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ASSESSMENT OF DEPENDENCE OF CHANGE IN LITHUANIAN RIVER RUNOFF ON SIZE OF DRAINED AREAS

Miseckaitė O., Taparauskiene L.
Aleksandras Stulginskis University, Institute of Water Resources Engineering, Kaunas dstr., Lithuania. E-mail: Otilija. Miseckaite@asu.lt

Following the data series of 62 years, it was determined that water balance of Nevezis basin is characterized by negative water balance during May-September due to higher evapotranspiration than average precipitation amount of the same period. It was stated that the average annual flow coefficient of the whole 10th hydrologic region of Lithuania was 0.3 till reclamation. It decreased to 0.28 during the period of intensive reclamation, however, the average annual flow was 0.35 from 1980, i.e., it increased in comparison with the period till reclamation. The average flow coefficient of warm period was 0.10 till reclamation, and remained the same during the period of 1956-1980, while the data of 1981-1995 show that the average flow coefficient increased – 0.11.

Most of the regulated rivers are situated in the middle part of Lithuania. There are 422 rivers in the basin of Nevezis and 383 (or 91 %) of them are regulated (the total of 252 rivers and 131 small streams) (Jablonskis et al., 2007). The length of Nevezis is 209 km, while the area of the basin is 6 146 km2, and the discharge at mouth is 30 m3s-1 (Fig. 1). While analyzing the change of Lithuanian river flow and its relationship with drainage intensity, first, it was sought to assess the income and expenses of water of river basins. The basin of Nevezis River is one of the most sensitive basin in Lithuania due to the lack of water during summer and potential anthropogenic pollution – was selected for water balance assessment. The basin of Nevezis belongs to the climatic sub-region of Central Lithuania, which is characterized by warm spring and summer, as well as the lowest amount of precipitation in the republic. The average annual air temperature is – 5.6-6.5 oC. 650–700 mm precipitation falls in the basin of Nevezis River each year, and 70 % of it – during the warm season (Kilkus and Stonevičius 2011).

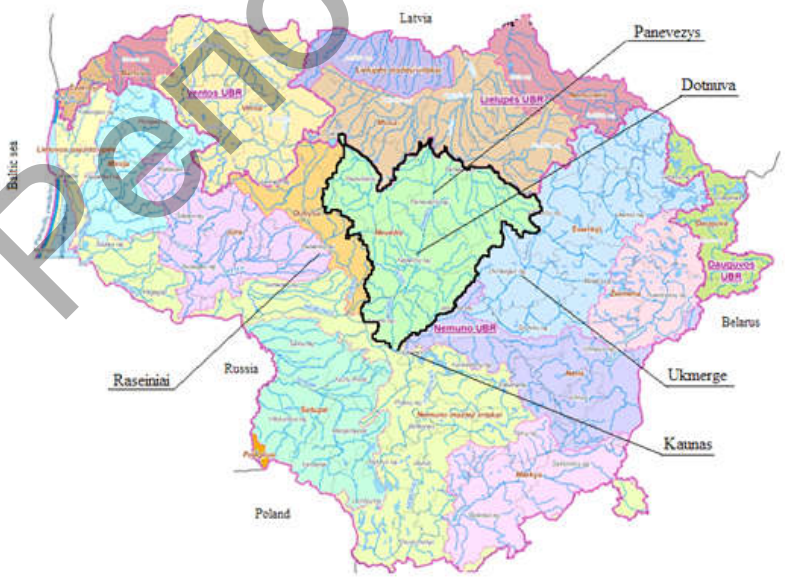

***Fig. 1**–Nevezis basin (Aplinkos apsaugos..., 2008)*

The terrain of basin is uneven – the highest point is 184 m above sea level, while the lowest – 20 m (at mouth), the average height of basin is 77 m, while the average surface slope of basin is 0.027 m km-2. Approximately 90% of all agricultural lands are drained in the basin of Nevezis River.

The data analysis in the present paper is based on the water balance method. Hydrological and meteorological data of period of 1945 – 2007 period of Kaunas, Dotnuva, Panevezys, Ukmerge and Raseiniai meteorological stations were followed. The collected data were used as base, while analyzing the possible change of soil moisture in the basin of Nevezis River. The balance of the whole basin was made, according to the simplified equation:

$$\Delta W_{n+1} = \Delta W_n - ET + H - N, \quad (1)$$

here ΔWn+1 - productive soil moisture at the end of the period, mm; ΔWn – productive soil moisture at the beginning of the period, mm; H – precipitation mm; N – flow from the layer of soil, mm; ET– evapotranspiration, mm. Determined, according to dependence, under Lithuanian climatic conditions:

$$ET = 0{,}5\sum d + 105 \quad (2)$$

here Σd – average amount of daily air humidity deficit during vegetation period, mb.

The calculations were made during vegetation period (May – September). It was assumed that at the beginning of vegetation, as snow has melt, the soil moisture deficit is equal to zero, the soil moisture reserve is equal to accumulative soil volume. Dirse (2001) determined that the productive reserve of soil moisture in Lithuanian loamy soil is 100 mm. Flow to deeper soil layers was considered only in case, when the productive reserve of soil moisture was equal or higher than 100 mm during the vegetation period.

Following the data series of 62 years, it was determined that the average precipitation amount during the vegetation period is lower than the evapotranspiration of the same period. The generalized patterns of precipitation and evapotranspiration are shown in Figure 2. According to research of Zhi et al. (2009), land use change increased evapotranspiration by 8.0%, while climate variability decreased it by 103.0%.

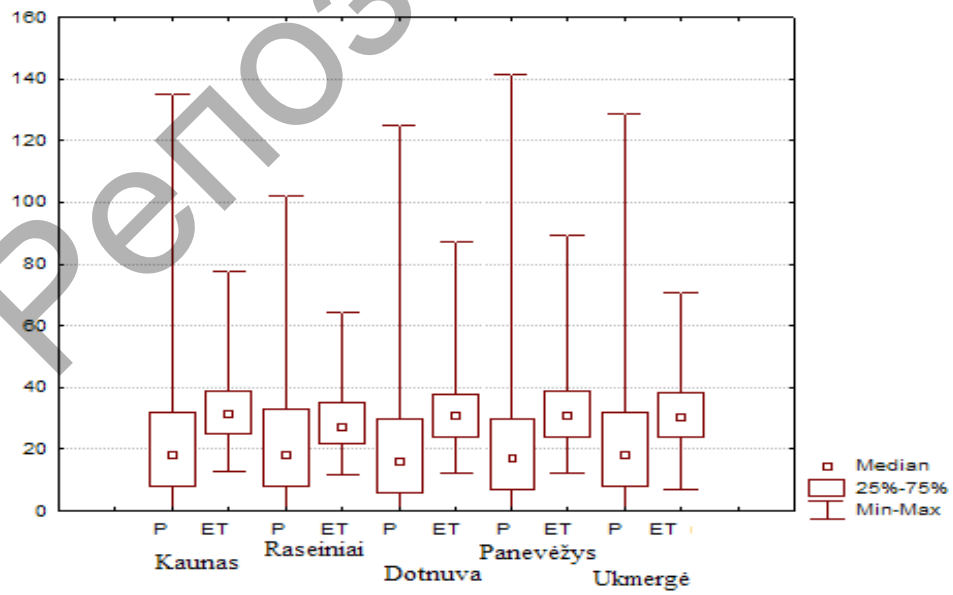

***Fig. 2** – Precipitation (H) and evapotranspiration (ET) in the basin of Nevezis*

The results of calculations of the water balance for the vegetation season during May – September are presented in Figure 3. The calculated water balance shows that the analyzed period is characterized by negative water balance. This demonstrates that the total evapotranspiration in the basin of Nevezis is often higher than the amount of precipitation.

After calculating the water balance, according to the moving averages of five years, it was revealed that the vegetation periods, when water expenses exceed income, dominate. The trend curves are clearly rising in the main part, which forms the water balance – along Panevezys and Dotnuva, while the trend is less significant, but still rising along Kaunas and Ukmerge. Finally, the trend remains neutral and water balance is close to zero only in the western part of basin, along Raseiniai. In summary, it might be stated that a negative water balance is typical for northern and central zone of basin of Nevezis River, while the eastern and western part of basin is characterized by water balance, which is close to zero.

The areas of wet land in the region of basins of Nevezis River make 70-90 % of total area. The analysis of change of too wet lands and drained areas within 1960-2007 years revealed that the drained areas made about 2% of total area of wet lands till 1960 (1.7 % of basin). What is more, 35 % of total area of wet lands (28% of basin area) was drained till 1971, and 58 % of area of basin of Nevezis River (Nevezis along Panevezys - 68%) on average or 70 % of total area of all wet lands was drained till 2000. Recently, the size of area of drained lands has been decreasing. The area of more than 361.0 ha has been drained in the basin of Nevezis, 354,118 ha from which was drained by drainage, while 7,470 – by ditches. Following the data of 2007, the drained areas left for self-decay made 4,932 ha (0.8 %), while those, drained by ditches, made 32 ha (0.01 %). It is quite complex to make a more accurate assessment of change of Nevezis flow due to reclamation, since there is a lack of observation data from the start of reclamation. According to available coefficients of river flow of hydrologic region, it is known that during the period, when there were not more than 1-3 % of drained areas in the basins of rivers, the annual flow coefficient in Dotnuvele (Dotnuva) was 0.29, and 0.10 during the period of June – October; while in Nevezis (Panevezys) the coefficient was 0.31 and 0.11, respectively.

During the period of 1956-1975 (the years of most intensive land drainage) the flow coefficient of Dotnuvele decreased – 0.25 (annual) and 0.05 (June – October), while the flow coefficient of Nevezis River increased – 0.35 (annual) and 0.15 (June – October). During the next 20 years the flow coefficient of Nevezis River increased to 0.36 and 0.18, respectively. Observations were no longer implemented in Dotnuvele. During the periods of 1956-1980 and 1981-1995 the annual flow coefficient also increased in other rivers of basin of Nemunas River – Juosta (Jackagalys) from 0.27 to 0.37, Nevezis (Dasiunai) from 0.28 to 0.36, Smilga (Pasmilgys) – from 0.27 to 0.30. The flow coefficient of warm period (June – October) also increased in Nevezis (along Panevezys and Dasiunai) from 0.15 to 0.18 and from 0.10 to 0.11. It remained the same in Juosta, and only the flow coefficient of Smilga decreased during June – October from 0.09 to 0.06.

In summary, it might be stated that the average annual flow coefficient of the whole 10th hydrologic region of Lithuania, which includes a major part of basin of Nevezis, was 0.30 till reclamation. It decreased to 0.28 during the period of intensive reclamation, however, the average annual flow was 0.35 from 1980, i.e., it increased in comparison with the period till reclamation. The average flow coefficient of warm period was 0.10 till reclamation, and remained the same during the period of 1956-1980, while the data of 1981-1995 show that the average flow coefficient increased – 0.11. After assessing the meteorological conditions and soil water balance of basin of Nevezis River, according to above analysis, it might be stated that the primary

reason of water lack in the basin of Nevezis River is climatic conditions. Drainage systems can hardly have a significant impact on wateriness of Nevezis River. A similar opinion is shared by Lukianas and Ruminaite (2009), who determined that more intensive drainage shortens the duration of spring flood and discharges the same water quantity within a shorter period, however, the annual duration of drainage flow demonstrates a small contribution of drainage to the total flow of rivers. After determining the common trends it also might be stated in the water balance in the basin of Nevezis River will be more negative in the future, since, according to research of Staras (2002), the changes in structure of water balance of basins of Lithuanian rivers in 21 century will be mostly determined by increase of precipitation amount (especially during the warm period), expected in scenarios of climate change, and predicted increase of air temperature. Therefore, precipitation will less accumulate in snow cover, while the evapotranspiration will increase.

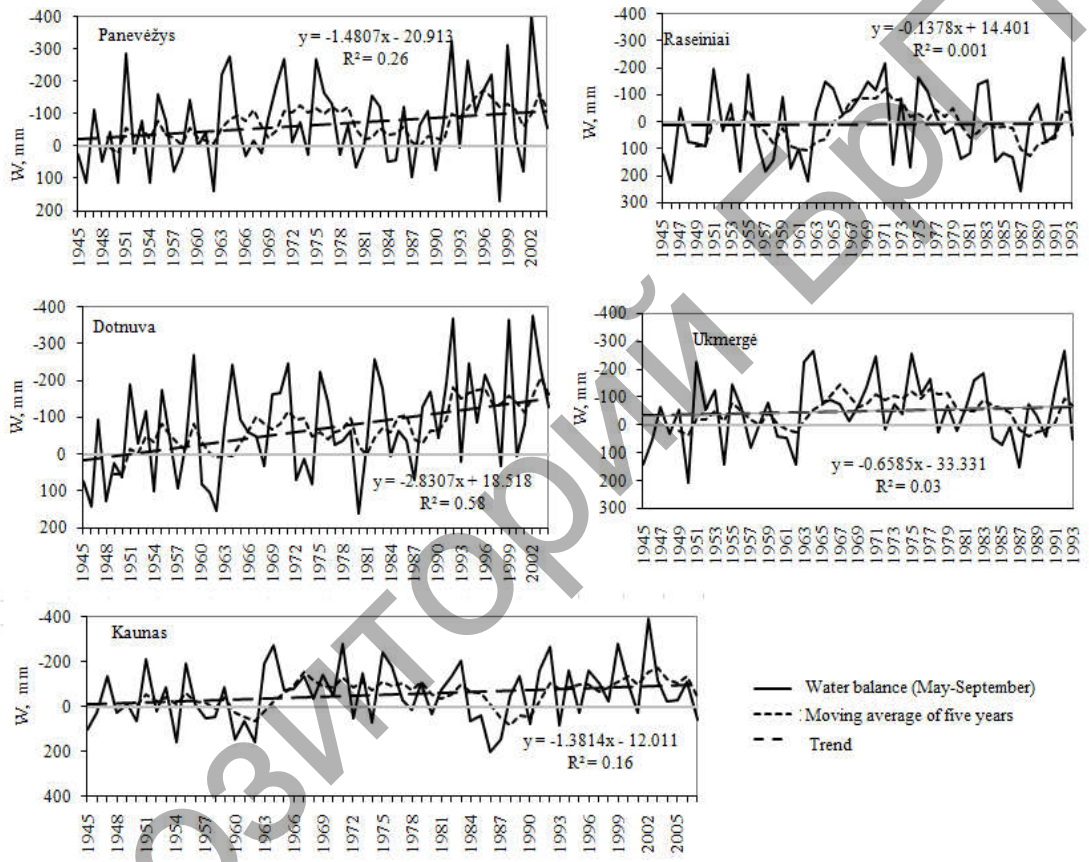

Fig. 3 *– Water Balance tendencies in the Basin of Nevezis*

Conclusions

The basin of rivers of Nevezis is characterized by negative water balance during the warm period, i.e., water income (precipitation) is lower than water expenses (evaporation). The common trends allow stating that the water balance in the basin of Nevezis River will be even more negative in the future.

While summarizing the observation data of period of 1951-1995 of the whole hydrologic region, it might be stated that as the number of drained areas increased, the flow coefficients decreased during spring season (March – May), while the flow coefficients of summer – autumn (June – October) increased.

The average annual flow coefficient was 0.30 till reclamation, it decreased to 0.28 during intensive reclamation. However, the average annual flow coefficient was 0.35 from 1980, i.e., it increased in comparison with the period till reclamation. The

average flow coefficient of warm period was 0.10 till reclamation, and remained the same during the period of 1956-1980, while the data of 1981-1995 show that the average flow coefficient increased – 0.11.

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ПОДХОДЫ К РЕШЕНИЮ ЗАДАЧ ОПТИМИЗАЦИИ СИСТЕМВОДОПОДГОТОВКИ НА ОБЪЕКТАХ ТЕПЛОЭНЕРГЕТИКИ

Адиканко И.И., Дубенок С.А.
Республиканское унитарное предприятие «Центральный научно-исследовательский институт комплексного использования водных ресурсов», г. Минск, Республика Беларусь,adikanko.ivan@gmail.com, dsnega@list.ru

Thermal energy facilities produce a peculiar kind of wastewater with high concentration of minerals. In order to improve the quality of waste wastewater it's necessary to perform an analysis and develop recommendations on optimization of water treatment systems based on the best available techniques.

Введение

Объекты теплоэнергетики имеют характерно высокий удельный расход исходной воды для выпуска продукции, а также специфические виды сточных вод, образующихся на различных процессах производства (водоподготовка, продувка, промывка оборудования и т.п.). Для осуществления основных производственных процессов (производство электроэнергии, пара и горячей воды) объекты теплоэнергетики используют, в основном, воду из поверхностных водных объектов, реже - из подземных источников. В соответствии с данными Государственной статистической отчетности об использовании воды по форме 1-вода (Минприроды) за 2014 год на крупнейших объектах теплоэнергетики были ис-