

Influence of nitrogen oxides on the process of absorption of greenhouse gases by chlorophyll-synthesizing microalgae

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The influence of nitrogen oxides on the CO₂ uptake rate by chlorophyll-producing microalgae of Chlorella type was investigated. Experimental dependences of microalgae concentration growth over time under certain values of nitrogen oxides concentration in the culture medium were obtained. The mathematical model of microalgae biomass growth depending on nitrogen oxides concentration was developed. Based on the solution of the mathematical model and the obtained experimental data, the concentration of nitrogen oxides for the maximal microalgae growth was determined.

Keywords: nitrogen oxides (N_xO_y), chlorophyll-synthesizing microalgae, biomass growth, mathematical model, optimum concentration.

Introduction

Nowadays, climate change on the Earth makes the world scientific community and world leaders of the states worry. One of the ways to solve this problem is to reduce the concentration of CO₂ in the atmosphere by incorporating the photosynthetic properties of plant organisms in industrial environments. This is one of the methods of biological purification, which is based on the ability of chlorophyll-synthesizing microalgae to involve to the metabolism schemes the substances that cause environmental pollution, using them for nutrition in the process of their life [1].

In the case of fuel combustion, in addition to carbon dioxide (CO₂) and sulfur (SO₂), a large amount of nitrogen oxides (N_xO_y) is formed, which is subsequently oxidized to NO₂ by the air. When it comes to the purification of industrial gas emissions with chlorophyll-synthesizing microalgae, it is important to determine the effect of nitrogen oxides on the processes of carbon dioxide absorption by microalgae.

From literary sources it is known that the concentration of nitrogen oxides that adversely affects the flora is within the range of 0.17 - 0.35 mg/m³ [2]. Therefore, it was important to investigate the concentration of harmful effects on microalgae of the Chlorella type and, therefore, research within these concentrations was the impetus for our work.

Description of the problem

The object of the laboratory research was Chlorella - the culture of green microalgae. Since nitrogen dioxide is absorbed by micro-algae in the form of anion NO₃⁻, for the study of the effect of nitrogen oxides on the growth of chlorophyll-synthesizing microalgae, an anion with the concentration of 1,7 mg / m³ was added to the first volume, 3,4 mg / m³ to the second, 8,5 mg / m³ - to the third, 15,6 mg / m³ to the fourth, 34 mg / m³ to the fifth, and 68 mg / m³ to the sixth one.

The growth of biomass chlorophyll-synthesizing microalgae under these conditions was determined by a photo-colorimetric method using a blue light filter according to Bouguer-Lambert-Ber.

Since the optical density is proportional to the concentration of algae, which is confirmed by the calibration graph, therefore the experimental data on the accumulation of algae biomass depending on the time within the studied nitrogen oxide concentration (N_xO_y) correspond to the value of optical densities [3].

Based on the results of experimental data and calculation values, graphically dependent changes in the concentration of algae cells in time at the appropriate concentrations of nitrogen oxides (N_xO_y) in a solution under the conditions of their single injection were obtained (Fig.1, Fig.2).

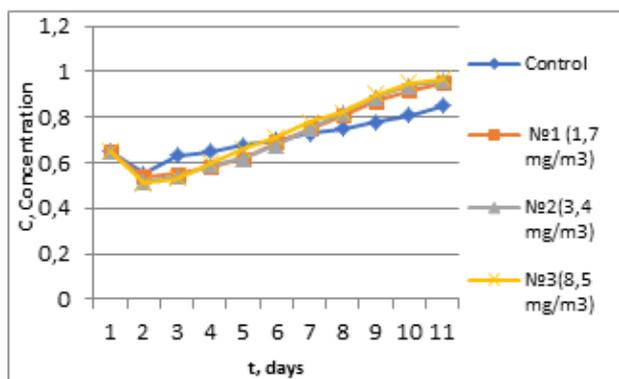


Fig. 1. Dependence of the change in the concentration of cells of algae in time at appropriate concentrations NO_3^-

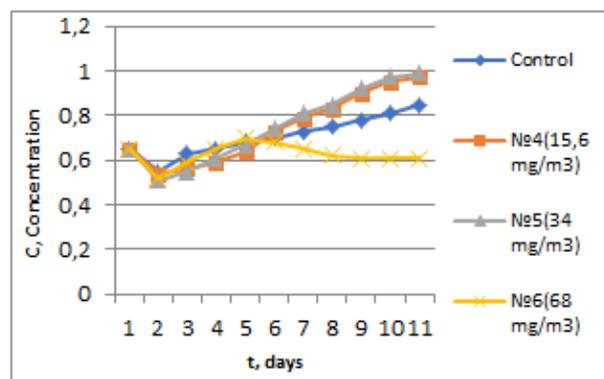


Fig. 2. Dependence of the change in the concentration of cells of algae in time at appropriate concentrations NO_3^-

The main goal of the work should be to find the critical concentration of NO_3^- at which a harmful effect on microalgae will come.

The mathematical formulation of the model for the growth of microalgal biomass under the condition of the presence of nitrogen oxides is to achieve a maximum of their growth, with a further reduction is the system of equations (Eq.1):

$$\begin{cases} \frac{dC}{dx} = k_1 C - k_2 C \\ \frac{dC}{dx} = k_1 C; & (1) \\ x = 0, C = C_o; \end{cases}$$

where, x – concentration of nitrogen oxides; C - concentration of algae in a suspension; k_1 , k_2 - coefficient of growth of biomass of algae.

The decision of the mathematical model has the form (Eq.2):

$$x_{\max} = \frac{\ln k_2 - \ln k_1}{(k_1 + k_2)}; (2)$$

Under these circumstances, calculating the growth factors for algae - k , according to experimental data of studies, it is always possible to calculate and predict the values of nitrogen oxide concentrations, which maximize the growth of microalgae in the absorption of carbon dioxide and to forecast equipment for the implementation of the technological process in practice.

Conclusion

A mathematical model of the growth of microalgae colonies in the absorption of carbon dioxide has been constructed under the presence of nitrogen oxides. Based on the decision of the mathematical model and the experimental results obtained, the calculated value of the optimum concentration of N_xO_y for the growth of microalgae of the *Chlorella* type is established. In addition, the solutions made will allow in the future to predict equipment for the implementation of the technology of absorption of greenhouse gases, provided N_xO_y is present.

References

- [1] Kolektiv avtoriv; za nayk. Red M. S. Malovanyi: Rozvutok i vidtvorenniya resyrsnogo potenzialy sybektiv ekologo-ekonomichnux, tyrustuchnux ta ekoinchormazinux sistem: monograchiya/ - L: Vudavnutstvo Lviv Polytechnic, 2015 - 340 c.(in Ukrainian).
- [2] Influence of nitrogen oxides on the human body and plants/[Electronic resource]/ Access mode: http://refs.co.ua/82015-Vozdeiystvие_oxidov_azota_na_organizm_cheloveka_i_rasteniya.html
- [3] Dyachok V., Huhlych S., Yatchyshyn Y., Zaporochets Y., Katysheva V. About the problem of biological processes complicated by mass transfer // Chemistry & Chemical Technology. – 2017. – T.11, № 1. – c. 111-116.