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Comparison of water levels of the Angrapa river in the middle of the 20th and early 21st century

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Abstract. The results of a comparative analysis of the characteristic water levels in the Angrapa River (Berestovo gauging station, Kaliningrad region) in the middle of the 20th and at the beginning of the 21st century are presented. A number of average annual discharges of the Angrapa river (Berestovo gauging station) have been restored for analogue rivers. It has been established that the average long-term levels of the Angrapa river have decreased over the period under review. At the beginning of the 20th century, intra-annual changes in water levels with a spring flood peak, summer-autumn low water and rises during rain floods on the Angrape River were noted in less than half of the cases. In the 21st century, such a change occurs only in some years, in other years there are several rises in the water level, from December to March-April. The highest level in the Angrapa river (Berestovo gauging station) was recorded during a rain flood. The hydrological regime of a water body has a significant impact on the conditions for the existence of ecosystems, the level regime of a river significantly affects the floodplain ecosystem. The data obtained can be used in the development of environmental measures.
Keywords: Angrapa river, Berestovo gauging station, water levels

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Сравнение уровней воды реки Анграпы середины XX и начала XXI века

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Аннотация. Представлены результаты сравнительного анализа характерных уровней воды в реке Анграпе (гидропост Берестово, Калининградская область) в середине XX и в начале XXI в. По рекам-аналогам восстановлен ряд средних годовых расходов р. Анграпы (гидропост Берестово). Установлено, что средние многолетние уровни р. Анграпы за рассматриваемый период уменьшились. В начале XX в. внутригодовое изменение уровней воды с весенним пиком половодья, летне-осенней меженью и подъемами во время дождевых паводков на р. Анграпе отмечалось менее чем в половине случаев. В XXI в. такое изменение встречается лишь в отдельные годы, в остальные годы наблюдается несколько подъемов уровня воды, начиная с декабря и по март-апрель. Наивысший уровень в р. Анграпе (гидропост Берестово) был зафиксирован во время дождевого паводка. Гидрологический режим водного объекта имеет значительное влияние на условия существования экосистем, уровенный режим реки существенно влияет на пойменную экосистему. Полученные данные могут быть использованы при разработке природоохранных мероприятий.

Ключевые слова: река Анграпа, гидропост Берестово, уровни воды

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Introduction

The Angrapa River plays an important role in the water economy of the Kaliningrad region, it is a receiver of drainage systems and wastewater from settlements located on its banks and is also used for recreational purposes.

The river is characterised by frequent changes in the direction of flow, large tortuosity and sheer steep banks. The Angrapa River basin, as well as other rivers of the Kaliningrad region, is in the zone of excessive moisture. Low land form of the territory, slow processes of surface water runoff, abundance of wetlands, significant amount of precipitation with low evaporation losses create favourable conditions for development of the hydrographic network. The river network is supplemented by a network of drainage canals and ditches.

Many scientific papers have been devoted to the study of various characteristics of the Angrapa River, primarily ichthyocenosis [1–14]. As a result of studies [2], 15 species of juvenile fish were found in the Angrapa River. Among the rivers of the Kaliningrad region, a greater number is observed only in the rivers Sheshupa and Neman. Species diversity of macroalgae of the Angrapa River and other rivers of the Kaliningrad region was studied in [3], the ecological and faunistic characteristics of molluscs of the Angrapa River were investigated in [4, 5]. Various aspects of the state of the Angrapa River ecosystems are considered in [6–8].

The above articles note that the state of the biocenosis of the Angrapa River is significantly influenced by hydrological characteristics, the works [10–14] are devoted to their research. However, changes in the characteristic levels of the Angrapa River remained poorly studied.

The purpose of this work is to perform a comparison of the characteristic levels of the Angrapa River in the mid-20th and early 21st century.

Materials and methods

The initial data were the results of observations of water levels in the Angrapa River (Berestovo gauging station) for 1954–1966 from hydrological yearbooks and for 2008–2020 from the online array of the Automated Information System for State Monitoring of Water Bodies.[1] Table 1 is compiled using data from the latter source.

Table 1. **Characteristic water levels of the Angrapa River (Berestovo gauging station), 2008–2020, cm from post zero**

Year	Medium level	Highest level		Lowest level	
		Value	Date	Value	Date
2008	138	264	27.01	108	03.08
2009	136	226	19.03	112	28.08
2010	136	270	22.03	112	12.07
2011	153	378	06.02	116	20.11
2012	148	294	26.02	114	10.09
2013	150	276	15.04	112	08.08
2014	131	252	27.03	92	27.11
2015	105	200	04.04	75	06.10
2016	125	224	12.12	90	04.10
2017	166	306	03.11	104	16.08
2018	126	254	02.02	88	10.07
2019	114	218	14.02	84	02.09
2020	104	165	03.02	82	15.08

Source: compiled by the authors.

[1] Automated information system of the state monitoring of water objects. URL: https://gmvo.skniivh.ru/ (accessed: 03.03.2023).

The hydrological post (HP) on the Angrapa River in the village of Berestovo (former name Shlappaken, 30 km from the confluence with the Pregolya River) was discovered in 1984 and is still in operation. The catchment area up to the post is 2460 km^2, the zero mark of the post H_0 = 23.85 metres of the Baltic system (mBS). Data for 1901–1913, 1918–1939, 1941–1943 and since 1953 are available in hydrological yearbooks without omissions. Observations for some years of the world wars and after them are lost.

In hydrological yearbooks water levels in rivers are given relative to the conditional zero of HP, during data processing they were converted to mBS:

$$H = 0.01 \cdot H_c + H_0, \quad (1)$$

where H_c – water level, cm from the HP zero.

Results and discussion

The reconstructed series of average annual expenditures from [14] for the peer rivers is presented in Figure 1. The linear trend shows a very slight average reduction values of discharge for 120 years of observations, the behaviour of the parabolic trend line is different. This line has a maximum in the mid-20th century and decreases in early 21st century, so it is of interest to compare the characteristic levels of the Angrapa River for these periods.

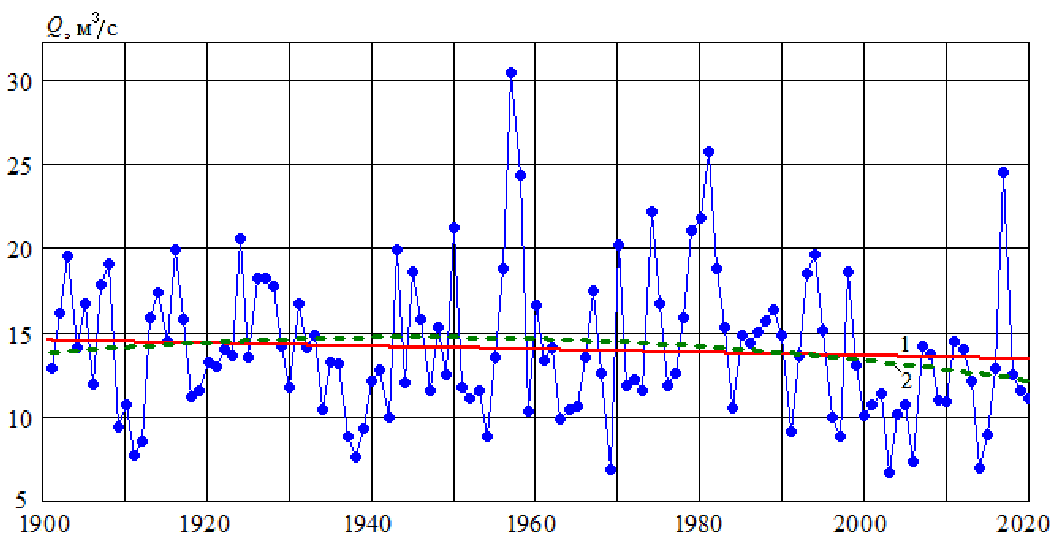

Figure 1. Mean annual discharge of the Angrapa River (Berestovo HP), 1900–2020:
***Dots* – results of observations; *1* – linear trend; *2* – parabolic**
Source: compiled by the authors.

Table 2 compares the characteristic annual levels of the Angrapy River of the mid-20th century and early 21st century. It can be seen that the average perennial levels have decreased by 17 cm, the lowest levels by 20 cm, and the highest levels by 14 cm. In general, this decrease in levels corresponds to the decrease in water discharge noted in Figure 1.

Table 2. **Comparison of characteristic annual levels of the Angrapa River, 1954–1666, 2008–2020, cm from post zero**

Typical annual levels	Period					
	1954–1966			2008–2020		
	Smallest	Average	Largest	Smallest	Average	Largest
Lowest	109	119	136	75	99.1	116
Middle	133	150	182	105	133	166
Highest	205	269	424	165	256	378

Source: compiled by the authors.

Figures 2 and 3 show examples of daily water levels of the Angrapa River. Already at the beginning of the 20th century, the intra-annual variation of water levels with the spring peak floods, summer-autumn low water periods and rises during rainfall floods (as in 1965 in Figure 2) were observed in less than half of the cases. In the 21st century, such a change is found only in some years; in other years, several water level rises are observed from December to March-April. The highest level of 28.19 mBS was recorded not in the spring flood but during the rain flood (19.08.1957), a similar phenomenon was observed on 3 November 2017 (Figure 3).

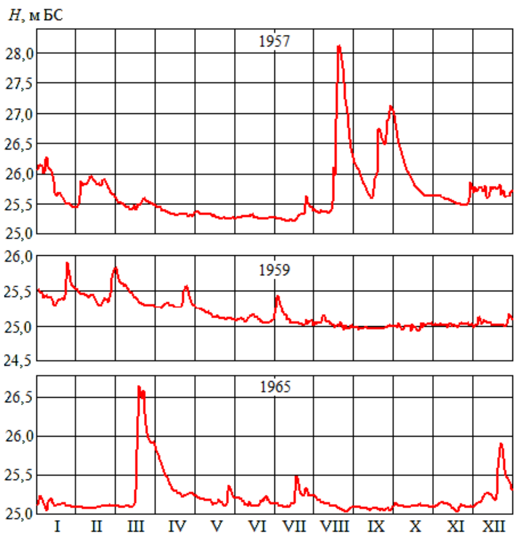

Figure 2. Daily water levels of the Angrapa River (Berestovo HP), 1957–1965
Source: compiled by the authors.

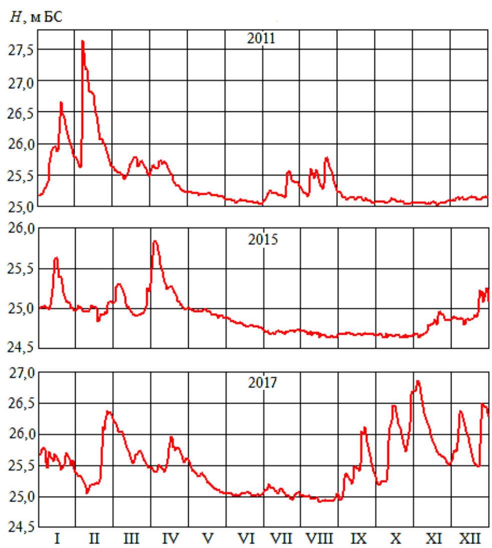

Figure 3. Daily water levels of the Angrapa River (Berestovo HP), 2011–2017
Source: compiled by the authors.

Figures 4 and 5 shows the results of averaging of water levels in the Angrapa River by years of observation:

$$Hs_i = \frac{1}{m}\sum_{j=1}^{m} H_{i,j}\ ;\ Hm_i = \min_j\left(H_{i,j}\right);\ Ha_i = \max_j\left(H_{i,j}\right), \qquad (2)$$

where m – number of years; $j = 1, 2, \ldots, n$; n – annual number of days.

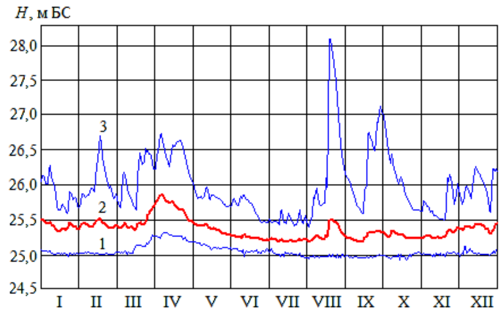

Figure 4. Characteristic daily levels of the Angrapa River (Berestovo HP) 1954–1966:
1 **– lowest Hm;** ***2*** **– average Hs;** ***3*** **– highest Ha**
Source: compiled by the authors.

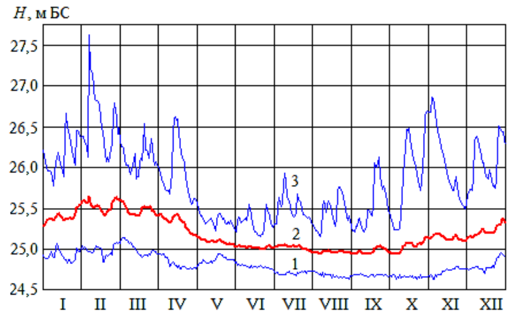

Figure 5. Characteristic daily levels of the Angrapa River (Berestovo HP) 2008–2020:
1 **– lowest Hm;** ***2*** **– average Hs;** ***3*** **– highest Ha**
Source: compiled by the authors.

Figure 6 compares the average daily water levels of the Angrapa River for 13 years of the mid-20th century (1954–1966) and early 21st century (2008–2020). The largest decrease in levels (more than 40 cm) occurred in April, this is due to the shift of spring flooding in the 21st century to an earlier period. Low water levels (June-September) decreased by about 20 cm compared to the values of the mid-20th century. During the cold season, especially in January-February, the 21st century levels were even higher than they were at the beginning of the 20th century. The reason is more frequent winter thaws, which lead to early snowmelt and rainfall. In some years, there was no ice on the river and no snow cover at all.

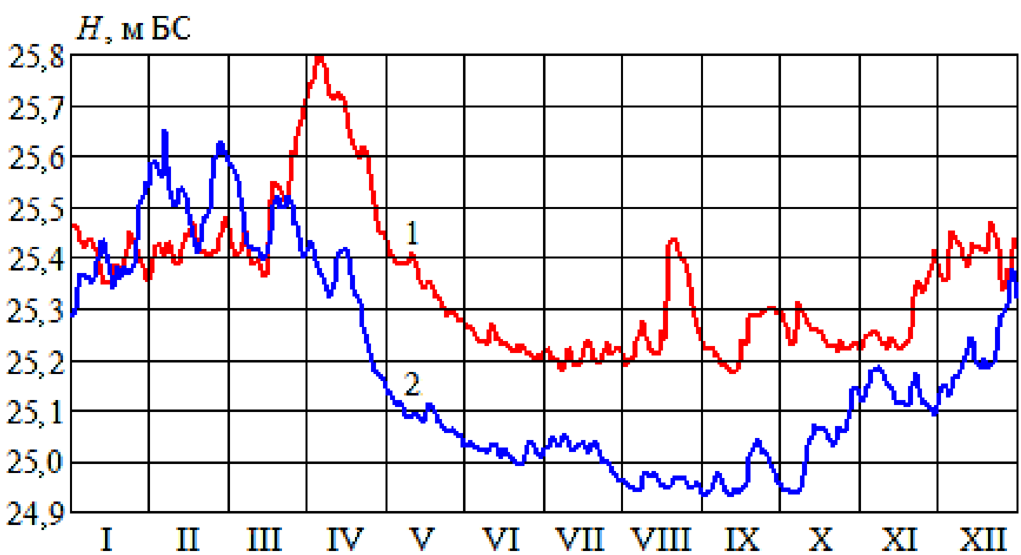

Figure 6. Comparison of average daily water levels of the Angrapa River (Berestovo HP):
1 **– mid-20th century;** ***2*** **– early 21st century**
Source: compiled by the authors.

Figures 7, 8 shows a comparison of the average annual frequency and duration of standing water levels of the Angrapa River for 13 years of the mid-20th century and early 21st century. In both cases, the highest frequency of levels occurred in the range of 25.0…25.2 mBS, but in the early 20th century there were 143 such days per year on average, while in the 21st century there were only 111 such days. In the 20th century, daily levels in the 24.8…25.0 range were observed only seven times, and below them, hardly any were observed. Whereas at early 21st century such levels were 70 and 46, respectively.

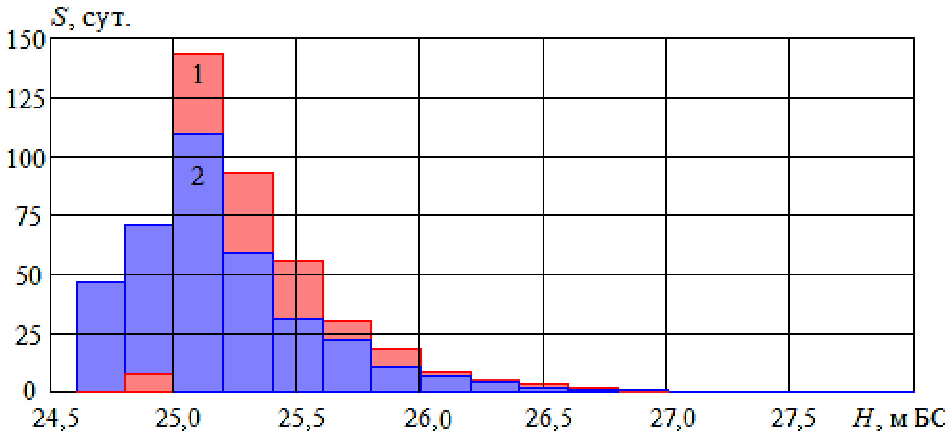

Figure 7. Annual average frequency of the Angrapa River levels (Berestovo HP):
1 **– 1954–1966;** ***2*** **– 2008–2020**
Source: compiled by the authors.

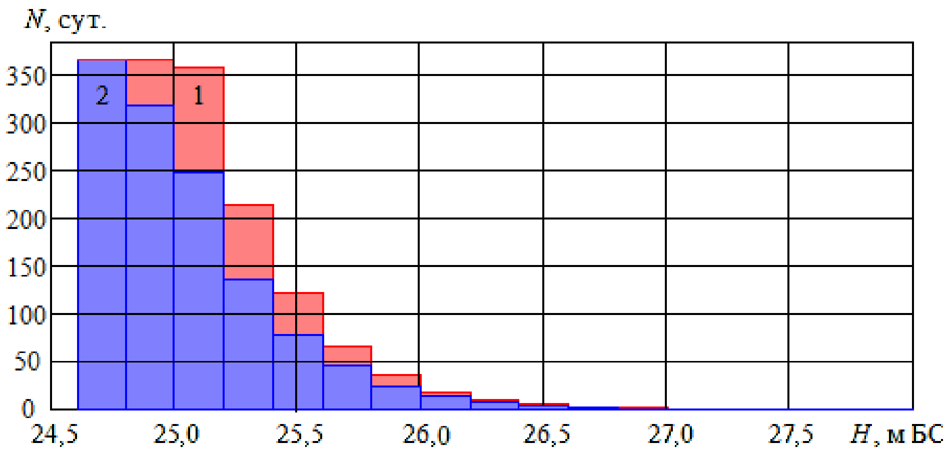

Figure 8. Mean annual duration of standing levels of the Angrapa River (Berestovo HP):
1 **– 1954–1966;** ***2*** **– 2008–2020.**
Source: compiled by the authors.

Conclusion

According to the obtained data, it can be concluded that for 120 years of observations there is a slight decrease in the average annual values of flow and water levels in the Angrapa River. The greatest decrease in average daily water levels, more than 40 cm, occurred in April, as there is a shift of spring flooding in the 21st century to an earlier period. At the same time, the highest frequency of levels for the period under consideration was observed in the range of 25.0…25.2 mBS. The distribution of runoff, fluctuations of water levels in the river affect its temperature regime, floodplain ecosystem and the state of biocenoses. The data presented in the article can be used in the development of environmental protection measures.

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