functioning of existing hydraulic structures in the water distribution do not sufficiently function, and besides that, the lack of water intake and metering facilities which leads to high water wastage. It was noted that the use of modern irrigation technologies in the implementation of irrigation in the canal to prevent uneven distribution of water along the length of the canal [15, 16, 18].

Considering all the above, the focus of the research is the development of proposals and recommendations for the repair and restoration of irrigation canals in the case of Khorezm province, in line with specialists and experts in this

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field. The main target of this paper is to analyze the technical condition of the canal and the existing hydraulic structures in it and to determine the priority in the repair or construction of new ones to use them at the required level.

Object of research. Water Users Association, Ak-Yab canal in Khiva District Khorezm province, rehabilitation and construction.

Materials and methods

Khiva district is an administrative unit in Khorezm province of Uzbekistan. The administrative center is the city of Khiva (Figure 1). Khiva district was formed in the 1920s and in 1938 became part of Khorezm province.

Figure 1. Map of the study area

The Ak-Yab canal was put into operation in 1938 in Khiva district. The maximum water delivery capacity of the canal is 12.0 m^3/sec, and 10.0 m^3/sec during normal operation. The total length is 18.5 km (including 1.15 km of concrete tributaries). The main source of water for the Ak-Yab canal is the Polvan main canal.

Methodology

Irrigation water loss was assessed by monitoring the technical condition of 25 hydraulic structures along the length of the Ak-Yab canal (dams, bridges, aqueducts, and water metering facilities). In the course of this research, the assessment of the technical condition of the canal and the hydraulic structures in the canal was carried out by observation. Normative and legal documents on ensuring the safety of hydraulic structures, as well as methods of statistical analysis were used to determine and assess the criteria for the safe operation of the canal and its hydraulic structures.

Additional requirements for a proper methodology development for the canal and its hydraulic structures were assessed by taking into

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account the actual condition of the canal and its hydraulic structures, depending on the function, level of perfection, design features, operating conditions and special requirements for safety. The current research was carried out with the use of software (R studio) to determine the priority of the Ak-Yab canal in terms of demand, prolongation of operation, and assessment of the condition of hydraulic structures, as well as repair or construction.

Results and discussion

Currently, the condition of the canal is not working at the required level, and the need to repair hydraulic structures in the canal is one of the major problems in supplying the required amount of water to crops. The need to rehabilitate the canal under study and the hydraulic structures in it is specific to each farm and will include:

- Preparation of a linear scheme of the canal and hydraulic structures in it (Figure 2);
- Reconstruction, maintenance or construction of a new canal and its hydraulic structures;
- Cleaning the canal from mud;
- Maintenance or construction of water metering structures (hydrounits) in the canal.

According to the observations made in the Ak-Yab canal, it is difficult to manage water in the canal, and the water supply to crops has deteriorated, and it is also arduous to supply water to the irrigated areas at the end of the canal. To prevent the above-mentioned problems, information on the technical and economic performance of the Ak-Yab canal is of great importance, including:

1. Service area: 6,670 ha.
2. Of this, the area connected to the reconstructed part: 3,975 ha, or 59.5 %.
3. The length of the section requiring the repair of the canal: 3,431 km; the existing concrete tributary, according to our research, was 1,405 km, requiring re-concrete coating.
4. The actual water capacity of the canal was 8 m3/sec which covers around 80% of the projected water consumption.

According to the analytical results, the decrease in water permeability was due to the turbidity of the canal. The concentration is that water use was not at the required level.

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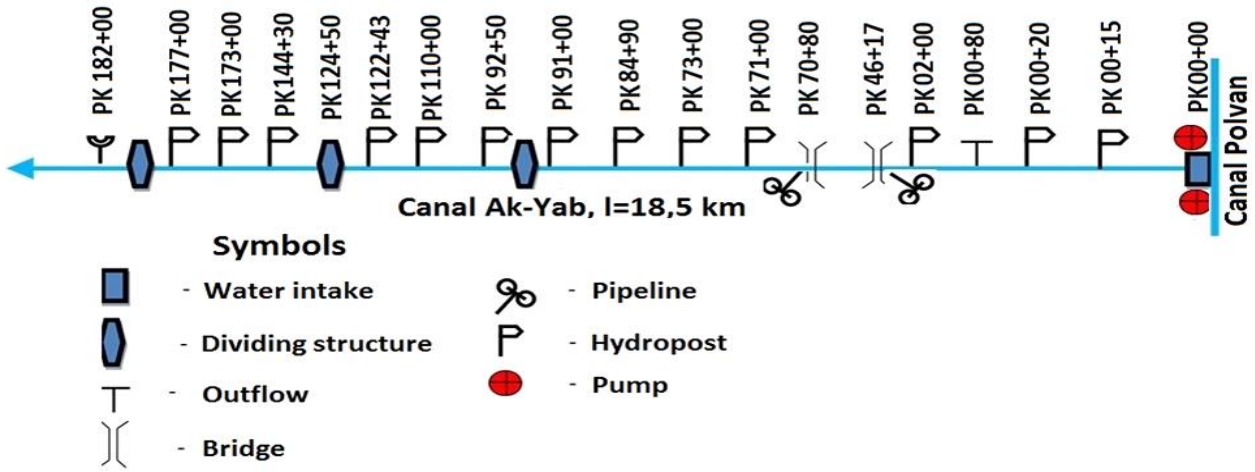

Figure 2. Vertical cross-sectional layout of the Ak-Yab canal

The reconstructed part of the Ak-Yab canal will supply water to 3,975 hectares of land on the territory of the Kenik-Polvon and Boz-Yab Water Consumers Associations (WCA) (Figure 3). The orientation of these WCAs by crop type is based on cotton. The normal water flow capacity of the canal is 5.0 m^3/sec, and the length of the canal is 3,431 km, of which 2,047 km are soil-founded (PK88 + 55 to PK102 + 60 and PK116 + 44 to PK 122 + 86), and 1,384 km (PK102 + 60 to PK 116+). 44) with concrete coating. According to the research output, it is necessary to reconstruct the part of the canal from PK89 + 55 to PK122 + 86.

Figure 3. Overall view of the Ak-Yab canal

The canal was the main source of riverbed modification. Based on the results of the monitoring, it was required to carry out mud removal works in the part of the canal from PK 89

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+ 00 to PK173 + 00.

The hydraulic structures in the canal are outdated and in need of maintenance. The metal equipment of the barrier structure at PK 91 + 44 was unusable and unsafe; the concrete parts were broken. The metal bridge of the hydrounit at PK 92 + 58 was unusable, and the core was not covered with concrete. Moreover, it was observed that there was no water-measuring point. Pedestrian bridges at PK 99 + 52, PK 100 + 40, PK 117 + 40 were built on the basis of craftsmanship, dangerous for the passage of the population.

In view of the above, there is a need to reconstruct the canal, repair existing facilities and build new ones. According to the results of the study, to ameliorate the demand for water of agricultural crops in the Ak-Yab canal network, to increase water efficiency, to improve the operational conditions of the canal, and to accessorize the canal area, it is important to implement the following measures:

1. Cleaning of the canal from 3,431 km of mud;
2. Reconstruction of 1,405 km of the canal;
3. Maintenance of one canal dam;
4. Construction of one water metering station;
5. Build a bridge for three pedestrian crossings.

By implementing the above measures, the waste of water in the canal could be prevented. All of the above activities are carried out through the priority of work performance.

In determining the water consumption, the loss of canal water to the soil at a distance of 1 km is determined by the following formula in accordance with the Construction Standards and Regulations (CSR) of Uzbekistan (No. 2.06.03-97) in soil-drained canals (1):

$$Q_f = 0.0116 \cdot K_f \cdot \mu \cdot (B + 2 \cdot d_c) \quad (1)$$

Where: Q_f - Water consumption per 1 km of absorption, m^3/sec; K_f - canal filtration index, (K_f=0.5 m/day); B - width of the canal along the water surface, m; d_c - depth of the water in the canal, m; μ - indicator depending on the water depth in the canal; the width and slope of the bottom.

The loss of water to the absorption in the concrete part of the canal is determined by the following formula (2):

$$Q_f = 0.0116 \cdot \frac{K_f}{t} \cdot \left[B + t + 2 \cdot d_c \cdot \left(\frac{d_c}{2} + \frac{m_t}{\sqrt{1+m^2}}\right)\right] \cdot \sqrt{1 + m^2} \quad (2)$$

Where: t - concrete coating thickness, m; m - side slope indicator.

As a result of our research, the filtration loss per 1 km of the concrete part of the canal from PK 88 + 55 to PK 102 + 60 was 0.029 m^3/s, from PK 102 + 60 to PK 122 + 86 - 0.058 m^3/sec. Reconstruction has been shown to increase water use by up to 20 % and crop yields by 16 %.

Based on technical and economic indicators and calculations with the help of a R studio, it was determined that the section of the canal from 8.9 km to 12.3 km should be reconstructed.

Conclusion

Based on the research conducted for the operation of the canal and its hydraulic structures at the required level and the supply of the required amount of water to the crop, the followings can be disseminated:

1. As a result of field observations, the technical condition of the canal and its facilities was possibly assessed.

2. The collected data on the observed condition along the canal length were entered into the program and analyzed.

3. Priorities for the repair of the canal length and hydraulic structures in it have been identified and measures were developed to ensure reliable and safe operation.

4. The technical condition of the hydraulic structures in the canal was thoroughly studied from the technical point of view and the causes of the damage were determined by means of calculations through the program.

5. Such recommendations were given for the repair or construction and modernization of the canal and its hydraulic structures.

In particular, the implementation of water-saving irrigation technologies (drip, sprinkler, subirrigation, etc.) is highly encouraged in the irrigation of crops.

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