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FITOPLÂNCTON DE ÁGUAS DE SUPERFÍCIE SOB A POLUIÇÃO DE ÓLEO (CAMPO DE SAMOTLOR, SIBÉRIA OCIDENTAL)

PHYTOPLANKTON OF SURFACE WATERS UNDER OIL POLLUTION (SAMOTLOR FIELD, WESTERN SIBERIA)

ФИТОПЛАНКТОН ПОВЕРХНОСТНЫХ ВОД В УСЛОВИЯХ НЕФТЯНОГО ЗАГРЯЗНЕНИЯ (САМОТЛОРСКОЕ МЕСТОРОЖДЕНИЕ, ЗАПАДНАЯ СИБИРЬ)

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RESUMO

O estudo do fitoplâncton de água doce do campo de Samotlor está associado à intensa produção de petróleo e a relatórios fragmentados sobre o estado das comunidades de zonas úmidas no norte da Sibéria Ocidental. Os dados obtidos se expandem e complementam as informações sobre algas em condições extremas. O objetivo desta pesquisa foi estudar a estrutura do fitoplâncton de corpos d'água de alta latitude sob a poluição por óleo. O método de estudos químicos e analíticos em águas superficiais revelou um excesso de 2-62 vezes de MPCfw. Pela quantidade de nitrogênio amoniacal, os corpos hídricos estudados são classificados como poluídos e muito poluídos. A quantidade de sulfatos, nitratos e fosfatos em todas as amostras de água é inferior à do padrão MPCfw. Durante o exame microscópico, 88 algas de 48 gêneros, 29 famílias, 10 classes e 7 divisões foram encontradas. A base da composição florística é composta por Bacillariophyta, Euglenophyta e Chlorophyta. Uma espécie dominante (método de Kolbe-Visloukh) e sete subdomínios foram identificados. As algas de maior sucesso no plâncton perfazem 4,5%. A revisão analítica mostrou a predominância de algas planctônicas, que são indiferentes à salinidade e ao pH, cosmopolitas e βmesosapróbicas em termos de saprobidade. De acordo com os dados obtidos, foi identificado um desvio significativo dos parâmetros na composição química da água, bem como na estrutura, dominantes e abundância do fitoplâncton da norma regional. O fitoplâncton com poluição por óleo é pobre em composição, e um número significativo de grandes taxa com um pequeno número de espécies enfatiza a complexidade dos processos fluorogênicos nas águas do campo de Samotlor. Os materiais podem ser aplicados em um estudo abrangente de corpos de água, suas características tipológicas, na organização do monitoramento ambiental e no desenvolvimento de medidas para proteger os ecossistemas aquáticos da poluição e eutrofização.

Palavras-chave: *Fitoplâncton, composição de espécies, composição química da água, poluição da água, abundância, campo petrolífero de Samotlor.*

ABSTRACT

The study of freshwater phytoplankton of the Samotlor field is associated with intense oil production and fragmentary reports on the state of wetland communities in the north of Western Siberia. The obtained data expands and complements the information about algae in extreme conditions. The goal of this research is to study the structure of the phytoplankton of high-latitude water bodies under oil pollution. The method of chemical-analytical studies in surface waters revealed excess standards in 2-62 times. By the amount of ammonium nitrogen, the studied water bodies are classified as polluted and very polluted. The amount of sulfates, nitrates, and phosphates in all water samples is lower than the standard MPCfw. During the microscopic examination, 88 algae from 48 genera, 29 families, 10 classes and 7 divisions were found. The basis of the floristic composition consists of Bacillariophyta, Euglenophyta and Chlorophyta. One dominant species (Kolbe-Visloukh method) and seven subdominants were identified. The most successful algae in plankton make up 4.5%. The analytical review showed the predominance of planktonic algae, which are indifferent to salinity and pH, cosmopolitan and β-mesosaprobic in terms of saprobity. According to the data obtained, a significant deviation of parameters in the chemical composition of water, as well as in the structure,

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dominants, and abundance of phytoplankton from the regional norm, was identified. Phytoplankton under oil pollution is poor in composition, and a significant number of large taxa with a small number of species emphasizes the complexity of the fluorogenic processes in the waters of the Samotlor field. The materials can be applied in a comprehensive study of water bodies, their typological characteristics, in the organization of environmental monitoring and the development of measures to protect aquatic ecosystems from pollution and eutrophication.

Keywords: *phytoplankton, species composition, water chemical composition, water pollution, abundance, Samotlor oil field.*

АННОТАЦИЯ

Изучение пресноводного фитопланктона Самотлорского месторождения связано с интенсивным процессом нефтедобычи и фрагментарными сводками о состояния водно-болотных сообществ в условиях севера Западной Сибири. Полученные данные расширяют и дополняют сведения о водорослях в экстремальных условиях. Целью исследования является изучение структуры фитопланктона высокоширотных водоемов в условиях нефтяного загрязнения. Методом химико-аналитических исследований в поверхностных водах выявлены превышения нормативов в 2–62 раза, по содержанию аммонийного азота исследуемые водные объекты отнесены к грязным и очень грязным, содержание сульфатов, нитратов и фосфатов во всех образцах воды ниже установленных значений ПДКрх. В ходе микроскопирования обнаружено 88 водорослей из 48 родов, 29 семейств, 10 классов и 7 отделов. Основу флористического состава составляют Bacillariophyta, Euglenophyta и Chlorophyta. Выявлен один доминирующий вид (метод Колбе – Вислоуха и семь субдоминантов. Наиболее преуспевающих водорослей в планктоне – 4,5% (Юрцев). Аналитический обзор показал преобладание планктонных водорослей, индифферентных по отношению к солености и pH среды, космополитнных в географическом отношении, бетамезосапробных в отношении сапробности. По полученным данным отмечено существенное отклонение параметров в химическом составе воды, а также в структуре, доминантах и обилии фитопланктона от региональной нормы. Фитопланктон в условиях нефтяного загрязнения характеризуется бедным составом, а значительное количество крупных таксонов с малым числом видов подчеркивает сложность флорогенетических процессов в водах Самотлорского месторождения. Материалы могут быть применены при комплексном исследовании водоемов, их типологической характеристике, при организации экологического мониторинга и разработке мер защиты водных экосистем от загрязнения и эвтрофирования.

Ключевые слова: *фитопланктон, видовой состав, химический состав воды, загрязнение воды, обилие, Самотлорское нефтяное месторождение.*

1. INTRODUCTION

Intense pollution and transformation of the environment make the study of the response of all ecosystem components to anthropogenic impact very important. Khanty-Mansiysk Autonomous Okrug – Yugra (KhMAO-Yugra) occupies a leading position among the subjects of the Russian Federation in oil production. During the development of an oil field using cluster drilling and its subsequent operation, the territory is contaminated with drilling waste. Micro-landscapes undergo negative changes during construction and operation of cluster sites as well.

The main sources of water pollution under oilfield operation include a number of pollutants: oil, petroleum products, drilling muds, sludge, formation water, etc. These substances are highly toxic and have a very negative impact on the diversity and number of organisms. Along with hydrocarbon pollutants, natural processes play a significant role in the pollution of the surface waters of KhMAO-Yugra. Surface precipitation and water flows carry into water bodies large volumes of allochthonous organic matter.

Samotlor oil field is one of the largest in Russia, located in the eastern part of the district (Nizhnevartovsk district), its area is 1,752 km^2. The territory belongs to the forest-swamp zone of Western Siberia, the middle taiga subzone. According to the landscape zoning of the Nizhnevartovsk district, the field is located in the Vakhovsk-Agansk province in the Nizhnevartovsk - Priobsk region (Middle Ob Region). Hummock-ridge and ridge-pool complexes make up 60–70% and in some places – up to 90% of the field.

The region is characterized by a continental type of climate, with average temperatures varying from minus 22 to minus 24°C in the coldest month of January and from plus 16 to plus 17°C in the hottest month of July. Under the conditions of the northern part of the West Siberian oil and gas province, it takes water bodies up to 10–12 years to self-purify from pollutants (Polozov, 2012).

Forest formations occupy a smaller area and are represented by species typical for the middle taiga subzone: *Pinus sylvestris L., Pinus sibirica Du Tour., Picea abies* (L.H. Karst. et al.). Common small-leaved tree species include *Betula pubescens* Ehr., *Populus tremula* L. and *Salix* L. (Lopatin *et al*., 2008).

Phytoplankton is an essential component of aquatic ecosystems that are actively involved in the formation of water quality and is a good biological indicator. The qualitative and quantitative changes occurring in phytoplankton under the influence of anthropogenic factors allow us to make an assessment of the state of the aquatic ecosystem and predict the biological consequences of such an impact. For the territory where the intense, long-term operation of a large oil field is carried out, this problem is extremely relevant. Algae are the primary link of trophic chains, creating a material basis for the further transformation of the substance and energy of water systems, and therefore, it is preferable to start the research of the negative effects produced by the oilfield with algae.

The goal of this research is to study the structure of phytoplankton in high-latitude water bodies under oil pollution.

2. MATERIALS AND METHODS

The environmental load in the Samotlor field is formed during the entire period of its development and is defined by the degree of influence of oilfield facilities on the environment. During the research, seven wetland oil-polluted sites located in the immediate vicinity of the sump rod-well pumps (clusters) were studied. All areas where research was carried out are mechanically deformed as a result of drilling, laying of clusters, exploitation, and recultivation. On the water surface traces of petroleum products are found.

43 samples of the autumn phytoplankton of 2015 served as the material for algological studies. Phytoplankton was sampled everywhere: ditches near the bunding of the clusters, large hollows, lakes, or shoreline. At the same time, the temperature of the water and pH activity (pHscan WP2) were measured, the color of the water was determined by eye, and samples were taken at five sites to determine its chemical composition. The bulk of chemical and analytical studies of water was carried out in the accredited testing laboratory of JSC SIC Yugraneftegaz.

In the selection of phytoplankton and its processing, classical methods were applied (Sadchikov, 2003). Algological material was collected by scooping from the surface layer of water, fixed with 40% formalin, concentrated by the sedimentary method, identified in water and permanent preparations prepared by enclosing their valves in Canada balsam. Diatom shells were cleaned of organic substances using the method of cold burning. The study was performed by the method of microscopy, using a Nikon ECLIPSE E200 and OLYMPUS SX41 light microscopes with 100 – 1000 magnification.

Species, intraspecific taxa, and taxa identified to the genus level were taken into account. When determining the species composition of the cyanoprokaryotic and algal communities, modern concepts regarding the nomenclature changes for algae were used (Guiry and Guiry, 2017; Komárek and Anagnostidis, 1998, 2005; Krammer and Lange-Bertalot, 1986, 1988, 1991). To determine the role of certain species in phytoplankton, the method of eye estimation of abundance was used, which was expressed in points on the Kolbe-Visloukh six-point scale (Stenina, 2009). Species with six points were recognized as dominants, four or five – as subdominants. Algae activity was assessed in %, depending on the frequency of occurrence in samples (active – found in 74-50% of samples, low-active (49-15%) and inactive (less than 15%) (Yurtsev, 1968). Ecological and geographical characteristics were determined using identification guides and floristic reports. The data on phytoplankton of wetlands of the Nizhnevartovsk region (Skorobogatova and Gidora, 2017; Skorobogatova, 2017) were used as background indicators.

3. RESULTS

At the first stage of the study, the chemical composition of water in several areas was studied. The results on the content of pollutants in the water samples taken at sites 1077, 163 and 1573 in the autumn of 2015 showed an excess of the MPCfw (Maximum Permissible Concentration of pollutants for fishery water use) for some indicators and vice versa (Table 1). dm^3

The study has shown that water is characterized by a neutral, slightly acidic or acidic medium reaction. Hydrogen index is closely connected with lithology and geological structure of river basins. Its change depends on the intensity of surface runoff, the soil structure in the area, as well as anthropogenic factors.

In all investigated samples, the content of sulfates, nitrates, and phosphates is below the established values of MPCfw. The natural sources of chlorides in natural waters are the processes of interaction of the atmosphere with soils, especially saline soils. Within the study area, the concentration of chlorides in water samples varied from 14.1 to 307.1 mg/dm^3. Standard MPCfw of Cl- is 300 mg/dm^3.

Sulfate concentrations in surface waters are subject to seasonal fluctuations and correlate with water mineralization. The sulfate content in the river and freshwater lakes ranges from 5–10 to 60 mg/dm^3. In water bodies in the plots, this index varies from 3.7 to 17.4 mg/dm^3. Standard MPCfw of SO_4^{2}– is 100 mg/dm^3.

Sources of biogenic substances are intrabasin processes, river runoff, precipitation, and human activity. The content of biogenic substances is associated with the creation and decomposition of organic matter in natural waters. Biogenic substances include nitrogen and phosphorus compounds. Inorganic nitrogen compounds are essential for plant life as nutrients. They are absorbed by plants in the process of photosynthesis. If the development of aquatic plants is intense, inorganic nitrogen can be completely removed from the water. In the studied water bodies the amount of nitrates varied from 1.4 to 4.1 mg/dm^3.

Ammonium nitrogen (ammonium salts NH_4^+) is an inorganic nitrogen-containing form, the source of which is the excretion of living aquatic organisms, biochemical degradation of organic matter after the death of aquatic organisms and domestic and industrial wastewater. According to this parameter, five classes of water quality are distinguished. According to the content of ammonium, the water bodies under study are classified as polluted (2.27 and 2.78 mg/dm^3) and very polluted water bodies (4.0 mg/dm^3) (MPCfw = 0.5 mg/dm^3) (Figure 1 – 3).

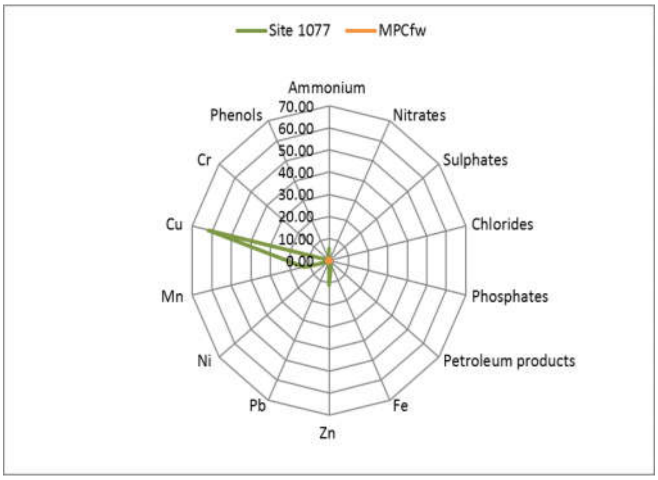

Figure 1. *Comparison of some substance concentrations in the water samples with MPCfw (Site 1077)*

Phenols and petroleum products are allochthonous organic substances found in surface waters in low concentrations. The amount of phenols in the surface water of water bodies of the license area is higher than MPCfw, and the average concentration is 0.0011 mg/dm^3.

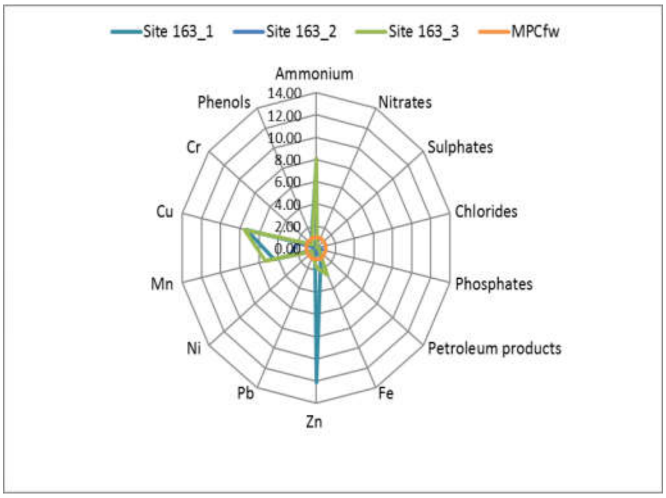

Figure 2. *Comparison of some substance concentrations in the water samples with MPCfw (Site 163)*

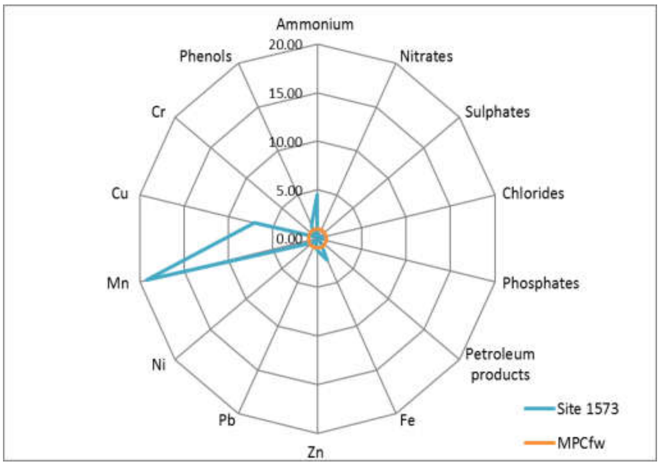

Figure 3. *Comparison of some substance concentrations in the water samples with MPCfw (Site 1573)*

Petroleum products in the natural waters of the study area in concentrations higher than MPCfw values (0.05 mg/dm^3) were not observed.

Heavy metals are primary pollutants, monitoring of which is mandatory in all environments. Metal ions are indispensable components of natural water bodies, depending on environmental conditions (pH, redox potential, the presence of ligands), they exist in different degrees of oxidation and are part of a variety of inorganic and organometallic compounds. Increased concentration of heavy metals in natural waters is often associated with acidification. Acid precipitation leads to a decrease in pH and the transition of metals from the sorbed state to the free state.

Surface waters are characterized by high concentrations of microelements. There are several reasons for this: high abundance percentage in drained rocks; solubility of many micro elements (including heavy metals). That is, surface waters provide conditions for creating high concentrations of microelements.

The concentration of Mn, Cu, Fe, and Zn in the surface water of the rivers of the study area varies widely. The amount of these metals in the studied water samples exceeds the MPCfw by 2–62 times (Figure 1–3). The amount of such heavy metals as Pb, Ni, Cr is not higher than the MPC in fishery waters.

The water of water bodies located throughout the region contains a large amount of biogenic iron. Being a biologically active element, iron, to a certain extent, influences the intensity of phytoplankton development and the qualitative composition of microflora in a water body. Iron is found in the amount of from 0.07 to 0.26 mg/dm^3 (MPCfw = 0.01 mg/dm^3). The high concentration of this element in some points is probably due to the natural and climatic conditions of Western Siberia and occurs as a result of flushing of humus-derived substances into the surface waters from the marshy territories, which can form mobile complex compounds with iron ions. Differences in the concentrations of this element are associated with the geology and soil cover of the drainage areas.

Significant amounts of manganese come from the process of dying and decomposition of hydrobionts, in particular, blue-green and diatomic algae, as well as higher aquatic plants. In plants, manganese is found in soluble form and is easily released from plant residues, forming higher concentrations in water. The amount of manganese in rivers ranges from 1 to 160 μg/dm^3 (Guseva, 2007). In water samples taken from surface reservoirs of the study areas, the amount manganese varied from 44 to 192 μg/dm^3.

The amount of copper in natural freshwater ranges from 2 to 30 μg/dm^3 (Guseva, 2007). The concentration of copper in the analyzed samples was less than 1 to 3 μg/dm^3. The average content of this element in the surface waters of the study area is 21 μg/dm^3, which corresponds to an excess of 21 MPCfw.

The next stage of the research is related to the study of phytoplankton in the sites. The total number of algae reflects a poor composition of plankton. Including algae identified to the genus level, 88 common species, types and forms of algae (henceforth referred to as species) making 48 genera, 29 families, 10 classes and 7 divisions were found (Table 2).

Bacillariophyta division occupies the first position by the rank, Euglenophyta comes second, and the third and fourth positions are occupied respectively by Chlorophyta and Cyanobacteria. A very high proportion of single-species taxa (23 genera or 47.9%, 11 families or 37.9%) was observed in the studied algaloenosis. Large taxa at the class level (Mediophyceae and Coscinodiscophyceae) also include only one species, respectively: *Cyclotella meneghiniana* and *Aulacoseira italica*.

In the studied areas of the field, the share of species in communities varies from 12.5% to 30.7% of all identified algae (Figure 4).

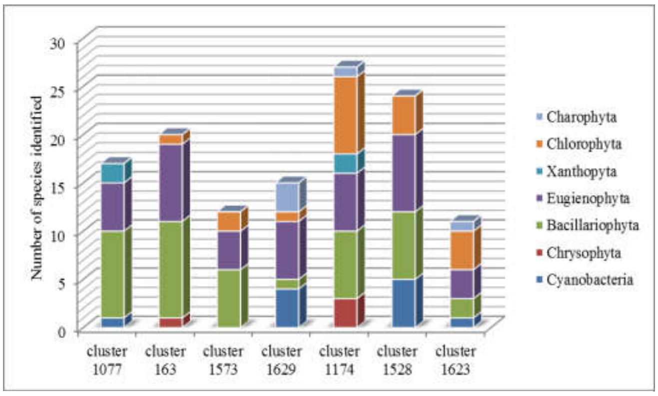

Figure 4. *Phytoplankton species composition by divisions in the studied wetlands of the Samotlor field (September 2015)*

Common algae developing in seven or six studied sites were not found. Algae most tolerant to oil pollution are developed in five sites: *Trachelomonas planctonica* and *T. volvocina*, in four – *Rhopalodia gibba*, *Trachelomonas hispida,* and *Lepocinclis acus*; in three – *Tabellaria flocculosa*, *Eunotia lunaris, Euglena variabilis* and *Nitzschia* sp., 11 species were identified in two sites: *Pseudanabaena limnetica, Dinobryon divergens, Cyclotella meneghiniana, Tabellaria fenestrata, Pinnularia rhombarea* var. *biundulata*, *Pinnularia* sp. 2, *Pinnularia* sp. 3, *Phacus orbicularis, Closterium subulatum, Closterium* sp. and *Spirogyra* sp. 1

Specific algae, i.e., those found only in one site, include 61 species or 69.3% of the total list, which also testifies to the extreme heterogeneity of the algal communities and their instability (Table 3).

No highly active species were identified in phytoplankton. Active species found in 72% of samples include Euglenophyta *Trachelomonas planctonica* and *T.volvocina*, in 57% of samples other Euglenophyta – *T.hispida* and *Euglena acus* were found. The group of low-activity species includes 4 species, observed in 43% of samples (*Tabellaria flocculosa, Pinnularia gibba, Eunotia lunaris,* and *Euglena variables*). The remaining 90.9% of the algae in the list are inactive, of which 15 species were found more often than others, in 29% of samples.

Site 1077 is sphagnum artificially flattened swamp in a suppressed Ledum pine forest. The water temperature is 10°C, the pH activity is 4.1. The color of water varies depending on the place of sampling from amber (swamp) to dirty yellow (ditch). The samples often contain flatworms, protozoa, and microscopic crustaceans. It means that intense decomposition of organic matter takes place in the water. 17 species of 11 genera, 9 families, 4 classes and 4 divisions were found in the phytoplankton of the site, including taxa not identified to the species level, due to their few number and small size. Their share in the total list of identified algae is 19.3%. The highest abundance was observed in 3 species: *Rhopalodia gibba* and *Characiopsis naegelii* (found only in this site), and *Euglena variabilis*, found en masse.

Site 163 is characterized by a large area of three interconnected open water bodies of sor origin and slow flowage. The water temperature fluctuated depending on the place of sampling from 10°C to 13°C, the watercolor is amber, pH ranges from 3.4 to 5.3. In these waters, thalli of filamentous algae were visually observed. The samples also contained worms, protozoa, and crustaceans, but their occurrence is much lower than that in the previous site. Plankton is represented by 20 algae of 13 genera, 10 families, 4 classes and 4 divisions. Their share in the site in the total list of identified algae is 22.7%. The highest activity is observed in algae Euglenopyta, which make up 40.0% of algae found in the site. The most numerous are β-mesosaprobic species: *Trachelomonas volvocinopsis* and *Lepocinclis acus*.

Sites 1573, 1629 and 1623 display the lowest diversity of algae, represented respectively by 12, 15 and 11 species. Their share in all identified algae is 13.6, 17.1 and 12.5% respectively. The most active species in the site 1573 are widespread *Trachelomonas planctonica* and *Monoraphidium komarkovae*; in the site 1629 –*Rhopalodia gibba* var. *ventricosa* and species of the *Spirogyra* genus; in the site 1623 – *Rhopalodia gibba and* species of *Spirogyra* genus found in the form of sterile thalli.

The diversity of the cyanoprokaryotic and algal communities in the site 1528 is 24 species of 18 genera, 15 families, 4 classes and 4 divisions. Algae are selected at 50 – 200 m from the cluster bunding in the *Typha latifolia* L. thickets, in hollows with a large number of *Spirodela polirhiza* (L. Schleid). On the water surface, oil streaks can be visually observed. The share in the total number of species in the studied sites is 27.3%. Dominant forms were not found. All algae are few in number.

The largest number of species was found near the bunding of the cluster 1174: 27 species, 19 genera, 14 families, 9 classes and 6 divisions. The share in the total species list is 30.7%. The highest abundance is shown by the species of the genus *Spirogira*.

From the ecological viewpoint, algae are predominantly planktonic species, indifferent to salinity and pH of the environment and cosmopolitan in terms of geographical distribution. In terms of saprobity, indicator species – β-mesosaprobic species – prevail.

4. DISCUSSION

There are a number of studies dedicated to the Samotlor field at the moment. Among them are the results of snow cover pollution (Kuznetsova, 2013). There are studies that characterize the state and variability of the hydrochemistry of fresh underground waters of KhMAO-Yugra, in which the maximum level of pollution is found in the Samotlor field area (Knyazeva, 2016; Moskovichenko and Ubaidulayev, 2014). The causes of degradation of terrestrial phytocoenoses (Guseva, 2007; Usmanov *et al.*, 2015a, 2015b) and disturbance of the landscapes of the north of Western Siberia (Peremitina *et al.*, 2017) have been studied. During oil development, the overall mineralization of water of KhMAO-Yugra has significantly increased (Reichert and Repkin, 2012; Ryabukha, 2016, 2018). Due to the increase in soil contamination by petroleum products, a decrease in the number of soil microorganisms in the Samotlor field (Reichert and Repkin, 2012) has been observed.

The data regarding cyanoprokaryotic and algal communities (CAL) of water objects of the Samotlor field are sporadic (Skorobogatova and Gidora, 2017). Literary sources concerning the problem under study mainly contain information on individual groups of soil algae (Kireeva *et al.*, 2007; Fazlutdinova and Sukhanova, 2014).

In general, the dynamics of specific species diversity in the studied areas were determined by the change in the number of green (from 0 to 9) and diatomic algae (from 2 to 9). Euglenophyta in each of the studied communities performed a significant floristic role, and their specific number varied by site from 3 to 8.

In terms of the number of species, as well as the composition of the leading genera and families, algal communities in the plankton of the studied sites can be characterized as made up primarily of diatomic algae and Euglenophyta with significant inclusion of green algae.

According to earlier observations, in high latitudes and under natural conditions, diatoms are always predominant in diversity and numbers, the green algae come second, and Euglenophyta and cyanobacteria occupy 4-5 positions. It is common knowledge that Euglenids, despite having chlorophyll, willingly switch to a mixotrophic type of nutrition and can conveniently live in complex organic environments. In addition, September in KhMAO-Yugra is the autumn period associated with a decrease in solar insolation, water temperature, and biodiversity. Therefore, the presence of ¼ part of the Euglenophyta in the algocenosis during this period is an unusual phenomenon (Lopatin *et al.*, 2008; Naumenko and Skorobogatova, 2009; Skorobogatova and Usmanov, 2016; Skorobogatova and Gidora, 2017; Skorobogatova, 2018).

Rich floras are characterized by increased values of such indicators of systematic diversity as "proportions of flora." Moreover, the more genera there are in the families, the more ancient they are, whereas the more species there are in the genera, on the contrary, the later stages of evolutionary development they are at (Skorobogatova, 2018). The ratios of the phytoplankton taxa of the Samotlor field show slight saturation of the algal flora of its plankton with species and low saturation with genera. The high proportion of monotypic genera in the taxonomic structure of the phytoplankton of the studied water objects (47.9%) is characteristic of ecosystems with more stringent living conditions. Such observations indicate an increase in the degree of water trophicity (Okhapkin, 1998; Skorobogatova, 2017).

The phytoplankton taxon ratios of the Samotlor field show insignificant algoflora saturation with its plankton species and low generic saturation.

The number of background or common algae species in the studied objects is 0% of the complete list of identified phytoplankton, which indicates that the algal community does not meet the parameters of a single algocenosis in the Samotlor field (Burkova, 2016).

It is known that the species composition, the complex of dominant species, the degree of development of algae varies depending on natural-climatic and anthropogenic factors. Many algae live everywhere, but for the development of most of them, optimum conditions are required. In this case, climatic factors (intensity of sunshine, water temperature, rainfall) for all sites were the same. Differences were observed in the degree of anthropogenic influence and the input of allochthonous substances associated with it, which increased the concentration of pollutants.

Certain concerns are caused by the excess of MPCfw of ammonium, copper, zinc, manganese, and iron in water samples in the studied areas.

Algae have been found in all studied samples, but the species diversity of the sites differed. Thus, in the surface waters of the site

1077, under the conditions of the excess of MPCfw of copper by 62, manganese – by 13, zinc – by 11, ammonium nitrogen – by almost 6 and iron – by more than 2 times, the type of community made up by diatomic algae and Euglenophyta includes 17 algae. In site 163, the community of diatomic algae and Euglenophyta consists of 20 species living in the conditions of the excess of MPCfw of copper by more than 7 times, manganese – by about 5, zinc – 12 times, ammonium nitrogen – 8 times. Site 1573 is also characterized as a community of diatomic algae and Euglenophyta and has the poorest specific composition (12 algae), the excess of MPCfw of copper by 7 times, manganese – by 19, ammonium nitrogen – by almost 5, iron – by 2.5 times.

The effectiveness of the use of MPC is not always high because the ecosystem is evolutionary equipped with special potential for possible hazardous effects. This is due to the fact that in addition to chemical contamination there are anthropogenic factors of non-chemical nature: thermal effects, the turbidity of water, change of hydrological regime, the area of water collection and level of anthropogenic development of the basin (Volkova *et al*., 2018).

The negative effects of zinc and cadmium were found in experiments when the primary production was at its maximum, and the number of cyanobacteria increased in water bodies. As the number of phytoplankton declined, the negative effect of these metals weakened. Copper ion is poisonous for algae, its toxicity increases at low pH values of the medium (Voropaeva, 2009). In this study, especially at pH 3.4 – 4.1, the toxicity of metals increases, while in neutral media they can be precipitated as insoluble compounds. The results of laboratory experiments of combined effects of such elements as copper, zinc, lead and tin show an inhibitory effect on algae under the same illuminance, temperature, and acidity.

The increase in the number of indifferent algae in phytoplankton to 30-40% suggests the forced adaptation of biocenosis to significant anthropogenic pollution (Voropaeva, 2009).

5. CONCLUSIONS

The study of MPCfw in surface waters showed significant excesses. For example, the concentration of copper in study sites exceeded MPCfw by 2 – 62 times, of manganese – by 2.8 – 19.2, zinc – by 0.5 – 12.1, ammonium – by 4.5 – 8.0, iron – by 0.7 – 2.7 times. By the amount of ammonium nitrogen, the studied water bodies are classified as polluted and very polluted. The amount of sulfates, nitrates, and phosphates in all water samples is below the standard MPCfw.

Phytoplankton found in seven sites of the Samotlor field included seven algae of 48 genera, 29 families, 10 classes and 7 divisions. Bacillariophyta, Euglenophyta and Chlorophyta algae comprise 76.1%.

The number of algae in plankton varies by site from 11 to 27 species. There is a large number of monotypic genera and families. Euglenophyta is well represented in each community. The dominant species is *Trachelomonas volvocinoohsis*. The subdominants include *Rhopalodia gibba, Characiopsis naegelii*, *Euglena variabilis, Lepocinclis acus, Trachelomonas planctonica, Monoraphidium komarkovae, Rhopalodia gibba* var. *ventricosa* species of *Spirogyra* genus. Species common for all sites were not found. Specific species make up 69.3% of the total list. No extremely active algae were found in plankton, 4.5% were active, and 4.5% low-active and the remaining 91.0% – inactive.

The taxonomic composition of the identified algae, the composition of the dominant (main) complex, is characterized by incompleteness of the cyanoprokaryotic algal community.

The analysis of the taxonomic structure of phytoplankton of the Samotlor field surface waters makes it possible to classify the studied communities as poor in composition and low in abundance. A large gap in species diversity between large individual taxa indicates the simplification of the structure of algal communities and their instability.

This research is the beginning of the study of surface water algae under the exploitation of oil fields of the Nizhnevartovsk district and may be recommended for ecologists, natural scientists, and environmental specialists.

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Table 1. *Chemical and analytical parameters of water of Samotlor field wetlands (September 2015)*

Parameter	MPCfw	Site 1077	Site 163.1	Site 163.2	Site 163.3	Site 1573
t (^{0}C)	–	10	10 …13	10 …13	10 …13	13
pH (units)	–	4,1	5,3	5,3	3,4	6,4
Ammonium (mg/dm^3)	0,5	2,78	4	4	4	2,27
Nitrates (mg/dm^3)	40	2,57	3,84	4,14	5,7	1,43
Sulfates (mg/dm^3)	100	5,14	17,36	7,11	5,99	3,73
Chlorides (mg/dm^3)	300	74,8	14,1	64,7	24,9	307,1
Phosphates (mg/dm^3)	0,2	0,05	0,05	0,12	0,06	0,06
Petroleum products (mg/dm^3)	0,05	0,025	0,02	0,02	0,02	0,02
Fe (mg/dm^3)	0,1	0,111	0,103	0,074	0,265	0,245
Zn (mg/dm^3)	0,01	0,111	0,121	0,0045	0,0172	0,0123
Pb (mg/dm^3)	0,006	0,002	0,002	0	0,0046	0,002
Ni (mg/dm^3)	0,01	0,0057	0,005	0,0035	0,005	0,0065
Mn (mg/dm^3)	0,01	0,127	0,044	0,028	0,053	0,192
Cu (mg/dm^3)	0,001	0,062	0,0073	0,0019	0,0075	0,0071
Cr (mg/dm^3)	0,02	0,0066	0,0063	0,0027	0,009	0,0074
Phenols (mg/dm^3)	0,001	0,001	0,0011	0	0,001	0,0015

Reference: MPCfw – maximum permissible concentration for fishery waters, Ci – concentration of i-th pollutant; 1077, 163.1., 163.2, 163.3, 1573 – site number.

Table 2. *Phytoplankton species composition of wetlands in the conditions of the Samotlor oil field exploitation (September 2015)*

Rank	Division	Class	Family	Genus	Species	Share in the total number of species (%)
4	Cyanobacteria	1	4	6	9	10,2
5-7	Chrysophyta	1	1	2	4	4,5
1	Bacillariophyta	3	12	17	28	31,9
2	Euglenophyta	1	2	7	22	25,0
5-7	Xanthopyta	1	3	3	4	4,5
3	Chlorophyta	2	6	12	17	19,4
5-7	Charophyta	1	1	1	4	4,5
	7	10	29	48	88	100

Table 3. *Phytoplankton species composition of wetlands in the conditions of the Samotlor oil field exploitation (September 2015)*

Taxon	Samotlor oil field cluster (№)						
	1077	163	1573	1629	1174	1528	1623
Cyanobacteria							
Anathece *clathrata* (West & G.S.West) Komárek, Kastovsky & Jezberová [=Aphanothece clathrata West & G.S.West]	-	-	-	-	-	+	-
Anabaena sp.1	-	-	-	-	-	-	+
Microcystis *aeruginosa* Kützing emend. Elenkin f. *aeruginosa*[=*Microcystis aeruginosa* Kütz. emend. Elenk.]	-	-	-	-	-	+	-
M. pulverea (Wood) Forti emend. Elenkin=[*M. pulverea* (Wood) Forti emend.	-	-	-	-	-	+	-

Elenk. f. *pulverea*]							
M. ichthyoblabe (G.Kunze) Kützing	-	-	-	-	-	+	-
Oscillatoria *limosa* C.Agardh ex Gomont	-	-	-	+	-	-	-
Oscillatoria sp.1	+	-	-	-	-	-	-
Pseudanabaena *limnetica* (Lemmermann) Komárek *[=Oscillatoria limnetica* Lemmermann]	-	-	-	+	-	+	-
Chrysophyta							
Chrysococcus *rufescens* Klebs	-	-	-	+	-	-	-
Dinobryon *divergens* O.E.Imhof	-	+	-	-	+	-	-
D. divergens var. angulatum (Seligo) Brunnthaler - Unchecked	-	-	-	-	+	-	-
D. sociale (Ehrenberg) Ehrenberg	-	-	-	-	+	-	-
Bacillariophyta							
Cyclotella *meneghiniana* Kütz.	-	-	+	-	+	-	-
Aulacoseira *italica* (Ehrenberg) Simonsen=[*Melosira italica* (Ehr.) Kütz.]	-	-	+	-	+	-	-
Synedra sp.	-	+	-	-	-	-	-
Tabellaria *fenestrata* (Lyngb.) Kütz.	-	+	-	-	+	-	-
T. flocculosa (Roth) Kütz.	-	-	+	-	+	+	-
Asterionella *formosa* Hassall	-	-	-	-	+	-	-
Fragilaria *acus* (Kützing) Lange-Bertalot [=*Synedra acus* Kützing]	-	-	-	-	-	-	+
Navicula *cryptocephala* Kützing	-	-	-	-	-	+	-
N. radiosa Kützing	-	-	-	-	-	+	-
Navicula sp.1	-	+	-	-	-	-	-
Pinnularia *abaujensis* var*. subundulata* (Ant.Mayer) R.M.Patrick =[*Pinnularia gibba* var*. subundulata* (Ant.Mayer) Frenguelli]	-	-	-	-	+	-	-
P. rhombarea var. *biundulata* (Otto Müller) Krammer [=*Pinnularia microstauron* f. *biundulata* O. Müll. Hustedt]	+	+	-	-	-	-	-
Pinnularia sp.1	+	-	-	-	-	-	-
Pinnularia sp.2	+	-	+	-	-	-	-
Pinnularia sp.3	+	-	+	-	-	-	-
Stauroneis *anceps* var.*gracile* Ehrenberg	-	+	-	-	-	-	-
Rhopalodia *gibba* (Ehrenberg) Otto Müller=[*Pinnularia gibba* Ehr.]	+	+	-	-	-	+	+
R.gibba var.*ventricosa* (Kützing) H.Peragallo & M.Peragallo	-	-	-	+	-	-	-
Eunotia *lunaris* (Ehr.) Grun. var. *lunaris*	+	+	-	-	+		-
E. pectinalis (Kützing) Rabenhorst	+	-	-	-	-	-	-
E. pectinalis var. *ventricosa* (Ehrenberg) Grunow=[*Eunotia pectinalis* var. *ventralis* (Ehr.) Hust.]	-	+	-	-	-	-	-
E. praerupta Ehrenberg	-	+	-	-	-	-	-
Gomphonema *acuminatum* Ehrenberg var. *acuminatum*	-	-	-	-	-	+	-
Hantzschia *virgata* (Roper) Grunow	+	-	-	-	-	-	-
Nitzschia sp.	+	-	+			+	-
Stenopterobia *intermedia* (F.W.Lewis) Van Heurck ex Hanna	-	-	-	-	-	+	-

Rhoikosphenia sp.	-	+	-	-	-	-	-
Eugienophyta							
Monomorphina *pyrum* var. *costata* (Conrad) Popova	-	+	-	-	-	-	-
Euglena *korshikovii* Gojdics	-	+	-	-	-	-	-
E.megalithos Skuja	-	-	-	+	-	-	+
E..variabilis G.A.Klebs	+	-	-	-	+	+	-
Euglena sp.1	-	+	-	-	-	-	-
Trachelomonas *planctonica* Swir.	+	+	+	-	+	+	-
T. hispida (Perty) F.Stein	-	+	-	+	+	+	-
T. volvocina Ehr.	-	+	+	+	+	+	-
T. volvocinopsis Svirenko	-	+	-	-	-	-	+
Strombomonas *fluviatilis* (Lemmermann) Deflandre	-	-	+	-	-	-	-
Phacus *caudata* var. *major* Philipose	-	-	-	+	-	-	-
P. longicauda (Ehrenberg) Dujardin	-	-	-	-	+	-	-
P.rotundus (Pochmann) Zakrys & M.Lukomska [=*Phacus longicauda* f. *rotundus* (Pochmann) Popova]	-	-	-	-	-	+	-
P. orbicularis K.Hübner [=*Phacus orbicularis* f. *communis* Popova]	+	-	-	-	+	-	-
P. pleuronectes (O.F.Müller) Nitzsch ex Dujardin	-	-	-	-	-	+	-
Phacus sp.1	-	-	-	-	-		+
Phacus sp.2	-	-	-	-	-	+	-
Cryptoglena *skujae* Marin & Melkonian [=*Phacus agilis* Skuja]	-	-	-	+	-	-	-
Lepocinclis *acus (O.F.Müller) B.Marin & Melkonian [=Euglena acus* (O.F.Müller) Ehrenberg]	+	+	+	+	-	-	-
L. ovum (Ehrenberg) Lemmermann	-	-	-	-	-	+	-
L. ovum f. *minor* Christjuk	+	-	-	-	-	-	-
Xanthopyta							
Tribonema *pyrenigerum* Paseher	-	-	-	-	+	-	
Tribonema sp.	+	-	-	-	-	-	-
Characiopsis *naegelii* (A.Braun) Lemmermann	+	-	-	-	-	-	-
Ophiocytium *gracilipes* (A.Braun) Rabenhorst	-	-	-	-	+	-	-
Chlorophyta							
Pandorina *morum* (O.F.Müller) Bory	-	-	-	-	-	-	+
Eudorina *elegans* Chodat	-	-	-	-	+	-	-
Sphaerocystis *planctonica* (Korshikov) Bourrelly	-	+	-	-	-	-	-
Pseudoschroederia *robusta* (Korshikov) E.Hegewald & E.Schnepf [=*Schroederia robusta* Korshikov]	-	-	-	-	+	-	-
Kirchneriella *obesa* (West) West & G.S.West	-	-	-	-	-	+	-
Monoraphidium *contortum (Thuret) Komarkova-Legnerova*	-	-	-	-	+	-	-
M. griffithii (Berkeley) Komárková-Legnerová	-	-	-	-	-	+	-
M. tortile (West & G.S.West) Komárková-	-	-	-	-	+	-	+

Legnerová							
M. komarkovae Nygaard	-	-	+	-	-	-	-
***Scenedesmus** arcuatus* (Lemmermann) Lemmermann	-	-	-	-	-	-	+
S. quadricauda (Turpin) Brébisson	-	-	-	-	-	+	-
***Tetradesmus** obliquus* (Turpin) M.J.Wynne [=*Scenedesmus obliquus* (Turpin) Kützing]	-	-	-	-	-	-	+
***Closterium** subulatum* (Kützing) Brébisson	-	-	+	-	-	+	-
Closterium sp.	-	-	-	+	+	-	-
***Goniochloris** laevis Pascher* *[=Pseudostaurastrum laeve* (Pascher) Bourrelly]	-	-	-	-	+	-	-
Staurastrum sp.	-	-	-	-	+	-	-
Staurodesmus sp.	-	-	-	-	+	-	-
Charophyta							
Spirogyra sp.1	-	-	-	+	-	-	+
Spirogyra sp.2	-	-	-	+	-	-	-
Spirogyra sp.3	-	-	-	-	+	-	-
Spirogyra sp.4	-	-	-	+	-	-	-
88	**17**	**20**	**12**	**15**	**27**	**24**	**11**

Reference: before a square bracket comes a species as identified in the modern nomenclature, in the square bracket is a species found in identification guides; "+" - the presence of algae, "-" - the absence of algae; 88, 17, ..., 11 - the number of algae found in the site.