Study of *Elodea canadensis* elimination of Sodium Dodecyl Sulphate and NH₄Cl

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Abstract. The absorption of an anionic surfactant - sodium dodecyl sulfate (SDS) by a *Elodea canadensis* was studied. Macrophyte (20 g / L wet weight) reduced the concentration of this surfactant from 2 mg / L by 90% within 2 days. A negative effect of SDS on the elimination of ammonium nitrogen by *E. canadensis* was shown with its content from 1·10⁻⁴ M. Thus, in the presence of 1·10⁻⁴ M SDS, *E. canadensis* reduced the concentration of ammonium nitrogen by 51% of the initial value in 2 days (in the control - without surfactants - 92% of the pollutant was absorbed).

1. Introduction

One of the most pressing problems for water bodies in different regions is pollution with detergents and nutrients (urea, ammonium, nitrates, phosphates). Both groups of substances can have a negative effect on aquatic organisms. Both biogens and detergents cause eutrophication of water bodies [1-3]. At the same time, surfactants - the basis of the latter - exhibit toxicity in certain concentrations. There are publications about their inhibition of the growth and physiological activity of aquatic plants. The latter plays an important role in the processes of self-purification of water bodies, especially shallow water bodies [4].

The problems of eutrophication are beginning to worsen for Lake Baikal as well. Here the situation is complicated by the very weak mineralization of the Baikal water. Therefore, an increase in the concentration of nutrients and detergents in Baikal should be easier to initiate eutrophication than in other water bodies. In our time, there is an intensified development of the tourist business on the shores of Lake Baikal. About 1.5-2 million tourists visit Baikal every year. The consequence of this is the formation of about 780 thousand tons of waste [5]. Every year, the lake receives about 60 million tons of wastewater from settlements and from enterprises located on its shores.

In recent years, a strong overproduction of filamentous algae has been observed on Lake Baikal. Subsequent death and decay of the phytomass, a sharp decrease in oxygen, have a negative impact on the hydrobionts of the lake [6].
To predict the situation in a reservoir with the accumulation of pollutants, information is needed on the processes of interaction in the "plants-biogens-surfactants" system. This is also important in terms of biotesting, as well as in the development of phytoremediation measures.

Sodium dodecyl sulfate (SDS) is one of the most widely used detergent components. This anionic surfactant is found in many household cleaning products, personal care and cosmetic, pharmaceutical and food products, as well as industrial and commercial cleaning products [7].

*Elodea canadensis* has long filled a huge number of various water bodies [8-10]. In the second half of the last century, it reached Baikal and other water bodies of its basin [11, 12]. At the same time, *E. canadensis* is characterized by high adaptive abilities and rapid growth. In addition, it is capable of efficiently eliminating nutrients and other pollutants in aquatic environments. The latter determines its wide application in phytoremediation technologies [13-15].

Based on the foregoing, the purpose of this communication was to study the effect of SDS on the ability of *E. canadensis* to absorb ammonium nitrogen from aqueous solutions.

2. Materials and methods

The research object *E. canadensis* was collected in the Angara River (Irkutsk) in the spring-autumn period of 2020. Before the experiments, elodea was adapted to laboratory conditions. For this, it was incubated for three days at a temperature of 8 °C under illumination of 3000 lx in settled tap water; the water intake was above the city of Irkutsk.

In the experiments, SDS of the pure grade (manufactured by OOO AO REACHIM) was taken as a surfactant. This anionic surfactant has a molecular weight of 288 g / mol. The structural formula of SDS is shown in Fig. 1 [7].

![Figure 1. Structural formula of sodium dodecyl sulfate](image)

*Study of surfactant absorption by E. canadensis.*

A weighed portion of *E. canadensis* (20 g / L wet weight) was placed in a freshly prepared SDS solution with a concentration of 2 mg / L. The plant was exposed to the test solutions for 2 days. The surfactant concentration in the solution was analyzed by a photometric method with methylene blue, in accordance with PND F 14.1: 2.15-95 [16]. In non-sterile conditions, SDS can undergo destruction. In this regard, the experimental results were compared with the kinetics of the surfactant content in the absence of plants.

*Study of the effect of surfactants on the elimination of ammonium nitrogen by E. canadensis.*

To prepare solutions of ammonium nitrogen, ammonium chloride (reagent grade) was used. The initial concentration of NH$_4^+$ in the experiments was 4 mg / L NH$_4^+$. A weighed portion of *E. canadensis* (20 g / L fr wt) was placed in a freshly prepared ammonium solution and incubated for 2 days. During this time, the content of ammonium nitrogen was periodically analyzed in the samples under study. For this, a photometric method with Nessler's reagent was used, in accordance with RD 52.24.486-2009 [17]. When assessing the effect of surfactants on the elimination of nitrogen by *Elodea*, SDS was added to the tested ammonium solutions at concentrations of 1·10$^{-5}$ M, 1·10$^{-4}$ M, 2·10$^{-3}$ M, 5·10$^{-3}$ M. The experimental results were compared with the kinetics NH$_4^+$ content in the absence of plants. All experiments were carried out under the same conditions as the adaptation of *Elodea* to laboratory conditions.
Statistical data processing
Statistical data processing was performed using the Microsoft Office software package. The experiments were carried out in 5 independent experiments, 3 replicates in each experiment. The conclusions were made under the P ≥ 0.95 probability of error-free prediction.

3. Results
Under the conditions of our experiments, *E. canadensis* (20 g / L fr wt) absorbed up to 92% of ammonium nitrogen (as a percentage of the initial) in 2 days of the experiment (Fig. 2).

![Figure 2. Changes in the ammonium concentration under the influence of the *E. canadensis* plant (concentration in % of the initial concentration)](image)

The study of the effect of SDS on the processes of elimination of ammonium nitrogen by *E. canadensis* revealed the following. This surfactant had a negative effect on the elimination of ammonium nitrogen by *E. canadensis* at its content from 1·10^{-4} M. In the presence of SDS at the indicated concentration, *E. canadensis* reduced the concentration of ammonium nitrogen by 51% of the initial one in 2 days (in the control - without the influence of the pollutant - 92% of the pollutant was absorbed). Lower concentrations of the tested surfactants had no visible effect in Fig. 3. It follows that the kinetics of changes in the content of ammonium cations with the content of SDS in the solution (1·10^{-5}; 2·10^{-5}; 5·10^{-5} M) was comparable to that with the absorption of elodea in the absence of this surfactant.
Figure 3. Change in ammonium concentration under the influence of E. canadensis in the presence of sodium dodecyl sulfate (concentration of NH$_4^+$ in % of the initial concentration)

Thus, SDS did not affect the ability of Elodea to eliminate nitrogen with its content of 5·10$^{-5}$ M. Moreover, the ability of E. canadensis to eliminate SDS has been shown. Thus, within 2 days of exposure, the macrophyte reduced the content of SDS in the water (at its initial concentration of 2 mg / L by 90% compared to the initial one (Fig. 4).

Figure 4. Changes in the concentration of sodium dodecyl sulfate (SDS) under the influence of the plant E. canadensis (concentration in% of the initial).

4. Discussion
The results obtained in our experiments showed a high efficiency of the E. canadensis macrophyte in the absorption of ammonium salts. The rate of elimination of ammonium nitrogen in this case is consistent with the data of other researchers [18, 19].

It was revealed that SDS at a content of 1·10$^{-4}$ M inhibited the process of ammonium elimination by elodea, and at lower concentrations (from 5·10$^{-5}$ and below) did not affect this process.
The described materials once again demonstrate the promise of *E. canadensis* as a possible object for use in phytoremediation technologies. It is important that it is also applicable for complex water pollution with biogenic elements and surfactants.

5. Conclusion
The concentrations of the anionic surfactant sodium dodecyl sulfate were revealed, which negatively affect the absorption of nitrogen by the aquatic plant *E. canadensis* from aqueous media. A surfactant in a concentration of 1·10^{-4} M reduced the absorption capacity of the macrophyte for NH\textsubscript{4} cations by 40%. Lower concentrations of sodium dodecyl sulfate did not affect the processes of nitrogen absorption by plants.

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