

Introduction to Bioleaching

Extraction of metals from low-grade ores by employing microorganism is called as bioleaching. Large quantities of low-grade ores are produced during the separation of higher-grade ores and are generally discarded in waste heaps. Metals from such ores cannot economically be processed with chemical methods. There are large quantities of such low-grade ores especially copper ores, which can be processed profitably by bio-leaching.

Mechanism of Bioleaching:

The process of bioleaching is accomplished by two ways:

- (i) Direct bioleaching
- (ii) Indirect bioleaching

(i) Direct Bioleaching: In this process, a physical contact exist between bacteria and ores and oxidation of mineral takes place through enzymatically catalysed steps.

Example: pyrite is oxidised to ferric sulphate

Thiobacillus ferrooxidans is oftenly used in microbial leaching. It is an autotrophic, aerobic, gram (-) negative rod shaped bacterium. It synthesizes its carbon substances by CO₂ fixation. It derives the required energy for CO₂ fixation either from the oxidation of Fe²⁺ to Fe³⁺ or from the oxidation of elemental sulphur or reduced sulphur compounds to sulfates.

1. $4\text{Fe} + 6\text{H}_2\text{SO}_4 + 3\text{O}_2 \rightarrow 2\text{Fe}_2(\text{SO}_4)_3 + 6\text{H}_2\text{O}$ (1)
2. $2\text{S} + 3\text{O}_2 + 2\text{H}_2\text{O} \rightarrow 2\text{H}_2\text{SO}_4$ (2)
3. $2\text{FeS}_2 + 7\text{O}_2 + 2\text{H}_2\text{O} \rightarrow 2\text{FeSO}_4 + 2\text{H}_2\text{SO}_4$ (3)

Thiobacillus thiooxidans oxidizes insoluble sulphur to sulphuric acid, which takes place in the periplasmic space. It is possible to dissolve iron through direct bacterial leaching as shown in the above reactions.

ii) Indirect Bioleaching:

This leaching process takes place without direct involvement of microorganisms but they indirectly support the leaching by producing agents responsible for oxidation of minerals. It can be explained by the process of oxidation of pyrite. Pyrite is a common rock mineral that is found in association with many ores. The pyrite is initially oxidized to elemental sulphur equation 4, which is subjected to further oxidation by *Thiobacillus*

ferrooxidans due to which sulphuric acid is formed which is shown in equation 2.



Processes of Bioleaching:

Methods described below are generally employed in large scale bioleaching processes:

(a) Slope Leaching:

Here the ores are first ground to finepieces and then dumped into large leaching dump.

Water containing inoculum of *thiobacillus* is continuously sprinkled over the ore.

Water is collected from the bottom and used to extract metals and generate bacteria in an oxidation pond.

(b) Heap bioleaching:

- Here the ore is dumped into large heaps called leach heaps.
- Water containing inoculum of *thiobacillus* is continuously
- Water is collected from the bottom and used to extract metal and generate bacteria in an oxidation pond.

(c) In situ bioleaching:

- In this process the ore remains in its original position in the earth.
- Surface blasting of earth is done to increase the permeability of water.
- Water containing *thiobacillus* is pumped through drilled passage to the ores.
- Acidic water seeps through the rock and collects at the bottom.
- Again, water is pumped from bottom.
- Mineral is extracted and water is reused after generation of bacteria.

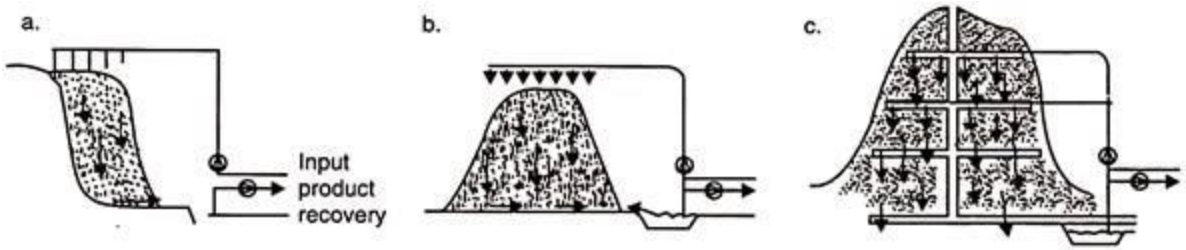


Fig. 12.1: Processes of bioleaching (a) slope bioleaching (b) heap bioleaching (c) in-situ bioleaching

Copper bioleaching:

Ores of copper from which copper is recovered are:

Chalcocite (Cu_2S)

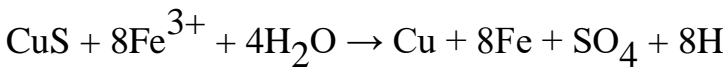
Chalcopyrite (CuFeS_2)

Covellite (CuS)

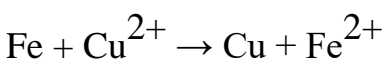
(a) Chalcocite is oxidized to soluble form of copper



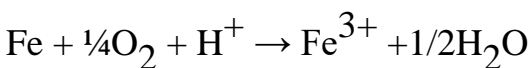
(b) Thereafter chemical reactions occur, i.e.



(c) Copper is removed.



(d) Fe^{2+} is transferred to oxidation pond



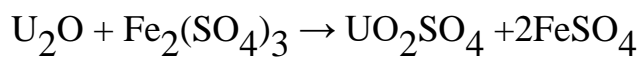
Fe^{3+} ions produced by the oxidation of ore pumped back to pile. Sulphuric acid is added to maintain pH.

Uranium leaching:

Uranium is extracted when insoluble tetravalent uranium is oxidized with a hot $\text{H}_2\text{SO}_4/\text{FeSO}_4$ solution to make hexavalent uraniumsulphate.

pH required for the reaction is 1.5-3.5 Temperature: around 35 degree C

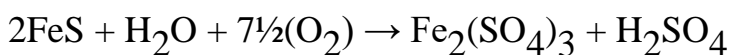
Following reaction take place in the process



Uranium leaching is an indirect process.

When *T.ferrooxidans* are involved in uranium extraction, they do not directly attack on ore but on the iron oxidants.

The pyrite reaction is used for the initial production of Fe



Gold and Silver Leaching

Microbial leaching of refractory process metal ores to enhance gold and silver recovery is one of the promising applications.

Gold is obtained through bioleaching of arsenopyrite/ pyrite.

Silver is also obtained by bioleaching of arsenopyrite but it is more readily solubilized than gold during microbial leaching of iron sulphide.

