

Automation of measuring primary production and destruction: possibilities and disadvantages

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ABSTRACT. The device for the automated determination of the primary production and destruction of organic matter in a water body by the oxygen method gives wide opportunities for study of functional characteristic changes under variation of environmental factors of small time scale. But severe weather conditions (high wind speed), long exposition without cleaning may effect on quality of measurements due to overgrowing of bottles. Set of short expositions during the day may show larger values of production and destruction than standard diurnal or semidiurnal exposition.

Keywords: Oxygen method, automation of measurements, phytoplankton primary production and destruction, wind stress, convection.

1. Introduction

Diurnal and synoptic variation of physical and chemical characteristics of water masses under changing weather conditions lead to changes of their biological parameters. Primary production and destruction can be measured by different methods (Vinberg, 1960; Mineeva, 2009). The most easy and widespread is oxygen light and dark-bottle method. But it is very laborious to study these processes in small time scales. Grechushnikova and Kremenestkaya (2013) showed the presence of diurnal and synoptic variation in activity of primary production obtained by classical method. Goncharov (2018) invented a device for automatic measurements, which made it possible to obtain a large volume of data in different synoptic conditions.

2. Materials and methods

The detailed description of measuring device can be found in (Goncharov et al., 2018). Measurement automation consists of periodical change of water in bottles by pump and replacing the titration method with automatic measurement of the dissolved oxygen by logger. After device tests in mesotrophic Mozaik reservoir (2016-2017) the optimal duration of exposition was accepted as three hours. During this period it was possible to record significant changes in the oxygen content in both bottles. In 2018 successful measurements were undertaken during June 24 – September 26 at a depth of 0.5 meters when weather changes influenced on water body structure (the depth

of the mixed layer, vertical distribution of temperature, stability, dissolved oxygen (O₂) and nutrients).

3. Discussion and Conclusions

During periods with slow wind (<3 m/s) O₂ content in the surface layer (first measurement after change of water in the bottles) increased in the day and decreased at night with amplitude 2-3 mg/L. In cyclonic weather O₂ content may decrease during day and night on 0.5-2 mg/L mainly due to wind stress, convective mixing and inactive primary production. Automatic registration recorded some special cases. For example – drop of O₂ content in the daytime (1.9-2.4 mg/L) during periods of stormy weather. The main limitation of continuous use of this device is the fouling (overgrowing) of bottles inside and out. It is especially important for the light bottle, because it leads to greater O₂ decrease at the dark time and more intensive production on the light due to periphyton inside the bottle. It is important to clean bottles every two or three days, during periods of intensive primary production – every day.

Daily values of gross production (GP) (counted as a sum of its values for every three hours) changed in accordance with changes in the weather. For example in August there were observed three periods of changes from windy cold cloudy weather to calm conditions. In such a situation GP values grew in two to three times (till 9.08 from 5 to 13, till 17.08 from 6 to 13 and till August 23-30 from 3-5 to 10-18 mgO₂/day). In August due to absence of oxygen in hypolimnion the content of mineral phosphorus (Pm) in the bottom layer exceeded

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0.6 mg/L and near the surface it exceeded 0.01 mg/L (in August 8, 10, 17 and 23 it was 0.16, 0.11, 0.12 and 0.18 mg/L respectively). It means that the productivity of water ecosystem was highest after the cold snap when surface layers were enriched with nutrients due to wind and convective mixing.

The suggested method allows making more accurate estimates of GP and D daily values by summing up results of three hour expositions during periods intensive primary production. In the light bottle at the end of intraday exposition bubbles of O₂ can be seen with the standard method. And in the dark bottle the concentration of O₂ may decrease to 0, but the time of its depletion in case of intraday exposition will be unknown. The maximum daily values of GP and D, measured by authors, were 19.4 and 20 mgO₂/day, and for the period 6:00-18:00 - 22.6 and 10.4 mgO₂/day.

D had a positive but not statistically significant relationship with water temperature, and achieved maximum values in calm weather, during intensive production process and growth of phytoplankton quantity (Q). The authors had no diurnal data about Q, but it is possible to make such a conclusion basing it on light reduction at 0.5 m at growth of radiation above the water, comparing adjacent days. Changes of net production (NP) also correspond to synoptic conditions, particularly wind speed: in calm weather NP either is small or negative, and its increase is timed to periods of wind growth. The same tendency can be seen with difference of water temperature and minimum air temperature, which characterizes the intensity of free convection. This accordance is revealed quite well by the middle of July, when Pm was less than 0.01 mg/L. So, dynamic and convective mixing replenished nutrients in the surface layer.

Automatic registration made it possible to reveal changes of day-to-day activity of NP and D. In the beginning of July after the phase of clean water NP measured every 3 hours was in the interval from -0.4 to 1 mgO₂/(3 h). And despite cloudy rainy weather its maximum daily values increased due to increase of nutrients. D changed from 0.15 to 1.3 mgO₂/(3 h) and reached maximum in the evening after 18:00 or 21:00. In the period of anticyclone weather in the end of August with calm conditions at night there can be found distinct changes of both characteristics. And D reached its maximum values especially at night (after

midnight or 3:00). NP changed in the interval from -0.8 to 1.5 mgO₂/(3 h) and it did not increase with the rise of water temperature. And for D it can be found a tendency to increase its maximum and minimum values (up to 3.9 and 2.3 mgO₂/(3 h) respectively). Automatic registration of PP has a big potential for application to study synoptic and day-to-day changes. Prompt care about bottles can help to avoid overgrowing and distortion of O₂ measurements. It is necessary to point out restriction of measurements during stormy weather.

Acknowledgments

Supported by the Russian Foundation for Basic Research (18-05-01066 A).

The author is grateful to A.V. Goncharov for his invaluable contribution to the measurements made on the reservoir.

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