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Reconstruction of the diurnal behavior of the concentration of chlorophyll in the surface and bottom water of the coastal zone of Lake Baikal on the basis of empirical calibration of fluorescence characteristics

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ABSTRACT. The paper presents the analysis of comparing the of synchronous measurements of fluorescence characteristics and the concentration of chlorophyll in Baikal water. The empirical coupling coefficient was determined and, according to the data of long-term measurements of fluorescence characteristics, the daily cycle of the concentration of chlorophyll was restored for different seasons of the year.

Keywords: Baikal, phytoplankton, chlorophyll-A, coastal zone, diurnal behavior.

1. Introduction

It is known that at the interface "water-atmosphere system" one of the most important regulators of the exchange of carbon gases CO_2 and CH_4 is the photosynthetic activity of aquatic biota (Domysheva et al., 2014). Knowledge of the concentration of chlorophyll is necessary to assess the degree of development of algae and their biomass. Currently, various methods for determining the concentration of chlorophyll by its fluorescence are widely used to with expedition assess the temporal variability and spatial distribution of chlorophyll over the water area of the studied object. The main problem in assessing the concentration of chlorophyll from the results of measurements of fluorescent signals is the need to choose a coupling coefficient **S** (CL = **S*** F) (Mikheeva, 1970; Itoh and Sugiura, 2004). Often used for calculations, the coefficient **S** is assumed to be constant, which even for one specific type of plankton requires a special study. When we are dealing with a dispersed medium, the detected fluorescence signal depends on the particle size distribution function, their shape, structure and complex refractive index (Lopatin and Sid'ko, 1988). To empirically estimate the coefficient **S**, we performed a correlation analysis of a long series of synchronous measurements of the fluorescence characteristics of **F** and the concentration of chlorophyll **CL** in the water of Lake Baikal in different seasons of the year. It is shown that both in separate series of measurements and in the combined data array, the value of the correlation coefficient R more 0.92. This result made it possible, on the basis of data from long-term measurements of fluorescence characteristics (Zavoruev et al., 2018), to restore the average daily pattern of the concentration of chlorophyll in the water of the coastal zone of Lake Baikal for different seasons of the year.

2. Material and methods

The fluorescence characteristics in water samples are measured using the slow induction method (first, the stationary fluorescence signal Fs is recorded, and then the signal after the photosynthesis inhibitor – **Fd**). The analysis of the diurnal variation of fluorescence characteristics was carried out on the basis of a series of regular measurements in all seasons of the year obtained in the coastal zone from 2004 to 2017. Since 2018, in the coastal zone and expeditions along the Baikal

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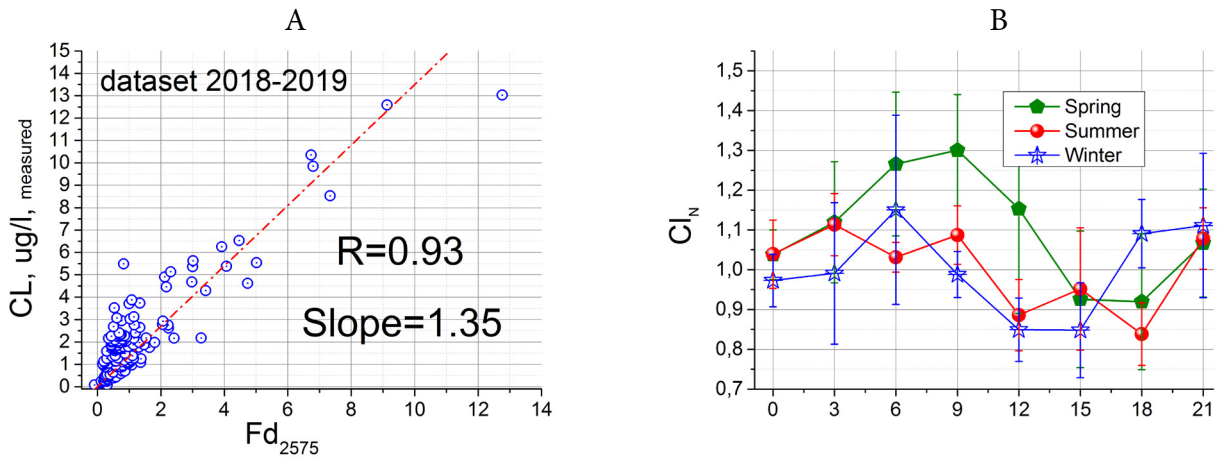

Fig.1. A - correlation diagram of the relationship between the fluorescent signal Fd_{2575} and the concentration of chlorophyll in the combined data array (here Fd_{2575} = (Fd - Fd_{is}) / 75, where Fd_{2575} is the signal from distilled water, and Fd = 75 is the average signal value over the entire array analyzed data). **B** - the restored daily variation in the concentration of chlorophyll in surface water for three seasons of the year.

water area, we started measuring the concentration of chlorophyll-A, using the spectrophotometric method**.**

3. Results

An analysis of the results of synchronous measurements of the fluorescence characteristics and chlorophyll concentration showed that in each observation cycle there is a close correlation between the values of **Fd** and **CL**. It turned out that in all the series the value of the correlation coefficient R is more than 0. 92. But it should be noted that the value of the coefficient **S** varies in the range 1.1-1.3 (coastal zone in the winter period of 2018 and 2019); 1.5-1.6 (water samples at various depths from 0 to 100 meters in June cruises 2018 and 2019), and the highest value S = 2 was recorded directly off the shoreline of the bays of Lake Baikal. Earlier, we showed that in each season there is a particular diurnal rhythm of variability of fluorescent characteristics, due to the activity of phytoplankton. Given some variation **S** coefficient values in several cycles of observation, for the reconstruction of the data of our long-term measurements of the fluorescence characteristics, we evaluated the combined array S for all series (Fig. 1A). Using the value of the coupling coefficient **S** = 1.35, the concentration of chlorophyll in the water of the coastal zone of Lake Baikal was calculated (an example of the normalized diurnal variation for surface water is shown in Fig. 1B).

4. Discussion and conclusion

Analyzing the obtained results, it should be noted that in the case when the concentration of chlorophyll is reconstructed using the empirical coefficient S in the same observation cycle, the uncertainty of the restored values of **CL** is on average 15%. When reconstructing the data of long-term measurements (there is no prior knowledge of the species composition of plankton), the use of the average value of S leads to an increase in the uncertainty of the restored values of C to 25-35%. In our opinion, this is quite acceptable for an operational assessment during monitoring measurements and for the development of empirical models.

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References

Domysheva V.M., Usoltseva M.V., Sakirko M.V. et al. 2014. Spatial distribution of carbon dioxide fluxes, biogenic elements, and phytoplankton biomass in the pelagic zone of Lake Baikal in spring period of 2010–2012. Atmospheric and Oceanic Optics 27: 529-535. DOI: 10.1134/S1024856014060049

Itoh S., Sugiura K. 2004. Fluorescence of photosystem I. In: Papageorgiou G.C., Govindjee (Eds.), Chlorophyll a fluorescence: a signature of photosynthesis. The Netherlands, Dordrecht, pp. 231-250.

Mikheeva T.M. 1970. Otsenka produktsionnykh vozmozhnostey yedinitsy biomassy fitoplanktona [Assessment of production capability of unit phytoplankton biomass]. In: Biologicheskaya produktivnost' evtrofnogo ozera [Biological productivity of eutrophic lake]. Moscow, pp. 50-70. (in Russian)

Lopatin V.N., Sid'ko F.Ya. 1988. Vvedeniye v optiku kletochnykh suspenziy [Introduction to optics of cell suspensions]. Novosibirsk: Nauka. (in Russian)

Zavoruev V.V., Domysheva V.M., Pestunov D.A. et al. 2018. Daily course of CO2 fluxes in the atmosphere–water system and variable fluorescence of phytoplankton during the open-water period for Lake Baikal according to long-term measurements. Doklady Earth Sciences 479: 507-510. DOI: 10.1134/S1028334X18040207