PennState
College of Earth and Mineral Sciences

John and Willie Leone Family
Department of Energy and Mineral Engineering

The Reprocessing and Revalorization of Critical Minerals in Mine Tailings

An International Perspective

EME Summer Research Internship Program 2021 - Caden Vitti; Dr. Barbara Arnold

Introduction

Mine tailings are the byproduct of mining and mineral processing and are mass produced every year. These tailings, especially those produced many decades ago, contain a wide variety of critical minerals and other valuable minerals that would be put to waste if not reprocessed.

The amount of mine tailings is continuously increasing due to the increased consumption of metals and minerals and the advancement of mining technologies, which has allowed for the exploitation of lower grade ore.

This literature review analyzes the economic and technological value of reprocessing mine tailings, the environmental benefits to remining, common practices used to obtain critical minerals from tailings, and various uses for tailings waste that are being explored.

Values of Reprocessing

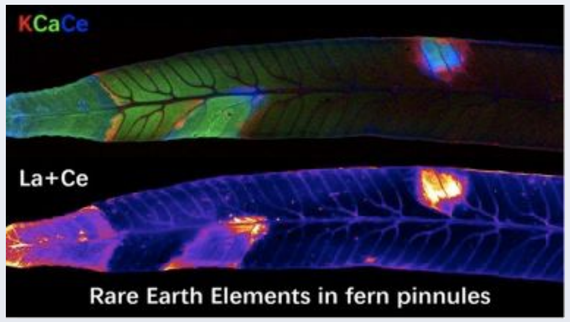
The recovery of critical minerals, especially valuable metals, can save millions of dollars in production and extraction costs per year. In local communities suffering from emmigration of mining workers after abandoning a mine, these metals can help to rebuild the local economies.

Many critical minerals, such as tin, have a variety of uses whose industries would benefit from reprocessing the mine tailings: construction, manufacture of vehicles, and packaging all rely on tin to different extents.

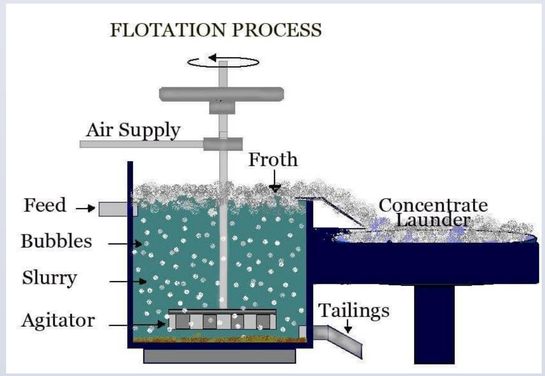
Rare earth elements in particular are used for several different technologies and are abundant in mine tailings: low carbon technologies, auto catalysts, digital technologies, magnets, video screens, catalytic stabilizers, medical imaging, lasers, cell phones, and more.

Processes of Extraction and Separation

Phyto-extraction: the cultivation of hyperaccumulator plants, which have the ability to collect high concentrations of certain metals in their shoots.

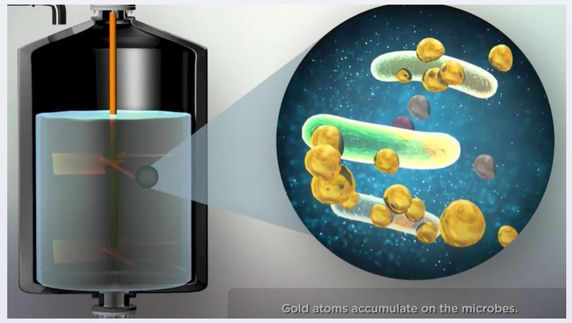


Froth flotation: the common practice of separating minerals by their attraction or repulsion from water (hydrophobicity).



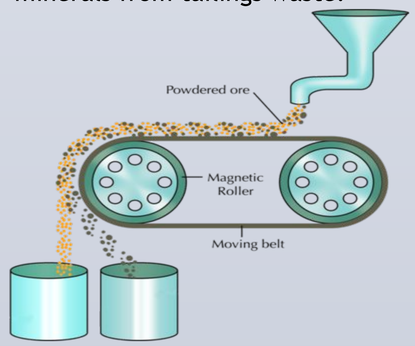
Dewatering: the removal of water from the particles in tailings to thicken the waste and increase pulp density.

Microbial biotechnology: the bioprocessing of rare earth elements (REEs) and other minerals through microorganisms and their ability to utilize such minerals for nutrients.



Hydrometallurgical recovery: the utilization of aqueous solutions through various methods - crystallization, leaching, solvent extraction, etc. - to separate and extract rare earth elements and critical minerals from mine tailings.

Magnetic separation: the use of screening and magnetic technology to separate minerals from tailings waste.



Potential Uses for Tailings

The practice of geopolymerization has allowed for advances in construction and industrial use. Eco-friendly geopolymer bricks are being created from copper mine tailings that meet construction standards. In addition, through geopolymerization of copper mine tailings, scientist are investigating the use of tailings for road base construction. It has been concluded that mine tailings can provide a substitute for filler materials in pavement.

Mine tailings can also be substituted for concrete specimens at up to 9% of conventional concrete by weight. This is applicable to a variety of the minerals found within these tailings.

Environmental Effects of Mining and How Reprocessing Can Help

Acid mine drainage, caused by the production of soluble iron and sulfuric acid from various ores in mine tailings, is one of the most detrimental effects of mining. In a Au-Ag-Cu mine in Tiouit, Morocco, about 743,000 tons of tailings are left over from 50 years of mining, with anywhere between 0.06-1.50% of those tailings containing sulfur or sulfide products.

Older mine tailings that were not as well processed may contain various heavy metals, which can affect surface and subsurface water sources and thus be detrimental to the plants and animals that rely on them.

The storage of excess mining waste - typically through coverage, burial, or disposal into large bodies of water contaminates the environment and can affect the species inhabiting that environment as well, such as the increase in larval mortality of Atlantic Cod as a result of ocean disposal of tailings waste in Norway.