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South African Coal Ash

SARS Tax Exemption No: 930012713

STRATEGY & INFORMATION OF THE SOUTH AFRICAN COAL ASH ASSOCIATION (SACAA) 2021

"A NEW START – A NEW CHALLENGE"

Past President: Deidre Herbst
President: Belinda Heichler
Administrator: Nico Pienaar

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THE WAY FORWARD: 2021 ONWARDS

1. Background:

The pandemic has also had a devastating impact on **SACAA** the utilization of ash in the past year, specifically since March 2020, this has constrained the development of new business and hampered the sustainability of existing business. Let us not dwell on the negative, looking forward **SACAA** hopes to be part of the recovery and success in the future. We in **SACAA** have now also found "The new normal".

Eskom have successfully awarded new contracts for ash procurement. This will be a wonderful opportunity to welcome new members to our association.

Many of the **SACAA** members have continued to raise concerns over the availability of ash from Eskom as a factor limiting current business and future growth, this continued in 2020 and was exacerbated by COVID 19. It will take some time for the successful off takers to establish them on site, but this is positive progress.

Dirk Odendaal who was elected president regrettably announced due to work commitment demands he could not continue as current President in December 2020. Upon our announcement to the MANCOM meeting held in December 2020 the MANCOM agreed by vote to elect Belinda Heichler as the placement President to the association.

It was also voted and agreed that Dr. Kelly Reynolds would take up the position as Vice Chairman to the association. **Welcome Kelly!**

As the President of **SACAA**, I would also like to thank all the members of **SACAA** who have contributed to the Work Streams which continued and counsel meetings. Your time and expertise is needed and much appreciated.

The **ASAPSA** Team, Nico Pienaar and his ladies who have over the last three years have continued to support the association have agreed to take on a bigger role in the successful administration of the association. Thank you, Nico, and your dynamic team, for all the support you have provided and look forward to your contribution over the next year. In order to recover some of the lost venue due to bad debt and lack of workshops planned Nico and his team have offered a reduced administrative fee for 2021. Once again, we are indebted to your kindness.

I call upon the MANCOM members to assist in recovering the bad debt venue and in due coarse each of you will be given a company/name

I also extend a challenge for every Mancom member to reach out to the new entrants who were awarded contracts by Eskom to sign up a new association member.

Whilst I deliberated on how to write this review, I called upon our stalwarts of the industry to write us a paragraph on why the association was formed and to perhaps see synergy of the initial visions vs our current vision of the success of the association, Mr. Richard Kruger who unfortunately due to bad heath is unable to contribute however Yvonne has indicated he still loves to read about the association so we will be sure to send him a copy. Dieter Heinichen is still suffering the after-effects of COVID-19 is recovering and I am sure in the future and share some of his highlights whilst he and Richard managed the association. Dieter we wish you all the best and look forward to receiving your news.

2. SACAA MEMBER BENEFITS

This Association could not function without the support of the member companies. They have stepped up in providing funding for many of the projects we undertake, and their sponsorship at our meetings bring in valuable financial support that allows us to keep our membership dues lower than most Associations our size.

In the meantime, our nation and the world struggle to deal with protecting those who are most vulnerable to serious health impacts while allowing society to resume the functions that make our country work and prosper. The economy, education, entertainment, recreation, and religious activities are still in various stages of recovery depending on state and local management.

Membership of **SACAA** provides support for the development, implementation, and continuation of effective programs for the management and use of ASH. There are numerous benefits for coal-burning electric utilities resulting from the use of ASH in lieu of disposal. In addition to avoiding disposal costs and creating revenue, added benefits come from public and government recognition of the utility as a supporter of sound policies for recycling and sustainable development. **SACAA** members share a common interest in using ASH as valuable products to enhance revenues, minimize disposal costs, reduce liability, and support environmental policies. **SACAA** members will be active at national, regional, state, and local levels.

Participate in Information Exchange and Networking Join Us for Educational Opportunities and Professional Growth Advance Your Market Awareness and Development

WE ARE THE FLY ASH INDUSTRY'S PIONEERS

3. ABOUT SACAA

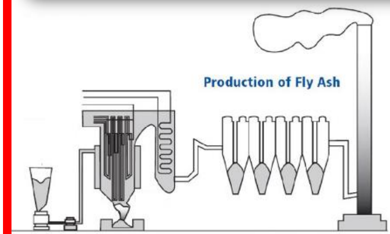
SACAA's role is to be the umbrella association for the "ASH" producers, marketers, users, universities, research organizations and individuals playing an active role in the promotion of responsible ASH utilization.

This is for growth and business development by our members for the benefit of the South African economy in compliance with the environmental legislation.

4. OUR SERVICES

SACAA has played an important role in establishing a Coal Combustion Product (CCP) industry in South Africa by providing a forum for the exchange of scientific and technical information on ASH utilization.

WHAT ARE THE "PRODUCTS" AND WHAT INDUSTRY IS SACAA



RECLAIM

Coal ASH from ponds, landfills, and production material is transformed into a consistent, high-quality product.

RECYCLE

Fly ASH can be used in more concrete mixes and at higher dosage rates for encapsulated beneficial use.

REUSE

Processing coal ASH from ponds provides a continual supply of low LOI, fly ASH for the construction industry.

RENEW

The process provides a permanent solution to remove coal ASH from the environment and reduce long-term risk.

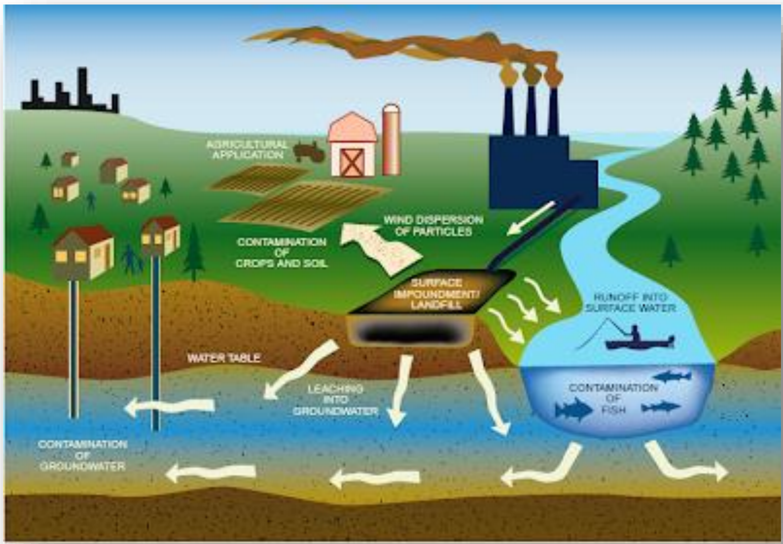
5. ASH UTILIZATION

Ash is generated in the combustion of pulverized coal in a coal-fired power station. The Ash produced is used not only for commercialization, but also complies to legislative requirements in using Ash for effluent management.

Due to the way in which our power stations burn coal, there is more than one type of Ash that is produced on the power station. Each of the differing Ash classification contains different particles and molecules and can be used for various different opportunities.

Coal received from the mine is ground to a fine powder, mixed with air and blown into a furnace where it burns spontaneously. The combustion of coal generates heat. The generated heat is used to convert water into steam at a very high temperature and pressure. The steam drives a turbine that rotates a shaft coupled to a generator that produces electricity.

Ash is generated during the combustion process. Fly Ash transport with flue gasses and settled out in the precipitator. Large ash particles (Bottom ASH) collect on the floor of the combustion unit. Fly and bottom ASH is evacuated from the power station via a conveyance system and disposed of at the station's ash disposal facility or recycled.



Coal combustion products — often referred to as "coal ASH" — are solid materials produced when coal is burned to generate electricity. There are many good reasons to view coal ash as a resource, rather than a waste.

Using it conserves natural resources and saves energy. In many cases, products made with coal ash perform better than products made without it.

6. FLY ASH

Fly ash is a powdery material that is captured by emissions control equipment before it can "fly" up the stack. Mostly comprised of silicas, aluminas and calcium compounds, fly ash has mechanical and chemical properties that make it a valuable ingredient in a wide range of concrete products. Roads, bridges, buildings, concrete blocks and other concrete products commonly contain fly ash. Concrete made with coal fly ash is stronger and more durable than concrete made with cement alone. By reducing the amount of manufactured cement needed to produce concrete, fly ash accounts for approximately 12 million tons of greenhouse gas emissions reductions each year.

Other major uses for fly ash include constructing structural fills and embankments, waste stabilization and solidification, mine reclamation, and use as raw feed in cement manufacturing. Power stations utilizes pulverized coal combustion to fire their boilers. 90% of the ash is classified as fly ash.

Fly ash, also known as pulverized fly ash, is the fine dust that is produced from the combustion process of the finely pulverized coal in the boiler fi re system. Fly ash can be obtained directly from a boiler unit ash bunker through an agreed written arrangement. This option may require infrastructure development.

Fly ash in the building and construction industry is widely applied where it is used as a cement extender (blended cements) or an ingredient in its own right in concrete (supplementary cementations material). Fly ash can be used as functional filler in plastics and rubber. Its particle shape aids processing and reduces the amount of polymer required.

Beyond concrete, fly ash is used in numerous other applications, including:

- Component in concrete products and grout
- Feedstock in the production of cement
- Fill material for structural applications and embankments
- Ingredient in waste stabilization and/or solidification
- Ingredient in soil modification and/or stabilization
- Component of flowable fill
- Component in road bases, sub-bases, and pavement
- Mineral filler in asphalt

7. BOTTOM ASH

Bottom ash is a heavier, granular material that is collected from the "bottom" of coal-fueled boilers. Bottom ash is often used as an aggregate, replacing sand and gravel. Bottom ash is often used as an ingredient in manufacturing concrete blocks.

Bottom ash is commonly used in bulk, unencapsulated applications, including the following:

- Filler material for structural applications, embankments, and backfill for retaining walls, abutments, and trenches
- Aggregate in road bases, sub-bases, and asphalt pavement
- Feedstock in the production of cement

8. COARSE ASH

Other major uses for bottom ash include constructing structural fills and embankments, mine reclamation, and use as raw feed in cement manufacturing.

The remaining 10% of ash is coarse ash, also known as boilers bottoms ash, which drops down from the furnace and collects at the bottom in the ash hopper of the boiler. Coarse ash can is identified as a sand-like product removed from the base of a pulverized fuel boiler. Coarse ash can be obtained from the power stations emergency dump or an agreed point that is safe and environmentally acceptable.

Uses & benefits:

Coarse ash can be used as a feedstock for the production of cement clinker and as an aggregate for the manufacture of concrete masonry units such as bricks and blocks.

9. CLINKER ASH

Clinker ash is obtained from a chain grate boiler process that was used in the older power stations. This ash forms larger clinkers that closely resemble stone formations.

Uses & benefits:
Clinker ash is a diminishing material but is mainly used in brick making.

10. NEW USES ON HORIZON

New beneficial uses for coal ash are continually under development. Researchers and ash marketers are currently focusing heavily on the potential for harvesting ash that has already been disposed for potential beneficial use. There is also renewed interest in the potential for extracting strategic rare earth minerals from ash for use in electronics manufacturing.

11. ASH IN CEMENTLESS CONCRETE

Replacing a limited resource such as Portland cement with wastes and/or by-products can possibly reduce the carbon footprint of concrete as an end product in infrastructures. The replacement of the Portland cement with wastes and/or byproducts can reduce the volumes and costs of ash management while fulfilling a niche in market for concrete structures.

12. 10 THINGS YOU DIDN'T KNOW ABOUT FLY ASH

1. The origin of ash
   Roughly 300 million years ago, the carboniferous period came to an end. Large rain forests died and the resulting tree rot and decaying vegetation morphed under pressure and high temperature into a carbon based sedimentary rock – coal. Soil was comingled in these sediments and became part of the coal formation. During pulverized coal combustion, the organic-based matter burn, the inorganic matters melt, then begin to harden as the gas cools, forming spherical mineral particles – fly ash. Fly ash is "heat treated" ancient dirt.

2. The types of ash
   Carbonaceous solid fuels and their ash products are created equal. Bituminous coal is the most abundant rank. It produces low-calcium Class F fly ash – desired for concrete durability.

3. Ash collection at power plants
   The electrostatic precipitator (ESP), used to collect fly ash at power plants was invented by Frederick Cottrell, a professor of chemistry at the University of California, Berkeley, in 1907 to protect the wine industry in northern California by capturing lead oxide and acid fumes from smelters that were damaging the nearby vineyards.

4. First successful production of PCFA
   Pulverized coal fly ash (PCFA), which is used in concrete for its Pozzolanic benefits, was first produced 101 years ago after engineers for the first time successfully burned pulverized coal continuously and at high efficiency in steam boilers to produce electricity.

5. The nature of the material
   Ash is derived from coal which is of natural organic origin. It contains most of the 92 naturally occurring elements. The bulk chemistry of ash is most similar to silicious rocks, particularly shale, which consist of the oxides of silicon, aluminum, iron, and calcium.

6. Pozzolans
   Pozzolans are inorganic minerals – naturally occurring ash – that consist of amorphous silicates and aluminates, which when combined with calcined lime and water react to form stable binding hydrates. The reaction was first described in 27-31 BC, by Vitruvius, an engineer and architect for Julius Caesar. Pozzolan-based concrete was extensively used in the Roman era for notable buildings, such as the Colosseum, built in 72-80 AD, and the Pantheon, completed in 120 AD. The term Pozzolan, or "powdery ash", comes from Pureoli.

7. Great dam projects
   Dam projects were some of the first adopters of ash use in structural concrete. The great dam building era in the USA, stretching from the 1940's through to the 1970's, spawned the technical interest in the material science for ash use in concrete.

8. Fly ash use is well regulated by Standards Specifications
   The first American standard specification for coal ash uses in concrete (ASTM C618) was initially published in 1971. It continues to be the standard benchmark and is very similar to many international standards, such as EN450 (Europe). AS/NZ S3582, (Australia and New Zealand), IS3812 (India), and GB/T 1596 (China). There are numerous other specifications to address local construction needs to ensure desired performance in concrete.

9. National Pozzolan deposits
   The historical gap between fly ash production and use as integrated and extrapolated from surveys is estimated to be about 2 billion tons over the last 100 years. Some of these deposits are technically and economically feasible to reclaim for beneficial use in concrete.

10. All of the above
   Reclaiming legacy ash and deposits is the cornerstone to meeting shortages in the world caused by plant closures. Although some markets can still rely on the remaining operating plants, imports from nations with surplus quality material can fill in some supply gaps in coastal markets. The use of natural Pozzolans, where available, can also hemp. In the long run, its all of the above…

13. CONCRETE, CONCRETE BLOCKS, AND CONTROLLED LOW-STRENGTH MATERIAL

Concrete is among the most widely manufactured products in the world today, used to build critical infrastructure ranging from bridges to tunnels, dams, pipelines, and other durable structures.

Traditionally, one of the main ingredients in concrete has been Portland cement, whose manufacture involves vast energy consumption and emissions production. Fly ash can be used as a partial substitute for cement in the manufacturing of concrete—saving much of these emissions while improving the strength and durability of concrete.

Fly ash and, to a lesser degree, bottom ash are both used in the manufacture of concrete blocks (standardized light construction blocks) and controlled low-strength material (CLSM)—flowable cementitious filler that boasts many operational and performance advantages over compacted soil in a range of fill applications.

CCPs Used in Concrete

- Fly Ash

CCPs Used in Concrete Blocks

- Fly Ash
- Bottom Ash

CCPs Used in Controlled Low-Strength Material

- Fly Ash
- Bottom Ash

<u>Concrete:</u>

Two millennia ago, Romans discovered that the ash from a volcano near the town of Pozzuoli, when mixed with water and lime, formed a cement that could be used to make a particularly durable type of concrete.' What they had discovered was that this siliceous volcanic ash was a natural pozzolan—a material that reacts chemically with calcium hydroxide to form cementitious compounds. Concrete made from this ash would be used to build the Pantheon, the Colosseum, and many other Roman structures that survive at least partially intact to this day.

"Modern" concrete production dates back only two centuries and is traced to the invention of Portland cement, a powder made by heating and grinding limestone, clay, and other materials' that, when subsequently mixed with water and aggregates, hardens into concrete through a chemical reaction called hydration. For much of the past 200 years, concrete production has used essentially four ingredients: air, water, aggregates, and cement. With the large-scale adoption of coal-fueled electricity production in the 20th century, however, a new source of pozzolanic material for use in concrete became available: fly ash.

Fly ash is a fine, powdery substance that "flies up" from the coal combustion chamber (boiler) and is captured by emission control devices, such as an electrostatic precipitator o fabric filter "baghouse" and scrubbers.' This material is virtually identical in its composition to volcanic ash, with pozzolanic properties that make it ideal in manufacturing concrete. As such, it can be used to replace up to 50 percent or more of the cement in concrete mixes depending on the intended application.

Substituting fly ash for a portion of the cement used to manufacture concrete confers significant economic environmental, and performance benefits, as it:

- Generally is less expensive than Portland cement.
- Improves concrete's workability and allows for the use of less water.
- Helps concrete achieve a higher compressive strength than that which uses only Portland cement.
- Mitigates against alkali-silica reaction and sulfate attack, which can degrade concrete's durability.

- Lowers concrete's heat of hydration, helping to prevent thermal cracking in mass concrete placements (such as dams and large foundations).
- Decreases concrete permeability, thereby improving its corrosion resistance.
- Lowers the greenhouse gas emissions associated with concrete manufacturing (each ton of fly ash used in replacement of Portland cement saves approximately one ton of carbon dioxide emissions).
- Avoids landfilling of ash.

14. Concrete Blocks

Bottom ash comprises the agglomerated ash particles formed in pulverized coal furnaces that are too large to be carried in the flue gases and are collected in a hopper at the bottom of the furnace. Elsewhere throughout the world, bottom ash is utilized in the manufacture of concrete masonry units—standardized cast blocks used widely in light construction work, such as retaining walls and low-rise construction projects.

Bottom ash is used as an aggregate material in such applications.

Fly ash is commonly specified for use in autoclaved aerated concrete (AAC) blocks. Made from fine aggregates, cement, and an expansion agent that causes the concrete to fill with air, these blocks combine insulation and structural capability for, use in walls, roofs, and floors?).

15. SOIL STABILIZATION, ROAD CASE / SUB-BASE, AND STRUCTURAL FILL

Arrange of coal combustion products are used in the stabilization of soils to improve their chemical and mechanical properties. Both Class C and Class F fly ashes are commonly specified to enhance soil's strength properties, stabilize embankments, control the shrink swell properties of expansive soils, and reduce soil moisture content to permit compaction. Coal combustion products can be particularly useful in stabilizing soil where structures such as roads and buildings are to be built upon it. Both Class C and Class F fly ashes are widely used to help provide stable road bases and sub-bases; bottom ash, boiler slag, and FGD gypsum are also used to varying degrees in base courses. Fly ash, bottom ash, and FGD materials arc also used in structural fill to build stable embankments and strengthen and level uneven ground.

CCPs Used in Soil Stabilization
- Fly Ash

CCPs Used in Road Base Sub-Base
- Fly Ash
- Bottom Ash
- Boiler Slag
- FGD Gypsum

CCPs Used in Structural Fill
- Fly Ash
- Bottom Ash
- FGD Gypsum

16. SOIL STABILIZATION

Fly ash is commonly added to soil to improve its stability before erecting a structure of one sort or another atop it. Addition of fly ash can be useful in improving its density, plasticity, water content, and strength performance.' Class C fly ash, which originates from subbituminous and lignite coals, is often used as a stand-alone material because of its self-cementing properties.' Class F fly ash, which originates from anthracite and bituminous coals, can be used in soil stabilization applications with the addition of a cementitious agent (e.g., lime, lime kiln dust, cement, cement kiln dust).

Fly ash is used in numerous geotechnical applications to:

- Enhance strength properties
- Stabilize embankments
- Control shrink swell properties of expansive soils
- Reduce soil moisture content to permit compaction

17. ROAD BASE / SUB-BASE

Stabilization of road base and sub-base is essential to road building as these layers form the foundation beneath the pavement that helps maintain the road over time and usage. A high-quality base incorporating fly ash, aggregates, and potentially a cementing agent may even outlive the life of the pavement itself.

Stabilization of aggregate road bases with fly ash has a lengthy and successful track record. Starting in the 1950s, blends of fly ash, aggregate, and lime known as pozzolan-stabilized base ("PSB") have been used to underpin high-traffic roads. Bottom ash and boiler slag have also been added to such mixes for use in the base courses of residential streets and haul roads.' Base courses stabilized by coal combustion products are a proven, cost-effective alternative for the foundation of both flexible and rigid pavements where "conventional" base materials are cost-prohibitive or otherwise not readily available.

As noted above, both classes of fly ash (C and F) are regularly used in stabilized base and sub-base mixtures. Owing to its self-cementing properties, Class C fly ash does not require a chemical reagent or activator (i.e., lime, cement, or kiln dust). In most cases it is mixed, at amounts in the 5-15 percent range, with aggregate and water. In certain instances, however, it is used alone as the base material without any aggregate. Class F fly ash is added, together with a chemical reagent or activator, in amounts typically comprising 8-20 percent of the mix when combined with coarse-graded aggregates, and in the 15-30 percent range when combined with sandy aggregates.

Fly ash-stabilized bases/sub-bases can:

- Add significantly to the strength and durability of base courses
- Allow for the use of lower-quality aggregates
- Reduce project costs'

Bottom ash, which can range from the consistency of fine to coarse-grained sand, and boiler slag, which comprises hard, durable granular particles, are both occasionally used as unbound fine aggregates or granular base material in pavement construction. When used in stabilized base applications, they may need to be blended with natural aggregates to meet specifications.

And while both bottom ash and boiler slag have cementitious properties, lowering the requirement for the use of other cementitious materials in the mix, they may require grinding to achieve the desired particle size.'

Stabilized PGD material has also successfully been used in base construction in a number of state road projects throughout the United States, including in Florida, Ohio, Pennsylvania, and Texas. Typically, in such instances, FGD scrubber sludge is dewatered, after which a combination of pozzolanic or self cementing fly ash, quicklime (or another activator), and Portland cement are added to ensure the mix meets the required compressive strength.'

18. STRUCTURAL FILL

Structural fill is material placed and compacted to create a strong, stable base for an intended use whether for a building foundation, highway embankment, or as backfill for a retaining structure. Frequently, fill material comprises soil and natural aggregates. Alternatively, coal combustion products ranging from fly ash to bottom ash and flue gas desulfurization material can be used where they are more readily and/or inexpensively available and can provide the same or sup nor performance to conventional fill material. The specific attributes of each coal combustion product determine its use in a particular application.

The use of fly ash in structural fills was pioneered in Great Britain in the 1950s. Its use dates to at least 1971 in the United States, when Minnesota and West Virginia specified it as the fill material of choice in several state r ad projects." In the half-century since, the use of fly ash to build embankments and strengthen and level uneven ground has expanded nationwide to projects ranging from shopping malls to housing developments, as well as diverse residential, commercial, and industrial developments.

When used as embankment or structural fill material, fly ash confers several advantages over soil and aggregate. For starters, it can be a cost-effective alternative where it is available in bulk quantity. A silt-like, lightweight material, it can be transported easily; generally does not require additional crushing or screening; and can be spread and leveled via bulldozer and grader, minimizing construction time and costs. Since fly ash is composed almost entirely of spherical-shaped particles, the material can be densely packed during compaction for low permeability to minimize seepage of water through an embankment. Finally, its high shear strength, compared to its weight, conveys good bearing support and minimizes settlement."

Bottom ash has likewise proven itself as a structural fill material in highway embankments—as well as for use in the backfilling of abutments, trenches, and retaining walls. Generally lighter than natural granular fill materials, bottom ash drains easily, is not sensitive to moisture variation, and can placed and compacted using the same equipment as fly ash. Nonetheless, as its particles are larger than fly ash, it may require grinding or screening prior to placement and compaction.

19. COAL ASH IS NOT TOXIC

Coal ash is not toxic. How do we know this?

When evaluating the material as a whole there is a wealth of information on the toxicity testing of cod ash in mammalian and aquatic species that demonstrates that coal ash is not toxic.

The constituents in coal, and coal ash, are naturally occurring in the world around us.

When looking at the trace elements present in coal ash on an individual basis, comparison of concentrations to screening – levels developed by the U.S. Environmental Protection Agency (EPA) for a child's and adult's daily exposure to soil in a residential setting demonstrates that all are below the screening levels, with the exception of the upper-bound concentrations of a few constituents.

Adverse health effects can only be caused by the constituents in coal ash, or coal ash itself, if one is (a) exposed to the material, and (b) exposed at a level high enough to elicit a response.

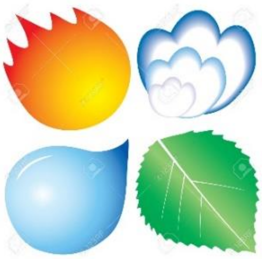
Toxicity Testing of Coal Ash Under the EU REACH Program

The European Chemical Agency (ECHA)' of the European Union (EU) regulates a comprehensive program of toxicity testing of materials that are put into commerce. This program is referred to as REACH—the Registration, Evaluation, Authorisation, and Restriction of Chemicals[2]—and has been in place since 2006. Coal ash has been registered for commerce under REACH, and the dossier for "Ashes (residues), coal," registration number EC# 931-322-8, is available for review.[3] The REACH program requires that the performance of a battery of toxicity testing be conducted to support the registration dossier, including mammalian (human health) and aquatic toxicity studies. A dossier is issued a registration number and published on the REACH website only after it has been reviewed by ECHA.

Studies relevant to human health have been conducted to address 10 different toxicity endpoints. The 47 mammalian toxicity studies have been conducted on coal ash as a whole material, not separate individual components. The REACH system classifies materials by hazard category—if no hazards are identified, based on their classification system definitions, then the conclusion is that no classification is warranted due to "data conclusive but not sufficient for classification." The terminology is a bit cumbersome but means there is no hazard to classify. A total of 39 studies have been conducted to address six types of aquatic toxicity, and in all cases the conclusion is that no classification is warranted due to "data conclusive but not sufficient for classification." Thus, the conclusion is no hazard.

By conducting the studies on ash as a whole material, they account for any cumulative, additive, synergistic, and/or antagonistic effects that single constituents may have in these complex mixtures. Taken together, this series of detailed and comprehensive toxicity testing and the conclusions of no hazard are good news—for the industry and for the community

20. COAL, COAL ASH AND ELEMENTS



Because coal is a natural geologic material, the inorganic elements and compounds in coal and in coal ash are also naturally occurring. The U.S. Geological Survey (USGS) has published detailed data on background levels of elements in U.S. soils.4 Because plants grow in soil and take up minerals from the soil, these elements are also naturally present in the foods we eat.' We are also exposed to soils every day—at home, at school, in parks. Therefore, we are exposed to these elements every day from our diet and from our incidental/inadvertent ingestion of soil when we are outside.

21. EVALUATING COAL ASH ON A CONSTITUENT SPECIFIC BASIS

The bulk of rocks/shales *and* coal ash are made up of silicon, aluminum, iron, and calcium (90%), with sulfur, sodium, potassium, magnesium, and titanium making up the minor elements (8V0) and "trace elements" that comprise less than 1% of the total content. The USGS conducted a survey of elements and inorganic compounds in coal ash.' The detailed compositional data for fly ashes and bottom ashes from the USGS can be compared to the EPA risk-based screening levels for residential soil.

Of the 20 trace elements evaluated in the full report, 15 are present in all ashes included in the evaluation at concentrations less than the EPA screening levels for residential soils. Concentrations of five constituents range to above the residential soil screening level in *some* but *not a//* of the coal ashes: arsenic, chromium, cobalt, thallium, and vanadium. However, these concentrations are only slightly above the screening levels. This comparison demonstrates that there would be no basis for health risk for incidental contact with coal ash or fly ash on a daily or an infrequent basis.

22. DON'T BE CONFUSED BY MISLEADING GRAPHICS

Every element on the periodic table can elicit an adverse effect if administered at high doses. It has been common for groups to scare people about coal ash by listing all of the adverse effects that can occur for each element and showing where those occur in the body. But the same graphics would be just as true if the words "coal ash" were replaced with "soil." Such graphics are even more misleading where they suggest that *any* exposure to coal ash (and, really, soil) *will* result in these adverse health effects. This is just not true. The information provided here • demonstrates that:

• Coal ash is not toxic—even at the high exposure levels used in animal tests;
• There are safe levels of exposure to each of the constituents in coal ash (and in soil), as defined by EPA; and whereas Class F fly ash generally contains le s calcium oxide. Class C provides strength in the early stages f construction, while Class F strengthens concrete over the long term.

Whether Class C or Class F, fly ash serves as a binder; it contains silica and alumina, minerals that give fly ash the properties of a _ type of substance known as a pozzolan. As a pozzolan, fly ash chemically reacts with lime (calcium hydroxide) and water in a pozzolanic reaction, forming a cementitious material analogous to Portland cement (which typically contains gypsum and a natural pozzolan such as volcanic ash).

It is important to note that the products of the pozzolanic reaction (such as calcium silicate hydrate) have a chemical identity distinct from the reactants (such as silicic acid, lime, and water) with different physical and chemical properties. In the presence of water and fine and coarse aggregates, cementitious materials such as Portland cement or pozzolanic reacted fly ash form concrete, a durable and strong substance. Therefore, concrete may be made from Portland cement, pozzolanic-reacted fly ash, or a combination of the two. The use of fly ash in concrete reduces the need for natural resources. Additionally, the use of fly ash in Portland cement concrete imparts properties that are favorable for many applications, such as improved fluidity to the pourable concrete mixture and strength to the hardened, cured product.'

Therefore, fly ash not only adds benefits to 4ncrete, but it is a sustainable product and reduces the use of aw material and resources in the production of cement and concrete. The life cycle of concrete starts with ingredients including water, Portland cement, fly ash, and aggregate. At the traditional end of a life cycle, or when the integrity of the material may merit modification, concrete may be cut, drilled, and/or demolished, resulting in the production of excess materials. At this point, the excess materials can be profiled or characterized, and managed via reuse, recycling, or placement in a containment area following best management practices.

The materials at this point are non-hazardous. In various countries, they are not defined as a waste, but rather as a construction material. Some countries have the regulations that may apply to the demolition, cutting, or sawing of concrete and the management of the materials.

To conclude, the use of fly ash in concrete results in a new product whose characteristics differ from raw fly ash. Fly ash is a safe and sustainable product that, when characterized and managed properly, does not pose a concern for human health or the environment. When drilled or demolished, fly ash does not revert to the characteristics of the raw ingredient, but rather maintains the characteristics of the new product—again, just like the ingredients of a cake and the resulting crumbs when sliced and served.

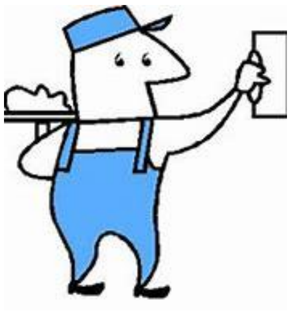
23. AGRICULTURE AND SOIL MODIFICATION

Modifiers have been added to soil to improve plant growth and crop yield for thousands of years. For the past 50 years, flue gas desulfurization (FGD) gypsum—calcium sulfate dihydrate—produced by the removal of sulfur by coal plant emission control devices, has been added to soil to improve its nutrient profile. It is now widely used to boost the characteristics and yield of crops ranging from peanuts to tomatoes and cantaloupes. To a lesser degree, alkaline fly ashes have been tested and used to enhance soil conditions and crop growth by balancing the pH of acidic soils and improving their water-retention capacity.

CCPs Used in Agriculture and Soil Modification

- FGD Material
- Fly Ash

The use of fertilizers soil additives intended to enhance plant growth dates back thousands of years. The ancient Egyptians, for example, used pigeon manure to boost the growth of their vegetable and fruit gardens. The 19' century English agricultural scientist Sir John Bennet I.awes is credited with inventing "artificial manure" precursor to the modern chemical fertilizer industry—when he patented a soil additive formed by treating phosphates with sulfuric acid. Today synthetic nitrogen fertilizers—typically produced using a highly energy-intensive procedure known as the Haber Bosch process underpin the productivity of much of modern agriculture.



Of course, there are many other types of fertilizers in use today, including those derived from phosphorous, organic waste, industrial byproducts, and even municipal sludge. Use of one versus the _ other may depend on any number of factors, including cost, availability, local soil and climatic conditions, and the specific crop that is being grown. Gypsum's value as a soil additive has been known in the U.S. since the colonial times,' and agronomists continue to find new uses for it today.

24. GYPSUM vs. SYNTHETIC GYPSUM

Traditionally, gypsum has been sourced from mines and quarries, and the United States today remains the largest producer of mined gypsum in the world. Since the passage of the Clean Air Act in 1970, however, a synthetic form known a flue gas desulfurization (FGD) gypsum has been available to the market.

FGD gypsum is produced when emissions control systems at coal-fueled power plants remove sulfur and oxides from flue gas streams. The scrubbers spray liquid lime or limestone slurry into the flue gas path, where it reacts with sulfur in the gas to form calcium sulfite, which is then converted to gypsum through forced air oxidation. The material is then dewatered and processed, resulting in a powder that is typically finer, purer, and more uniform than mined gypsum, but which bears the identical chemical composition: CaSO4 2H20 (calcium sulfate dihydrate).

As is obvious from its chemical formula, FGD gypsum is rich in both calcium and sulfur—two nutrients that are essential to virtually all crops. As such, FGD gypsum can be highly effective when applied to areas with calcium-poor soils and to crops with high calcium requirements. FGD gypsum is often applied to peanut fields, as well as to fruit crops such as cantaloupes and tomatoes that require calcium to strengthen their skin, reduce their blemishes, and improve their shelf life.' FGD gypsum's sulfur is an increasingly important soil additive as a result of the reduction of atmospheric sulfur deposition (largely as a result of its removal by emissions control devices) and the reduced level of sulfur found in much of today's nitrogen and phosphorous fertilizers.' Owing to its fine and uniform consistency, FGD gypsum is easily spread via conventional agricultural equipment. And, as it is only moderately soluble in soil,' FGD gypsum releases sulfur over the course of multiple years—minimizing the need for repeated applications.

As with any fertilizer or chemical additive, a range of considerations should be kept in mind when deciding whether and when to apply gypsum. FGD gypsum is not suitable for all soil types, soil conditions, or crops—and any use of FGD gypsum as a soil amendment requires a well-characterized study of the soil before application.

Moreover, individual states may have regulations and standards that need to be observed regarding its use. It is typically recommended that the relevant state department of agriculture or state extension service be consulted br-fare-FGD gypsum is used as a soil amendment.' Appropriate application rates then can be determined to accomplish specific soil improvement goals.

That said, agricultural scientists continue to research and test new applications for FGD gypsum that could become increasingly important in the coming years. One promising avenue of research is in the use of FGD gypsum to reduce the incidence and impact of "algal blooms"—caused by the runoff of phosphorous and nitrogen fertilizers into waterways—that are increasingly polluting U.S. water basins and threatening both human drinking supplies and wildlife. Spread over affected croplands, FGD gypsum has been shown to be effective in binding with phosphorus to make it less soluble and thus less able to run off into the water.")

25. FLY ASH IN SOIL MODIFICATION

To a lesser degree, fly ash has also been investigated and used to modify and improve soil properties for agricultural crops.

Physically, fly ashes comprise silt-sized particles, which can be useful in helping transform the texture of sandy and sandy-clay soils to loamy, which is more favorable for agricultural cultivation." In dry conditions, clayey soils can form dense, hard clods, leading to poor soil-seed contact and lower germination.' Fly ash has been shown to increase the water retention capacity in sandy soils and the ability of soil to transmit water in clayey soils.13

Chemically, fly ashes are comprised primarily of oxides of silicon, aluminum, iron, and calcium, with lesser amounts of magnesium, potassium, sodium, titanium, and sulfur. Many of these elements have been shown to increase the nutrient uptake and yield of certain crops. Fly ash has been demonstrated to improve the crop yields of alfalfa and barley, among other crops, under certain soil conditions." Fly ashes' typically high alkalinity
most have a pH in the range of 8-12'5—mean they can be used 's effectively as a liming agent to neutralize acidic soils and improve their nutrient status.

As with FGD gypsum, soil testing and characterization, as well as chemical analysis of the fly ash itself, should be undertaken before it is applied to agricultural soils.

26. WHERE DO WE STAND IN SOUTH AFRICA?

South Africa's Power Producer's Revised Coal Ash Strategy and Implementation Progress. The South African electricity public utility Eskom has embarked on a process to increase utilization of the ash produced through the electricity generation process at its coal-fired power stations. In the 2014-2015 financial year, 119.2 million tons of coal was consumed, producing 34.4 million tons (28.904 of ash. About 70/0 of the Eskom ash is sold from 6 of the 13 coal-fired power stations.

Many stations are currently running out of ash storage space, and expansion of the ash disposal facilities is required, which could affect security of supply because of limited ashing areas. Additionally, legislative requirements lead to extra requirements for ash storage facilities, requiring high capital expenditure. Increased utilization of ash will postpone or ultimately avoid such capital expenditure. The South African legislative framework strictly governs ash utilization. For this reason, Eskom has rejuvenated its Ash Utilization Project by submitting an application to the Department of Environmental Affairs on behalf of the industry. Eskom is therefore leading an advocacy campaign for ash utilization.

Ash could play a key role in business development, job creation, skills transfer, and localization. The development of small brick-making facilities in close proximity to power stations is ideal. It is imperative to develop new markets that consume high volumes of ash, including road construction and agriculture and land rehabilitation.

The backfilling of mines with ash provides an opportunity; tied collieries are located in close proximity to power stations and could absorb high volumes of ash and benefit the ability to rehabilitate mines and mine closures cost efficiently. Care needs to be taken for the environmental and health impacts of this application.

Multiple benefits can be derived from dealing with ash in an environmentally responsible way. Not only will the environmental footprint be limited, new applications will reduce CO_2 emissions, acid mine drainage can be treated, and mine rehabilitation will be supported. Eskom cost reduction benefits could eventually filter through to the electricity consumer in terms of electricity price, and satisfactory socioeconomic benefits can be realized.

<u>ESKOM Strategy</u>

To manage the increased utilization of ash, Eskom has developed an ash strategy approved by the Eskom and Rotek company boards, in which the scope of the programme was defined, including a programme roadmap and implementation plan.

<u>The strategy details:</u>

- The adoption of cost avoidance rather than a revenue recovery model
- The development of an ash strategy per power station
- Consultation with the Department of Environmental Affairs (DEA) and relevant government departments to change the ash classification
- Submission of exclusion documents to the government, on behalf of industry, to ease the legislative constraints on users
- Unlocking of legislative constraints
- Exploration of all possible ash utilization technologies and applications
- Collaboration with industrial stakeholders
- Development of customer interfaces for sales, take-off points, etc.
- Research (pilot plants, literature reviews, technology development)

27. ASH LEGISLATION

All ash applications make use of one or more of the unique properties of the material (Laven et al., 2016):

- The pH, which is greater than 11.5 when initially produced and weathers to a minimum of 8.5 over time
- The spherical shape of the ash particle, which improves flow characteristics and allows for effective compaction
- The wide range of particle sizes, which increases surface area and allows for effective compaction
- The pozzolanic nature of ash, which allows for setting of the ash once wet

Several ash applications are available internationally, ranging from low to extremely high cost (Electric Power Research Institute Inc. [EPRI), 2016), including rare earth metal extraction from ash, mine backfilling, mine drainage treatment, soil amelioration, land reclamation, road construction, paint, rubber, zeolite production, and geopolymers (EPRI, 2016). However, cementitious uses—that is, the inclusion of ash in cement-based bricks and the use of fly ash in cement itself—are by far the biggest users in South Africa (Eskom, 2016). Each technology has its own constraints, of which transport is one of the most limiting factors (EPRI, 2016); therefore, any new developments need to be near the power plants.
The classification of ash as a hazardous waste needs to be addressed for ash utilization to progress. At present, companies that want to utilize ash require a waste management license to operate (RSA, 2009). This license costs approximately 200,000 rands. (R200,000) and requires 2 years for processing, thus making it impossible for small business to achieve.

To this end, Eskom consulted with the DEA regarding the process of application for exclusion from waste legislation constraints for ash off-takers. It was recommended that a Regulation 9 document submitted to obtain exclusion from the need for a waste management license for various applications (RSA, 2009).

Eskom, through Zitholele Consulting, submitted the Regulation 9,... document to cover four of the largest volume usage applications. These applications were mine drainage treatment and backfilling, soil amelioration and land reclamation, road construction and brick and cement development.

On consultation with the DEA, the timelines for the Regulation 9 approvals was estimated at approximately 24 months, at the earliest. Because of the urgent nature of the approval requirements for brick makers, it was decided to submit a Section 74 document for a temporary exclusion permit from the waste management legislation. This exclusion is temporary and is terminated once a decision is finalized on the Regulation 9 request.

28. CLASSIFICATION OF ASH

The hazardous classification of ash in South Africa is unique worldwide. In the waste type classification is the strictest in the world. Internationally, ash is classified as a by-product or resource depending on the country (Laven et at 2016). According to the National Environmental Management Waste Act (NEMWA), to classify ash, a full inductively coupled plasma analysis and complete leaching (varying protocols) of the ash are required (RSA, 4) 09; DEA, 2013). Table 2 explains the leachable concentration per and total concentration (TC) allowed for the different Table 3 expands on the allowable concentrate waste, and or each type.

Several studies of Eskom ashes have identified that most ashes fall into the Type 3 category, low risk. These studies all indicate that the triggers are just over the total concentration threshold (TCT) or leachable concentration threshold (LCT) 0 concentrations. Table 4 shows a snapshot of the total elemental concentrations found in Eskom ashes; a robot colour coding scale has been used to identify trigger elements. In this case, the main trigger elements are arsenic, barium, copper, and lead. However, the concentrations detected are much nearer the TCTO than the TCT1 concentrations. In this case, more elements trigger the classification, including arsenic, boron, chromium, manganese, molybdenum, selenium, and vanadium, mainly because of the leaching protocol, which requires acidification of the sample. More recent protocols like the Leaching Environmental Assessment Framework (LEAF) are more indicative because leaching is conducted at several different pH levels. When the leaching protocol is conducted, total dissolved solids and sulphate concentrations are also trigger agents.

As part of Eskom's ash utilization strategy, each power station's fly, bottom, fresh, and weathered ashes were resampled for full analysis of both total and leachable concentrations. These samples are being analyzed according to SANS 10234 (South African Bureau of Standards, 2008) to determine the toxicity of the ashes and are being subjected to the LEAF protocol. The results of these analyses will be used to advise the DEA on the possible leaching risks of ash in nonacidic environments and will be compared with international results and associated risks, leading to a possible exclusion of coal combustion products from the waste classification.

29. CONCLUSION

At present, coal ash is classified as a hazardous waste because of its heavy metal concentrations. The legislation governing this classification is extremely strict and is being reviewed in association with international norms and standards. Eskom's ash strategy aims to utilize ash in such a way as to benefit from an associated avoided cost linked to the handling and storage of the ash. To permit ash utilization, a Regulation 9 submission has been handed to the DEA to allow for exclusion of the hazardous classification of ash when used in brick making, cement, road construction, soil amelioration, and mine backfilling.

Kind regards,
Belinda Heichler
SACAA President

Periodic Table of Elements