

Heavy metals and cyanobacteria: towards bioremediation

Heavy metals are one of the most common pollutants worldwide, being a serious hazard to the environment and public health. These metals are usually removed from polluted waters by physicochemical methods that can have substantial costs, low efficiency for contaminants present in low concentrations and generally do not allow to recover the metal. The use of microorganisms or their isolated extracellular polymeric substances (EPS) (e.g. slimes) can overcome these limitations.

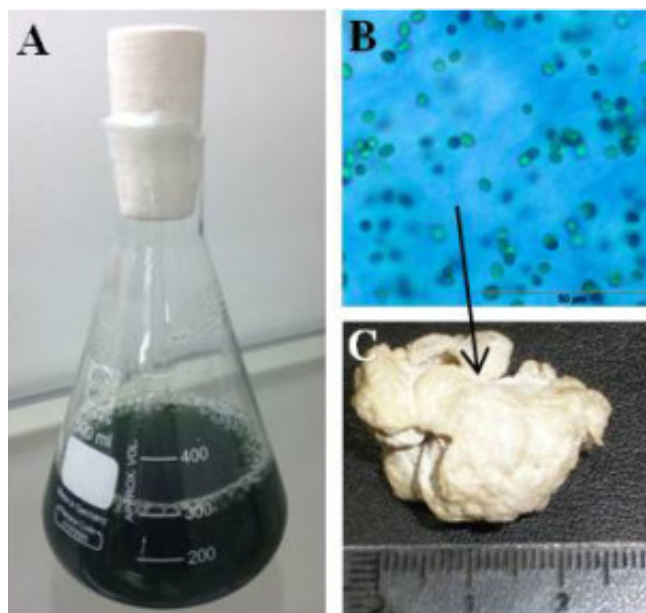


Fig. 1. Cyanobacteria sp. CCY 0110 culture (A), cells stained with an EPS specific dye Alcian blue (B) and the isolated lyophilized polymer (C).

Cyanobacteria are a diversified and ubiquitous group of bacteria that perform photosynthesis similar to algae and plants. In addition, several strains are capable of producing extracellular polymeric substances (EPS), which can be associated with the cell surface or be released into the environment, and that in nature have different roles associated with protection against UV, desiccation, etc. EPS-producing cyanobacteria or their isolated polymers can be useful to remove heavy metals from polluted waters, since these microorganisms are easy to cultivate, have minimal nutritional requirements and exhibit fast metal removal rates. Additional advantages of these EPS compared to those produced by other microorganisms are their particular characteristics: (i) overall negative charge due to the presence of specific groups (sulfate and uronic acids), increasing the polymer affinity towards metal cations, (ii) high number of different sugar residues (usually 6 to 10) increasing the number of possible polymer conformations, and (iii) high hydrophobicity (repel water molecules). However, the characteristics of each metal removal system strongly depend on

the metal, organism and/or EPS utilized. These metal removal systems can be based on an active uptake of the metal by the cells and/or a passive biosorption of the cations. Some metals are essential to cell life (e.g. copper and iron), while others are not (e.g. cadmium and lead). However, in excess, all metals are deleterious to the cells, leading to the development of strategies by the cyanobacterial cells to avoid/minimize the toxicity of the metals. In this context, the effects of the presence and concentration of copper, lead, cadmium and lithium, heavy metals commonly found in polluted water bodies, were evaluated on the cells of *Cyanothece* sp. CCY 0110, a unicellular and marine cyanobacterium previously shown to be a highly-efficient EPS producer. In this work the effects induced by the metals in the cell growth, internal ultrastructure and EPS production were evaluated. In addition, the proteomes (set of proteins within the cell) of cells grown in the absence or presence of different concentrations/times of exposure to copper or cadmium were compared using tagging technology (iTRAQ).

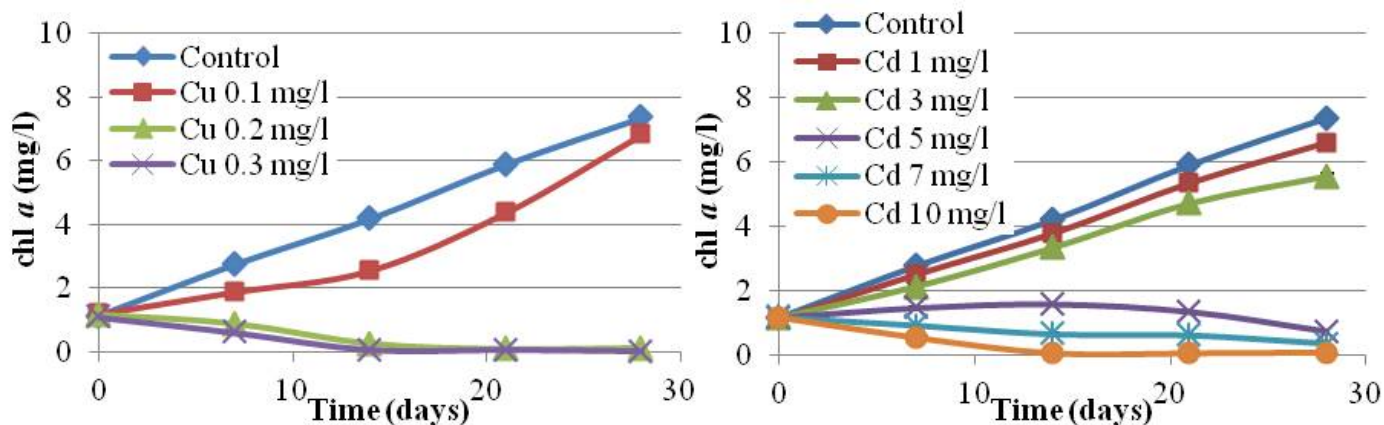


Fig. 2. Effects of different concentrations of copper (Cu) and cadmium (Cd) on *Cyanothece* sp. CCY 0110 growth.

The results revealed that each heavy metal affected the cells in a different manner, being copper the more deleterious, followed by lead, cadmium and lithium. The EPS production was not altered. All metals led to changes in the cell structure, mainly at the photosynthetic apparatus. The comparison of the proteomes allowed to distinguish specific effects related to the time of exposure and/or the concentration of the metals, which were associated to several important metabolic processes (e.g. photosynthesis, carbohydrate metabolism, and nitrogen and amino acid metabolism). Moreover, the results strongly suggest that in the presence of copper, the cells tune down their metabolic rate to invest energy in the activation of detoxification mechanisms, resulting in a remarkable recovery. In contrast, the toxic effects of cadmium were cumulative, revealing lower efficiency of the mechanisms of a non-essential metal detoxification compared to those of an essential one. The knowledge generated by this study can contribute to the implementation of heavy metal removal systems based on cyanobacterial EPS or their isolated polymers.

Publication

[Effects of heavy metals on *Cyanothece* sp. CCY 0110 growth, extracellular polymeric substances \(EPS\) production, ultrastructure and protein profiles.](#)

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