AVALIAÇÃO DO ESTADO DO RIO TOBOL NA SEÇÃO TRANSVERSAL DA CIDADE YALUTOROVSK

ASSESSMENT OF THE TOBOL RIVER STATE IN THE YALUTOROVSK CITY BACKGROUND

ОЦЕНКА СОСТОЯНИЯ РЕКИ ТОБОЛ В ФОНОВОМ СТВОРЕ Г. ЯЛУТОРОВСК

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RESUMO

Este trabalho aborda o problema do estado de leito do rio Tobol na seção transversal. Os estudos foram conduzidos em um laboratório credenciado especializado, com amostras obtidas em um local situado a uma distância de 426,5 km do estuário. Os estudos de monitoramento mostraram que o rio está poluído. O desenvolvimento de industrias e a expansão do setor agrícola nesta região podem levar a uma deterioração do rio Tobol. A esse respeito, é necessário dar mais atenção à minimização do impacto antropogênico sobre os recursos hídricos e conduzir estudos ambientais sistemáticos para a identificação oportuna de problemas ambientais e a gestão eficaz de riscos ambientais. Os resultados dos estudos realizados são aplicáveis ao realizar as observações futuras do estado do rio Tobol, a fim de determinar em tempo útil o estado qualitativo do rio e tomar medidas ambientais preventivas.

Palavras-chave: *avaliação, condição de fundo, água, substâncias nocivas, poluição fluvial.*

ABSTRACT

The article considers the problem of the background state of the Tobol River on the background section. The studies were conducted in a specialized accredited laboratory with sampling at an organized site at a distance of 426.5 km from the mouth. Monitoring studies have shown that the river is polluted. The development of industrial enterprises and the expansion of the agricultural sector in this region may lead to a deterioration of the Tobol River. In this regard, it is necessary to pay more attention to minimizing the anthropogenic impact on water resources and to conduct systematic environmental studies for the timely identification of environmental problems and effective environmental risk management. The results of the studies carried out are applicable when conducting follow-up observations of the state of the Tobol River in order to timely determine the qualitative state of the river and take preventive environmental measures.

Keywords: *assessment, background condition, water, harmful substances, river pollution.*

АННОТАЦИЯ

В статье рассмотрена проблема фонового состояния реки Тобол на фоновом створе. Исследования проводились в специализированной аккредитованной лаборатории с отбором образцов в организованном створе на расстоянии 426,5 км от устья. Мониторинговые исследования показали, что река является загрязненной. Развитие предприятий промышленности и расширение

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сельскохозяйственной отрасли в рассматриваемом регионе может привести к ухудшению состояния реки Тобол. В связи, с этим необходимо уделять большее внимание минимизации антропогенного воздействия на водные ресурсы и проводить систематические экологические исследования для своевременного выявления экологической проблемы и эффективного управления экологическим риском. Результаты проведенных исследований применимы при проведении последующих наблюдений за состоянием реки Тобол с целью своевременного определения качественного состояния реки и принятия превентивных экологических мер.

Ключевые слова: *оценка, фоновое состояние, вода, вредные вещества, загрязнение рек.*

INTRODUCTION

Water pollution is an actual problem of the modern world. The causes of pollution are the intensive development of industry (for the territory of Western Siberia oil and gas production and processing) and population growth, which leads to an increase in industrial and domestic wastewater. In some cities of Russia, the concentration of suspended solids, oil products, phenols, ammonium nitrogen, sulfates, and heavy metal salts in river water exceeds the MPC value by about 20 times (Rosa *et al.*, 2018). Oil and petroleum products are very dangerous because when they enter the water they form a film on its surface that prevents oxygen from entering (Medvedev and Medvedeva, 2013; Sivkov and Omelchuk, 2015). Oxygen starvation leads to the death of most aquatic organisms. This reason leads to a decrease in catches in the internal waters of the state.

An increase in population leads to the growth of cities and, as a consequence, an increase in the flow of municipal wastewater into water bodies. These drains are a source of infection of rivers and lakes by pathogens. A great contribution to water pollution is made by synthetic detergents, used both in everyday life and in industrial and agriculture. Chemicals contained in synthetic detergents enter the water bodies with sewage and lead to changes in the biological and physicochemical regimes of water bodies and streams. As a result, oxygen saturation decreases, the activity of bacteria capable of processing organic matter to the mineral component is paralyzed. (Valavanidis and Vlachogianni, 2011; Altayeva *et al.*, 2017; Yergobek *et al.*, 2018).

Industrial effluents contain more than 40% of mineral pollutants, which include salts, alkalis, acids, sand (clay) and other mineral substances and 60% of organic and biological pollutants (bacteria, viruses, fungi, algae). River pollution is largely the result of the discharge of untreated agricultural, stormwater and municipal wastewater. The deterioration of the quality of wastewater occurs due to an increase in the share of chemical production discharges. (Brown *et al.*, 2004; Bagul *et al.*, 2015; Pezzini *et al.*, 2016; Alves *et al.*, 2017).

To reduce contamination of wastewater with a small number of them, enterprises are limited to diluting effluent with river water. When diluting 1 m^3 of wastewater, 20 to 30 m^3 of pure natural water is necessary. In modern conditions with a huge amount of wastewater, dilution is not enough. The use of various methods of wastewater treatment can reduce the level of pollution by 80-95%. However, the cost of treatment facilities can reach up to 20% of the cost of construction of the enterprise itself. The solution to the problem of wastewater discharge is the transition of the enterprise to a closed cycle of water supply.

Large pollution of surface waters occurs in rural areas. It requires measures to clean them from impurities of dairies, meat processing plants, fish factories, depots, workshops, garages, warehouses of fuel and lubricants, fertilizers, pesticides, city and town sewers. Water pollution also comes from water transport, discharging waste oil and household waste.

In Russia, the assessment of the background state of surface waters is carried out in accordance with GOST 17.1.3.07-82 (USSR State Committee for Standards, 1982), which establishes general requirements for the monitoring network, sampling and processing the data obtained. The principles of organizing the monitoring of the state of surface waters are presented in Figure 1.

Rational use of water resources, as well as timely making, informed decisions on water use depends on timely receipt by management bodies of necessary information on the quantitative and qualitative characteristics of a water body, meteorological characteristics, pollution levels, etc. (Skvortsov, 1960).

The purpose of the article is to conduct studies on the background conditions of water in the Tobol River at a distance of 426.5 km from its mouth. So, as the Tobol River affects the territory of two states (the Russian Federation and the Republic of Kazakhstan), flowing along such water-consuming cities as Denisovka, Lisakovsk, Rudny, Kostanay, Kurgan, Yalutorovsk and Tobolsk (flowing along settlements with a total population of about one million people and flows into the key waterway of Western Siberia – the Irtysh River), the study of the background state of the water in the Tobol River and the implementation of measures for its improvement are relevant. Industrial enterprises using water for technological needs have a great influence on watercourses, directly in the production process, when washing equipment, etc.

MATERIALS AND METHODS

The Tobol River flows through the territory of two states – the Republic of Kazakhstan and the Russian Federation (Kurgan and Tyumen regions). Its length is 1591 km., The basin area is 426 thousand km2. The Tobol River belongs to the Irtysh River basin and is its left tributary. Several major tributaries flow into the Tobol, such as the Tura, Tavda, Iset, Ui (all left) and Ubagan (right).

Tobol is formed at the confluence of the Kokpektysay and Bozbiye rivers. The middle and lower course of the river runs within the West Siberian Plain in a wide valley with a winding bed. Tobol plain river. In the Tobol basin – about 20 thousand lakes with a total area of 9 thousand km2. The flow of the river is mainly snowy, and the proportion of rainwater increases downstream. The flooding period lasts from the first half of April to mid-June in the upper reaches and to the beginning of August in the lower reaches. In the flood Tobol is spreading heavily, flooding vast areas. Therefore, the river basin is replete with lakes (about 20 thousand). The average water flow in the upper reaches (898 km from the mouth) is 26.2 m^3 / s, at the mouth 805 m^3 / s (maximum is 348 m^3 / s and 6350 m^3 / s, respectively). It freezes in the lower reaches in late October – November, in the upper reaches in November. Ice weather is held until April-May.

The Tobol River is of high economic importance. Such industrial cities as Rudny, Kostanay, Lisakovsk, Kurgan, Yalutorovsk, Tobolsk are located on the river. To provide the mining enterprises of the Republic of Kazakhstan with water, as well as to adjust the water level in the upper reaches of the Tobol, several hydroelectric power plants were built, the construction of which resulted in the appearance of reservoirs (the largest Verkhnetobolskoye and Karatomarskoye). At 470 kilometers from the mouth of the Tobol, River navigation is carried out.

At the first stage of organizing observations of the quality of surface waters, the location of the control point is selected to carry out a set of works to obtain data on water quality. Control points are primarily organized on water bodies that are of great economic importance. Background observations are created on streams that are not polluted by sewage. To conduct background monitoring on the Tobol River, a background monitoring point was organized. Location identified at 426.5 kilometers from the mouth of the river.

The control point was located taking into account the existing use of the Tobol River for household needs and long-term plans for the development of the economy on the basis of reconnaissance studies, which included analysis of information on water users, sources of water pollution, discharges of pollutants during accidents, data on water regime (water, ice, thermal), physiographic signs and conducted preliminary surveys.

Samples were taken on the background section of the Tobol River, which is located at 426.5 km from the mouth, which is located downstream from the city of Yalutorovsk. A sampling of water was carried out in a glass container, before sampling, the washed vessels were rinsed twice with distilled water and then filled with water for analysis. Water samples were studied in a specialized accredited laboratory using laboratory equipment according to the following methods:

• determination of the concentration of sulfates and chlorides was carried out by ion chromatography using an ion chromatograph Metrohm 881 Compact 1C pro;

• total iron concentration in water was determined by using the method of atomic emission spectrometry in the ICP on the ICP spectrometer Varian 720-ES;

• the study of the nitrite content in water was carried out by the photometric method using a photoelectric concentration colorimeter KFK-3;

• phosphate concentration in water was determined by using the photometric method in a spectrophotometer Unico 2100;

• when determining the content of petroleum products and COD, a photometric method was used using the Fluorat-02-3M fluid analyzer;

• the study of the content of solids and suspended solids in water was carried out by a gravimetric method using laboratory electronic scales BP 221S and CPA 224S;

• $BOD_{complete}$ and dissolved oxygen in water were determined using the amperometric method using a multiparameter fluid analyzer InoLab Multi 9310.

It should be noted that the method of ion chromatography has proven itself in the studies of M. Neal, C. Neal, H. Wickham, and S. Harman (Neal *et al.*, 2007). The method of atomic emission spectrometry is noted as one of the main methods for determining the concentration of iron in the studies of J. Namieśnik and A. Rabajczyk (Namieśnik and Rabajczyk, 2010). The photometric method, implemented in spectrophotometers, has proven itself in the studies of S.Z. Salahova, Sh.A. Topchiyeva, I.Kh. Alakbarov and M. Ramazanov (Salahova *et al.*, 2017).

RESULTS AND DISCUSSION:

3.1. Results of analysis of water samples in the Tobol River

As a result of studies in the water of the Tobol River: sulfates and chlorides; phosphate and total iron; nitrite and oil products; dry residue and suspended matter; COD, $BOD_{complete}$ and dissolved oxygen.

The observations were carried out in the ice-free period from April to October 2016. Water during the entire observation period at the control solution had a weak alkaline reaction of the medium (pH = 7.6 ÷ 8.0).

The results of the analysis of the content of sulfates and chlorides in water samples are presented in Figure 2. The content of chlorides during the observation period was 2.2 and more times lower than the maximum permissible concentration (MPC in the water of drinking water and cultural-domestic water bodies is 350 mg / dm^3). The value of the sulfate content in water increases from spring to autumn and in September the peak value of this substance (142.7 mg / dm^3) is noted, which is 3.5 times lower than the MPC.

The data on the content of phosphates and iron in the river are presented in Figure 3. The content of phosphates during 2016 was below the MPC (3.5 mg / dm^3) 10.9 or more times. The iron concentration from May to August is below the MPC (300 mg / dm^3); in April, September and October, the MPC was exceeded by 1.6, 2.8 and 4.6 times, respectively, due to snowmelt and pollution due to effluent discharge by metallurgical plants of the Sverdlovsk and Chelyabinsk regions.

The dynamics of changes in the content of nitrites and petroleum products is shown in Figure 4. The concentration of nitrites is within the maximum permissible concentration (3.3 mg / dm^3). The value of petroleum products is also within the normal range (0.3 mg / dm^3).

The results of the analysis of the content of dry residue and suspended solids in the samples are shown in Figure 5. The amount of suspended solids during the observation period ranges from 9.8 to 44.8 mg / dm^3, and the dry residue content is from 221.7 to 685 mg / dm^3.

The dynamics of changes in COD, BOD and dissolved oxygen in the water of the Tobol River is shown in Figure 6. In water samples, the value of BOD ranges from 1.8 to 6.1 mg / dm^3. The COD value for four months out of seven exceeds the MPC (30 mg / dm^3), with the highest values set at the beginning and at the end of the observation period 43.8 and 39.5 mg / dm^3, respectively. The level of dissolved oxygen, the content of which in accordance with the regulations should not fall below 4 mg / dm^3, in August decreased to a value of 1.86 mg / dm^3. The above fluctuations can be associated with seasonal and daily changes depending on temperature, physiological and biological activity of microorganisms.

The results of the analysis of salinity in the water of the background section are presented in Table 1. Its value is within the normal range (1000 mg / dm^3). Thus, we can say that in the background section of the Tobol River there is an excess of MPC in three parameters.

3.2. Assessment of the dynamics of changes in the

concentration of harmful impurities in the Tobol River

The conducted studies allowed to assess the state of the water body and trace the dynamics of changes in concentrations of harmful impurities in the ice-free period.

PH in p. Within seven months from April to October, the Tobol changes slightly from 7.6 to 8.0 pH units. An almost neutral or slightly alkaline reaction of the environment is optimal for all aquatic inhabitants of the Tobol River. The harmlessness of such a reaction environment is confirmed by many domestic and foreign studies. O. N. Davydov and Yu. D. Temnikhanov (Davydov and Temnikhanov, 2004), as well as L. Ya. Kurovska and G. A. Strilko (Kurovska and Strilko, 2016) confirm that a pH in the range of 6.5–8.5 does not have a physiological effect on fish. The characteristic value was noted in other studies (Pryadko *et al.*, 2012).

An important component of ionic runoff and an indicator of the mineralization and genesis of natural waters are chloride ions. In rivers, the usual chloride content is from 20 to 30 mg / dm^3. When the content of chlorides is more than 350 mg / dm^3, the water acquires a salty taste, and at a concentration of from 500 to 1000 mg / dm^3 it adversely affects digestion (Afanasyeva et al., 2014). When the chloride content is more than 350 mg / dm^3, water consumption is limited. Our research has established that the concentration of chlorides during the entire observation period did not exceed 350 mg / dm^3, and the maximum value was observed in September and amounted to 154.2 mg / dm^3. The content of sulfates and phosphates in the Tobol River does not change in the qualitative composition of the water in the Tobol River, which is 3.5 and 10.9 times less than a multiyear average, respectively.

A low content of chlorides, sulfates, and phosphates can most likely be associated with a reduction in agricultural land, the elimination of agricultural enterprises and possibly a decrease in the flow of rivers over a long-term period. This opinion is also shared by T.V. Zhuldybina and V.A. Obyazov (Zhuldybina and Obyazov, 2015) in studies of the rivers of the Trans-Baikal Territory, and other scientists (Asaeda et al., 2009). Research M. Hunt, E. Herron and L. Green (Hunt *et al.*, 2012) found that the chloride content is much higher in water bodies located in areas with high residential and industrial buildings.

One of the informative indicators of the hydrochemical state of rivers is the total iron content. The iron concentration from May to August is below the MPC; in April, September and October, the maximum permissible concentration is 1.6, 2.8 and 4.6 times higher, respectively, which can be attributed to snowmelt and industrial discharges from metallurgical combines of the Sverdlovsk and Chelyabinsk regions, and also with receipt from city sewage. According to some researchers (Pryadko et al., 2012: Feng, 2005), the increase in iron occurs in the urban segment, especially in the period of intense precipitation. Research results (Kadhum et al., 2016) indicate that in samples of sedimentary rocks taken in the upper reaches of the river, metal concentrations were lower, and in sedimentary rocks in the middle and lower reaches of the river – higher.

The content of nitrites has a fairly pronounced seasonal dynamics, their greatest concentration is noted at the end of summer and is associated with the activity of phytoplankton. The value of the content of petroleum products within seven months varies slightly – from 0.009 to 0.013 mg / dm^3. At the same time, the values of nitrites and oil products during the entire observation period do not exceed the norm.

One of the indicators of water pollution is the amount of BOD. According to S.V. Svishcheva (2012), the BOD value directly depends on the number of heterotrophic bacteria, which in turn determine the degree of water pollution (Ukrainian Scientific Center for Water Protection, 1995). Thus, the BOD value is determined from the need for oxygen, which is necessary for the mineralization of unstable organic matter.

Natural waters have low BOD values ranging from 0.5 to 2 mg / dm^3 (Kholodnov et al., 2015). If their values increase, this indicates water pollution. In our water samples from the Tobol River, the BOD value during the observation period ranges from 1.8 to 6.1 mg / dm^3. An increase in the BOD value by the end of summer is associated with phytoplankton activity.

One of the main sanitary requirements of water quality is the content of oxygen in it, which affects the processes of self-purification (Gizatulina and Gizatulin, 2017). The oxygen content in water is significantly influenced by pollutants dissolved in water. Petroleum products have a particular impact on the oxygen content, which forms a film on the surface of the water and prevent gas exchange between water and the atmosphere, as well as reducing the degree of saturation of water with oxygen (Voloshina, 2006; Belyuchenko *et al.*, 2007).

In surface waters, the content of dissolved oxygen can vary from 0 to 14 mg/dm^3 and undergo significant seasonal and daily variations (Kholodnov et al., 2015). A decrease in the concentration of dissolved oxygen to 2 mg / dm^3 causes a massive death of aquatic organisms. The level of dissolved oxygen in the Tobol River, the content of which in accordance with the standards should not fall below 4 mg/dm^3 met the requirement, but in August it was noted to decrease to 1.86 mg/dm^3. The above reduction can be associated with seasonal and daily changes depending on temperature, physiological and biological activity of microorganisms.

Chemical oxygen consumption (COD) is the amount of oxygen equivalent to the amount of consumable oxidant needed to oxidize all reducing agents contained in water (Shubina and Zagorodnikova, 2009; RD 52.24.421-95). Our research has established that the COD value during the study period is almost within the normal range (30 mg / dm^3), only at the beginning of the summer period its value slightly decreases (1.2 times). The highest values were established at the beginning and at the end of the observation period of 43.8 and 39.5 mg / dm^3, respectively. The obtained dynamics of changes in the COD correlates with the results obtained by A. Tiwari, A.C. Dwivedi and P. Mayank (Tiwari *et al.*, 2016; Takashi *et al.*, 2009).

The amount of suspended substances for the observation period ranges from 9.8 to 44.8 mg/dm^3, and the solids content varies from 221.7 to 685 mg/dm^3. Such a value of these indicators can probably be attributed to snowmelt, industrial discharges from metallurgical plants of the Sverdlovsk and Chelyabinsk regions, as well as to the flow of urban wastewater.

The value of the mineralization parameter in the water of the background section during the entire observation period is within the normal range (1000 mg/dm^3).

CONCLUSIONS:

Consideration of the values of the content of harmful impurities in the water of the Tobol River confirmed the fact that the river is polluted and if water users do not follow water protection measures, its qualitative and quantitative characteristics will only deteriorate.

It should also be noted that due to the emerging development of industrial enterprises in the region and the growing number of agricultural enterprises with the use of additional agricultural land, the situation may turn out to be worse, therefore, it is necessary to pay great attention to minimizing the anthropogenic impact on water resources and conduct continuous environmental monitoring for the timely identification of environmental problems and effective environmental risk management.

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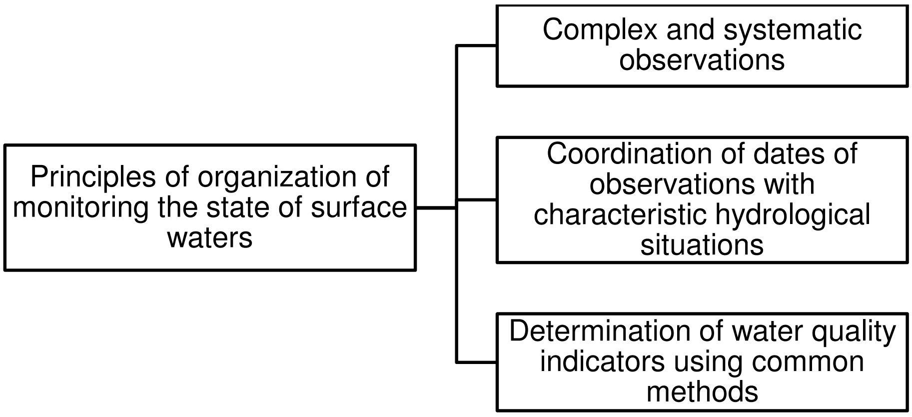

Figure 1*. Principles of organization of monitoring the state of surface waters*

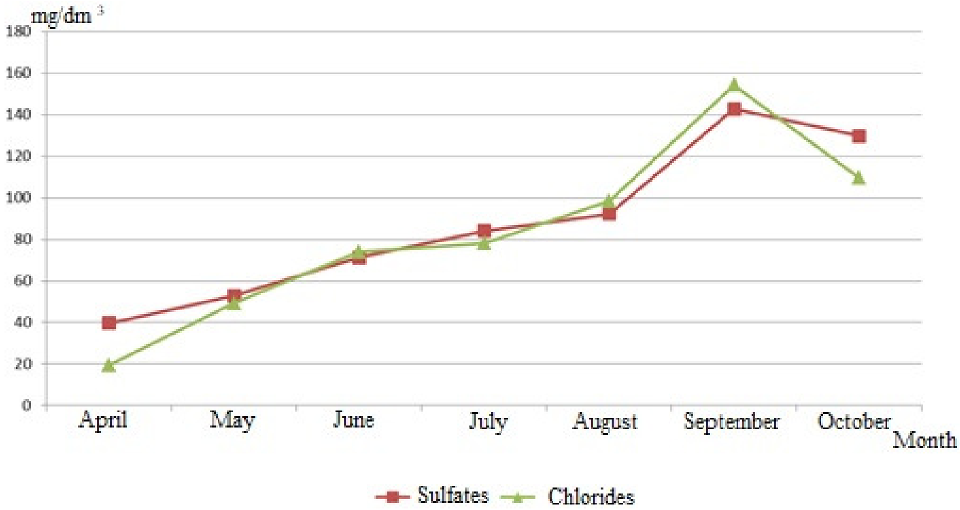

Figure 2*. Dynamics of changes in the content of sulfates and chlorides in the water of the Tobol River*

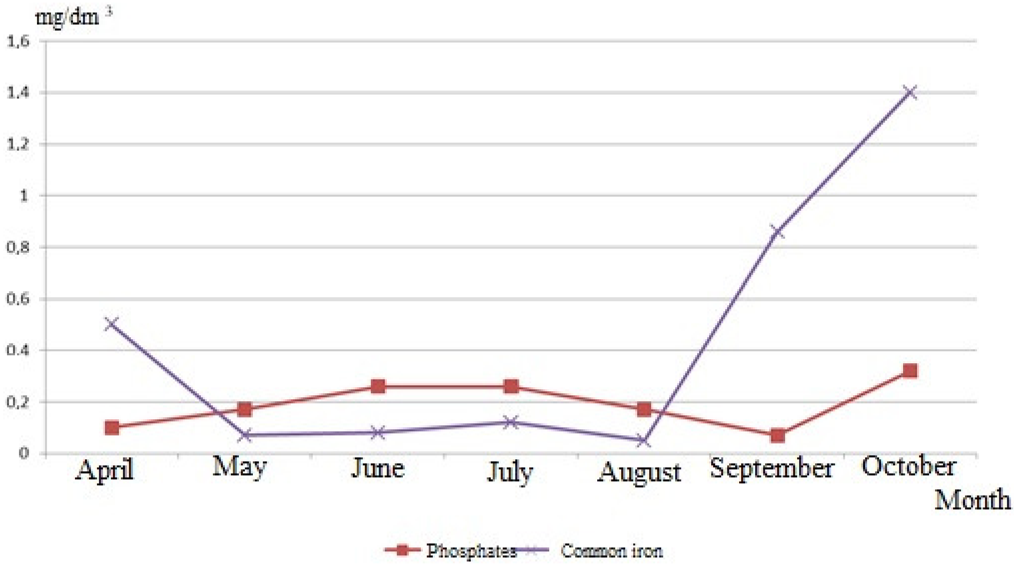

Figure 3*. Dynamics of changes in phosphate and total iron in the water of the Tobol River*

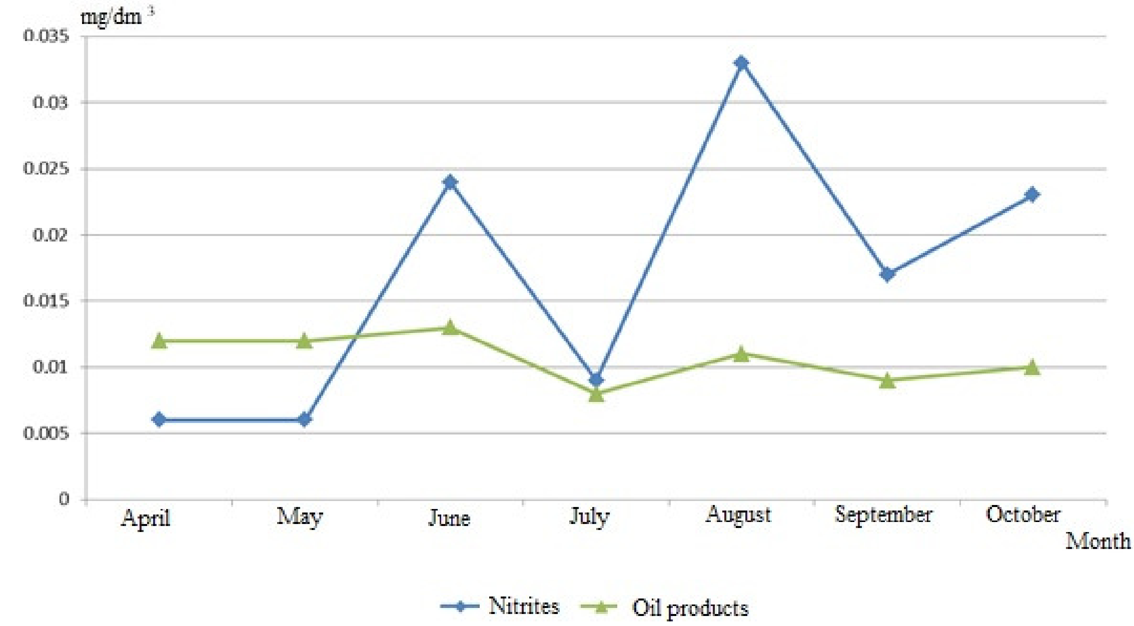

***Figure 4**. Dynamics of changes in the content of nitrites and oil products in the water of the Tobol River*

***Table 1**. Water salinity in the Tobol River*

Month	April	May	June	July	August	September	October
Mineralization, mg/dm^3	224.1	290.0	312.0	403.0	472.0	526.0	381.0