

Evaluation of changes in the river Viliya annual runoff under the fluctuation climate conditions

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1. Introduction

43% of the territory of Belarus belongs to the Baltic Sea basin (the system of the Neman, the Western Dvina, the Western Bug, the Viliya and the Lovat). The transboundary expending of these river basins works towards to the intense use of water resources for water supply, agriculture, hydropower engineering and navigation. The Viliya is considered to be one of the most loaded rivers. The fact takes place due to the direct water withdrawals for submission into the Vileyka-Minsk water system, and the impact of the current climate fluctuations (Volchak and Parfomuk 2019). They require effective trans-boundary water resources management in the context of such intensive use of water resources and the currently observed climate changes which in turn requires a more detailed assessment of changes in hydro-meteorological criteria.

The aim of the research is to analyze long-term variability of the average annual consumption of water in the basin of the River Viliya (Belarus) in the period 1949 - 2017 in the conditions of the changing climate.

2. Initial data and methods

There are three operating gauging stations on the researching area (Vileyka Town, Steshytsy Village, Mikhalishki Village). The series of annual water consumption during the period 1949 - 2017 are used as the source hydrological data. Missing data in the series of observations was renovated with the help of the applied program "Hydrologist" (Volchak and Parfomuk 2009).

The first step of the research was the analyses of the long-term versatility of the annual average air temperature in three weather stations in the basin of the River Viliya. There were reviewed several periods of observations - the entire observation period (1949 - 2019), as well as broken down into two intervals (1949 - 1978 and 1979 -2019). For the entire research period, the trend of average annual air temperature in the basin of the River Viliya was on average 2.5 °C/100 years. The analysis also showed that during the period 1979 - 2019 there is a trend of increasing average annual air temperatures, the temperature rise is more than 1.8°C over 40 years, whereas during the previous period (1949 - 1978) the temperature remained practically changeless. It is important to note that during the reporting period in the basin of the River Viliya average annual rainfall has increased. This fact should be considered when carrying out hydro-meteorological calculations. Considered climatic changes influence directly on the water regime of the River Viliya.

The next step of this work is to evaluate inter-annual flow variability of the River Viliya. The analysis included valuation of the autocorrelation, trend and statistical homogeneity of the series. There is a graph of a chronological change of annual water consumption at the river stations of the River Viliya in Fig. 1. To evaluate the significance of the linear trend the Student's t-test and the coefficient of correlation are used. The results of the evaluation are shown in table 1.

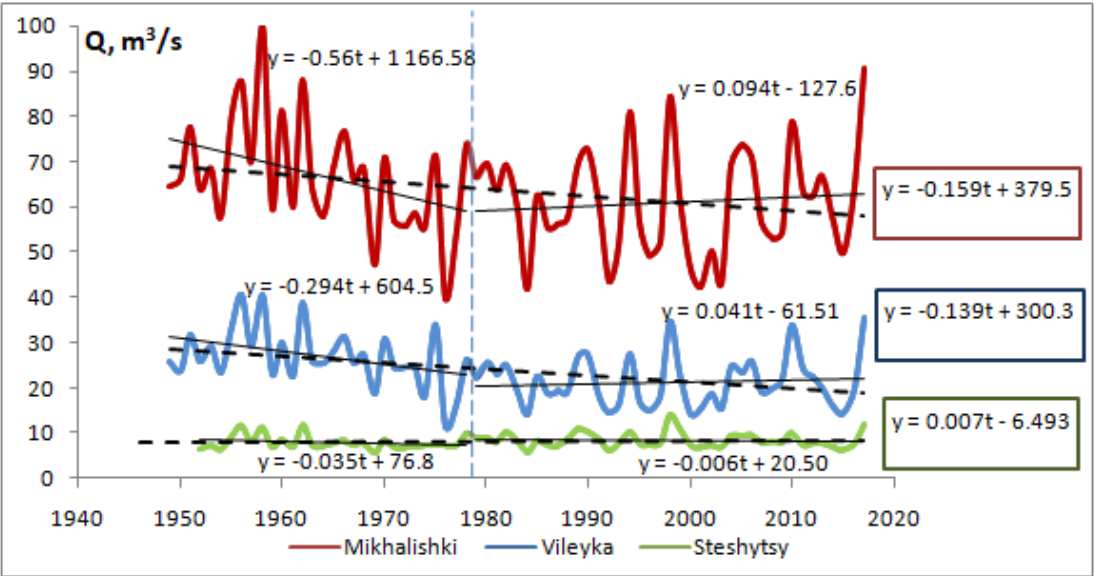


Figure 1. The chronological current of the average annual water consumption at the river stations of the River Viliya during the period 1949 - 2017.

Table 1. An evaluation of the long-term dynamics of annual runoff of the River Viliya for different intervals.

Station	Average annual	Trend equation	Correlation coefficient	Significance of the correlation coefficient	Significance of trend parameters
Averaging period 1949-2017					
Vileyka	23.81	$y = -0.139 * t + 300.3$	0.246	significant	significant
Mikhalishki	63.57	$y = -0.159 * t + 379.5$	0.144	not significant	significant
Steshytsy	8.17	$y = 0.007 * t - 6.493$	0.138	not significant	not significant
Averaging period 1949-1978					
Vileyka	27.1	$y = -0.294 * t + 604.5$	-0.044	not significant	significant
Mikhalishki	67.0	$y = -0.56 * t + 1166.58$	-0.031	not significant	significant
Steshytsy	7.92	$y = -0.035 * t + 76.8$	-0.077	not significant	not significant
Averaging period 1979-2017					
Vileyka	21.3	$y = 0.041 * t - 61.51$	0.174	not significant	not significant
Mikhalishki	60.9	$y = 0.094 * t - 127.6$	0.161	not significant	not significant
Steshytsy	8.31	$y = -0.006 * t + 20.5$	0.286	not significant	not significant

The homogeneity of the series was tested with the involvement of the Student's t-test (for expected value) and the Fisher test (for variance). The ranks were divided into 2 periods: before 1978 and after. As the use of the Student's t-test is possible only to normally distributed random variables, then first the data were checked for the normality of distribution. This was done using the criteria of Kolmogorov-Smirnov and Shapiro-Wilks. The results of the test for uniformity of the series of annual usage are shown in table 2 (the highlighted values are statistically significant).

Table 2. The criteria for the statistical tests of homogeneity of the series.

Station	Averaging period	Criterion	
		F	t
Vileyka	1949-1978 – 1979-2017	1.41	3.94
Mikhalishki	1949-1978 – 1979-2017	1.16	2.07
Steshytsy	1952-1978 – 1979-2017	1.15	1.22

3. Results

The researches have shown that the formation of a water mode of the river River Viliya takes place against the background of statistically significant positive dynamics of average annual air temperature and annual precipitation in recent decades. As shown by the joint analysis of Fig.1, tab. 1 and 2 the average annual runoff at the river river stations station of Steshitsy Village increased during the period 1949 - 2017. There are statistically significant linear negative trends for average annual water consumption at the river stations of the Vileyka Town and Mikhalishki Village during the period 1949 - 2017. For these stations the statistics of the Student's t-test of equality of mathematical expectations exceeded the critical value at a significance level of 5%. Thus the average annual water consumption in the temporal series of the Viliya in the river stations of Vileyka Town and Mikhalishki village the statistical heterogeneity is

determined. No statistically significant changes in the current are observed at all stations during the period 1979 - 2017. It is concerned to the run-off regulation due to the Vileyka water storage reservoir.

References

- Volchak A, Parfomuk S (2019) Assessment of changes in the Viliya River runoff in the territory of Belarus, *Limnological Review*, Vol. 18, No. 4, pp. 185–196.
- Volchak A, Parfomuk S (2009) The application package for definition of characteristics of the river runoff, *Bulletin Of Polesky State University*, No. 1, pp. 22–30.