Intra-annual runoff distribution of the Podolia tributaries of the Dniester River by separate water periods

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SUMMARY

A large number of scientific researches have been devoted to the study of the Dniester River Basin, but so far there are no comprehensive studies of the region's river basin-systems. The intra-annual distribution of river runoff is determined by zonal and azonal factors, and therefore its study includes a comprehensive assessment of the runoff formation. The research was conducted for six left tributaries of the Dniester River (the Zolota Lypa River, the Koropets River, the Strypa River, the Seret River, the Nichlava River, and the Zbruch River) within Ternopil region for the entire available observation period. The calculation of the intra-annual runoff distribution of the Podolia tributaries of the Dniester was made using the real-year model. Three model-years were chosen for the calculation: wet-water year, average-water year, and low-water year. A comparative analysis of the intra-annual runoff distribution in different water periods (low period and wet period) was also carried out. It was established that the intra-annual distribution of the left-bank tributaries of the Dniester River runoff is characterized by a decrease in the spring flood volume and an increase in the summer-autumn and winter low periods runoff volume from the annual between the studied periods, which is caused by modern climate changes.
Introduction

The Dniester River is the second longest and wateriest river in Ukraine, which is distinguished by the heterogeneity and diversity of the water runoff formation conditions of both the Dniester itself (in terms of its length) and its numerous tributaries. Therefore, the research of the Dniester Basin and the basins of its tributaries has always attracted the attention of scientists (Kozhemyakin and Chornomorets, 2018, Mudra, 2017). Despite a large number of publications, especially with the analysis of the hydrological regime of the Ternopil region rivers, until now there are no comprehensive studies of the river-basin systems of the region (Kapusta et al., 2022). The intra-annual distribution of river runoff is determined by zonal and azonal factors, and therefore its study includes a comprehensive assessment of the runoff formation. Studying and calculating the intra-annual runoff distribution is an extremely important task of hydrology from both a practical and a scientific point of view (Gorbachova, 2014, Snizhko and Pavelchuk, 2014).

Method and Theory

The intra-annual runoff distribution is mainly determined by climatic factors. Climate changes, due to changes in the components of the water balance, determine changes in the intra-annual runoff distribution. Local physical-geographical factors (lakes, forest cover, wetlands, catchment area, soil, depth of groundwater, karst, etc.), in turn, also affect the intra-annual runoff distribution. Influencing factors are divided into two main groups: climatic factors and underlying surface factors (including anthropogenic factors). Among the groups presented above, runoff-forming factors (direct) that, in particular, form runoff, indirect and conditional are distinguished. The runoff-forming factors are precipitation and groundwater, its distribution on the territory is subject to the law of geographical zoning. The indirect factors are air and soil temperature, air vapour-pressure deficit, evaporation. And the conditional factors are the basin area, average height/length/width of the catchment, the erosion depth, density of the river network, etc. The anthropogenic influence is attributed to the underlying surface factors, and by the genetic influence to the indirect factors (Grebin, 2010; Bolbot et al., 2020).

To conduct the research, the observation data of the average monthly water runoff for six left tributaries of the Dniester (the Zolota Lypa River, the Koropets River, the Strypa River, the Seret River, the Nichlava River, and the Zbruch River) within Ternopil region for the entire available observation period were used (to 2020 inclusive).

In the presence of sufficient observation data (at least 15 years), it is recommended to calculate the intra-annual runoff distribution using the real-year model or the seasons combining method. In the research the calculation of the intra-annual runoff of the Podolia tributaries of the Dniester is performed using the real-year model method. This method consists of choosing from the available water runoff series of observations three models of real years, characterized by water content and flow distribution with empirical assurance of annual and seasonal flow close to the given one (Gopchenko et al., 2014). The intra-annual flow distribution is calculated according to water management years, the beginning of which falls on the wet season (spring flood). The boundaries of the seasons are chosen to be the same for all years for the observation period, rounded to the nearest month. The estimated probability of exceeding the flow for a year is determined in accordance with the water management use of the river water runoff. To calculate the intra-annual runoff of the Dniester Basin rivers chosen three model-years: wet-water year - the value of the average annual water runoff is close to the average annual water runoff (25% assurance); average-water year in terms of water content – the value of the average annual water discharge is close to the average annual water discharge of 50% assurance; low-water year - the value of the average annual water discharge is close to the average annual water discharge of 75% assurance.
Results

Firstly, the intra-annual distribution of the region’s river runoff was estimated for the entire observation period (Figure 1). For the Podolia tributaries of the Dniester River Basin, March and April are the months with the largest runoff volumes, accounting for 10-18% of the total annual runoff (depending on the year’s assurance). The months with the lowest runoff volume are November, December, and January, accounting for 5-6% of the annual runoff. The most assurance season for all considered water gradations is the summer-autumn low period, during which 52-57% of the annual water runoff passes.

\[\text{Figure 1 Intra-annual runoff distribution by month on the example of the Seret River – Chortkiv hydrological gauge (for the long-term period 1945-2020)}\]

In the course of the work, the intra-annual flow distribution for the Podolia rivers was evaluated and a comparative analysis of the intra-annual runoff distribution for the water periods, which were selected in previous works, was performed. According to the difference integral curves for the Dniester Basin rivers were distinguished two low periods - 1949-1966, 1983-1997 and two wet periods - 1967-1982, 1998-2011 (Figure 2).

A comparative analysis of the results of the study showed that for wet-water years there is a tendency to decrease the share of spring flood in the wet period by 8%. For the low period of the same gradation of water years, the share of low periods (summer-autumn and winter) increased in the range of 6-8%.

In an average-water year in terms of water content, the intra-annual runoff distribution for low and wet periods has similar trends. A decrease in the share of spring flood in the range of 4-8% was found on an annual basis.

The impact of climatic changes and economic activity in the basin was most clearly manifested in low-water years. The biggest differences between the distribution of the runoff in the determined water periods were revealed. In the wet period, the share of spring flood decreased by 12%, and the share of the winter low period increased by 6%. Since spring flood is not a pronounced period of the water regime for the low period, the decrease in its share was insignificant (by 2%). On the other hand, noticeable changes occurred for the summer-autumn low period - its share increased by 8%.
Therefore, regardless of the water year type, in particular, during the wet period, the share of the spring period runoff (during the spring flood) was decreased. A slight increase in the share of winter runoff was recorded, which is clearly visible in low-water years. This is due to the increase in the frequency of winter floods caused by climate changes, which are observed for the entire territory of Ukraine (Obodovskyi et al., 2021; Bolbot et al., 2021).

**Conclusions**

The modern intra-annual runoff distribution of the Podolia tributaries of the Dniester River Basin is characterized by a decrease in the spring flood runoff volume, which is associated with an increase in air temperature during the period of snow accumulation, a decrease in the winter amount of precipitation, and an increase in the summer-autumn and winter low periods runoff from the volume of annual runoff between studied periods.

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**Figure 2** Intra-annual runoff distribution by seasons for different year assurance (25%, 50%, 75%) on the example of the hydrological gauge the Seret River - Chortkiv

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References


Grebin V. V. (2010). Modern water regime of rivers of Ukraine (landscape and hydrological analysis). Kyiv. 316 p. [In Ukrainian].


