Bioremediation of polluted waters using microorganisms

Water pollution can be caused by contamination with organic compounds, inorganic compounds, for example heavy metals, or by contamination with microorganisms and represent a great concern for authorities worldwide. The contamination of aquatic ecosystems caused by mining is one of the most damaging anthropogenic activity to the environment. Some of the most common metal and metalloids found in the contaminated aquatic ecosystems are lead, chromium, mercury, uranium, selenium, copper, zinc, cadmium, nickel, silver and gold (Figure 1). The toxicity of the metals is the main concern. They are not just being toxic to human health, but also to the fauna and flora.

Although heavy metals are considered micronutrients, depending on the exposure levels, they become toxic, especially to humans. Because they have strong electrostatic interaction and binding affinity toward the same binding site as essential metal ions at cellular level, they cause destabilization of different structures such as cell wall, enzymes and nucleic acids. Major damages caused, at molecular level, by heavy metals contamination include mutagenesis, hereditary genetic disorders and even cancer.

Besides being toxic and nonbiodegradable, heavy metals also accumulate in living organisms. When referring at aqueous ecosystems, heavy metals in high concentrations can be accumulated, and the toxic effect can further increase and this progressive augmentation of a metal, as it advances in the food chain, is called augmentation. This process occurs as the lower organisms provide food for the organisms found in the higher trophic level, the pollutants that cannot be metabolized but are fat soluble, they will accumulate in the fatty tissues of the living organisms.

A more safe and environmental friendly way of cleaning the contaminated waters is represented by the bioremediation processes. Bioremediation process can be shortly described as the ability of some biological molecules to bind and concentrate ions or other molecules that are present in water.
Microorganisms used in bioremediation processes (Figure 1) include bacteria, yeast, fungi and microalgae, they can act as methylators, which are able to modify toxic species, and they can alter the chemical properties of metals.

![Biological Remediation Diagram](image)

**Figure 1. Microorganisms used in bioremediation and the most common metals that employ microorganisms in bioremediation processes**

Some of the biological and physicochemical techniques used so far (e.g. evaporation, sorption, osmosis, ion exchange, precipitation, electrochemical treatments), to remove heavy metals from the contaminated wastewaters, although cost-effective, they are not environmental friendly. Therefore, biological remediation using microorganisms comes as a more efficient alternative. The microorganisms are considered a biological tool that can remove and recover heavy metals from contaminated waters.

The great advantage of using microorganisms in remediation processes is that even a small concentration of microorganisms can act on pollutants, and the microbes can adapt to extreme conditions. The most common and effective microorganisms species used in bioremediation are bacteria and fungi, but algae and yeast are also frequently chosen (Table 1).
Table 1. Examples of microorganisms used in bioremediation treatments of heavy metal

<table>
<thead>
<tr>
<th>Bacteria</th>
<th>Arthrobacter spp.</th>
<th>Fungi</th>
<th>Penicillium canescens</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Pseudomonas veronii</td>
<td>Aspergillus versicolor</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Burkholderia spp.</td>
<td>Aspergillus fumigatus</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Kocuria flava</td>
<td>Cladospora fascicularis</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Bacillus cereus</td>
<td>Spirogyra spp.</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Sporosarcina ginsengisoli</td>
<td>Cladospora spp.</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Escherichia coli</td>
<td>Algae</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Bacillus subtilis</td>
<td>Yeast</td>
<td>Saccharomyces cerevisiae</td>
</tr>
<tr>
<td></td>
<td>Enterococcus faecium</td>
<td></td>
<td>Candida utilis</td>
</tr>
<tr>
<td></td>
<td>Staphylococcus aureus</td>
<td></td>
<td>Saccharomyces boulardii</td>
</tr>
</tbody>
</table>

In the process of biological remediation, the microorganisms can be used even in their natural occurring form. The technology is based on either a single type of organisms or a consortium of microorganisms that convert highly toxic compounds to less toxic chemical through metabolic pathways. They can degrade, decompose or transform contaminants into less toxic metabolites or nontoxic end products, or they can use these pollutants as potential energy source.

References