ORIGINAL ARTICLE

INTERNATIONAL JOURNAL OF ARTIFICIAL INTELLIGENCE

ISSN: 2692-5206, Impact Factor: 12,23
American Academic publishers, volume 05, issue 04,2025

Journal: https://www.academicpublishers.org/journals/index.php/ijai

INFLUENCE OF CLIMATIC CONDITIONS ON THE MAXIMUM FLOWS OF WATER DISCHARGED INTO THE LOWER WATER RESERVOIR

B.F.Khikmatov,
Civil Protection Institute Ministry of Emergency Situations
Republic of Uzbekistan,
fvvfmi.uz
B.R.Rapikov
National University of Uzbekistan named after Mirzo Ulugbek,

barkamol_rapiqov@mail.ru

Abstract: The article is devoted to studying the dependence of the maximum flow rates of water discharged into the lower pool through reservoir dams on weather and climatic conditions, using the Tokhtogul reservoir as an example. For this purpose, a statistical assessment of the relationship between air temperature and maximum water flows discharged from the Tohktogul reservoir in the autumn and winter seasons into its lower pool ($r = 0.911 \pm 0.008$) was carried out and a regression equation for this relationship was obtained. As a result, it was possible to predict the maximum water flows of the Naryn river in the autumn-winter seasons depending on air temperature.

Keywords: reservoir, dam, tailwater, maximum water flow, air temperature, flood, assessment.

I. Introduction

Currently, specialized scientific centers worldwide are paying significant attention to studying hazardous hydrological processes, particularly the breaching of dam reservoirs under various influencing factors. When reservoirs are operated in an energy-driven mode, especially during autumn and winter seasons, the discharge of maximum water volumes from dam reservoirs into downstream sections increases, leading to hazardous hydrometeorological phenomena such as floods and mudflows [1,11,14,15,16]. Moreover, disasters associated with peak river discharges of different origins have become more frequent in recent years. These events cause substantial material and moral damage to various economic sectors and the population, and, in some cases, result in human casualties [3,7,10,12]. Therefore, current research focused on assessing the hydrometeorological and socio-economic dependencies of maximum water discharges from reservoirs operating in energy-driven modes is of great relevance.

II. Research Objectives and Tasks

The primary objective of this study is to examine the impact of weather conditions on the maximum water discharges released into downstream sections of reservoirs operated in an energy-driven mode, using the Toktogul Reservoir as a case study. To achieve this objective, the main tasks of the study include analyzing the daily peak water discharges from the Toktogul

ORIGINAL ARTICLE

INTERNATIONAL JOURNAL OF ARTIFICIAL INTELLIGENCE

ISSN: 2692-5206, Impact Factor: 12,23
American Academic publishers, volume 05, issue 04,2025

Journal: https://www.academicpublishers.org/journals/index.php/ijai

Reservoir dam into the downstream section, statistically evaluating their dependence on air temperature, and developing practical recommendations based on the obtained results.

The Toktogul Reservoir and the daily peak water discharges released from its dam into the downstream section have been chosen as the **research object**. The study focuses on analyzing the hydrometeorological and socio-economic dependencies of water discharges from the reservoir, which constitutes the subject of this research.

III. Main Results and Discussion

The emergence of this extraordinary situation is directly linked to the Toktogul Reservoir and its operation in an energy-driven mode. Over the past decade, the neighboring Kyrgyz Republic has primarily operated the Toktogul Reservoir for energy production purposes [11,15]. Consequently, the current hydrograph of the Naryn River has transformed into an almost complete inverse of the hydrograph that represents its natural water regime (Figure 1).

During the winter months, due to increased electricity demand, the Toktogul Hydropower Station operates at its maximum capacity. As a result, the peak water discharges in the Naryn River also occur in the winter months, as illustrated in Figure 4. In this graph, the water inflows (labeled as "Inflow") represent data provided by the Kyrgyz National Energy Holding Company, while the water outflows (labeled as "Outflow") correspond to measurements taken at the "Uchkurgan" hydrological station of UzHydromet.

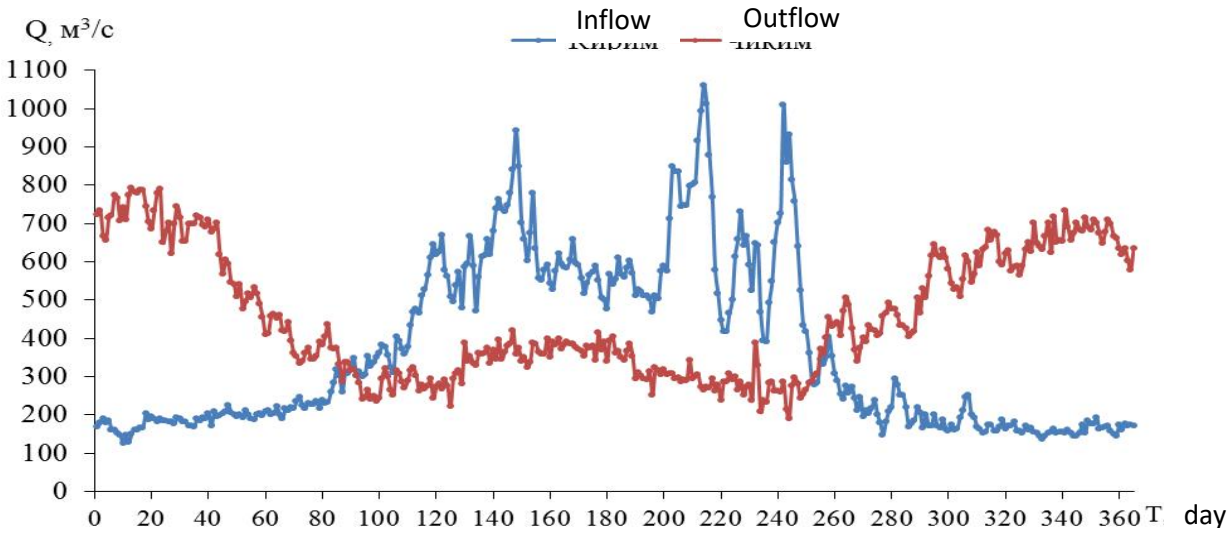

Fig. 4. Changes in the inflow and outflow elements of the Tokhtogul reservoir during the year (2020)

Therefore, the main reason for the discrepancy between the hydrographs shown in Figure 1 is the sharp drop in air temperature during the winter months, which in turn leads to an increased demand for electricity generation. To meet this demand, the volume of water released

ORIGINAL ARTICLE

INTERNATIONAL JOURNAL OF ARTIFICIAL INTELLIGENCE

ISSN: 2692-5206, Impact Factor: 12,23
American Academic publishers, volume 05, issue 04,2025

Journal: https://www.academicpublishers.org/journals/index.php/ijai

from the reservoir dam into its downstream section must be significantly increased. Below, we discuss the hydrometeorological aspects of this process.

To achieve the research objective, we utilized air temperature data from the Uchkurgan agrometeorological station, administered by UzHydromet, located along the Naryn River. Information on the water discharges from the Toktogul Reservoir dam was obtained from the engineering service of the Kyrgyz National Energy Holding Company, as previously noted. Using these hydrometeorological data, chronological graphs of water discharges and air temperatures were plotted for September–December 2022 and for January–February 2023, when the extraordinary conditions arose [2].

As can be seen from the resulting graph, an inverse relationship exists between the average daily water discharges released from the Toktogul Reservoir into the downstream section and fluctuations in air temperature: when air temperature decreases, the volume of water released to the downstream section increases (Figure 2).

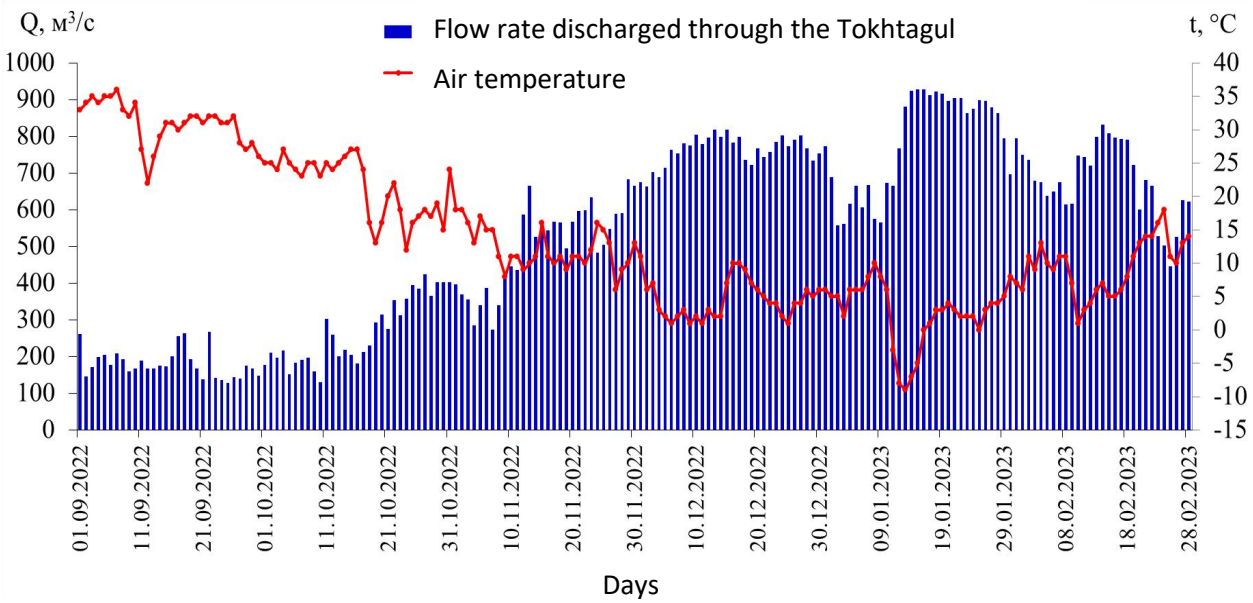

Fig. 2. Changes in air temperature (t) and water flow rates (Q) discharged through the dams of the Tokhtagul reservoir (autumn-winter season, 2022-2023)

Based on this graph, the variations in air temperature and the volume of water released from the reservoir dam into the downstream section were analyzed. Specifically, from January 11 to January 21, 2023, the average daily air temperature in the region dropped sharply (to as low as -10 °C), and during nighttime hours, it fell below -20 °C. As a result, the demand for electricity increased, prompting the Toktogul Hydropower Station to operate at full capacity. This situation led to an increase in the volume of water discharged from the reservoir into the downstream section, with average daily peak flow rates reaching up to 1000 m³/s. Notably, this flow rate remained at approximately 1000 m³/s from January 12 through January 28, a span of 17 days.

ORIGINAL ARTICLE

INTERNATIONAL JOURNAL OF ARTIFICIAL INTELLIGENCE

ISSN: 2692-5206, Impact Factor: 12,23
American Academic publishers, volume 05, issue 04,2025

Journal: https://www.academicpublishers.org/journals/index.php/ijai

It was precisely this scenario—namely, several consecutive days of maximum, unchanging discharge from the reservoir dam—that caused significant damage to the banks of the lower reaches of the Naryn River, specifically the section flowing through Naryn District of Namangan Province in Uzbekistan. It should be emphasized that this study relied on average daily flow data. In reality, instantaneous peak flow rates (i.e., measured at specific moments) likely exceeded 1000 m³/s.

To enhance the practical significance of the results, a statistical evaluation was performed on the relationship between the average daily peak discharges from the Toktogul Reservoir during autumn–winter seasons and the average daily air temperatures (Figure 3).

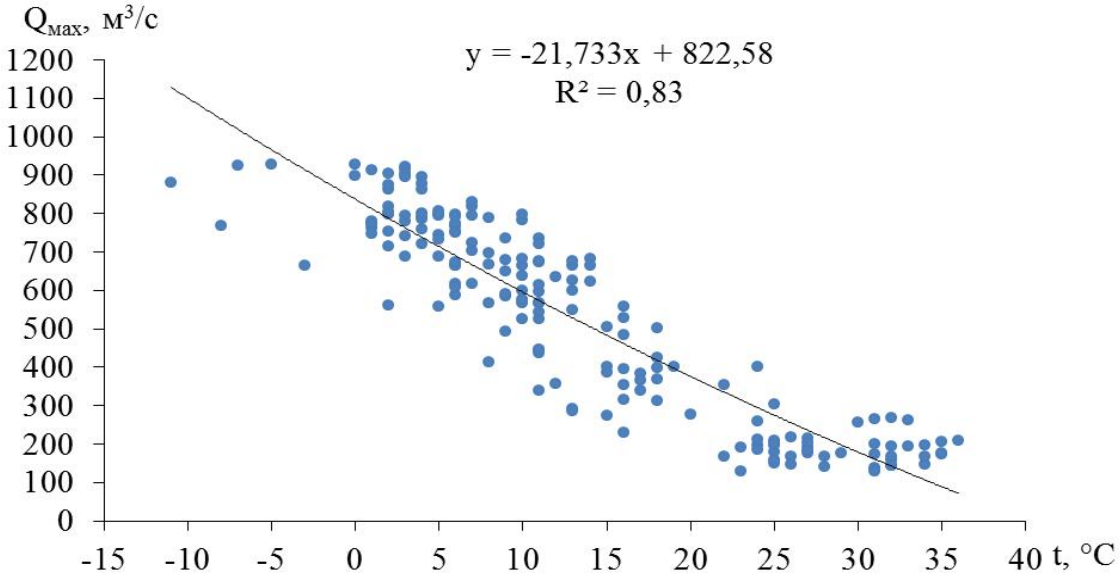

Fig. 3. Dependence of the maximum water flows released from the Tokhtagul reservoir in the autumn-winter seasons on air temperature, 2022-2023.

Based on the above graph, a statistical assessment was made of the relationship between two variables, namely the average daily maximum water discharges (Q_{max}) released from the reservoir during the autumn–winter season of 2022–2023, and the corresponding air temperatures (t) recorded on those dates. The regression equation expressing the relationship between these variables was obtained in the following form:

$$Q_{max} = -21.73t + 822.6, \quad (1)$$

where: Q_{max} — average daily maximum water discharges; t — air temperature.

ORIGINAL ARTICLE

INTERNATIONAL JOURNAL OF ARTIFICIAL INTELLIGENCE

ISSN: 2692-5206, Impact Factor: 12,23

American Academic publishers, volume 05, issue 04,2025

Journal: https://www.academicpublishers.org/journals/index.php/ijai

The accuracy of this regression equation was evaluated using the simple correlation coefficient. Its value was determined to be $r \pm \sigma_r = 0{,}911 \pm 0{,}008$. These figures indicate that the derived relationship can be reliably used in practice. In particular, using the above regression equation, it is possible to forecast the maximum water discharges in the Naryn River during the autumn–winter seasons based on air temperature data. Most importantly, given that the information on average daily water discharges is provided by the Kyrgyz National Energy Holding Company and air temperature data are measured by UzHydromet in accordance with standard requirements, one can draw a positive conclusion regarding the reliability of the study's results.

IV. Conclusion

In recent decades, the growth of average daily water discharges up to their maximum values released from the Toktogul Reservoir dam—operating in an energy-driven mode—has led to frequent occurrences of destructive phenomena such as floods and inundations along the banks of the Syr Darya and Naryn Rivers. No one can rule out the possibility that such adverse hydrological events may also occur downstream from other large reservoirs in Tajikistan, such as the Nurek Reservoir or the Rogun Reservoir (the latter still under construction). This situation underscores the necessity of continuing research in this field in a systematic manner.

References:

1. Abdukhalilov, D. (2021). The Role of Hydroelectric Power Stations in the Energy System and Their Future Indicators. In "Uzbekhydroenergetics" Scientific and Technical Journal, Issue 2, pp. 31–32. Tashkent.
2. Alekseevskiy, N. I. (2006). Hydrophysics: A Textbook for University Students. Moscow: Academic Center "Akademiya". 176 pp.
3. Arsenyev, G. S. (2005). Fundamentals of Managing Hydrological Processes: Water Resources. A Textbook. St. Petersburg: Publishing House of the Russian State Hydrometeorological University (RSHU). 231 pp.
4. Avakyan, A. B., Saltankin, V., & Sharapova, V. A. (1987). Reservoirs. Moscow: Mysl. 325 pp.
5. (Ed.) Edelshtein, K. K. (2015). Hydrological Regime of the Moscow Region Reservoirs (Observations, Diagnosis, Forecast). Moscow: "Pero". 286 pp.
6. Gotlib, Ya. L., Zhidkikh, V. M., & Sokolnikov, N. M. (1976). Thermal Regime of Power Station Reservoirs. Leningrad: Gidrometeoizdat. 203 pp.
7. Denisov, Yu. M. (1986). On Calculating the Maximum Water Discharges of Rain Floods. In Proceedings of SARNIGMI (Central Asian Scientific Research Institute of Irrigation), Gidrometeoizdat, pp. 23–43. Moscow.
8. Irrigation of Uzbekistan. Vol. III (1979). Tashkent: Fan. 357 pp.
9. Mamedov, M. A. (1989). Calculations of Maximum Water Discharges of Mountain Rivers.

ISSN: 2692-5206, Impact Factor: 12,23
American Academic publishers, volume 05, issue 04,2025
Journal: https://www.academicpublishers.org/journals/index.php/ijai

Leningrad: Gidrometeoizdat. 184 pp.

10. Nikitin, A. M. (1991). Reservoirs of Central Asia. Leningrad: Gidrometeoizdat. 163 pp.
11. Rapiqov, B. R. (2022). The Influence of the Toktogul Reservoir on the Variability of the Naryn River Flow. In Bulletin of the Geographical Society of Uzbekistan, Vol. 62, pp. 111–116. Tashkent.
12. Shakhidov, A. F. (2007). Calculation of Mixed Maximum Water Discharges of Mountain Rivers. Tashkent: NIGMI. 91 pp.
13. Edelshtein, K. K. (2014). Hydrology of Lakes and Reservoirs. Moscow: “Pero”. 399 pp.
14. Hikmatov, B. F. (2023). Calculation of Probable Maximum Water Discharges from Rivers and Dam Reservoirs. Tashkent. 184 pp.
15. Hikmatov, F., & Rapiqov, B. (2021). Transition of the Toktogul Reservoir to an Energy-Driven Mode and Related Issues. In “Uzbekhydroenergetics” Scientific and Technical Journal, Issue 2, pp. 36–38. Tashkent.
16. Khikmatov, B., Dergacheva, I., Starovatov, A., & Khikmatov, F. (2020). Calculation of the Hydrograph of the Breakthrough of High Mountain Lakes in Uzbekistan (Examples of Ihnach-Large Lake). TEST Engineering and Management, Vol. 83 (March–April), pp. 8508–8515.