Analyzing the Rare Earth Elements (REE's) and Trace Metals in Tailings

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Abstract

In the process of producing bitumen from oil sand, a by-product called tailings is produced. Tailings are a mixture of clay, fine particles, water, solvent and residual bitumen. The industry's current approach is to leave them in tailings ponds; however, that may cause environmental impacts to the ecosystems around them due in part to the toxic trace metals found in them. Research has shown that there are also valuable rare Earth elements (REEs) present in tailings. REEs found in tailings include Cerium, Neodymium, Lanthanum etc. Iron, Titanium, and Zirconium are not considered REEs but are still valuable enough to be extracted. The objective of this research was to determine the concentration of REEs and trace metals in bitumen froth treatment tailings (FTT). Our research team used acid digestion and inductively coupled plasma mass spectroscopy (ICP-MS) to measure the concentration of REEs and trace metals in several samples of FTT ash. We learned that Cerium was the most prevalent REE in tailings samples (>1000ppm), followed by Neodymium and Lanthanum. Zirconium was the most prevalent trace metal found in this tailings sample (>1000ppm), followed closely by Vanadium. Knowing the exact concentration of harmful trace metals in tailings will allow us to determine the extent of tailings ponds environmental effect and toxicity. Collecting and selling expensive metals found in tailings could be the start of a new precious metals economy in Alberta, which would provide new investment opportunities and jobs. This would also encourage corporations to invest in finding new ways to extract these precious metals, resulting in more purified tailings and less tailings overall going into tailings ponds.

Key words:
bitumen, froth treatment tailings, Gupta lab, rare earth elements, trace metals, oil sands, TGA, alberta, chemical engineering

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Introduction

- Rare Earth Elements (REEs) and trace metals are concentrated mostly in tailings compared to other parts of the oil sands production process, though this is still a relatively low concentration.[1]
- REEs found in tailings include Cerium, Neodymium, and Lanthanum etc. Iron, Titanium, and Zirconium are not considered REEs but are still valuable enough to be extracted. [2]
- REEs are currently not being collected from tailings, but if they were this could support Alberta's precious minerals economy as well as potentially reduce the amount of tailings being dumped in tailings ponds.
- Trace metals include elements such as Lead, Cadmium, Mercury, Vanadium. Many are toxic to humans and wildlife.
- The objective of this research is to determine the concentration of REEs and trace metals in bitumen froth treatment tailings.

Methods

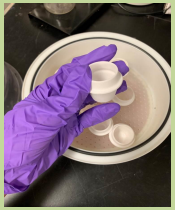

Figure 1. Crucible

Figure 2. Muffle Furnace

Ash preparation from tailings

Place FTT in Ceramic Crucibles

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Place FTT in Muffle Furnace

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Heat at 10°C/min to 800°C

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Residence time of 2 hours

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Collect ash for analysis

Methods (cont'd)

Analysis for metals

Acid Digestion

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Inductively coupled plasma mass spectroscopy analysis (ICP-MS)

Analysis for REEs

Three step acid digestion

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Inductively coupled plasma mass spectroscopy analysis (ICP-MS)

Results

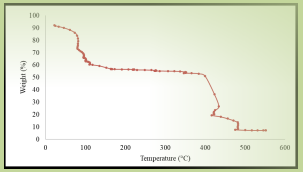

Figure 3. Thermal behavior of FTT in thermo gravimetric analyzer (TGA)

Figure 4. Thermo gravimetric analyzer

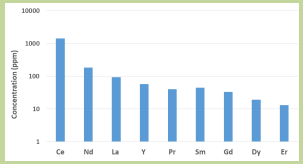

Figure 5. REEs in FTT ash. The concentration is presented in log scale

Figure 6. Dried FTT

Figure 7. FTT Ash

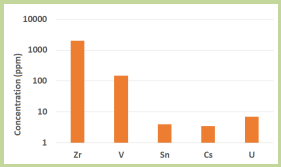

Figure 8. Trace Elements in FTT ash. The concentration is presented in log scale

Conclusion

- The FTT lost up to 90% of its initial weight when heated to 550 °C. It has a mostly steady weight loss except for notable drops at 100°C and 400°C.
- Cerium is the most prevalent REE in tailings (>1000ppm), followed by Neodymium and Lanthanum.
- Zirconium is the most prevalent trace metal found in this tailings sample (>1000ppm), followed closely by Vanadium. Mercury, Lead, and Arsenic are also confirmed to be present in tailings but their exact concentrations are yet to be determined.
- The next step in this research would be finding suitable, low-cost methods to extract REEs and treat toxic trace metals in FTT.
- Research one step further could look at capturing these minerals and solvents before they reach tailings ponds. Combined, these two approaches would reduce total water usage while accelerating the reclamation process.

Application

- Knowing the exact concentration of harmful trace metals in tailings will allow researchers to determine the extent of tailings ponds environmental damage and toxicity.
- Lanthanum and Yttrium are both expensive metals. Collecting and selling them from tailings could be the start of a new precious metals economy in Alberta, which would provide new investment opportunities and jobs.

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