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Trends in the 30-day minimum winter runoff of rivers flowing out of lake Sevan

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ABSTRACT

Formulation of the problem. Studies of trends in the minimum 30-day winter runoff of rivers flowing out of the lake. Sevan has acquired great practical importance and significant interest from the point of view of calculating the ecological flow, due to the increased use of water resources for various types of economic activities, in particular, in connection with the development of the economy, hydropower, irrigation, population growth and improving living standards. Calculations of the minimum runoff are especially relevant in relation to solving the problems of water supply to settlements, industrial and agricultural enterprises, as well as assessment of irrigation norms of agricultural plots.

The aim of the work. Analysis and assessment of trends in the minimum 30-day winter runoff of rivers flowing out of the lake Sevan.

Methods. The following methods were used in the work: mathematical-statistical, correlation, cartographic, extrapolation, interpolation, spatial analysis, analogy.

Results. During the research, the characteristics of the winter minimum 30-day water consumption for the entire observation period were calculated for hydrological posts on the rivers of the lake Sevan basin, which have a number of observations for 40 years or more. Supply curves are constructed, the values of the winter minimum 30-day runoff are estimated, with security of 90, 95 and 99.5% for 12 sites. The values of the flow rates, its coefficients of variation (Cv) and asymmetry (Cs) are determined. The analysis of the temporal distribution of the studied hydrological characteristics was carried out, the coefficients of the linear trend of the minimum 30-day winter runoff were determined. Close correlations have been obtained between the values of the average monthly minimum water consumption and the minimum 30-day winter water consumption. These dependencies can be used to predict the minimum 30-day winter water consumption of the rivers of the territory under consideration. It is established that for the rivers of the lake Sevan basin is characterized by synchronicity of fluctuations in annual and winter runoff. It was revealed that most of the rivers flowing into the lake Sevan (by more than 58% of posts), there is an increase in the amount of winter runoff, i.e. a positive trend in its change. Based on the results obtained, a distribution map of the linear trend coefficients of the minimum 30-day winter runoff in m^3/sec / 10 years with an observation period from december to march was constructed.

Keywords*: Armenia, rivers of the Lake Sevan basin, low-water, 30-day winter minimum runoff, statistical characteristics, linear trend coefficient.*

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Introduction. For the effective and safe use of river resources, it is necessary to assess the water resources of the territory or specific water bodies, determine the maximum, minimum, and other characteristic water consumption, assess the impact of economic activity on the river regime, on dangerous hydrological processes [1-5].

For water management purposes, it is important to assess the main hydrological characteristic for the winter, which limits the possibility of taking water from the river – the minimum average monthly flow rate. It is the winter runoff and its minimum values that can serve as the lower limit for the use of water resources in the territory of this catchment area, which should be taken into account when planning the location of water-intensive industries.

Minimum water consumption belongs to the category of basic hydrological characteristics widely used in the practice of hydrological calculations. At the same time, the average 30-day (monthly) and daily water consumption are most often used in calculations, although sometimes minimum 5-, 7- or 10-day water consumption is used. In case of prevention of any interruptions or reduction of water supply in the water supply of industrial enterprises, the minimum average daily water consumption is applied in the calculations. Estimated security is usually assigned in the range of 75-97% [4-7].

Characteristics of minimum runoff are used in sectors such as hydropower, biotechnology, water transport, agriculture, construction design, reclamation and fisheries. In connection with the ongoing climate change urgent problem of assessing the implications of these changes is becoming for the water-dependent industries [9-11, 14].

The purpose of this work is to calculate the rate of minimum 30–day winter river water flow, coefficients of variability (Cv) and asymmetry (Cs), minimum expenses of various security, to analyze and evaluate the patterns of distribution of changes in the minimum 30-day winter expenses of the rivers of the lake Sevan basin in the series of long-term observations.

Materials and methods of research. In the course of the research, the relevant literary sources were analyzed and used [18, 20, 23, 25-26, 28-29]. The change in the values of the minimum 30-day winter river runoff was analyzed according to long-term observations in twelve river channels flowing into Lake Sevan, differing in physical and geographical conditions of runoff formation and catchment area.

In recent decades, there have been significant increases in flow-forming climatic indicators (temperature and precipitation, especially liquid precipitation during the cold period), which led to intra-annual uneven river flow and an increase in winter low-water runoff [11-13]. An analysis of the long-term dynamics of the 30-day winter minimum runoff illustrates a stable increase in values for most of the studied rivers. The ongoing climate changes lead to the transformation of the water regime of rivers [19, 22, 24].

For most rivers, similar transformations of the intra-annual flow distribution are observed. There is a redistribution of runoff during the year, characterized by an increase in winter low-water runoff and a reduction in spring flood costs. The depth of freezing is a factor regulating the ratio of winter and spring runoff. When it decreases, the layer of winter runoff-forming moisture increases, and, as a result, winter runoff increases and spring runoff decreases. In general, an increase in natural flow regulation improves water use conditions in low-water seasons, but a decrease in spring flooding creates a problem with filling reservoirs, and this should be taken into account when developing measures to adapt to climate change.

The hydrologic simulation results reveal climate change as the dominant factor and land cover change as a secondary factor in regulating future river discharge. The combined effects of climate and land cover changes will slightly increase river discharge in summer but substantillay decrease discharge in winter. This impact on water resources deserves attention in climate change adaptation planning [16].

As initial data, the work uses data from long-term observations of water consumption for the period from the date of the opening of hydrological posts up to 2020. The processing of instrumental data from 12 hydrological posts of the "Center for Hydrometeorology and Monitoring" of the SNCO of the Ministry of Environment of the Republic of Armenia was carried out.

The following methods were used in the study: mathematical and statistical, extrapolation, interpolation, correlation, cartographic, as well as methods of analysis and analog.

Results and discussion. A characteristic feature of the water regime of the rivers of the lake Sevan basin is a long and stable low–water period. On the rivers of the studied territory, minimal water consumption is observed during the summer-autumn and winter low-water periods. In this paper, only the minimum 30-day river water consumption of the winter period is discussed.

The main parameters of the distribution of the minimum river flow are the norm, coefficients of variation and asymmetry, and water consumption of various levels. These runoff characteristics are determined in relation to the minimum 30-day runoff. At the same time, observations over a long period of time were used as initial information. The main determining factors of the minimum flow are climatic and hydrogeological conditions, under the influence of which the territory under consideration is characterized by an uneven distribution of river flow (table 1).

From the data in the table. 1 it can be seen that small values of the *Cv* coefficient of variation are observed on rivers with a relatively large underground supply – Masrik, Karchaghbyur, Gavaraget. Relatively high values are observed on rivers fed by rain and meltwater, as well as on small rivers.

In nine rows, the values of the coefficients of variation are less than 0.30, and in the rest - from 0.30 to 0.60. The average value of the coefficient of variation for the entire lake Sevan basin is 0.31. For winter minimum average monthly river water expenditure (Q), such variation values are quite small, so, it can be assumed that winter minimum average monthly expenditure is quite stable and has relatively small risk values. The coefficient of asymmetry of the Cs series, in contrast to the coefficient of var-

Table 1

Statistical characteristics of the minimum 30-day discharge of the waters of the rivers of the lake Sevan basin for the period from the XI to the III month

River – point	*Q, м³/sec*	*Flow modulus, l/s•km²*	*Cv*	*Cs*	*Cv/Cs*	*Calculation error standard*			*Security water consumption %, m³/sec*		
						$\bar{\sigma}$	σ_{C_V}	σ_{C_S}	90	95	99.5
Dzknaget - Tsovag-yugh	0.17	2.06	0.42	2.15	0.20	0.009	0.06	>0.29	0.111	0.108	0.106
Drakhtik - Drakhtik	0.065	1.66	0.50	1.20	0.42	0.008	0.04	0.46	0.030	0.025	0.016
Pambak - Pambak	0.075	3.68	0.28	0.94	0.30	0.006	0.04	>0.35	0.052	0.047	0.037
Masrik - Tsovak	2.36	3.51	0.19	-0.06	-3.17	0.091	0.02	>0.34	1.801	1.64	1.22
Karchaghbyur - Karchaghbyur	0.90	7.76	0.17	0.31	0.55	0.035	0.02	0.31	0.754	0.705	0.584
Vardenis - Vardenik	0.54	4.62	0.29	0.29	1.00	0.041	0.04	>0.34	0.366	0.305	0.150
Martuny - Geghovit	0.66	7.81	0.29	0.34	0.85	0.036	0.01	0.31	0.423	0.365	0.227
Argichi - Getashen	2.20	6.01	0.25	1.12	0.22	0.089	0.03	>0.27	1.60	1.49	1.25
Tsaghkashen – Vaghashen	0.49	5.30	0.23	-0.57	-0.40	0.018	0.02	>0.42	0.345	0.305	0.202
Личк – Личк	1.58	47.9	0.34	0.95	0.36	0.207	0.08	>0.46	0.971	0.866	0.672
Bakhtak– Tsaghkar	0.16	1.11	0.60	0.71	0.85	0.019	0.07	0.33	0.043	0.027	0.005
Gavaraget – Noratus	2.77	5.93	0.14	0.20	0.70	0.053	0.02	>0.25	2.28	2.12	1.71

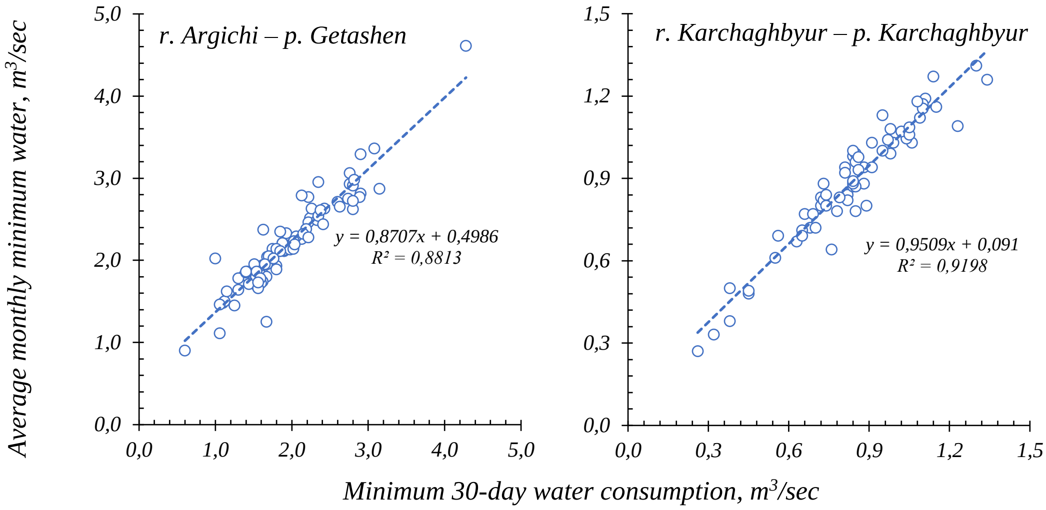

Fig. 1. Correlation between the values of the average monthly minimum water consumption of the winter period and the winter minimum 30-day water consumption

iation, has large values. The average value of the asymmetry coefficient is 0.65. For all 12 points under discussion, the ratio of the coefficients of asymmetry and variation does not exceed one, with the exception of the Masrik River.

Strong correlations were obtained between the values of the average monthly minimum water consumption and the minimum 30-day winter water consumption (fig. 1). It can be used to predict the minimum 30-day winter water consumption.

To determine the synchronicity of fluctuations in the values of annual and seasonal runoff, an analysis of the average annual and 30-day values of the minimum runoff of the winter period was carried out. Conducting such an analysis is due to the fact that the low-water runoff is an integral part of the annual runoff and determines the close relationship between these values. A comparison of the values of the annual runoff and the 30-day values of the minimum runoff of the winter period illustrates a certain interdependence in changes in these values (fig. 2). It has been established that the synchronicity of fluctuations in annual and winter runoff is characteristic of the rivers of the lake Sevan basin. The maximum synchronicity of fluctuations in annual and winter runoff is typical for rivers with predominantly underground feeding.

Calculations have shown that there is an increase in the volume of winter runoff in most rivers flowing into Lake Sevan (by more than 58% of the posts), i.e. a positive trend in its change. Linear trend coefficients of the minimum 30-day winter

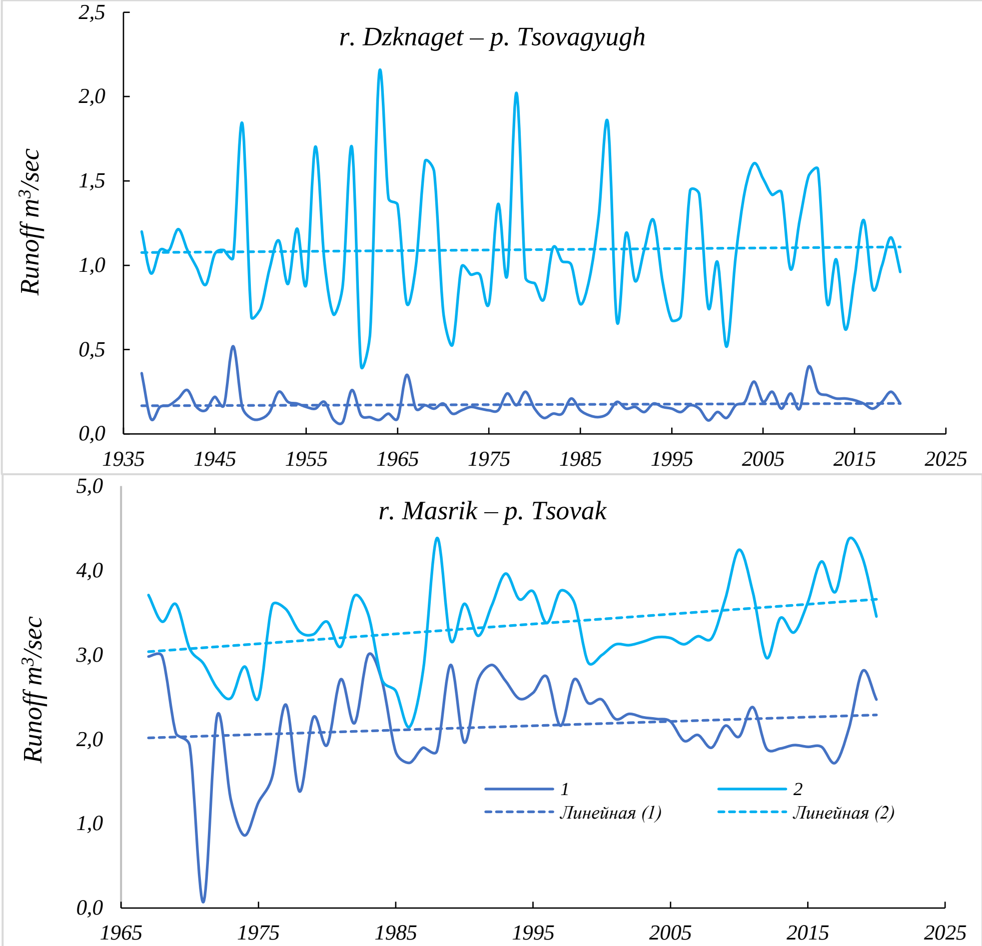

Fig. 2. Change in the values of the 30-day minimum runoff of the winter low-water (1) and annual runoff (2) in m^3/sec.

runoff (m^3/sec / 10 years) rivers of the lake. Sevan basin is represented by a map that gives a visual representation of its distribution throughout the studied area (fig. 3). As can be seen from the figure, the regional specificity of the distribution of the minimum 30-day winter runoff of the winter low-water is confirmed by the spatiotemporal heterogeneity in dynamics. The values of the linear trend coefficient of the minimum 30-day winter runoff for the rivers of the studied lake Sevan basin is located in the ranges from – 0.162 to + 0.124 m^3/sec / 10 years.

The most significant changes in the minimum 30-day winter runoff are observed in the Argichi rivers (+0.124 m^3/sec /10 years) and the Lichk (–0.162m^3/sec /10 years). On the Karchaghbyur river, the linear trend coefficient of the minimum 30-day winter runoff is + 0.046 m^3 / sec /10 years, on the Drakhtik, Martuni, Tsaghkashen rivers– + 0.010–+0.020 m^3/sec / 10 years, on the slag and Pambak rivers-from + 0.001 to + 0.010 m^3/sec / 10 years. In general, an increase of runoff of winter low-water has an important practical significance, since the amount of runoff during this period is a limiting factor for guaranteed and sustainable water consumption.

In the basins of the Masrik, Vardenis, Lichk, Bakhtak and Gavaraget rivers, the minimum 30-day winter runoff decreases over the entire observation period. At the same time, on the Vardenis River, the linear trend coefficient of the minimum 30-day winter runoff is 0.045 m^3/sec /10 years, on the Masrik, Bakhtak and Gavaraget rivers – from 0.009 to 0.025 m^3/sec/10 years. Such rivers should be the focus of attention all the more in connection with the maintenance of the ecological flow of the river by appropriate measures.

Studies show that the increase in minimum winter water consumption, observed since the second half of the 70s, is due to an increase in winter air temperature, that is, climate change. Characteristic features of climate change for the Lake Sevan basin is an increase in air temperature in the near–surface layer, especially significant in November – March, with minor changes in the temperature of the warm period and a slight increase in precipitation [16, 17, 21]. The main climatic factor contributing to the increase in minimum winter runoff is the increase in winter air temperature. The main factors influencing the increase in winter river runoff are a decrease in the depth of soil freezing and, accordin-

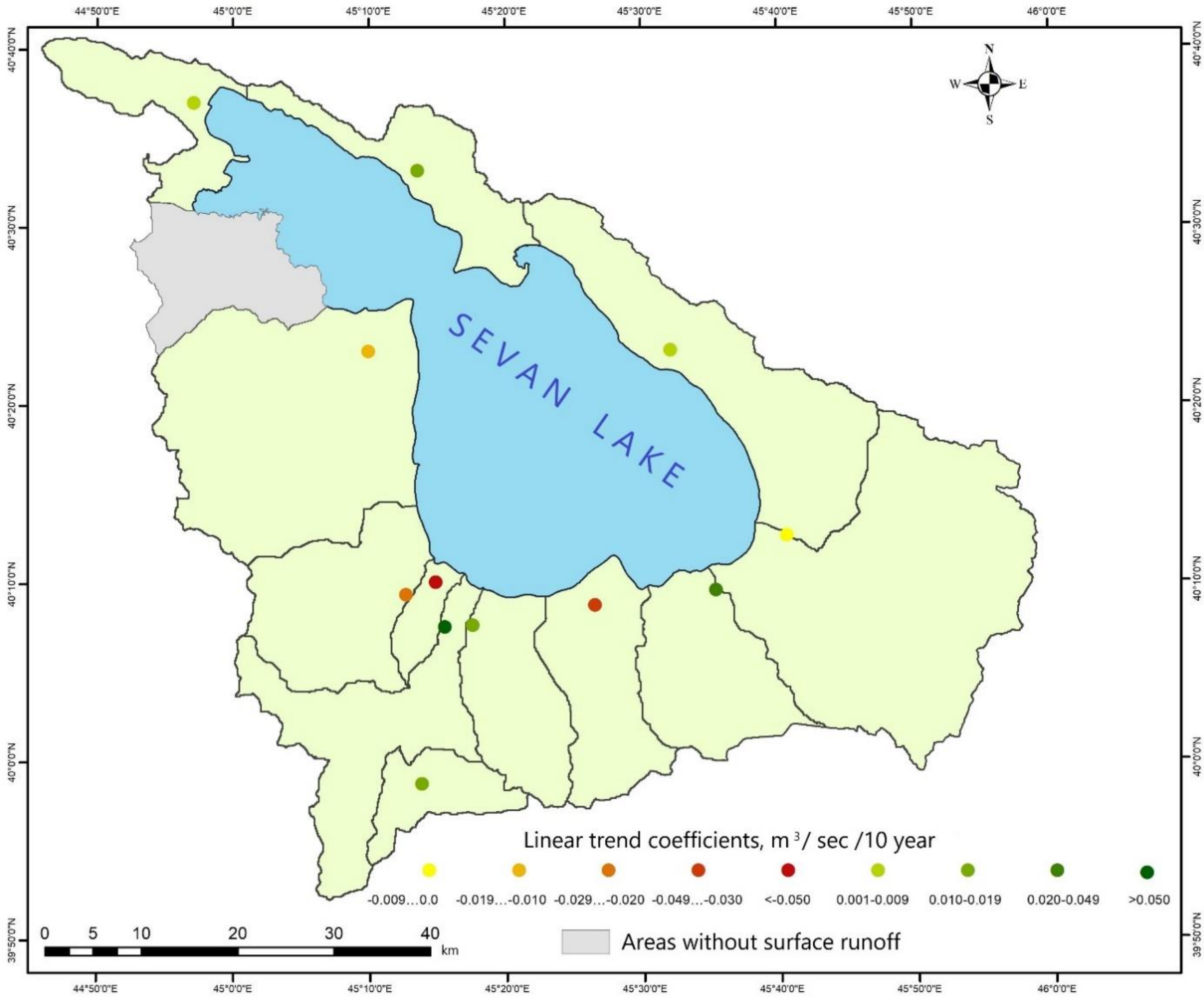

Fig. 3. Distribution of the linear trend coefficients of the minimum 30-day winter runoff in m^3/sec / 10 years for the entire observation period (December – March). The lake Sevan basin.

gly, the migration of moisture in winter to the freezing front and its accumulation in the frozen layer, the presence of thaws and an increase in autumn soil moisture. The impact of climatic changes caused by an increase in ambient temperature changes the heat and mass transfer in the active soil layer and reduces the depth of freezing.

Conclusions. Based on the results of the work performed, the following conclusions can be drawn.

As a result of the conducted research, a widespread uneven distribution of changes in the 30-day minimum runoff of winter low-water in the Lake Sevan river basin has been established, manifested mainly in an increase in the values of winter low-water.

The linear trend coefficient of this characteristic is practically for the majority of observation posts (more than 58% of posts) in the territory of the lake Sevan basin is positive and does not exceed 0.13 m^3/sec / 10 years, at other observation posts (42% of posts) it has negative values.

At the same time, despite the predominance of unidirectional changes, the rivers of the studied basin are characterized by regional differences, primarily due to the area, density of the river network and the physical and geographical conditions of the catchment areas. The values of the linear trend coefficients of the minimum 30-day winter runoff for the studied rivers of the lake Sevan basin is in the range from – 0.162 m^3/sec / 10 years (Argichi) to + 0.124 m^3/sec / 10 years (Lichk).

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Bibliography

1. *Больбот Г.В. Оцінка багаторічних коливань мінімальних витрат води річок басейну Сіверського Дінця / Г.В. Больбот // Гідрологія, гідрохімія і гідроекологія. Одеса, 2019. № 3 (54). С. 31-33. http://nbuv.gov.ua/UJRN/glghge 2019_3_12*

2. *Гідролого-гідрохімічна характеристика мінімального стоку річок басейну Дніпра / За ред. В.К. Хільчевського. К.: Ніка-Центр. 2007. 184 с.*
3. *Гопченко Є.Д., Лобода Н.С., Овчарук В.А. Гідрологічні розрахунки [Текст]. Одес. гідрометеорол. ін-т. Одеса : ТЕС, 2014. 484 с.*
4. *Гопцій М.В., Овчарук В.А., Кущенко Л.В., Прокоф'єв О.М., Гоян Ю.О. Мінімальний водний стік району басейну річок Приазовя в період літньо-осінньої та зимової межені. / М.В. Гопцій, В.А. Овчарук, Л.В. Кущенко, О.М. Прокоф'єв, Ю.О. Гоян // Гідрологія, гідрохімія і гідроекологія. Одеса, 2021. № 2 (60). 18-26. https://doi.org/10.17721/2306-5680.2021.2.2*
5. *Гоян Ю.О., Гопцій М.В., Кущенко Л.В. Особливості циклічності у коливаннях мінімального стоку у період межені на території Приазов'я за сучасних кліматичних умов / Ю.О. Гоян, М.В. Гопцій, Л.В. Кущенко // Екологія, неоекологія, охорона навколишнього середовища та збалансоване природокористування. Харків, 2020. С. 52-54.*
6. *Гребінь В.В. Сучасний водний режим річок України (ландшафтно-гідрологічний аналіз) [Текст] / В.В. Гребінь. К.: Ніка-Центр. 2010. 316 с.*
7. *Жовнір В.В., Гребінь В.В. Аналітичний огляд досліджень мінімального стоку води / В.В. Жовнір, В.В. Гребінь // Гідрологія, гідрохімія і гідроекологія. Одеса, 2018. № 1 (48). С. 16-24.*
8. *Kouidri Sofiane, Megnounif Abdesselam, Ghenim Abderrahmane Nekkache. Long-term seasonal characterization and evolution of extreme drought and flooding variability in northwest Algeria / S. Kouidri, A. Megnounif, N. Ghenim Abderrahmane.//Meteorology, Hydrology and Water Management, 2019. № 7 (2). P. 63-71.*
9. *Кущенко, Л.В. Дослідження дефіцитів водності та індексів посухи для зони недостатньої водності України / Л.В. Кущенко // Гідрологія, гідрохімія і гідро екологія. Одеса, 2021. № 4 (62). С. 34-46. https://doi.org/10.17721/2306-5680.2021.4.3*
10. *Кущенко Л.В., Овчарук В.А., Прокофєв О.М., Гопцій М.В., Андреєвська Г.М. Мінімальний та екологічний стік річок у зоні недостатньої водності України / Л.В. Кущенко, В.А. Овчарук, М.В. Гопцій, О.М. Прокоф'єв, Г.М. Андреєвський // Екологічні науки. 2021. № 2 (35). С. 30-36. https://doi.org/10.32846/2306-9716/2021.eco.2-35.5*
11. *Лобода Н.С. Вплив змін клімату на водні ресурси України у сучасних та майбутніх умовах (за сценарієм глобального потепління А1В / Н.С. Лобода // Український гідрометеорологічний журнал. Одеса, 2014. № 15. С. 149-159. http://nbuv.gov.ua/UJRN/Uggj_2014_15_23*
12. *Лобода Н.С.., Сербова З.Ф, Божок Ю.В. Вплив змін клімату на водні ресурси України у сучасних та майбутніх умовах (за сценарієм глобального потепління А1В / Н.С. Лоюода, З.Ф. Сербова, Ю.В. Божок // Український гідрометеорологічний журнал. 2014. № 15. Р. 149-159. http://nbuv.gov.ua/UJRN/Uggj_2014_15_23*
13. *Loboda N.S., Kozlov M.O. (2020). Assessment of water resources of the Ukrainian rivers according to the average statistical models of climate change trajectories RCP4.5 and RCP8.5 over the period of 2021 to 2050 / N.S. Loboda, M.O. Kozlov // Ukrainian Hydrometeorological Journal. 2020. № 25. P. 93-104. https://doi.org/10.31481/uhmj.25.2020.09*
14. *Ovcharuk V. Engineer substantiation of estimated characteristics of maximum rivers runoff during floods under climate change / V. Ovcharuk // Ecological Significance of River Ecosystems. Elsevier. 2022. P. 351-382. https://doi.org/10.1016/B978-0-323-85045-2.00018-2*
15. *Optimization of Hydrographic and Water-management Regionalization of Ukraine according to World Approaches and Principles of the EU Water Framework Directive // Hydrobiological Journal (USA). 2016. № 52 (5). P. 81-92. https://doi.org/10.1615/HydrobJ.v52.i5.90*
16. *Chen H., Tong S., Yang H., Yang J. Simulating the hydrologic impacts of land-cover and climate changes in a semi-arid watershed / H. Chen, S. Tong, H. Yang, J. Yang // Hydrological Sciences Journal. IAHS LIMITED, Oxford, 2015. № 60(10). P.1739-1758. https://doi.org/10.1080/02626667.2014.948445*
17. *Margaryan V.G. (2020). Assessment of the features of extreme low temperatures of the surface air layer in the lake Sevan basin (Armenia) / V.G. Margaryan // Izvestiya Tula State University. Earth Sciences, 2020. № 3. P. 52–64.*
18. *Margaryan V., Sedrakyan A., Sayadyan H., Reshetchenko S., Dmitriiev S. Modern changes in climatic characteristics and winter minimum average monthly runoff in the basin of lake Sevan / V. Margaryan, A. Sedrakyan, H. Sayadyan, S. Reshetchenko, S. Dmitriiev // Visnyk of V.N. Karazin Kharkiv National University. Series "Geology. Geography. Ecology", 2023, (59). P. 178-189. https://doi.org/10.26565/2410-7360-2023-59-13*
19. *Martyniuk M., Ovcharuk V. Study the influence of zonal and azonal factors on the maximum flood runoff in the Vistula basin (within Ukraine) / M. Martyniuk, V. Ovcharuk // International Baltic Earth Secretariat Publication, 2020. № 18. P. 209.*
20. *Martyniuk M., Ovcharuk V. Determining the characteristics of the maximum runoff of the rare Acta Hydrologica Slovaca. 24. 1. Probability of exceeding the Vistula River basin within Ukraine / M. Martyniuk, V. Ovcharuk //Ecology, neo-ecology, environmental protection and sustainable use of nature: proceedings VIII international. Science. Conf. young scientists. Kharkiv, Ukraine, 2023. P. 229–231.*
21. *Martyniuk M., Ovcharuk V. Indentification of areal with potential significant flood risk using specialized in the Vistula river basin within Ukraine / M. Martyniuk, V. Ovcharuk // Acta Hydrologica Slovaka, 2023. № 24 (1). P. 94-100. https://doi.org/10.31577/ahs-2023-0024.01.0011*
22. *Sedrakyan, A., Margaryan, V., Reshetchenko, S., & Dmitriiev, S. Physical meaning of temperature and evaluation of distribution laws (in the area of the Lake Sevan basin). Visnyk of V. N. Karazin Kharkiv National University, Series "Geology. Geography. Ecology", 2023, (58), 231-240. https://doi.org/10.26565/2410-7360-2023-58-18*

23. Smith L.C., Pavelsky T.M., MacDonald G.M., Shiklomanov A.I., Lammers R.B. Rising minimum flows in northern Eurasian rivers: A growing influence of groundwater in the high-latitude hydrologic cycle / L.C. Smith, T.M. Pavelsky, G.M. MacDonald, A.I. Shiklomanov, R.B. Lammers // Journal of Geophysical Research. Biogeosciences. 2007. № 112. https://doi.org/10.1029/2006JG000327
24. Renata J. Romanowicz. The Influence Of Climate Change On Hydrological Extremes: Floods Droughts October 2017 / J. Rena Romanowicz // Floods Droughts October, 2017. https://doi.org/10.31988/SciTrends.3899
25. Reshetchenko S. Dmitriiev S., Cherkashyna N., Goncharova L. (2020). Climate indicators of changes in hydrological characteristics (a case of the Psyol river basin) / S. Reshetchenko, S. Dmitriiev, N. Cherkashyna, L. Goncharova // Visnyk of V. N. Karazin Kharkiv National University, Series "Geology. Geography. Ecology", 2020. № 53. P. 176-189. https://doi.org/10.26565/2410-7360-2020-53-12
26. Tallaksen L.M. Hydrological Drought: Processes and Estimation Methods for Streamflow and Groundwater / Tallaksen, L.M. Henny, 2004. 579 p.
27. Volchek A.A., Gryadinova O.I. Minimum runoff of the rivers of Belarus: monograph / A.A.Volchek, O.I. Gryadinova // Brest. state University named after A.S. Pushkin. Brest: BrSU. 2010. 169 p.
28. Šugareková M., Zeleňáková M. Flood risk assessment and flood damage evaluation–The review of the case studies / M. Šugareková, M. Zeleňáková // Acta Hydrologica Slovaca. 2021. № 22. 1. P. 156–163. https://doi.org/10.31577/ahs-2021- 0022.01.0019
29. Шакірзанова Ж. Р., Погорелова М.П., Мостій А.С., Блага А.О., Стратійчук О.В. Методика прогнозування сезонного меженного стоку річок Півдня України для забезпечення сталого водокористування / Ж. Р. Шакірзанова, М.П. Погорелова, А.С. Мостій, А.О. Блага, О.В Стратійчук. Одеса. 2021. С. 109-110.
30. Шакірзанова, Ж.Р. Довгострокові гідрологічні прогнози: конспект лекцій / Ж.Р. Шакірзанова. Одеса. 2010. 154 с.

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References

1. Bolbot, G.V. (2019). Estimation of long-term fluctuations of the minimum water consumption of the rivers of the Seversky Donets basin. Hydrology, hydrochemistry and hydroecology. 3 (54), 31-33. http://nbuv.gov.ua/UJRN/glghge_2019_3_12 [in Ukrainian]
2. Khilchevskoho V.K. (2007). Hydrological and hydrochemical characteristics of the minimum river runoff of the Dnieper basin. K.: Nika-Tsentr, 184. [in Ukrainian]
3. Hopchenko, Ye.D., Loboda, N.S., Ovcharuk, V.A. (2014). Hydrological calculations. Odesa: TES. 484. [in Ukrainian]
4. Goptsiy, M.V., Ovcharuk, V.A., Kushchenko, L.V., Prokofiev, A.N., Hoyan, Yu.A. (2021). Minimal water runoff of the Azov river basin area during summer-autumn and winter low-water periods. Hydrology, Hydrochemistry and Hydroecology. 2 (60), 18-26. https://doi.org/10.17721/2306-5680.2021.2.2 [in Ukrainian]
5. Hoian, Yu.O., Hoptsii, M.V., Kushchenko, L.V. (2020). Peculiarities of cyclicity in the fluctuations of the minimum runoff in the period limited in the territory of the Azov Sea under modern climatic conditions. Ecology, neoecology, environmental protection and balanced nature management. Kharkiv, 52-54. [in Ukrainian]
6. Hrebin, V.V. (2010). Modern water regime of rivers of Ukraine (landscape-hydrological analysis. K.: Nika-Tsentr, 316. [in Ukrainian]
7. Zhovnir, V.V., Hrebin, V.V. (2018). Analytical review of studies of minimum water runoff. Hidrolohiia, hidrokhimiia i hidroekolohiia. 1 (48), 16- 24. [in Ukrainian]
8. Kushchenko, L.V. (2021). Research of water deficits and drought indices for the zone of insufficient water content of Ukraine. Hydrology, hydrochemistry and hydroecology, 4 (62), 34-46. https://doi.org/10.17721/2306- 5680.2021.4.3
9. Kushchenko, L., Ovcharuk, V., Prokofiev, O., Goptsiy, M., Andreevskaya, G. (2021). Minimal and environmental runoff of rivers in the zone of the insufficient water content of Ukraine. Environmental sience. 2 (35), 30-36. https://doi.org/10.32846/2306-9716/2021.eco.2-35.5 [in Ukrainian]
10. Kouidri, Sofiane, Megnounif, Abdesselam, Ghenim, Abderrahmane Nekkache. (2019). Long-term seasonal characterization and evolution of extreme drought and flooding variability in northwest Algeria//Meteorology, Hydrology and Water Management. 7 (2). 63-71. [in Ukrainian]
11. Loboda, N.S. (2011). The impact of climate change on the water resources of Ukraine (modeling and forecasts based on climate scenarios). Global and regional climate change, 340-351. Available at: http://eprints.library.odeku.edu.ua/id/eprint/3771 [in Ukrainian]
12. Loboda, N.S., Serbova, Z.F., Bozhok, Yu.V. (2014). The impact of climate change on Ukraine's water resources in current and future conditions (according to the scenario of global warming A1B). Ukrainian Hydrometeorological Journal. 15, 149-159. http://nbuv.gov.ua/UJRN/Uggj_2014_15_23 [in Ukrainian]
13. Loboda, N.S., Kozlov, M.O. (2020). Assessment of water resources of the Ukrainian rivers according to the average statistical models of climate change trajectories RCP4.5 and RCP8.5 over the period of 2021 to 2050. Ukrainian Hydrometeorological Journal, (25), 93-104. https://doi.org/10.31481/uhmj.25.2020.09

14. *Ovcharuk, V. (2022). Engineer substantiation of estimated characteristics of maximum rivers runoff during floods under climate change: Ecological Significance of River Ecosystems. Elsevier. 351-382. https://doi.org/10.1016/B978-0-323-85045-2.00018-2*
15. *Optimization of Hydrographic and Water-management Regionalization of Ukraine according to World Approaches and Principles of the EU Water Framework Directive. (2016). Hydrobiological Journal (USA). 52 (5), 81-92. https://doi.org/10.1615/HydrobJ.v52.i5.90*
16. *Chen, H., S. Tong, H. Yang, J. Yang. (2015). Simulating the hydrologic impacts of land-cover and climate changes in a semi-arid watershed. Hydrological Sciences Journal. IAHS LIMITED, Oxford, Uk. 60(10): 1739-1758. https://doi.org/10.1080/02626667.2014.948445*
17. *Margaryan, V.G. (2020). Assessment of the features of extreme low temperatures of the surface air layer in the lake Sevan basin (Armenia). Izvestiya Tula State University. Earth Sciences. 3, 52–64.*
18. *Margaryan, V., Sedrakyan, A., Sayadyan, H., Reshetchenko, S., Dmitriiev, S. (2023). Modern changes in climatic characteristics and winter minimum average monthly runoff in the basin of lake Sevan. Visnyk of V.N. Karazin Kharkiv National University, series "Geology. Geography. Ecology", (59), 178-189. https://doi.org/10.26565/2410-7360-2023-59-13*
19. *Martyniuk, M., Ovcharuk, V. (2020). Study the influence of zonal and azonal factors on the maximum flood runoff in the Vistula basin (within Ukraine). International Baltic Earth Secretariat Publication, 18, 209.*
20. *Martyniuk, M., Ovcharuk, V. (2023). Determining the characteristics of the maximum runoff of the rare Acta Hydrologica Slovaca. 24. 1. Probability of exceeding the Vistula River basin within Ukraine. Ecology, neo-ecology, environmental protection and sustainable use of nature: proceedings VIII international. Science. Conf. young scientists (Kharkiv, Ukraine, 229–231).*
21. *Martyniuk, M., Ovcharuk, V. (2023). Indentification of areal with potential significant flood risk using specialized in the Vistula river basin within Ukraine. Acta Hydrologica Slovaka. 24 (1), 94-100. https://doi.org/10.31577/ahs-2023-0024.01.0011*
22. *Sedrakyan, A., Margaryan V., Reshetchenko S., Dmitriiev, S. (2023). Physical meaning of temperature and evaluation of distribution laws (in the area of the lake Sevan basin). Visnyk of V.N. Karazin Kharkiv National University, series "Geology. Geography. Ecology", (58), 231-240. https://doi.org/10.26565/2410-7360-2023-58-18*
23. *Smith, L.C., Pavelsky, T.M., MacDonald, G.M., Shiklomanov, A.I., Lammers, R.B. (2007). Rising minimum flows in northern Eurasian rivers: A growing influence of groundwater in the high-latitude hydrologic cycle. Journal of Geophysical Research. Biogeosciences. 112. https://doi.org/10.1029/2006JG000327*
24. *Renata, J. Romanowicz (2017). The Influence Of Climate Change On Hydrological Extremes: Floods Droughts October. https://doi.org/10.31988/SciTrends.3899.*
25. *Reshetchenko, S., Dmitriiev, S., Cherkashyna, N., Goncharova, L. (2020). Climate indicators of changes in hydrological characteristics (a case of the Psyol river basin). Visnyk of V.N. Karazin Kharkiv National University, series "Geology. Geography. Ecology", (53), 176-189. https://doi.org/10.26565/2410-7360-2020-53-12*
26. *Tallaksen, L.M., Van Lanen, Henny. (2004). Hydrological Drought: Processes and Estimation Methods for Streamflow and Groundwater.*
27. *Volchek, A.A., Gryadinova, O.I. (2010). Minimum runoff of the rivers of Belarus: monograph. Brest. state University named after A.S. Pushkin. Brest: BrSU. 169.*
28. *Šugareková, M., Zeleňáková, M. (2021): Flood risk assessment and flood damage evaluation–The review of the case studies, Acta Hydrologica Slovaca. 22, 1, 156–163. https://doi.org/10.31577/ahs-2021-0022.01.0019*
29. *Shakirzanova, Zh. R., Pogorelova, M.P., Mostiy, A.S., Blaga, A.O., Stratiychuk, O.V. (2021). Methodology for forecasting the seasonal boundary runoff of rivers of the South of Ukraine to ensure sustainable water use. Second AllUkrainian Hydrometeorological Congress: abstracts, 109-110. http://eprints.library.odeku.edu.ua/id/eprint/9319/1/LobodaNS_OvcharukVA_ShakirzanovaJR_Proceedings_Hydrometeorological_congress_2021_71- 72.pd [in Ukrainian]*
30. *Shakirzanova, Zh.R. (2010). Long-term hydrological forecasts: Lecture notes. Odesa: TPP Publishing House. http://eprints.library.odeku.edu.ua/id/eprint/98/1/ShakirzanovaZhR_Dovgostrokovi_gidrologichni_prognozy_KL_2010.pdf [in Ukrainian]*

Тенденції тридцятидобового мінімуму зимового стоку річок басейну озера Севан

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У роботі наводяться результати дослідження динаміки мінімального зимового стоку річок басейну озера Севан за тридцятидобовий період, що сьогодні має практичне значення в розрахунку екологічного стоку внаслідок посилення господарського використання водних ресурсів, гідроенергетики, іригації. Дослідження мінімального стоку є актуальним під час вирішення водогосподарських рішень для населених територій, промислових та сільськогосподарських підприємств, а також для визначення оцінки зрошувальних норм для польових ділянок. Аналіз та оцінка тенденцій зимового стоку на гідропостах річок басейну озера Севан проводилися за допомогою часових рядів мінімальних тридцятидобових витрат за період сорок років. Математико-статистичні, картографічні методи дозволили встановити особливості просторового розподілу показників на досліджуваній території. Побудовано криві живлення та визначено значення зимового мінімуму тридцятидобового стоку із забезпеченістю 90, 95, 99,5% для дванадцяти ділянок. Визначені значення витрат, коефіцієнти кореляції його варіацій (Cv) та асиметрії (C_s). Аналіз часового розподілу досліджуваних гідрологічних показників та коефіцієнти лінійного тренду мінімального зимового стоку вказують на тісний зв'язок між значеннями середньомісячного мінімального водоспоживання та мінімальним зимовим водоспоживанням. Для річок басейну озера Севан характерним є синхронність коливань річного та зимового стоку. На більшості річок (понад 58% постів) спостерігається збільшення значень зимового стоку, що не перевищує 0,13 $м^3/с$ на 10 років, для решти постів (42%) спостерігається зворотна тенденція. Побудовані картографічні твори розподілу коефіцієнтів лінійного тренду мінімального зимового стоку за період з грудня по березень вказують на переважання односпрямованих змін на досліджуваних річках. Представлені річки басейну озера Севан мають регіональні відмінності в розподілі гідрологічних показників, що обумовлено площею, густотою річкової мережі та фізико-географічними особливостями водозборів. Значення коефіцієнтів лінійного тренду мінімального зимового стоку для річок басейну озера варіює в межах від 0,162 $м^3/с$ на 10 років (Аргічі) до 0,124 $м^3/с$ на 10 років (Лічок). Отримані залежності дозволяють поліпшити прогноз мінімального зимового водоспоживання досліджуваної території.

***Ключові слова**: Вірменія, річки басейну озера Севан, маловодний період, зимовий мінімум стоку за тридцять днів, статистичні характеристики, коефіцієнт лінійного тренду.*

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