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Research Article

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Control the Uniformity of Hydrometric Data

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ABSTRACT

Objective: The purpose of the study is to study the influence of series of hydrometric observations on the transfer of hydrometric sources along the river in order to convert the results and analyze them. since individual long-term series cannot unambiguously characterize the impact of climate change and economic activity on river flow.

Theoretical Framework: The prerequisite for the study is the presence of a logical theory of the formation of water flow along the length of the river in various physical and geographical conditions, as well as the presence of a relationship between charge of water in the river and water levels in it.

Method: A graph-analytical research method was used, which makes it possible to clearly determine the deviations of measurement data over time from the main trend. The analysis was carried out based on the materials of long-term observations of river flow on the state hydrometeorological observation network of Ukraine.

Results and Discussion: The studies carried out confirm all the theoretical justifications for the theory of water flow in river beds and show a reliable way to check for the presence of distortion in runoff calculations when moving observation sites. Using the proposed method, it is possible to easily determine whether the transfer of gauges is the cause of flow distortion or economic activity, etc.

Research Implications: The research results indicate the need to clarify periods with homogeneous data and determine the rate of water flow from them for use in design and forecasting. A thorough analysis of the morphometry and regime of the river will allow us to determine the optimal location of the hydrological post.

Originality/Value: Despite the wide popularity of the graphic-analytical method for studying the homogeneity of observation series, it has not been used in the proposed form. The importance of the development is that the proposed method allows you to quickly determine the interruption time of a series of observations and make appropriate adjustments to the water cadastre materials.

Keywords: Reliability, Observation, Hydrological, Graphic Analysis, Charge of Water

Introduction

Ensuring the uniformity and reliability of materials of hydrometeorological observations is an important part of the formation of climatic, water and other state cadastres of the results of observations of the state of the environment. What is evidenced by the regulatory documents of various states, including Ukraine [1-4]. There are a number of statistical methods for detecting violations of the homogeneity of series of observations, which are successfully used in the practice of hydrological calculations, especially in cases where the time of occurrence of the inhomogeneity is known heterogeneidad [5-7].

Sometimes researchers state the presence of heterogeneity of the hydrological series, but are unable to identify the time of the disturbance and the cause of its occurrence. As a rule,

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economic activity is named among the main reasons, and they try to identify precisely these periods in a series of observations and check them for uniformity.

Theoretical Framework

When conducting observations of water flow at stationary hydrological stations, there are cases when observers are forced to move observation sites upstream or downstream from the main hydrological station [8]. The main reasons for the occurrence of such situations are economic activities in the riverbed (construction of locks, dams, reservoirs, etc.), on the floodplain or catchment, and in conditions of natural disasters (severe floods, shallowing, etc.), with changes in climatic conditions, natural development of the hydrographic network, etc. there are also situations that affect the uniformity of observations. Thus, the occurrence of support from dams and sluices causes changes in the level regime at the water measuring post, as well as overgrowth with aquatic vegetation.

In the instructions of the Hydrometeorological Service of different years of issue, the transfer of a water metering station is spoken of as a costly measure, entailing a disruption in the continuity of a series of observations and much attention is paid to the requirements for choosing an observation site [1,2]. Special and educational literature speaks of the need to locate a new post as close as possible to the old one in order to maintain the continuity of a series of observations in one place (in view of the great value of long-term observations in one place) [8].

However, there are situations when, as a result of strong floods or high waters, there are strong deformations of river beds, destruction of hydrometric devices, etc., requiring the re-equipment of water metering posts and the relocation of cross sections.

Such cases can be traced on posts with long observation periods. For example, the Trubizh-Baryshivka hydrological station was opened on September 1, 1945, 50 km from the mouth of the Trubizh River. Vodpost is located on a site with an artificial channelized channel, was closed on March 31, 1960 due to the influence of variable support from channel lock No. 7 since January 1958, which is located 1.9 km downstream of the water measuring device [9]. The Trubizh - Baryshivka post, sluice №7 was opened on March 16, 1960. Observations at the new and old posts are not comparable, as the river regime has changed. Information about the influence of economic activities on the river regime is placed in the description of posts in hydrological yearbooks and directories [9,10]. In the given example, the influence of economic activity on the homogeneity of the series of observations is obvious. However, there are cases when the reasons for the heterogeneity of the series are not so noticeable. The objective of the research was to show the possible reasons for the occurrence of violations of the homogeneity of hydrometric measurements and methods for their detection.

Methodology

The study used observation materials of the Hydrometeorological Service of Ukraine. These are mainly materials on measuring water flow in rivers using the velocity-area method and materials on average and typical water flow per year. The characteristics of the hydrological posts used in the analysis are given in Tables 1 and 2. The characteristics of the hydrological posts along the Prut River are given separately in Table 2, since it provides extended information. The number of water-gauging posts along the Prut River has been constantly changing over the long-term observation period; at most posts, observations were mainly carried out for water levels. Figure 1 shows a map-scheme of the location of the hydrological posts under study.

Table 1: Characteristics of hydrological posts

River - post	Catchment area, km^2	Distance from mouth, km
Trubezh - Baryshevka, sluice No. 7	1990	48
Noreen - Slavenshchina	804	5,0
Zapadny Bug – Kamenka Bugskaya	2350	689

Source: State Water Cadastre of Ukraine

Table 2: Main hydrographic characteristics of hydrological observation points on the Prut River

River - post	Distance from mouth, km	Distance from source, km	Catchment area, km^2	Note
Prut - Vorokhta	955	12	48,3	
Prut - Tatarov	932	36	366	
Prut - Yaremcha	914	54	597	
Prut - Kolomyia	867	100	1130	
Prut - Snyatin	815	153	3240	
Prut - Chernivtsi	772	195	6890	
Prut-Lipkany	665	302	9200	Republic of Moldova
Prut - Korpach	596	371	11000	also
Prut-Costesht	557	410	11900	also
Prut - Branesti	546	421	12300	also
Prut - Valya - Rusului	460	507	14600	also
Prut - Ungheny	387	630	15200	also
Prut-Leuseni	278	689	16000	also
Prut - Leovo	216	755	23400	also
Prut - Kagul	87	880	25500	also
Prut - Brynza	45	922	27300	also

Source: State Water Cadastre of Ukraine

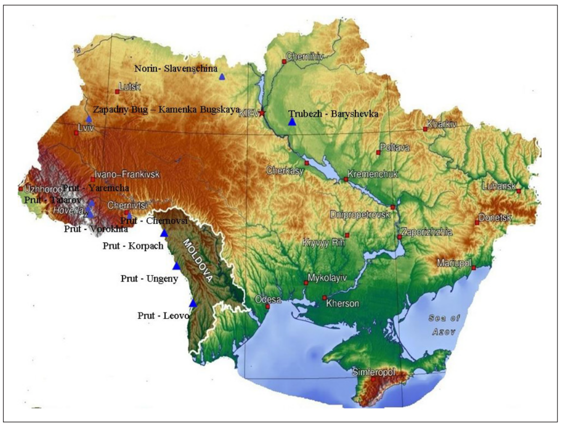

Figure 1: Layout of water metering stations (location of the water metering station).

Source: http//Ukraine_topo_en.jpg and State Water Cadastre of Ukraine.

The Prut River originates in the Carpathians, on the south-eastern slope of Mount Goverla, 15 km southwest of the village of Vorokhta, the total drop of the river is 1577 m, with a length of 967 km and a catchment area of 27540 km^2 [11,12].

The beginning of observations on the Prut River near the village of Tatarov dates back to 1909. At that time, the settlement was called Podlesnyuv, later Kremenets and at present it is Tatarov.

The main research method was a graphical analysis of long-term observations of water runoff by the Hydrometeorological Service of Ukraine.

Visual representation of observation data in graphical dependences over time, in space or among themselves, makes it possible to orientate about the errors of the data set or the measurements themselves, etc.

The premise of the study is the presence of a logically justified and practically verified theory of changes in the flow of water along the length of the river in certain physical and geographical conditions, as well as the presence of a close relationship between the charge of water in the river and the water levels in it [13,14].

The difference between a hydrological (water measuring) post and a hydrometric structure is that a water measuring post is a permanently fixed site for measuring the water content of a stream, the main measuring instruments for daily measurement of water levels and its temperature are located here. While a hydrometric device is a device on the river, intended for measuring water flow, it can coincide with a water measuring post or, if necessary, it can be moved up and down from the main water measuring post.

Results and Discussions

The most characteristic indicator of changes in the hydrological regime in the creation of the post is the relationship between water consumption and water levels, however, these relationships are also affected by the flow of sediments, channel deformations, vegetation, etc.Furthermore, limitations of the study and possible directions for future research are discussed. It is essential that both the results and the discussion are based on solid evidence and that they contribute significantly to the advancement of knowledge on the topic addressed [13-15].

Therefore, for some rivers, it is easy to trace changes in the hydrological regime under the influence of economic activity and shifting posts, but not for others. Yes, we have noted it before, that the dependence of costs on water levels for the Norin River - Slavenshchyna region shows some stratification of points, which arose due to measurements of charge of water in different hydrometric cross section (No. 3, No. 4, No. 5) [16,17]. In creation No. 3, the measurements were carried out at the borders in the root channel, in No. 4 mainly in water harvesting taking into account the floodplain, in creation No. 5 at increased water flows (Figure 2).

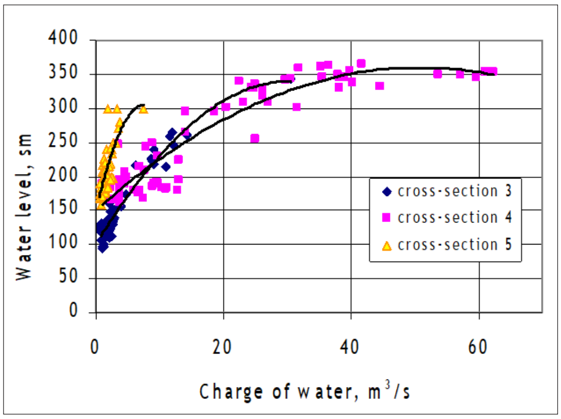

Figure 2: Correlation of charge of water and water levels at the hydrological station of the Noryn River - Slavenshchyna

Source: data analysis

In 2001, at the hydrological station of the Zapadny Bug River - Kamenka Bugskaya, the observation platform was moved 3 km downstream, the reason for the relocation being an increase in the water depth at the station. As a result, the long-term series of observations turned out to be heterogeneous, which is clearly visible on the graph of the change in water depth over time (Figure 3), but is practically not visible on the connection of water consumption and water levels at the hydrological post (Figure 4) [17].

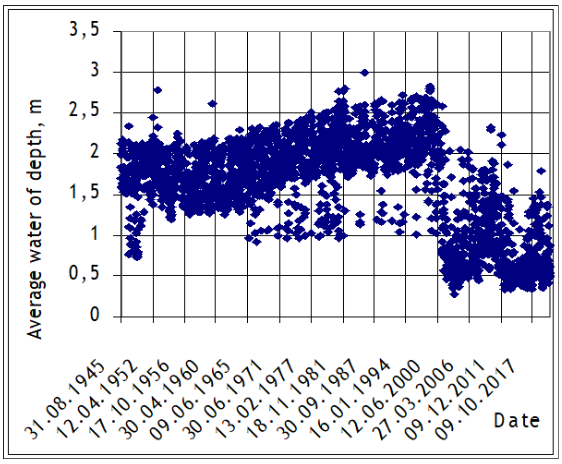

Figure 3: Change in water depth over time in the Western Bug River - the city of Kamenka-Bugskaya

Source: data analysis

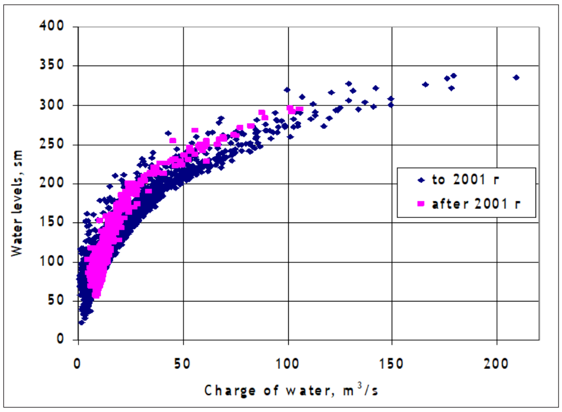

Figure 4: The relationship between charge of water and water levels at the hydrological station Western Bug River - the city of Kamenka-Bugskaya

Source: data analysis

The limits of permissibility of moving measuring sections up or down from the main water gauging post are discussed more in a qualitative aspect (absence of backwater, deformations, etc.) [2]. while there are no quantitative recommendations on how to determine the moment when moving a hydrometric section will essentially become a transfer of the post and will significantly distort the measurements obtained over time. Along the length of the river, both the morphometric parameters of the river channels and the flow rates and volumes of water runoff, catchment areas, etc. change, which affects the homogeneity of the series of observations. How can we determine the limit at which the homogeneity of the series will not be violated?

Let us consider this issue using the example of moving hydrometric sections along the Prut River - Tatarov water gauging post. The high flood of 1997 forced observers in May 1997 on the Prut River - Tatarov settlement to move the hydrometric cross-section 5.5 km below the water gauging post, and subsequently the transfer of the cross-section over long distances upstream and downstream became regular (Figure 5). Along the ordinate axis, the numbers of hydrometric cross-sections No. 1 are 160 m higher than the main water gauging post, No. 2 is 5.5 km lower than the main water gauging post, No. 3 in 2003 was located 4.0 m lower than the main water gauging post, in 2011 the hydrometric cross-section was located 4.5 m higher than the main water gauging post: No. 4 - in 2002 it was located 4.0 km lower than the main post, in 2012-2013 it was located 4.5 km higher than the main post; the water gauging post on 06.11.2020 was moved 1.8 km below the previous location of the water gauging post, then measurements are taken at the post site.

As a result, over a more than 20-year observation period, a significant distortion of a number of water depths (Figure 6), current velocities, etc. has been observed.

The distortion of the water flow values is also evident from a number of long-term observations of water flow at the Prut-Tatarov river post (Figure. 7), and the graph of the relationship between flow rates and levels also reflects the non-uniformity of observations from year to year (Figure. 8).

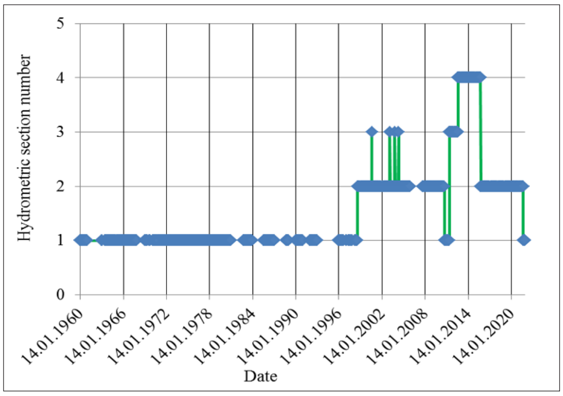

Figure 5: Change in the location of water flow measurement sites over the years.

Source: data analysis

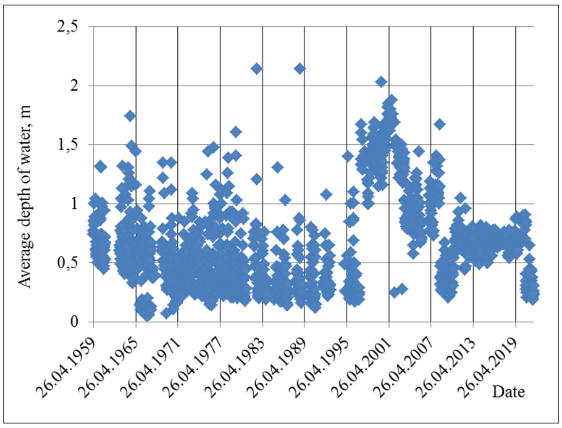

Figure 6: Change in the average water depth in the Prut River - Tatarov settlement over a long period based on water flow measurement data.

Source: data analysis

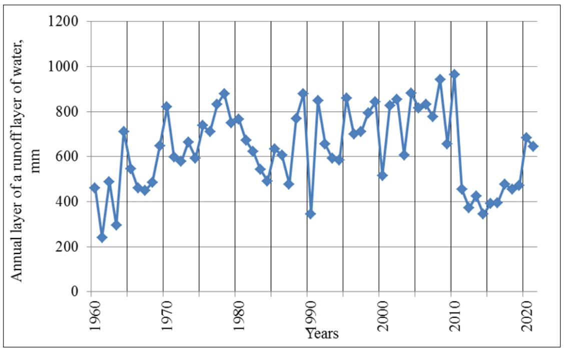

Figure 7: Change in average annual runoff layer over time at the Prut-Tatarov post

Source: data analysis

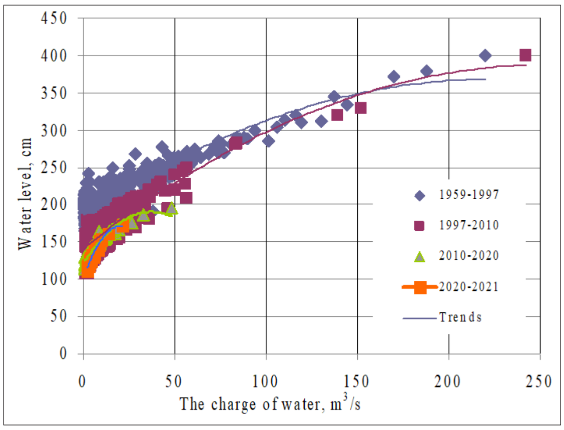

Figure 8: Dependence of charge of water on water levels at the Prut-Tatarov river water gauging station.

Source: data analysis

The transfer of hydrometric sections below or above the main water gauging station leads to a change in the catchment area and, as a consequence, in the volumes of runoff recorded at the hydrometric section. Thus, the transfer of the section 5.5 km downstream of the Prut River from the Tatarov water gauging station adds approximately 76 km^2 to the catchment area and 0.034 km^3 to the runoff volume per year (for 1966 years). (Figure 9,10).

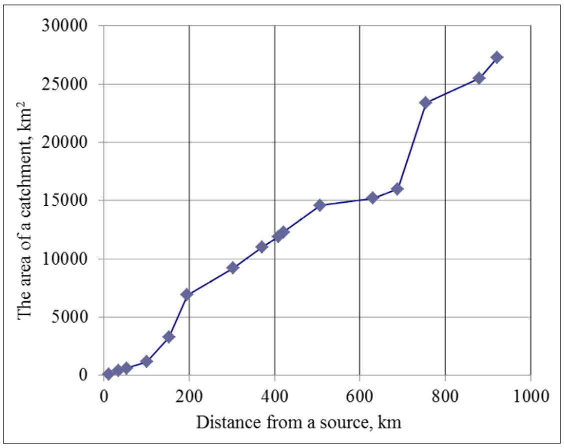

Figure 9: Dependence of the catchment area of the Prut River on the distance from the source.

Source: data analysis

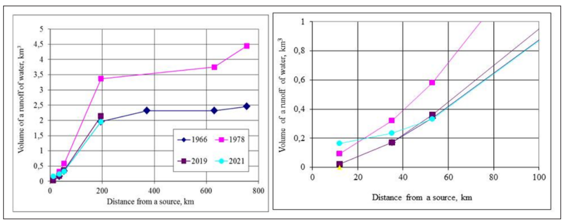

Figure 10: Increase in runoff volume along the Prut River.

Source: data analysis

The change in the catchment area and runoff volumes leds to a violation of the homogeneity of the relationships between runoff and precipitation, evaporation, etc., since for individual years the points will lie on individual curves, forming a field of points around the main curve. The spikes in the curves of the time dependencies turn out to be completely unrelated to climate change, the influence of the latter is barely noticeable due to the constant transfer of hydrometric sections up and down the river (Figure 7). In addition to interference in runoff calculation and analysis of climate influence, etc., heterogeneity of measurements can be the cause of incorrect assignment of characteristic values of soda runoff and as a result of incorrect design of hydraulic structures, assignment of measures during outstanding floods and elimination of their consequences, etc. If we keep in mind that the permissible error in water flow measurements is 5-10% and the transfer of a hydrometric section by 1 km changes the runoff volume by 0.00618 km^3, i.e. by 10% of the runoff, it turns out that it is impossible to transfer hydrometric sections in these physical and geographical conditions by more than 1 km [2,6]. However, it should be borne in mind that the flow of additional volumes of water in rivers often occurs pointwise due to the inflow of tributaries along the length of the river. And on the section of the river under consideration there is a tributary - the Zhenets River, which flows into the Prut River below the Prut River - Tatarov water gauging post by 400 m. It turns out that the main tributary on the section between the water gauging post and the hydrometric sections comes from the Zhenets River and the flow distortions occur due to it. Taking this into account, it is impossible to move the hydrometric sections below the mouth of the Zhenets River.

Conclusion

The conducted studies show that the transfer of hydrological posts in mountainous areas over significant distances (more than 1 km) entails a violation of the homogeneity of a number of observations over time. As a result of such transfers, we have additional posts of single observations of water runoff along the river. That is, when analyzing changes in water runoff over time, such observation materials should be divided into separate periods and analyzed separately. When analyzing changes in water content in space, adjusted distances to the source or mouth should be added to the characteristics of the post position, the area and slope of the catchment should be adjusted for each case of flow measurement not in a fixed place. In the case of the Prut-Tatarov water gauging post, the catchment area at the hydrometric sections changed, an additional volume of runoff appeared due to the addition of the catchment area of the tributary - the Zhenets River, the mouth of which is located 0.4 km below the original water gauging post and 1.4 km higher from the new location of the post (since the end of 2020). This explains the differences in the flow regime at temporary hydrometric sections.

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