MINING WASTE RESIDUE CONCRETE
ALUMINA SHORTENED DOCUMENT
(For more detailed information, please contact our office)

INTRODUCTION -

Using industrial waste or byproducts are a critical ingredient in our resilience as caretakers of our environment. The mindset of some Mine Owners is to perform what is necessary; what is mandated by law no matter what the environmental impact. Even at low to no economic impact to "some" Owner's pocketbooks, even entertaining the concept of doing something different or better with waste materials is akin to dragging an angry cat by the back legs over a soft couch with claws embedded and tearing the fabric all the way. In this case, the couch and fabric are a metaphor for "how we've always done it." This fact is demonstrated transparently in this paper and identifies some strengths and weaknesses in our current efforts, and threats in our efforts relative to metal mining and processing. Waste hydroxides, sulfites/sulfates, silica, and other materials may be used as described herein.

The United States Environmental Protection Agency (EPA) has something called "Superfund". From the EPA's website, a Superfund program is "responsible for cleaning up some of the nation's most contaminated land and responding to environmental emergencies, oil spills and natural disasters. To protect public health and the environment, the Superfund program focuses on making a visible and lasting difference in communities, ensuring that people can live and work in healthy, vibrant places."

As listed on the EPA's Superfund website page, there are currently about 1,400 Superfund Sites, and a few hundred proposed sites. Therein, the government is responsible to monitor and clean the sites largely requiring Owners to pay for the monitoring and cleaning, but many times the monitoring and cleanup is occurring from tax-payer dollars. Many of these sites are metal mines where processing chemicals and heavy metals are leaching into waters of the United States. Many times, the cleanup is limited to capping materials in-place and constructing subsurface containment walls and extraction wells to isolate and remove contaminants from waters of the United States. In every occurrence relative to chemicals and heavy metal leaching, monitoring wells are installed to ensure mitigative measures are effective, and continual monitoring occurs due to the risk of leakage. In the events of walls, liners, and capping for in-place permanent disposal, this land is effectively and irrevocably lost to the public and no further use is possible. Yet, we couldn't find one Red Mud Impoundment on the EPA's website. With respect to non-Superfund and Superfund sites where the government has allowed permanent waste disposal, thousands of acres of land in the United States are permanently lost. While mining is a necessary part of life on the planet, granting the permanent loss of land to mining waste storage when the loss is unnecessary, is a problem.

The Periodic Table of the Elements separates metals into Alkali Metals, Alkaline Earth Metals, Transition Metals, and Other Metals. Regardless of the characterization and separate from the primary classification, most contain many of the same or similar byproducts including silica ($SiO2$), calcium (Ca), sodium (Na), and hydrogen (H) to name a few. This fact is evidenced in the mining of aluminum, lithium, gold, copper, uranium, and many others where the byproducts are stored somehow near the extraction site and after removing the primary metal. With the exception of mineral mining for construction materials aggregates, all of the metal extraction mining requires significant processing. Some of the processing leaves hazardous materials including heavy metals, radioactivity, and undesirable chemical residue. Done correctly, all of the risks are mitigated, and the wastes are transformed into useful and valuable products.

Using electric vehicles and trucks is a great way to reduce an organization's carbon footprint, but only if the power to charge the vehicles is done so responsibly along with consuming the waste in a constructible fashion. Otherwise, driving your electric vehicle through or around mountains of waste materials from the mining and refinement won't necessarily be pleasant or possible. Likewise, the computer used to author this document has many aluminum, lithium, and other metallic components that make the writing possible, but the waste generated from the production is more than an eyesore in many communities. It has become a hazard and has been purposefully overlooked for decades.

ALUMINA -

Alumina production is an immense industry and aluminum is used in thousands of products including beverage containers, aviation, electronics, construction building materials, space travel, electric and hydrocarbon motors, chemical processes, and many other products. Aluminum is one of many Strategic Materials listed by the Department of Defense, Defense Logistics Agency. While aluminum recycling occurs on a massive basis, about 130 million metric tons are produced annually, contributing about 240 million metric tons of bauxite residue to impoundments annually. Bauxite residue contains an abundance of sodium hydroxide, metals, and other constituents, and sometimes ionizing radiation.

The sodium hydroxide in the bauxite residue is a hazardous product. The hazards consist of the ability of sodium hydroxide to digest proteins (harmful to humans), an elevated pH, corrosion in metals, and corrosive to Portland Cement. The National Institute for Occupational Safety and Health (NIOSH) and the Occupational Safety and Health Administration (OSHA) have maximum permissible exposure limits for sodium hydroxide. The New Jersey Department of Health – Hazardous Substance Fact Sheet indicates that "exposure to 10 milligrams per cubic meter is immediately dangerous to life and health."

Billions of tons of residue continue to be placed in tens of thousands of acres of impoundments, with no current large-scale plan of use besides capping the impoundments permanently or dumping the waste into large bodies of water. There is no question that the sodium hydroxide and TENORM in the residue present an immediate and long-term risk to humans and our planet. Any and all beneficial use scenarios should and must be implemented.

NORM is an acronym for Naturally Occurring Radioactive Materials. NORM is present in various products including petroleum, coal, and various minerals including some sources of Bauxite. TENORM is an acronym for Technologically Enhanced Naturally Occurring Radioactive Materials. TENORM occurs when materials containing NORM are processed and the NORM is further concentrated in the processed product, or its waste. In the instances where NORM exists in the bauxite ore, the TENORM is elevated in the Red Mud. TENORM is the result of various naturally occurring radioactive materials "sometimes" occurring in bauxite which can include Potassium 40, Thorium, Cesium, Radium, and Uranium. These are just a few broader types, but all are ionizing radioactive materials, all have relatively long half-lives, and all are not a positive impact to human exposure, very similar to and associated with RADON.

Alumina producers don't always purchase bauxite ore that contains NORM. However, many of these alumina producers find bauxite ore based upon price and import the material from all over the world. The majority of very large impoundments have any number of different bauxite sources, and some likely contained NORM.

The Bayer process primarily consists of using sodium hydroxide (caustic soda) as a digestive mechanism for extracting alumina from the bauxite mineral. Whatever sodium hydroxide and other products can be extracted from the digested alumina is removed, and the Red Mud is left in impoundments. The left-over residue consists of a combination of sodium hydroxide, ferrous oxide, silicon dioxide, aluminum oxide, calcium hydroxide, titanium, and other trace materials, sometimes radioactive.

MAKING CONCRETE FROM RED MUD

Most if not all alumina processing facilities have records of where the bauxite originated, and the majority of facilities have information on various constituents of the bauxite including aluminum, calcium, silica, ferrous, magnesium, and other influencing materials. Likewise, most bauxite materials containing elevated NORM have been documented over the years. While the influencing constituents of the various bauxite sources are not variable enough to alter the final concrete recipe, the existence of elevated TENORM and other red mud characteristics must be established prior to retrieval of the red mud. The site study in three efforts is performed consisting of a document review, a field sampling and testing program, and the development of a 3-dimensional model that includes mixing variable materials in order to achieve low radiation emittance and a consistent concrete/cement product.

Typical Geopolymer materials other than Cold Fusion Concrete are produced using a liquid hydroxide and/or liquid silicate as pozzolan activators. Cold Fusion Concrete utilizes all dry materials including sodium or potassium metasilicate and/or sodium or potassium metasilicate pentahydrate as an activator. Sodium or potassium metasilicate/pentahydrate are alkali salts, have an elevated pH, and are anhydrous or pentahydrate versions of silicates. Sodium or potassium liquid hydroxides and/or silicates while unnecessary, can be used in conjunction with Cold Fusion Concrete technology and as demonstrated herein, without compromising quality.

Generally speaking, Cold Fusion Concrete is a silicon dioxide primary chemistry relying upon the glassy components of directly installed silicon dioxide, various minerals, and waste materials to achieve an approximate 70% SiO_2 content, which is extremely similar to glass chemistry. The silicon dioxide, aluminum, and calcium constituents in red mud, or lithium, gold, copper, silver, or other mining waste are either primary, or majority constituents in Cold Fusion Concrete. As such, the synergy between Cold Fusion Concrete and mining waste is profound. The Ferrous and other metal components of the waste present no deleterious reactions in the final product and heavy metals are encapsulated safely within.

Sodium hydroxide that is found in the bauxite residue is corrosive to glass, or SiO_2 materials. However, sodium hydroxide is used in the process of making sodium metasilicate. Sodium metasilicate is the primary activator used in Cold Fusion Concrete and while the sodium hydroxide digested the glassy components to make sodium metasilicate, the reformation of SiO_2 during the reaction with water, calcium, and aluminum in Cold Fusion Concrete results in resistance to further sodium hydroxide corrosion. Accordingly, while sodium hydroxide is typically corrosive to glass, the reformation of the cementitious structure is durable and not susceptible to further degradation in sodium hydroxide; it is beneficial.

Carbon dioxide sequestration has become a primary focus garnering world-wide attention. Unfortunately, the technology surrounding carbon dioxide sequestration is typically fashioned around the most simplistic and technologically basic approach as is possible, including adding carbon dioxide to Portland Concrete and converting calcium hydroxide into carbonates. The process has positives and negatives.

Adding carbon dioxide to concrete materials as a curing and sequestering mechanism can occur with long term benefits. With respect to calcium hydroxide carbonation, should the calcium carbonate molecule be attached to a glassy silicon dioxide molecule, the calcium carbonate is refined into a moisture and chemical resistant material. The same is true for metallic oxide molecules that are converted into carbonates from carbon dioxide curing. The silicon dioxide containing long chain molecule that includes calcium, ferrous, magnesium, aluminum, manganese, and other metal carbonates is of significantly higher quality due to the presence of the silica/silicon attachment. This process occurs in abundance in Cold Fusion Concrete technology, which in simplistic terms is just turning short chain molecules into long chain molecules through covalent bonding.

The carbon sequestration into Bauxite Residue Concrete is not limited to the calcium components using our technology. The ferrous, aluminum, and magnesium oxides in the sodium hydroxide rich residue experience partial dissolution when subjected to an environmentally benign solution, which converts the oxides to fluid hydroxides and allows carbon dioxide to react and form ferrous, aluminum, and magnesium carbonates. The dissolution is enhanced significantly if the residue is exposed to other currently patent pending processes. The carbon dioxide in any sequestering process is most effectively introduced in the form of a cellular bubble, by pouring liquid carbon dioxide into the mixture, or by injecting carbon dioxide gas that distributes evenly throughout the mixture.

For producing a dry cement material for delivery to ready mix facilities and incorporation into mineral aggregate and water for concrete mixtures, dry Cold Fusion Concrete materials are combined after the red mud is sequestered, dehydrated, and reduced in size to approximately 1 to 20 microns.

After mixing and placing the concrete in the element intended for construction, the feature is cured normally for from one to twenty-eight days, cured with the application of about 140^{o}F heat or infrared, or, cured by passing a direct or alternating current through the concrete for a minimum of 30 seconds. When electrical curing is the chosen option, care should be exercised in applying a very low voltage initially until the material loses cohesion (which typically takes about 5 to 15 seconds), then increasing the voltage until the material reaches and internal temperature of about 190^{o}F.

Generally speaking, the resulting concrete achieves compressive strength of from 4,000 to 10,000 pounds per square inch (psi), similar modulus properties as Portland mixtures, low permeability, and elevated resistance to freeze and thaw cycling and chemical attack.