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STUDY OF THE OVERREGULATION OF THE SOUTHERN BUH RIVER

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Abstract. In the course of the study, the volume of reservoirs in the Southern Buh River basin was studied; the ratio of the areas of the water mirror of the reservoirs of the river basin by region is determined; the dynamics of the capacity of the reservoirs of the Southern Buh River basin over a certain period, as well as the dynamics of the capacity of the reservoirs of the Southern Buh River within the Mykolaiv region, are evaluated; the density of reservoirs along the river bed is analyzed. It is determined that the largest useful volume of reservoirs falls in Mykolaiv region (34 %). It is shown that the largest area of the water mirror is located in Vinnytsia region (31 %), and the smallest – is in Kyiv and Odesa regions (2 %). It is shown that the largest increase in the volume of reservoirs falls on the period of the 60s of the twentieth century. It is determined that the average density of artificial reservoirs is about one reservoir for every 10 km of the river, which indicates the critical overregulation of the river. A significant level of river regulation, along with several advantages, has environmental challenges, especially in the context of current climate change issues. These issues require further research in the direction of studying the optimality of the volume of reservoirs because of maintaining the river's ability to self-regulate processes, preserving the unique hydroecosystems of the river, which should be taken into account in managing water resources.

Keywords: Southern Buh, overregulation of the river, reservoirs.

1. Introduction

The relevance of the study of river regulation is due to the significant impact of hydraulic structures on natural ecosystems, water resources and hydrological regimes. Under the current conditions of intensive urbanization and industrial development, non-compliance with environmental legislation, overregulation of rivers become a critical cause of ecological imbalance, biodiversity degradation and deterioration of water quality, violation of the integrity of the hydroecosystem. This is especially important in the context of climate change, which exacerbates the problem of water scarcity and requires finding solutions for effective river basin management. The study of this topic will help to develop strategies for the sustainable use of water resources and the conservation of the river ecosystem.

One of the features of the Southern Buh River basin is significant overregulation. Overregulation of a river is a change in the natural water regime of a river as a result of human activity, mainly due to the construction of hydraulic structures such as dams, reservoirs, canals, as well as flow regulation. These anthropogenic actions lead to changes in the number, speed and seasonality of the watercourse.

The issue of overregulation was covered in the works of domestic scientists (Denysyk, Lavryk, 2018; Ilyin, 2011; Hayetskyi, 2010; Hulyk, S., Hulyk, O., 2016; Khilchevskyi, Grebin, 2020, Zyhar, 2024) and many foreign researchers (Gupta S., Gupta S. K., 2021; Rivaes et al., 2022; Sharifi et al., 2024), regional and basin aspects of the distribution of reservoirs, their impact on natural landscapes (Khilchevskyi, Grebin, 2021; Kuyzyk, Taranova, 2023; Kuyzyk, Blotnyy, 2022) were highlighted.

Overregulation can have low environmental consequences, namely: affect the habitats of fish and other aquatic organisms, changing the conditions for their life; can lead to a decrease in the number and species diversity of aquatic organisms; It can change the temperature of the water, the concentration of oxygen and the level of pollution (Tsaryk et al., 2018).

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The main role of reservoirs and dams is to regulate water flow; provision of drinking water to settlements and industrial enterprises; use for irrigation of agricultural land; for the needs of hydropower, as well as for recreation and fishing. Reservoirs are also used for recreation and fishing, which is also of economic importance for the development of the region, the comfort of living of the population. The main parameters of reservoirs are: usable volume (the volume of water that can be used for various purposes, for example, water supply, irrigation, energy or recreation); surface area (the total area of the reservoir when filled, which affects evaporation, heat transfer, and interaction with ecosystems) and maximum depth (the deepest point of the reservoir, which is important for determining its storage potential and its impact on water circulation and thermal processes). These parameters affect the functioning of reservoirs and determine their efficiency in environmental and technical terms.

Taking into account the above-mentioned consequences of overregulation, we were faced with the task of studying the dynamics of reservoir creation, comparing the volume of reservoirs by region and analyzing the dynamics of reservoir capacity in the Southern Buh River basin.

The purpose of the study is to study the overregulation of the Southern Buh River.

Following the goal, the following tasks were set: to estimate the volume of reservoirs in the regions of the river basin; determine the ratio of the areas of the water mirror of the reservoirs of the Southern Buh River basin by region; to assess the dynamics of the capacity of the reservoirs of the Southern Bug River basin over a certain period, as well as the dynamics of the capacity of the reservoirs of the Southern Buh River within the Mykolaiv region; analysis of the density of reservoirs along the river.

The object of the study is the overregulation of the Southern Buh River given the factor of reservoirs.

The subject of the research is the main characteristics of reservoirs, as well as the dynamics of their creation.

Mathematical methods included statistical data processing, graphical reflection of data for high-quality visual evaluation of results using the MS Excel software product.

2. Theoretical part

The reservoirs of the Southern Buh River basin are located within Khmelnytsky, Vinnytsia, Kyiv, Cherkasy, Kirovohrad, Odesa, and Mykolaiv regions. Figure 1 shows a diagram showing the distribution of the useful volume of reservoirs by region. Scheme of Fig. 1 shows that the largest useful volume of reservoirs falls in the Mykolaiv region (34 %), and the smallest – in the Kyiv region (1 %). Other oblasts are distributed as follows: Vinnytsia (22 %), Kirovohrad (22 %), Cherkasy (10 %), Khmelnytsky (9 %), and Odesa (2 %).

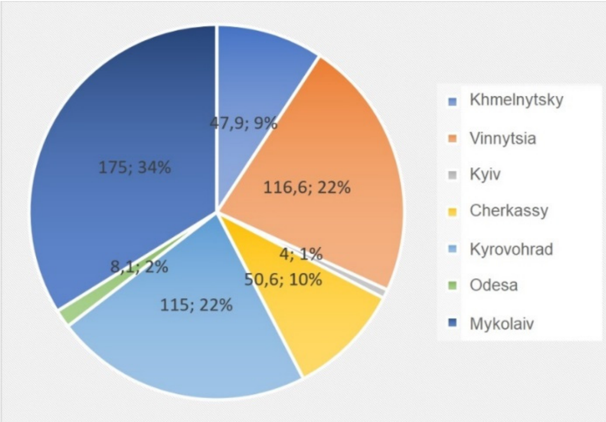

Fig. 1. Volume of reservoirs (million cubic meters /%) of the Southern Buh River basin by region

Next, the task arose to investigate the distribution of the water mirror area by region, since the number of reservoirs does not yet determine the strength of the anthropogenic load on the hydrological regime of the river. Fig. 2 shows a diagram showing the distribution of the water surface area of reservoirs in *hectares* by areas of the river basin. Analysis of the data shows that the largest mirror area is in Vinnytsia region (31 %), and the smallest – in Kyiv and Odesa regions (2 %). Other areas are distributed as follows Thus: Kirovohrad (19 %), Mykolaiv (18 %), Khmelnytsky (16 %), Cherkasy (12 %).

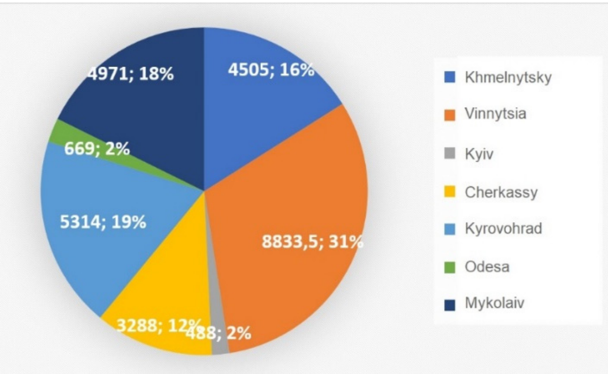

Fig. 2. The area of the water mirror of the reservoirs of the Southern Buh River basin by region

Along with the study of the water surface area, there was a need to analyze the dynamics of changes in the useful volume of the river reservoirs. Diagram of Fig. 3 shows the dynamics of increase in the useful volume of reservoirs in the Southern Buh basin since the 1890s. Let's outline the key points. In the initial period of 1890–1950, the volume of reservoirs until 1950 was very low. A slight increase in volumes was observed in the period 1890–1900 (3.3 million cubic meters), as well as in 1921–1930 (2.5 million cubic meters). There were practically no new reservoirs in the periods of 1901–1910, 1931–1940.

In the middle of the twentieth century, 1951−1970, namely, in the period 1951–1960, there was a rapid increase in the volume of reservoirs to 62.8 million cubic meters. The largest growth was observed in 1961–1970, when the volume reached 152.8 million cubic meters. At the end of the twentieth century, 1971–2000, namely in the period 1971–1980, the volumes decreased to 61.9 million cubic meters. m, but remained a significant indicator. Further, in 1981–1990, the volumes fell to 21.6 million cubic meters. m, which indicates a decrease in the pace of construction. From 1991 to 2000, there was an even greater decrease in volume to 1.3 million cubic meters. At the beginning of the 21st century, 2001–2024, namely in the period 2001–2010, the volume was only 1 million cubic meters. In 2011–2020, there was a slight increase in volume to 2.03 million cubic meters. In the period 2021–2024, there was no new construction of reservoirs.

Thus, the largest volume of reservoirs was created in the middle of the twentieth century, especially in the period 1961–1970. After the 1970s, the rate of construction of reservoirs decreased significantly. In recent decades (2001–2024), the volume of new reservoirs has been very low, which may indicate a change in the approach to water management or restrictions in the construction of new facilities. These changes are related to economic, environmental or social factors that affect the development of water supply infrastructure.

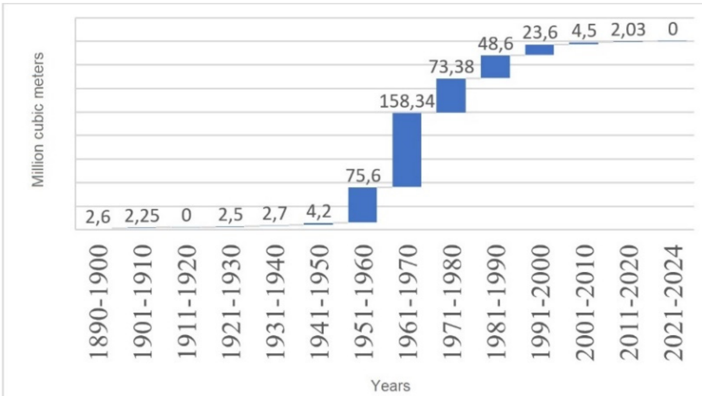

Fig. 3. Dynamics of reservoir capacity in the Southern Buh river basin

Since the largest useful volume of reservoirs falls on the Mykolaiv area (34 %), we will analyze the dynamics of the capacity of reservoirs of the river basin for this territory. Diagram of Fig. 4 indicates that the largest increase in the volume of reservoirs falls on the period of the 60s of the twentieth century.

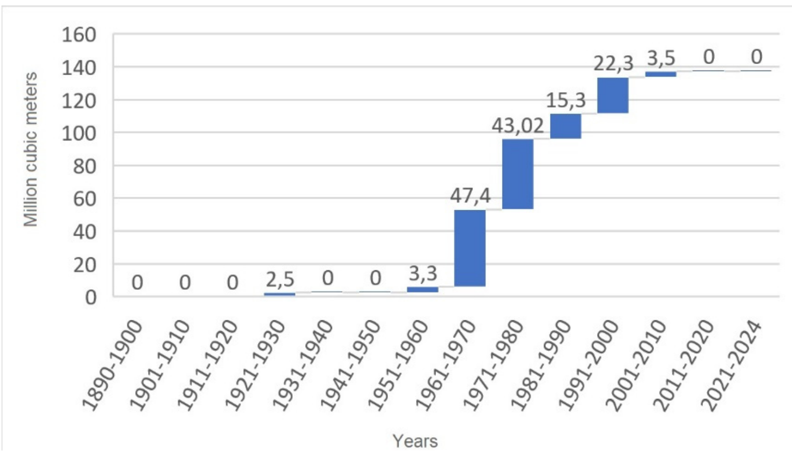

Fig. 4. Dynamics of reservoir capacity of the Southern Buh River within the Mykolaiv region

3. Results and Discussion

Analysis of the data showed that in the period 1890–1950 the volume of reservoirs was very low or non–existent. The increase in volume begins only in 1921–1930 (2.5 million cubic meters) and 1890–1900 (3.3 million cubic meters). In the middle of the twentieth century, in the period 1951–1970, especially in 1951–1960, there was a significant increase in the volume of reservoirs to 47.4 million cubic meters. The next period, 1961–1970, shows an even greater increase to 43.02 million cubic meters. At the end of the twentieth century, 1971–2000, namely in the period 1971–1980, the volumes increased to 22.3 million cubic meters. In 1981–1990, the volume increased to 15.3 million cubic meters. From 1991 to 2000, the volume increased slightly to 3.5 million cubic meters. m.

At the beginning of the 21st century (2001–2024), in the period 2001–2010, the volume remained unchanged. In the period 2011–2020 and 2021–2024, no new reservoirs were built.

Thus, the largest volume of reservoirs was created in the middle of the twentieth century, especially in the period 1951–1970. After the 1970s, the rate of construction of reservoirs decreased significantly. In recent decades (2001–2024), the volume of new reservoirs has been very low, which may indicate a change in the approach to water management or restrictions in the construction of new facilities. These changes are due to economic and environmental factors that affect the development of water supply infrastructure.

The next stage of the study was the analysis of the density of construction of reservoirs along the river bed (Fig. 5). Thus, at a distance of 0−100 km from the mouth there are 14 reservoirs. At a distance of 100−200 km from the mouth − 6 reservoirs. Further, at a distance of 200–300 km from the mouth, there are 11 reservoirs. At a distance of 300–400 km from the mouth, 9 reservoirs were built. At a distance of 400−500 km from the mouth − 8 reservoirs. At a distance of 500–600 km there are 8 reservoirs. Further, at a distance of 600−700 km from the mouth, there are 9 reservoirs. At a distance of 700−806 km from the mouth − 5 reservoirs.

Thus, a high density of reservoirs is observed at distances from 100 to 200 km and from 0 to 100 km from the mouth of the river (16 and 14 reservoirs, respectively). The average density of reservoir construction is observed at distances from 200 to 300 km and from 600 to 700 km with 11 and 9 reservoirs, respectively. Lower reservoir densities are observed at distances of 300 to 400 km, 400 to 500 km, and 500 to 600 km with 9, 8, and 8 reservoirs, respectively. The lowest density of reservoir construction is observed at distances from 700 to 806 km with 5 reservoirs.

So, based on the data of the graph of the Fig. 5 shows that the average density of reservoirs along the Southern Bug River is approximately 9.93 reservoirs for every 100 km of the river. Based on the preliminary calculation of the average density per 100 km (9.93), it is possible to estimate the average density per 10 km. The average density for every 10 km ≈ 9.93/10 ≈ ≈ 0.993 ≈ 1.

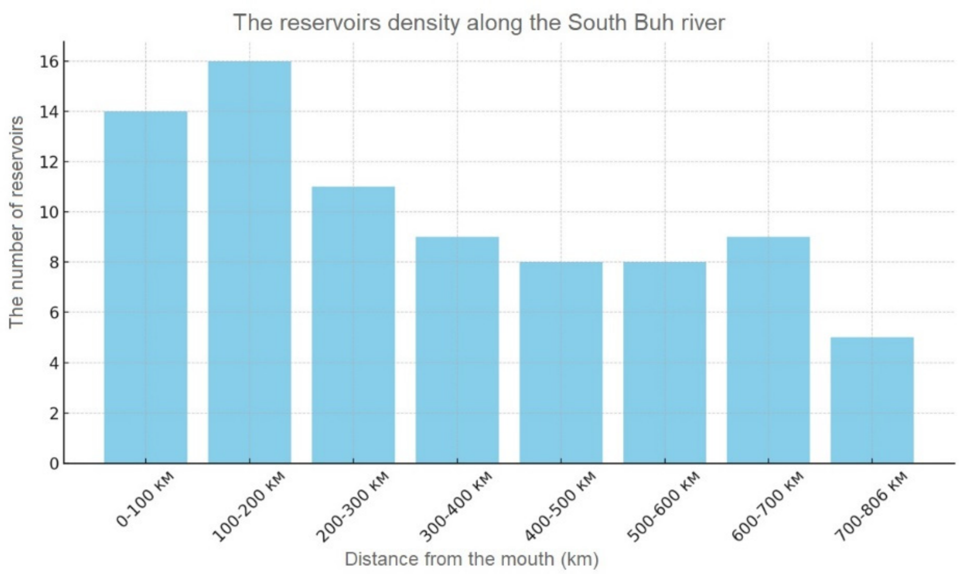

Fig. 5. The density of the reservoirs of the Southern Buh river

Based on it, the graph of Fig. 5 draws several conclusions and possible scenarios for the development of the situation regarding the density of reservoirs. As noted above, the highest density of reservoirs is observed at a distance of 100–200 km from the mouth, which may indicate favorable geographical or economic conditions for the creation of reservoirs in these areas. Lower density in the 400–600 km range may be due to the terrain or lower economic needs in these areas.

However, a high concentration of reservoirs in an area of 100–200 km can lead to significant regulation of the river, which will negatively affect the natural processes of self-purification, biodiversity and water regime in this area. If the trend towards the creation of new reservoirs in this region continues, it could lead to increased environmental problems such as eutrophication, increased water temperatures, and a decrease in the amount of oxygen, which affects flora and fauna.

At a distance of 700–806 km from the mouth of the river, the smallest number of reservoirs is observed. This indicates less impact of anthropogenic activities in these areas or less favorable conditions for their creation. If in the future there are plans to increase reservoirs in these areas, this may lead to an increase in the overregulation of the entire river system, which will require additional studies of the impact on ecosystems and the water regime.

The concentration of reservoirs in certain areas can be the result of intensive agriculture, industrial production or the need for water supply in settlements. This can cause competition for water resources between different industries and communities. In the event of population growth and economic needs in the region, an increase in the number of reservoirs is likely, which may increase the risks of conflicts over water resources.

Thus, the approximate average density of reservoirs is about one reservoir for every 10 km, which again proves the fact of high regulation of the river. Such a high density of reservoirs indicates that the water resources of the river are actively used for various needs, such as agriculture, industry, drinking water supply and recreation. In other words, reservoirs contribute to the development of the region by providing water supply, irrigation, and energy. A large number of reservoirs help regulate the flow of the river, preventing floods and ensuring a stable water regime throughout the year.

At the same time, intensive overregulation harms the ecosystem of the river, in particular on biodiversity, fish stocks and water quality. The restructuring of the natural channel and the creation of many reservoirs lead to changes in ecosystems that can be unfavorable for many species of plants and animals, creating challenges related to sustainable water management and maintaining ecological balance.

In general, such a density of reservoirs indicates a significant level of overregulation of the river, which has both its advantages and challenges that should be taken into account in the management of water resources.

Based on the obtained regularities, it is possible to outline possible scenarios for the development of the situation with the density of the reservoirs of the Southern Buh River. Thus, if the density of reservoirs increases, we should expect increased regulation of river flow, which can worsen the ecological condition and increase the risks to biodiversity. If reservoirs in the most regulated areas are under control and measures are taken to reduce the negative impact, the situation may stabilize. In the case of implementation of environmental initiatives aimed at the rehabilitation of river ecosystems, some reservoirs can be dismantled or optimized to reduce their negative impact.

4. Conclusions

It is determined that the largest useful volume of reservoirs falls on the Mykolaiv region (34 %).

The largest area of the mirror falls on the Vinnytsia region (31 %), and the smallest – on the Kyiv and Odessa regions (2 %).

Analysis of the dynamics of increase in the useful volume of reservoirs in the Southern Bug basin, starting from the 1890s, showed that the largest volume of reservoirs was created in the middle of the twentieth century, namely in the period 1961–1970. After the 1970s, the rate of construction of reservoirs decreased significantly. In recent decades (2001–2024), the volume of new reservoirs has been very low. The largest increase in the volume of reservoirs falls on the period of the 60s of the twentieth century.

The average density of artificial reservoirs is about one reservoir for every 10 km of the river bed, which indicates the critical overregulation of the river.

A significant level of overregulation of the river has several advantages and environmental challenges, especially in the context of climate change issues. These issues require further research in the direction of studying the optimality of the volume of reservoirs in view of maintaining the river's ability to self-regulate processes, preserving the unique hydroecosystems of the river, which should be taken into account managing water resources.

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