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FEATURES OF THE HYDROLOGICAL AND HYDROCHEMICAL REGIMES OF THE CHIRCHIK RIVER UNDER CLIMATE CHANGE CONDITIONS

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Abstract: The article presents the results of research on the hydrological and hydrochemical regimes of the Chirchik river. This research is devoted to a scientific or practical problem, such as insufficient effectiveness of existing monitoring. Factual data on the concentration of pollutants, most often exceeding the maximum permissible concentrations, are presented. An analysis of the study of the spatial distribution of pollutants (PV) along the river length is presented, which allows for the identification of the most polluted areas. The dependence of the concentration of pollutants on the water content of the year was considered.

Key words: pollution, quality, water resources, anthropogenic factor, river, petroleum products, wastewater, industry, utilities, multi-water, water consumption.

Introduction. The problem of rational use of water resources and their protection from pollution is one of the pressing problems of our time.

The decree of the President of the Republic of Uzbekistan states: "The increase in the discharge of pollutants into water bodies leads to the pollution of open watercourses and, as a consequence, causes irreparable damage to aquatic flora and fauna, as well as affects public health"[1].

Currently, there is a need to assess and predict the quality of river water. Currently, there is a need to assess and predict the quality of river waters, and primarily transboundary rivers. This also applies to the transboundary Syrdarya River. The issues of protecting and sustainably using transboundary water resources of the river basin concern the interests of many people living in the region. This problem is especially relevant for regions with a tense water balance, where the development of an economic sector may be hindered not only by the quantitative but also by the qualitative depletion of water resources. Such regions include the Chirchik River basin. The Chirchik River with its tributaries enters the Syr Darya River basin and is its right-bank tributary.

After the Chirchik River flows into the Syr Darya River, the territory of the Republic of Kazakhstan begins after 90 km. Therefore, the Chirchik River's pollution can significantly affect the water quality in the lower reaches of the Syr Darya River.

Due to the intensive use of the Chirchik River basin's water resources for various purposes and the discharge of untreated or poorly treated wastewater into the river, the quality of both surface

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and groundwater is deteriorating over time. In some areas, the river water has become unsuitable not only for fish farming, which places stricter demands on water quality, but also for domestic and drinking water supply.

Object of research. The Chirchik River basin is located in the north-eastern part of the Republic of Uzbekistan. (Fig. 1). From a hydrological point of view, the river belongs to the most well-studied river basins of Central Asia.

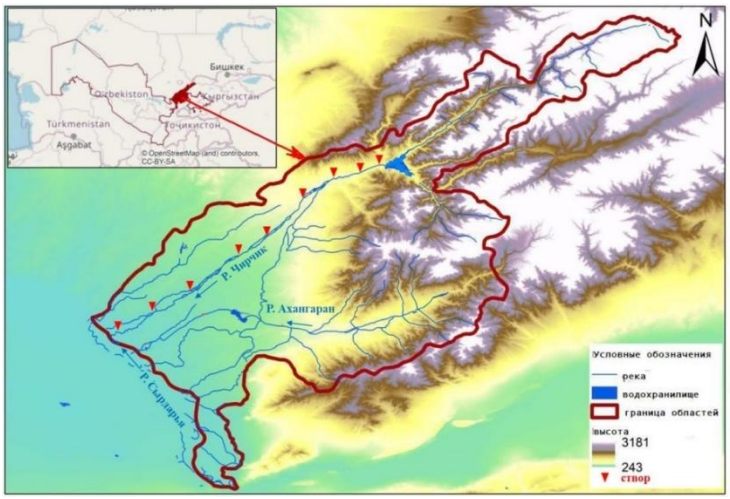

Fig-1. Location of the study object

The basin area of the river is 14900 km2, length -161 km [10]. The river flows through an area with intensive economic activity. Even in the drain formation zone, there are objects that are sources of pollution. The Chirchik River basin district is the largest industrial center of Uzbekistan. The main place in its complex economic complex is occupied by industry and agriculture. Here, almost all the republic's machine-building products serving cotton growing and the cotton processing industry are produced, and machines for the mining, chemical, food, and light industries are manufactured.

Multidisciplinary agriculture occupies an important place in the district's economy. The total area of irrigated land in the Tashkent region is 399.2 thousand hectares, which is 9.15% of the total area of the Republic. About 4 million people live in cities, more than 1 million in rural areas, the population density here is very high - about 200 people per 1 km2. The entire economy of the region is closely linked to the intensification of water use. The high degree of Chirchik River water use leads to its intensive pollution by wastewater discharges. In the prospective plans for the development of the sectors of the republic's economy, the issue of water source purity will be a primary problem as the basis of balance in the ecological situation of the basin [2].

Household wastewater, industrial wastewater, and agricultural wastewater have a significant impact on water quality. These factors have a noticeable impact on the nature of surface water pollution.

One of the significant sources of river water pollution is also the discharge of collector-drainage waters from numerous irrigated areas of the Tashkent region. Irrigated lands in the

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Tashkent region are mostly not saline, so the existing collector network can fully handle land leaching.

The most characteristic features of the climate of this territory are its continentality, as well as the abundance of heat throughout the growing season. In the foothills, an average of 435-514 mm of precipitation falls annually, while in the mountains it is 895 mm and more. In the plains, there is a shortage of moisture in most years. In summer, in July-August, there is practically no precipitation. Changes in Air Temperature and Precipitation Using the Tashkent Meteorological Station as an Example Meteorological observations have been conducted since the late 19th century. Figure 1 shows graphs of Tashkent GMS for as an example 2013-2023

Figure 1. Average long-term trend of average air temperature for 2013-2023

Changes in air temperature at this station are observed in a positive trend. Over 150 years, the average annual air temperature in Tashkent has increased by 1.2°C. During periods of warming, the amount of atmospheric precipitation has not undergone significant changes [12].

Subject of research. Study of the spatial (along the river) distribution of pollutants (PV). This is of greatest interest, as it allows us to identify the most polluted areas, hypothesize possible sources of pollution, and subsequently identify them, as well as propose measures for protection from pollution and cleaning.

Materials used. In this study, the results of ground data from Uzhydromet's hydrological posts and water quality observation points in the Tashkent region were used [4]

Research methods. The work used mathematical statistics, cartographic methods, and generalized methods for assessing the hydroecological state of the water body.

Main results and their discussions. To characterize the hydrological regime, we selected a series of observations of water flow at the Gazalkent hydropost from 1991 to 2021. The upper watershed of the Chirchik river mouth is outside the zone of anthropogenic influence and characterizes the natural regime of the river [11].

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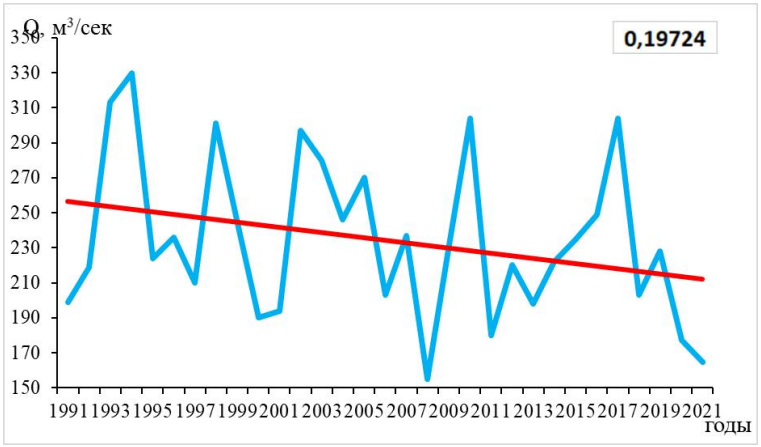

Figure 2 Chronological course of average annual water discharges of the Chirchik River for 1991-2021 (Gazalkent)

A negative trend is observed in the changes in average annual water discharges for the Chirchik River (Figure 2). During the period under study, the hydrological regime of the studied rivers was characterized as follows: low-water - 2008 and high-water - 1994, and medium-water - 2015.

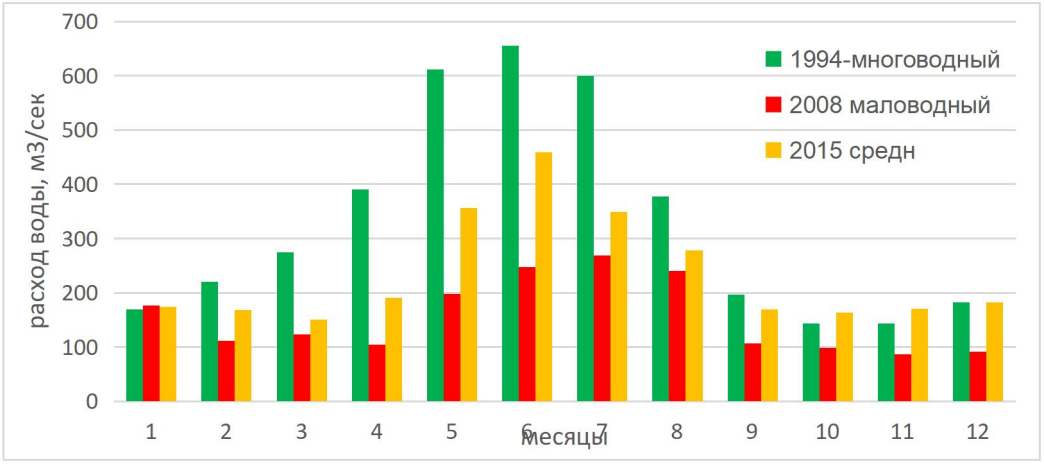

Fig. 3. Spatial change in nitrite concentration over the characteristic years in the Chirchik River

Analysis of the obtained data on the intra-annual distribution of water discharges showed that the Chirchik River floods occur in May-August. This depends on the type of river feeding. As the Chirchik River belongs to the snowy-glacial type of feeding, it is due to the peak flow during the summer months due to the melting of glaciers (see Figure 3).

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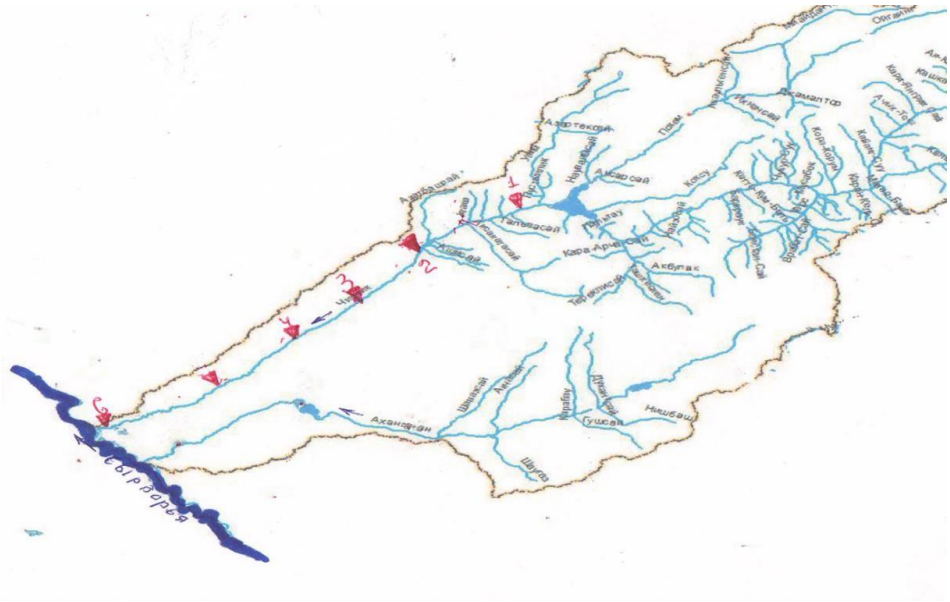

Fig. 4 Situational diagram of the Chirchik River with an indication of water quality monitoring points

To date, the state of surface water quality of the Chirchik River is assessed at 9 observation points of the Uzhydromet (see Figure 1), and for the study of water quality, we have selected 6 main channels on the Chirchik River from its upper reaches to the mouth

1. Gazalkent city - 0.3 km above Gazalkent city;
2. Chirchik city - 0.5 km below the city, 3.0 km below the "Maxam-Chirchik" JSC wastewater discharge;
3. Tashkent city - higher than the city;
4. Tashkent city - within the city limits, 3 km below the Sergeli industrial zone embankment;
5. Novomikhaylovka settlement, 1.6 km below the settlement;
6. Chinoz city - 3.5 km from the mouth (Figure 4).

Based on the results [2,7,8,9] and our own research, COD (chemical oxygen demand- an integral indicator of water quality characterizing the content of difficult-to-oxidize organic substances), BOC $_5$ (biological oxygen consumption over five days - an indicator characterizing the content of easily-oxidizing organic substances) were adopted as the main controlled indicators. In addition, the actual concentrations of petroleum products, from heavy metal ions - copper ions, nitrogen-containing pollutants of both industrial and organic origin (nitrates, nitrites, ammonia) were studied.

One of the important integral indicators characterizing the state of water quality is the biological oxygen consumption (BOC). By the magnitude of this indicator, one can judge the presence of easily oxidizing organic substances in water. However, throughout the entire Chirchik riverbed, the concentration of BOC and COD does not exceed the maximum permissible concentration (MPC). Figure 5 shows the distribution of average long-term BPK and CPK values along the length of the Chirchik River [4].

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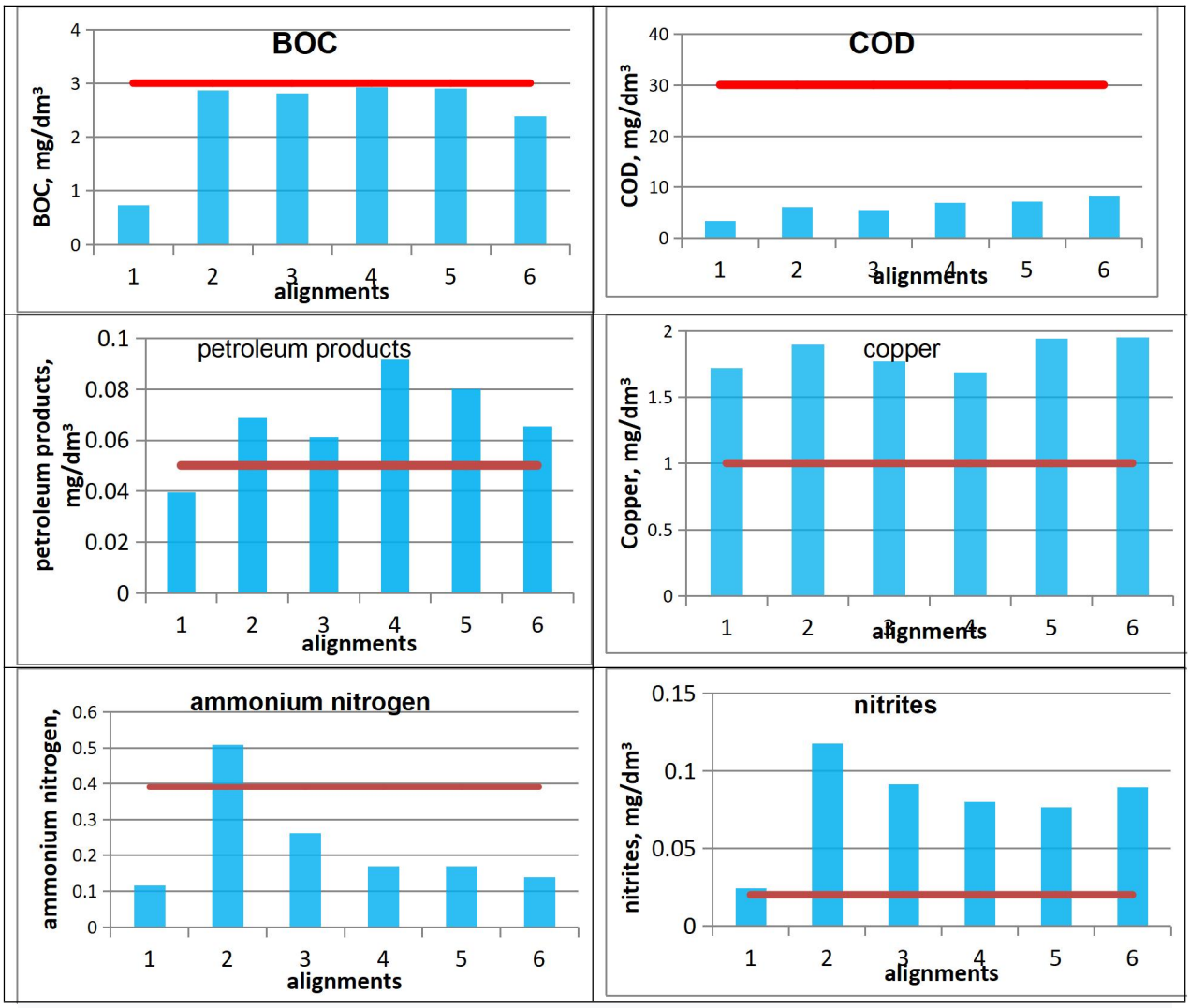

Fig. 5 Average long-term change in the concentration of pollutants along the Chirchik River

-концентрация ЗВ - MPC

It can be confidently stated that Chirchik and its industrial zone, as well as the territory of the city of Tashkent, have a strong influence on the quality of surface waters to increase the content of BOC and COD. Analyzing the visual information of the river from the "Maxam-Chirchik" JSC wastewater discharge point to the "Novomikhailovka" dam, the largest amount of easily oxidized organic matter enters the river.

Moreover, taking into account the peculiarities of economic activity in this section of the river, it can be assumed that the main sources of pollution by such organic substances are agriculture and communal-domestic services. The largest contribution to the pollution of the river with organic substances in this area is made by these two industries.

The change in oil product concentrations along the river's length shows that the most urbanized sections of the river contribute the most to surface water pollution. In Figure 5, the

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pollution zones are clearly distinguished. Moreover, the Tashkent city zone contributes the most to river water pollution. The trend of increasing oil product concentration from the "Maxam-Chirchik" dam to the "Chinaz" dam indicates insufficient reliable protection of the water source from this type of pollution.

The main sources of ammonium nitrogen in the Chirchik River basin appear to be concentrated in the upper reaches above the "Maxam Chirchik" JSC discharge - 0.51 mg/dm^3. Below this channel or such sources are absent or do not have any significant impact on water quality. For this very reason, the spatial distribution graph appears so flat, with a clearly expressed tendency to decrease concentration below the 2nd channel towards the mouth of the river (see Figure 5).

A high content of copper ions in a section, where it would seem that at least they should not be found in high concentrations (1.90 µg/dm3), may indicate either natural pollution or a non-specific source of copper ions entering surface waters. These may be either abandoned workings or tailings from old processing plants.

Regarding the sharp increase in the concentration of copper ions in section 2, this increase is apparently related to the discharge of industrial wastewater in this area, or to the old wastewater collectors containing high concentrations of copper ions in the industrial areas of Chirchik city, and their possible leaks, including filtration losses. If we consider the age of the deposits, the geology of the riverbed base, and the close relationship between the surface and underground tributaries of the Chirchik River, the appearance of increased concentrations of copper ions along the entire length of the river is not surprising.

Table 1

Limits of fluctuation of pollutants in the water of the Chirchik River (1991-2021)

Hydraulic solutions	COD		BOC		petroleum products		nitrites		copper	
	min	max	min	max	min	max	min	max	min	max
1	1,5	4,82	0,39	1,72	0,01	0,14	0,001	0,08	0,01	3,6
2	2,6	12,6	1,04	5,12	0,02	0,18	0,019	0,36	0,9	4,4
3	3,93	9,3	1,38	6,2	0,04	0,19	0,04	0,137	0,3	4,3
4	3,81	12,7	1,62	6,35	0,02	0,11	0,08	0,358	0,01	3,4
5	2,6	12,68	1,62	4,53	0,01	0,24	0,014	0,201	0,5	3,8
6	3,8	13,37	1,27	5,29	0,01	0,24	0,004	0,328	0,6	4,2
REM	15,0мг/дм3		3,0мг/дм3		0,02мг/дм3		0,02мг/дм3		1,0 мкг/дм3	

Along the river's length, a steady increase in nitrate nitrogen concentration is observed from the upper reaches to the mouth, and throughout the entire river, the nitrate nitrogen concentration does not exceed the REM [5].

Discussion. The constant increase in concentration from the upper reaches to the lower ones, starting from the city of Gazalkent towards the city of Tashkent, with all certainty, indicates a constant increase in the volume of pollutants containing nitrite forms of nitrogen-containing substances entering surface waters (Table 1).

Based on the analysis of changes in nitrite nitrogen concentrations in the surface waters of the Chirchik River, it can be said with a certain degree of certainty that the main sources of

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pollution by this form of nitrogen-containing pollutants are concentrated in the section of the river below the "Maxam-Chirchik" JSC discharge and above Tashkent city, and the increased nitrite content in the Chinoz channel may be caused by discharges of polluted wastewater.

Considering that the main source of such pollution in the conditions of the Chirchik River basin is wastewater containing fecal pollutants, it can be said that the protection of surface waters from untreated or poorly treated municipal wastewater is unsatisfactory.

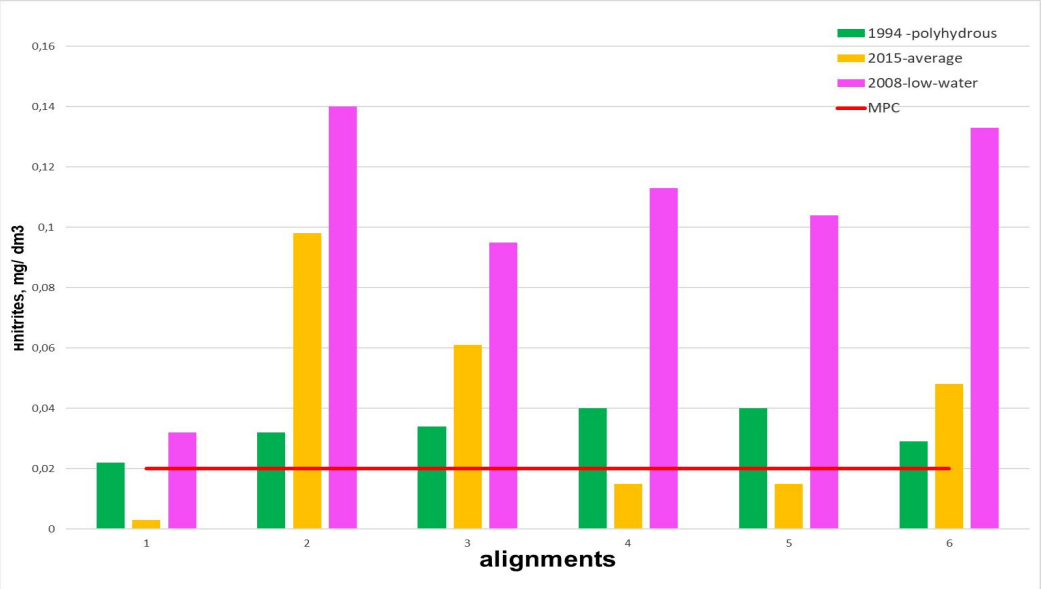

Fig. 6. Spatial change in nitrite concentration over characteristic years
(Chirchik River, Gazalkent gauging station)

In Figure 6, it was established that in high-water years, the nitrite concentration decreases (increase in REC 1.6 times), in medium-water years (increase in REC 4.9 times), and conversely, in low-water years, the concentration value increases (increase in REC 7 times). This indicates that under changing climate conditions, the river's sanitary condition depends on the year's water content. The lower the water content, the higher the concentration of pollutants. In order to maintain a favorable ecological situation and the required water quality in the lower reaches of the Chirchik River, special discharges of the minimum water volume along the riverbed are provided, which is called sanitary (ecological) discharge [6]

Conclusion.

1. The analyses we conducted allowed us to determine the list of pollutants (nitrites, petroleum products, and copper ions) that most often exceed the maximum permissible concentrations and have a dominant influence on the formation of surface water quality indicators in the Chirchik River.
2. Based on the results of the analysis of the spatial distribution of pollutants, it was possible to identify the most polluted areas (Chirchik, Tashkent, and Chinoz cities) and possible sources of pollution (wastewater discharge from the "Suv ta'minot" branch of the Chirchik Aeration Station, the Bektemir treatment plant, and the "Maxam-Chirchik" JSC treatment plant). These results allow for their further identification and, moreover, to propose measures for protection from pollution or cleaning.

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3. Water contaminated with untreated municipal and domestic wastewater can serve as a cause of infectious diseases and even their epidemics. In the mouth of the river, pond fishing is developed: in artificially created shallow water bodies, separated by temporary dams from the main channel of the Chirchik River. Pollution can cause significant damage to the fish population.

4. The banks of the Chirchik River are densely populated and, as our surveys have shown, have numerous restaurants, unauthorized quarries, cafes, and dacha buildings with small poultry and livestock farms. All household wastewater, including fecal wastewater, is discharged into the river without any treatment; of course, no account is taken of all these numerous discharges, and the water quality in the Chirchik River deteriorates from them, especially in terms of nitrogen-containing substances. The "Maxam-Chirchik" plant, Chirchik city's aeration station, and the Bektemir treatment plant, Salar aeration station have significant impact on their concentration.

5. It has been established that in high-water years, the nitrite concentration decreases, and conversely, in low-water years, the concentration value increases. This suggests that under changing climate conditions, the river's sanitary condition depends on the year's water content.

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