Adsorption and accumulation of Cd(II) ions by *Spirulina platensis* cells

A. Khizanishvili, A. Belokobilsky, L. Mosulishvili, E. Ginturi, N. Kuchava, A. Rcheulishvili

E. Andronikashvili Institute of Physics Academy of Sciences Georgia, Tbilisi, Georgia

Versatile studies of heavy metals effect on microorganisms in addition to the theoretical interest have particular importance for such practical problems as treatment of waste water, water bodies and soils for toxic metals removal, application of microorganism biomass as biological indicators of environment contamination, development of technologies of high-purity biomass cultivation for food and feed stuffs or production of biomass enriched in essential elements and so forth [1].

Cadmium is a heavy metal and like other heavy metals it tends to be accumulated in organism. In human organism cadmium is most effectively bound by high-molecular proteins (e.g. albumin) and nonprotein sulfhydryl groups (e.g. metalthionein) and is accumulated by kidneys (30-40%) and liver (20-25%). Cadmium adsorption can entail decrease of zinc, magnesium and chromium content and increase iron and calcium deficit in organism. It is known that Cd(II) affects carbohydrate metabolism, hippuric acid synthesis in liver and activity of some ferments. The excess of Cd(II) in organism, damaging DNA and destructing reparation mechanisms of damaged DNA, can cause genetic changes and cancer [2].

Blue-green alga *Spirulina platensis* (*S.platensis*) is a promising object for studies of different metals absorption and accumulation processes. Cell wall of *S.platensis* consists of polysaccharides, proteins and lipids having lots of negative carboxyl and phosphate groups, which are the dominant binding sites of toxic and heavy metals cations [3].

In figure 1 the behavior of Cd(II) concentration in the nutrient is shown in the cell growth dynamics. When loading nutrient with Cd(II) (0.1÷10 mg/L), its concentration in the nutrient practically does not vary with cell growth, decreasing to only a small extent by the 5-6 cultivation days. Although Cd(II) is accumulated by cells in small amounts, its effect is quite significant. Under Cd(II) load of 40mg/L, binding of cadmium considerable amount by cells as well as strong inhibition of cell growth are observed. Such amounts of Cd(II) suppress heavily normal functioning of cells.

Though *S.platensis* cells accumulate cadmium from the nutrient weakly, its toxic effect on cells appears as growth inhibition, photosynthesis disturbance and it is verified by microscopic control (fig. 2). Cytological examination of *S.platensis* cells with different cadmium content showed changes in cytoplasm structuring and yellowing of the cells. Both control *S. platensis* cells and cells, cultivated in the medium loaded with 80mg/L of Cd(II), appear in fluorescent microscope as given in fig. 2 (a, b) When adding orange acridine dye, *S. platensis* living cells fluoresce in ultraviolet. The green fluorescence is due to two-strand sections of RNA and DNA. The yellow-orange fluorescence is caused by single-strand RNA and DNA sections, which occur during denaturation. The red-brownish background is due to chlorophyll *a*, phycocyanin C and possibly mucopolysaccharides. It is distinctly seen that cadmium destroys *S. platensis* cells.

Experiments on cadmium adsorption in the time interval from 0 to 60 minutes are shown in fig. 3 for algae cultivation at different temperatures. At t 5°C *S. platensis* biomass during the initial period of 5-15 min adsorbs up to 20% of the total cadmium content in the nutrient. During the following 20 min about 8% of the adsorbed cadmium is released into the nutrient. For temperature 35 and 40°C, when metabolic processes in cells are more intensive, the levels of the

initial adsorption and following release are lower. It seems that *S.platensis* cells resist to cadmium adsorption on their surface because at 5°C, when metabolism processes are inhibited, much more Cd(II) is adsorbed during the initial period of 10 min than in the case of cell normal functioning at 35°C and 40°C.

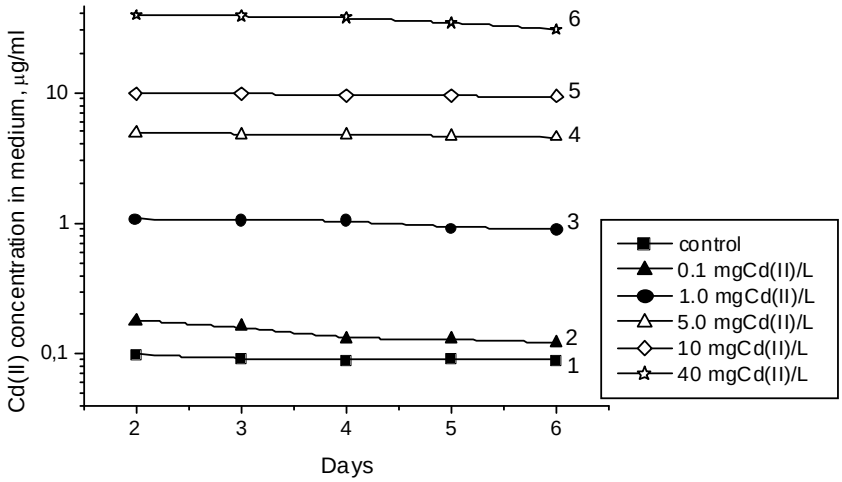
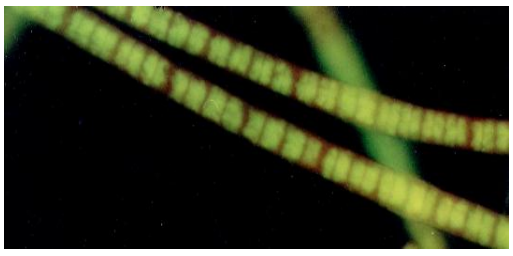
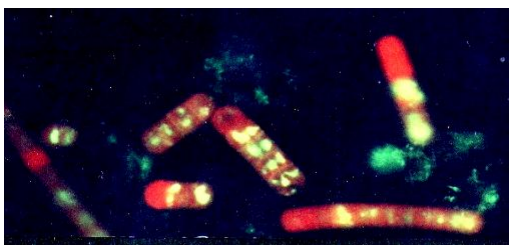


Fig.1. Cd(II) ions concentration dynamics in the nutrient at different loads (accumulation).



a



b

Fig. 2. Photographs of *S. platensis* cells in fluorescent microscope:
a) control cells;
b) cells, cultivated in the nutrient with Cd(II) load 80 mg/L.

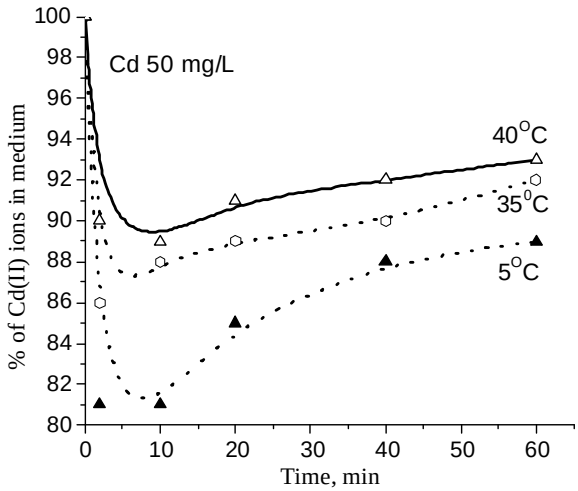


Fig. 3. Short-term dynamics of Cd(II) content in the nutrient (%) (adsorption).

References

1. Snow Elizabeth T. *Biol. Trace Element Res*. **1992**, 21, 61-71.

2. Carrnichael W. W. *Sci. American*. **1994**, 78-86.

3. Vonshak A. (Ed.). Spirulina Platensis (Arthrospira): Physiology, cell-biology and Biotechnology. Taylor&Francis, London, **1997**.