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Determination Of Hydraulic Resistance Under Regulated Flow Conditions Of A River Channel

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Abstract: This article covers the problem of determining the hydraulic resistance of the water flow under regulated channel conditions in the lower reaches of the Amu Darya River. New empirical relationships have been developed based on the relationship between morphological changes in the riverbed, water discharge, flow velocity, and channel roughness. In the study, field observation data for the Tuyamuyun, Kipchak, Nietbaytas, Samanbay, and Kyzylzhar hydroposts were analyzed, and the relationship between water discharge and average velocity was determined based on formula (13). The results showed that with an increase in water discharge, the channel roughness decreases and the hydraulic resistance of the flow changes accordingly. The practical values of the calculated Shezi coefficient and the Darcy coefficient were determined, and their influence on the kinematic parameters of the flow was assessed. The obtained results are recommended for use in the design of water management facilities and in the refinement of hydraulic calculations in regulated channels.

Keywords: Amudarya, hydraulic resistance, Chezy coefficient, water discharge, hydropost, channel roughness, empirical dependence.

Introduction: Currently, the need for water resources is growing in various sectors of the national economy, including irrigation, energy, and others. This process leads to a rapid increase in water intake from rivers and, as a result, a tendency towards a decrease in the volume of annual water flow. Such changes in the water balance prompt humanity to seriously consider the need for rational and careful use of water resources. Therefore, the problem of accurate accounting of water flow in rivers and the correct assessment of the hydraulic parameters of water flows and channels is of current scientific and practical importance.

When studying riverbeds and water flow in them, water discharge measurements are usually carried out in straight-line and hydraulically stable sections. Since in such sections the depth and cross-sectional area do not have significant changes along the length, the flow movement can be conventionally considered uniform. This, in turn, theoretically simplifies the problem of determining the hydraulic resistance of the channel and facilitates the application of calculation models.

METHOD

Field observations, hydrological archival data, and satellite imagery were used for the research. For each hydropost, data on long-term water discharge, water level, and average velocity were analyzed. The main morphometric indicators of the channel - width, depth, and slope - were determined as a result of measurements.

Processing and analysis of empirical data were carried out in the Microsoft Excel program. The Darcy-Weisbach and Chezy formulas were used to determine the hydraulic parameters of the water flow. Based on the relationship between water discharge and average velocity (formula 13), the proportionality coefficient (K) and degree indicator (m) were determined by separate regression analysis for each hydropost.

Also, the interaction of channel roughness, hydraulic radius, and Chezy coefficient was analyzed, and their relationship with hydraulic resistance (λ) was clarified. The calculated results were compared with the data of actual water consumption measured in field conditions, and the accuracy of the developed empirical relationships was assessed.

RESULTS

One of the main problems of river hydraulics is the determination of the average water flow velocity. This velocity is determined depending on the geometric shape of the channel, its roughness, water density, and interaction with silt deposits. Therefore, the main task in determining river discharge is to reliably determine the coefficient of hydraulic resistance and derive the general equation of water flow from it.

In this case, for uniform flow, the equality of two forces can be used: the acting shear stress (τ), equal to the component of the force of gravity, and the resistance force.

According to the above theoretical premises, the general equation of uniform fluid motion can be written in the following form: the basic equation for uniform fluid motion can be taken as follows:

$$\tau_0 = \rho g R I, \tag{1}$$

here: τ_0 —friction stress at the boundaries (bottom) of the flow; ρ —liquid density; g —acceleration of free fall; $R = \frac{\omega}{\chi}$ —hydraulic radius; ω —living cross-sectional area; χ —wetted perimeter length, in riverbeds $\chi \approx B$; I —slope of the water surface, equal to the slope of the bottom of the flow in uniform motion $I_0 = \sin\alpha_0$; α_0 —angle of inclination of the bottom of the flow; $I = \frac{z_v - z_n}{l} = \frac{h_l}{l}$; z_v, z_n — marks of the water surface in sections located at a distance l; h_l —specific energy (pressure) losses along the flow length.

In this case, we can take the basic equation for the uniform flow of water as follows:

$$\frac{h_l}{l} H = \frac{\tau_0}{\gamma} \tag{2}$$

or

$$h_l = \frac{\tau_0}{\gamma} \frac{l}{R} \tag{3}$$

If we consider this expression,

$$\frac{\tau_0}{\gamma} = \lambda \frac{v^2}{2g} \tag{4}$$

here:
- h_l — pressure loss in the calculated section of the riverbed;
- l — length of the calculated section;
- R — hydraulic radius; this parameter can be taken equal to the average flow depth in riverbeds, R=H.
- τ_0 — tangential stress;
- γ — specific weight of water;
- λ — pressure loss coefficient, hydraulic resistance or Darcy coefficient;
- v — average water flow velocity;
- g — gravitational force per unit mass

Then expression (3) has the form:

$$h_l = \frac{\tau_0}{\gamma}\frac{l}{R} = \lambda\frac{l}{H}\frac{v^2}{2g} \quad (5)$$

This formula (5) is the Darcy-Weisbach formula. One of the important hydrodynamic characteristics of the flow - the average velocity - is currently used in the practice of hydraulic engineering construction according to the formula proposed by the French scientist A. Chezy in the middle of the 18th century. The formula is obtained in the following sequence:

$$h_l = \lambda\frac{l}{4\gamma}\frac{v^2}{2g} \quad (6)$$

If we find the velocity from expression (6),

$$v^2 = \frac{8Hgh_l}{\lambda l}; \quad (7)$$

Then expression (7)

$$v = \sqrt{\frac{8g}{\lambda}}\sqrt{Hi} = C\sqrt{Hi} \text{ teng bo'ladi.} \quad (8)$$

here

$$\text{Chezy, } C = \sqrt{\frac{8g}{\lambda}}; \quad (9)$$

or

$$\sqrt{\frac{8g}{\lambda}} = \frac{1}{n}H^{\frac{1}{6}} \quad (10)$$

If we determine the hydraulic resistance (λ) in the riverbed from expression (10),

$$\frac{8g}{\lambda} = \left(\frac{1}{n}\right)^2 \cdot \left(H^{\frac{1}{6}}\right)^2$$

or

$$\frac{8g}{\lambda} = \frac{1}{n^2}H^{\frac{1}{3}}$$

In this case, the hydraulic resistance (λ) in the riverbed will have the following form.

$$\lambda = \frac{8g \cdot n^2}{\sqrt[3]{H}} \quad (11)$$

The water consumption in the river is written as follows.

$$Q = BHv \quad (12)$$

However, the results of the previous analysis show that as a result of scientific research conducted in the territory of the lower reaches of the Amu Darya River, it became known that the actual water flow velocity in the riverbed is precisely expressed by formula (13). That is:

$$\text{V} = K \cdot Q^y \quad (13)$$

Here $Q-$ River discharge, m³/s;

$K-$ proportionality coefficient;

$y-$ Degree indicator.

The degree indicators and proportionality coefficients, calculated on the basis of this formula, were manifested at different values at each hydropost. This indicates the presence of individual characteristics related to hydraulic structures, changes in water consumption, and other hydrological factors affecting the operation of hydroposts.

During the study, the regularities of the change in the water flow velocity in the riverbed depending on the water discharge were analyzed. Based on the obtained results, empirical expressions are given that can be used to assess the kinematic parameters of the water flow in the riverbed using the constructed graphical relationships.

As noted above, since the values of the proportionality and degree indicators differ in the selected hydroposts located in the lower reaches of the Amu Darya River, the empirical relationships between the proportionality coefficient (K) and the degree indicator (y) for each hydropost were determined separately (Fig. 1-5). According to the research results, these dependencies $K = f(y)$ are mainly represented in the form of a linear function.

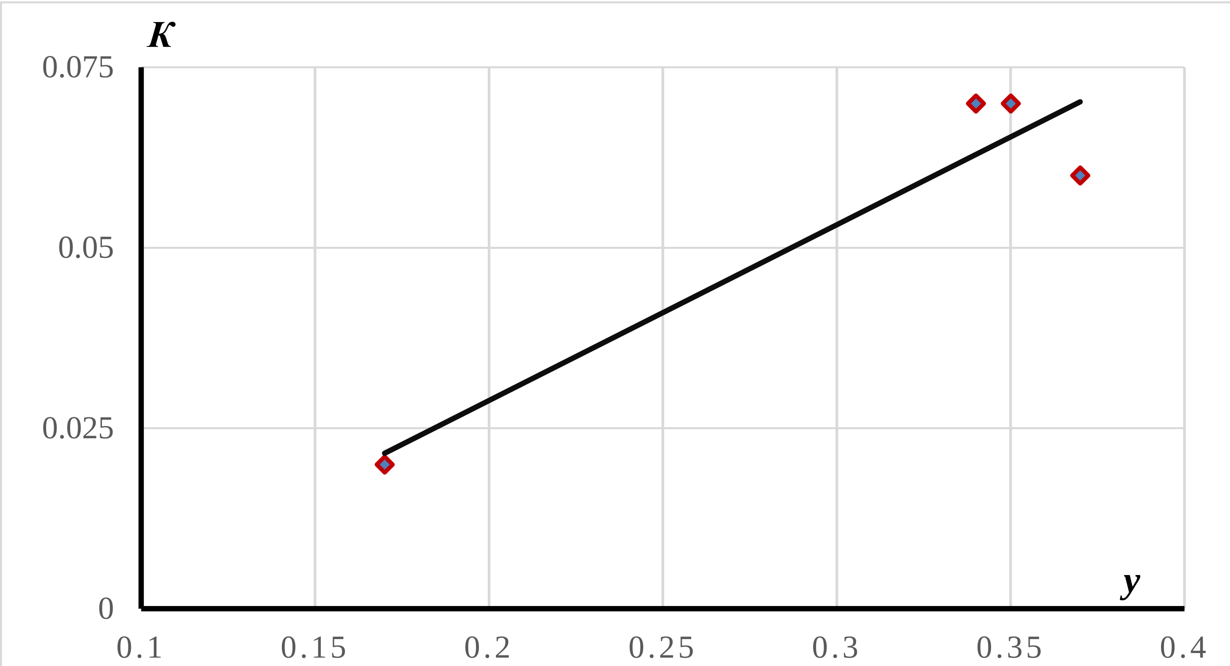

Figure 1. Graph of the dependence $K = f\ (y)$ for formula (13) for the Tuyamuyun hydropost.

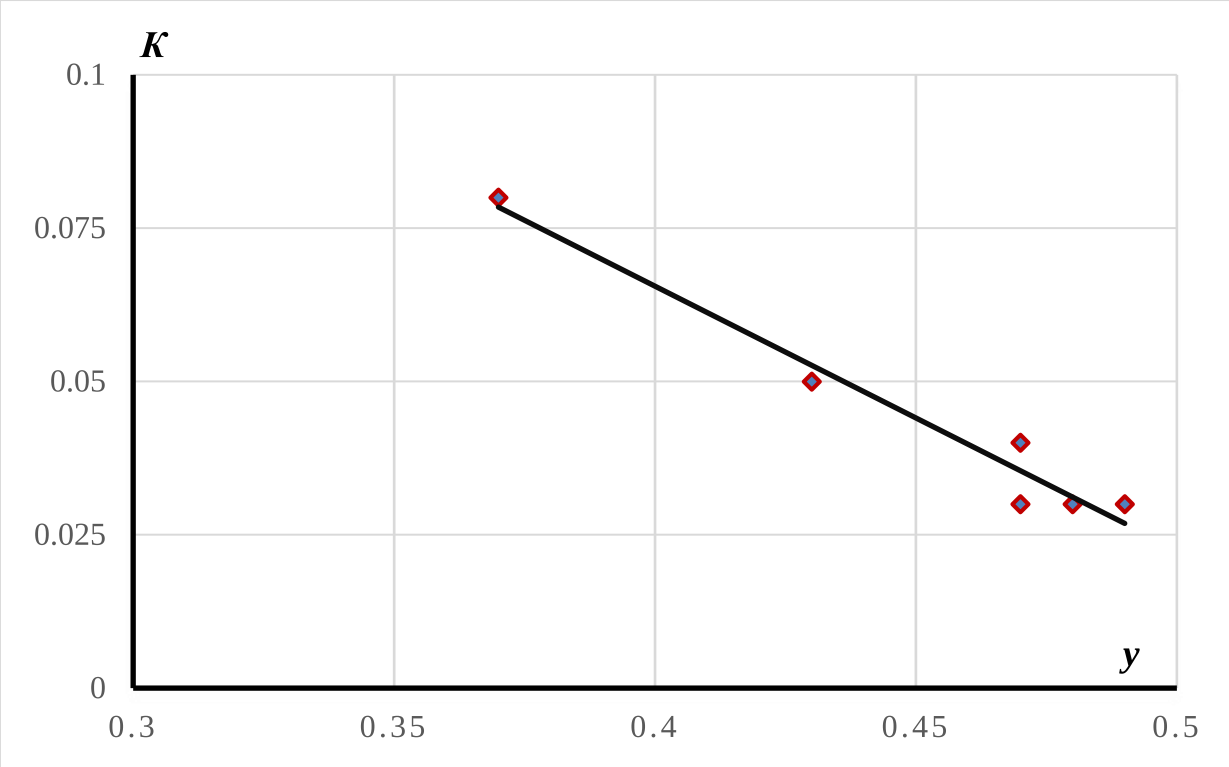

Figure 2. Graph of the dependence $K = f(y)$ for formula (13) according to the Kipchak hydropost.

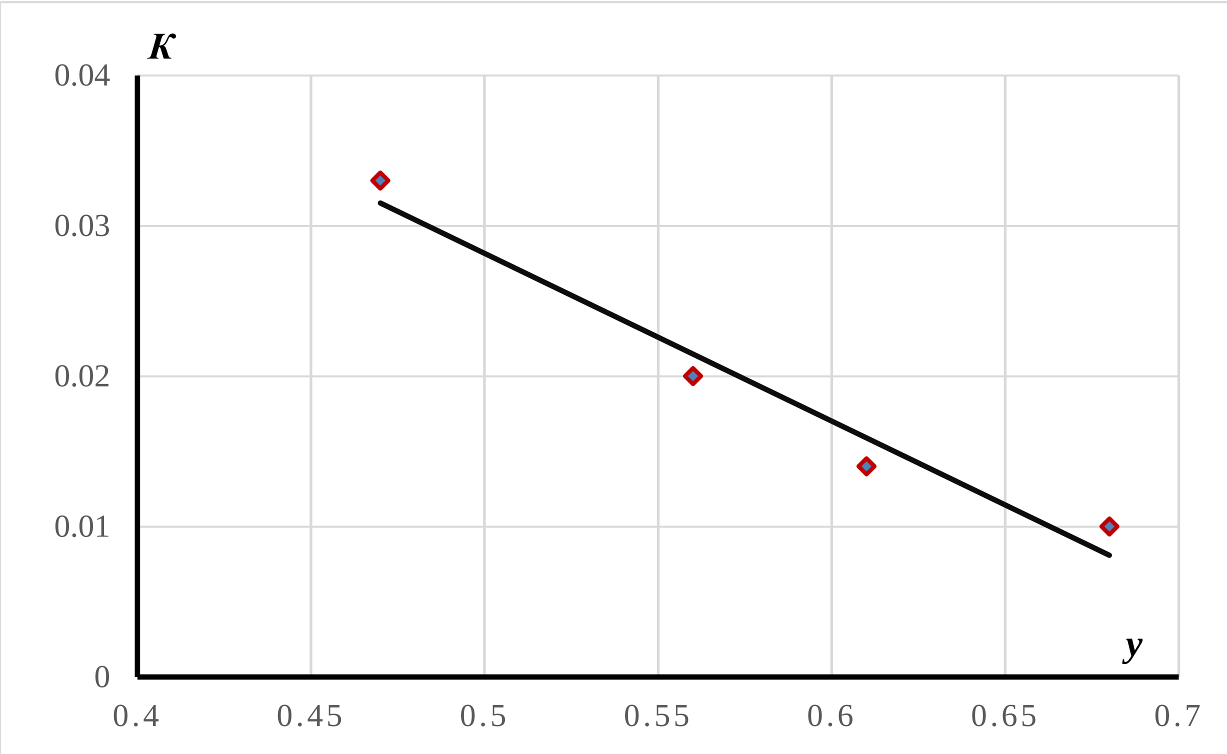

Figure 3. Graph of the dependence $K = f(y)$ for formula (13) for the Nietbaytas hydropost.

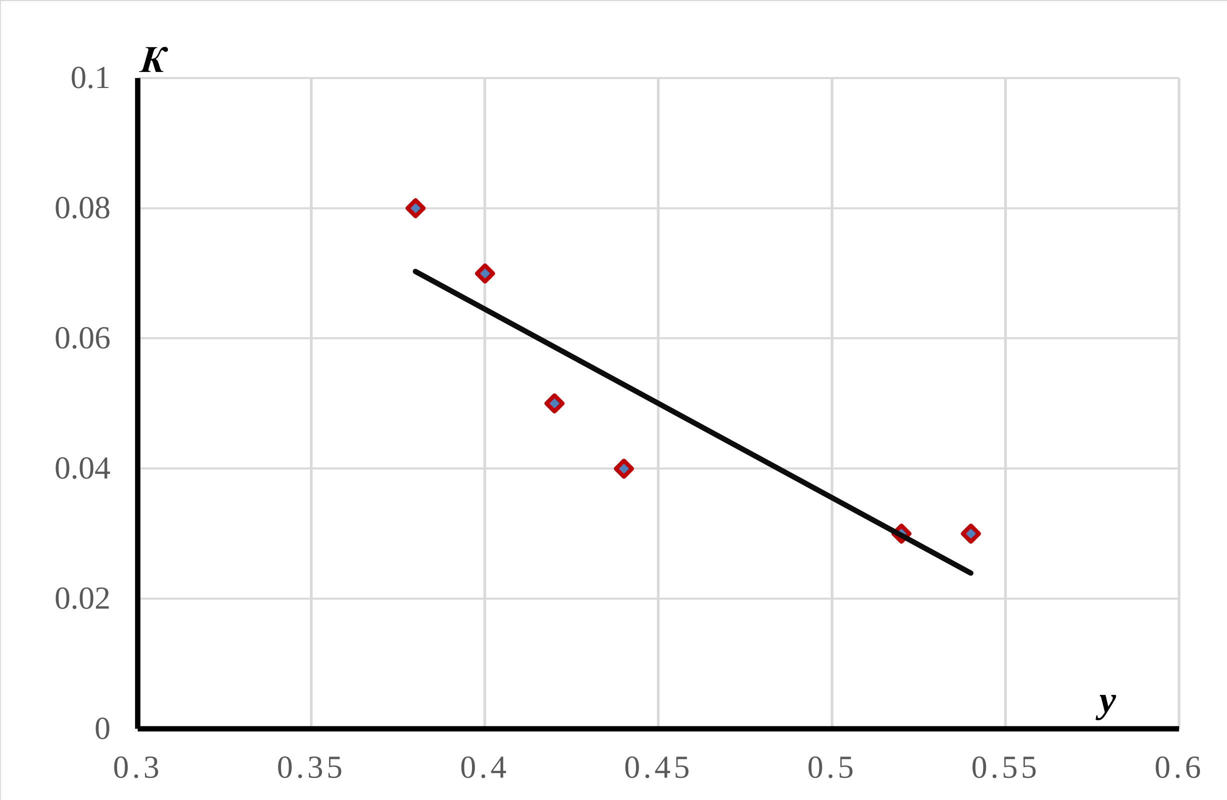

Figure 4. **Graph of the dependence $K = f\ (y)$ for formula (13) for the Samanbay Hydropost.**

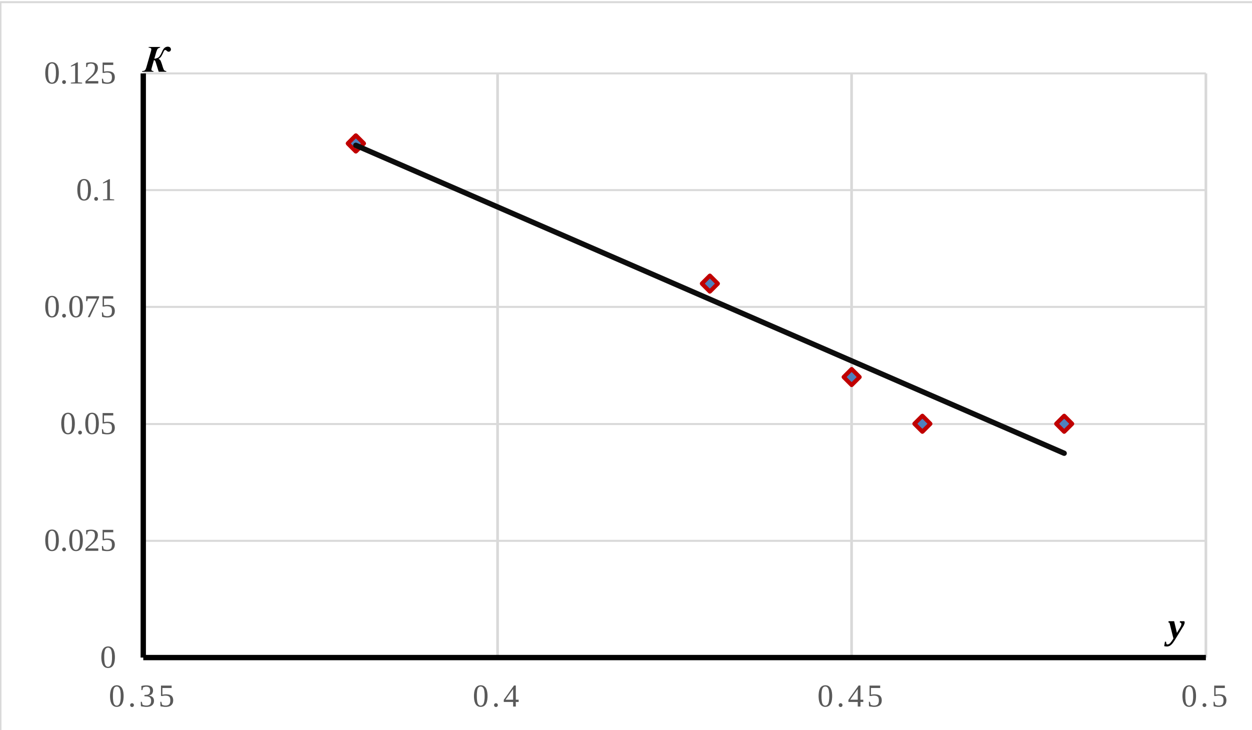

Figure 5. Graph of the dependence $K = f\ (y)$ for formula (13) for the Kyzylzhar hydropost.

The identified correlation coefficients have the following indicators: for the Tuyamuyun hydropost R^2=0,90, for the Kipchak hydropost R^2=0,96, for the Nietbaytas hydropost R^2=0,96, for the Samanbay hydropost R^2=0,81, and for the Kyzylzhar hydropost R^2=0,97.

For the Tuyamuyun Hydropost:

Thus, in order to determine the unknown parameters K and y, determined by formula (13), the corresponding analytical expressions were obtained from the dependencies $K = f(y)$ constructed for each hydropost.

$$K = 0.24 \cdot y - 0.02 \quad (14)$$

For the Kipchak Hydropost:

$$K = -0.43 \cdot y + 0.24 \quad (15)$$

For the Nietbaytas Hydropost:

$$K = -0.11 \cdot y + 0.08 \quad (16)$$

For the Samanbay Hydropost:

$$K = -0.29 \cdot y + 0{,}18 \quad (17)$$

For the Kyzylzhar Hydropost:

$$K = -0.66 \cdot y + 0.36 \quad (18)$$

Based on the results of formulas (14, 15, 16, 17, 18), it is possible to calculate the exact value of the proportionality coefficient (K) in formula 13 by applying different values of the parameter (y) separately for each hydropower station. At the same time, formula 13 describes the functional relationship between the water discharge in the river and the water flow velocity in the riverbed.

DISCUSSION

The Chezy coefficient, which depends on the hydraulic resistance of the riverbed, as shown by K.V. Grishanin, depends on three factors: viscosity of the liquid, roughness of the walls, and change in cross-sectional shape along the length. It should be noted that this is not a complete list of factors; it can also include vegetation in the riverbed, sharp turns of the riverbed (meander-shaped), glaciers, etc. These factors also indicate the complexity of the problem of calculating hydraulic resistances and the need to use their integral characteristics. From formula (11), it can be seen that, taking into account the accepted assumption of equality of hydraulic resistance, the unsteady flow has a functional relationship with hydraulic resistance, which is inversely proportional to the steady uniform Shezi coefficient. The results of processing the data of field studies showed that one of the determining parameters of hydraulic resistance is the roughness of the riverbed. Therefore, using the formulas obtained for the roughness of the riverbed (19) and the flow rate (13), the calculations were compared with the actual flow rate of the riverbed in the lower reaches of the Amu Darya.

$$n_{riverbed} = \frac{K}{Q^m} \quad (19)$$

here: K- proportionality coefficient;

m- degree indicator

The results of comparing the calculated formula with the actual flow rate of the riverbed in the lower reaches of the Amu Darya showed that to study the dynamics of this important feature of the riverbed, which significantly affects the river's carrying capacity, the hydraulic and morphological characteristics of these hydroposts, located in the zones of influence of hydraulic structures and bridges, were adopted. Based on these morphological features, in the upper zones of hydraulic structures, a rise in the bed of the riverbed occurs, and in the lower reaches, a decrease in the bed of the riverbed occurs, it is an intensive channel process that influences the occurrence of changes in channel roughness with an increase in river discharge. Calculations were carried out using the Chezy-Mann formula and the continuity equation of the flow to determine the dynamics of the average flow velocity and the hydraulic resistance of the channel in high-water years.

CONCLUSION

The dynamics of the kinematic parameters of the flow in the lower reaches of the Amu Darya has a close indicator and accuracy when calculated according to the calculation formula (13) compared to the Chezy formula. It can also be noted that it is close to the dynamics of hydraulic resistance, according to which it can be concluded that channel deformations continue in the considered section, which confirms the results of field studies.

REFERENCES

1. IA Ibragimov, UA Juraev, DI Inomov. Hydromorphological dependences of the meandring riverbed forms in the lower course of the Amudarya river. IOP Conference Series: Earth and Environmental Science. (2022-01-18, Volume: 949, 1-8 p.) https://iopscience.iop.org/article/10.1088/1755-1315/949/1/012090
2. V.S. Altunin. Kinematic and morphological dependencies of river flow and their application to the calculation of deformations of the bridge bed. Abstract. Moscow, 1965
3. G.V. Jeleznyakov, B.B. Danilevich. Accuracy of hydrological measurements and calculations. Gidrometeoizdat, L., 1966, p.237.
4. Ilhom A. Ibragimov, Dilmurod I. Inomov, Fotimabonu T. Xaydarova. BIO Web Conf. International Scientific-Practical Conference “Modern Trends of Science, Innovative Technologies in Viticulture and Winemaking” (MTSITVW2022) (2022-11-10, 1-6 p. **Volume** 53, 2022) https://doi.org/10.1051/bioconf/20225301003
5. I.A. Ibragimov, D.I. Inomov, I.I. Idiyev, Sh.Sh. Mukhammadov, S.S. Abduvohitov. Assessment of the effect of adjusted river flow on crops. BIO Web Conf. 103 00012 (2024). https://doi.org/10.1051/bioconf/202410300012
6. Mirzayev M.A., Inomov D.I., Ibragimov I.A. Coefficient of roughness of river bads. Экономика и социум. (2023-09-25, №9(112). https://www.iupr.ru/9-112-2023
7. Ibragimov I.A., Inomov D.I., Yavov A.U. The theory of the process of deformation of the river itself. IJTIMOIY-GUMANITAR FANLARNING ZAMONAVIY YONDASHUVLARI (2022-01-07, Volume: 1, 17-19 б.) http://conf.iscience.uz/index.php/igfzy/article/view/39
8. Mirzaev, M. (2023). Present-day state of technical water supply system “Kuyimozor” at auxiliary pump station. IOP Conference Series: Earth and Environmental Science. 1138. 012009. 10.1088/1755-1315/1138/1/012009.