Bioremediasi Logam berat

Nur Hidayat

Pendahuluan

- Metal wastes are produced by a variety of sources including mines, tanneries, and electroplating facilities and through the manufacture of paints, metal pipes, batteries, and ammunition
- Sulfide and oxidized ores exposed during mining operations have the potential to produce leachate solutions that contain high concentrations of dissolved metals
- These leachate solutions can affect the quality of plant and animal health in surface water used for agriculture, recreation, and human consumption.
- Metal contamination has been linked to birth defects, cancer, skin lesions, mental and physical retardation, learning disabilities, liver and kidney damage, and a host of other maladies.

Pendahuluan

- Rapid alteration in their toxicity hence assumes importance for a safe environment.
- Through the decades a number of microorganisms have been discovered to help in the reduction of metal contamination

Strategies of metal bioremediation

- Metals are not degradable.
- Unlike hydrocarbons, biodegradation of metals into innocuous CO2 and water is not possible.
- Irrespective of the available reactions, the same metal will still be present but bacterial strains have been found to have the capacity to concentrate or remediate them into forms that are precipitated or volatilized from solution and hence less toxic and easily disposable.
- In other words, microorganisms can only alter the speciation of metal contaminants and convert them into non-toxic form

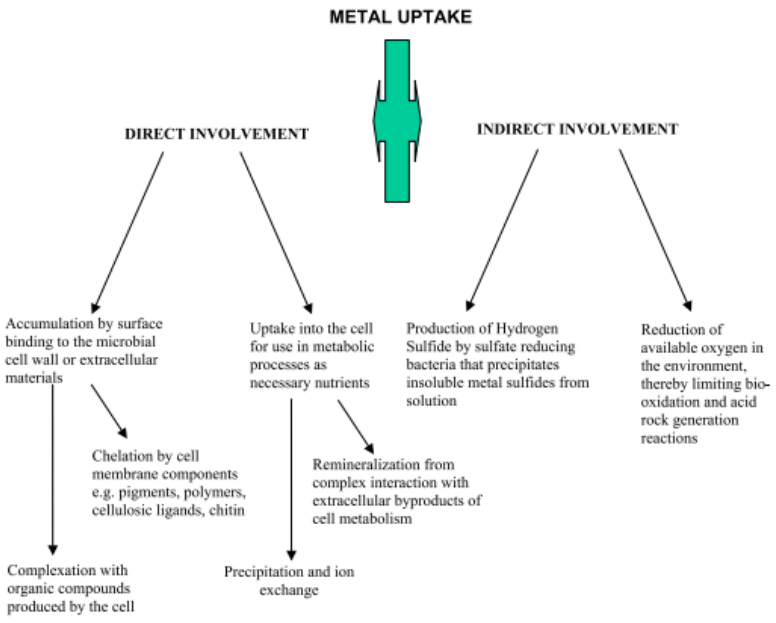

Fig. 1. Different microbial processes for metal uptake and sequestration.

Biosurfactants and metal remediation

- Microbial compounds that exhibit particularly high surface activity and emulsifying activity are classified as biosurfactants
- These are structurally diverse surface active compounds capable of reducing surface and interfacial tension at the interfaces between liquids, solids, and gases, thereby allowing them to mix or disperse readily as emulsions in water or other liquids.
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Biosurfactant

- In general, their structure includes a hydrophilic moiety consisting of amino acids, peptides, anions or cations; mono-, di-, or polysaccharides, and a hydrophobic moiety consisting of unsaturated or saturated fatty acids.
- Accordingly, the major classes of biosurfactants include glycolipids, lipopeptides and lipoproteins, phospholipids and fatty acids, polymeric surfactants, and particulate surfactants

biosurfactants enhance the desorption of heavy metals from soils in 2 ways:

- Complexation of the free form of the metal residing in solution. This decreases the solution phase activity of the metal and, therefore, promotes desorption according to Le Chatelier's principle.
- Direct contact of biosurfactant to sorbed metal at solid solution interface under conditions of reduced interfacial tension, which allows biosurfactants to accumulate at solid solution interface.

biosurfactant

- rhamnolipid biosurfactant produced by various *Pseudomonas aeruginosa* strains capable of selectively complexing cationic metal species such as Cd, Pb, and Zn
- surfactin from Bacillus subtilis, for the removal of heavy metals from a contaminated soil and sediments
- A single washing with 0.5% rhamnolipid removed 65% of the copper and 18% of the zinc, whereas, 4% sophorolipid removed 25% of the copper and 60% of the zinc. Surfactin was less effective, removing 15% of the copper and 6% of the zinc.

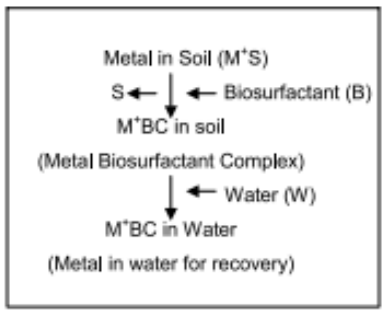

Fig. 2. Use of biosurfactant for metal recovery.

biosurfactant

- Saponin was effective for the removal of heavy metals from soil attaining 90–100% of Cd and 85–98% of Zn extraction
- biosurfactants have advantage over synthetic surfactants in their small size, less toxicity, biodegradability, specificity, and ease and manipulation of production process while they score over exopolysaccharides in selectivity and small size.
- The effectiveness of the use of biosurfactants for metal remediation increases in terms of cost involved at sites co-contaminated with organic compounds.

Metal remediation in co-contaminated soils

- Bioremediation of such sites can be impaired by the presence of heavy metals, making cleanup of the contaminated site more challenging
- reduced cadmium toxicity *by P. aeruginosa* rhamnolipid leading to an enhanced naphthalene biodegradation by a *Burkholderia* sp
- rhamnolipid reduces metal toxicity might involve a combination of rhamnolipid complexation of cadmium and rhamnolipid interaction with the cell surface to alter cadmium uptake resulting in enhanced rates of bioremediation

Metal remediation in co-contaminated soils

- The efficiency of biosurfactants for stimulating biodegradation of contaminants is uncertain given the specificity observed between biosurfactant and organism.
- biosurfactant can stimulate some organisms but also can inhibit some microorganisms
- biosurfactant into co-contaminated sites for in situ treatment may be more environmentally compatible and more economical than using modified clay complexes or metal chelators such as EDTA

Metal remediation and biofilms

- Many of the geochemical and biological processes mediated by microorganisms are localized by cells within a matrix of extracellular polymeric secretions (EPS), composed of polysaccharides, proteins, and nucleic acids collectively called a “microbial biofilm.”
- Protected within the matrix, cells have a better chance of adaptation and survival (especially during periods of stress) than when cells are present in solution
- Biofilm can sorb water, inorganic and organic solutes, and particles

Metal remediation and biofilms

- Various microbial biofilms have been found to sorb metals by varying activities.
- One major microbial community involved in the formation of biofilms, especially in metal contaminated waters, is the group of sulfate reducing bacteria (SRB), which are highly efficient in the anaerobic degradation of many organic pollutants as well as in the precipitation of heavy metals from waste water as metal sulfide

biofilms

- A simultaneous increase in the EPS content of the biofilm was also observed suggesting the role of EPS and biofilm in the entrapment of metal precipitates. Similar results were obtained in a previous study with biofilms exposed to cadmium
- trace metal interactions with microbial biofilms in natural and engineered systems.

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Breakthroughs and Views

Enhancement of metal bioremediation by use of microbial surfactants

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