Researchers seek ways to recycle the alumina refining waste that caused catastrophe in Hungary

Sarah Everts

Ripe for reuse Researchers are looking for alternative uses for the red mud that devastated the Hungarian countryside.

Nobody expects a red tide of toxic, highly alkaline sludge to come rushing through one's neighborhood. But that's exactly what happened on Oct. 4 in Hungary, when a reservoir containing pH-13 waste from bauxite mining burst open, releasing 700,000 m³ of red mud, as it's called. The toxic flood killed eight people, burned hundreds of others, and caused one of the country's biggest environmental disasters to date.

A staggering 70 million tons of red mud is produced worldwide every year to extract alumina from bauxite in a process that’s been used for more than 100 years. Researchers have long tried to find ways to recycle or reuse the waste—well before the disaster in Hungary. “There are gigatons of red mud lying around,” says Marcel Schlaf, a chemist at the University of Guelph, in Ontario. “We’d like to do something useful with it.”

Potential applications range from incorporating red mud into bricks and roof tiles to using the mining waste as a catalyst for processing biofuel—but all of these are in development and still need safety testing. However, if one or more of these approaches are successful, it might turn red mud into a useful resource.

Red mud gets its rusty color from iron oxide, which can be as much as 50% of the material. In addition to iron oxide, red mud also contains “whatever else is found in the rock besides alumina,” explains Karen Hudson-Edwards, an environmental geochemist and mineralogist at the University of London, Birkbeck. Depending on the mining site’s geographical location, red mud can contain metals such as copper, chromium, nickel, and gallium. The mud also can
have radioactive elements such as uranium or radium, as well as arsenic, fluoride, sulfates, and titanium dioxide.

Sodium hydroxide is required to get alumina out of bauxite and is what makes red mud so extremely alkaline. For every ton of alumina removed, the refining process produces about 2 tons of red mud. The extracted alumina is processed by the metals industry into aluminum products—or is used to make chemical-grade ceramics, glasses, and zeolites, the type of materials produced by MAL Magyar Alumínium, which owns the reservoir responsible for the Hungarian catastrophe.

Most refiners unload red mud into reservoirs open to the environment and let the material settle until the sodium hydroxide separates from the sludge and can be recovered for future refining or be neutralized, says Chris Bayliss of the London-based International Aluminium Institute, an industry group. When a reservoir fills up, soil is often placed on top, greenery is planted, and then a new reservoir is built. Other disposal methods included dumping red mud into the Mediterranean Sea or Pacific Ocean.

Finding a way to use red mud constructively “is an admirable idea,” Hudson-Edwards says. “I’m in favor as long as human health and the ecosystem are fully looked after.” To do so, researchers must ensure that any toxic components, such as arsenic, radioactive elements, and heavy metals, are stably contained and don’t leach out in any recycling applications, she says.

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One proposed use for red mud is as an ingredient in bricks and roof tiles. The challenge is to ensure that toxic ingredients are at safe levels. For example, George N. Angelopoulos, a chemical engineer at the University of Patras, in Greece, found that red mud from Greek bauxite mines has to be limited to 30% of the total content of bricks to keep chromium at safe levels. In Hungary, local bauxite contains radioactive thorium and radium, which limit the safe amount of Hungarian red mud to 15% of the total content of bricks (J. Haz. Mat. 2008, 150, 541).

Other researchers would like to use red mud’s primary ingredient, iron oxide, as a catalyst for hydrogenation, hydrodechlorination, and oxidation. Catalytic applications haven’t been successful to date because red mud’s performance doesn’t match that of commercial iron oxide catalysts.

However, Schlaf thinks he’s found a catalytic application that can use red mud produced from mines in Quebec just as it is.

Schlaf is trying to turn two waste streams—red mud and biomass waste from agriculture and forestry—into a useful resource by using the red mud as a catalyst to make biomass into usable biofuel.

The first step in converting material such as wood chips, bark, or waste wheat straw to biofuel is pyrolysis, a process in which the biomass is liquefied at high temperatures. The resulting liquid is brown, acidic, and viscous, with an unfortunate tendency to separate into an unusable resin that has a watery layer on top, Schlaf says. He’s using the iron oxide, titanium dioxide, aluminum oxide, silicon dioxide, and sodium hydroxide in red mud to catalyze a potpourri of ketonization, hydrogenation, and neutralization reactions that stabilize the biofuel after pyrolysis and before the unfortunate separation step occurs. So far, the setup has worked in a lab setting.

Justin Hargreaves at the University of Glasgow, in Scotland, and his collaborators are developing an entirely different application for red mud. They are flowing methane over red mud to make hydrogen gas, in addition to iron carbide, iron metal, and carbon. They are hoping that the carbide can be used to remove chromate and copper from drinking water in India using red mud produced there, Hargreaves says. Because iron is magnetic, red mud is removed from the purified water with a magnet.

The feasibility of the project is contingent on making sure heavy metals from the red mud that get incorporated into the iron and iron carbide material are permanently sequestered there and can’t be transferred to the drinking water. The idea is also contingent on the red mud being free of radioactive elements.

Research on finding constructive, safe uses for red mud is still in its infancy. With incredibly large volumes of red mud being produced annually, finding ways to recycle the material safely won’t necessarily avert catastrophes such as the one in Hungary. But constructive applications of the mineral-rich waste may one day help make the material a useful resource and reduce the amounts that are stored in open reservoirs.