

Inga Zinicovscaia · Liliana Cepoi *Editors*

Cyanobacteria for Bioremediation of Wastewaters

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Forward and Preface

This book depicts some aspects of wastewater bioremediation using cyanobacteria. Cyanobacteria – one of the key actors in bioremediation – have big advantages over other life forms: specific adaptations of some representatives such as the desiccation resistance, the ability to fix nitrogen and to switch easily to mixotrophic nutrition etc. As mixotrophes, cyanobacteria are able to metabolize various organic substrates, including persistent organic pollutants, breaking them down into less toxic or non-toxic substances and using them as nutrients. Furthermore, cyanobacteria have the ability to use ammonium ions as a source of nitrogen, which is important in domestic and agricultural wastewater purifying. The ability of cyanobacteria to adsorb the microelements by the activation of membrane transport system is essential in bioremediation. These mechanisms ensure an active bioaccumulation and removing of metals from polluted environments. The mechanisms of conversion of toxic metal ions into less toxic forms are: formation of nanoparticles, their chelation and inclusion in the certain organic compounds of biomass. Thus, the accumulation of heavy metals by cyanobacteria from the polluted water, in addition to the positive environmental impact, may provide an opportunity to obtain metal nanoparticles both on cell surface and inside the cells. Moreover, it is possible to obtain biomass with metals (Fe, Zn, Cu, Cr, etc.) included in some fractions – a suitable raw material for the production of some preparations for metal deficiency treatment. In this case the toxicological potential of cyanobacteria should be taken into account, only well studied and certified for human and animal consumption species can be used.

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Chapter 1

Introduction

Liliana Cepoi and Inga Zinicovscaia

Human activities in recent decades have brought many advantages to modern civilization, but they also caused the accumulation of various pollutants in the environment. The situation facing the current generation of human beings can be defined as “stress of waste excess”, mainly due to the technological progress and industrial production. It took decades for people to realize the necessity to remediate environmental damages. This requires essential investments and special technologies, among them bioremediation can be considered as one of the most promising.

Bioremediation is defined as the process of using living organisms to clean up and return the contaminated environment to its original condition by accumulation and/or degradation of dangerous xenobiotics. Being a natural process, bioremediation occurs in the environment for millions of years. At the same time, it is successfully applied in the waste management programs using modern technologies for water and soil decontamination. Biological technology allows treatment “*in situ*” which essentially reduces technology cost.

Microorganisms are key players in bioremediation, providing different mechanisms and pathways of transformation and transfer of hazardous substances from one medium to another. Among other priorities of microorganisms as depolluting agents are their ubiquity, small size, high rate of reproduction and large surface-to-volume cell ratio.

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These features are also characteristic for cyanobacteria – one of the oldest photosynthetic prokaryotes group on the Earth. Cyanobacteria have big advantages over other life forms, which allowed them to survive in different conditions. Their biochemical processes and specific adaptations of some representatives such as the desiccation resistance and the ability to fix nitrogen make them very flexible. Additional advantages of cyanobacteria are their high availability, presence in saline water virtually in unlimited quantities, and their autotrophic nutrition, which greatly reduce their industrial cultivation cost. At the same time cyanobacteria have the ability to switch easily to mixotrophic nutrition depending on the composition of the available nutrient medium. As mixotrophs, cyanobacteria are able to metabolize various organic substrates, including persistent organic pollutants, which they use as nutrients, breaking them down into less toxic or non-toxic substances. Thus, the utilization of various nutrition modes is the advantage of cyanobacteria in the bioremediation process. Another very important aspect of cyanobacteria use in wastewater purification is based on their ability to use ammonium ions as a source of nitrogen.

Providing of cyanobacteria cells with metal ions, which are required to build their enzyme systems occurs through mechanisms involving sequestration of metals from dilute medium and conditions, which do not facilitate their transition into the cell. The ability of cyanobacteria to adsorb and transport the microelements by the activation of membrane transporter system involving metal permease, metal oxidase and metal reductase is essential in this case. These evolutionary emerging mechanisms for vital needs of cyanobacteria ensure in fact an active bioaccumulation and removing of metals from polluted environments. Heavy metal ions, especially those with multiple valences, are highly toxic to living cells including cyanobacteria, but could be converted into less toxic forms by biosorption and bioaccumulation. One of the mechanisms used by Cyanobacteria for this purpose is the formation of nanoparticles through reduction of metal ions. Thus, the accumulation of heavy metals by cyanobacteria from the polluted water, in addition to the positive environmental impact, may provide an opportunity to obtain metal nanoparticles both on cell surface and inside the cells.

Another mechanism used in cyanobacteria protection strategies for reducing the toxicity of metal ions is their chelation and inclusion in the composition of certain organic structures, such as amino acids, oligopeptides, proteins, oligo- and polysaccharides, etc. According to some authors, this aspect deserves special attention. Thus, in controlled technological conditions using media with certain metals, can obtain biomass with metals (Fe, Zn, Cu, Cr, etc.) included in some fractions. This biomass is a suitable raw material for the production of some preparations for metal deficiency treatment, because it allows to reduce metal toxicity for the body and to increase its bioavailability compared to traditional forms of these preparations. The toxicological potential of cyanobacteria should be taken into account, only well studied and certified for human and animal consumption species can be used. A good example for this purpose is *Arthrospira platensis* (*Spirulina*) – an extremely

valuable for its biochemical composition cyanobacterium, consumed for centuries and recognized as safe for use.

This book reflects the listed above aspects of biosorption and bioaccumulation, hoping to attract the interest of experts to collect new data that would allow highlighting useful information both for bioremediation technologies and for obtaining of valuable preparations using cyanobacteria.