

Technology Roadmap for Bauxite Residue Treatment and Utilization



"The coastal plain of Perth, Western Australia was once part of the Indian Ocean floor, and is characterized by poor sandy soils and limestone outcrops. The soils drain freely, allowing fertilizers to leach into waterways where they boost nutrient levels and can lead to problems such as algal blooms. The application of bauxite residue to these sandy soils will aid the retention of phosphates and moisture as well as reducing the need to apply lime for soil pH adjustment. In areas where bauxite residue has been applied there has been a significant increase in crop yield and a significant reduction in the level of phosphorus being leached into local waterways."

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Executive Summary

The treatment and use of bauxite residue (sometimes known as red mud) was the focus of a recent meeting sponsored by the Aluminum Association. Representatives from Alcoa, Alcan, and Kaiser were joined by several outside technical experts (Appendix A) to discuss various approaches and set priorities for possible collaborative research efforts.

The group assigned the highest priority to the following approaches for residue treatment:

- metal recovery from residue
- removal of desilication product (DSP) before it becomes residue
- beneficiation of bauxite
- consolidation
- use for removing SO₂ and CO₂ from gaseous streams
- use for levee construction, including both dikes in disposal areas and road bases

The key technical, economic, environmental, and market factors influencing the success of each approach were determined. Research needs for the approaches listed above were identified and discussed and priorities assigned.

The group indicated that a top priority in *metal recovery* is a joint brainstorming effort between the aluminum industry and outside experts, perhaps part of a collaborative development effort with other metal producers. A key research need under *removal of DSP* is the development of a cost-effective means of recovering soda from DSP product. In the area of *bauxite beneficiation*, the focus should be on the development of new separation technology.

Aluminum companies have joined together to work cooperatively on the common problem of treating bauxite residue. The next step in this process is to identify specific pre-competitive research activities for the highest-priority needs based on the output of the workshop. Aluminum companies with a potential stake in the outcome should collaborate to jointly seek government funds or fund university research. By leveraging their resources and knowledge, the companies will be able to develop economical solutions faster than they could acting independently.

1 Introduction

For decades, the aluminum industry has been investigating options for treating, disposing, and using bauxite residue (or red mud), a byproduct of the Bayer process to extract aluminum oxide from bauxite ore. This report examines the issues surrounding bauxite residue, discusses different approaches for treatment/disposal/utilization, and identifies research and development needs for some of the most promising options.

Alumina Production and Bauxite Residue

The starting material for electrolytic smelting of aluminum is pure, anhydrous aluminum oxide (Al_2O_3), also known as alumina. The principal ore from which aluminum is extracted is called bauxite. The principal ingredients contained in the bauxite are hydrated aluminum oxide, iron oxide (which gives it its reddish-brown color), silicates (e.g., clay, quartz), and titanium dioxide.

The Bayer process is used to produce alumina from bauxite. Because of variability in ores, each alumina plant is almost tailored to suit a particular bauxite. In the Bayer process, the bauxite is crushed and ground, then mixed with a solution of caustic soda and pumped into large autoclaves. There, under pressure and at a temperature of 110°C to 270°C , the alumina contained in the ore is dissolved to form sodium aluminate. The silica in the bauxite reacts and precipitates from solution as sodium-aluminum-silicate.

The remaining residues consist partly of minerals that do not dissolve during the caustic treatment of the bauxite (e.g., iron and titanium oxide), calcium carbonate and calcium aluminates from lime addition, and also of what is known as the desilication product (DSP), which contains not only silica but considerable quantities of unrecoverable alumina and soda. Some bauxite residues contain as much as 24% TiO_2 , 43% Al_2O_3 , and 54% Fe_2O_3 , depending on the mineralogical make-up of the bauxite. The residue also contains trace amounts of the metals niobium, gallium, zirconium, thorium, scandium, and vanadium. The residue settles out of solution and is separated from the sodium aluminate solution, washed to recover the caustic soda, and pumped to disposal areas.

The worldwide alumina industry produces over 70 million dry metric tons of bauxite residue annually. Australia is the largest alumina refiner in the world, processing around 30% of the total alumina (see text box next page).

The production of one ton of aluminum metal yields 1.5 to 4 tons of bauxite residue (on a dry basis) to be disposed. The worldwide average of residue in disposal sites is 50% solids in the residue.

Distribution of World Alumina Production

<u>Region</u>	<u>Amount/Major Producer</u>
East Asia/Oceania	39%/Australia
South America	16%/Brazil and Venezuela
North America	22%/United States
Europe	22%
Africa	1%/Guinea

Source: Alumina Refineries and Producers of the World

Overview of Bauxite Residue Treatment

Bauxite residue is removed during the Bayer process by gravity settling or filtering the solids from the sodium aluminate liquor. Storage methods, which involve the dewatering of the residue, are tailored to suit local situations and legislation. Methods that do not preclude the future exploitation of the residue can be considered under the headings stacking and nonstacking.

Stacking calls for residue that is dense enough to require (if it is to be conveyed) vacuum, pressure, or high-pressure filtration to ensure the desired degree of dewatering. Alternatively, a common stacking method consists of spreading a thin layer of residue over a broad area and then extending the next layer only when the first is completely dry.

Nonstacking methods provide for the discharge of bauxite residue into lagoons. Such lagoons may not be naturally impervious but can be made so by means of plastic sheeting or clay to prevent seepage of the caustic liquid into the subsoil. The mud that settles on the bottom can be drained and stored. A layer of water is kept over the surface of the mud, or the lake is sprayed periodically with water to keep the dust hazard to a minimum. Eventually, lagoons can be covered with a layer of topsoil when they are closed.