Chapter 1
Biomining Microorganisms' Molecular Aspects and Applications in Biotechnology and Bioremediation

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ABSTRACT

The effective dissolution of metals is widely known with the help of microorganisms called bioleaching or biomining used for the extraction of metals from their ores. Usually the microorganisms involved in biomining are chemolithoautotrophic and extremophilic in nature, since they are living in highly acidic environments (pH 1-3.0) containing heavy concentrations of metals. The commonly found genera of archea are Sulfolobus, Acidianus, Metallosphaera, and Sulfurisphaera. Throughput microbial genomics and proteomics analysis provides novel insights of metabolism mechanisms of bioleaching microbes. These microbes are having significant impact on the bioremediation of acid mine drainage (AMD) resulted from many industrial operations. Using these microbes, various metals including Ni, Cd, Cu, Fe, As, Pb, Hg, Cr, Mn, Zn, etc. are removed from the environment. Biomining microorganisms are having significant applications in the biotechnological processes including extraction of gold from ores, extraction of nickel from low-grade sulfide ores, extraction of copper from chalcopyrite, etc.

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INTRODUCTION

An ore is a naturally occurring source from which metals can be extracted. Ores are generally present in oxide forms. Different metals are having their respective ores, e.g. bauxite (Al_2O_3) is a very common ore found on earth from which metal aluminium can be extracted. Haematite (Fe_2O_3) is an ore of iron, pyrolusite (MnO_2) is an oxide ore of manganese. Mining is defined as the approach of extraction of metal ores from deep underground (Johnson, 2014). The metal ores are naturally present in earth's crust in very large amount. Ores are commonly found in oxide forms e.g. bauxite (Al_2O_3), haematite (Fe_2O_3), rutile (TiO_2) or in sulfide forms e.g. pyrite (FeS_2), chalcopyrite ($CuFeS_2$) etc. The metals are extracted from its ores by -

1. **Ores Concentration:** To remove the unwanted rocks by purifying and concentrating ores (Wang et al., 2010).
2. **Reduction to Crude Metal:** The metals in the form of crude ones are reduced from their oxide forms for easy purifications (Lovley, 1995).
3. **Refining:** In order to obtain the pure metal from crude mixture of different metals purification can be followed (Tuncuk et al., 2012).

Electrolysis process can be applicable to obtain pure metal from metal oxides (Chen et al., 2000). In electrolysis of $Al_2O_3.2H_2O$, positively charged metal Al^{3+} can be attracted to negatively charged cathode whereas O^{2-} attracts towards positively charged anode.

BACKGROUND

Historically *in situ* leaching of copper was reported by Galen, a naturalist and physician in AD166 which were later came to know due to microbial community (Cummins &McAuliffe). Copper sulfate was used to be extracted from the rock by flow of water on its surface which later on percolates into and resultant solution contained high concentrations of copper sulfates. Further crystals of copper sulfate were recovered by evaporating the solution. However, the Romans were used to obtain the pure copper by a process of heating and melting, collectively known as smelting. The Chinese people in 1096 used to follow the cementation process for extracting the copper from copper sulfate. However, the bioleaching process was first observed and understood by Paracelsus the Great (1493 – 1541) (Cummins &McAuliffe). He observed the deposition of copper onto iron at the spring in Zifferbrunnen, Hungary. He aided in the process of bioleaching and during 1750 around 200ton per annum copper was recovered using bioleaching in the same area.