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Features of measuring dynamic biochemical parameters in the middle Ob

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Abstract Indicators that reflect metabolic processes of living organisms in the water of the middle course of the Ob River were measured in different seasons of 2016 and 2017. In the winter period, the processes of catabolism predominate. They intensify in mid-February. At this time a sharp decrease in dissolved oxygen (O_2) in the water is observed, which results in fish kills. The most intense catabolic processes occur in March, before the river ice breakup. In summertime there is no difference between the day and night periods. It is probable that the internal heterogeneity of water flows has a more significant effect on dynamic indices than the processes of photosynthesis.

1. Introduction

The hydrochemical composition of large rivers flowing into the Arctic Ocean is important for predicting the effects of climate change and anthropogenic impact on the matter flows between the continent and the ocean in the Arctic [1-7]. Therefore, a considerable attention is paid to the assessment of dissolved organic carbon, moving from the territory of Western Siberia with river flow. The largest river of Western Siberia is the Ob. It is well-known that the river Ob contains a large amount of organic matter. Its high concentration is explained by the influence of tributary water, which is formed on swampy catchments [8,9]. On the other hand, a significant amount of carbon with river runoff into the global ocean behaves similar to dissolved carbon dioxide (CO_2), which is formed by animal and plant respiration. In the daytime oxygen accumulates in water due to the processes of photosynthesis. At night, carbon dioxide accumulates as a result of respiration of plants and animals. Therefore, carbon dioxide in continental rivers can be an indicator of climatic processes [10]. Dissolved carbon dioxide is a dynamic indicator of metabolism, but it has not been studied in the Ob River.

The purpose of this work is to estimate dissolved CO_2 in the Ob River and analyze its dynamics in different seasons of the year. This information helps determine the variability of the CO_2 concentration in river water in different seasons and estimate the effect of ice cover on it. The daily dynamics allows assessing the influence of biological processes on the content of CO_2 in the Ob River. The same mechanisms cause the development of negative phenomena in water bodies and mass fish kills in the winter and summer periods.

2. Materials and Methods

The concentration of carbon dioxide and oxygen in water was used as dynamic indicator of biochemical processes. We investigated the area of the middle Ob, where the main part of the hydrochemical river flow is formed. The hydrological system of the Ob is usually divided into three main parts. The southern Ob is the area of the river system from the riverheads to the Tom River outlet. The middle Ob is the area from the Tom River outlet to the Irtysh River outlet. The lower Ob is the area from the Irtysh River outlet to the Gulf of Ob [11]. The main part of the hydrochemical flow of the Ob is formed on paludified watershed areas during snow thawing.

Measurements were made in years 2016 and 2017. A workstation for CO_2 measuring was set up at the Kaibasovo research station, Tomsk State University. The workstation is located in the flood plain of the Ob River (N57.246142 degrees, E84.181919 degrees). The measurements were made with the Vaisala Carbon Dioxide Meter GM70 equipment (GMP 222 sensor), with an interval of 5 minutes. Dissolved oxygen was measured by an automatic MiniDOT device with an optical sensor. The measurements were made at a depth of 150 cm. At the same time we measured water temperature, air temperature, its humidity and atmospheric pressure (HOBO, USA). The diurnal dynamics of CO_2 was measured every month. Before the river ice breakup, CO_2 was measured under ice for one month.

3. Results and Discussion

The concentration of dissolved CO_2 in the Ob River varies significantly during the year (Figure 1). The lowest concentration of CO_2 is observed in summer, the highest in winter. The biggest increase in the dissolved CO_2 concentration begins during the freeze-up period and reaches its maximum in December-January. The concentration of oxygen has a negative correlation with the concentration of carbon dioxide. However, this pattern is violated in winter. The ice and snow cover prevent the sunlight from coming in and the processes of photosynthesis stop.

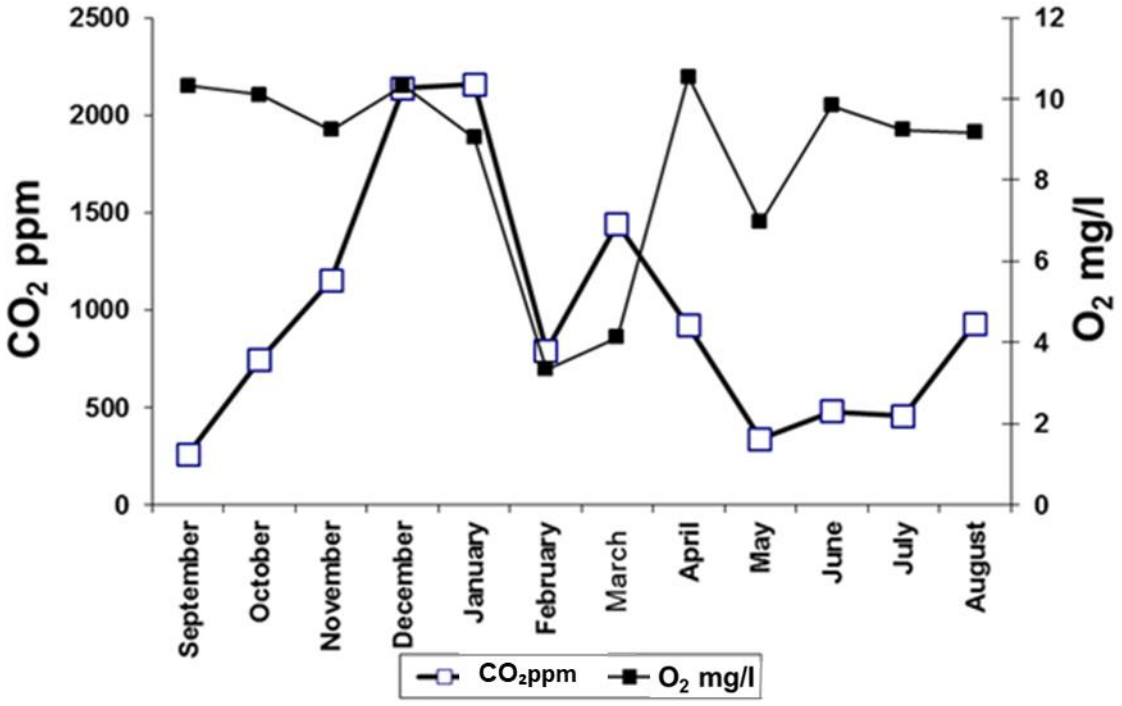

Figure 1. Annual dynamics of CO_2, O_2 and temperature

It should be noted that the oxygen concentration remained high until mid-February, and the carbon dioxide concentration was comparatively low at that time. However, from mid-February, the

concentration of dissolved oxygen started decreasing in the river, while the concentration of dissolved carbon dioxide increased (Figure 2). The maximum concentration of CO_2 was registered in early March and the minimum concentration of O_2 in mid-March. Such a change in the concentration of CO_2 and O_2 takes place due to a phenomenon that is typical for the Ob basin, and is the cause of fish kills. In Figure 2 we see that it starts in the middle of February and reaches its peak in the middle of March. In late March of 2017, thaws and the arrival of thawed water into the river were registered. The oxygenated meltwater increased the oxygen content in the river. This process is also well illustrated in Figure 2.

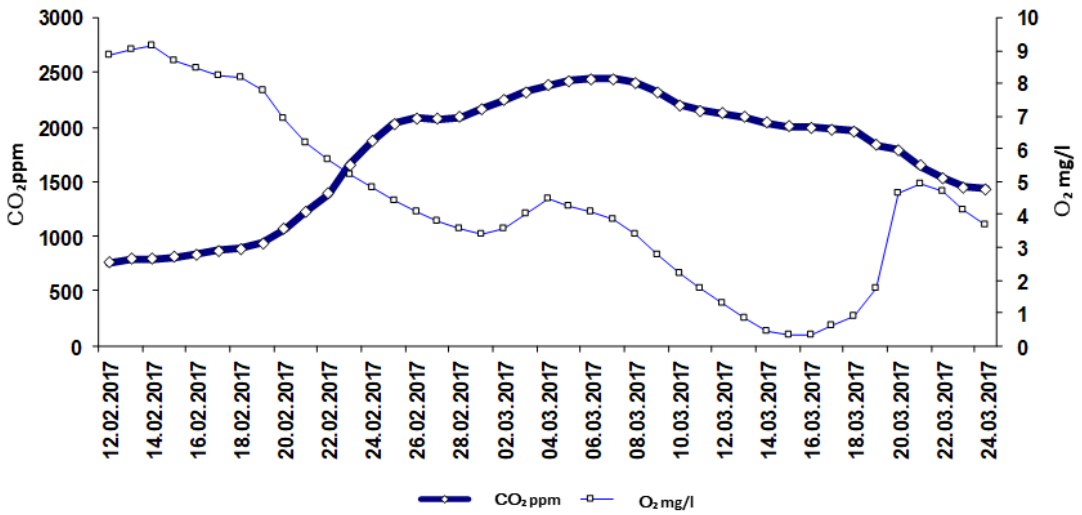

Figure 2. Dynamics of CO_2 and O_2 in winter, during fish kills

The highest content of CO_2 in the Ob River is characteristic for the winter period, when the river is covered with ice. The maximum content of CO_2 is observed in early March. In winter the content of CO_2 and O_2 does not change during the day. Figures 3 and 4 show the plots of the dynamics during the lighttime and darktime over the twenty-four period. The average value of the oxygen content does not change, and the change in the mean value of CO_2 is only 25 ppm. The standard deviation of O_2 during the day is 0.012%, and at night 0.007%, the standard deviation of CO_2 is 26.39% and 21.22% day and night, respectively (Table 1.).

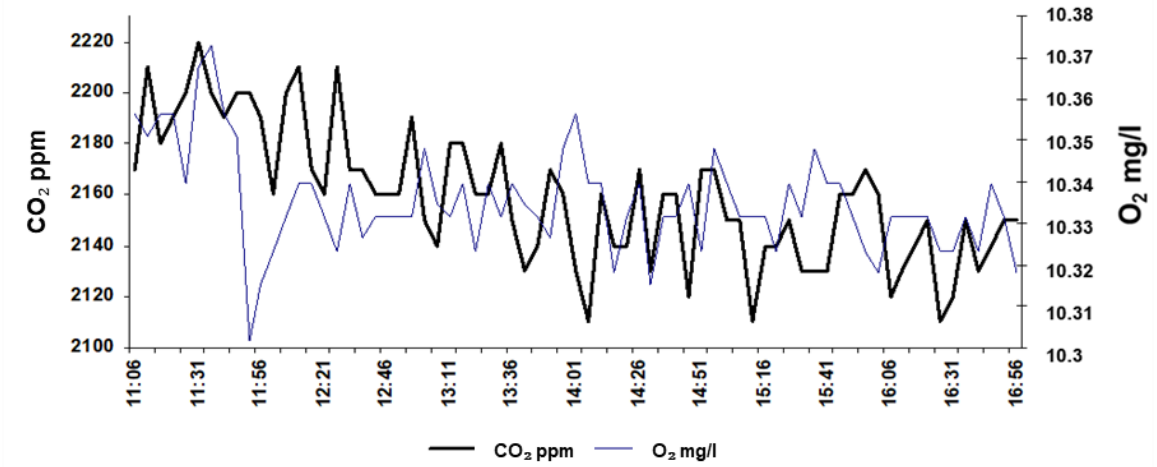

Figure 3. Dynamics of CO_2, O_2 in the lighttime (January)

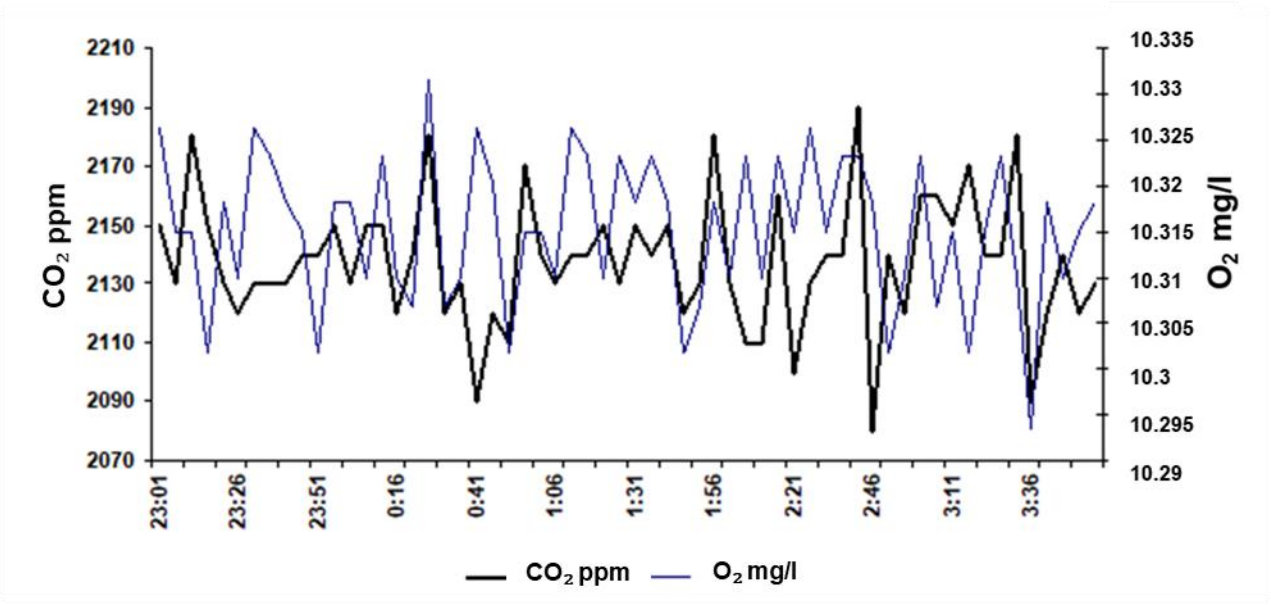

Figure 4. Dynamics of CO_2, O_2 in the darktime (January)

Table 1. The content of O_2 and CO_2 in the river Ob in daytime and nighttime

	Valid N	Mean	Minimum	Maximum	Std.Dev., %
			daytime		
O_2	71	10.3 mg/l	10.3	10.4	0.012
CO_2	71	2159 ppm	2110	2220	26.39
			nighttime		
O_2	96	10.3 mg/l	10.3	10.3	0.007
CO_2	96	2134 ppm	2080	2190	21.22

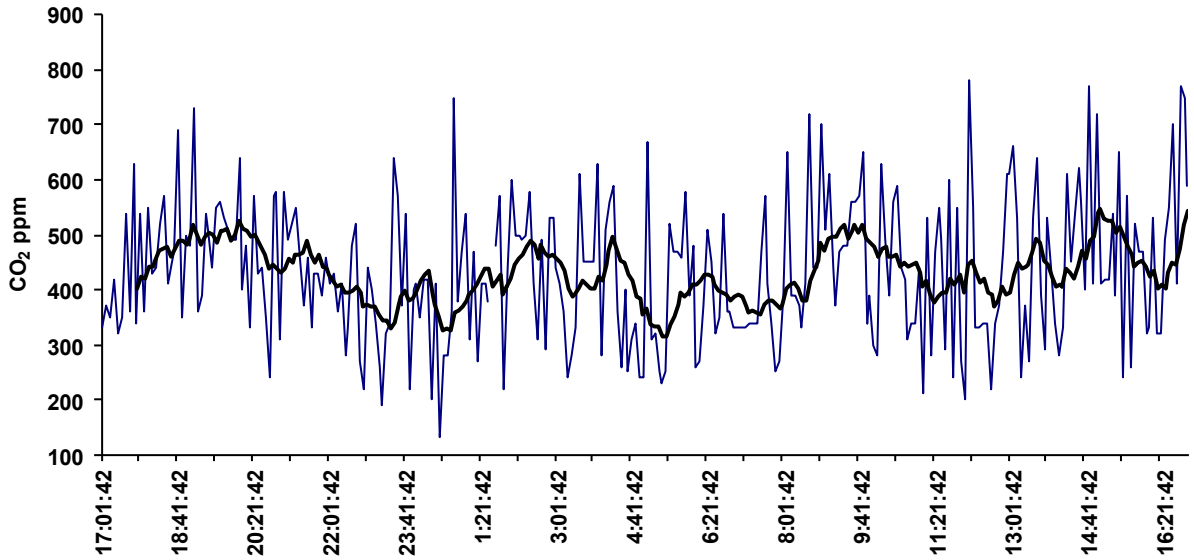

Figure 5. Daily dynamics of dissolved CO_2 in June. The bold black line shows a smoothed curve obtained by 10-point averaging

The daily dynamics of CO_2 in the Ob in summer is shown in Figure 5. The presented plot does not reveal any regularities in the content of dissolved CO_2 during the twenty-four hours. One might expect the increase of CO_2 in the night period and its decrease in the daytime. This pattern usually works due to photosynthetic processes. However, this regularity is not visible in river water; it is likely that the heterogeneity of water flows has a more significant effect on the content of CO_2 than the processes of photosynthesis. Inhomogeneity is likely to be created by enriched dissolved CO_2 waters of the tributaries and CO_2-enriched groundwater [9, 12].

4. Conclusion

The content of dissolved CO_2 in the Ob River is highly heterogeneous. The maximum concentration is registered in early March, before the river breakup, and the minimum content in the autumn period. Dissolved CO_2 accumulates in the river during winter, the freeze-up period. The daily picture caused by the processes of photosynthesis was not detected; it is overlapped by the heterogeneity of the streams inside the river.

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