Science of Law, 2025, No. 3, pp. 144-151
DOI: 10.55284/rrbn6j58

Experiments on Determination of Water Consumption in Case of Free Flow under Gates in Irrigation Networks

Fatxulloyev Alisher[1]*, Gafarova Aziza[2], Hamroqulov Jasur[3], Mamatkulova Lobar[4], G'opporova Zarnigor[5]

[1,2,3]Tashkent Institute of Irrigation and Agricultural Mechanization Engineers" National Research University, Uzbekistan; a.gafarova@tiiame.uz
[4]Termez State University of Engineering and Agrotechnology, Uzbekistan.
[5]Navoi state University of Mining and technologies, Uzbekistan.

Keywords:
Consumption coefficient,
Digital technology,
Field research,
Free flow,
Irrigation networks,
Laboratory tests,
Mobile application,
Water consumption.

Abstract. Efficient use of water resources and their accurate accounting are among the most important tasks in irrigation networks. In particular, accurate measurement of water flow through gates (sluices) in water distribution on the scale of irrigated fields remains an urgent problem. In this regard, determining the flow coefficient *(μ)* when water flows freely under the gate is of great importance. Since μ varies depending on the variable hydraulic parameters such as the gate opening height *(h)*, the water level in the upper reaches (*H*), the compressibility, and velocity coefficients. Although μ is given in the literature in a number of intermediate values, it has been found that using it as a constant number in field and laboratory tests leads to significant errors. The main hydraulic parameters of the flow under the gates were determined in laboratory conditions, taking into account different opening heights *(h)* and head at the upstream *(H)*. Then, the experiments were re-checked in field conditions and compared with the available hydro post data. As a result, a method for determining *μ* was developed to determine the water flow at any opening height (i.e., when the ratio *α*/*H* is different). This method provides high accuracy in determining the water flow compared to other similar formulas. The study also introduced digital technologies, and a mobile application for smartphones was created. This mobile application allows you to quickly determine the value of *μ* and calculate water consumption based on the gate opening height and upstream water flow. By entering the gate width *(b)*, opening height *(h)*, and *H* values, you can get results within seconds. Thus, the water distribution process will be faster, less expensive, and a fair relationship between farmers and water authorities will be ensured.

1. INTRODUCTION

The rational use of water resources, their accurate monitoring and planned allocation remain one of the priorities of the world, as agriculture accounts for the largest share of water consumption in many countries (70-80 percent) and water resources are becoming increasingly limited due to climate change [United Nations. 2015; IPCC. 2022].

The "Clean Water and Sanitation" area (SDG 6) of the United Nations Sustainable Development Goals aims to introduce integrated water resources management and increase water efficiency indicators by 2030 [FAO. 2017]. Therefore, many countries are implementing large-scale reforms to modernize irrigation systems, establish water allocation and monitoring based on modern digital technologies [Crabbe A D. 2019].

In Uzbekistan, this issue has also been identified as a priority area of state policy, and a number of legal and policy documents have been adopted to optimize water consumption in irrigation networks, introduce water-saving technologies and digital methods. In particular, the "Uzbekistan-2030 Strategy" (Presidential Decree Uzbekistan No. UP-158) stipulates the widespread introduction of digital technologies in the field of irrigation, the provision of privileges for farms in monitoring water flow, accounting for water resources and periodic monitoring. At the same time, scientists who have studied the hydraulics of this process have determined the main parameters of water flow for the effective use of locks, including the compression coefficient *(ε)*, the velocity coefficient *(φ)* and the resulting total flow coefficient *μ* [Conrad C, Dubovyk O. 2020].

Many studies have shown that μ cannot be taken as a constant number due to the influence of several factors such as the opening height (a) and the water level at the top (H) when water flows under the gates [Andersen V M. 2020, Danel P F. 2021]. Therefore, there is a need to accurately measure the water flow using gates in internal irrigation networks, recalibrate them, and take into account complex hydraulic processes depending on the opening height [Andersen V M. 2020].

In practice, gates are often used only for water distribution, but the theoretical foundations for assessing the compression regime, head conditions, and velocity regimes to perform the function of an accurate water meter are not always fully taken into account. In particular, the coefficients determined in the laboratory may vary slightly in the field due to turbidity, fine sediments, and other factors in irrigation networks [Alisher Fatxulloyev et al., 2021]. In this regard, improving the mechanisms for accurate water flow measurement using gates in our country will increase water management, as farmers can accurately calculate the flow based on online monitoring of the equipment they have at their disposal without installing additional hydraulic structures [Alisher Fatxulloyev et al., 2021; Fatxulloyev A.M. et al., 2023].

At the same time, the "Concept of Water Management Development (2020–2030)", approved by Presidential Decree No. PP–6024, provides for the widespread introduction of digital technologies in irrigation systems and the provision of preferences to farmers using water metering devices, which further strengthens the political will in this regard. A number of studies have shown that when accurately measuring water flow through gates, the flow coefficient *(μ)* can increase or decrease by 5–10 percent when the opening height *(φ)* and water level *(H)* ratio *(a/H)* are different, indicating that it is necessary to adopt the

*Corresponding author.

coefficient in a dynamically changing form for each gate installation [Alisher Fatkhulloev et al., 2020; Andersen V M. 2020, Alisher Fatxulloyev et al., 2021; Alisher Fatxulloyev et al., 2023]. Thus, the conclusion of these studies is that the accurate measurement of water consumption with the help of gates in irrigation internal networks requires not only hydraulic principles, but also the integration of digital tools, which at the same time is important for saving water resources, regulating the accounting system, and ensuring the transparency of the water distribution process. Thus, re-adaptation of existing dams, creation of special programs and preparation of simplified applications for farmers is one of the urgent tasks facing the irrigation sector.

2. MATERIALS AND METHODS

Experimental studies on the study of water flow under flat gates were carried out in the Hydrology Laboratory of "Tashkent Institute of Irrigation and Agricultural Mechanization Engineers" National Research University (NRU "TIIAME") [Chow W T. 1959; Andersen V M. 2020, Alisher Fatkhulloev et al., 2020; Alisher Fatxulloyev et al., 2021; European Commission. 2021; A M Arifjanov et al., 2022; Anvar Sherov et al., 2022; Alisher Fatxulloyev et al., 2023; Martina Zeleňáková et al., 2025].

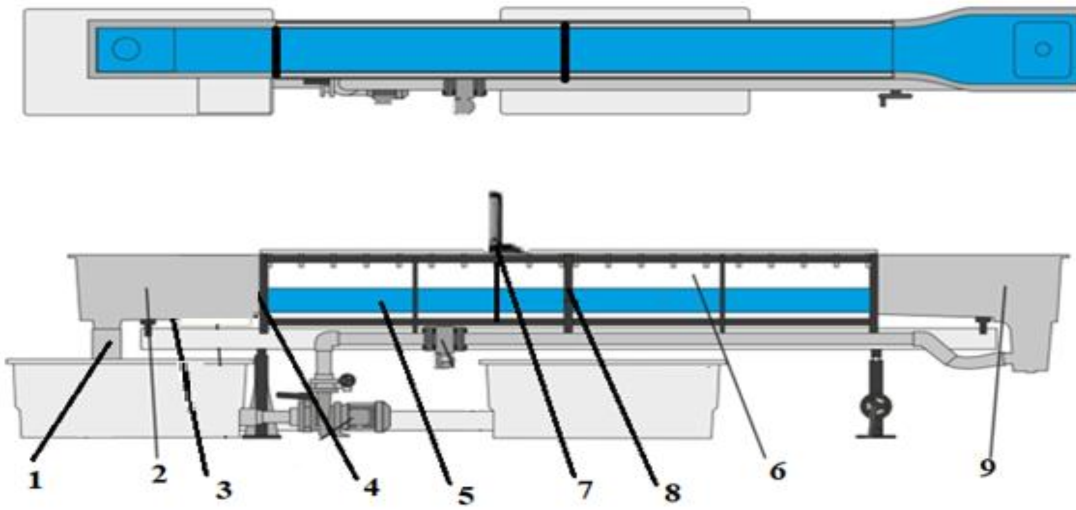

Figure 1: Calculation scheme of the experimental device.

The hydrometric trough consists of a water inlet-1, a second culvert with a settling block-3, a second culvert the Cippoletti Trapezoidal Weir (TCTW-30)-4, a settling block-5, a rectangular mirror trough with a length of 15.0 m-6, a needle rail for monitoring the water level-7, a flat gate (gate) with dimensions *b=0.35 m*, *h=0.4 m* and a threshold height *δ =0.003 m*-8, and a water outlet-9. To reduce the error in determining the water flow, the water flow flowing through the control culvert (TCTW-30) was calibrated by repeated volumetric measurements (Figure 1:).

The experiments were conducted in all cases with hydraulic processes in the outflow of water from a flat gate, i.e., upstream of the gate, in the Froude number range (*Fr=0.6-0.7*), with flow conditions not being buried . Gate opening height $a = \mathbf{0,015-0,045}$ was carried out at different water consumptions in the interval. The purpose of the research is to determine the coefficient of consumption in the unburied state according to the height of the opening of the gate *a,* the pressure *H* at the top of the gate and the state of the connection of the gates [Aybek Arifjanov and Alisher Fatxullaev 2019; Andersen V M. 2020, Alisher Fatkhulloev et al., 2020; Alisher Fatxulloyev et al., 2021; Aybek Arifjanov et al., 2023; Alisher Fatxulloyev et al., 2023].

The study involves studying the process of accurately measuring water flow through gates in irrigation internal networks in laboratory and field conditions, as well as developing practical solutions based on digital technologies. First, hydraulic trays equipped with flat gates were analyzed in laboratory conditions, where the water flow was determined by comparison with a reference meter (waterfall and ultrasonic sensor) [Andersen V M. 2020; Alisher Fatxulloyev et al., 2021; Fathullaev A.M. et al., 2023]. The opening height *(a)*, water level *(H)*, gate width *(b)* and flow regime were recorded as the main variables, and in each case the practically measured Q_T value was compared with the theoretical $Q = \mu ab\sqrt{2g(H-\varepsilon a)}$ [Alisher Fatxulloev, Aziza Gafarova. 2019; Andersen V M. 2020; Alisher Fatxulloyev et al, 2021; Fatxulloyev A.M. et al., 2023]. The consumption coefficient was calculated $\mu_{\text{т}}$ for each experimental condition $\mu_{\text{т}} = \frac{Q}{ab\sqrt{2gH}}$using the means, and using regression methods $\mu_{\text{т}} = f\left(\frac{a}{H}\right)$ [Alisher Fatxulloev, Aziza Gafarova. 2019; A Fatxulloyev et al., 2020; Andersen V M. 2020; Danel P F. 2021; Fatxulloyev A.M. et al., 2023; Saydulla Khushvaktov et al., 2024]. Later, measurements were repeated in field conditions, that is, at the sluice gates of the internal channels of the water-receiving household networks on the Tashkent and Fergana main canals.

The purpose of experiments in natural field conditions is to compare and verify the results obtained in experimental conditions in real conditions. In field measurements, Q_T was determined based on data from portable radars, GR-21 type turntables, and existing water meter posts, and at the same time, it was compared with Q_d using a formula developed based on laboratory studies [Fatxulloyev A.M. et al., 2018; A Fatxulloyev et al., 2020; A.Fatkhulloev et al., 2023]. In this case, several experiments were conducted in the range from the minimum opening of the gate to the maximum opening and studied its dependence on the flow coefficient. To increase the speed of the measurement process, a mobile application was developed for the Android platform. All laboratory and field data were checked through statistical analysis, and regression coefficients and errors were estimated; When analyzed using AR, MA, and regression diagnostics, the difference between experimental and field studies was considered reliable, not exceeding 5% [Crabbe A D. 2019; A Fatxulloyev et al., 2020; Fatxulloyev A.M. et al., 2023]. Thus, in this study, as a general approach, an accurate water consumption measurement mechanism was created by validating empirical formulas developed in laboratory conditions using flat shutters in field conditions.

3. RESULT AND DISCUSSION

3.1. Laboratory Results and Modeling

In order to accurately measure the water flow in laboratory conditions, several experiments were conducted on a hydraulic tray equipped with a flat gate adapted for an irrigation system. To increase the accuracy of water flow measurement, various water measurement devices were used, namely a weir, a portable ultrasonic sensor and a modern radar.

During each experiment, the gate opening height*, a (m)* and the water level at the upper edge, *H (m)*, were repeatedly measured, and the experimental data Q_T (l/s) were recorded using reference equipment. Although the flow coefficient was determined experimentally, its value varies significantly under the influence of various conditions and hydraulic processes. Therefore, it is necessary to develop separate connections for different hydraulic processes, namely, unburied and buried cases, in natural field conditions. Based on the experiments conducted, the flow rate coefficient was determined to be a dimensionless quantity $(\frac{a}{H})$, which is related to the flow regime *(Re),* energy state *(Fr),* and other hydrometric elements (Figure 2-4:).

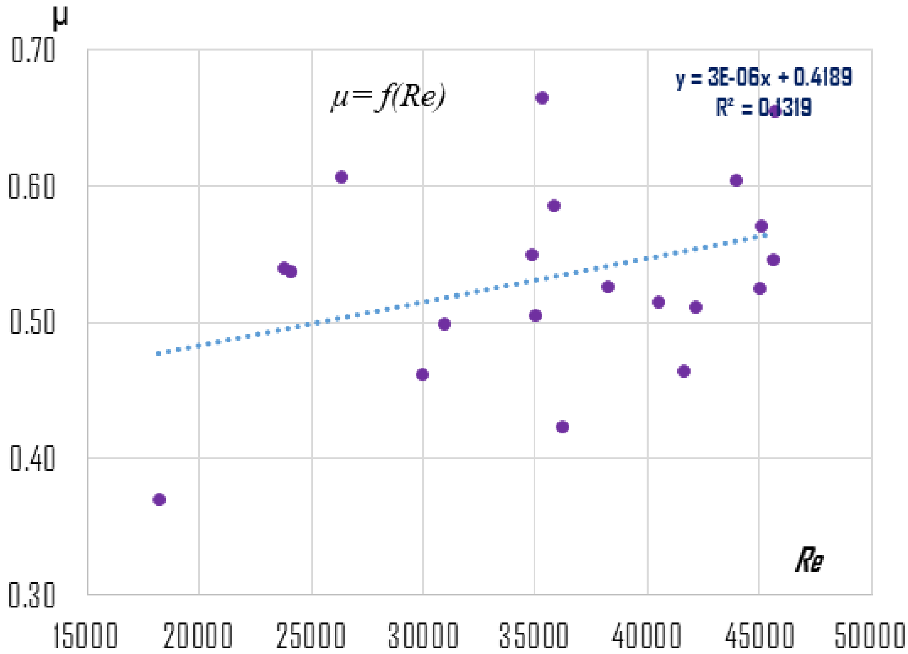

Figure 2:

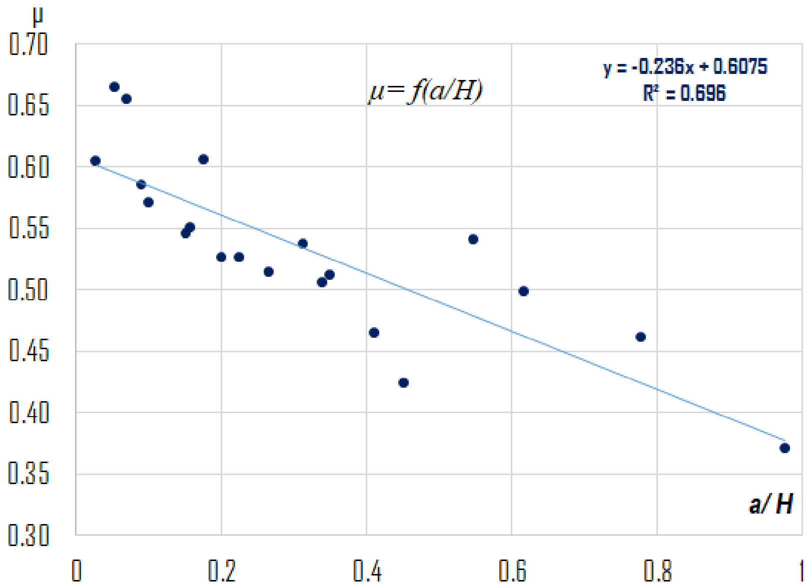

Figure 3:

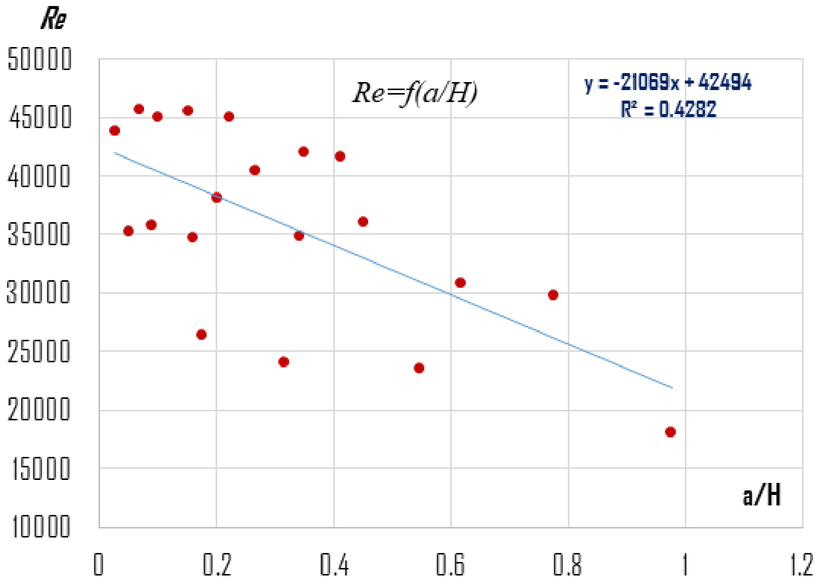

Figure 4:

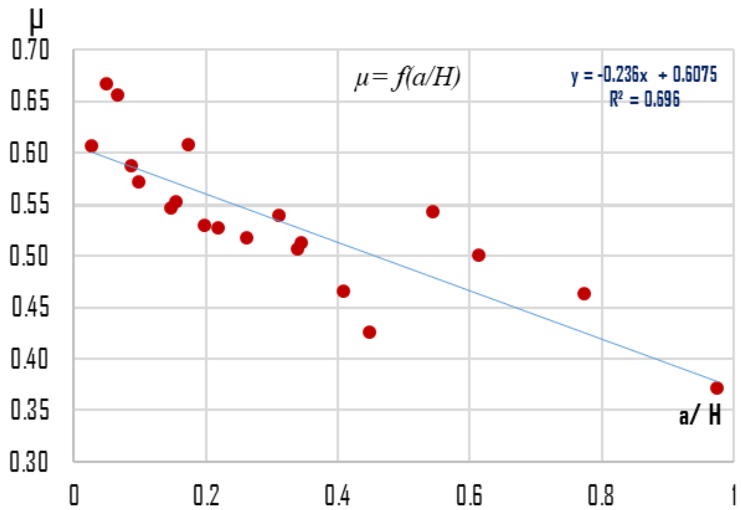

Figure 5:

The experimental results show that the flow rate of water under the gate is almost independent of the flow regime. The experiments were conducted in the range of *Re=18000-46000,* and the dependence of the flow coefficient on *μ= f (Re)* was found to be relatively small, $R^2=0.13$. The energy state of the flow, in the range of *Fr=0.27-0.85*, shows a linear relationship between *μ=f(Re)* and $R^2=0.99$.

Also, the main goal of the study is to determine the dissipation factor under experimental conditions in the case of free flow of current through flat gates, taking into account the dependence of the dissipation factor on dimensionless quantities, and the relationships $Re=f(\frac{a}{H})$, $Fr=f(\frac{a}{H})$ and $\mu=f(\frac{a}{H})$.

The experimental results show that $\frac{a}{H}$ the relationship between the movement mode and is very small, the correlation coefficient is $R^2=0.42$. Data analysis shows that the relationship between the consumption coefficient and the energy state of the flow with the adopted dimensionless quantity is at the required level. Thus, $\frac{a}{H}$ the correlation coefficient of $Fr=f(\frac{a}{H})$ *is* $R^2=0.65$ and the correlation coefficient of $\mu=f(\frac{a}{H})$ is $R^2=0.7$, which indicates the reliability of the experimental results. In order to ensure the reliability of the obtained results, field tests were carried out.

Field studies were conducted on water intake structures and irrigation networks from the Tashkent Main Canal, Khandam Main Canal in the Tashkent region, and the Big Fergana Main Canal in the Fergana region. Field studies were conducted on irrigation networks located in various geographical conditions of the Republic of Uzbekistan. Acceptance of these areas as a research object directly consists in taking into account the influence of different operating conditions, diversity of the composition of river flows, soil conditions and other indicators.

The field research method was conducted in accordance with the experimental method.

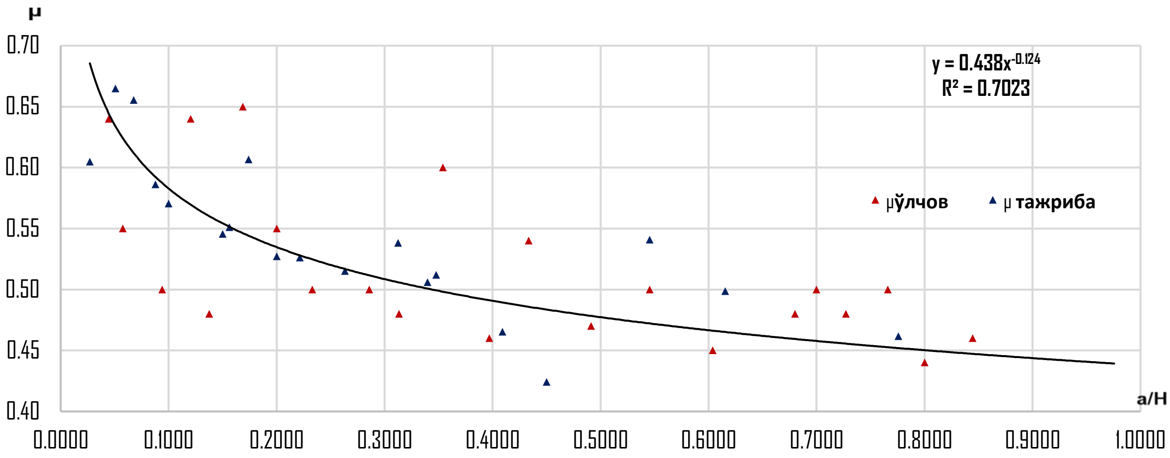

Figure 6: Comparison chart of laboratory and field experiments at the water intake point PK 223+39 of the Nau irrigation network

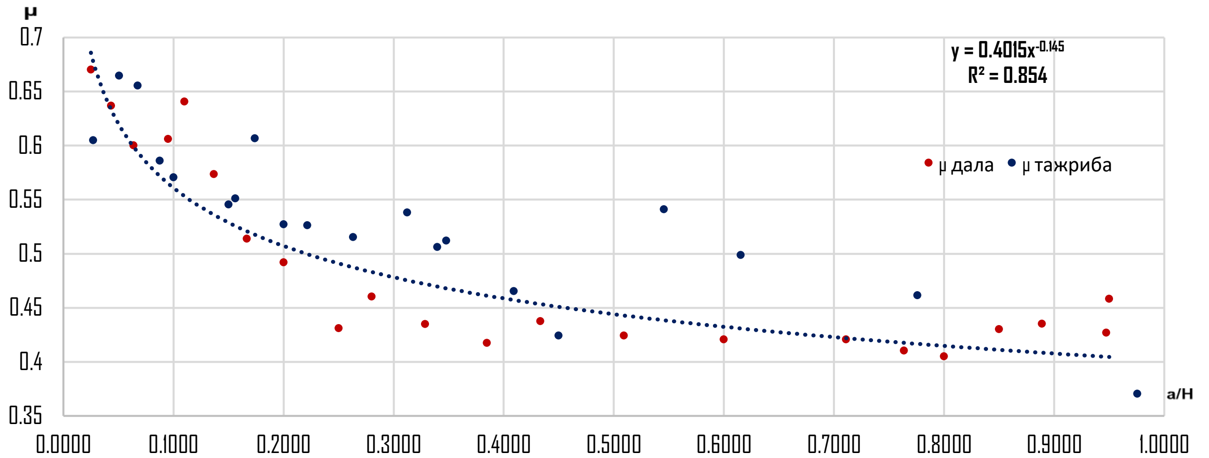

Figure 7: Comparison chart of laboratory and field experiments at the PK 2036+15 water intake of the Middle Kurgan irrigation network.

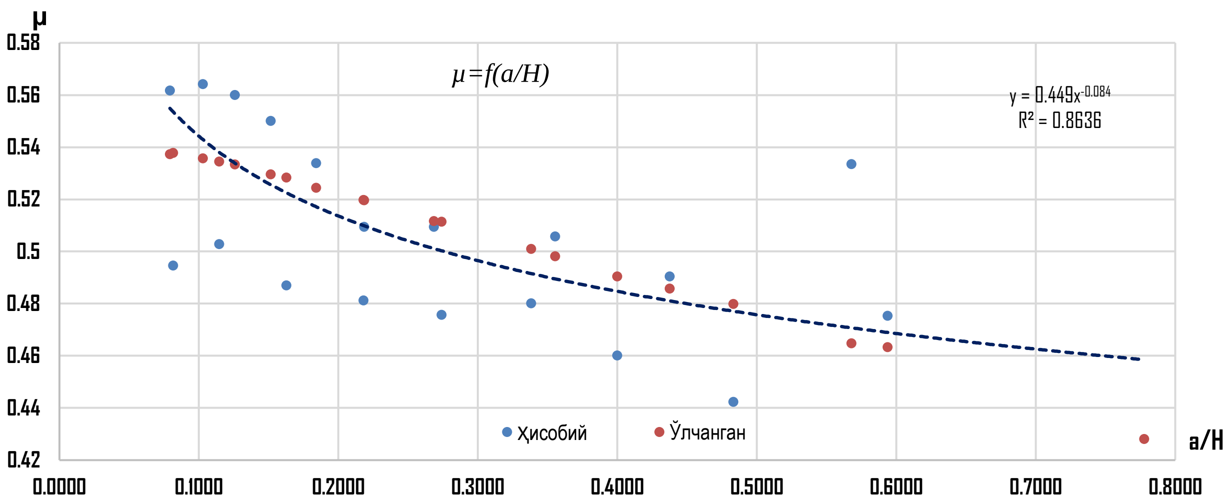

Figure 8: Graph of the change in the discharge coefficient of the Sangra Canal intake as a function of the ratio a/H.

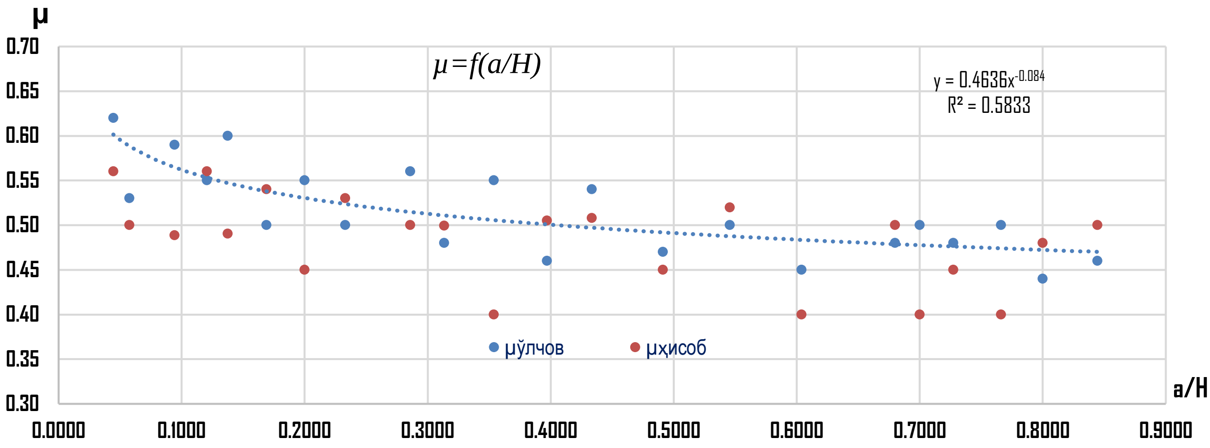

Figure 9: Graph of the change in the flow coefficient at the water intake point PK 223+39 of the Nau irrigation network depending on the ratio a/H

3.2. Experimental Data and Statistical Analysis

Based on experimental data obtained in laboratory conditions, the relative difference between the theoretical model and the practically measured Q_t was observed in the range of 3–5%. According to the data shown in the graphs (Figure 2-5:), the determined consumption coefficient μ for each experimental point was determined by the following formula:

$$\mu = \frac{Q}{ba\sqrt{2gH}}$$

The experiment according to the regression analysis, $\frac{a}{H}$ and μ showed a high correlation between the correlation coefficient $R^2 = 0.93$ in graph 2 equal to , which means that the model is 93% accurate and the statistical reliability of the relationship between the theoretically calculated data and the experimentally measured data is high.

Experiments conducted on the Tashkent and Big Fergana canals, the difference in the gate opening position was up to 7% at small opening, and at medium opening, the difference was 3-4%. Figure 2: laboratory and field conditions$\frac{a}{H}$ and μcompared the relationship between and its correlation coefficient $R^2$is 0.88 These results, when compared with various studies [Hager WH. 2010; United Nations. 2015; Conrad C, Dubovyk O. 2020], confirm that the model is consistent with general trends and that dynamic calibration to local conditions is required.

In global studies, for example, in the models proposed by Chow [Chow W T.1959] and Danel [Andersen V M. 2020; Danel P F. 2021; Fatxulloyev A.M. et al., 2023;., $\frac{a}{H}$ the dynamic change associated with the ratio of the expenditure coefficient is assumed to be in the range of 0.60–0.75. In the experimental data we obtained, the values μ also ranged from approximately 0.59 to 0.73, which reflects the compliance of the model with global trends. This indicates a high μcorrelation between theoretical and experimental data and ensures the scientific reliability of the model.

Compared with data calculated based on global models, due to the influence of hydraulic processes in local conditions, $\frac{a}{H}$ There were very small differences (3-7%) in the values developed μ by the ratio. One of the important advantages of this model is the ability to accurately calculate and control water flow in irrigation internal networks equipped with flat gates.

Based on the results of the above experimental and field studies, the following formula was developed to determine the flow rate of water flowing under flat gates:

$$\mathrm{Q} = \frac{0{,}44\ ab\sqrt{2gH}}{(\frac{a}{H})^{0{,}12}}$$

This connection allows you to determine the flow rate corresponding to the opening state of the flat gate. In practice, adopting the same flow rate for all cases leads to a large amount of error. In order to widely and conveniently use these methods in practice, a mobile application has been developed, in which, based on the input of controlled parameters of the flat gate, namely the gate opening height and the corresponding water level at the upper level, the software automatically determines the flow rate and allows you to directly calculate the water flow.

The fact that the results of experimental studies conducted in laboratory conditions and field conditions are ±3-4% when compared with the results of real hydroposts indicates that this method is effective in practice.

To simplify the calculation process for users, a mobile application has been created to determine water consumption using flat gates (Certificate DGU 31015, 2024) [Fatxulloyev A.M. et al., 2018; Fathullaev A.M. et al., 2023].

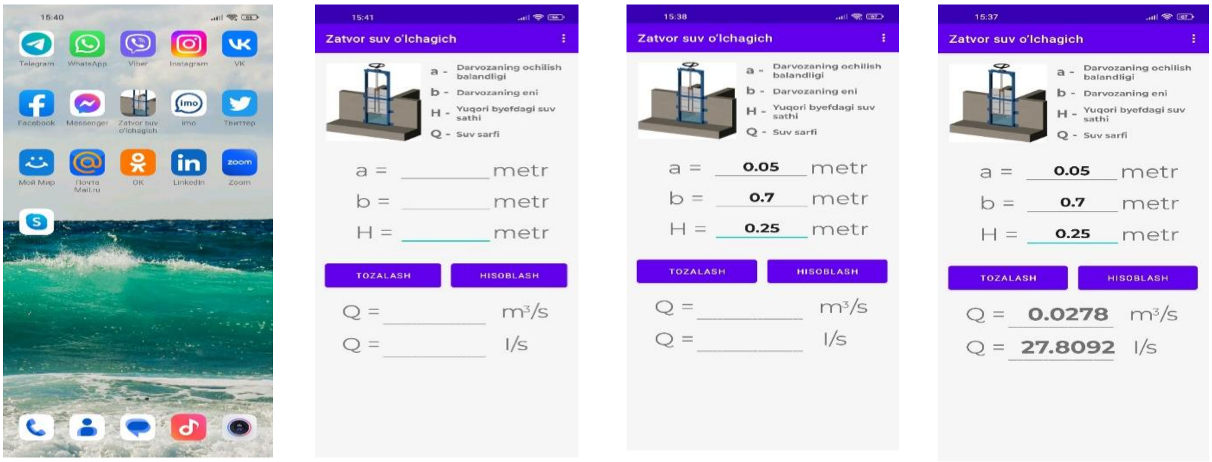

Figure 10: How to use the mobile application.

Through this mobile application, the user a can directly measure water consumption by automatically calculating the flow rate by entering basic parameters such as the gate opening height and water level H. One of the main advantages of the mobile application is that it saves users time and ensures high accuracy of the calculation process by automating the calculation.

The application allows for automatic calculation of dynamic calibration and correction coefficients, taking into account various operating conditions and local dynamic changes in the objects. This method avoids the adoption of the same flow rate for each object, and at the same time significantly increases its accuracy and speed. Also, the technological solutions of the mobile application are consistent with modern scientific methods, and its results reflect common trends with models proposed in global studies (for example, Chow, Danel, Andersen) [Chow W T.1959; Hager WH. 2010; Andersen V M. 2020; Danel P F. 2021].

This approach plays an important role in ensuring technical and economic efficiency in rational management and calculation of water resources in irrigation networks.

4. CONCLUSION

In this study, a method for accurately measuring water discharge through flat gates was extensively studied in laboratory and field conditions. Each experiment μaimed to determine the discharge coefficient based on various hydraulic parameters, namely the gate opening height and the water level at the upper level. The relative difference between the theoretical model and the experimentally measured values in the laboratory conditions was at the level of 3-5%, reflecting the statistical reliability of the model.

The R^2 coefficient obtained through graphical analysis was 0.93, demonstrating a high correlation between theoretical and practical results. When compared with the models proposed in global scientific studies, for example, by Chow [Chow W T.1959; Andersen V M. 2020] and Danel [Altuinin V S. 2018; Andersen V M. 2020; Danel P F. 2021], the dynamic change of the discharge coefficient determined in this study was accepted in the range of approximately 0.60−0.75, indicating that this model works in accordance with global trends. The modernity and relevance of this model are ensured by the results of experimental data and statistical analysis.

In general, the scientific results of the research indicate that the model is compatible with global trends, the possibility of accurate measurement through modern technologies, and highly reliable results are obtained. This model is important in providing accurate and reliable monitoring of irrigation facilities by introducing dynamic calibration and correction coefficients suitable for local operating conditions.

REFERENCES

Fatxulloyev, A., Gafarova, A., Otakhonov, M., & Allayorov, D. (2020). The hydraulic efficiency of the soil channels. *IOP Conference Series: Materials Science and Engineering, 883*, 012042. https://doi.org/10.1088/1757-899X/883/1/012042

Fatxulloyev, A., Abduraimova, D., Otakhonov, M., Atakulov, D., & Samiev, L. (2020). Method designing of open drainages. *IOP Conference Series: Materials Science and Engineering, 883*, 012047. https://doi.org/10.1088/1757-899X/883/1/012047

Fatxulloyev, A., Allayorov, D., & Otakhonov, M. (2020). Study of hydraulic parameters for concreting channels. *IOP Conference Series: Earth and Environmental Science, 614*, 012054. https://doi.org/10.1088/1755-1315/614/1/012054

Arifjanov, A. M., Fatxulloyev, A. M., Rakhimov, K. T., Otakhonov, M. Y., & Allayorov, D. Sh. (2022). Changes in hydraulic parameters in canals with sides lining. *IOP Conference Series: Earth and Environmental Science, 1112*, 012129. https://doi.org/10.1088/1755-1315/1112/1/012129

Fatkhulloev, A., Otakhanov, M., Khoshimov, A., & Bakhromova, D. (2023). Calculation of release time of water in soil layer. *E3S Web of Conferences, 401*, 01037. https://doi.org/10.1051/e3sconf/202340101037

Fatkhulloev, A., Gafarova, A., & Hamraqulov, J. (2020). The importance of mobile applications in the use of standard water measurements. In *2019 International Conference on Information Science and Communications Technologies (ICISCT)* (p. 9011816). IEEE. https://doi.org/10.1109/ICISCT47635.2019.9011816

Fatxulloev, A., & Gafarova, A. (2019). Study of the process of cultivation in soil fertile irrigation canals. *E3S Web of Conferences, 97*, 05025. https://doi.org/10.1051/e3sconf/20199705025

Fatxulloyev, A., Gafarova, A., & Hamroqulov, J. (2021). Improvement of water accounting for irrigation systems. *IOP Conference Series: Materials Science and Engineering, 1030*, 012145. https://doi.org/10.1088/1757-899X/1030/1/012145

Fatxulloyev, A., Gafarova, A., & Hamroqulov, J. (2021). Experimental studies of determining the discharge coefficient of hydro gates. *E3S Web of Conferences, 264*, 03050. https://doi.org/10.1051/e3sconf/202126403050

Fatxulloyev, A., Rakhimov, Q., Allayorov, D., Samiev, L., & Otakhonov, M. (2023). Calculation of effective hydraulic parameters of concrete irrigation canals. *Journal of Water and Land Development, 56*(I–III), 14–20. https://doi.org/10.24425/jwld.2023.143739

Sherov, A., Gafarova, A., & Xasanov, A. (2022). Mathematical modelling of unstable slow-moving water flow in South Mirzachul main channel. *AIP Conference Proceedings, 2432*, 040029. https://doi.org/10.1063/5.0091272

Arifjanov, A., & Fatxullaev, A. (2019). Natural studies for forming stable channel sections. *Journal of Physics: Conference Series, 1425*, 012025. https://doi.org/10.1088/1742-6596/1425/1/012025

Arifjanov, A., Fatxulloyev, A., Khujaev, I., Gafarova, A., & Allayorov, D. (2023). Model for calculating the hydraulic parameters of channels with a dynamically stable section. *E3S Web of Conferences, 365*, 03018. https://doi.org/10.1051/e3sconf/202336503018

Zeleňáková, M., Arifjanov, A., Abd-Elhamid, H. F., Gergeľová, M. B., Fatxulloyev, A., & Allayorov, D. (2025). The effect of lining hydraulic properties on the efficiency and cost of irrigation canal reconstruction. *Water Resources Management*. https://doi.org/10.1007/s11269-025-04218-2

Khushvaktov, S., Djumanov, J., Anorboev, E., Mamirov, F., Abdullaev, B., Gafforova, M., & Gafarova, A. (2024). Some aspects of automation of water consumption accounting. *BIO Web of Conferences, 141*, 03021. https://doi.org/10.1051/bioconf/202414103021

Fatxulloyev, A. M., Gafarova, A. I., Allayorov, D. Sh., & Hamroqulov, J. S. (2023). Experimental investigation of flow under sluice gates. *Central Asian Journal of Theoretical and Applied Sciences, 4*(10). https://cajotas.centralasianstudies.org

Altuinin, V. S. (2018). *Water measurement devices in irrigation networks*. Kolos.

Chow, V. T. (1959). *Open-channel hydraulics*. McGraw-Hill.

European Commission. (2021). *Research and innovation in sustainable water management: Horizon 2020*. European Commission.

FAO. (2017). *Water for sustainable food and agriculture*. FAO.

Hager, W. H. (2010). Hydraulics of submerged weirs and gates. *Journal of Hydraulic Engineering, 136*(11), 928–931.

IPCC. (2022). *Climate change 2022: Impacts, adaptation and vulnerability*. Cambridge University Press.

United Nations. (2015). *Sustainable development goals: Goal 6 – Clean water and sanitation*. United Nations.

Andersen, V. M. (2020). Analytical modeling of flow below vertical sluice gates. *Irrigation Science, 40*(2), 89–102.

Andersen, V. M. (2020). Design of weirs and gates in irrigation canals. *Agricultural Water Management, 125*, 118–124.

Conrad, C., & Dubovyk, O. (2020). Smart irrigation technologies in arid regions. *Environmental Modeling & Software, 123*, 19–29.

Crabbe, A. D. (2019). Innovative approaches to irrigation channel flow measurement. *Journal of Irrigation Engineering, 35*(2), 45–53.

Danel, P. F. (2021). Flow under sluice gates: A new empirical approach. *Water Journal, 58*(4), 205–216.

Fathullaev, A. M., Gafarova, A. I., Hamrokulov, J. S., & Allayorov, D. Sh. (2023). *Closed water meter* (Software Certificate No. DGU 31015). Ministry of Justice of the Republic of Uzbekistan.

Fatxulloyev, A. M., Gafarova, A. I., & Hamroqulov, J. (2018). *Program for calculating water consumption of Thomson and Cipoletti water culverts* (Software Certificate No. DGU 05908). Ministry of Justice of the Republic of Uzbekistan.

Fatxulloyev, A. M., Gafarova, A. I., & Hamroqulov, J. S. (2023). *Program for calculating water consumption in hydro melioration systems* (Software Certificate No. DGU 31014). Ministry of Justice of the Republic of Uzbekistan.