DOI: 10.12731/2658-6649-2022-14-2-296-311
UDC 556.18

ASSESSMENT OF SURFACE WATER QUALITY (ON THE EXAMPLE OF THE CHUMYSH RIVER)

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The surface water pollution issue is urgent as it is the most extensive issue. Large-scale pollution of the environment causes damage to rivers, lakes, water reservoirs, and soils. Pollutants and products of their transformations sooner or later come from the atmosphere to the surface of the Earth. Issues of clean water and protection of aquatic ecosystems become increasingly acute as the historical development of society develops. Furthermore, the influence of scientific and technological progress on nature rapidly increases. Currently, there is a unified criterion for assessing water quality is the maximum permissible concentration (MPC) of substances contained in it in the Russian Federation. The Chumysh River flows in the Kemerovo Region and Altai Krai and is a tributary of the Ob River. The Chumysh River has a length of 644 km and a basin area of 23,900 square km. The assessment of the surface water quality of the Chumysh River is carried out based on data processing of the Roshydromet Federal Service for Hydrometeorology and Environmental Monitoring of Russia, which is located on the studied water object near the city of Zarinsk. The primary research goal is to assess the quality of surface waters of the Chumysh River in Zarinsk and Talmenka urban-type settlement. During the study period (nine years), the authors have identified the elements as the primary substances that have provided the most critical contribution to pollution. A comprehensive assessment has been carried out for these substances, and the substances that provide the most significant contribution to surface water pollution are selected based on the product of the points. This factor is of great importance for developing the measures that aim at their purification and planning the future use of the Chumysh River waters.

Keywords: *surface water quality; integrated pollution assessment; sampling; combinatorial water pollution index; water quality class*

For citation. *Slazhneva S.S., Kozyreva Y.V., Maurer M.A. Assessment of Surface Water Quality (on the Example of the Chumysh River). Siberian Journal of Life Sciences and Agriculture, 2022, vol. 14, no. 2, pp. 296-311. DOI: 10.12731/2658-6649-2022-14-2-296-311*

ОЦЕНКА КАЧЕСТВА ПОВЕРХНОСТНЫХ ВОД (НА ПРИМЕРЕ РЕКИ ЧУМЫШ)

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Проблема загрязнения поверхностных вод актуальна, так как является наиболее обширной. Масштабное загрязнение окружающей среды наносит ущерб рекам, озерам, водохранилищам, почвам. Загрязняющие вещества и продукты их трансформаций рано или поздно попадают из атмосферы на поверхность Земли. Вопросы чистой воды и защиты водных экосистем становятся все более острыми по мере исторического развития общества. Кроме того, быстро возрастает влияние научно-технического прогресса на природу. На территории Российской Федерации, в настоящее время, единым критерием оценки качества воды является предельно допустимая концентрация (ПДК) содержащихся в ней веществ. Река Чумыш протекает в Кемеровской области и Алтайском крае и является притоком реки Обь. Протяженность реки Чумыш составляет 644 км, а площадь бассейна – 23900 км^2. Оценка качества поверхностных вод реки Чумыш проводится на основании обработки данных Федеральной службы по гидрометеорологии и мониторингу окружающей среды России (Росгидромет), которая расположена на исследуемом водном объекте в районе г. Заринск. Основной целью исследований является оценка качества поверхностных вод реки Чумыш в Заринске и пгт Тальменка. За исследуемый период (девять лет) авторы определили элементы как первичные вещества, внесшие наиболее критический вклад в загрязнение. Для этих веществ проведена комплексная оценка, и по произведению баллов выбраны вещества, способствующие загрязнению поверхностных вод больше всего. Этот фактор имеет большое значение для разработки мероприятий по очистке вод и планирования дальнейшего использования вод реки Чумыш.

Ключевые слова: *качество поверхностных вод; комплексная оценка загрязнения; отбор проб; комбинаторный индекс загрязнения воды; класс качества воды*

Для цитирования. *Слажнева С.С., Козырева Ю.В., Маурер М.А. Оценка качества поверхностных вод (на примере реки Чумыш) // Siberian Journal of Life Sciences and Agriculture. 2022. Т. 14, № 2. С. 296-311. DOI: 10.12731/2658-6649-2022-14-2-296-311*

Introduction

Issues of clean water and protection of aquatic ecosystems become increasingly acute with the historical development of society. The issue of surface water pollution is currently relevant since the threat of a shortage of clean drinking water on the planet is becoming increasingly clear. Large-scale environmental pollution damages rivers, lakes, reservoirs, and soils. Pollutants and products of their transformations sooner or later fall from the atmosphere to the surface of the Earth.

In the current research, the authors employ differentiated and integrated assessment methods to determine the degree of water body contamination and water quality. The method of a comprehensive assessment of the degree of surface water pollution by hydrochemical indicators bases on determining the level of pollution by conducting a detailed component-by-component analysis of the water composition. Furthermore, the contamination is compared with the permissible concentrations and the frequency exceeding the standards.

The final complex indicator of water quality is determined by summing up the individual indicators that assess the contribution of each pollutant separately [10].

Currently, the unified criterion for assessing water quality is the maximum permissible concentration (MPC) of the substances contained in it. However, the objectivity of the information depends not on the MPC level alone. The objectivity and accuracy of the information are influenced by many factors (how often samples are taken, how many indicators are determined, how often the excess concentrations of pollutants occur in the samples) [8].

The Chumysh River flows in the Kemerovo Region and Altai Krai and is a tributary of the Ob River. The Chumysh River has a length of 644 km and a basin area of 23,900 square km. The river has two sources: Tom-Chumysh and Kara-Chumysh, which originate from one of the slopes of the Maimandzhinsky Ridge. The Chumysh River begins at the confluence of these two rivers and flows primarily through the Biysko-Chumysh Upland. The upper reaches of the river have rapid characteristics and rapid flow. The Chumysh feeds on thawed snow waters. The river freezes in winter, and ice drift begins in April. The Chumysh flows into the Ob 88 kilometers below the city of Barnaul.

The Chumysh River is navigable; however, only as far as the Zakharovo Pier. The river basin is located within the Southwestern part of the Salair Ridge and the Pre-Salair Plain, the Biysko-Chumysh Upland. The banks comprise solid rocks that are occupied by mixed forests. There are often rock outcrops in the riverbed. The Chumysh flows in a winding and rapid riverbed. Sometimes there are sections of a relatively straight riverbed with a width of 25–40 m. Within the limits of a wide valley, the river becomes flat, and the riverbed becomes broad-bottomed, freely meandering. The intensity of coastal erosion increases to 30–50 m/year. The channel sediments of sandy composition predominate. In the lower flow of the river, the width of the riverbed reaches 250 m. The river is located in the backwater of the Ob River (the backwater extends for a distance of approximately 100 km from the mouth of the Chumysh).

Materials and methods

Scientists and environmentalists focus close attention on the issues of studying and evaluating the purity of reservoirs. The results of their research from various positions and bases in the global, Russian, and territorial dimensions are presented in the works of D. A. Agulov and A. V. Ivanova [1], W. A. Ahsan et al. [14], H. Aziz et al. [15], G. Babayan et al. [16], A. Chugai and T. Safranov [17], L. V. Golovatyuk and T. D. Zinchenko [4], A. Ivanova [6], M. Islam et al. [19], S. Feroz et al. [18], Y. Yurova and V. Shirokova [21], V. Vorobiev et al. [20], M. B. Zaslavskaya et al. [5].

The primary research goals are to analyze the regulatory framework for the legal regulation of water bodies, identify the features and monitor the water bodies, and assess surface water pollution.

The research employs the guidance document No. 52.24.643-2002 [10] entitled “Method of comprehensive assessment of the degree of surface water pollution by hydrochemical indicators,” the primary goal of which is defined by Article 78 of the Water Code of the Russian Federation. It implies the provision of valuable statistical information on the surface water pollution level in the country at the national level based on hydrochemical indicators. The guidelines create a basis for processing the data of regular observations of the government monitoring of water bodies for the chemical composition for an integrated assessment of the surface water quality for a complex of pollutants observed by the network of the State Monitoring Service (SMS) of the Federal Service for Hydrometeorology and Environmental Monitoring (Roshydromet).

The basis of the complex method is the assessment of the degree of contamination of a water body by a set of pollutants – for any water body at the point of water sampling, for any specific period, and according to any set of hydrochemical indicators. A unique feature of the method is to conduct a detailed component-by-component analysis of the chemical composition of water and its regime in the first stage and then use the obtained estimated components at the second stage in order to simultaneously consider the unity of observed ingredients and water quality indicators.

The authors utilize a classifier developed in Rostov-on-Don [10] to determine the water quality class according to the value of the specific combinatorial water pollution index (SCWPI). Each class has an individual name (Table 1).

Table 1.

Determination of water quality classes in accordance with the SCWPI value (RD 52.24.643-2002)

Class	Rank	SCWPI	Name
1		<1	Conditionally pure
2		1–2	Lightly polluted
3	a	2–3	Polluted
	b	3–4	Severely polluted
4	a	4–6	Dirty
	b	6–8	Dirty
	c	8–10	Very dirty
	d	10–11	Very dirty
5		Exceeding 11	Extremely dirty

The combinatorial water pollution index value – SA – implies the sum of the generalized evaluation points for each ingredient.

$$S_A=\sum S_i, \quad (1)$$

Specific combinatorial index of water pollution S'_A:

$$S'_A= S_A/I, \quad (2)$$

i – the total number of ingredients in the water reservoir under study.

The assessment of the surface water quality of the Chumysh River is carried out by processing the data of the Roshydromet observation network, which is located at the water object under consideration in the Zarinsk area. Observational frequency occurs seven times a year.

Results

The authors conduct a comprehensive assessment of the Chumysh River water quality. Furthermore, the authors calculate the specific combinatorial water pollution index (SCWPI) indicator, determine the water quality class, and identify the substances that have made the most critical contribution to pollution.

Contamination of the surface waters of the Chumysh River in the alignment near Zarinsk and Talmenka is carried out for 11 substances: sulfates, chlorides, oxygen, biochemical oxygen consumption in five days, ammonium nitrogen, nitrite nitrogen, nitrate nitrogen, bichromate oxidability, iron, volatile phenols, and petroleum products.

Table 2 presents the water quality class of the Chumysh River in 2011–2019 as a result of a comprehensive assessment.

Table 2.

Classification of the Chumysh River surface water quality by the SCWPI size

Year	SCWPI value (Zarinsk/Talmenka)	Water quality class (Zarinsk/Talmenka)	Pollutants (Zarinsk/Talmenka)
2011	4.1/3.69	4A Dirty/3B Very dirty	—
2012	4.18/4.36	4A Dirty	—
2013	3.72/4.34	4A Dirty	Petroleum products/–
2014	3.03/3.51	3B Very dirty	—
2015	3.56/3.88	3B Very dirty	—
2016	2.91/4.03	3A Polluted/4A Dirty	—
2017	4.36/4.19	4A Dirty	—
2018	3.68/4.62	4A Dirty	Iron
2019	3,874.00	3B Very dirty	—

According to Table 2 and the change in the SCWPI value, one can observe that the Chumysh River water quality class constantly changes from 3 to 4A Dirty.

Fig. 1 undoubtedly illustrates the results presented in Table 2, which indicate the change in the SCWPI indicator value.

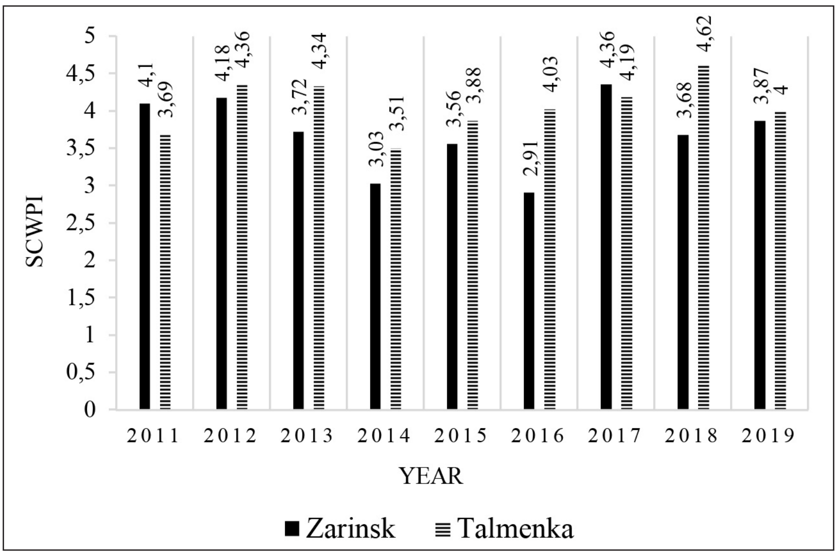

Fig. 1. Change in the SCWPI value for 2011–2019 of the Chumysh River in the Zarinsk area

According to the results presented in Table 2 and Fig. 1, one can note the stable quality of the surface water of the river for the considered nine-year period.

Since the value of the SCWPI indicator depends on the content of pollutants involved in the comprehensive assessment, one should consider the change dynamics in the concentrations of individual ingredients in the river waters for the 2011–2019 period.

For the convenience of the analysis, the authors consider the dynamics of the average concentrations of substances not in units of their content in surface waters but fractions of the MPC. This factor will allow the authors to demonstrate the presence or absence of exceeding the MPC for each substance that affects water quality and the multiplicity of exceeding the MPC (if any).

Fig. 2 demonstrates the dynamics of the biochemical oxygen consumption in five days of preserving the object in the surface waters under study in the Zarinsk and Talmenka areas for the 2011–2019 period. There is a tendency to reduce the five-day biochemical oxygen consumption concentration in the Chumysh River waters. The lowest concentration was recorded in 2017, which was the highest in 2011 and 2012.

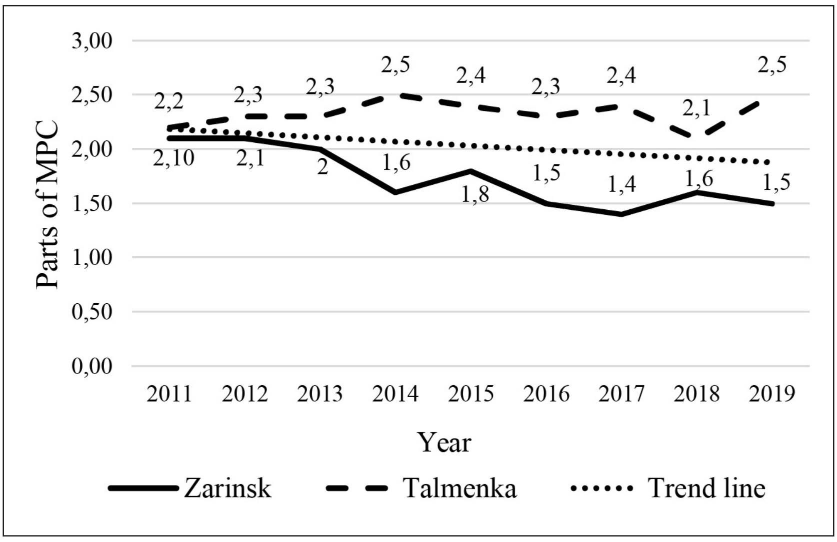

Fig. 2. The average concentration of the biochemical oxygen consumption in five days in the surface waters of the Chumysh River in Zarinsk and Talmenka areas for the 2011–2019 period

Fig. 3 represents the dynamics of the petroleum product content in the surface waters of the Chumysh River in Zarinsk and Talmenka for the 2011–2019 period.

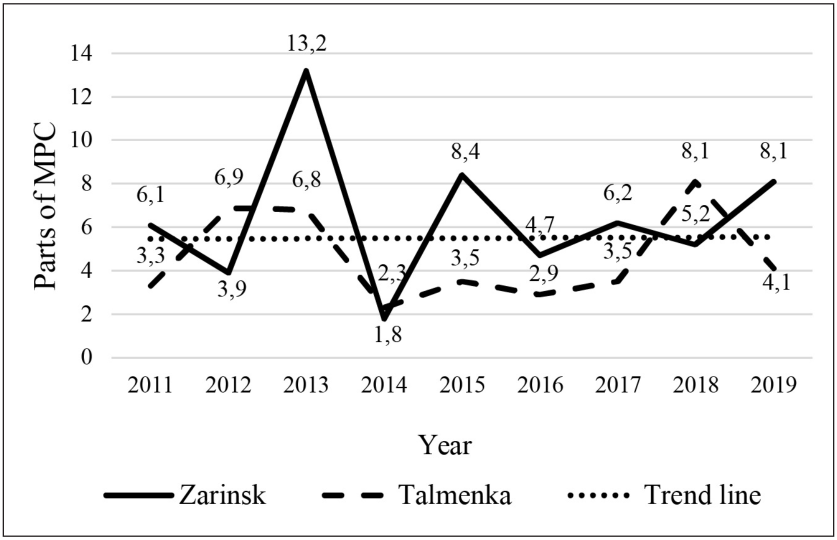

Fig. 3. The average concentration of petroleum products in the surface waters of the Chumysh River in Zarinsk and Talmenka for the 2011–2019 period

According to Fig. 3, one can note that, on average, the concentration of the pollutant in surface waters remains constant, the trend line confirms. The lowest concentration was recorded in 2014, which was the highest in 2013. The peak content of petroleum products in 2013 can be explained by the following features: a hot summer, deficient levels due to this significant increase, and a sharp decline and a minimum in 2014 (an abnormal flood).

Analyzing the dynamics of the total iron content for the 2011–2019 period, one has found an increase in the stem in Zarinsk and Talmenka areas.

Such a change in the concentration of iron in the stem can be attributed to the most common reasons. Iron compounds enter surface waters through the chemical weathering of rocks, and a significant amount enters reservoirs with underground runoff and industrial and agricultural wastewater.

Contamination of surface waters with this element can affect both the composition of the microflora of the reservoir and the rate of development of phytoplankton.

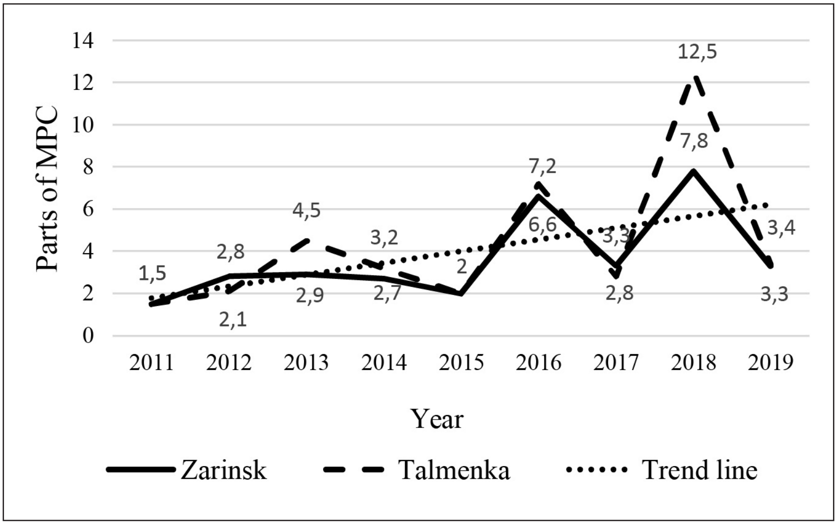

Fig. 4. The average concentration of iron in the surface waters of the Chumysh River in Zarinsk and Talmenka for the 2011–2019 period

Fig. 4 depicts an upward trend in average concentrations in the surface waters of the Chumysh River despite a decrease in average concentrations in the 2013–2015 period. High iron content is typical for many water bodies in Altai Krai, and the Chumysh River is no exception. The highest average concentration of iron was observed in 2018, and it was due to a rapid increase in the total wastewater discharge of Housing and Communal Management LLC in Zarinsk and various repair works.

Incidentally, the dynamics of the specific combinatorial water pollution index and pollutants in the considered sections of the Chumysh River can reveal the following:

- The quality class of the surface water of the object of study in the area near Zarinsk varies from 3A Polluted to 4A Dirty;
- The following substances contribute most to surface water pollution: biochemical oxygen consumption in five days, petroleum products, and iron;
- The observed stability of the SCWPI value depends directly on the constant average concentration of petroleum products, an increase in the average concentration of total iron, and a decrease in the concentration of biochemical oxygen consumption in five days.

Discussion

Surface water is a natural object of multicomponent variable composition that humans use for various purposes. Therefore, assessing the quality of surface water is an urgent task.

Proponents of a comprehensive assessment of the degree of surface water pollution by hydrochemical indicators [2; 7; 13] developed at the Hydrochemical Institute (Rostov-on-Don) consider this method to be the most relevant.

The essence of the method is to identify a set of the most characteristic pollutants for Russia as a whole rather than for one water body. One should note that traditional observation and control methods possess one fundamental drawback – they are not operational.

Another method used in national research bases on developing the Bavarian water use service [11]. The research aims at assessing the quality of transboundary water bodies.

The analysis of international and Russian experience in the field of research has shown that there is currently no unified methodology. There are also no uniform criteria for assessing the degree of pollution of water bodies in all countries worldwide, which causes difficulties in matters of their protection.

Substantial amounts of petroleum products enter the surface waters with the wastewater of oil production, oil refining, chemical, metallurgical, other industries, and municipal water. Some petroleum products enter the water due to intravital secretions by plant and animal organisms and their postmortem decomposition [12].

Studies assessing the quality of surface waters of the Chumysh River have not been conducted before. Detailed studies in the Chumysh River basin aim at studying the water quality of bottom sediments, the pigment characteristics of phytoplankton as an indicator of the environmental state of the reservoir [3; 7], and the toxicity assessment of bottom sediments of the Chumysh River using the Allium test have been carried out by N. N. Chernysheva, L. P. Khlebova, O. S. Goryaninova, A. P. Krainov [9]. Bezmaternykh [3] has assessed the ecological condition of the river. The Chumysh uses zoobenthos as an indicator of water pollution.

Conclusion

The paper considers the dynamics of changes in the SCWPI value and the primary substances that contribute to the pollution of the Chumysh River. The primary observation points are in Zarinsk and Talmenka. According to the data obtained during the research, the water quality class in the Chumysh River changes. Near Zarinsk, it varies from 3A Polluted to 4A Dirty, and in Talmenka, it changes from 3B to 4A Dirty.

A comprehensive assessment of the contamination of the surface waters of the Chumysh River has been carried out for 11 substances. After the product of the points, substances that have an adverse impact on surface water quality are selected.

Therefore, in the course of the conducted study, the authors identify three substances near Zarinsk and Talmenka: biochemical oxygen consumption in five days, petroleum products, and iron (an increase in the average concentration in surface waters is noted for iron), which makes the most critical contribution to surface water pollution.

References

1. Alagulov D. A., Ivanova A. V. Otsenka zagryazneniya khlorid-ionami malykh rek Nizhnevartovskogo rayona [Assessment of chloride ion pollution of small rivers in the Nizhnevartovsk region]. *Siberian Journal of Life Sciences and Agriculture*, 2020, vol. 12, no. 1, pp. 64-70. https://doi.org/10.12731/2658-6649-2020-12-1-64-70
2. Bardyuk V. V., Stoiko L. S. K voprosu o kompleksnoy otsenke kachestva vody [On the issue of comprehensive assessment of surface water quality]. *Ekonomika i Ekologichesky Menedzhment* [Economics and Environmental Management], 2011, no. 2, pp. 2-9.
3. Bezmaternykh D.M. *Zoobentos kak pokazatel ekologicheskogo sostoyaniya pritokov Verkhney Obi (na primere rek Barnaulka, Bolshaya Cheremshanka i Chumysh)* [Zoobenthos as an indicator of the ecological state of the tributaries of the Upper Ob River (on the example of the Barnaulka, Bolshaya Cheremshanka, and Chumysh rivers]. Diss. cand. bio. sciences. Barnaul, 2003. 177 p. https://earthpapers.net/zoobentos-kak-indikator-ekologicheskogo-sostoyaniya-pritokov-verhney-obi
4. Golovatyuk L.V., Zinchenko T.D. Bioticheskiye identifikatory v otsenke kachestva vody etalonnoy reki: Sravnitelnyy analiz bioindikatsionnykh indeksov reki baytugan (Vysokoye Zavolzhye) [Biotic indices in water quality assessment for reference rivers: A comparative analysis of bioindication indices of the Baitugan River (High Zavolzhye)]. *Uchenye Zapiski Kazanskogo Universiteta. Seriya Gumanitarnye Nauki* [Scientific Notes of Kazan University. Humanities Series]. 2020, vol. 162, no. 1, pp. 134-150. https://doi.org/10.26907/2542-064X.2020.1.134-150

5. Zaslavskaya M. B., Irina O. N., Efimova L. E. Sopostavleniye effektivnosti parametrizatsii kachestva rechnykh vod razlichnymi metodami v usloviyakh znachitelnogo antropogennogo vozdeystviya [Comparing the effectiveness of river water quality parametrization by various methods in conditions of significant anthropogenic impact]. *Geografia i Prirodnye Resursy* [Geography and Natural Resources]. 2019, vol. 40, no. 2, pp. 122-128. https://doi.org/10.1134/S1875372819020045
6. Ivanova A. V. Dinamika migratsii antropogennykh primesey v malykh rekakh Nizhnevartovskogo rayona [Dynamics of anthropogenic impurities migration in small rivers of the Nizhnevartovsk region]. *Siberian Journal of Life Sciences and Agriculture*. 2020, vol. 12, no. 1, pp. 84-91. https://doi.org/10.12731/2658-6649-2020-12-1-84-91
7. Kirillova T. V., Kotovshchikov A. V. Pigmentnyye otsenki kak pokazateli ekologicheskogo sostoyaniya reki Chumysh v rayone goroda Zarinska [Pigment criteria as indicators of the Chumysh River ecological condition near the city of Zarinsk]. *Mir nauki, kultury, obrazovaniya* [The World of Science, Culture and Education]. 2010, vol. 6-1, no. 25, pp. 248-252.
8. *Organizatsiya i provedeniye regulyarnykh nablyudeniy za sostoyaniyem i zagryazneniyem poverkhnostnykh vod sushi* [Organization and conduct of routine observations of the state and pollution of land surface waters], 2011. URL: http://www.pfo.meteorf.ru/assets/files/771/rd%2052.24.309-2011.pdf
9. Chernysheva N. N., Khlebova L. P., Goryaninova O. S., Krainov A. P. Otsenka toksichnosti donnykh otlozheniy rek Chumysh s ispolzovaniyem Allium-testa [Toxicity evaluation of bottom sediments of the Chumysh River using the Allium test]. *Vestnik Altayskogo Gosudarstvennogo Agrarnogo Universiteta* [Bulletin of the Altai State Agrarian University]. 2016, vol. 9, pp. 39-45. https://www.asau.ru/files/vestnik/2016/9/039-045.pdf
10. *RD 52.24.643-2002 Metodicheskiye ukazaniya. Metod kompleksnoy otsenki stepeni zagryazneniya vody po gidrokhimicheskim pokazatelyam* [RD 52.24.643-2002 Guidelines. Method of complex assessment of the degree of contamination of surface waters by hydrochemical indicators], *2002.* URL: https://docs.cntd.ru/document/1200039667
11. Frumin G. T., Fetisova Yu. A. Alternativny podkhod k otsenke kachestva vodnykh transgranichnykh vodnykh obyektov [Alternative approach to estimation of quality of water of transboundary water objects]. *Uchenyye Zapiski Rossiyskogo Gosudarstvennogo Gidrometeorologicheskogo Universiteta* [Scientific Notes of the Russian State Hydrometeorological University]. 2018. no. 50, pp 177-186. https://readera.org/alternativnyj-podhod-k-ocenke-kachestva-vod-transgranichnyh-vodnyh-obektov-140228947

12. *Khimiya vody* [Water chemistry], n.d. URL: https://wwtec.ru/index.php?id=218
13. Shutova K. O. Otsenka sostoyaniya prirodnykh resursov Altayskogo kraya po sosedstvu s se'yu Rosgidrometa [Assessment of the state of Altai Krai natural environment objects]. *Polzunovsky Vestnik* [Polzunovsky Bulletin]. 2006, no. 2-1, pp. 392-395. https://studylib.ru/doc/2108575/ocenka-sostoyaniya-obek-tov-prirodnoj-sredy-altajskogo-kraya-po
14. Ahsan W. A., Ahmad H. R., Farooqi Z. U. R., Sabir M., Ayub M. A., Rizwan M., Ilic P. Surface water quality assessment of Skardu springs using Water Quality Index. *Environmental Science and Pollution Research*, 2021, no. 28, pp. 20537–20548. https://doi.org/10.1007/s11356-020-11818-5
15. Aziz H. A., Abu Amr S. S., Hung Y. T. Surface water quality and analysis. In: Wang, L. K., Wang, M. H. S., Hung, Y. T., Shammas, N. K. (eds) *Integrated natural resources management. Handbook of environmental engineering*. 2021, vol. 20. Springer, Cham. https://doi.org/10.1007/978-3-030-55172-8_3
16. Babayan G., Reshetnyak O., Zakrutkin V. A. Comparative assessment of river water quality in mountain regions of Russia and Armenia. *Water Resources*. 2021, vol. 48, no. 1, pp. 102-110. https://doi.org/10.1134/S0097807821010115
17. Chugai A., Safranov T. Assessment of technogenic loading on the surface water bodies of the separate regions of the North-Western Black Sea. *Journal of Ecological Engineering*. 2020, vol. 21, no. 5, pp. 197-201. https://doi.org/10.12911/22998993/122672
18. Feroz S., Siyabi S., Mohammed N., Eltayeb M. Assessment of ground and surface water quality and its contamination. *International Journal of Environmental Analytical Chemistry*. 2021, (published online). https://doi.org/:10.1080/03067319.2021.1873975
19. Islam M., Nasrin T., Islam M. Determination of surface water quality for irrigation in Dinajpur. *Turkish Journal of Agriculture - Food Science and Technology*. 2021, vol. 9, no. 10, pp. 1782-1791. https://doi.org/10.24925/turjaf.v9i10.1782-1791.4208
20. Vorobiev E. V., Usova E. V., Orkhova Y. V. Analysis of Sources of Anthropogenic Pollution of the Transboundary River, the Serevsky Donets, Based on the Dynamics of the Anion Composition (Nitrites, Nitrates, Sulfates, Chlorides, Phosphates) in 2007-2016. IOP Conference Series: Earth and Environmental Science. 2021, vol. 720, no. 1, 012059. https://doi.org/10.1088/1755-1315/720/1/012059
21. Yurova Y., Shirokova V. Geoecological assessment of anthropogenic impacts on the Osetr River basin. *Geosciences (Switzerland)*. 2020, vol. 10, no. 4, 121. https://doi.org/10.3390/geosciences10040121

Список литературы

1. Агулов Д.А., Иванова А. В. Оценка загрязнения хлорид-ионами малых рек Нижневартовского Района // Siberian Journal of life sciences and agriculture. 2020. Т. 12, №1. С. 64-70. https://doi.org/10.12731/2658-6649-2020-12-1-64-70
2. Бардюк В.В., Стойко Л.С. К вопросу комплексной оценки качества поверхностных вод // Экономика и экологический менеджмент. 2011. №2. С. 2-9.
3. Безматерных Д.М. Зообентос как индикатор экологического состояния притоков Верхней Оби: на примере рек Барнаулка, Большая Черемшанка и Чумыш: Дис. кн. био. наук. Б., 2003. С. 177. https://earthpapers.net/zoobentos-kak-indikator-ekologicheskogo-sostoyaniya-pritokov-verhney-obi
4. Головатюк Л.В., Зинченко Т.Д. Биотические идентификаторы в оценке качества воды эталонной реки: Сравнительный анализ биоиндикационных индексов реки байтуган (Высокое Заволжье) // Ученые записки Казанского университета. Серия естественные науки. Т. 162, №1. С. 134-150. https://doi.org/10.26907/2542-064X.2020.1.134-150
5. Заславская М.Б., Ерина О.Н., Ефимова Л.Е. Сопоставление эффективности параметризации качества речных вод различными методами в условиях значительного антропогенного воздействия // География и природные ресурсы. 2019, Т. 40, №2. С. 122-128. https://doi.org/10.1134/S1875372819020045
6. Иванова А.В. Динамика миграции антропогенных примесей в малых реках Нижневартовского Района // Siberian Journal of Life Sciences and Agriculture. 2020. Т. 12, №1. С. 84-91. https://doi.org/10.12731/2658-6649-2020-12-1-84-91
7. Кириллова Т.В., Котовщиков А.В. Пигментные критерии как показатели экологического состояния реки Чумыш в районе города Заринска // Мир науки, культуры, образования. 2010. Т. 6-1, №25. С. 248-252.
8. Организация и проведение режимных наблюдений за состоянием и загрязнением поверхностных вод суши, 2011. URL: http://www.pfo.meteorf.ru/assets/files/771/rd%2052.24.309-2011.pdf
9. Оценка токсичности донных отложений реки Чумыш с использованием Allium-теста / Чернышева Н.Н., Хлебова Л.П., Горянинова О.С., Крайнов А.П. // Вестник Алтайского государственного аграрного университета. 2016. Т. 9. С. 39-45. https://www.asau.ru/files/vestnik/2016/9/039-045.pdf
10. РД 52.24.643-2002 Методические указания. Метод комплексной оценки степени загрязненности поверхностных вод по гидрохимическим показателям, 2002. URL: https://docs.cntd.ru/document/1200039667
11. Фрумин Г.Т., Фетисова Ю.А. Альтернативный подход к оценке качества вод трансграничных водных объектов // Ученые записки Российского государственного гидрометеорологического университета. 2018. №50. С.

177-186. https://readera.org/alternativnyj-podhod-k-ocenke-kachestva-vod-transgranichnyh-vodnyh-obektov-140228947

12. Химия воды, н.д. URL: https://wwtec.ru/index.php?id=218
13. Шутова К.О., Оценка состояния объектов природной среды Алтайского края поданным сети наблюдений Росгидромета // Ползуновский вестник. 2006. №2-1, С. 392-395. https://studylib.ru/doc/2108575/ocenka-sostoyaniya-obektov-prirodnoj-sredy-altajskogo-kraya-po
14. Ahsan W. A., Ahmad H. R., Farooqi Z. U. R., Sabir M., Ayub M. A., Rizwan M., Ilic P. Surface water quality assessment of Skardu springs using Water Quality Index // Environmental Science and Pollution Research, 2021, no. 28, pp. 20537–20548. https://doi.org/10.1007/s11356-020-11818-5
15. Aziz H. A., Abu Amr S. S., Hung Y. T. Surface water quality and analysis. In: Wang, L. K., Wang, M. H. S., Hung, Y. T., Shammas, N. K. (eds) Integrated natural resources management. Handbook of environmental engineering. 2021, vol. 20. Springer, Cham. https://doi.org/10.1007/978-3-030-55172-8_3
16. Babayan G., Reshetnyak O., Zakrutkin V. A. Comparative assessment of river water quality in mountain regions of Russia and Armenia // Water Resources. 2021, vol. 48, no. 1, pp. 102-110. https://doi.org/10.1134/S0097807821010115
17. Chugai A., Safranov T. Assessment of technogenic loading on the surface water bodies of the separate regions of the North-Western Black Sea // Journal of Ecological Engineering. 2020, vol. 21, no. 5, pp. 197-201. https://doi.org/10.12911/22998993/122672
18. Feroz S., Siyabi S., Mohammed N., Eltayeb M. Assessment of ground and surface water quality and its contamination // International Journal of Environmental Analytical Chemistry. 2021, (published online). https://doi.org/:10.1080/03067319.2021.1873975
19. Islam M., Nasrin T., Islam M. Determination of surface water quality for irrigation in Dinajpur // Turkish Journal of Agriculture - Food Science and Technology. 2021, vol. 9, no. 10, pp. 1782-1791. https://doi.org/10.24925/turjaf.v9i10.1782-1791.4208
20. Vorobiev E. V., Usova E. V., Orkhova Y. V. Analysis of Sources of Anthropogenic Pollution of the Transboundary River, the Serevsky Donets, Based on the Dynamics of the Anion Composition (Nitrites, Nitrates, Sulfates, Chlorides, Phosphates) in 2007-2016 // IOP Conference Series: Earth and Environmental Science. 2021, vol. 720, no. 1, 012059. https://doi.org/10.1088/1755-1315/720/1/012059
21. Yurova Y., Shirokova V. Geoecological assessment of anthropogenic impacts on the Osetr River basin // Geosciences (Switzerland). 2020, vol. 10, no. 4, 121. https://doi.org/10.3390/geosciences10040121

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Поступила 26.01.2022 Received 26.01.2022
После рецензирования 10.02.2022 Revised 10.02.2022
Принята 28.02.2022 Accepted 28.02.2022