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Relationship of Underground Runoff Components of Mountain Rivers and Atmospheric Precipitations

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ABSTRACT: the article is devoted to the study of the relationship between the underground component of mountain rivers runoff with atmospheric precipitation in an example of Ugam river. For this purpose, the volume of annual groundwater runoff was determined by using the method of vertical dismemberment of the hydrograph. A statistical assessment of the relationship between the volume of groundwater runoff and atmospheric precipitation in different seasons was performed. A relatively close relationship was found out between the annual volume of groundwater runoff and atmospheric precipitation estimated for hydrological year.

KEYWORDS: river, water discharge, hydrograph, precipitation, fed sources, underground recharge, statistical analyses of relationship, regression equation, correlation coefficient, practical application.

I. INTRODUCTION

In recent years, the development of new lands, the expansion of irrigated agricultural land and the growth of the population in Uzbekistan have led to a significant increase in water demand. Therefore, an accurate assessment of the quantity and quality of surface and groundwater resources for solving the problem of their effective use has of great scientific and practical importance. In the conditions of Uzbekistan, where groundwater is intensively used, research on studying of relationship between the volume of underground component of the runoff of mountain rivers and climatic factors has a particularly important scientific and practical challenge.

The first studies of the influence of meteorological factors, including atmospheric precipitation and air temperature, on the formation of river runoff in Central Asia was on date back to the beginning of the 20th century. In particular, V.G. Glushkov, E.M. Oldekop, L.K. Davydov, N.L. Korzhenevsky, V.L. Shultz, O.P. . Shcheglova, AN Vazhnov, MN Bolshakov, AM Vladimirov and others [6; 10-13 p., 9; 41-52 p.]. Currently, research in this direction continues at the Department of Land Hydrology of the National University of Uzbekistan (F.Kh. Khikmatov, D.P. Aitbaev, B.E. Adenbaev, G.X. Yunusov, Sh.Sh. Mukhammedjanov, F.Ya. Artikova and others). However, in the studies of the abovementioned scientists, no special attention was paid to the study of dependence of underground component volume of river runoff on atmospheric precipitation falling on the river basin.

According to the results of the research carried out in the late 19th - early 20th centuries by A.I. Voeikov came to the conclusion that "rivers are the product of the climate of their basins". Developing this theoretical conclusion, he believed that "the characteristics of the water regime of rivers can be used as an indicator of climate" [6; 107-109 p.]. Based on this idea, he developed a climatic classification of rivers. As known, in this classification, all the rivers in the world by A.I. Voeikov were divided into the following types: 1) rivers receiving water from melting snow on plains and low mountains (up to 1000 m); 2) rivers that receive water from melting snow in the mountains; 3) rivers that receive water from rains and have high water in the summer; 4) rivers in which flooding occurs due to snow melting in spring or early summer, and a significant part of the river water is delivered by rains; 5) water is delivered by rain: it is

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higher in colder months, but the correct periodic change is small; 6) water is delivered by rain; it is higher in cold weather than in summer, and the difference is significant; 7) the absence of rivers and, in general, permanent streams due to climate drought; 8) countries where the rainy time is short and the rivers have water few times, and the rest of the time dry or turn into a series of puddles with an underground flow; 9) countries without rivers [6; 107-109 p.].

For all types of rivers identified by A.I. Voeikov, groundwater is one of the main sources of water formation. Unfortunately, despite this, to date, the issue of the relationship between groundwater and atmospheric precipitation is insufficiently studied in scientific literature.

The main aim of this study is statistical assessment of the relationship between groundwater runoff of Ugam river and atmospheric precipitation. To achieve this goal, data discharge of Ugam river, measured at the Khodjikent hydrological gauge, and the values of monthly and annual precipitation were taken from the data of Pskem meteorological station.

Based on the purpose of the work, the annual volume of the underground flow component of Ugam river was determined using the method of vertical dismemberment of the hydrograph from annual flow.

At the next stage of the study, the initial materials on atmospheric precipitation were subjected to primary processing. Their sums were estimated either hydrological year (October-September) and the winter (October-March) and summer (April-September) seasons.

Correlation coefficients representing the tightness of the relationship between the annual volume of the underground component of Ugam river and precipitation were determined using standard statistical methods. The calculations were performed for the following three types: 1) $W_{gw} = f(\Sigma X_{X\text{-}IX})$; 2) $W_{gw} = f(\Sigma X_{X\text{-}III})$; 3) $W_{gw} = f(\Sigma X_{IV\text{-}IX})$, where: Wgw - annual (calendar year) volume of the underground component of Ugam river runoff; $\Sigma X_{X\text{-}IX}$ is the sum of atmospheric precipitation for a hydrological year; $\Sigma X_{X\text{-}III}$ - the sum of atmospheric precipitation for the cold half of the year; $\Sigma X_{IV\text{-}IX}$ - the amount of atmospheric precipitation for the warm half of the year.

The graphical representation of the Type I of dependence is shown in Fig. 1.

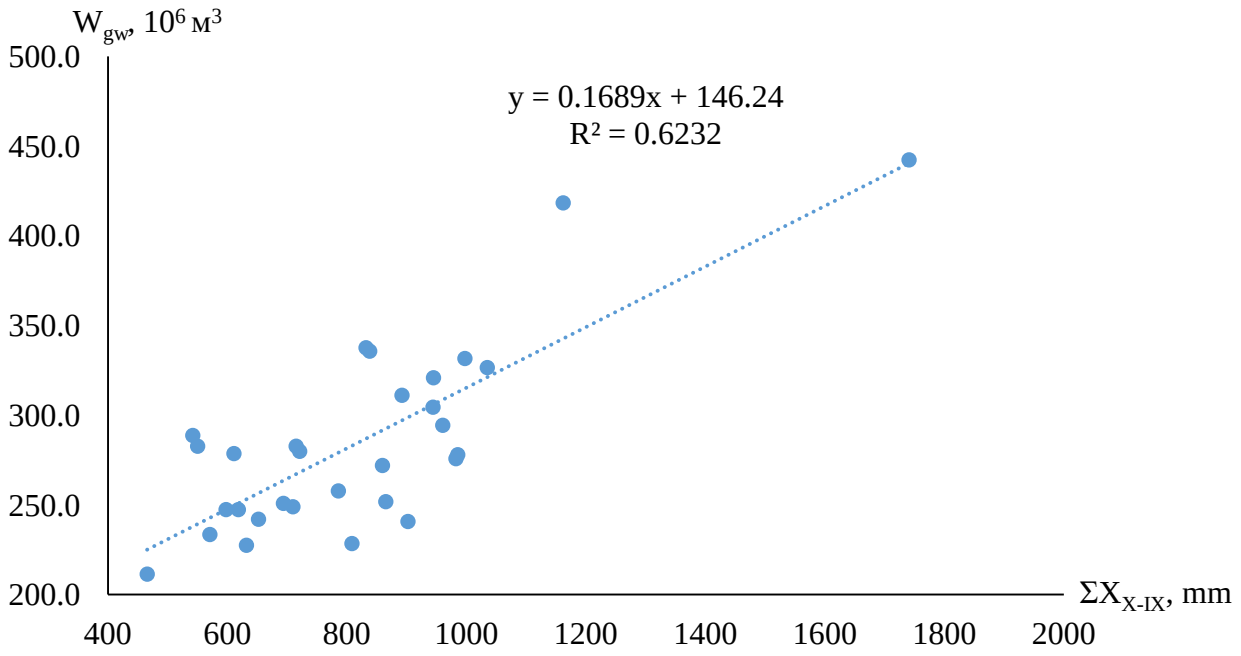

Fig. 1. Graph of the dependence of the volume of underground component Ugam river runoff from annual amount of atmospheric precipitation ($\Sigma X_{X\text{-}IX}$)

Based on the results of statistical analysis, regression equations developed characterizing the relationship between the volume of underground runoff of Ugam river. Ugam river and precipitation, different design seasons were developed. Paired correlation coefficients reflecting the accuracy of these regression equations and their errors are presented in Table 1.

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Table 1
Statistical characteristics of relationship between the volume of underground component of Ugam river runoff and precipitation

Correlation types	Regression equation	Correlation coefficient and its error, $r \pm \sigma r$
I	$W_{gw} = 0{,}1689\Sigma X_{X\text{-}IX} + 146{,}2$	0,789 ± 0,026
II	$W_{gw} = 0{,}2107\Sigma X_{X\text{-}III} + 165{,}9$	0,735 ± 0,033
III	$W_{gw} = 0{,}3528\Sigma X_{IV\text{-}IX} + 194{,}4$	0,616 ± 0,047

As shown in the table, a high degree of tightness of correlation corresponds to the type I, i.e. relationship between the volume of underground component of Ugam river and total values of atmospheric precipitation for hydrological year. The value of the correlation coefficient for this type was r = 0.789 ± 0.026.

Relatively high values of the correlation coefficients were also obtained for the types II and III relationships, the values of which were, r = 0.735 ± 0.033 and r = 0.616 ± 0.047 respectively. This result of the assessment of relationship is explained by the fact that the rivers are fed by groundwater throughout the hydrological year.

II. CONCLUSION

Summarizing the results of the study, the following conclusions can be made:

1. The values of correlation coefficients and obtained regression equations representing the relationship between the volume of the underground components of Ugam river runoff and atmospheric precipitation recorded in different seasons of the year fully comply with the criteria of statistical analyses;

2. Analysis of correlation coefficients values characterizing the tightness of the relationship between the underground components of Ugam river and atmospheric precipitation showed that its highest value corresponds to the relationship between the values of variables of the calendar (W_{gw}) and hydrological ($\Sigma X_{X\text{-}IX}$) years (r = 0.789 ± 0.026);

3. The regression equations obtained as a result of the statistical analysis of relationships between variables are recommended for using in special hydrological estimations and forecasts related to the refinement of underground components of mountain river runoff, especially during low-water periods.

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