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Dynamics of anthropogenic pollution of the Glubokaya River in the Rostov Region

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Introduction. The article deals with the problems of deterioration of water quality in rivers in the Rostov region, their shallowing and drying out. The degradation of reservoirs is associated with various aspects of economic and industrial anthropogenic activities. The degree of influence depends on the intensity of the negative impact, and can be reduced if environmental measures are implemented.

Problem Statement. The objective of this study is to monitor the water quality of the Glubokaya River in the Rostov region on different sections of the river and to assess the degree of anthropogenic impact.

Theoretical Part. Water quality studies were carried out in three channels of the Glubokaya River on the territory of the cities of Millerovo and Kamensk-Shakhtinsk, as well as near them. The content of ammonia, phosphorus was determined by spectrophotometric analysis methods and petroleum products by IR photometric analysis method. The results of the study of water quality in the reservoir are compared with the normative values for three years with a certain periodicity.

Conclusions. The results of the studies on changes in the chemical composition of water at various sites in dynamics, taking into account the degree of anthropogenic load, are analyzed.

Keywords: chemical composition, pollution of water bodies, anthropogenic impact.

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Introduction. The Rostov region belongs to the industrially developed regions. Many local large enterprises are engaged in aviation and mechanical engineering, housing-and-municipal services and agriculture, produce chemical products and construction materials. The activities of such companies have a negative impact on the environmental situation. We are talking about air and water pollution, outdated approaches to the disposal of production and consumption waste, degradation of soil cover, frequent cases of dangerous burning of dry vegetation. The improvement of the state of the environment (including reservoirs recovery) is possible only with an integrated approach to solving environmental problems.

Almost all reservoirs of the Rostov region are exposed to anthropogenic impact of varying degrees of intensity. The results of long-term monitoring of river pollution indicate that wastewater discharges from enterprises, as well as surface runoff, including agricultural land and livestock complexes, are particularly harmful[1]. In recent years, there has been a constant deterioration of water quality in the rivers of the Rostov region, their shallowing and drying up. Possible causes are climate change [1] and an increase in anthropogenic load.

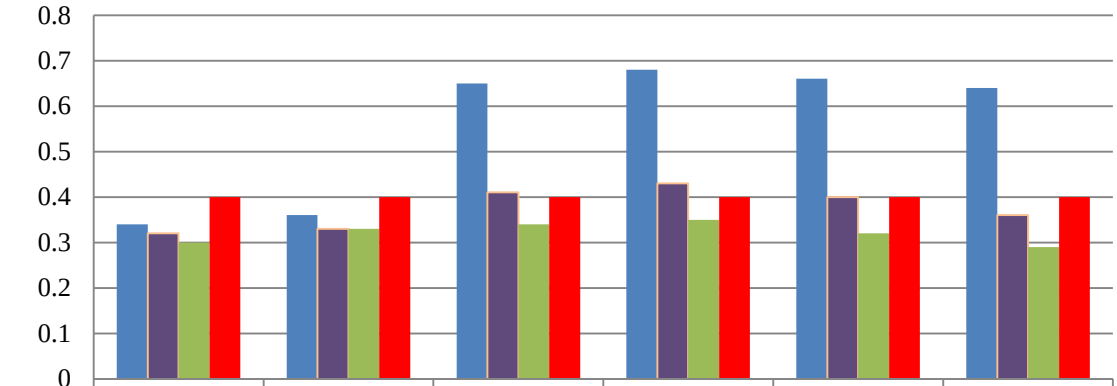
Problem Statement. Within the framework of the presented work, the state of the Glubokaya River on the territory of the cities of the Rostov region Millerovo and Kamensk-Shakhtinsky, as well as in their vicinity, was studied. The dynamics of changes in water quality for three years has been recorded. The main sources of negative impact on the

[1] Water Cadastre of the Russian Federation. Surface and groundwater resources, their use in quality. Federal Service for Hydrometeorology and Environmental Monitoring. Saint Petersburg, 2016. p. 163. (In Russ.).

reservoir are listed, taking into account the quantitative and qualitative characteristics of pollutants in different sections of the river.

Theoretical Part. The object of the study is the water quality of the Glubokaya River in the Rostov region. The samples were taken in 2019-2021 according to GOST 31861-2012[2] to determine hydrochemical parameters and chemical composition of water. Observation of changes in the quantitative and qualitative characteristics of pollutants entering the reservoir was compared with possible causes of anthropogenic impact.

For three years, during warm periods, water quality monitoring was carried out on three sections of the river. The content of ammonia and phosphorus was determined by spectrophotometric analysis methods, petroleum products — using infrared (IR) photometry using special techniques [3, 4, 5]. As part of the research, expeditionary water sampling was carried out six times a year. Information has been collected on all factors affecting water quality. The content of pollutants was determined experimentally [2] (Fig. 1-8). Here and further, the unit of measurement of concentration and maximum permissible concentration (MPC) is milligrams per cubic decimeter.



	April	May	June	August	September	October
2019	0.34	0.36	0.65	0.68	0.66	0.64
2020	0.32	0.33	0.41	0.43	0.40	0.36
2021	0.30	0.33	0.34	0.35	0.32	0.29
MPC	0.4	0.4	0.4	0.4	0.4	0.4

Fig. 1. NH_4 concentration in the Glubokaya River above Millerovo

The studies have shown that the main pollutants of the Glubokaya River are nitrate nitrogen, phosphorus and petroleum products. Figure 1 shows the annual concentration of ammonium compounds in the Glubokaya River above Millerovo.

From June to October, there was a significant excess of ammonium nitrogen. This can be explained by:

— the influence of agricultural activity (the effluence of dissolved mineral fertilizers from storm drains)

— the decrease in the volume of water in the driest periods.

In April 2019, 43 mm of precipitation fell, which was 108 % of the norm, in May — 77 mm (164 % of the norm)[6, 7, 8]. Table 1 shows the average temperatures.

[2] GOST 31861-2012. Water. General requirements for sampling. Federal Agency for Technical Regulation and Metrology. Moscow, 2019. p. 2–14. (In Russ.).
[3] RD 52.24.383-2018. Mass concentration of ammonium nitrogen in the waters. Photometric measurement method in the form of indophenol blue. Federal Service for Hydrometeorology and Environmental Monitoring. Rostov-on-Don, 2018. p. 18–25. (In Russ.).
[4] RD 52.24.382-2019. Mass concentration of phosphate phosphorus in the waters. Measurement method by photometric method. Federal Service for Hydrometeorology and Environmental Monitoring. Rostov-on-Don, 2019. p. 10–13. (In Russ.).
[5] RD 52.24.476-2007. Mass concentration of petroleum products in the waters. The method of performing measurements by the IR photometric method. Federal Service for Hydrometeorology and Environmental Monitoring. Rostov-on-Don, 2007. p. 13–17. (In Russ.).
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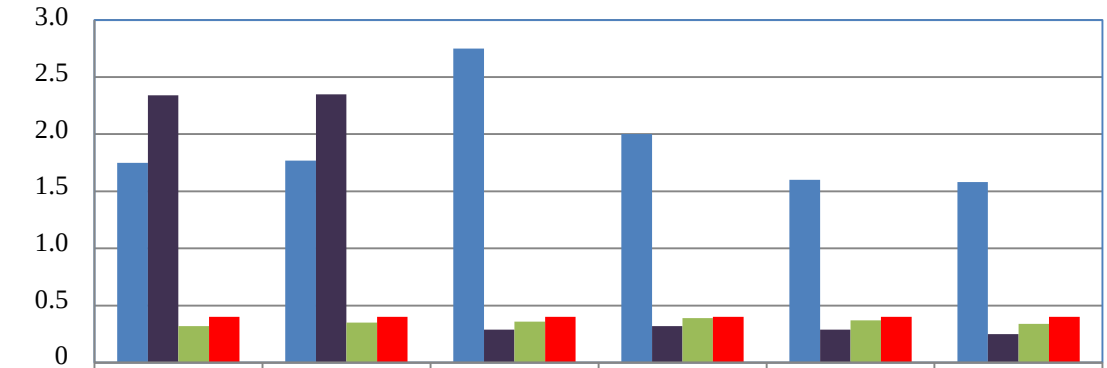
[7] idem. 2020 year.
[8] idem. 2021 year.

Table 1

Average temperatures in 2019-2021, °C

Month	0.5 km above Millerovo	0.5 km below Millerovo	Within the boundaries of Kamensk-Shakhtinsky
2019			
April	10.6	14.1	13.0
May	22.3	24.6	22.5
June	24.2	18.9	24.6
August	23.8	25.0	24.9
September	19.5	20.2	20.0
October	12.9	13.1	13.4
2020			
April	16.2	13.3	16.9
May	26.4	25.5	26.2
June	27.8	28.2	27.4
August	26.5	20.0	25.6
September	19.5	18.2	19.1
October	12.7	10.7	15.2
2021			
April	8.6	7.7	7.9
May	21.0	24.1	21.8
June	21.6	17.6	20.1
August	24.6	23.5	25.8
September	16.4	16.7	17.8
October	5.2	5.9	6.8

Fig. 2. shows data on the content of ammonium compounds in the water downstream

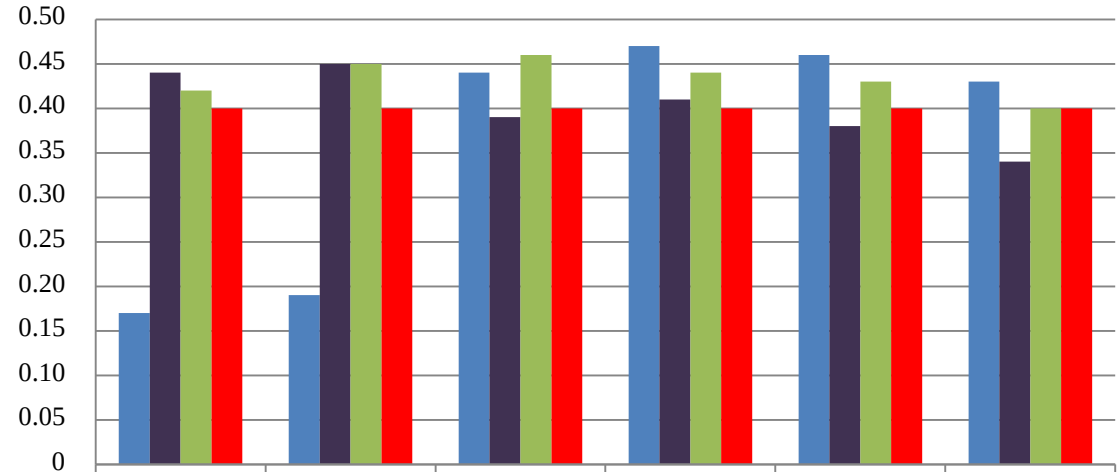


	April	May	June	August	September	October
2019	1.75	1.77	2.75	2.0	1.6	1.58
2020	2.34	2.35	0.29	0.32	0.29	0.25
2021	0.32	0.35	0.36	0.39	0.37	0.34
MPC	0.4	0.4	0.4	0.4	0.4	0.4

Fig. 2. NH_4 concentration in the Glubokaya River below Millerovo

In this case, a multiple increase in the content of ammonium compounds is obvious. Abnormal concentrations were recorded in 2019. This is due to the production activity of local companies. The largest objects affecting the environment are the Millerovo glucose-maltose plant and the Vodokanal (water services company). In 2020 and 2021, the intensity of the negative impact on the river decreased due to the shutdown of the enterprises.

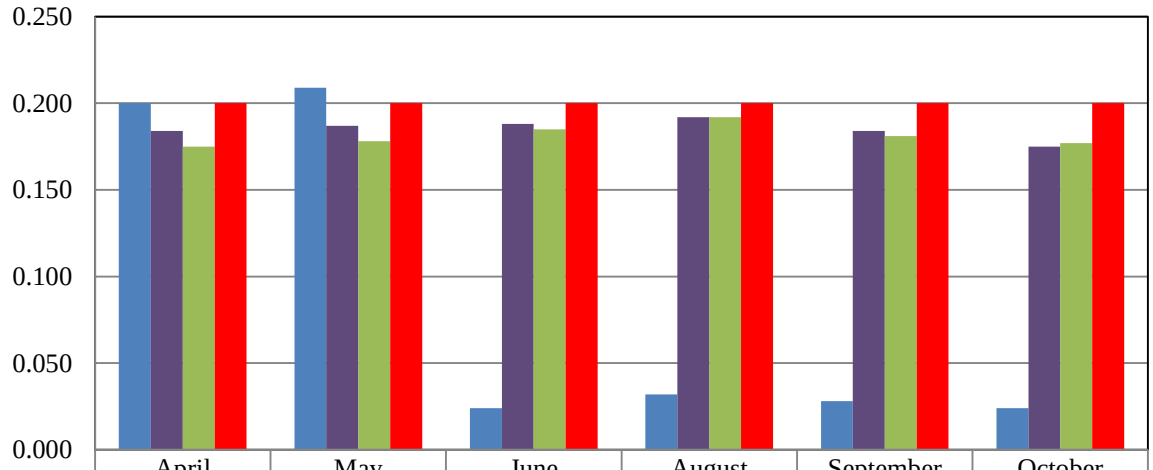
Fig. 3 shows the monitoring data of the Glubokaya River in the area of Kamensk-Shakhtinsky, located 90 km downstream. There was a slight decrease in the concentration of ammonium compounds due to the mechanism of self-purification of the reservoir.



	April	May	June	August	September	October
2019	0.17	0.19	0.44	0.47	0.46	0.43
2020	0.44	0.45	0.39	0.41	0.38	0.34
2021	0.42	0.45	0.46	0.44	0.43	0.40
MPC	0.4	0.4	0.4	0.4	0.4	0.4

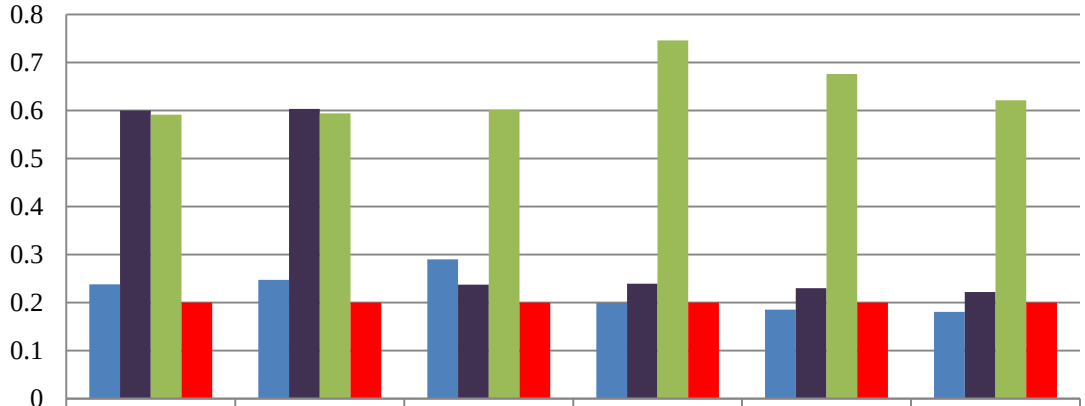
Fig. 3. NH_4 concentration in the Glubokaya River near Kamensk-Shakhtinsky

Figures 4-6 show the dynamics of phosphate concentration in the Glubokaya River during the year.



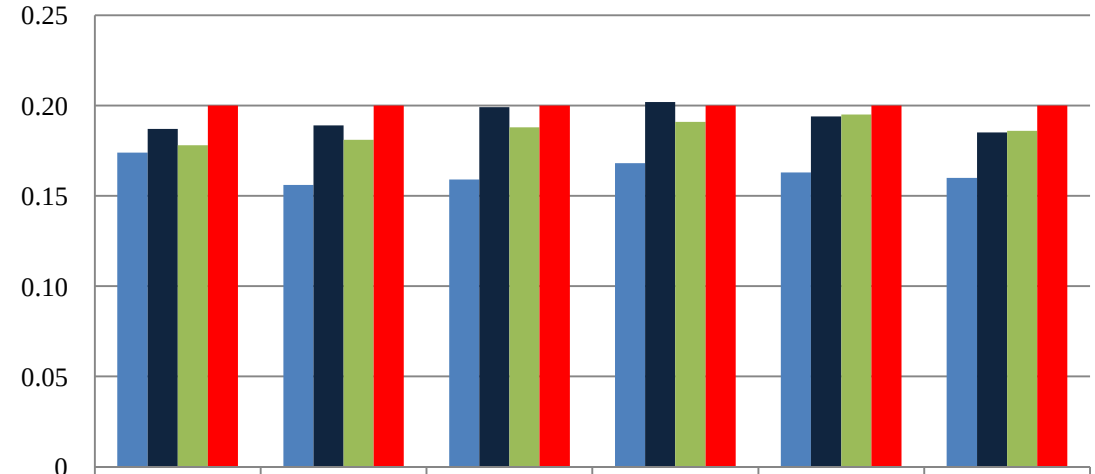
	April	May	June	August	September	October
2019	0.200	0.209	0.024	0.032	0.028	0.024
2020	0.184	0.187	0.188	0.192	0.184	0.175
2021	0.175	0.178	0.185	0.192	0.181	0.177
MPC	0.2	0.2	0.2	0.2	0.2	0.2

Fig. 4. PO_4 concentration in the Glubokaya River above Millerovo



	April	May	June	August	September	October
2019	0.238	0.247	0.29	0.199	0.185	0.181
2020	0.600	0.603	0.237	0.239	0.230	0.222
2021	0.591	0.594	0.601	0.746	0.676	0.621
MPC	0.2	0.2	0.2	0.2	0.2	0.2

Fig. 5. PO_4 concentration in the Glubokaya River below Millerovo

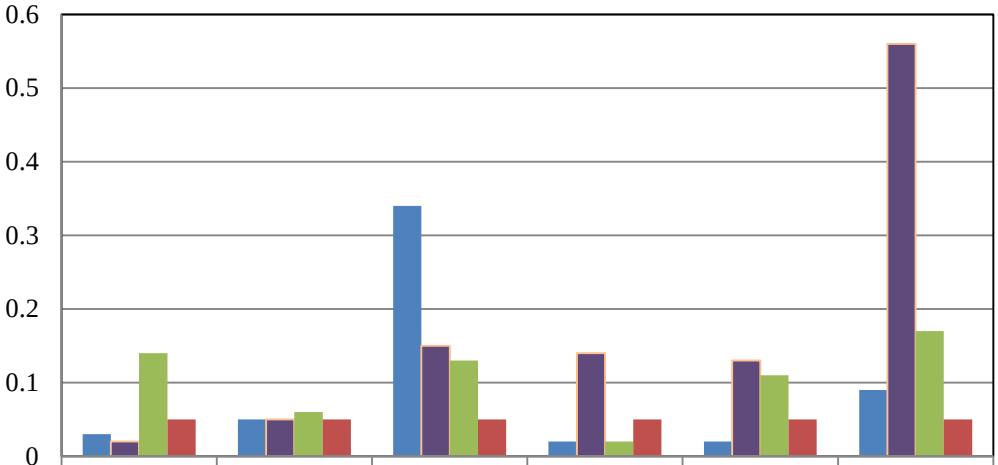


	April	May	June	August	September	October
2019	0.174	0.156	0.159	0.168	0.163	0.16
2020	0.187	0.189	0.199	0.202	0.194	0.185
2021	0.178	0.181	0.188	0.191	0.195	0.186
MPC	0.2	0.2	0.2	0.2	0.2	0.2

Fig. 6. PO_4 concentration in the Glubokaya River near Kamensk-Shakhtinsky

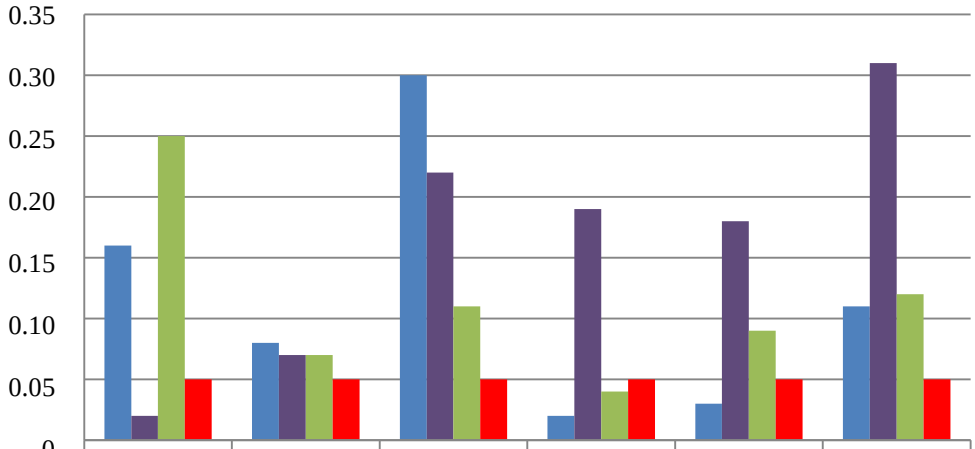
Monitoring data allow us to conclude about the adverse impact on the river of enterprises and the urban ecosystem of Millerovo. The greatest excess of phosphate concentration was recorded in 2021 in the water downstream of the city.

Figures 7-9 show the results of determining the dynamics of the content of petroleum products.



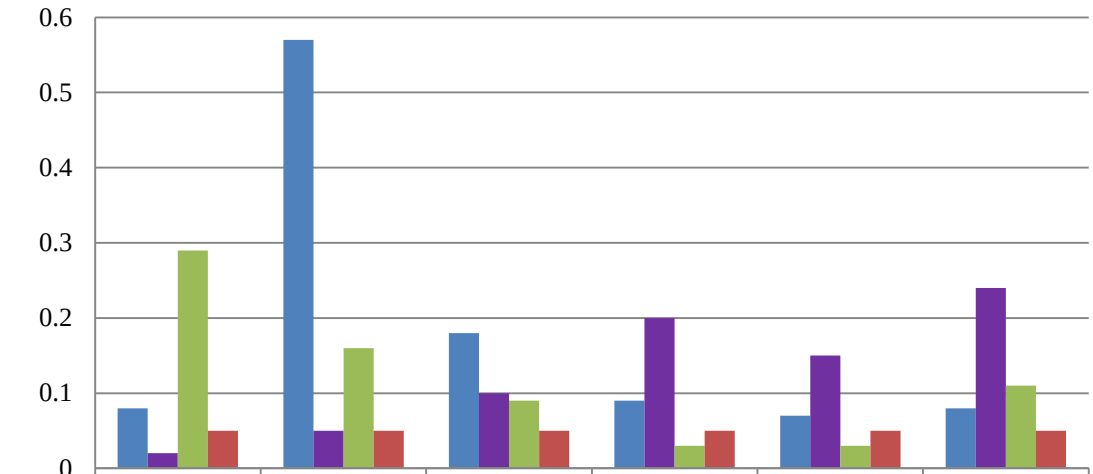
	April	May	June	August	September	October
2019	0.03	0.05	0.34	0.02	0.02	0.09
2020	0.02	0.05	0.15	0.14	0.13	0.56
2021	0.14	0.06	0.13	0.02	0.11	0.17
MPC	0.05	0.05	0.05	0.05	0.05	0.05

Fig. 7. Concentration of petroleum products in the Glubokaya River above Millerovo



	April	May	June	August	September	October
2019	0.16	0.08	0.30	0.02	0.03	0.11
2020	0.02	0.07	0.22	0.19	0.18	0.31
2021	0.25	0.07	0.11	0.04	0.09	0.12
MPC	0.05	0.05	0.05	0.05	0.05	0.05

Fig. 8. Concentration of petroleum products in the Glubokaya River below Millerovo



	April	May	June	August	September	October
2019	0.08	0.57	0.18	0.09	0.07	0.08
2020	0.02	0.05	0.10	0.20	0.15	0.24
2021	0.29	0.16	0.09	0.03	0.03	0.11
MPC	0.05	0.05	0.05	0.05	0.05	0.05

Fig. 9. Concentration of petroleum products of the Glubokaya River in Kamensk-Shakhtinsky

Oil pollution occurs at any time on all sections of the river. This allows us to talk about unauthorized discharges, for which both legal entities and individuals are responsible. According to statistics, petroleum products are the most common environmental pollutants. This is due to the wide range of compositions with petroleum products used in industry and in everyday life. The level of pollution decreased during the lockdown periods.

Table 2 summarizes the monitoring results, which make it possible to track the dynamics of the average annual indicators of river pollution in Millerovo.

Table 2

Dynamics of pollution indicators of the Glubokaya River in Millerovo (2019-2021), mg/dm^3

Indicator	**Year**			**MPC**
	2019	**2020**	**2021**	
O_2	7.43	7.16	7.81	4.0
ultimate BOD	3.37	3.27	3.30	2.0
NH_4	1.9	0.97	0.35	0.5 (0.4N)
NO_3	0.37	0.38	0.50	40 (9.0N)
NO_2	0.05	0.06	0.08	0.08 (0.02N)
Petroleum products	0.12	0.16	0.11	0.05
$Fe_{общ}$	0.52	0.61	0.65	0.1
PO_4	0.22	0.36	0.63	0.2
Ca^{2+}	201.2	321.6	301.9	180
Mg^{2+}	121.6	193.8	182.2	40.0
Na+K	480.8	163.8	222.4	120
SO_4	610.5	769.5	757.2	100
Cl	642.2	524.8	549.4	300
Mineralization	2572	2483	2511	1000

To assess the quality of the Glubokaya River on the territory of the Millerovsky and Kamensky districts, the specific combinatorial index of water pollution (SCIWP) was calculated and compared with the MPC.

Quantitative chemical analysis recorded an excess of MPC of sulfates, total iron, BOD_5, three forms of nitrogen, phosphates and petroleum products.

On average, SCIWP is within the 4th class of categories "A" and "B" with a rating of "dirty". The level of water pollution ranges from "dirty" to "very dirty".

According to the results of the study, it can be concluded that in 2019-2021 all indicators exceeded the maximum permissible values. This indicates a violation of clause 6 of Article 56 of the Water Code of the Russian Federation.[9].

The influence of industrial and municipal water intakes on river runoff is especially significant in the area of large cities [3]. The most serious sources of pollution of the Glubokaya River are municipal and industrial wastewater. The water quality is negatively affected by the glucose-maltose plant, the Vodokanal and other Millerovo enterprises.

According to the quality criteria, the condition of water bodies is determined, as well as the suitability of water for the habitat and development of commercial fish and organisms [4]. In the Rostov region, active silting of small riverbeds, the spread of woody and shrubby vegetation in them, the presence of numerous non-engineering structures were noted. All this leads to degradation of water resources and prevents their use as sources of water supply. The water-bearing capacity and fishery importance of reservoirs are decreasing. In addition, in most cases, silting and overgrowing of riverbeds prevents the trouble free passage of flood waters, which is fraught with flooding of the territories of 179 settlements of the Rostov region.

Conclusions. The analysis of the state of reservoirs of the Rostov region on the example of the Glubokaya River has confirmed the shortage of high-quality water resources. The discrepancy between the state of surface waters and the current standards has been revealed. This situation hinders the sustainable supply of drinking and industrial water to the territories.

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Contribution of the authors:

O. V. Dymnikova — scientific supervision, analysis of the research results, revision of the text, conclusions formulation; A. E. Borman — formulation of the main concept, goals and objectives of the study, calculations, text preparation.