NEUTRON ACTIVATION ANALYSIS FOR DEVELOPMENT OF MERCURY SORBENT BASED ON BLUE-GREEN ALGA SPIRULINA PLATENSIS

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ABSTRACT

Epithermal neutron activation analysis was used to study interaction of blue-green alga *Spirulina platensis* with toxic metal mercury. Various concentrations of Hg(II) were added to cell cultures in a nutrient medium. The dynamic of accumulation of Hg was investigated over several days in relation to *Spirulina* biomass growth. The process of Hg adsorption by *Spirulina* biomass was studied in short-time experiments. The isotherm of adsorption was carry out in Freindlich coordinates. Natural *Spirulina* biomass has potential to be used in the remediation of sewage waters at Hg concentrations ~ 100 μg/l.

INTRODUCTION

Mercury and its compounds are widely used in various branches of industry, agriculture and medicine penetrating the environment in one or another way. A considerable anthropogenic part of the environmental pollution by Hg is contributed by Hg pyrometallurgy, non-ferrous metallurgy, production of chlorine and caustic soda, consumption of fuel, garbage etc. Mercury holds the first position for toxicity among other heavy metals. Medico-biological studies of the last decades showed the gravity of the «mercury hazard» related to the transition of chronic poisoning by Hg vapor from the professional diseases into the disease of population.

Thus, the necessity to study the peculiarities of Hg interaction with living systems is obvious. A blue-green microalgae Spirulina platensis (S. platensis), which is widely used as a basis for pharmaceuticals and also as a biologically active food additive for humans and animals, is considered as a living system. Algae are often used in water remediation from heavy metals [1–3]. The processes of accumulation and adsorption of mercury by biomass of the blue-green alga S. platensis depending on the Hg concentration in the medium, where the growth of spirulina cells occurs, were studied.

MATERIALS AND METHODS

Experiments. Cultivation of *S. platensis* was carried out in a standard Zaroukh alkaline water-salt medium, mercury glycinate ($HgNCH_2COOH$) was used as a nutrient loading.

In the first series of experiments to study the Hg accumulation by the *S. platensis* cells the concentrations of nutrient medium loading by mercury constituted 100, 50, 5, 1, 0.1 μg Hg/L. Samples in all the series were taken every 24 hours.

In the second short-term series of experiments to study the Hg adsorption by *S. platensis* concentration of nutrient medium loading was 500 μg Hg/L. Dynamics of the adsorption processes, usually taking place during 1-2 hours, were studied during 1 hour. Samples were obtained in 2, 10, 20, 40 and 60 minutes after the beginning of cultivation.

Analysis. Mercury content in the samples was determined by epithermal neutron activation analysis (ENAA) at the pulsed fast reactor IBR-2 (FLNP JINR, Dubna). Earlier we used the technique of ENA analysis of *S. platensis* samples both to determine its background elemental content and to study accumulation processes of some trace elements [4,5]. The samples were irradiated for 5 days and their activity was measured twice in 4 and 20 days. The mercury content was determined by γ-line with the energy 279.1 keV of isotope ^{203}Hg. Here the influence of interference lines ^{75}Se and ^{182}Ta was taken into consideration. The ENAA data processing and determination of Hg concentrations were performed with the help of programs used in FLNP JINR.

RESULTS AND DISCUSSION

The results of experiments to study Hg accumulation from nutrient medium by the *Spirulina platensis* biomass at cell cultivation during 6 days at various Hg concentrations are presented in Fig.1. In all the cases the exponential character of decrease of Hg content is observed. The curves are well approximated by the function $y=y_0+Ae^{-x/t}$.

Such character of dependence seems to be clear, as the number of *S. platensis* cells grows exponetially, the number of sites of Hg(II) ion binding surpasses considerably the number of Hg(II) ions in nutrient medium. This results in blocking of toxic Hg ions and their removal from the nutrient medium. Such mechanism may serve as one of the important ways for biosphere to «self-purify» from heavy metals with the help of microorganisms.

The results of investigation of Hg adsorption process by the *S. platensis* cells are presented in Fig. 2. The experimental data obtained by ENAA method approximate well by the polynomial of the third order: $y=0.3586-0.02286x+0.00332x^2-0.0000406482x^3$. As seen from the obtained curve, the maximum Hg content is adsorbed by the *S. platensis* biomass within 50 minutes and then a diminution of concentration is observed. Similar character of dependence of Hg(II) accumulation was also obtained in paper [6].

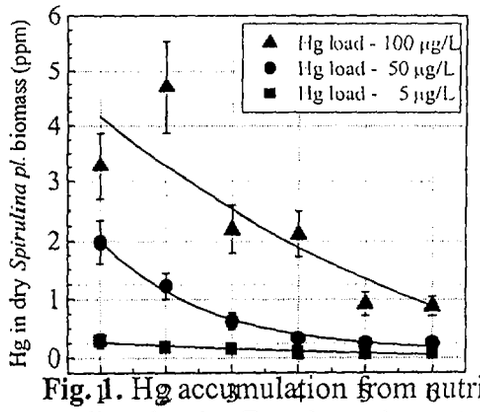

Fig. 1. Hg accumulation from nutrient medium by the *Spirulina platensis* biomass at various loading during 6 days.

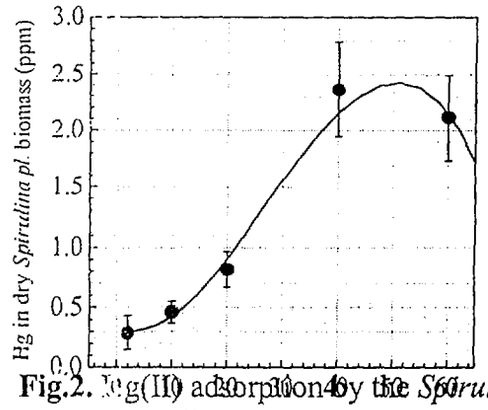

Fig.2. Hg(II) adsorption by the *Spirulina platensis* cells. Time (min.)

If we take into account that Hg content in control samples constituted approximately 0.007 ppm, than it turns out to be that in 50 minutes the *S. platensis* biomass accumulates mercury in about 300 times more. Thus, at relatively low Hg concentrations (of the order of 100 μg/L) in the medium *S. platensis* can be used in the remediation of industrial and sewage waters from mercury.

Here, it should be also noted, that the *S. platensis* biomass consisting of long trichoms can be easily gathered (separated) by filtration, which makes the technological process considerably cheaper and simpler.

CONCLUSIONS

1. By the ENAA method it is possible to control the rate of Hg assimilation from nutrient medium by the *S. platensis* biomass in the course of its cultivation in open ponds.
2. At Hg concentrations of the order of 100 μg/L the *S. platensis* biomass in its natural state may be used to accumulate Hg(II) ions for the purpose of their removal from the cultivation medium.
3. The *S. platensis* biomass is suitable for fast remediation of industrial and sewage waters from mercury by way of biosorption and subsequent separation with the help of filtration.

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