SMALL RIVER BASIN. PHYSIOGRAPHICAL FEATURES AND WATER DISCHARGE CHARACTER

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În articolul dat sunt prezentate date privind caracteristicile fizico-geografice și regimul scurgerii, de exemplu, r. Bălţata. Sunt expuse tendinţele de reducere a caracterului scurgerii râului în diferite perioade ale anului şi sunt descrise tendinţele dependenţei dintre volumul debitului şi schimbările climatice.

Cuvinte cheie: râuri mici, scurgerea râului, schimbarea climei, modelul regresional.
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Introduction

Deficit of fresh water is being increasingly experiencing by human society year by year due to climate change impact. Mean global air temperature has been growing steadily since 1750, the year representing the conventionally agreed beginning of the Industrial Age [3]. Although climate change impact on individual river basin is relatively uncertain so far, its main directions have been determined quite well. Among such directions [1] one should mention:

- decreasing runoff and water accessibility due to rising temperature, growing evaporation, as well as because of changes in occurrence and quantity of precipitation;
- increasing frequency and intensity of extreme weather events;

- rising temperature can also negatively impact on biodiversity of rivers and lakes.

In order to fully understand local and regional consequences of climate change and, based on the accumulated knowledge, to develop adequate response to problems and challenges of small rivers, we have carried out research in Baltata River Basin.

Results and discussion

Baltata River is one of Dniester River's right tributaries; it is included among the numerous group of Moldova's small rivers. Basin's area is 153.9 sq.km, the longest distance from north-west to south-east is 27.47 km long, its width is 7,74 km. It neighbors Ichel River Basin to the north-west, Bic River Basin to the south, and other small rivers, Dniester's tributaries, to the north and east (Figure 1).

Major part of the basin's territory is located within the steppe zone; minor part to the north-west belongs to the forest-steppe zone. Landforms are dominated by those characteristic to flatlands. In the lower course it is represented by lowlands; while in the upper course highland forms dominate. Absolute altitude varies between 16 and 219 m above the sea level, with an average of 120 m. Slope angle varies between almost horizontal to quite steep slopes (about 17°), with an average of 4°28′. Slope angles between 2° and 5° are the most frequently met, while sub-horizontal surfaces compose less than 0.1% of the basin's territory. Western slope aspect is more dominant (30%) than eastern and southern (both 26%) ones, while northern and north-eastern aspects are even less frequent (18%).

Regular instrumental measures of water discharge have been operated at the hydrological station close to Baltata village between 1954 and 2012, with two pauses in 1958-1960 and 1978-1983.

For the analysis of the river water discharge there were chosen two approximatively equal periods at the beginning and at the end of the period of available observations: 1961-1976 (1st) and 1996-2012 (2nd). Such an approach has allowed us to compare changes in the total water discharge as well as in its annual variations and trends of change, which took place in the period under consideration. Herewith, one must consider that Baltata hydrological station is located in the middle course and, therefore, the results shown here refer to the discharge being formed upstream.

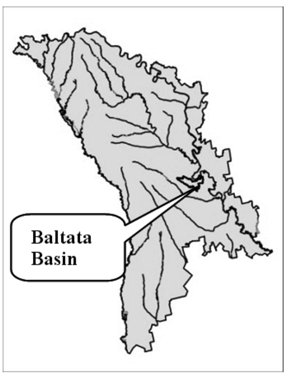

Figure 1. Location of Baltata River Basin.

On the other hand, due to the fact that this part of the river catchment is the least exposed to human activities (e.g. there are no in-stream man-made reservoirs), one can suppose that the observed changes in water discharge are mainly caused by changes in regional climate. Thus, comparison of seasonal and annual water discharge in the two considered periods (Table 1) highlights its diminishing in all the seasons, except autumn, when higher values are registered [2, 4-7]. Particularly, spring water discharge has diminished at the beginning of the century by more than 40% comparing to 1970s; similarly, winter and summer digits have felt by 15-20%. As a result, annual indicators for Baltata River water discharge have diminished by 1/5.

The highest monthly water discharge has been registered in March and February, outstanding in the 1st period of observations (Figure 2). In the same period, the second peak of water discharge has been observed in June-July. However, in the last years, river water discharge registered in February and March has significantly felt down, as well as the summer maximum. At the same time, against a background of equalization of mean monthly dicits, share of the autumn discharge has increased.

Table 1. Baltata River water discharge in the two periods of observations.

Season	Periods of observation		Change in water discharge	
	1961-1976	1996-2012	Abs., l/sec	Rel., %
Winter	49.0	41.7	-7.3	-15.0
Spring	77.9	46.4	-31.5	-40.4
Summer	49.3	38.7	-10.6	-21.4
Autumn	35.6	41.8	6.2	17.4
Annual	53.0	42.2	-10.8	-20.5

Inter-annual variability and multi-annual trends in water discharge can be observed on the Figure 3. As one can see, in some seasons directions of change in water discharge, outlined in the second half of the past century, have been kept until present day, while in other seasons those trends have changed their sign.

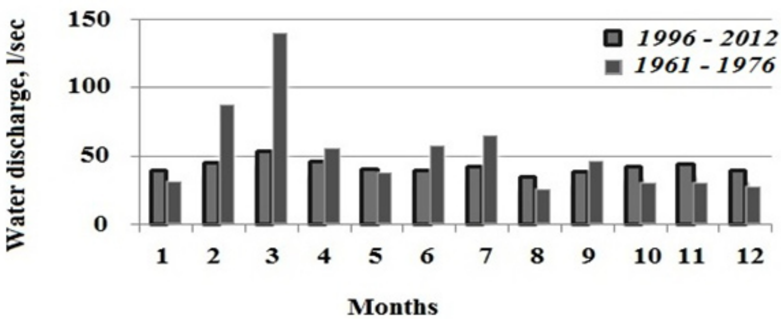

Figure 2. Monthly figures of Baltata River water discharge in the two periods of observations.

Particularly, decreasing water discharge in the winter-spring period is still continuing, while previously registered growth in discharge in the summer and autumn periods has turned to decreasing trend at the beginning of the second period 1996-2012. This diminishing of water discharge has caused a drop in its annual figure by 3.5 l/sec. We suppose that the mentioned changes are caused by changes in temperature and humidity in the area.

In order to check this hypothesis, we made a regression analysis of annual water discharge vs. air temperature and precipitations (Figure 4, Table 2). Mean maximal and minimal figures of air temperature, as well as monthly amount of precipitation for the analyzed years, necessary for modelling, are registered at the nearest Baltata weather station.

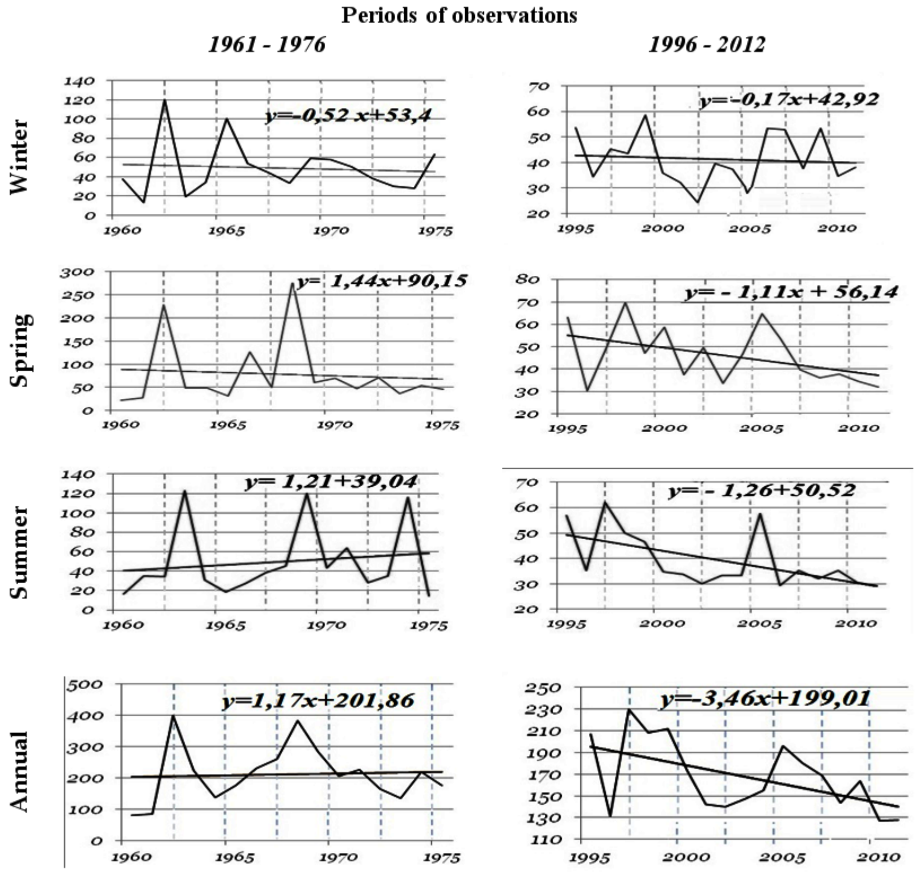

Figure 3. Hydrographs and trends of Baltata River water discharge in the two periods of observations, l/sec. *Note: Slope coefficients of the trend lines reflect mean annual change of water discharge in the analyzed period; x is consecutive number of the year in the series of observations.*

As one could expect, there is an inversely correlated relationship between air temperature and annual water discharge in Baltata River, i.e. than higher the temperature, the lower the discharge. It is explained by the fact that temperature rise causes increase in evaporation from the earth surface and, as a consequence, lowering the share of precipitation, which reaches the river stream. Although this relationship is quite moderate (coefficient of the simple paired correlation $r = 0.332$ (Table 2)), it is statistically significant at the 90% confidence level (*p-value = 0.07*). Judging by the value of regression coefficient we can conclude that a 1°C increase in mean annual air temperature would cause a diminishing of annual water discharge by 0.6 m^3/sec.

The opposite dependence is observed in the case of precipitation: increase of snow- and rainfalls causes natural growing of water discharge. Particularly, rise of annual precipitation sums by 10 mm would be responsible for growth of water discharge by about 0.3 m^3/sec. Thus, direct impact of precipitation is responsible for the 30% of river water discharge. However, the observed positive relationship is very weak ($r = 0.14$) and statistically insignificant (*p-value = 0.45*).

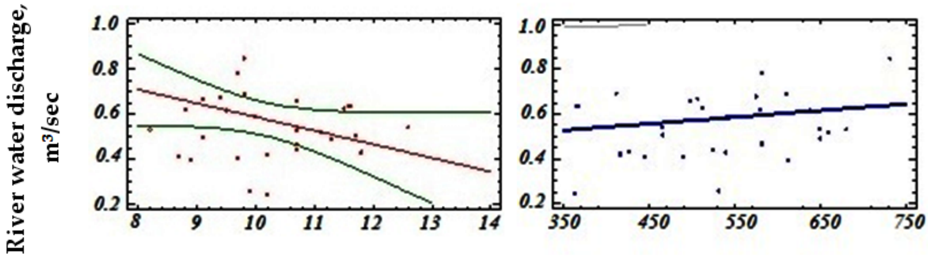

Figure 4. Graphs of simple linear regression of Baltata River annual water discharge vs. mean annual air temperature and precipitation.

Table 2. Parameters of linear regression models of Baltata River annual water discharge (*Q, m³/sec*) vs. mean annual temperature (*T*) and precipitation (*P*)

Linear regression type	Air temperature	Precipitation sums
Simple	Q = 1,196 – 0,061T; *r = -0,332; p = 0,068*	Q = 0,424 + 0,294*10⁻³P; *r = 0,140; p = 0,452*
Multiple	Q = 1,063 – 0,059T + 0,208*10⁻³P; *R = 3,465; p = 0,167*	

Conclusion

1. The water discharge in the winter-spring period is still continuing, while previously registered growth in discharge in the summer and autumn periods has turned to decreasing trend at the beginning of the second period 1996-2012.

2.There is an inversely correlated relationship between air temperature and annual water discharge in Baltata River, i.e. than higher the temperature, the lower the water discharge.

3. The impact direct of precipitation is responsible for the 30% of river water discharge. However, the observed positive relationship is very weak and statistically insignificant.

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