

**Biomining:  
A Green Technology to Mine Valuable Metals**

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## **Introduction:**

Biomining is the process of extracting valuable metals from ores and mine tailings with the assistance of microorganisms. It is a very low capital, low operational cost, and a low energy input process. This technology is also environmentally friendly as it generates minimal amount of pollutants. It has the added benefit of mining low grade ore and/or mine tailings. The depletion of high grade ores and the onerous environmental burden inherent in the pyrometallurgical technologies are forcing mining companies to examine alternative metal-extractive procedures. Biomining can undoubtedly provide such a green technology to exploit mineral resources. Physical-chemical processes utilized in conventional mining technologies necessitate large amounts of energy for roasting/smelting and produce harmful gaseous emissions such as sulfur dioxide; biomining will help eliminate these problems. Furthermore, the tailings generated by biomining operation are less chemically active. The biological activity these tailings would support is reduced to a minimum as they have already been bioleached. The modest nutritional requirements and the irrigation needed to support the select microbial life in a heap or the tank reactors are indeed less expensive than the enormous cost associated with pyrometallurgical processes.

## **What is Biomining?**

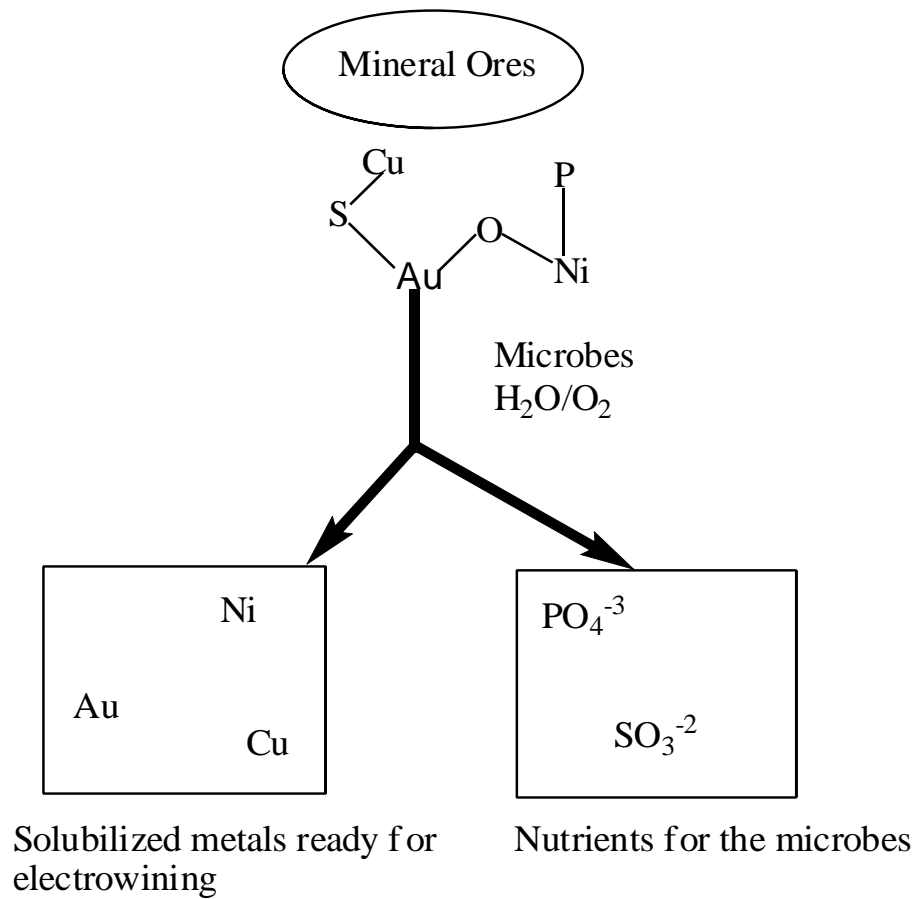
Biomining is the process of extracting valuable metals from ores and mine tailings with the assistance of microorganisms. It is an effective and green technology to mine metals.

### **Biomining an Effective Mining Technology:**

1. Low infrastructure
2. Low-labour input
3. Green Technology, low gaseous emission
4. Low energy demand
5. Low operating cost compared to other mining technologies
6. Cleaner tailings
7. Mine high/low grade ores and economically viable tailings

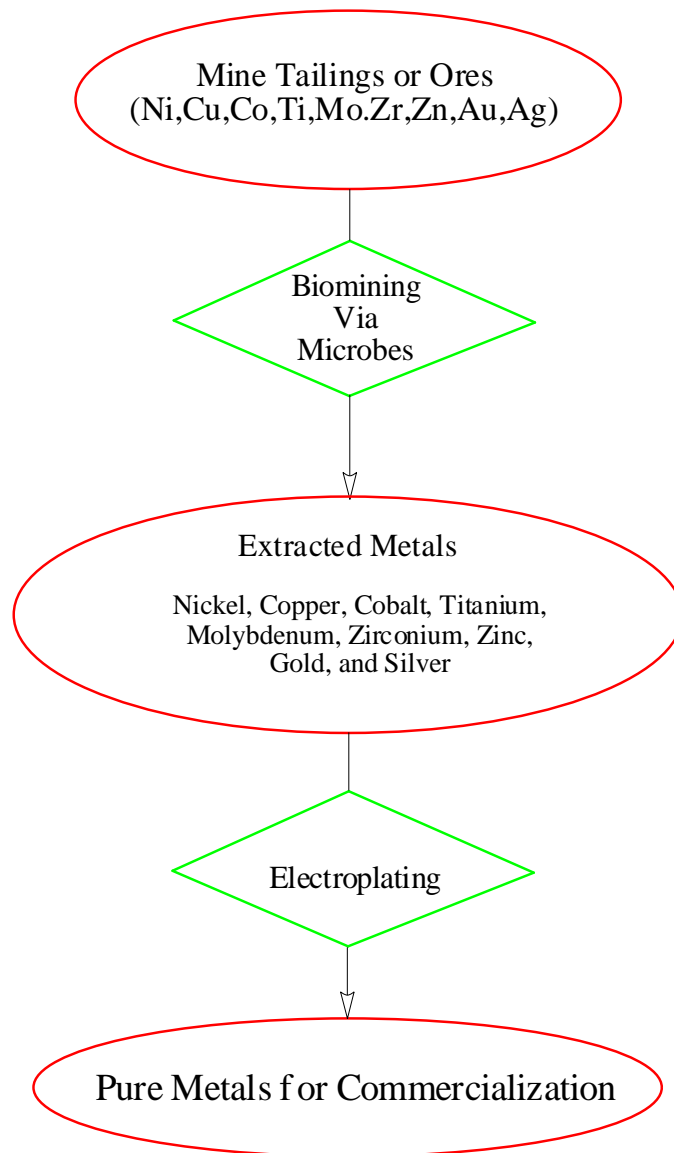
# How Biomining Works?

## A Schematic of Biomining

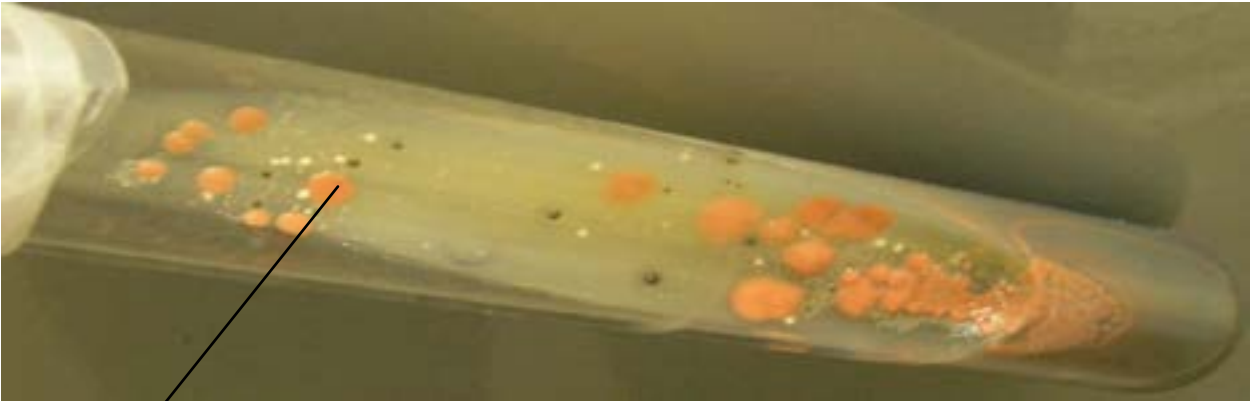


The main aim of this technology is to utilize biooxidation and biotransformation to decompose the mineral matrix and exposed the entrapped valuable metals.

## From Tailings/Ores to Pure Metals The Biomining Way



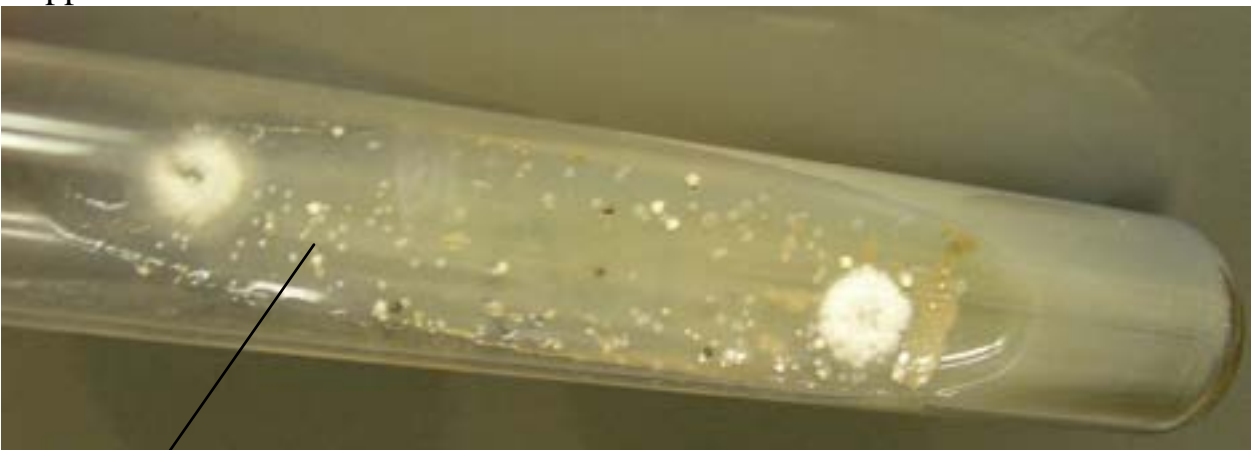
Bio mining Technology at Laurentian University  
Biominers:



Cobalt Miners

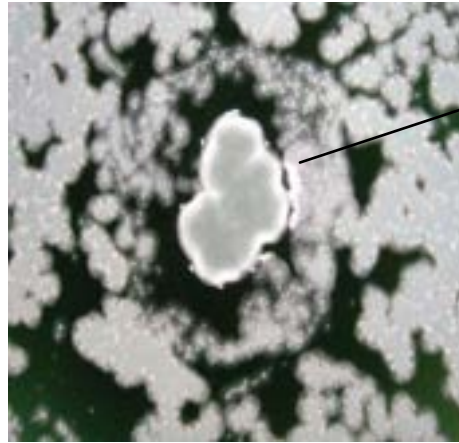
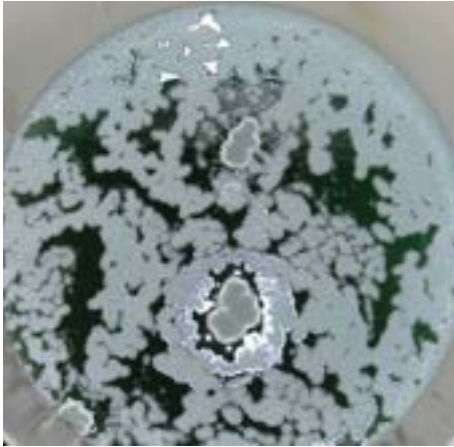


Copper Miners



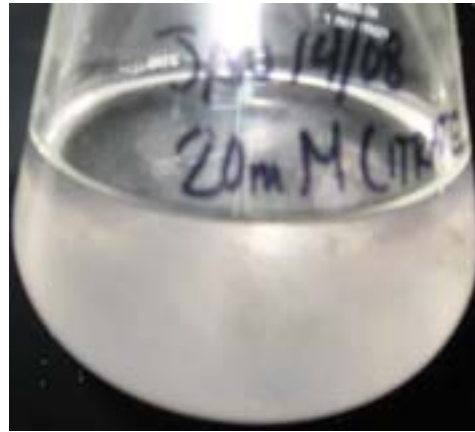
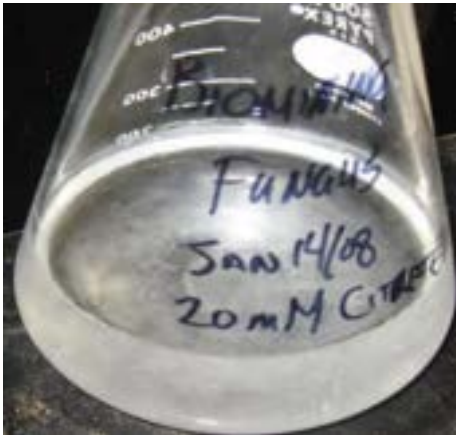
Nickel Miners

## Bio miners:



Microbial  
Mat

Fungi in the non-stirred reactor



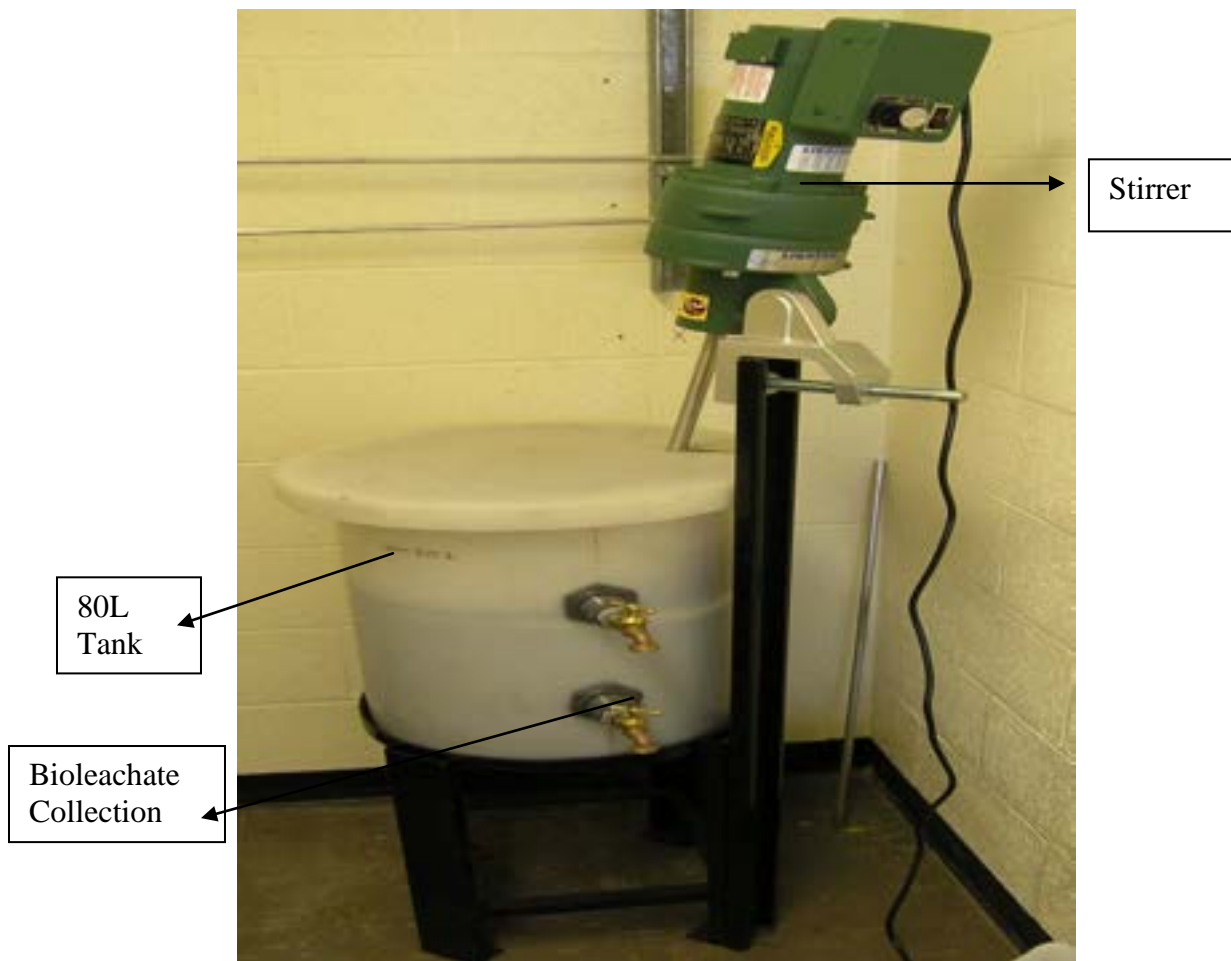
Bio mining fungus. (Used for Pt, Au, Ag, Ni, Cu, and Zn.)

## Types of Reactors

Shake Flask Reactors:



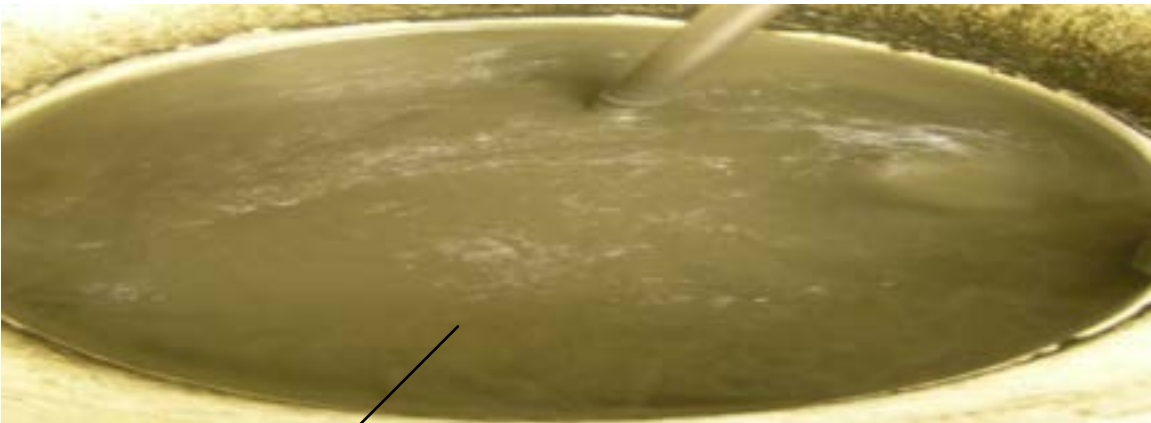
## Continuous-Stirred Bioreactor:



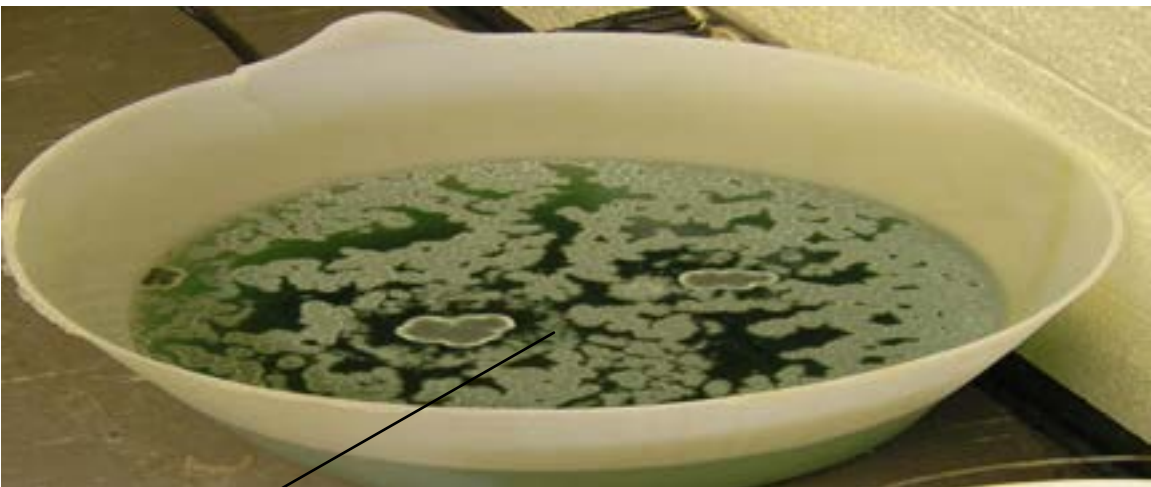
Inside Continuous-Stirred Bioreactor:



Tailings being stirred (day 1).



Tailings being stirred, (day 3)



Tailings that settled, (Final day 21)

# Flat Heap Bioreactor:



Collection Tank

Ore/Tailings slurry

Flat Bed Bioreactors:



Day 1 Tailings with fungus (Day 1)



Before



Fungus mixed with tailings (week 7).



After

# Automated Nutrient-fed Bioreactor:

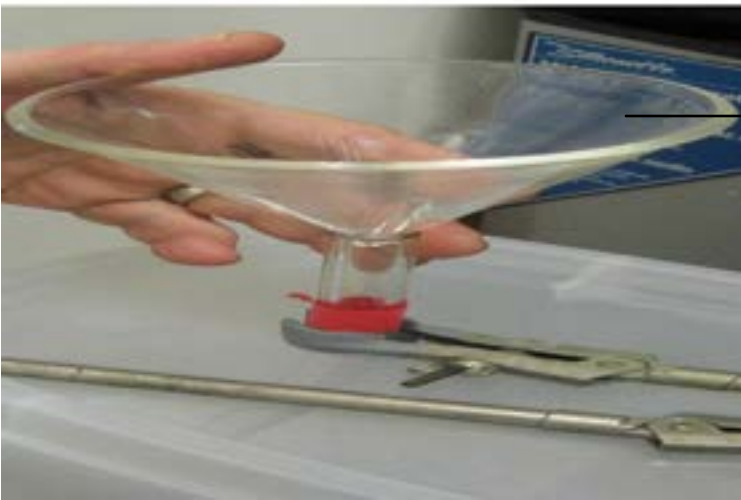


Nutrient  
Feeder



No microbial activity after biomining process.

## Heap Bioreactor:



Initial nutrient input

## Nutrient Delivery System



Continuous nutrient delivery system

## Inside of Heap Reactor

Sample collected from Heap Bioreactor:



Spun Samples (from Heap Bioreactor):



Sample in centrifuge bottle



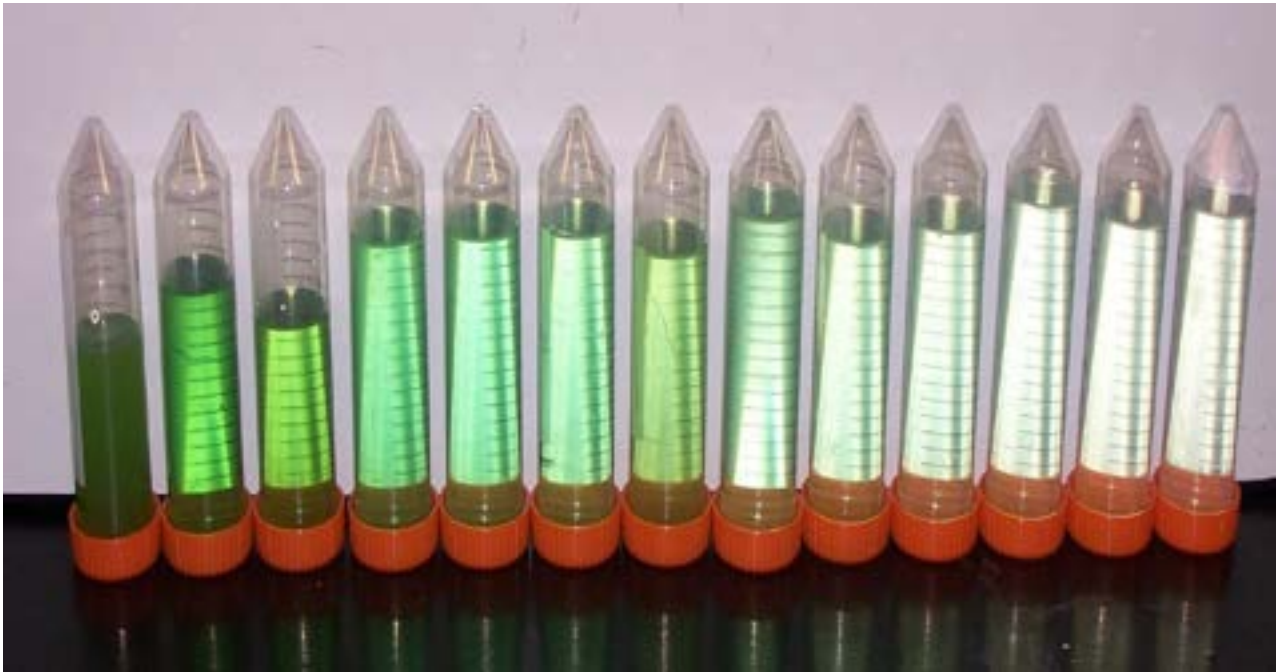
Orange-yellow colour

Bioleachate sample (day 3 high concentration of Nickel)



Bioleachate Sample (day 13 Iron deposits)

Bioleachate:



Left to right – day 1 to 13  
70% recovered in first week.

## Conclusion:

1. We have identified a microbial consortium that can extract valuable metals (Au, Ag, Cu, Ni, and Zn) from mine tailings, low and high grade ores.
2. Heap bioleaching is the most effective and economical process with a high yield of metals extracted.
3. Following the exploitation of the tailings or ore bodies, the microbial population is reduced drastically returning to natural levels. The population was controlled by nutrients and water concentration in the laboratory conditions after 3 weeks of being deprived of nutrients, 99.9% of the microbial system was eliminated.

## **Concluding Remarks:**

Bio mining is a green technology that can help mine valuable metals with minimal impact on the environment. It necessitates low energy and is not labour-intensive. As metal-rich surface ores get depleted, the mining of low grade ores and ores from the deep will become economically viable. However, pyrometallurgical processes will be ineffective to extract these ore bodies due to the cost, the energy demand, and the pollution associated with these technologies. Bio mining will become very attractive even in the Nordic countries where this technology has not been readily accepted. In tropical countries, this technology is routinely utilized to mine such commodities as copper, zinc and gold. The microbial-mediated preconcentration performed while mining gold is known to effectively double the yield of this metal. Bio mining offers tremendous potential as a technology to mine or preconcentration valuable metals and needs to be fully exploited in a mineral-rich country like Canada. To apply this technology to your mining needs, please contact Dr. V. Appanna .

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