https://doi.org/10.33271/nvngu/2022-5/148

V. Andrieiev[1],
orcid.org/0000-0001-8749-8478,
H. Hapich[2],
orcid.org/0000-0001-5617-3566,
V. Kovalenko[2],
orcid.org/0000-0003-3865-597X,
S. Yurchenko[2],
orcid.org/0000-0001-5148-2626,
A. Pavlychenko[3],
orcid.org/0000-0003-4652-9180

1 – Dniprovsky State Technical University, Kamianske, Ukraine, e-mail: Andreev_V_G@ukr.net
2 – Dnipro State Agrarian and Economic University, Dnipro, Ukraine
3 – Dnipro University of Technology, Dnipro, Ukraine

EFFICIENCY ASSESSMENT OF WATER RESOURCES MANAGEMENT AND USE BY SIMPLIFIED INDICATORS

Purpose. Development of simplified indicators for assessment of the effectiveness of local water flow management and use in reservoirs and ponds.

Methodology. The methods of integral assessment by specific indicators that characterize the operational parameters of the reservoir are used. Analytical formulas for calculating specific indicators are applied, their values are in the range from "–1.0" to "+1.0", which greatly simplifies the perception of the received information.

Findings. General characteristic of the artificial water objects of the study is given. Coefficients of operational parameters of reservoirs and regulation of local surface flow have been determined. Specific and integral indicators of the management effectiveness assessment of local surface water resources have been established. A formula for calculating the comparative total risk indicator and a conventional distribution scale are proposed, according to them the effectiveness of local water resources management within administrative units or river basins is evaluated for the elements of the sample taken for the study. The ratio of parameters of the total area of the territory occupied by ponds (44 %) to the area occupied by reservoirs (56 %) was determined, according to which the ponds will retain only 25 % of the total volume of water resources. For almost all studied elements of the sample, the value of the average depth is less than 2 meters, and the volume is up to $1 \cdot 10^6$ m^3. Thereby, most reservoirs act as evaporation ponds, which leads to the deterioration of the water resources quality. The determined coefficients of local surface flow regulation for 9 out of 11 administrative regions of the Steppe Zone of Ukraine range from 0.22 to 1.36, which is a significant excess of the permissible norms of modular coefficients for 95 % coverage within 0.05–0.25. For Kherson (2.14) and Odesa (6.45) regions, this parameter exceeds the requirements of the Water Code of Ukraine by many times (with a norm of 0.05 and 0.2, respectively).

Originality. Specific integral indicators of local water flow regulation and characteristics of operational parameters of reservoirs on the territory of the administrative regions of the Steppe Zone of Ukraine are proposed and determined. A point assessment of the impact of artificial water bodies on the surrounding natural environment is provided, which substantiates and emphasizes the conclusions regarding the irrationality of water use and the further exploitation of such a significant number of artificial water bodies, in particular small ponds.

Practical value. Specific indicators of the effectiveness of the management and use of local water flow held in the ponds and reservoirs of the Steppe Zone of Ukraine simplify the perception of the received information and shorten the time of making management and water protection decisions.

Keywords: *water resources, efficient use, water safety, artificial reservoir*

Introduction. The provision of water resources and water safety of countries are the main components of sustainable development. The effectiveness and rationality of their use, taking into account the requirements of environmental safety, are currently main indicators of the country's development level. Modern tendencies to reassess the efficiency of water resources use, taking into account the ecological component, lead to radical changes in the system of their management and regulation, have made it possible to "retake" rivers from impractical hydrotechnical structures and return them to their natural flow [1, 2]. In particular, when researching the topic, the authors [3] proposed the coefficient of ecological and economic efficiency of water resources use (K_{ew}). This parameter is defined as the ratio of the water volume used in all sectors of the economy to the gross domestic product per capita. According to the data [4, 5], an approximate indicator K_{ew} is given for certain European countries for 2020 (Fig. 1). The coefficient K_{ew} for Ukraine is 2.65, which indicates the low efficiency of water resources use. This situation is related to the fact that in the *20th* century, the management paradigm envisaged the maximum satisfaction of human needs due to the unlimited exploitation of natural resources with maximum profit. As a result, the environment was on the verge of degradation, with dire consequences for human health and life itself [6, 7].

Significant changes taking place in almost all areas of activity, and, first of all, in the economics, directly or indirectly have noticeably changed the dynamics of nature use, in particular water. Today, Ukraine is a country that has a significant potential for development, due to the previously built (during the *20th* century) and planned activities for the reconstruction and construction of new capacities in the water management complex.

The presence of a significant raw material base for industry and land resources for agriculture required the involvement of significant amounts of water resources. Accumulation and retention of water occurred due to the construction of reservoirs and ponds. The first were built according to project solutions with appropriate engineering justification. Ponds were built mainly on small rivers and watercourses in order to provide the necessary volumes of water for the needs of small-scale irrigation, poultry and animal husbandry, fish farming and recreation.

During long-term operation for more than 50–70 years, artificial reservoirs have turned rivers into fragmented areas with cascades of ponds [8, 9]. This situation has led to a number of environmental problems which are manifested in a decrease in the quality of water resources (high mineralization of water) [10, 11], lack of water flow and self-cleaning ability of watercourses [12, 13], pollution of water bodies, and others [14]. Due to similar problems of technical and ecological exploitation of reclamation systems [15], a significant number of irrigated areas decreased from more than 2.3 million ha in 1990 to 0.5 million ha in 2021.

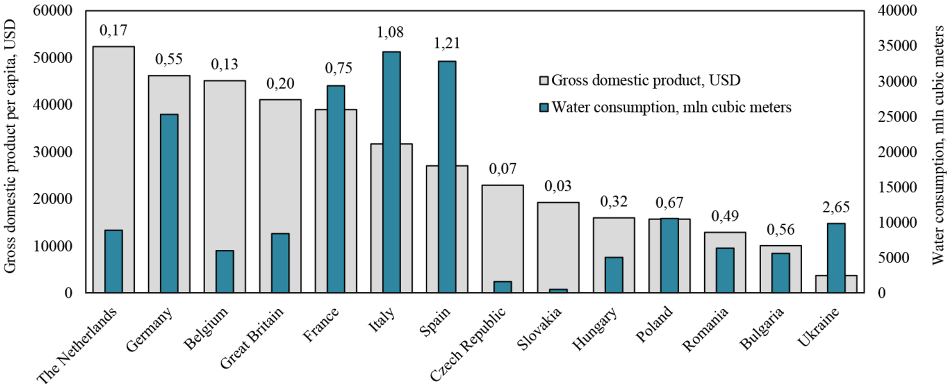

Fig. 1. Comparative indicators of the ecological and economic efficiency of water resources use in European countries

Simplified assessment indicators can provide an operational evaluation of the state of local water resources management and use at the initial stages of research. In the future, this will allow one to deal more deeply with the problem at the point level and implement integrated approaches to the management of water and land resources [16].

An indicator is something that gives an idea of more significant events and things, or allows one to feel tendencies or phenomena that are still impossible to be detected. The main function of the indicator is to simplify information and help in decision-making, a wider understanding of the problem by the public and people who are not specialists in a specific field of knowledge.

In [17], the issue of obtaining well-timed environmental data based on simplified indicators is considered. These include the selection of indicators in small samplings, the use of previous data and the development of new indicators. In this case, the informative value and timeliness of obtaining data improves significantly the possibilities of operational decisions and the development of short-term forecasts and plans for improving the environmental situation in any field.

The main function of the indicator is to inform, and its informative value is ensured by ease of understanding. Further linking with other indicators and creating an overall view in relation to a specific environmental problem or anthropogenic load from economic activity allow expanding the objectivity of the obtained data.

The peculiarities of functioning of the water management complex in Ukraine in the conditions of the Covid-19 pandemic and martial law determine the need to develop an operational methodology for assessing the effectiveness of management and use of water resources accumulated in ponds and reservoirs. Such methods should be grounded upon the use of simplified indicators based on minimal set of criteria and be used for: development and adjustment of local and regional environmental and water management programs; improvement of state policy in the field of water management and related industries; tracking qualitative and quantitative changes in the state of the environment; monitoring of emerging problems and effectiveness of already implemented measures; comparing regions, administrative units or river basins; formation of understanding of problematic areas of further development; study on the cause-effect and mutual relation between economic activity and the natural environment.

Thus, the aim of the research is the development and implementation of simplified indicators for the general assessment of the effectiveness of artificial water bodies (reservoirs and ponds) management and use on territories with water scarcity (Steppe Zone of Ukraine).

Methods of research. To develop a general indicator of the use efficiency of artificial reservoirs located in the Steppe Zone of Ukraine, a method of integral assessment of positive and negative specific indicators is proposed; these indicators characterize the operational parameters of the reservoir and are related, first of all, to the quantitative parameters of water flow regulation. Positive factors and specific indicators should include beneficial volumes of accumulated water resources, as well as quantitative indicators of the water volume per unit of occupied area of reservoirs. The indicators that have a negative impact on the environment should include the alienation of areas under reservoirs and ponds, as well as the integrated indicator of local surface water flow regulation only in ponds and reservoirs as one of the main signs of changing tendencies in the ecological state of artificial reservoirs. All specific indicators are proposed to be determined by simple mathematical ratios (Table 1).

The calculation algorithm is built in such a way that the obtained data of specific indicators are in the range from “–1.0” to “+1.0”. This greatly simplifies the perception of the received information, makes it possible to compare the elements of the sample, identify the most problematic issues in the management and use of local water resources, and shortens the time for making management decisions.

In order to obtain a comparative total risk indicator, which evaluates the efficiency of management and use of water resources in different administrative units (regions, districts) or river basins, a conditional scale of distribution is proposed. Since the impact of any human economic activities and intervention in the natural environment cannot a priori be a positive factor, the distribution scale contains only a division from a satisfactory state to a threatening impact on the environment (Table 2).

This distribution contains not only quantitative characteristics, but also qualitative evaluation parameters based on the principle of simple division and comparison of the obtained results.

Results and discussion. Due to the change in climatic conditions, long-term predictive models of the moisture supply for the territory of Ukraine show a change in the zoning of the country’s territory. Based on the research of scientists from the Institute of Water Problems and Reclamation of Ukraine [18], a corresponding zoning map was constructed (Fig. 2). By 2100, 11 administrative regions will be located in the Steppe Zone, for which studies have been conducted to assess the effectiveness of management and use of local water resources.

Statistical reports and data [19, 20] regarding the total recorded number of artificial reservoirs on the territory of administrative regions are as follows (Table 3).

The analysis presented in Table 3 shows the low efficiency of using water resources accumulated in ponds (Fig. 3). As a percentage from the number of built objects, ponds make up about 96.8 %, occupying almost half of the area taken by artificial reservoirs (44.4 %) and holding only 24.5 % of the volume of water resources. We note that the water from the ponds is almost not used to meet the needs of industry, agriculture and domestic water supply; the fact is obvious that further exploitation of these ponds is impractical, especially in the conditions of the climate change consequences – the total drying up of small reservoirs.

The application of the proposed approach with the use of minimal set of criteria to the express assessment of the general effectiveness of the artificial reservoirs use in the Steppe Zone of Ukraine allows establishing important calculation parame-

Table 1

Formulas for calculating specific indicators

No.	Specific indicator	Formulas for calculating	Explanation for formulas
1	The coefficient of beneficial use of reservoirs	$K_v^{res} = \frac{V_{us}^{res}}{V_{full}^{res}} \cdot 100\ \%$	V_{us}^{res} – beneficial volume of reservoirs, m^3; V_{full}^{res} – full volume of reservoirs, m^3; S^{res} – area under reservoirs, m^2; V_{full}^{pond} – water volume in ponds, m^3; S^{pond} – area under ponds, m^2; S_{region}^{ter} – area of administrative unit (region), m^2; V_o^m – local water flow rate, m^3; K_i – coefficient of *i*-indicator of assessment; $K_{\max}$ – maximum rating coefficient for this indicator; $K_{\min}$ – minimum rating coefficient for this indicator; *n* – a total number of evaluation indicators
2	The coefficient of beneficial use of the volume to the area of reservoirs	$K_v^{res} = \frac{V_{full}^{res}}{S^{res}}$	
3	The coefficient of beneficial use of the volume to the area of ponds	$K_v^{pond} = \frac{V_{full}^{pond}}{S^{pond}}$	
4	The coefficient of alienation of the area under reservoirs	$K_{sub}^{res} = \frac{S^{res}}{S_{region}^{ter}} \cdot 100\ \%$	
5	The coefficient of alienation of the area under ponds	$K_{sub}^{pond} = \frac{S^{pond}}{S_{region}^{ter}} \cdot 100\ \%$	
6	The local water flow regulation coefficient	$K_v^{zar} = \frac{V_{full}^{res} + V_{full}^{pond}}{V_0^m}$	
7	Point for special K-indicator (coefficient)	$N_K = \frac{K_{i i \geq \min}^{i \leq \max} - K_{\min}}{K_{\max} - K_{\min}}, \quad \left(0 \leq N_K \leq 1\right)$	
8	The total indicator of risk (inefficiency of use) of water resources	$R = \sum_{i=1}^{n} \frac{\left(N_{K v}^{res} + N_{K vs}^{res} + N_{K vs}^{pond}\right)}{n} - \sum_{i=1}^{n} \frac{\left(N_{K v}^{zar} + N_{K sub}^{res} + N_{K sub}^{pond}\right)}{n},$ $\left(-1 \leq R \leq +1\right)$	

Table 2

Assessment indicators of effectiveness of artificial reservoirs use

Evaluation interval	Determination of the indicator of impact on the natural environment	Digital designation
"+1.0"–"+0.5"	satisfactory	I
"+0.49"–"±0.0"	unsatisfactory	II
"±0.0"–"–0.5"	dangerous	III
"–0.51"–"–1.0"	threatening	IV

ters (Table 4). According to the proposed methodology, it was determined that only for two regions (Luhansk and Zaporizhzhia) the integral indicator for evaluating the effectiveness of local surface water resources management has a satisfactory assessment of the impact on the surrounding natural environment. First of all, this can be explained by the smallest number of artificial reservoirs in the region, a high percentage of beneficial volume and a low coefficient of local water flow regulation. Seven regions are characterized by an indicator of unsatisfactory use of artificial reservoirs. Two regions (Odesa, Kherson) have an indicator of the dangerous impact of ponds and reservoirs on the natural environment. For almost all analyzed administrative regions, the average value of the indicator K_v^{pond} (which characterizes an important morphometric characteristic of ponds – the average depth) is less than 2 meters.

Fig. 2. Long-term forecast of moisture supply conditions of the territory of Ukraine according to the annual climatic water balance until the year 2100

This situation substantiates and emphasizes the conclusions about the irrationality of use and unproductive losses (evaporation, filtration) of water and the further exploitation of such a significant number of artificial reservoirs, in particular small ponds. Local water flow regulation coefficients for most regions (values 0.22–1.36) exceed significantly the requirements of the Water Code of Ukraine, according to which their quantitative indicators should not exceed 0.05–0.25. And for Kherson and Odesa regions (the value of the coefficient is 2.14 and 6.45, respectively), it is several times higher than the permissible values (0.05 and 0.2, respectively), which is a key factor in the dangerous impact of ponds and reservoirs on the natural environment.

Conclusion.

1. Anthropogenic and climatic factors cause a change in the average annual water flow in the direction of its decrease, and most often, with a high coefficient of fragmentation and regulation of the river, to its complete termination. The ratio of the parameters of the total area of the territory occupied by ponds (44 %) to the area occupied by reservoirs (56 %) is indicative, when the ponds will retain only 25 % of the total volume of water resources. The average value of the indicator K_v^{pond} is less than 2 meters (average depth) for almost all the studied elements of the sampling. Thus, most reservoirs with a volume of up to $1 \cdot 10^6$ m^3 begin to act as evaporation ponds, which

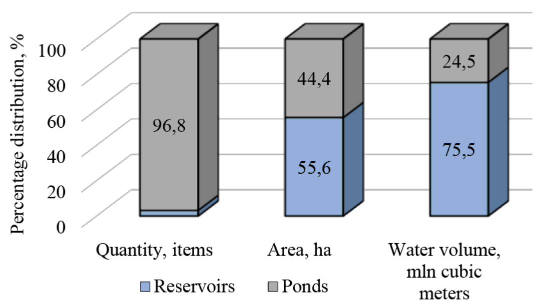

Fig. 3. Percentage distribution according to the main parameters of water bodies in the research area

Table 3

General characteristics of water bodies in the research area (Steppe Zone of Ukraine)

No.	Region	Area of the region, km^2	Local water flow rate, mln m^3	Reservoirs				Ponds			Artificial water bodies in total		
				amount, items	area, km^2	volume, mln m^3		amount, items	area, km^2	volume, mln m^3	amount, items	area, km^2	volume, mln m^3
						full	useful						
1	Dnipropetrovsk	31,914	872	101	201.0	909.0	742.6	3292	188.1	274.8	3393	389.1	1183.8
2	Donetsk	26,517	1050	130	181.9	863.6	619.8	2146	122.0	270.4	2276	303.9	1134.0
3	Zaporizhzhia	27,180	638	28	24.7	74.8	64.2	1174	92.4	159.8	1202	117.1	234.6
4	Kirovohrad	24,588	956	84	95.0	264.3	213.0	2761	179.0	205.1	2845	274.0	469.4
5	Luhansk	26,684	1496	73	74.0	254.0	191.6	360	29.6	76.7	433	103.6	330.7
6	Mykolaiv	24,598	582	45	75.9	374.7	230.8	1153	98.7	97.2	1198	174.6	471.9
7	Odesa	33,310	357	64	587.0	2106.7	934.1	992	121.2	198.0	1056	708.2	2304.7
8	Poltava	28,748	1965	69	64.7	149.9	113.0	2688	199.6	278.1	2757	264.3	428.0
9	Kharkiv	31,415	1832	57	330.5	1497.3	1357.0	2538	131.7	228.6	2595	462.2	1725.9
10	Kherson	28,461	136	15	137.4	138.3	66.2	1154	123.2	152.4	1169	260.6	290.7
11	Cherkasy	20,900	1037	38	59.2	118.7	85.8	2984	174.6	246.6	3022	233.8	365.3
Total on the territory		304,315	10,922	704	183.1	6751.3	4618.1	21,242	146.0	2187.7	21,946	329.1	8939

Table 4

Risk assessment (use inefficiency) of water resources in the research area

No.	Region	The coefficient of beneficial use of reservoirs, %	Point	The coefficient of beneficial use of the volume to the area of reservoirs, m^3/m^2	Point	The coefficient of beneficial use of the volume to the area of ponds, m^3/m^2	Point	Coefficient of alienation of the area under reservoirs, %	Point	Coefficient of alienation of the area under ponds, %	Point	Local water flow regulation coefficient	Point	Total indicator of risk (inefficiency of use) of water resources
1	Dnipropetrovsk	81.7	0.81	4.52	0.89	1.46	0.30	0.630	0.32	0.589	0.66	1.357	0.18	0.28
2	Donetsk	71.8	0.59	4.75	0.95	2.22	0.76	0.686	0.36	0.460	0.48	1.080	0.14	0.44
3	Zaporizhzhia	85.8	0.90	3.02	0.51	1.73	0.46	0.091	0.00	0.340	0.32	0.368	0.02	0.51
4	Kirovohrad	80.6	0.78	2.78	0.45	1.15	0.10	0.386	0.18	0.728	0.85	0.491	0.04	0.09
5	Luhansk	75.4	0.67	3.43	0.62	2.60	1.00	0.277	0.11	0.111	0.00	0.221	0.00	0.73
6	Mykolaiv	61.6	0.37	4.94	1.00	0.98	0.00	0.308	0.13	0.401	0.40	0.811	0.10	0.25
7	Odesa	44.3	0.00	3.59	0.66	1.63	0.40	1.762	1.00	0.364	0.35	6.447	1.00	-0.43
8	Poltava	75.4	0.67	2.32	0.33	1.39	0.25	0.225	0.08	0.694	0.81	0.218	0.00	0.12
9	Kharkiv	90.6	1.00	4.53	0.90	1.74	0.47	1.052	0.58	0.419	0.43	0.942	0.12	0.41
10	Kherson	47.9	0.08	1.01	0.00	1.24	0.16	0.483	0.23	0.433	0.44	2.136	0.31	–0.25
11	Cherkasy	72.3	0.60	2.01	0.25	1.41	0.27	0.283	0.11	0.835	1.00	0.352	0.02	0.00

leads to the deterioration of the quality of water resources.

2. The coefficients of operational parameters of reservoirs are determined as a ratio between their morphological characteristics. The local water flow regulation coefficients for 9 of 11 administrative regions of the Steppe Zone of Ukraine range from 0.22 to 1.36, which is a significant excess of the permissible norms of the Water Code of Ukraine (Article 82), according to which the permissible values of flow regulation coefficients should not exceed 0.05–0.25 (permissible norms of modular coefficients of 95 % coverage). For Kherson (2.14) and Odesa (6.45) regions, this parameter exceeds the requirements by many times (with a norm of 0.05 and 0.2, respectively). The obtained simplified calculated indicators emphasize the ecological danger of the impact of these ponds and reservoirs on the surrounding natural environment.

3. The proposed methodology for determining specific and integral indicators of the effectiveness of local surface water resource management can be the basis for the development and implementation of a number of activities to ensure the "satisfactory" indicator and further, for more extensive research involving other criteria and signs of the effectiveness of water resources management. Activities should include the entire range of water protection areas up to the dismantling of dams of artificial reservoirs. Taking into account the experience of European countries and the United States of America to improve environmental safety in the management of water resources (water use), the following is relevant in the future:

- carrying out a detailed assessment of the suitability of the operation parameters of the ponds and reservoirs in the basins of small rivers with the requirements of the current environmental protection legislation;
- performing an ecological, social and economic assessment for each water body;
- ranking ponds and reservoirs according to the ecological danger of water use;
- developing regional, district or basin programs for liquidation of ponds and reservoirs which do not fulfil their water management functions.

References.

1. Rybalova, O., Artemiev, S., Sarapina, M., Tsymbal, B., Bakhareva, A., Shestopalov, O., & Filenko, O. (2018). Development of methods for estimating the environmental risk of degradation of the surface water state. *Eastern-European Journal of Enterprise Technologies*, *2*(10(92)), 4-17. https://doi.org/10.15587/1729-4061.2018.127829.

2. *New Report Alert – Free Rivers: Status of US Dam Demolition Works* (n.d.). Retrieved from https://cutt.ly/4JjgL9X.

3. Slaba, L.A., & Smetanina, T.V. (2019). Regarding the procedure for ranking different spheres of production according to the indicator of environmental economy. *Materials of the 3rd International scientific and practical internet conference "Effective functioning of ecologically stable territories in the context of the sustainable strategy development: agro-ecological, social and economic aspects"*, (pp. 26-29). Retrieved from https://cutt.ly/vVn98C2.

4. *Annual use of water in the countries of the world* (n.d.). Retrieved from https://www.worldometers.info/water/.

5. *Ranking of countries by GDP per capita* (n.d.). Retrieved from https://nonews.co/directory/lists/countries/gdp-per-capita.

6. Adamenko, Y.S., Arkhypova, L.M., & Mandryk, O.M. (2017). Territorial normative of quality of hydroecosystems of protected territories. *Hydrobiological journal*, *53*(2), 50-58. https://doi.org/10.1615/HydrobJ.v53.i2.50.

7. Rybalova, O., Malovanyy, M., & Bondarenko, O. (2022). Method of Assessing the Potential Risk to the Health of the Population During Recreational Water Withdrawal. *Journal of Ecological Engineering*, *23*(5), 81-91. https://doi.org/10.12911/22998993/146998.

8. Hapich, H., Pikarenia, D., Orlinska, O., Kovalenko, V., Rudakov, L., Chushkina, I., ..., & Katsevych, V. (2022a). Improving the system of technical diagnostics and environmentally safe operation of soil hydraulic structures on small rivers. *Eastern-European Journal of Enterprise Technologies*, *2*(10(116), 18-29. https://doi.org/10.15587/1729-4061.2022.255167.

9. Hapich, H., Andrieiev, V., Kovalenko, V., & Makarova, T. (2022b). The analysis of spatial distribution of artificial reservoirs as anthropogenic fragmentation elements of rivers in the Dnipropetrovsk Region, Ukraine. *Journal of Water and Land Development*, *53*(IV–VI), 80-85. https://doi.org/10.24425/jwld.2022.140783.

10. Hapich, H., Andrieiev, V., Kovalenko, V., Hrytsan, Yu., & Pavlychenko, A. (2022). Study of fragmentation impact of small riverbeds by artificial waters on the quality of water resources. *Naukovyi Visnyk Natsionalnoho Hirnychoho Universytetu*, (3), 185-189. https://doi.org/10.33271/nvngu/2022-3/185.

11. Osadchyi, V.I. (2017). Resources and quality of surface water in Ukraine under conditions of anthropogenic load and climate change. *Visnyk of the NAS of Ukraine*, (8), 29-46. https://doi.org/10.15407/visn2017.08.029.

12. Vyshnevskyi, V., & Shevchuk, S. (2021). Thermal regime of the Dnipro Reservoirs. *Journal of Hydrology and Hydromechanics*, *69*(3), 300-310. https://doi.org/10.2478/johh-2021-0016.

13. Malovanyy, M., Moroz, O., & Popovich, V. (2021). The perspective of using the «open biological conveyor» method for purifying landfill filtrates. *Environmental Nanotechnology, Monitoring and Management*, *16*, 100611. https://doi.org/10.1016/j.enmm.2021.100611.

14. Trus, I.M., & Gomelya, M.D. (2021). Desalination of mineralized waters using reagent methods. *Journal of Chemistry and Technologies*, *29*(3), 417-424. https://doi.org/10.15421/jchemtech.v29i3.214939.

15. Rokochynskiy, A., Turcheniuk, V., Prykhodko, N., Volk, P., Gerasimov, Ie., & Koç, C. (2020). Evaluation of Climate Change in the Rice-Growing Zone of Ukraine and Ways of Adaptation to the Predicted Changes. *Agricultural Research*, (9), 631-639. https://doi.org/10.1007/s40003-020-00473-4.

16. Kozhushko, L.F., Stashuk, V.A., Khvesyk, M.A., & Rokochynskyi, A.M. (2018). *Water management in Ukraine: problems and innovation of development*. Rivne. ISBN 978-617-7328-61-1.

17. Jamous, N., & Müller, K. (2013). Environmental Performance Indicators. *Environmental Science and Engineering*. https://doi.org/10.1007/978-3-642-32720-9_1.

18. *About the state of water resources of the state and features agricultural production in the context of climate change* (n.d.). Retrieved from https://cutt.ly/IJziVy7.

19. Hrebin, V.V., Khilchevskyi, V.K., Stashuk, V.A., Chunarov, O.V., & Yaroshevych, O.Ie. (2014). *Water Fund of Ukraine: Artificial body of water – reservoirs and ponds*. Kyiv: Interpres.

20. Khilchevskyi, V., Grebin, V., Zabokrytska, M., Zhovnir, V., Bolbot, H., & Plichko, L. (2020). Hydrographic characteristic of ponds distribution in Ukraine – Basin and regional features. *Journal of Water and Land Development*, (46), 140-145. https://doi.org/10.24425/jwld.2020.134206.

Оцінювання ефективності управління та використання водних ресурсів за спрощеними показниками

В. Андрєєв[1], *Г. Гапіч*[2], *В. Коваленко*[2], *С. Юрченко*[2], *А. Павличенко*[3]

1 – Дніпровський державний технічний університет, м. Кам'янське, Україна, e-mail: Andreev_V_G@ukr.net

2 – Дніпровський державний аграрно-економічний університет, м. Дніпро, Україна

3 – Національний технічний університет «Дніпровська політехніка», м. Дніпро, Україна

Мета. Розробка спрощених показників оцінки ефективності управління й використання місцевого стоку у водосховищах і ставках.

Методика. Використані методи інтегральної оцінки за питомими показниками, що характеризують експлуатаційні параметри водойми. Застосовані аналітичні формули розрахунку питомих показників, значення яких знаходяться в інтервалі від «–1,0» до «+1,0», що значно спрощує сприйняття отриманої інформації.

Результати. Наведена загальна характеристика штучних водних об'єктів дослідження. Визначені коефіцієнти експлуатаційних параметрів водойм і зарегулювання місцевого стоку. Установлені питомі та інтегральний показники оцінки ефективності управління місцевими водними ресурсами. Запропонована формула розрахунку порівняльного сумарного показника ризику та умовна шкала розподілу, за якими оцінюється ефективність управління місцевими водними ресурсами в межах адміністративних одиниць або річкових басейнів для елементів вибірки, взятої до дослідження. Визначені співвідношення параметрів загальної площі території зайнятих під ставками (44 %) до площі зайнятої водосховищами (56 %) за якої ставки утримають лише 25 % від загального об'єму водних ресурсів. Практично для всіх досліджуваних елементів вибірки значення середньої глибини становить менше 2 метрів, а об'єм до $1 \cdot 10^6$ м^3. Через це більшість водойм працюють як ставки-випаровувачі, що призводить до погіршення якості водних ресурсів. Визначені коефіцієнти зарегулювання місцевого стоку для 9 з 11 адміністративних областей степової зони України коливаються в межах 0,22–1,36, що є суттєвим перевищенням допустимих норм модульних коефіцієнтів для 95 % забезпеченості в межах 0,05–0,25. Для Херсонської (2,14) та Одеської (6,45) областей цей параметр у рази (при нормі 0,05 та 0,2 відповідно) перевищує вимоги Водного кодексу України.

Наукова новизна. Запропоновані й визначені питомі інтегральні показники зарегулювання місцевого стоку та характеристики експлуатаційних параметрів водойм на території адміністративних областей Степу України. Надана бальна оцінка впливу штучних водних об'єктів на навколишнє природне середовище, що обґрунтовує й підкреслює висновки щодо нераціональності використання води та подальшої експлуатації такої значної кількості штучних водойм, зокрема невеликих ставків.

Практична значимість. Питомі показники ефективності управління й використання місцевого стоку, що утримують у ставках і водосховищах Степу України, спрощують сприйняття отриманої інформації та скорочують час прийняття управлінських і водоохоронних рішень.

Ключові слова: *водні ресурси, ефективність використання, водна безпека, штучна водойма*

The manuscript was submitted 21.12.21.