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Composition and abundance of phytoplankton in Ob River (Western Siberia, Russia)

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Abstract. The paper presents the results of phytoplankton study in the Ob (a large Siberian Lowland River) from its source to mouth. The sampling was carried in the period of open water during the last decades on the key sites of the river – near the mouths of large tributaries, big cities and settlements. Based on the complex classification of surface waters, Lake Teletskoye (like the upper reaches of river basins) is distinguished by the lowest trophic status (oligo- and even ultraoligotrophic). The Upper Ob trophicity is estimated as mezotrophic ($0.6-2.0 \text{ g/m}^3$), the Middle Ob – oligo- ($<0.1-0.5$), meso- and eutrophic ($2.1-10.0 \text{ g/m}^3$), the Lower Ob – both oligo- and mezotrophic, and the Gulf of the Ob – from oligo- to meso- and eutrophic one. The results of the saprobiologic analysis suggest that the greatest number of bioindicators belong to β -mesosaprobionts that is indicative of the β -mesosaprobic environment. The ecological state of the sampling area is assessed as “quite pure” by the phytoplankton biomass and “slightly contaminated” – by the Saprobic Index, thus corresponding to I (very pure), II (pure) and III (slightly contaminated) classes of water quality. According to the description of the crisis zones, the environmental status of the river is still good and corresponds to the stages of “reversible changes” and “threshold state”. The water quality and ecosystem state in different years are similar that could be evidence of the river ecosystem stability through time and space. Though the Ob ecosystem is capable of self-purification, it calls for further conservation to avoid the water quality deterioration.

1. Introduction

According to the European Water Framework Directive, phytoplankton is one of four biological objects used for determining the ecological status of water bodies and assessing the water quality [1]. In small streams, plankton mainly consists of epilithon and epiphyton algae drifted from the coastal habitats. Large rivers have already mature phytoplankton consisting mostly of typical planktonic organisms. The Ob River stretches from the confluence of rivers Biya and Katun' up to the Gulf of Ob and the Kara Sea. Being a large river of Siberia, the Ob is also one of the largest river systems in Russia and worldwide [2] by its length (3650 km), the catchment area (2990 th.km^2) and the average long-term water discharge in the mouth ($12700 \text{ m}^3/\text{s}$). The Ob is divided into three sections by its nature, alimentation and water regime formation: the upper (up to the mouth of the Tom –1020 km), the middle (up to the mouth of the Irtysh –1500 km) and the lower one (up to the Gulf of Ob –1160 km) (Figure 1) [3]. At the confluence with the Kara Sea, the Ob forms the unique estuary -the Gulf of Ob that is of 800 km long, 30-80 km wide and 25 m deep. The river has been transformed insignificantly; the Novosibirsk Reservoir is the only man-made water body built here [4]. The aim of



the current research is the analysis of composition and abundance of phytoplankton in the Ob and the Gulf of Ob to assess the trophic level and water quality of the river. Different data on phytoplankton from the upper sections of the Ob to its lower reaches were involved.

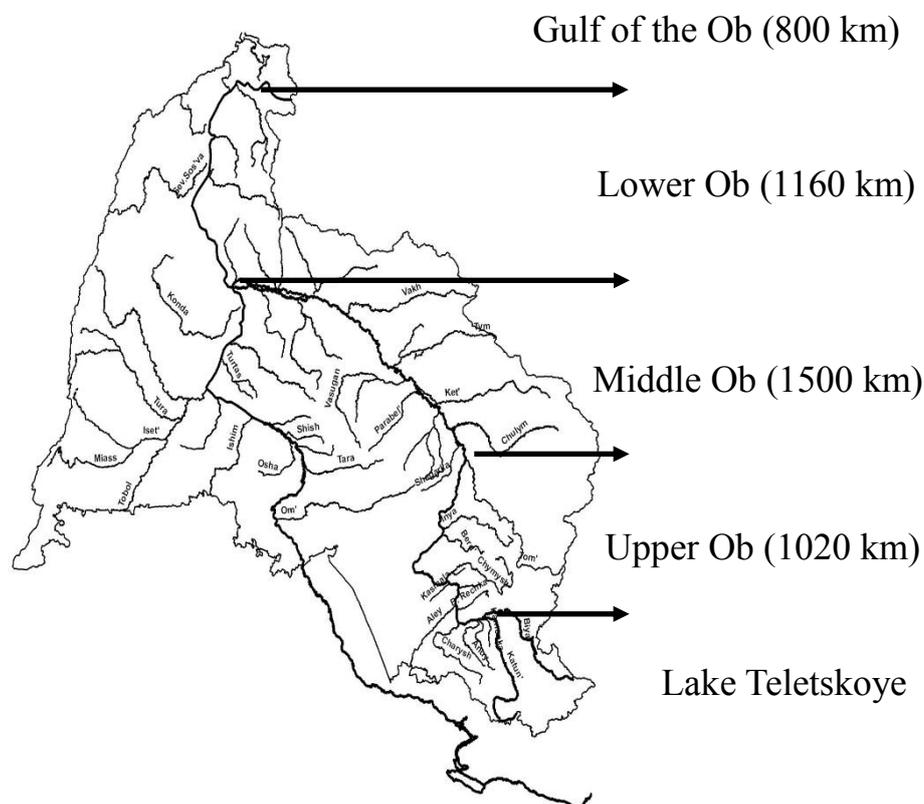


Figure 1. The Ob River watershed with sections

2. History of the study

Ob River phytoplankton, its composition and abundance as well as its drift were the object of algologists attention for many decades. The review of the algal flora studies was made by M.S. Kuksn and with co-authors in the mid of the 60s of XX century [5, 6]. Algal communities from the Ob river and waterbodies of its catchment were characterized by T.G. Popova [7] based on latitudinal zones. In the 90s and 2000s, the interest to the plankton study in the Ob and the Gulf of Ob increased due to large-scale development of oil and gas fields in the north of Western Siberia.

3. Results and discussion

In the source of Biya River a deep Lake Teletskoye is situated. Long-term investigations (1989-2013) prove that the lake phytoplankton is diverse in composition but poor in quantity; small-celled diatoms and some cryptomonads, in some years and seasons – cyanobacteria and gold algae dominate here. Monthly monitoring (June 1999 - April 2002) of phytoplankton in the source of Biya River showed that phytoplankton number ranged from 70.9 till 231.4 th.cells/l with an average of 131.7 ± 7.9 th.cells/l, biomass – 0.04-0.3 and 0.1 ± 0.02 g/m³, respectively. There was a slight inter-annual fluctuation of phytoplankton abundance. In 2000, the average number of phytoplankton (111.9 ± 12.4 th.cells/l) was lower than in 2001 (141.5 ± 15.7 th.cells/l), whereas its biomass – practically the same in both periods (0.1 ± 0.01 and 0.1 ± 0.02 g/m³, respectively) [8]. Plankton development had two peaks: the first, the least – in winter during the under-ice period with the predominance of cryptomonads *Chroomonas acuta* Utermöhl, *Cryptomonas* sp. and pennate diatoms, largely

Achnantheidium minutissimum (Kützing) Czarnecki with species from genera *Cymbella*, *Gomphonema*, *Nitzschia*, *Navicula*; and the second, the highest – in late summer and early autumn with the development of plankton pelagic complex – *Ch. acuta* and small centric diatoms *Cyclotella*, *Stephanodiscus* and *Stephanocostis* species.

3.1. The Upper Ob

The Upper Ob is a typical lowland river with low flow velocity (usually not more than 1 m/s and about 0.7 m/s during low water), relatively high water discharge (the average water runoff at Barnaul in April-November, 2001 was 2446 m³/s), low water temperature in spring (0.2 °C in early April), high water temperature in summer (up to 22.2 °C in mid August) and low transparency (0.40-0.62 m during the studied period). As compared to the Biya, the Upper Ob was distinguished by well-developed phytoplankton with predominance of autotrophic algae. It should be noted that truly planktonic forms as well as algae abundance in the water column increased. A characteristic predominance of diatoms in the Holarctic rivers was observed (up to 45.6% of total number of species). During the study period (from April to September), the abundance and biomass of the Upper Ob phytoplankton reached 500.8 th.cells/l and 1.1 g/m³ (1993) [9], near Barnaul city it was 1259.0 th.cells/l and 0.8 g/m³ (2001) [10], near Kamen-on the-Ob – 1003.7 th.cells/l and 0.8 g/m³ (2004), respectively. Most of species-indicators of saprobity were beta-mesosaprobic, and saprobic index did not exceed 2.08 that corresponded to the oligo-beta-mesosaprobic zone.

3.2. Middle Ob

Phytoplankton from the Middle Ob is determined by specific natural conditions of the area, namely by the excessively moisturized catchment. Phytoplankton composition is characterized by great homogeneity throughout the zone. Diatoms are the predominant group among algae too. The leading role in the algae composition mostly belongs to planktonic forms – centric colonial diatoms of *Aulacoseira*, a share of which in total phytoplankton number increases downstream. Phytoplankton number ranges within 154.7-2817.6 th.cells/l biomass – 0.2-3.2 g/m³ (1999) [11]. Significant differences in phytoplankton abundance near the banks and in the midstream were not observed.

3.3. Lower Ob

In the Lower Ob, phytoplankton number and its biomass changed considerably. In the 90s of XX century, they ranged 8.7-1606.8 th.cells/l and 0.07-1.3 g/m³ (1993-1994.), later – 83.3-1179.7 th.cells/l with the average of 363.2 ± 147.5 th.cells/l and 0.04-0.5 g/m³ with the average of 0.2 ± 0.06 g/m³ (2015). Phytoplankton number from the Gulf of Ob changed to a greater extent – 189.0-5763.5 th.cells/l (the average of 1931.5 ± 334.2 th.cells/l), biomass – 0.1-2.7 g/m³ (the average of 0.9 ± 0.2 g/m³) (2015). The value of saprobic index corresponds the beta-mesosaprobic zone (1.51-2.50) that is indicative of a moderate organic pollution of the Ob River water. This index in the Gulf of Ob is slightly higher (1.76-2.15, average 1.87 ± 0.03), in the Lower Ob – a bit less (1.80-1.96 and 1.84 ± 0.02) [12].

4. Conclusion

According to the complex classification of surface waters [13], the Lake Teletskoye water is the lowest trophic status (oligo- and even ultraoligotrophic) what is usually typical for upper reaches of the river basins. The Upper Ob trophicity is estimated as mezotrophic (0.6-2.0 g/m³), the Middle Ob – oligo- (<0.1-0.5), meso- and eutrophic (2.1-10.0 g/m³), the Lower Ob – both oligo- and mezotrophic, the Gulf of Ob – from oligo- to meso- and eutrophic.

The ecological state of the sampling area is assessed as “quite pure” by phytoplankton biomass and “slightly contaminated” – by the Saprobic Index, thus corresponding to I (very pure), II (pure) and III (slightly contaminated) classes of water quality. According to the description of crisis zones [14], the environmental status of the river is still good and corresponds to the stages of “reversible changes” and “threshold state”. The “ecological regress” state was not revealed because the decrease in

phytoplankton diversity, simplification in the food chain and temporal structure are absent. Previously, N.A. Gajewski et al. [15] described the trophic state of water ecosystems of the Ob and Taz Gulfs during the period of open water (2002-2008) as mesotrophic-eutrophic, and noted that trophic levels of the water were similar for the studies made in 1960 [16] and 1980-2002 [17-19]. It means that the water quality and ecosystem state in different years are similar that could be indicative of the river ecosystem stability through time and space.

By and large, structural features of phytoplankton and its abundance are the evidence of quite safe state of the river. The Ob ecosystem is capable of self-purification now and before [20]; the environment changes are reversible. However, there is a threat to aggravate the current situation in the most contaminated areas, especially downstream the cities, where the inflow of municipal wastewater occurs. Similar to the numerous large world rivers, the Ob is in need of care to avoid its deterioration, especially during the flood periods when the phytoplankton is not diverse and can't maintain the self-purification processes due to income of large amount of terrigenous material from the catchment basin, transparency deterioration, increase in water turbulence and, as a consequence, attenuation of physiological activity of the algae.

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