ISSUE 1 • 2012

ASH at work

Applications, Science and Sustainability of Coal Ash

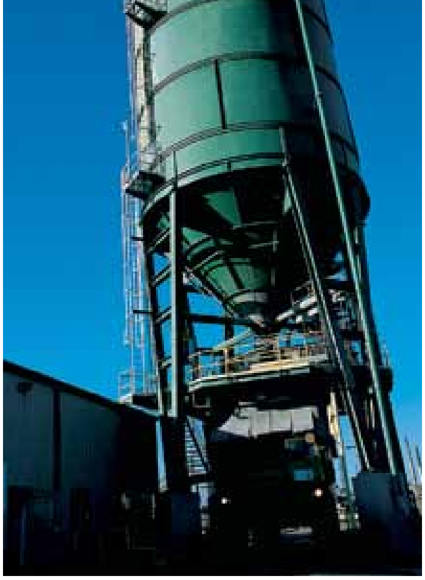
CCPs on the Farm

Why Gypsum is the Hot New (Old) Tool for Agriculture

Coal Combustion and Gasification Products Journal **Inside**

PLUS:

ACAA Coal Ash Material Safety Study
Leachate Procedures Explained
Meet the New ACAA Chair
And much more…

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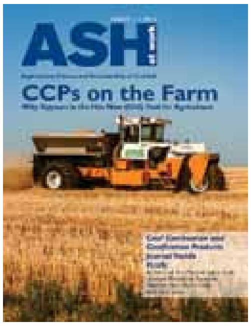

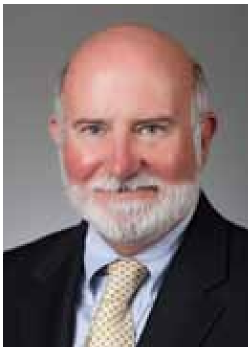

THERE IS LIFE BEYOND THE EPA…

By Thomas H. Adams, Executive Director ACAA

"These activities are part of the mission of the ACAA – to encourage the beneficial use of CCP."

While there is no question that the U.S. Environmental Protection Agency (EPA) has occupied the vast majority of our attention for the last three years and six months, there are other things in which we have been participating.

Make no mistake – our primary mission since EPA began to consider new Coal Combustion Product (CCP) disposal regulations has been to remove any form of hazardous waste designation from consideration by the agency as soon as possible. I would love to report that we have been successful, but we are just not there yet. The longer the cloud of potential hazardous waste regulations lingers over the beneficial use industry, the more damage is done to CCP beneficial use. We will continue our efforts for as long as it takes. The battle is on-going at the EPA, on Capitol Hill, and in the courts.

But life does go on while the disposal regulatory effort continues. Just as we have done in the past, the ACAA continues to be active with user organizations such as the American Association of State Highway and Transportation Officials (AASHTO), American Concrete Institute (ACI), ASTM International, the Concrete Joint Sustainability Initiative (CJSI), and the National Ready Mixed Concrete Association (NRMCA).

We also interact with affiliated organizations such as the Anthracite Region Independent Power Producers Association (ARIPPA), Canadian Industries Recycling Coal Ash (CIRCA), the Center for Applied Energy Research (CAER) at the University of Kentucky, the Electric Power Research Institute (EPRI), the European Coal Combustion Products Association (ECOBA), the Gypsum Association, the Industrial Resources Council (IRC), the Midwest Coal Ash Association, the Texas Coal Ash Users Group (TCAUG), the Utility Solid Waste Activities Group (USWAG), and the World Wide Coal Combustion Products Network (WWCCPN).

We also have interaction with governmental organizations beyond the EPA such as the Bureau of Reclamation, the Federal Highway Administration (FHWA), the National Energy Technology Laboratory (NETL – a part of the Department of Energy), the National Institute of Standards and Technology (NIST), the Office of Surface Mining, and the U.S. Department of Agriculture (USDA).

We also work on an ad-hoc basis with other organizations. For example, the ACAA participated on a panel to review and revise regulations for structural fills in Virginia. As the Colorado Department of Public Health and Environment (CODPHE) has been meeting to consider beneficial use regulations, the association has attended as often as schedules permit. For the past three years we have participated in the Anna Maria Island Workshops which discuss and debate trends and developments in cement and concrete markets in North America and beyond. We are currently working with a regional task group in Florida reviewing beneficial use opportunities and challenges. This group is being led by Professor Tim Townsend at the University of Florida's Hinkley Center for Solid and Hazardous Waste Management.

The organizations and initiatives mentioned above are by no means a complete representation of our activities and relationships.

The point of calling attention to these activities is that we *are* active beyond the EPA. These activities are part of the mission of the ACAA – to encourage the beneficial use of CCP. Would we like to be more involved in these activities? You bet we would. Just think back a few years to the rapidly growing beneficial use rate supported by an expanding economy and a successful government/industry partnership known as the Coal Combustion Products Partnership (C2P2). The beneficial use rate was increasing each year and was on track to hit the 50 percent level by 2012. Those achievements represent the kind of work the ACAA is designed to do. But an economic collapse and the cloud of regulatory uncertainty created by the Environmental Protection Agency has taken us backward.

We cannot allow these hurdles to stop us from working with industry allies and user groups, so we will continue that important work. However, until the black cloud of regulatory uncertainty is gone, the EPA will be the main consumer of our time and talent. If only a rotten economy was the only thing we had to conquer! ❖

DIVERSE AND INCLUSIVE – THE EFFORTS OF MANY HELP ACAA SUCCEED

By Lisa Cooper, ACAA Chair, PMI Ash Technologies

I am deeply honored to serve as Chair of the American Coal Ash Association for a variety of reasons.

"ACAA got the point across to many that CCP recycling cannot be associated with hazardous waste designations. The sooner this issue is taken out of play, the sooner our industry will be able to add jobs, increase investment, stop hemorrhaging and get back to the business of recycling."

ACAA is an inclusive, diverse, sound and vibrant organization. Beneficially using Coal Combustion Products is a mantra that attracts diverse constituencies beyond the traditional utilities and ash marketers; including but not limited to environmental, design, remediation and legal service professionals, academics, technology companies, cement companies, wallboard companies, international ash associations, universities and municipalities.

During these difficult times, we have grown our membership ranks into a robust and dynamic organization. This breadth of talent within our membership is what enables us to continue to be successful. I would like to share with you a note from one of our newest members after she attended her first ACAA meeting in Norfolk:

"Joining the ACAA was the culmination of the last several years of my professional career. I had worked on analysis of EPA's proposed regulation of Coal Combustion Products including helping prepare formal comment on the proposed rule, and producing a report for members of Congress working on legislation to prevent a hazardous waste designation. I even had the opportunity to testify before Congress and present the results of my studies. Through this work, I had come to understand the important economic and environmental benefits of recycling coal ash. I am an engineer at heart (and by degree) and believe that any sensible coal ash regulation should be based on science and sound economic reasoning. I realized my beliefs aligned with the mission of ACAA. My first ACAA event as the newest individual member was the summer meeting in Norfolk. I was immediately welcomed by member liaison Alyssa Barto and the ebullient Annely Noble and introduced to other members. I enjoyed a wonderful women's luncheon where we discussed the paths our careers have taken. During the meetings and reception, I ran into people who I had previously worked with and made many new connections. I was so charmed by the open and friendly attitudes of everyone I met. How extraordinary that I felt part of this group at my first meeting! The second day I enjoyed presentations on coal ash use, benefits, and safety. It is exciting to be part of an association whose mission is recycling and sustainability. I am impressed by the level of commitment and volunteerism that is prevalent throughout the association. Reflecting on what I have experienced and learned at my first meeting, I realized that ACAA is more than an industry group. ACAA is a community that I am privileged to be a part of." by Dawn Santoianni

Whether new or existing member, and especially as travel budgets continue to dwindle, we must re-double our efforts to make ACAA meetings affordable, meaningful and enlightening. For instance, in Norfolk, one key issue that was raised to me by the Chair of our Technical Committee, Keith Bargaheiser, is a product labeling concept that would apply to concrete, much like food labels at the grocery store. The concrete product labels would detail "green" attributes. ACAA will be looking at the Product Category Rule (PCR) that would *require* labeling called Environmental Product Declarations (EPD) and possibly Health Product Declarations (HPD). (See the article in INFOCUS CONCRETE, SUMMER 2012 article by Douglas Rublin entitled, "PCRs and EPDs: Are You Ready for the Future?" http://tinyurl.com/PCRs-EPDs.)

The first day of the Kansas City Fall meeting was designed to focus on a variety of topics including updates on technical issues. Many of these technical issues warrant further consideration from a marketing and regulatory standpoint. As we consider these issues, our hope is not only to educate ourselves but determine decisive steps, if any, for the Association.

It is through attendance at our meetings that you can most effectively add your voice to our collective dialogue. Mark your calendars for the ACAA Winter Meeting on January 29-30 in Richardson, Texas. There we will focus the agenda on coal plant retirements and supply issues, as well as updates on key EPA developments in Alaska and Puerto Rico.

Another reason ACAA has made us all proud is by raising the truthful and green profile of CCP beneficial use. ACAA along with other stakeholders was able to engage a fractured federal government in a real dialogue regarding CCPs. ACAA got the point across to many that CCP recycling cannot be associated with hazardous waste designations. The sooner this issue is taken out of play, the sooner our industry will be able to add jobs, increase investment, stop hemorrhaging and get back to the business of recycling. Although the Transportation Bill passed without inclusion of our issue, we will not give up! We will continue to work with stakeholders to pry open every opportunity to ensure that CCP beneficial use remains an American and international success story.

> **"We will continue to work with stakeholders to pry open every opportunity to ensure that CCP beneficial use remains an American and international success story."**

But be assured, it will take all of our voices to be successful. As Nobel Laureate Aung San Suu Kyi stated in June of this year:

"The French say ..To be forgotten is to die a little."

We must have your voices heard by neighbors, state and federal governments and elected officials. Please schedule time, even if on your evenings and weekends, to send an e-mail, leave a message, or write a personal note to elected officials about the importance of CCP recycling to our environment, economy and this election. I am confident we will triumph on this issue, but we can't allow ourselves to be forgotten or die because we rest on past achievements or rely on only a few people. We want the entire industry that safely recycles CCP to succeed.

In closing, thank you for electing me as Chair to work with you and for the Association. I promise to do my best and be approachable. I want to hear good and bad. Please call, e-mail, stop me in the hall, and invite me to coffee or drinks. I want to get to know you, your company's hot button issues and the value you find within ACAA now and in the future. I look forward to working with you! ❖

CCPS IN AGRICULTURE

Gypsum Is A 'Win-Win' For Utilities and Agriculture

By Dan Zinkand

Ron Chamberlain, director of gypsum programs for Beneficial Reuse Management, and Indiana farmer Jack Maloney examine corn stalk from fields treated with gypsum.

More than 200 years ago Ben Franklin spread gypsum on his clover fields in Pennsylvania and saw amazing results. But because gypsum is expensive to mine and transport the practice virtually disappeared in American agriculture, except for certain specialty crops like peanuts and potatoes.

Now – thanks to the growing availabilty of flue gas desulfurization (FGD) gypsum and a undeniable buzz in the agricultural industry – gypsum application is quickly becoming an integegral management practice for crop growers focused on improving soil quality, sustainability and profitability on their farms.

In fact, gypsum has captured headlines such as, "Farmers See Greener Fields with Gypsum Use," "Gypsum Gains Ground," and "Miracle Sulfur Source?" in leading farm magazines. Major articles have appeared recently in *Farm Journal, Hoard's Dairyman, Progressive Farmer*, and more farm papers, including a six-page December 2011 cover article in the American Society of Agronomy's Crops and Soils. A 2011 reader survey by *No-Till Farmer* reported that gypsum use among no-tillers has jumped 400 percent since 2008.

So if you've been thinking of byproduct gypsum as just an expensive disposal problem, think again. There's a growing agricultural market that's ready and waiting, and many compelling reasons for why this is happening.

Indiana farmer Rodney Rulon has been applying gypsum to his fields for seven years.

Wisconsin farmer Ken Ihlenfeld saw significant improvements to alfalfa crop yields after applying gypsum to fields.

GYPSUM HELPS SOIL

Using gypsum as a soil amendment can help farmers reverse the effects of compaction and other soil quality problems compounded by years of heavy equipment traffic and intensive farming systems. Concrete-like fields – often with tight clay soils – are hard to farm and nearly impermeable to moisture.

Gypsum helps improve the infiltration of rainfall into farm fields, says Dr. Darrell Norton, who spent years at the U.S. Department of Agriculture's National Soil Erosion Research Lab at West Lafayette, Indiana.

Water that infiltrates into the soil profile can be used by crops later in the growing season, Norton explains. Better infiltration reduces soil erosion and the movement of phosphorus that exists in soluble forms that can pollute bodies of water.

Gypsum (CaSO4 2H2O) dissolves with moisture into calcium and sulfate. Inceasing soluble calcium improves aggregate stability to set the stage for improved soil structure.

"Using gypsum as a soil amendment is a great 'green' story for the coal industry and agriculture," says Dr. Norton. "This is why other researchers and I call this opportunity a 'win-win' for both industries."

Applying gypsum to the soil protects its particles from breaking down when raindrops hit the surface of fields, Dr. Norton says. This happens through a physical-chemical reaction.

"There are few electrolytes in rainwater," he says. "Gypsum is an electrolytic source which keeps the soil flocculated. That is, it keeps the clay particles clumped together or aggregated."

Gypsum does more than improve the soil. It also contains calcium and sulfur. Since the advent of federal clean air regulations, technology has reduced the airborne deposition of sulfur on fields by about 50 percent, Dr. Norton says. After nitrogen, phosphorus and potassium, sulfur is the nutrient most important to crop production.

"Growers used to get this important meso-nutrient for free," Norton says, referring to sulfur. "In gypsum we have a very low-cost product that helps farmers produce more abundant and better quality food."

CORN AND SOYBEAN FARMER BELIEVES

Since Rodney Rulon and his cousins, Roy and Ken Rulon, began using gypsum on their Indiana corn and soybean acres seven years ago, they've seen improved water infiltration and less runoff.

"We started using gypsum in our problem fields and then after seeing benefits there, started using it across all of our acres two years ago," says Rulon, whose family farms about 5,800-acres. They hosted the 2012 Midwest Soil Improvement Symposium, a gypsum educational event co-sponsored by the Rulons, GYPSOIL and the Conservation Technology Information Center on August 21.

While the Rulons have not specifically used gypsum to restore nutrients, Rodney Rulon says he's observed the benefits of boosting sulfur levels.

"In low sulfur conditions, I think you can see a yield boost immediately and directly," he says, refering to his corn crop. "In the last couple of years, the soybean fields where we have applied gypsum have been our best-yielding fields. These beans have more green color to them and they look better early on in the growing season."

Year in and year out, the direct yield benefits of applying gypsum can vary, Rulon says.

"In one year, the increased water infiltration may make a big difference, especially when it's dry," he says. "And in another year, when there's more moisture, you may not see as much of a difference. Using GYPSOIL is one of those things that we do to build the soil structure and tilth over time."

STRONG TRACK RECORD

Fellow Indiana farmer Jack Maloney agrees applying gypsum to his fields is an integral part of a well-managed system that has increased his corn and soybean yields during the past 10 years.

Maloney began applying about 2,000 pounds of gypsum per acre every other year as advised by his agronomist Ron Chamberlain, who founded GYPSOIL and now works for its parent company Beneficial Reuse Management.

Maloney, who farms near Brownsburg, outside of Indianapolis, now applies 1,000 pounds of GYPSOIL every other year on his corn and soybean fields for a maintenance program.

He started applying gypsum because it allowed him to feed fields with the calcium and sulfur they need without altering the pH levels. Using gypsum to improve the soil structure and water infiltration is all part of an intricate system, Maloney says.

"All of the parts of the system need to be there: cover crops, no-till, sub-surface drainage, soil fertility, air and water management and gypsum. You can't just cherry pick and use one and expect great results."

This system helps create healthy root systems that not only hold the fertility in place and reduce erosion, but also enable crop roots to use the nutrients in the soil.

"Without the roots of the corn and soybeans and the cover crops that grow from fall until spring, the nutrients will go down through the soil and go out the sub-surface tile drains," Maloney says.

With gypsum in an integrated crop management system, farmers will increase their profits, Maloney says.

"My corn and soybean yields have increased every one of the past 10 years," he says. "Ten years ago, my corn yield with USDA

Dr. Darrell Norton, formerly of the U.S. Department of Agriculture's National Soil Erosion Research Lab, is a leading proponent of gypsum use in agriculture.

was 165 bushels per acre. Now it's just under 200 bushels an acre."

To put that in perspective, at the prices many farmers saw in the fall of 2011, that 35-bushel-per-acre increase amounts to an additional $210 more per acre in gross revenue.

GYPSUM BENEFITS ALFALFA, TOO

Ken Ihlenfeld of West Bend, Wisconsin, farms 2,500 acres, including 400 acres of alfalfa used for his 400-cow dairy operation. In early 2011 he spread one ton of gypsum per acre to alfalfa in test strips compared to no gypsum. Ihlenfeld harvested 0.6 ton of alfalfa more later in the summer where he spread the gypsum versus untreated land. He then applied gypsum to the rest of his alfalfa ground last fall.

"Gypsum is a win-win for us because it boost yields by correcting the sulfur deficiency and the calcium helps loosen up our compacted soils," says Ihlenfeld.

Expanding Market

While corn, soybeans and alfalfa are often associated just with the Midwest, these crops and others that benefit from gypsum are produced throughout the South, Southeast and Atlantic states. Corn and hay are grown in the Great Plains and the West, too. This widespread production bodes well for demand for using gypsum as a soil amendment, says Chamberlain.

"We are definitely seeing interest among farmers, universities and the U.S. Department of Agriculture beyond the Midwest for using gypsum," Chamberlain says. "This includes researchers in the South, the Southeast and the Mid-South. And USDA research is continuing to expand on how gypsum can help improve soil, crops, yields and profits throughout the country. Gypsum has the potential to help farmers improve their soil, yields and profits."

Dr. Leo Espinoza, a soil scientist with the University of Arkansas, has been studying the use of gypsum in the South, especially where fine particles of soil — silt — can "cement" over the soil when it rains. This "cementing" creates a crust on the surface.

Soil crusting can make it difficult for plants to emerge, Dr. Espinoza says. When crusted soil receives rainfall or irrigation, most of the water runs off, instead of soaking down into the soil where plants can use it for extended periods of time. Gypsum helps eliminate the crust and contributes to more moisture movement deeper into the soil profile which is important for southern crops like cotton.

Gypsum also has promising benefits for very acidic sub-soils in regions of the Mississippi River Delta, where high levels of aluminum become toxic to plant roots, resulting in a "chemically compacted" layer, Dr. Espinoza says. This layer, referred to as a "fragipan," is found about 10-20 inches deep and hinders the growth of plant roots, he says.

Unlike lime, gypsum can move down the soil profile and alleviate the detrimental effect of high aluminum levels, Dr. Espinoza says. Some of his fieldwork has shown increased root depth and water infiltration in plots where gypsum was applied, compared to untreated plots.

GREAT FUTURE FOR GYPSUM

Dr. Norton says he believes the future looks good for the use of gypsum in agriculture because he believes farmers are more focused on soil quality than ever before.

Back in the mid-1990s, precision agriculture meant measuring and mapping yields in farms. But increasingly, it means the precision planting of seeds and placement and timing of nutrients, Norton notes.

"Farmers are using precision management of water, nutrients and crop genetics, and are also paying more attention to the soil," he says.

Gypsum has the potential to make a huge impact on improving soil and water quality, says Norton. "Using gypsum as a soil amendment is the most economical way to cut the non-point runoff-pollution of phosphorus," Norton says. "In fact, gypsum is by far the best way to reduce phosphorus runoff into bodies of water. This can also be done by co-applying gypsum with poultry litter or other animal manure."

Dr. Norton notes that the utility industry has sponsored a number of seminars on the use of gypsum as a soil amendment in agriculture. However, he believes the industry as a whole needs to wake up to the opportunity that agriculture presents as a viable market for byproduct gypsum.

"Gypsum can benefit the environment, farmers and the world's food supply," he says. "Landfilling gypsum not only potentially consumes productive farmland, it also locks away a valuable product." ❖

Dan Zinkand is a freelance writer based in Salem, OR.

NEW THREE-YEAR PROJECT TO ADVANCE THE USE OF FGD GYPSUM TO IMPROVE WATER QUALITY

By Ken Ladwig, Senior Program Manager, Electric Power Research Institute

EPRI | ELECTRIC POWER RESEARCH INSTITUTE

Sediment-laden water runoff from agricultural fields is a major source of nutrient loading in many impaired waterways in the United States. Excess nutrients lead to harmful algal blooms that damage aquatic resources and degrade water supplies. The dead zone in the Gulf of Mexico, disruption to recreation and fisheries in Western Lake Erie, and decline of native oysters in Chesapeake Bay are illustrations of the damage caused by these excess nutrients.

Development of effective and economical practices to restore soil conditions is necessary to prevent the continuing loss of nutrients in runoff and the key to mitigating non-point source pollution in agricultural landscapes and improving water quality.

The value of using flue gas desulfurization (FGD) gypsum in agriculture to improve crop yields and overall soil quality is well demonstrated (see accompanying articles). More recently, FGD gypsum has been shown to play an important role in controlling total phosphorus and soluble reactive phosphorous, which are major contributors to the nutrient problem in waterways. The United States Department of Agriculture-Agricultural Research Service (USDA-ARS) and others have been evaluating the use of FGD gypsum for phosphorous control in the Southeast, upper Midwest, and Chesapeake Bay for about the last five years. It is estimated that phosphorous reductions of 40 – 70 percent can be achieved using FGD gypsum*.

The Electric Power Research Institute (EPRI) initiated a three-year project in 2012 designed to take this application from research to practice in partnership with leading research scientists, agronomists, industry participants, and outreach professionals. The project will consist of three major components:

- Demonstrate at a field scale the practical application of FGD gypsum to reduce the potential for release of phosphorous and other nutrients from agricultural soils at several sites;
- Use the field demonstration results as a basis for developing best management practices (BMPs) that are incorporated into USDA-Natural Resources Conservation Service (NRCS) Practice Standards.
- Perform extensive education and outreach activities to extend the practice to the agricultural community.

Field demonstrations will be performed over a minimum of two years using the following methods: 1) selecting operating fields with high soil phosphorous levels, 2) applying FGD gypsum to portions of these fields, 3) collecting soil and water samples from the gypsum treated and untreated areas of the fields, 4) measuring soil characteristics that influence nutrient export, and 5) measuring nutrient export in water. The main objective of this part of the project is to transition previous research at the laboratory and field plots stage to larger-scale field application.

Areas currently targeted for field demonstrations are the Maumee River and Grand Lake St. Marys watersheds in northwestern Ohio, and the Lower Fox River watershed in east-central Wisconsin. These watersheds discharge to Lake Erie, the Wabash River (Mississippi River watershed), and Lake Michigan, respectively, and have been cited as areas with severe water quality problems related to non-point agricultural runoff. The Maumee River and Grand Lake St. Marys field demonstrations will be led by The Ohio State University, and the Lower Fox River field demonstration will be led by the University of Wisconsin. The GYPSOIL Division of Beneficial Reuse Management will provide the FGD gypsum and ground support with field applications and monitoring. The demonstrations will require collaboration with local growers and agricultural consultants.

Using the findings from the field demonstrations, we will work with state officials and the USDA-NRCS to develop the use of FGD gypsum application as a BMP for phosphorous control in Ohio and Wisconsin. We will also engage other states in the region, to begin development of BMPs and initiate additional field demonstrations. In addition to setting standards for use, BMPs for nutrient control have implications for water quality trading that will be qualitatively explored in this project. We hope to begin the process whereby farmers can benefit from using FGD gypsum BMPs, not only through improved crop productivity, but also by selling nutrient credits within nutrient markets that are under development in these watershed communities.

Education and outreach are major components of this project, and are critical to its successful execution. Greenleaf Advisors will lead extensive education and outreach activities, which will include workshops, meetings, and communication briefs in Ohio and Wisconsin, as well as surrounding states. We will engage with watershed leadership, crop producers and consultants, state officials, NRCS staff, and conservation groups to communicate project findings and to transfer knowledge for improving land management practices and water quality in the region.

Successful use of FGD gypsum for controlling phosphorous in runoff from agricultural fields provides benefits on many different levels. The public benefits include improved water quality and associated recreation and resource utilization. Crop producers stand to realize benefits such as reduced fertilizer requirements, improved soil conditions, improved crop yields, and higher profits. And for power companies, every ton of FGD gypsum used is one less ton going to a landfill.

The project is currently funded by EPRI, power companies, and the ACAA Educational Foundation. Proposals have been submitted for a USDA Conservation Innovation Grant and Great Lakes Restoration Initiative Grant. The project has also received a broad level of support from regional conservation organizations, including The Nature Conservancy, Ducks Unlimited, and the Ohio Environmental Council.

FGD gypsum is a vastly underused resource. In 2010, U.S. utilities produced 22 million tons of FGD gypsum, and only about one-half was used, primarily in wallboard production. Significant quantities of FGD gypsum are currently produced in the Midwest agricultural belt. While use of FGD gypsum in agriculture has been proven through previous research, adoption of the practice has generally been slow, although it has been increasing in recent years. The development of agricultural BMPs, along with the extensive education and outreach proposed here, are necessary to encourage broader adoption. ❖

*Brauer et al., 2005; Bryant et al., 2011; Favaretto et al., 2006; Norton, 2008; Watts et al., 2010

Ken Ladwig is senior project manager at the Electric Power Research Institute (EPRI). EPRI is an independent nonprofit organization carrying out research on technology, operations and the environment for the global electric power industry.

"FGD gypsum is a vastly underused resource. In 2010, U.S. utilities produced 22 million tons of FGD gypsum, and only about one-half was used, primarily in wallboard production."

Ad Index

PAID ADVERTISEMENT

INTERMODAL ISLAND HOPPING FOR CONSTRUCTION MATERIALS

InBulk Technologies' ISO-Veyors save time and money in the transportation, storage and distribution of cements and related minerals, providing an economical platform for sustainable supply chain development.

Whether it's for cement, fly ash, limestone, dry mortars, screeds or ground blast furnace slag, when it comes to transporting, storing and discharging 'dry bulk' construction materials, InBulk Technologies has developed a commercially and logistically viable alternative to traditional storage silos and dedicated road, or rail wagons

The ISO-Veyor is an intermodal tank container, facilitating easy transition between road and rail and sea. Instead of decanting the material from one mode of dedicated equipment to another, transport chains are simplified with ISO Veyors. All that is moved around is the container as the product remains securely stored inside. Once filled at source they remain sealed until the point of final delivery. This removes the need for intermediate handling or storage of the contents. The ISO-Veyor can be handled efficiently and easily by standard container infrastructure available across rail terminals, intermodal yards, depots and ports.

The ISO-Veyor has been custom designed to offer greater efficiency and speed. The clever part is that the 'fluidization' membrane is designed to follow the curvature of the tank barrel, avoiding the need for space consuming cones. This allows superior payloads and discharge performance in terms of both time and residue remaining. With the simple addition of an air supply (and without tipping so reduced opportunity for accidents or need for a costly tipping chassis) The ISO-Veyor discharges its contents in less than 30 minutes and leaves very little material behind following discharge.

Supply chain flexibility

The major advantage that the ISO-Veyor system offers is transportation flexibility.

Without any double handling, cement, ash or slag cement can be loaded at a plant in a truck mounted unit, and then transported to a rail or barge or shipping terminal for trans-shipment to markets or destinations hundreds of miles away.

InterBulk GROUP

What is the ISO-Veyor and why is it different?

ISO-Veyors offer increased choice for dry bulk materials. Patented and built by InBulk Technologies, ISO-Veyors are versatile, intermodal containers for effective transportation and storage. The standard H Type ISO Veyor is 20' and made from mild steel. It is ideal for all types of cement, limestone, ash and a wide range of minerals used within construction, mining and general materials supply.

Compared to traditional designs for dry bulk tanks, the ISO-Veyor comes with a number of design improvements which provides better performance during operation, such as horizontal discharge (without need for tipping) and residues of only 0·2% following discharge.

The ISO-Veyor complies fully with the specifications for intermodal freight containers and can be handled and moved from one mode of transport to another like any standard shipping container across rail, road and shipping options. The innovative design is capable of multiple discharges of powders without the need to calibrate and has a class leading payload.

King of the Islands

One area where InBulk have witnessed a surge of activity is from customers operating either on or between Islands. Some scenarios include temporary construction projects, where the ISO-Veyor provides and ideal system for intermodal deliveries without the requirement to make investments in fixed storage silos or large scale storage facilities.

In previous situations, aluminium powder road tankers have been used on RORO ships, which represent a lot of wasted space on a ship compared to an ISO-Veyor. The ISO-Veyor is a convincing environmentally friendly option as it allows its owners to make choices between the most efficient or cost effective means of transport.

The ability for the material to be stored horizontally, up to four units high, for several months at a time, also offers on-site storage options that in the past were hampered by economics or space limitations or lack or trailers or railcars.

The products able to be transported in ISO-Veyors has extended across minerals like cement, fly ash, ground granulated blast furnace slag, white cement, aluminates and waste materials. Future developments may well see this range extended to chemicals and food grade versions, which would be fully cleanable in line with current systems for liquid ISO-Tanks.

Dean Reilly, Marketing Manager at InBulk explains; "Through our parent group's global network, InBulk now have the ability to offer a managed dry bulk logistics service almost anywhere in the world. We are experiencing a large volume of new enquiries, especially from island locations. The enquiries have included ISO-Veyors travelling to the Caribbean from the USA. Rail from USA to Canada is also becoming more of an option. Asia, Indonesia and Malaysia are also interesting markets, with huge scope for development."

The ISO-Veyor has made notable strides in key overseas markets such as the US. Lafarge North America became the first American owners and operators of the ISO-Veyor. Lafarge North America's Montreal office also ordered more of the 20' PH type ISO-Veyor for marine shipments of cement powders to Newfoundland customers from Halifax and Montreal.

Make the move to intermodal with InBulk:

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FARM AID: GYPSOIL CONNECTS FARM MARKET TO FGD GYPSUM

By Kevin Orfield

Indiana farm boy and Purdue agriculture college graduate Ron Chamberlain has worked in agronomy for over 43 years marketing crop inputs, including fertilizer, seed and agricultural chemicals. He eventually established an agronomy consultancy to help crop growers maximize productivity while sustaining their resources and profits.

Chamberlain recognized synthetic gypsum's enormous potential in the early 2000s when he saw improvements in soil condition on farms where it was used. But often growers had difficulty sourcing gypsum when they needed it, so Chamberlain began working with Indianapolis Power and Light Company (IPL) to organize truckloads of material for his clients. Impressed further with gypsum's impact, he established GYPSOIL™ brand gypsum in 2006.

Ron Chamberlain began working with agricultural applications for synthetic gypsum in the early 2000s.

"I saw that gypsum could help transform tight, difficult-to-farm soils into softer, more garden-like soils that soaked up rainwater and produced better crops," Chamberlain says from his office near Indianpolis.

A BUSINESS OPPORTUNITY TAKES ROOT

As an agronomist, Chamberlain easily preached the gospel of gypsum to farmers, but the challenges related to logistics, marketing and regulatory requirements soon became more than he wanted to manage. In 2008, Chamberlain met two men who would help him fulfill his vision of realizing gypsum's full potential: Robert Spoerri, chief executive officer, and David Schuurman, chairman, of Beneficial Reuse Management. Based in Chicago, Beneficial Reuse was working on a recycling project with IPL at the time and the three were introduced through a mutual business associate. The company creates partnerships between industrial companies that generate materials suitable for beneficial reuse and others that can use these materials in projects and products. Repurposing IPL's flue gas desulfurization (FGD) gypsum that was destined for a landfill was a perfect fit.

In 2009, Chamberlain sold GYPSOIL to Beneficial Reuse. He continues to work as their agronomist, educating others on the benefits of gypsum in agriculture. "It's been a great partnership," says Spoerri. "We're in a very good position to lead an industry transformation. It's an exciting opportunity for us that helps energy companies reduce costs and farmers improve yield, while benefiting the environment."

Prior to partnering with Beneficial Reuse, Chamberlain had been selling 15,000 to 18,000 tons of GYPSOIL a year. After purchasing GYPSOIL in July 2009, Beneficial Reuse sold 40,000 tons of gypsum the first year and has more than doubled sales every year since, with projected sales of 500,000 tons in 2012.

Beneficial Reuse signed its first major gypsum marketing agreement with Milwaukee-based We Energies in October 2009. Before 2008, when We Energies began producing gypsum as a byproduct from its state-of-the-art new emission cleaning operations, FGD gypsum was not available to Wisconsin farmers. "We're somewhat unique in Wisconsin in that we use wet scrubbers, which produce gypsum," says Bruce Ramme, manager of land quality in the environmental business unit at We Energies. "Most of the other utilities in Wisconsin use dry scrubbers, which do not produce gypsum."

Last year, We Energies distributed almost 100,000 tons of gypsum via Beneficial Reuse, representing 50 percent growth from the previous year. "In my entire career I've never seen growth quite that quickly for a market entry like this," says

Ramme. "We're actually at a point now where (gypsum) demand exceeds supply – I never would have envisioned that in 2008. This huge growth is a tribute to how the product works for the farmers in the field, to Beneficial Reuse's excellent customer service, and to the GYPSOIL brand."

ENORMOUS MARKET POTENTIAL

Like many utilities that produce FGD gypsum, We Energies also supplies gypsum to the wallboard industry. At its peak, this market consumed about 8.5 million tons of gypsum nationwide per year* and it was quite common for wallboard plants to be built right next to power plants. But the demand for wallboard declined sharply after the housing market bust.

Meanwhile the supply of FGD gypsum from power plants continued to increase, doubling between 2002 and 2010, from 11 million to 22 million tons*. Future growth for even higher production is expected. The potential agricultural market for byproduct gypsum is enormous – there are over 320 million acres of farmland in the United States**, much of which can benefit from gypsum.

"The cost of landfills is very high and they are very difficult to license and permit today," adds Ramme. "Byproduct reuse of gypsum is a huge economic advantage for We Energies and its customers."

But selling gypsum is more complicated than just opening the doors and inviting farmers to come and get it. Gypsum must compete with all the other inputs and farming practices available to today's sophisticated crop operations, and the growers must be educated about the benefits that gypsum can offer. Further, logistics are complicated, and as a byproduct, gypsum is tightly regulated in most states, requiring scrupulous attention to regulatory compliance.

"Beneficial Reuse is able to bridge the gap between the utility companies, who are looking for ecologically friendly ways of using the byproduct instead of filling up landfills, and the agricultural community, where there is potentially a huge demand. Our company understands growers' needs and the agronomic potential for using gypsum both as a soil amendment and as a cost effective source of nutrients," explains Spoerri.

An agronomy classroom: Ron Chamberlain speaks to farmers about the use of gypsum in soils.

LOGISTICAL CHALLENGES

Because GYPSOIL's first partners were IPL and We Energies, its markets developed initially in Indiana and Wisconsin. Today, Beneficial Reuse partners with 11 suppliers representing 25 power plants and has permits to sell GYPSOIL in 17 states in the Southeast and Midwest. Ultimately, the company hopes to distribute gypsum in all 50 states.

Logistics presents a major hurdle to achieving this goal. Of the 150 utilities that produce gypsum, only a handful are west of the Mississippi River. "The biggest challenge is to identify where is the supply and where is the demand and marry the two," says Schuurman. "It's very complex. It's not always easy to find a source of gypsum near our largest potential markets. We have to reach these markets at an affordable cost and make the economics work for both the farmers and the utilities."

To accomplish these tasks, Beneficial Reuse has established a network of 230 distributors, including a number of traditional farm coops. Most of the current distribution areas are serviced by truck, but beyond a certain distance the cost of transport becomes prohibitive. To reduce costs, Beneficial Reuse is working on more cost-effective solutions such as setting up a distribution network via rail and barging for river transport.

Although gypsum is produced year round, it is principally only sold to farmers in the spring and fall. Beneficial Reuse has set up numerous locations to store GYPSOIL locally so it is available when needed. "Two-thirds of our sales are in the fall," says Dana Meier, byproducts manager, IPL. "We can't produce enough in the fall to meet the demand, so offsite storage is essential. We're also working with Beneficial Reuse to find ways to increase storage both onsite and offsite to ensure the product is available when the farmers need it."

Beyond pushing the product through a distribution network, Beneficial Reuse's marketing strategy also involves pulling in customers through advertising and awareness campaigns. GYPSOIL is advertised in the major farm publications and is represented at the top farm shows in its market areas. This year, Beneficial Reuse held its second Midwest

Beneficial Reuse Management executives Dave Schuurman and Robert Spoerri.

Soil Improvement Symposium August 21 near Indianapolis.

"It's a great opportunity to educate the crop consultants who growers turn to for advice," explains Spoerri. "Last year, 200 consultants, researchers, agronomists and growers attended the first Midwest Soil Improvement Symposium at the University of Wisconsin. We brought in researchers, agronomists, and other experts to discuss the different aspects of agricultural gypsum and had panel discussions lead by growers with lots of experience with gypsum on their farms."

NAVIGATING THE REGULATORY MAZE

In addition to addressing logistical and marketing challenges, Beneficial Reuse must also meet regulatory and reporting requirements, which vary from state to state. States in the Southeast already have experience with gypsum, which is used in specialty crops such as peanuts, so the regulatory process is relatively straightforward. Other states are completely unfamiliar with gypsum, so the process can be quite complex, taking up to a year to get the proper permits.

"It's an arduous process. We have two people who do nothing but file regulatory reports," Schuurman says. "To help ensure the process goes smoothly, we'll meet with regulators and give them a presentation on how gypsum works, what other states are doing, and what we think the appropriate standards are for establishing a rational regulatory framework for the material."

FUTURE MARKET OPPORTUNITIES

The Mississippi River Delta region represents a significant opportunity for Beneficial Reuse and GYPSOIL. Decades of repeated tillage and the impact of heavy equipment have left the clayey soils compacted, erosive and prone to suffering during drought, requiring heavy irrigation to produce crops. As a soil amendment, gypsum loosens the soil particles to improve the soil tilth and permeability, thus capturing early spring rainwater for use later on in the season by the crop. The calcium in GYPSOIL can also displace aluminum, a major limiting factor in crop productivity in the Delta and other regions.

"There's a tremendous opportunity to turn these soils around," says Chamberlain, who spends countless days on the road, educating growers at tradeshows, meetings, and other events; visiting growers and agronomists one-on-one and walking through fields to observe soil and crop conditions.

"The farmer's potential return on investment for gypsum is huge," says Chamberlain. "When you balance soil and improve its quality, the costs for inputs, including tillage, machinery, fuel, fertilizer and labor go down. But it's a new paradigm for people. Our challenge has been to create awareness of gypsum's benefits, work through regulatory barriers, and find logistical solutions that ensure cost-effective distribution."

ENVIRONMENTAL IMPACT

By reducing emissions while generating profits and reducing costs, their agricultural gypsum project won We Energies the prestigious 2010 Governor's Awards of Excellence in Environmental Performance. The award also recognized We Energies' commitment to helping others in the industry by sharing information and expertise.

Beyond reducing emissions and landfilling, a significant environmental impact of gypsum is reducing the amount of nutrient runoff in sensitive watersheds. Beneficial Reuse is working with utilities to support studies by university researchers and agronomists to demonstrate how gypsum can be a very important tool in mitigating phosphorus pollution in our nation's waterways.

"We're really excited about the new research related to ameliorating phosphorous runoff," says IPL's Meier. "Indiana, including the Indianapolis area, has many areas that could benefit from the reduction of phosphorus runoff. The research will be important to demonstrating gypsum's effectiveness in this area and expanding its use even more."❖

* 2002-2010 Coal Combustion Product (CCP) Production & Use Survey Reports, ACAA, Aurora, CO.

** Acreage Report for Principal Crops Released by National Agricultural Statistics Service, Agricultural Statistics Board, USDA, June 30, 2009.

Kevin Orfield is a freelance writer based in Mequon, Wisconsin.

ENVIRONMENTAL RISK ASSESSMENT FOR GYPSUM TELLS POSITIVE STORY

By Karen Bernick

"…the risk assessment has shown that FGD gypsum contains extremely low concentrations of most trace elements, about the same as found in mined gypsum and, in most cases, lower than background soils."

Amending soils with flue gas desulfurization (FGD) gypsum offers a host of promising benefits to agriculture, and this beneficial use provides an opportunity for power plants to reduce disposal costs.

But is it safe?

The answer appears to be a resounding "yes" according to early reports from a comprehensive risk assessment by the U.S. Department of Agriculture (USDA) and U.S. Environmental Protection Agency (EPA). The assessment, likely to be concluded in 2013, addresses potential risks that land applications of FGD gypsum could pose to human health or the environment.

"USDA and EPA felt that a risk assessment would help states in their beneficial use designation process," says Rufus Chaney, a research agronomist at the USDA-Agricultural Research Service's Environmental Management and Byproduct Utilization Laboratory, in Beltsville, Maryland.

Beneficial use of non-hazardous materials, such as gypsum used for soil amendment, is regulated at the state level, explains Chaney, who is an expert in the study of trace elements, plant uptake, bioavailability, soil chemistry and toxicity. For the past 35 years he has performed intricate risk assessments for the use of biosolids in soils; remediation of toxic sites; cadmium, lead and arsenic trouble spots; and other contaminant risks in plant uptake and food. He is the lead USDA researcher on the FGD gypsum risk assessment.

The USDA-EPA assessment examines what Chaney calls "new" FGD gypsum, a high quality form of synthetic gypsum sought by agricultural crop producers for its soil improvement benefits, calcium and sulfur supplies, purity and relative low cost versus mined gypsum. The same material is used for producing wallboard. It is a byproduct at coal-fueled power plants equipped with state-of-the-art emission scrubbing systems, and is created after fly ash removal. Forced oxidization is used to transform calcium sulfite into calcium sulfate dihydrate, a highly pure and consistent form of synthetic gypsum.

Chaney says "old" FGD gypsum was produced during fly ash removal and often had excessive residues of boron, arsenic and selenium. "These were a source of concern, depending on the coal source," he says.

But contaminants in the new material are at levels so low that Chaney and his team have found no evidence of any toxicity risks. "FGD gypsum is good stuff," he says.

Chaney says the only risk he has identified occurs if livestock producers allow ruminants to eat large quantities of stockpiled gypsum. "If livestock producers prevent ruminants from eating gypsum by fencing in stockpiles, and limit grazing until after a rainfall to wash adhering FGD gypsum from forage leaves, the sulfate risk is prevented," he says.

RISK ASSESSMENT PROCEDURES

The USDA-EPA risk assessment evaluated an exhaustive list of possible pathways for contaminant exposure from applied FGD gypsum, including via:

- Farm and garden crops
- Soil ingestion by children, livestock and wildlife
- Livestock, wildlife and soil organism exposure to crops grown on amended soils
- Leaching and runoff from amended fields

Data were collected from a number of USDA-EPA collaborative FGD-gypsum field studies recently completed or currently underway in Alabama, Georgia and Mississippi, along with other data from gypsum experiments sponsored by the Electric Power Research Institute (EPRI) in Ohio, Indiana, Wisconsin and North Dakota. Assessments were performed to identify and quantify any potential contaminants in soil, water, plant and gypsum soil amendments collected in the various experiments.

TRACE ELEMENTS

Soil scientists use milligrams (mg) per kilogram (kg), which is equal to parts per million, to describe the concentration of trace elements in soil. Elements are usually considered at trace levels if they are found at 100 ppm or less. In the FGD gypsum assessment, Chaney looked for trace element concentrations higher than corresponding concentrations in "background" or typical uncontaminated U.S. agricultural soils as documented by the U.S. Geological Survey and USDA.

If a trace element in FGD gypsum is lower than the level in background U.S. soils, Chaney says contamination problems have not been found. "No matter how hard we try, no matter how many 100 years we apply this quality of gypsum, we are not going to be able to build up the concentration level with the new FGD gypsum," Chaney says.

Chaney says the risk assessment has shown that FGD gypsum contains extremely low concentrations of most trace elements, about the same as found in mined gypsum and, in most cases, lower than background soils. [See Figure 1.]

SELENIUM

"With the exception of selenium and boron, trace elements in FGD gypsum are lower than the 95th percentile of US background soils," Chaney says.

Chaney notes that the selenium level in FGD gypsum is not able to cause risk because of the high levels of calcium sulfate which comprise gypsum. "Selenate in FGD gypsum is in a matrix of calcium sulfate, and the sulfate inhibits uptake of selenate by plants," Chaney says. "There is no evidence to suggest it would be a toxic factor to humans, livestock, or wildlife or have any adverse route from plants growing on amended soils." This selenate would be a low-grade fertilizer and improve the nutritional quality of forages grown on FGDG amended soils, Chaney adds.

"The USDA-EPA risk assessment evaluated an exhaustive list of possible pathways for contaminant exposure from applied FGD gypsum…"

ARSENIC

Arsenic levels in FGD gypsum are lower than 95 percent of US background soils (10.1 vs. 12 mg/kg) but Chaney says there is a debate within the EPA about the appropriate limit for arsenic in soils.

"Toxicologists at EPA have calculated that the limit for soil arsenic should be 0.43 mg/kg soil based on cancer risk," explains Chaney. Recently they have proposed to reduce this 17-fold lower, which would be 0.025 mg As/kg soil, about 1/20th of normal soil arsenic concentration, according to Chaney. The proposed increase to the arsenic cancer slope factor is for one in a million chance of lifetime (70 years) risk for several cancers in humans with high arsenic exposures from contaminated drinking water.

The present 0.43 limit suggests that nearly all soils would be deemed toxic, Chaney says. "That number is below the 1st percentile of US natural soil – average US soil arsenic is 5 ppm," he explains. "We have found no evidence that this level of natural soil arsenic actually comprises risk to humans or the environment."

OTHER TRACE ELEMENTS

Boron is slightly higher in concentration for FGD gypsum than background soils but no cause for alarm, says Chaney. At typical fertilizer application rates, FGD gypsum supplies no more boron than a farmer would typically add if he or she were adding it as fertilizer. Further, boron does not accumulate in soils over time, and boron fertilizers are periodically applied for many crops (alfalfa, vegetables, etc.).

Mercury is another trace element that is sometimes associated with Coal Combustion Products, but Chaney says most of the mercury goes into fly ash and not the gypsum. Some FGD gypsum has slight elevations of mercury above typical background soils and mined gypsum, but Chaney says no risk has been identified. He explains that soil is a natural "sink" for aerosol mercury meaning soils and plants may emit mercury during the day but collect mercury at night; emissions vary by season (loss in summer but accumulation in winter) so it is difficult to identify a risk from the small amount added by gypsum over long periods of beneficial use applications.

Chaney says the many positive benefits of using FGD gypsum on cropland, combined with the lack of risks to human health or the environment, spells a very positive story for beneficial reuse in agriculture. ❖

Karen Bernick is a marketing communications consultant based in Iowa.

Trace Elements in NEW Gypsum and Soils		
Element	FDG-G-95%ile	95%ile-US Soil
As	10.1*	12.
B	146.	.
Cd	0.29	0.6
Co	<2.0	17.6
Cr	8.69	70.
Cu	2.52	30.1
Mo	2.48	2.16
Ni	2.39	37.5
Pb	1.0	38.0
Se	27.9	1.0
Zn	15.0	103.

*Midwest Soil Improvement Symposium, August 23, 2011. EPRI data analyzed by Dayton at Ohio State University. USGS soil data (right column) published by: Smith, D.B., W.F. Cannon, L.G. Woodruff, R.G. Garrett, R. K. Klassen, J.E. Kilburn, J.D. Horton, H.D. King, M.B. Goldhaber and J.M. Morrison. 2005. Major- and trace-element concentrations in soils from two continental-scale transects of the United States and Canada. USGS Open-File Report 2005-1253.]

Figure 1 – Trace Elements in "New" Gypsum and Soils

COAL ASH MATERIAL SAFETY

Analysis of New Federal Government Data Shows Coal Ash Comparable to Residential Soils

By Lisa JN Bradley, Ph.D, DABT, Vice President, Environment, AECOM

Coal Combustion Products (CCPs), or coal ash, are the materials remaining after the combustion of coal. Coal is an important natural resource for our nation's economy and our energy security. Almost half of our nation's electricity is generated by burning coal according to the US Energy Information Administration (US EIA, 2012). It is estimated by the American Coal Ash Association (ACAA) that in 2010 approximately 130 million tons of CCPs were generated and of this amount, approximately 55 million tons, or 42.5% of CCPs were put into beneficial use (ACAA, 2011).

These beneficial uses include the use of CCPs in concrete, gypsum wallboard, blasting grit, roofing granules, and a variety of geotechnical and agricultural applications. Every ton of coal ash used beneficially equates to a ton of the material not placed in disposal, as well as a replacement of a ton of virgin materials that would otherwise have been used in these products. For certain beneficial uses an estimated 0.7 tons of greenhouse gas emissions are avoided for every ton of coal ash used (USEPA, 2008). These benefits are recognized by the ACAA, whose mission is to encourage the beneficial use of coal combustion products CCPs in ways that are protective of the environment, technically appropriate, commercially competitive, and supportive of a more sustainable society.

After the events in Kingston, Tennessee, and the subsequent USEPA proposed rulemaking, when coal ash is mentioned in the news, it has often been described as "toxic coal ash." Environmental groups often single out the toxic effects of specific constituents without discussing concentrations, or putting them into an exposure or risk context. An article in *ASH at Work* (Bradley and Ward, 2011) provided context for the misuse of this term, and discussed the constituents in coal ash in comparison to background levels in soils in the U.S. Some of the information in that article relied on a report of constituent concentrations in coal ash by the Electric Power Research Institute (EPRI) (EPRI, 2010).

Since the *ASH at Work* article, the U.S. Geological Survey (USGS) published a report providing data for concentrations of metals and inorganics in coal ash from five power plants across the United States (USGS, 2011). Because these are data independently collected and reported by a respected government agency, ACAA worked with AECOM, a global engineering and consulting firm, to conduct a human health risk-based evaluation of the USGS coal ash data, specifically, the data that represent coal ash that could be put into beneficial use. The report, titled "Coal Ash Material Safety – A Risk-Based Evaluation of USGS Coal Ash Data from Five US Power Plants" is available on the ACAA website (AECOM, 2012). This article provides a synopsis of the report.

OVERVIEW

The ACAA and AECOM report is the first to provide a detailed, risk-based evaluation of separate coal ash datasets from a range of U.S. power plants each utilizing coal from a separate U.S. coal province. The purpose of the USGS report was to follow constituents in coal as they transit through the power plant. Thus the USGS report provides data for various forms of input coal, as well as various stages of coal ash in production – many from points in operational processes that do not represent the final coal ash produced. As the purpose of the ACAA and AECOM report is to evaluate beneficial use of coal ash, only those datasets that represent coal ash from each power plant that could be put into beneficial use were evaluated. A risk-based evaluation of all of the coal ash data sets produced by the USGS was beyond the scope of the project, and was not germane to the objective.

To provide a conservative evaluation, it was assumed that coal ash could completely replace the soil in a residential yard. The evaluation used risk-based screening levels developed by the USEPA (2012) that are protective of a child's direct exposure to residential soils (including ingestion, dermal contact and inhalation routes of exposure). These screening levels are considered by the Agency to be protective for daily exposure by humans (including sensitive groups) over a lifetime. Constituent concentrations in coal ash were also compared to background concentrations in soils in the U.S. The USGS data do not address, nor are they appropriate for, the evaluation of the potential for constituent leaching from coal ash. This evaluation addresses direct contact with coal ash, a scenario that is appropriate for the evaluation of beneficial uses.

The results indicate that with few exceptions constituent concentrations in coal ash are below screening levels for residential soils, and are similar in concentration to background U.S. soils. Thus, coal ash does not qualify as a hazardous substance based on its composition, and it also should not be classified as hazardous on a human health risk basis. Because exposure to constituents in coal ash used in beneficial applications, such as concrete, road base, or structural fill would be much lower than conservatively assumed for a residential scenario, these uses should also not pose a direct contact risk to human health.

METHODS

Coal ash data were downloaded from the USGS report website. Data for eight coal ashes from five different power plants in five states were evaluated as shown in Table 1.

Concentration data are available for 20 trace elements – so called because they generally comprise less than 1% of the total constituents in either soil or coal ash. Two types of risk-based analyses were conducted using the USGS data to provide for a complete analysis. Summary statistics were calculated using a USEPA statistical program (USEPA, 2011) to provide the 10^{th} to 90^{th} percentile values for each constituent for graphical comparisons to the USEPA residential soil screening levels. To account for potential cumulative risk effects, USEPA methods were used to calculate exposure point concentrations for each dataset for use in conducting cumulative risk screens.

The evaluation uses a worst-case approach by assuming that exposure to CCPs put into beneficial use could be at the same level and intensity as that of a resident child and adult's exposure to soils in a backyard setting. USEPA Regional Screening Levels (RSLs) were used to compare to the coal ash data (USEPA, 2012). These are risk-based screening levels developed by the agency to be protective of a child's direct exposure to residential soils (including ingestion, dermal contact and inhalation routes of exposure). These screening levels are considered by the agency to be protective for daily exposure by humans (including sensitive groups) over a lifetime, and include consideration of both potential cancer and noncancer effects.

To understand the results of the graphical evaluation, it is first important to understand how the graphs were prepared and what the information represents. Figure 1 shows the USEPA residential soil screening levels for the trace elements; they are presented as green bars with the top of the bar corresponding to the screening level, and have been ordered from highest screening level on the left to the lowest screening level on the right (see the sidebar for a chemical symbols listing). Arsenic is the only constituent classified by USEPA as a carcinogen for the oral route of exposure; the screening levels shown for arsenic represent the range of USEPA target risk levels (see the note to Figure 1 for more detail).

In addition to arsenic, five of the constituents are identified by USEPA as potential carcinogens by the inhalation route of exposure (beryllium, cadmium, hexavalent chromium, cobalt and nickel); however, their screening levels are driven by potential noncancer effects (i.e., screening levels based on potential carcinogenic effects are much higher than the screening levels presented on the table). Concentrations reported by USGS for total chromium have conservatively been assumed to be hexavalent chromium for this analysis. Thus, the screening level shown in Figure 1 is for hexavalent chromium (the screening level for the common trivalent chromium form is much higher than the scale on this chart). As provided in the notes to Figure 1, the screening level shown for hexavalent chromium has been derived using the toxicity information currently available from USEPA's authoritative database of toxicity values. This treatment of chromium is discussed in detail in the report.

TABLE 1.

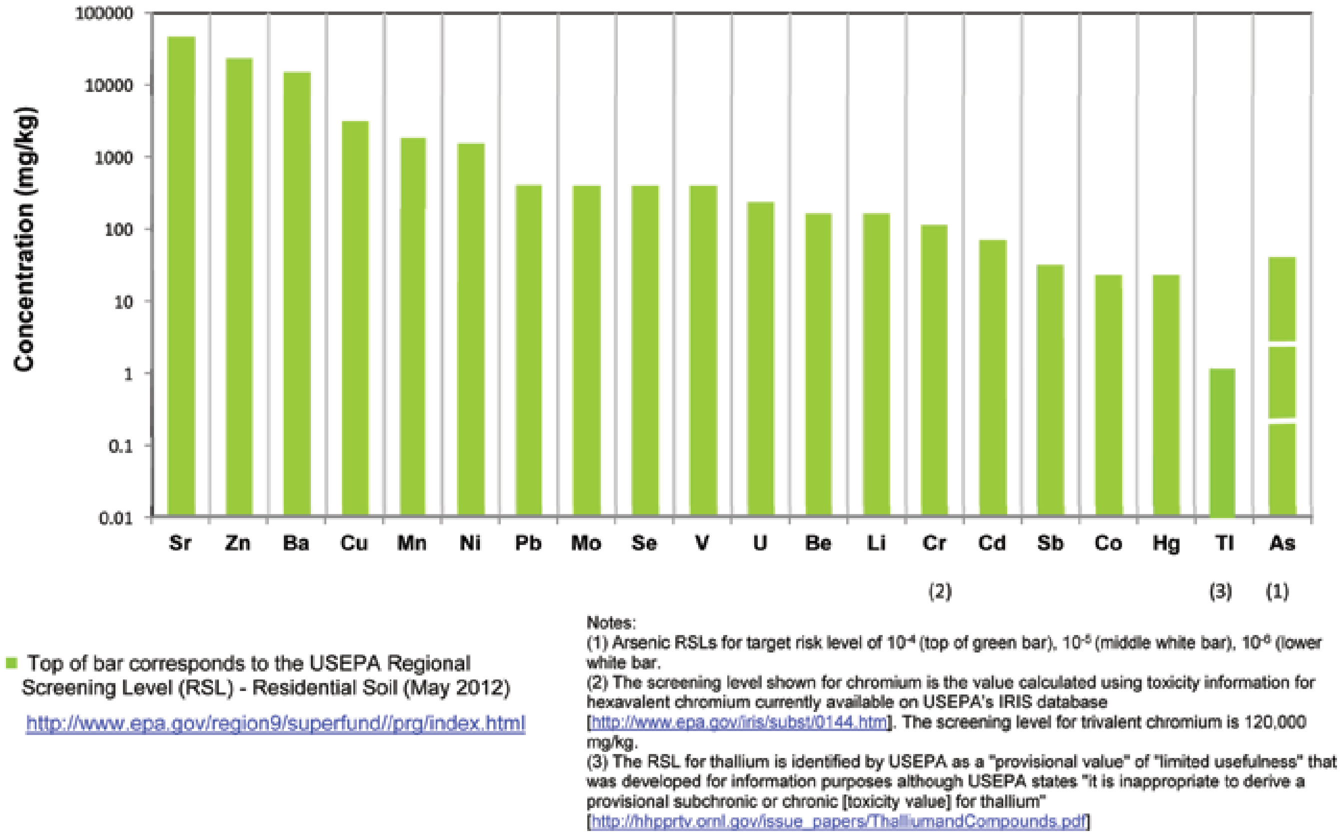
State	Coal Source	Coal Ash	# Samples
Alaska	Nenana Coal Province	Fly/Bottom Ash	19
Indiana	Illinois	Fly Ash	13
New Mexico	San Juan	Fly Ash Product	16
		Bottom Ash	18
Ohio	Appalachian	Fly Ash	13
		Bottom Ash	15
Wyoming	Powder River	Fly Ash	15
		Bottom Ash	15

RESULTS

When plotted on the chart in Figure 1, constituent concentration ranges that fall within the green bar ranges are below the USEPA screening level for residential soil. If coal ash is the "toxic" material that some groups characterize it to be, we would expect that the constituent concentrations as reported by the USGS would all be above the residential soil screening levels. This is simply not the case.

The results of the graphical evaluation are shown in Figure 2 (note, larger one-page versions of each of these charts are available in the report (AECOM, 2012).) The purple bars represent the 10^{th}-90^{th} percentile ranges for each constituent in each type of coal ash evaluated. Of the 20 trace elements evaluated, 15 are present in all ashes included in this evaluation at concentrations less than the USEPA screening levels for residential soils. These are: antimony, barium, beryllium, cadmium, copper, lead, lithium, manganese, mercury, molybdenum, nickel, selenium, strontium, uranium, and zinc. Concentrations of five constituents range to above the residential soil screening level in some but not all of the coal ashes: arsenic, chromium (assumed to all be in the hexavalent form), cobalt, thallium, and vanadium. Moreover, these concentrations are only slightly above the screening levels.

Summary statistics were calculated for the combined bottom ash and the combined fly ash data sets. These combined data sets are compared to background levels of these constituents in U.S. soils as well as the residential soil screening levels in Figures 3 and 4. As shown, constituent concentrations in coal ash are similar to constituent concentrations in background soil.



As – Arsenic	Hg – Mercury	Se – Selenium
Ba – Barium	Li – Lithium	Sr – Strontium
Be – Beryllium	Mn – Manganese	Tl – Thallium
Cd – Cadmium	Mo – Molybdenum	U – Uranium
Co – Cobalt	Ni – Nickel	V – Vanadium
Cr – Chromium	Pb – Lead	Zn – Zinc
Cu – Copper	Sb – Antimony	

Figure 1 – USEPA Regional Screening Levels for Residential Soils

In a separate analysis, a cumulative risk screen was conducted for each of the data sets (details of the method are provided in the report (AECOM, 2012).) The results indicate that potential risks for the upper bound concentration of arsenic in the Ohio power plant fly ash are slightly above the USEPA target risk range of 1 in ten thousand to 1 in one million. Potential risks for arsenic for all other coal ashes are within the USEPA target risk range. All risks for constituents that are potential carcinogens by the inhalation route of exposure (beryllium, cadmium, hexavalent chromium, cobalt and nickel) are within or well below USEPA's target risk range. Again, these risk estimates conservatively assume daily residential exposure to these coal ashes. To provide context for the USEPA target risk range of 1 in ten thousand to 1 in one million, the background cancer rate in the US is 1 in two for men, and 1 in three for women (ACS, 2012).

This conservative screening has also identified non-cancer risks above USEPA's target of 1 for arsenic in the Ohio power plant fly ash, and lithium in the Indiana fly ash. Chromium in this analysis was identified slightly above USEPA's target of 1 for three of the coal ashes. In this risk screening, all chromium was assumed to be in the hexavalent form (the trivalent form is essentially nontoxic) and dose-response values currently on USEPAs database were used for this analysis. Data for the Alaska power plant coal ash indicate that hexavalent chromium makes up only 0.25% of the total chromium, and literature data indicate that hexavalent chromium can comprise up to 5% of total chromium. Thus, the assumption that all chromium is in the hexavalent form for all coal ashes in this analysis is conservative (i.e., is likely to overestimate risks).

Cobalt and thallium results were each above the USEPA target of 1 for five of the scenarios evaluated. However, there are great uncertainties in the derivations of the toxicity values used to evaluate these two constituents. The toxicity value for cobalt is a provisional value from USEPA. Other regulatory agencies have declined to develop a long-term toxicity value for cobalt citing a "lack of suitable data." The estimated dietary intake in the U.S. is higher than the toxicity value. Similarly, USEPA evaluated the data for thallium and concluded that there were not suitable data to develop a toxicity value. However, USEPA provided "…an appendix with

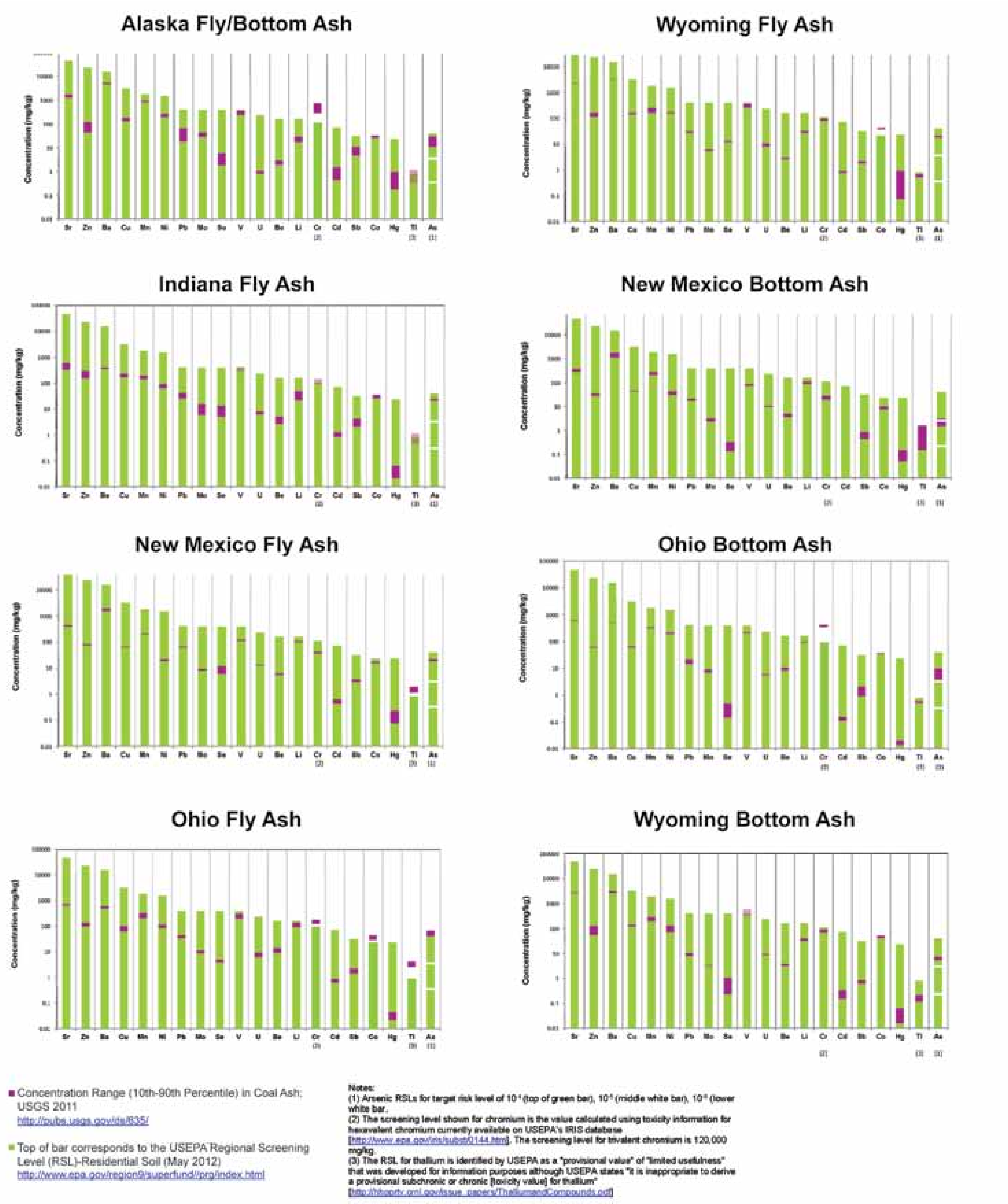


Figure 2 – Comparison of 10th to 90th Percentile USGS Database Constituent Concentrations in Coal Ash to USEPA Screening Levels for Residential Soils

a 'screening subchronic and chronic p-RfD' is provided, recognizing the quality decrements, which may be of value under certain circumstances" and noted in that appendix that "[F]or the reasons noted in the main document [because of limitations in the database of toxicological information], it is inappropriate to derive a provisional subchronic or chronic p-RfD for thallium." Thus the results for thallium and cobalt must be viewed recognizing these great uncertainties.

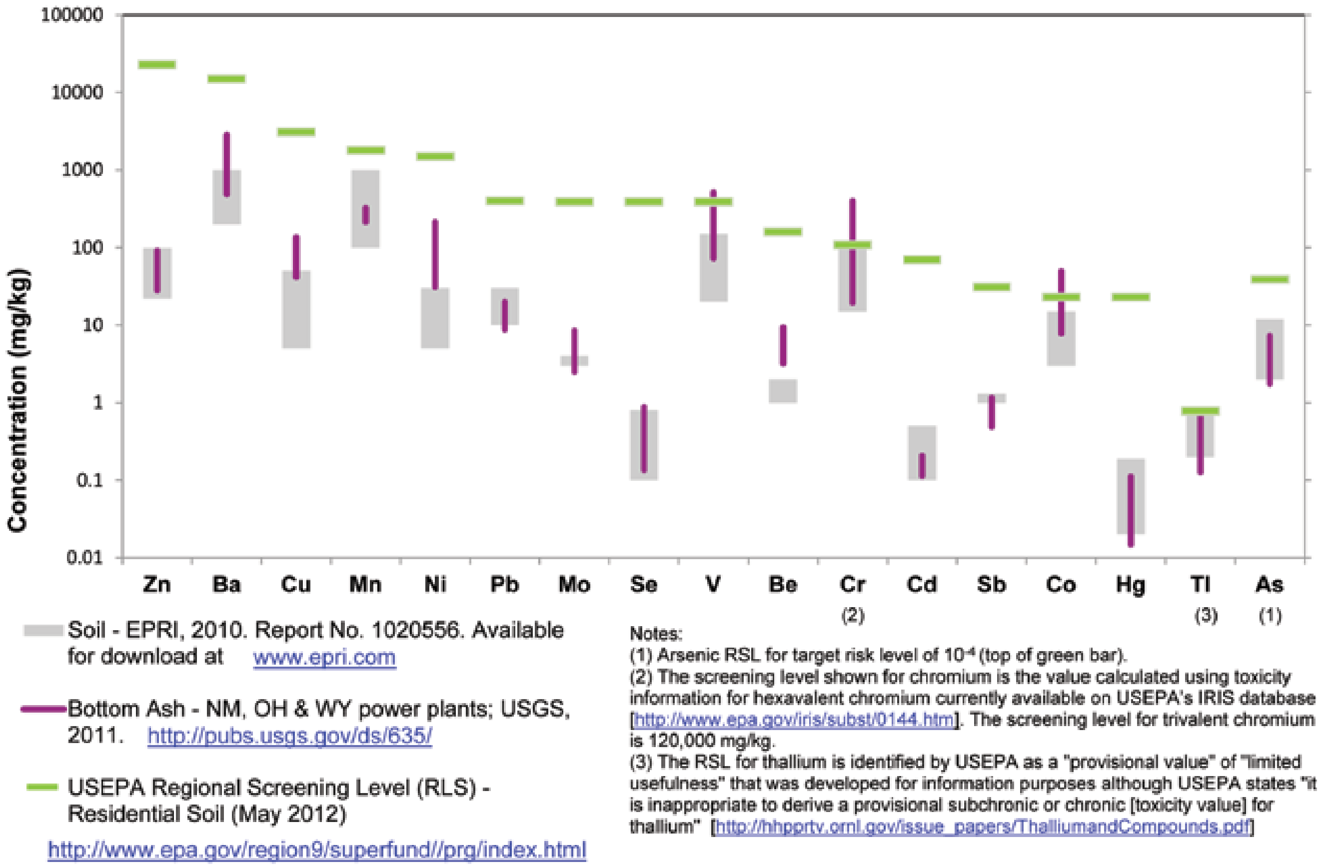


Figure 3 – Comparison of 10th and 90th percentile USGS Database Constituent Concentrations in Bottom Ash and Background Levels in US Soils to the USEPA Regional Screening Levels for Residential Soils

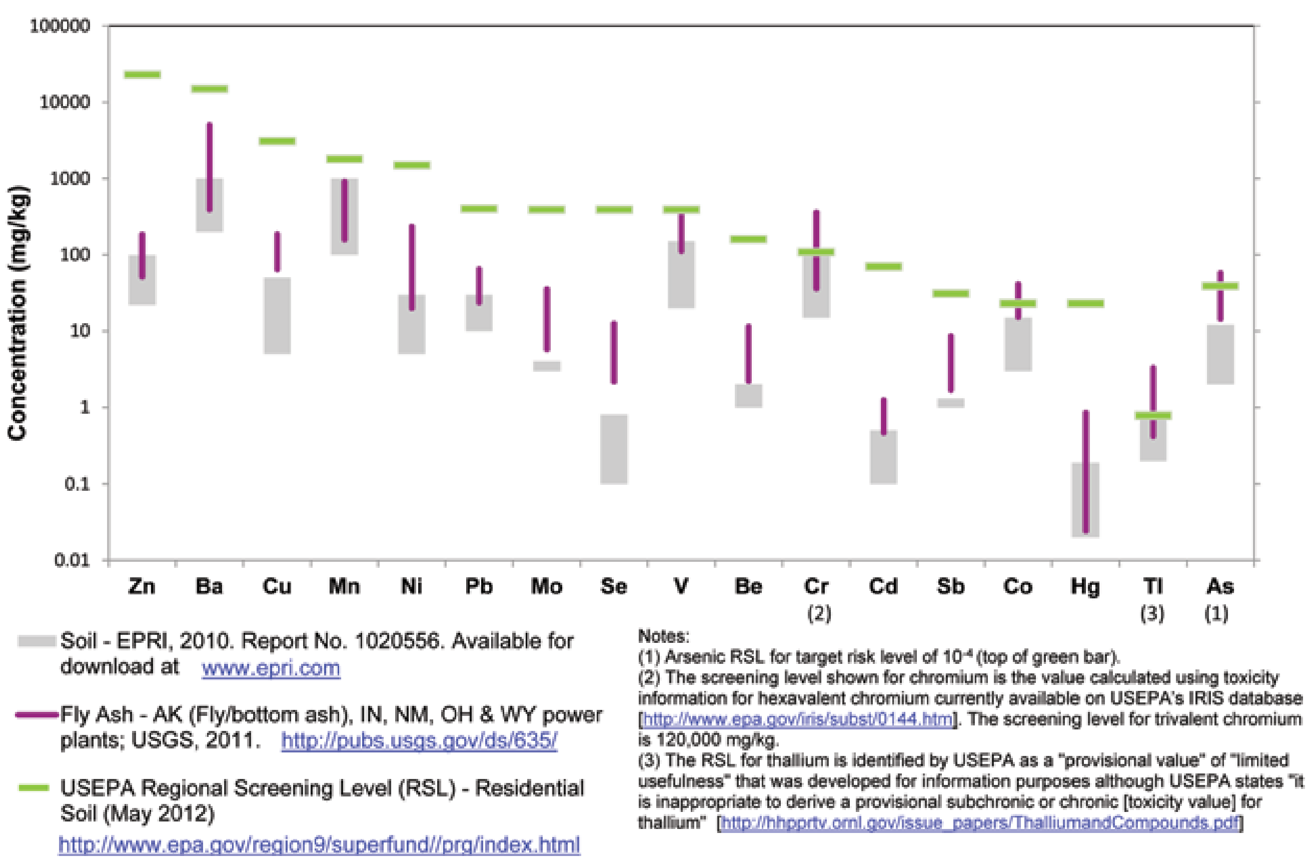


Figure 4 – Comparison of 10th and 90th percentile USGS Database Constituent Concentrations in Fly Ash and Background Levels in US Soils to the USEPA Regional Screening Levels for Residential Soils

CONCLUSIONS

These risk results represent a residential scenario where coal ash is available as soil for exposure by children and adults on a daily basis, underscoring the very conservative and health-protective nature of this evaluation. The results indicate that with few exceptions constituent concentrations in coal ash are below screening levels for residential soils, and are similar in concentration to background U.S. soils. Thus, coal ash does not qualify as a hazardous substance based on its composition (i.e., does not meet the criteria for listing a hazardous waste set forth in 40 CFR 261.11), and it also should not be classified as hazardous on a human health risk basis. In the majority of beneficial use settings, exposure would be far less than that assumed for the residential scenario used here. Therefore, this assumption provides for a conservative evaluation of potential risk for CCP beneficial uses. Because exposure to constituents in coal ash used in beneficial applications, such as concrete, road base, or structural fill would be much lower than assumed for a residential scenario, these uses should also not pose a direct contact risk to human health.

It is hoped that this straightforward, clear, and transparent evaluation of coal ash data collected and reported by the USGS will be used to inform both USEPA's regulatory decision making and their beneficial use risk evaluation process. In addition, it is equally important that the environmental groups that have so vocally characterized coal ash as "toxic" recognize these results and use them to temper their public characterization of the material.

IMPACT ON REGULATION AND LEGISLATION

USEPA is in the process of developing regulations for the disposal of coal ash. As this process has been delayed, Congress has taken action. A bill to provide for the regulation of coal ash disposal, The Coal Residuals Reuse and Management Act, H.R. 2273, passed the House of Representatives by a bipartisan vote of 267 to 144. That bill was introduced into the Senate as S. 1751. Because of the importance of coal ash as a construction material in the transportation industry (ARTBA, 2011), H.R. 2273 was offered as an amendment to the House version of the Transportation Bill, H.R. 4348. While the coal ash amendment was removed from the transportation bill in-conference, during the conference process, it was amended to provide certain improvements, and that revised bill has been introduced into the Senate as S 3512. Each of these pieces of legislation would amend Subtitle D of the Resource Conservation and Recovery Act (RCRA) to set the bar for the regulation of coal ash by establishing a robust set of minimum federal requirements for the management and disposal of coal ash that will ensure safety and the protection of human health and the environment. The results of this study support a Subtitle D, non-hazardous, regulation for the disposal of coal ash. The swift development of such regulation, either by legislative or administrative means, would provide the coal ash beneficial use industry the certainty it needs to continue its successful recycling activities. ❖

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LEACHING TEST METHODS

Development of "LEAF" Adds New Capabilities and Complexities to Materials Testing

Editor's Note: The debate surrounding the U.S. Environmental Protection Agency's coal ash disposal rulemaking has focused attention on the tests used to determine if trace minerals contained in coal cash can leach into groundwater. **ASH at Work** *asked ACAA member TestAmerica Laboratories to summarize leaching test methods – both existing and proposed.*

By Patricia McIsaac, Larry Matko, Michael H Dunn and Richard Sheets of TestAmerica

Leaching test tools are used to estimate the potential release of constituents of concern from waste material prior to its disposal, to assess the waste treatment, or to evaluate the material for beneficial use or treatment effectiveness as well as site remediation options.

OVERVIEW OF LEACHING

In environmental testing, leaching is the process to transfer constituents from solid materials such as waste, soil, sludge, sediment, combustion residues including coal combustion residues [CCR], stabilized materials, construction materials and mining wastes to a contact liquid. The extent to which constituents in the solid phase will transfer to the liquid phase will be dependent on many factors including the specific physical, chemical and biologic conditions of the material, constituents of concern, the leaching fluid and the exposure time.

A leaching test can include a batch test or a dynamic test. The batch leaching test includes mixing the material with leaching fluid to create leachate. The leachate is subsequently analyzed for constituents of concern. The goal of this approach is to have the system reach equilibrium. In the dynamic tests, the material and the leaching fluid is periodically or continuously renewed to create the leachate. The leachate is subsequently analyzed for constituents of concern. Time is an important variable in the dynamic leaching tests and the exposure can occur over weeks to months. The goal of the dynamic test is to determine the mass transfer rate and equilibrium is not intended to be achieved.

The goal of all leaching tests is to assess a specific property of the solid material and/or to simulate environmental conditions. The leaching test which is selected should be based on the regulatory requirements of the program and objectives of the project that supports the end use of the data generated.

There are a variety of leaching tests and no one leachate test can be used to evaluate the leaching behavior of all materials over a broad range of field scenarios.

The following describes two current U.S. EPA SW-846 leaching methods and four U.S. EPA pre-SW 846 methods:

Toxicity Characterization Leaching Procedure [TCLP] – U.S. EPA SW 846 Method 1311

In the Hazardous and Solid Waste Amendments of 1984, Congress directed EPA to revise and expand the existing toxicity characteristics which are used to identify solid wastes that are hazardous due to their potential to leach toxic constituents. In 1990, EPA promulgated the revised Toxicity Characteristic which includes TCLP.

TCLP has a specific list of organic and inorganic regulated compounds with regulatory levels based on health-based concentration limits and dilution attenuation factors developed using a subsurface fate and transport model. Federal regulation for the use of TCLP can be found in 40 CFR 261.24. If the constituent's concentration is equal to or exceeds the concentrations in 40 CRF 261.24, the material is defined as being hazardous based on its toxicity characteristics.

TCLP is a batch leaching test which is appropriate for its intended use as a screening test for wastes which may be disposed of in a solid waste landfill or similar conditions. TCLP does not simulate the release of contaminants to non-groundwater pathways.

Synthetic Precipitation Leaching Procedure [SPLP] – U.S. EPA SW 846 Method 1312

SPLP is designed to estimate the mobility/leachability of both organic and inorganic analytes in liquids, soils and wastes in a mono-disposal situation. The extraction fluid is based on the region of the country where the sample is located. The SPLP is a batch leaching test in which the extraction fluid is intended to simulate precipitation. Therefore, east of the Mississippi River the extraction fluid is at a pH of 4.2 and west of the river the pH is 5.0. The method indicates that the user compare constituents of concern concentrations in the 1312 extract with levels identified in the appropriate regulations. There are no federal regulations requiring the use of SPLP.

TCLP and SPLP are both a single batch leaching test which provide a single data point for each constituent of concern. These methods do not provide any data to understand the release control mechanism or the rate of leaching.

A laboratory technician conducts testing under LEAF Method 1314.

DEVELOPMENT OF NEW PROCEDURES

Beginning in the early 1990's, a concern existed that there may be instances where TCLP or SPLP would be used outside of the intended use and users may not be familiar with the resulting limitations of the data. This led to an effort to develop a new suite of leaching tests that is under consideration today.

U.S. EPA'S LEACHING ENVIRONMENTAL ASSESSMENT FRAMEWORK [LEAF]

U.S. EPA's Office of Resource Conservation and Recovery initiated the review and validation process of a new generation of leaching testing. These four leachate tests are being considered for inclusion in U.S. EPA's Method Compendium SW-846. The sources for these methods are from published leaching methods and international standards with additional collaboration between Vanderbilt University, the Energy Research Centre of the Netherlands and DHI in Denmark. The background documentation and methods can be found in U.S. EPA's Background Information for the Leaching Environmental Assessment [LEAF] Methods – EPA/ 600/R-10/170, November 2010.

The LEAF test methods are a suite of four leaching tests which include three batch tests and one dynamic test. These tests can be interpreted individually or integrated and can provide information on the leaching behavior of a solid material over a wide range of potential scenarios. The LEAF test method takes into consideration the factors of pH, liquid/solid ratio as well as the granular, compacted or monolithic form of the material.

The central mechanism for these leachate tests is either equilibrium or mass transfer. Equilibrium control release occurs with the slow percolation of the leaching fluid through a porous or granular material. Mass transfer rate control release occurs when flow of the leaching fluid is at the external boundary of a monolith or percolation is very rapid relative to mass transfer of constituent release to the percolating waters.

These methods are applicable to a wide range of solid material including combustion residues, coal combustion residues [CCR], soils, sediments, industrial process residues and construction materials with the focus on disposal, beneficial use, waste delisting and the evaluation of treatment effectiveness and site remediation options.

LEAF test methods are a tiered and flexible testing approach which increases in detail and complexity depending on the purpose of the testing. In the proposed approach, Tier 1 testing may be applicable for screening purposes and can be a single batch extraction or modified version of a leaching test. Tier 2 is equilibrium based testing that can characterize the liquid solid partitioning over a broad range of scenarios as a function of pH and liquid-solid ratio [L/S]. The equilibrium testing for Tier 2 can include LEAF Methods 1313, 1314 and 1316. Tier 3 is the mass transfer testing using LEAF Method 1315. Using a tiered approach can provide a project-specific design which may be more realistic of the site conditions but can require significantly more testing.

A SUMMARY OF THE LEAF TEST METHODS IS BELOW:

Liquid–Solid Partitioning as a Function of Extract pH for Constituents in Solid Materials using a Parallel Batch Extraction LEAF Method 1313

LEAF Method 1313 is a leaching method which requires particle-size reduced solids material. Using dilute acids and bases at pH values ranging from 2 to 13 and natural conditions, ten leachates are generated

THE FOLLOWING TABLE SUMMARIZES THESE SIX LEACHING TESTS:

Leaching Test	Reference Documents	Summary Description	Comments
Toxicity Characteristic Leachate Procedure [TCLP]	U.S. EPA SW 846 Method 1311	Samples are preliminarily evaluated for solids and particle size. The liquid to solid ratio is 20:1. The sample is then leached with appropriate fluid. A pH 2.9 acetic acid is used for moderate to high alkaline material and pH 4.9 acetate buffer is used for all other materials. The total time for the leachate generation is 18 hours.	This is a single point leachate test. Predicts the mobility of both organics and inorganics analytes in landfills. It is used to classify material as hazardous or non-hazardous for purposes of disposal in a landfill.
Synthetic Precipitation Leachate Procedure [SPLP]	U.S. EPA SW 846 Method 1312	Samples are preliminarily evaluated for solids and particle size. The liquid to solid ratio is 20:1 and the samples are then leached with appropriate fluid. The extraction fluid is based on the region of the country where the sample is located. For samples east of the Mississippi River, the extraction fluid pH is 4.2, and for materials west, the pH is 5.0. The total time for the leachate generation is 18 hours.	This is a single point leachate test. Predicts the mobility of both organics and inorganics analytes into ground and surface waters. SPLP fluid simulates precipitation.
Liquid –Solid Partitioning as a Function of Extract pH for Constituents in Solid Materials using a Parallel Batch Extraction Procedure	U.S. EPA Background Information for the Leaching Environmental Assessment Framework [LEAF] Test Methods EPA/600/R-10/170 LEAF or pre EPA Method 1313	This is a pH dependent batch leaching procedure. Ten parallel extractions of a particle sized reduced solid material in dilute acid or base and reagent water. Series of eluates having pH values ranging from 2-13 as well as natural condition. Liquid solid ratio is 10:1. Eluate is centrifuged and filtered; then analyzed for constituents of concern. Total time to generate the eluate is 5 days for material with 85%; greater solids; 8 days for material with less than 85% solids.	This method is designed to provide aqueous extracts representing the liquid-solid partitioning [LSP]curve as a function of pH for inorganics and non volatile organics in solid materials

from the solid material in parallel extractions. The leachates are then analyzed for the constituents of concern as a function of pH. The constituents of concern can be inorganics and non-volatile organics. This data can be used to estimate the liquid/solid partitioning of the constituents of concern.

Liquid –Solid Partitioning as a Function of Liquid-Solid Ration for Constituents in Solid Materials using an Up-Flow Percolation Column Procedure – LEAF Method 1314

LEAF Method 1314 is a column leaching method which requires particle size reduction to accommodate the column diameter. It is an equilibrium based up-flow percolation column test. The constituents of concern can be inorganics and non-volatile organics. This leaching test is used to characterize the liquid / solid partitioning between solid phase and the eluate as a function of the liquid to solid ratio. This method provides five options for the generation of the leachate and the subsequent preparation of the analytical samples based on the level of detailed data which is required.

Mass Transfer Rates of Constituents in Monolithic or Compacted Granular Materials using a Semi-dynamic Tank Leaching Procedure- LEAF Method 1315

LEAF Method 1315 is a flux based leachate method for the analysis of a monolith or compacted granular material. The material is continuously immersed in reagent water at a specified liquid to solid surface area. The constituents of concern are inorganics. This leaching test provides the mass transfer rates of the constituents of concern under diffusion controlled release conditions as a function of leaching time through the material.

Liquid- Solid Partitioning as a Function of Liquid-Solid Ratio for Constituents in Solid Materials using a Parallel Batch Extraction Procedure- LEAF method 1316

LEAF Method 1316 is a leaching method which requires particle size reduced solids material. Using natural pH of the solid material, five eluates are generated from the solid material in parallel extractions over a range

THE FOLLOWING TABLE SUMMARIZES THESE SIX LEACHING TESTS CONT.:

Leaching Test	Reference Documents	Summary Description	Comments
Liquid –Solid Partitioning as a Function of Liquid-Solid Ration for Constituents in Solid Materials using an Up-Flow Percolation Column Procedure	U.S. EPA Background Information for the Leaching Environmental Assessment Framework [LEAF] Test Methods EPA/600/R-10/170 LEAF or pre EPA Method 1314	This is a dynamic leaching procedure. Eluate is introduced into a column with packed particle sized reduced solid material in an up-flow pumping mode. Flow rate is maintained between 0.5-1.0 L/Day. Eluant is collected at predetermined times, filtered and analyzed for constituents of concern. Total time to generate the eluate is approximately 14 days.	This method is designed to provide the liquid-solid portioning [LSP] of inorganic constituents and nonvolatile organics in granular solid material as a function of liquid to solid [LS] ratio under percolation conditions.
Mass Transfer Rates of Constituents in Monolithic or Compacted Granular Materials using a Semi-Dynamic Tank Leaching Procedure	U.S. EPA Background Information for the Leaching Environmental Assessment Framework [LEAF] Test Methods EPA/600/R-10/170 LEAF or pre EPA Method 1315	This is a hybrid batch and dynamic leaching procedure. Leaching of continuously water saturated monolithic or compacted granular material in an eluant-filled tank with periodic renewal of the leaching solution. LS ratio of 9 mL eluant per cm2 of surface area. Eluant is collected at predetermined times and analyzed for constituents of concern. Eluate is centrifuged and filtered for constituents of concern. Total time to generate the eluate is approximately 63 days.	This method is designed to provide the mass transfer [release rates] of inorganic analytes contained in a monolith or compacted granular material. Under diffusion controlled release conditions, as a function of leaching time.
Liquid- Solid Partitioning as a Function of Liquid-Solid Ratio for Constituents in Solid Materials using a Parallel Batch Extraction Procedure	U.S. EPA Background Information for the Leaching Environmental Assessment Framework [LEAF] Test Methods EPA/600/R-10/170 LEAF or pre EPA Method 1316	Five parallel extractions of a particle-size reduced solid material in reagent water over a range of L/S values from 0.5 to 10 mL eluant/g dry material. Depending on particle size, sample is tumbled between 24 and 72 hours. Eluate is centrifuged and filtered for constituents of concern. Total time to generate the eluate of test is 2 days.	This method is designed to provide the liquid-solid partitioning [LSP] of inorganic and non volatile organics at the natural pH of the solid material as a function of liquid to solid ratio [L/S] under conditions that approach liquid-solid chemical equilibrium.

of liquid to solid ratios. The leachates are then analyzed for the constituents of concern. The constituents of concern can be inorganics and non-volatile organics. This data can be used to estimate the liquid/solid partitioning of these constituents of concern as a function of liquid to solid ratio.

The four LEAF test methods are the next generation of leaching methods and are a considerable shift from the current U.S. EPA SW-846 approach of TCLP and SPLP. These LEAF test methods are a tool to assess the potential release of constituents of concern which can reflect the actual environmental and management conditions of the material in the field. ❖

Patricia McIsaac is a Product Manager for TestAmerica with over 30 years of environmental laboratory experience. Her role within Test America is to coordinate the development of new test offerings at TestAmerica to support the emerging needs of clients.

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Rick Sheets is the Soil/Sediment Scientist at TestAmerica's Pittsburgh laboratory. He has over 30 years' experience in laboratory testing and geotechnical support services and specializes in geotechnical testing and leachate transport studies. Rick is instrumental in the development and execution of the four LEAF procedures at the Pittsburgh laboratory.

LEADERSHIP CHANGES

Meet the New ACAA Chair, Lisa Cooper

Lisa Cooper on site at a PMI power plant installation.

The summer membership meeting of the American Coal Ash Association featured a changing of the guard for ACAA leadership. Mark Bryant of Ameren stepped down as ACAA Chairman after four years of service. The new Chair of the Board for the 2012-14 term will be Lisa Cooper of PMI Ash Technologies.

Lisa is an Owner, General Counsel, and Senior Vice President at PMI. Located in Cary, North Carolina, PMI is one of the first companies to commercialize a carbon burn-out technology to allow coal fly ash to be sold as a partial replacement for portland cement even after environmental controls have been installed at power plants.

Lisa was formerly Vice President at Progress Materials; Director of Environmental, Health and Safety at Progress Fuels; and Associate General Counsel at Progress Energy Services. Prior to that, she spent seven years practicing law following her graduation from Syracuse University and Syracuse College of Law.

ASH at Work had a few questions for Lisa as she assumes her new responsibilities:

Q: When was the first time you heard about coal ash?

A: I have been involved with coal ash since approximately 1985. I have worked with or on behalf of utilities and addressed numerous opportunities and issues involving coal ash.

Q: You have worked both on the utility and marketing sides of the coal ash industry. Do you think that give you a different perspective?

A: Yes, definitely!

Q: This is a challenging time to assume the position of ACAA chair. Any fears about stepping up now?

A: Fears, concerns and hopes all wrapped into one. From a U.S. political standpoint, dialogue has become so polarized that stalemate is the norm. Stalemate challenges and suppresses jobs and investment within our CCP recycling industry. Failure to act prolongs paralysis within our industry. This is my biggest fear. My concern is that we within the industry become disenchanted that positive change will occur and use our voices for other non-CCP grassroots efforts. My hope is we remain united, change the status quo and get EPA and others to stand up and endorse the safe recycling of yesterday's, today's and tomorrow's fly ash, gypsum and other CCPs.

Q: How would you describe the past three years of the coal ash industry's history?

A: The last three years, from a jobs and financial perspective, have been very difficult for our industry. It has also been very demoralizing. We have seen elected officials flip-flop on our issues and observed unfettered access for

"My hope is we remain united, change the status quo and get EPA and others to stand up and endorse the safe recycling of yesterday's, today's and tomorrow's fly ash, gypsum and other CCPs."

certain groups within federal agencies while we wait for calls or a meeting. But, ACAA has been a grassroots organization that has remained ethical, with high veracity and despite our limited resources made things happen when no one thought we could. In many ways, it has been quite inspiring!

Q: You're the first woman and the first attorney to hold the position of ACAA chair. What do you think that says about you and about the Association?

A: I think it speaks very highly of the Association to elect a person based upon their prior service to the Association regardless of their sex or background. (Lawyers are just below lobbyists, Sirhan Sirhan and Casey Anthony with respect to most hated persons in America.) Seriously, I am deeply honored to serve as the Chair.

Q: Assuming that coal ash is ultimately designated (again) as a "non-hazardous" material, what do you see as the ongoing challenges for the beneficial use industry as it recovers from the regulatory debate?

A: The top challenge for the domestic recycling industry post-non-hazardous designation will be to rebuild our brand with the American public as it has been deeply harmed.

Q: Are there new opportunities out there, as well?

A: Yes, there are and will be many new opportunities. The question will be if we can make it to take advantage of them and will reasonable incentives be offered, awarded or shared with our recycling industry that are offered to others.

Q: What are your top priorities for your term as ACAA chair?

A: My top priorities are:

1. To ensure that ACAA speaks with one strong voice for the CCP recycling industry.

2. To promote diversity within the ACAA organization with special emphasis on the role of women in leadership.

3. To help our government and regulators understand the important role that the coal ash industry plays in sustainable energy programs for this country.

Q: What advice would you give to ACAA members who want to get the most out of their Association membership?

A: In order to get the most out of your ACAA membership, members must get involved in the ACAA. By doing this, you will see issues through different lenses, provide opportunities for growth for yourself and your company. Also, speak up! Please know we want to hear your thoughts – good or bad! ❖

ASH ALLIES

Environmental Council of the States – On the Front Lines Protecting Human Health and the Environment

*This new recurring feature of **ASH at Work** will introduce readers to some of the many organizations the American Coal Ash Association works with to promote responsible regulation and encourage beneficial use of Coal Combustion Products. "Ash Allies" invited the Environmental Council of the States – which represents state level environmental protection agency leaders – to describe its mission and relationship to coal ash.*

By R. Steven Brown, Executive Director, Environmental Council of the States

The Environmental Council of the States (ECOS) is the national non-profit, nonpartisan association of state and territorial environmental agency leaders. The mission of ECOS is to enhance the ability of states to protect and improve human and environmental health. Since 1993, ECOS has facilitated a quality relationship among state and federal agencies in the delivery of environmental protection under both state and federal law.

ECOS manages an affiliate – the Interstate Technology and Regulatory Council (ITRC) – which is a public-private coalition working to eliminate barriers to the use of innovative environmental technologies so that compliance costs are reduced. ITRC produces documents and training that broaden technical knowledge and expedite quality regulatory decision-making.

In addition, ECOS has six standing committees (Air, Water, Waste, Compliance, Cross-Media, and Planning), as well as numerous workgroups and forums, which provide for the exchange of ideas, views, and experiences on specific topics. The committees manage various projects, and develop resolutions subject to approval by the full membership. Resolutions may cover a topic in general, may target a specific federal agency activity, or may provide state agency views on legislation. ECOS presents and advocates these positions to the U.S. Environmental Protection Agency (EPA), the Department of Defense, the Department of Energy, Congress, and others.

In March 2010, ECOS adopted through its Waste Committee a resolution entitled "The Regulation of Coal Combustion Products" (see http://www.ecos.org/files/4018_file_Resolution_08_14_2010_version.doc).

The policy statement urges EPA to steer clear of federal regulation of coal combustion waste (CCW), maintaining that federal regulations would be duplicative of most state programs. ECOS adds, however, that if EPA does adopt a federal regulatory program for state CCW waste management programs, the regulations should be developed under federal rules on solid waste rather than hazardous waste. The resolution asserts that designating CCW a hazardous waste could create disposal and liability concerns that would impact the beneficial use of coal ash. In the two years since passage of the resolution, ECOS has advocated its position extensively with U.S. EPA and in Congress.

"The policy statement urges EPA to steer clear of federal regulation of coal combustion waste… ECOS adds, however, that if EPA does adopt a federal regulatory program for state CCW waste management programs, the regulations should be developed under federal rules on solid waste rather than hazardous waste."

Twice a year, ECOS holds full membership meetings during which all of its committees and many of the workgroups and forums hold sessions to address critical issues and confer with high-level personnel of EPA and other federal agencies. These two conferences, the Spring Meeting and Annual Meeting, are open to all interested attendees. The 2013 Spring Meeting is slated for March 4-6 in Scottsdale, Arizona, and will celebrate the 20th anniversary of ECOS. For full information, visit the Events section at www.ecos.org.

The ECOS staff is headed by Executive Director R. Steven Brown, who joined the association as Deputy Director for Research in 1996 after having assisted in ECOS' creation in 1993. He has worked on environmental protection since graduating from the University of Kentucky with an MS in Zoology and an MA in English in 1976. From 1985 to 1996, Brown was Director of The Council of State Governments' Environmental Policy Center, where he conducted environmental and technical policy studies on state-federal issues. He previously worked for Kentucky's Division of Air and the Division of Permits and with private engineering firms. A native Kentuckian, he has authored numerous articles, monographs, and books on the environment and technology. ❖

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ASH CLASSICS

Roots of Coal Combustion Products Use in Agriculture Run Deep

By David Goss, Former ACAA Executive Director

*"Ash Classics" is a recurring feature of **ASH at Work** that examines the early years of the National Ash Association (NAA) and issues and events that were part of the beneficial use industry's defining years.*

The theme for this issue of *ASH at Work* addresses the use of CCPs in agriculture. In 2010, total tonnage of CCPs reported under the category of "Agriculture" on ACAA's Production and Use Survey Report was 508,721 tons. ACAA first began tracking agricultural uses in 1995, at which time the tonnage was reported to be 14,681 tons. That's an impressive increase over the last 17 years. Preliminary data for 2011 indicate the tonnage for this application to be approximately the same as in 2010.

Agricultural uses may be defined differently by utilities reporting their data. Whereas the use of FGD gypsum as a soil amendment in peanut crops may be clearly understood to be an agricultural application, another company may consider the use of FGD gypsum to aid in revegetation of a mining site to be a mining application. Although the end benefit in both cases is the same, the data may be reported in either category. For this reason, the annual CCP survey is simply an indication of trends, not a precise method of tracking where all CCPs are used.

The National Ash Association carried its first article on agricultural benefits of using CCPs in Issue 1, Volume 1 in 1969. At that time, the Agronomy Department of the Virginia Polytechnic Institute in Blacksburg, Virginia, had signed a contract with the Office of Solid Waste, Bureau of Mines to conduct a three-year study, "Chemical and Physical Reactions of Soils with Flyash of Importance to its Agricultural Utilization." The study focused on two aspects of soil conditioning, especially in mining settings: 1) correction of nutrient deficiency by fly ash applications and; 2) studies involving rate of release of elements in fly ash during equilibration with soil. In 1971, a follow-up article indicated that "Results of the greenhouse studies indicated that application of selected fly ash samples to soil either completely or partially corrected the five nutrient deficiencies of plants."

From 1971 through the 1980s, articles appeared periodically in the *ASH at Work* newsletter highlighting new efforts or research for agricultural uses. In every symposium from 1970 to the present, one or more papers have been presented on CCP uses for agriculture, soil improvements, land reclamation, as fertilizers, in erosion control, to treat plant diseases and numerous other unique and sometimes unsuccessful efforts.

Early work with the Bureau of Mines led the way for substantial research in reclamation of surface mine spoils and soils. A good deal of the early research was conducted in West Virginia, in partnership with the U.S Forest Service and state agencies. Subsequent studies and projects in Pennsylvania, Texas, Ohio, Missouri, and Maryland led to the widespread use of CCPs in mine remediation, re-vegetation and treatment of acid mine drainage. Especially noteworthy were demonstrations of application rates of up to 150 tons of fly ash per acre in soil with pH levels of about 3, which previously had prevented incursion of natural vegetation. ASTM also issued two standards in the early 2000s (an effort led by ACAA member Debra Pflughoeft-Hassett) addressing the use of CCPs in reclamation and re-vegetation. The two standards have been used extensively and were developed as a direct result of the early successful research studies and field demonstration projects.

"The National Ash Association carried its first article on agricultural benefits of using CCPs in Issue 1, Volume 1 in 1969."

During the 1970s, other innovative research was conducted with measured success. Two researchers from the University of Notre Dame found that fly ash could be used to reduce inorganic phosphates, organic phosphates and carbonaceous organic wastes from the bottom of Stone Lake in Michigan. A federal geologist found that air emissions from a coal-fueled plant in New Mexico were having a favorable effect on the surrounding area, noticeably improving arid desert soil. The air emissions were providing increased nutrients needed for plant life, including potassium, calcium and phosphorus. (Today these emissions are captured and placed in landfills or disposal units). In 1978, a field project in Wisconsin showed that direct application of sub-bituminous fly ash provided results comparable to agricultural limestone to achieve soil neutralization. Greenhouse and crop testing was done on alfalfa, oats, wheat, barley and corn.

In 1983, a rather unique experiment was conducted by researchers at the Cooperative Shellfish Aquaculture & Technology Center in Maryland to develop oyster reefs utilizing fly ash. A blend of crushed shells added to fly ash along with 6% hydrated lime created stable material for the reefs. Testing showed that "…levels of leachate from the mixes were lower than levels of metals found in oysters and in some Chesapeake Bay bottom muds."

In the late 1980s, the U.S. Department of Agriculture (USDA) began testing flue gas desulphurization materials in agricultural settings. While some research was promising, they found that not all FGD system materials could be used successfully and it really wasn't until widespread use of forced oxidation systems that sufficient quantities of FGD gypsum were available for many more suitable applications. USDA maintains an extensive database of technical reports and other information on the use of industrial byproducts in agriculture. There are more than 530 citations on the use of CCPs in this database. Over the last two decades, researchers at the USDA have conducted numerous studies on various soil amendments, including fly ash, FGD gypsum and other scrubber residues.

Beginning in 1995, ACAA started tracking the use of CCPs in agriculture, a use that has grown to over 500,000 tons annually by 2010. Extensive testing by the Electric Power Research Institute, The Ohio State University, the University of Kentucky's Center for Applied Energy Research, USDA field offices, the USDA laboratory in Beltsville, Maryland, and other academic institutions have pioneered many CCPs uses. From crop improvements to livestock pads and from soil amendments to reduction of water run-off, CCPs have shown they can be used in many land applications and at a cost less than competing products. Furthermore, in many cases they release fewer metals to the environment than other commercial products.

Partnerships between utility producers, soil scientists and growers have resulted in significant improvements to many crop yields while offering lower operating costs. A Google search on CCPs in agriculture

ASH AT WORK

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ASH RESEARCH GAINS GROUND

Plant Nutrient Study At VPI Shows Results

Plants cannot be grown continuously on soils without replenishment of nutrients removed in harvesting of crops. Nutrients that frequently must be applied to soils to insure adequate amounts for plant growth are boron, calcium, copper, magnesium, manganese, molybdenum, nitrogen, phosphorus, potassium, sulfur, and zinc. The nutrients that must be applied to attain high yields vary for different soils and crops. The required levels of application depend largely on the amount of plant available nutrients in soil, the chemical and physical properties of soil governing plant uptake of nutrients, and the amount of nutrients required by plants for normal growth.

Cooperative research is being conducted by the Morgantown Energy Research Center of the Bureau of Mines and the Agronomy Department, Virginia Polytechnic Institute and State University, to determine if fly ash-soil mixtures supply a higher amount of nutrients to plants than soil alone. The initial phase of the research was to determine the contents of nutrients in fly ash obtained from various power plants. This research indicated that fly ash ranged widely in nutrient content and with the exception of nitrogen, usually contained higher amounts of plant nutrients as compared with soil.

Soil pH is among the more important chemical properties governing the ability of plants to obtain nutrients. As examples, molybdenum sorption by plants increases as soil pH increases and, in contrast, zinc sorption increases as soil pH decreases. Laboratory analyses showed that fly ash from various power plants ranged from slightly acid to highly alkaline in reaction, and that application of large amounts of alkaline fly ash increased soil pH to high levels. These results indicated that fly ash application changes soil pH and, thereby, affects plant sorption of nutrients from soil.

The laboratory data on nutrient content and neutralizing power of fly ash was used in designing pilot greenhouse experiments to determine if the amounts of five nutrients—*boron, molybdenum, phosphorus, potassium, and zinc*—sorbed by plants were higher from fly ash-soil mixtures than from soil alone. Results of these studies indicated that application of selected fly ash samples increased the amount of each of the five nutrients sorbed by plants. Application of alkaline fly ash to an acid soil increased alfalfa growth by correction of molybdenum deficiency and by increasing soil pH. Increasing the pH of the soil alleviated toxicities associated with very low pH. Application of acid fly ash to an alkaline soil corrected zinc deficiency of corn by supplying soluble zinc and by decreasing soil pH. The decrease in soil pH increased the availability of indigenous soil zinc. *Results of the greenhouse studies indicated that application of selected fly ash samples to soil either completely or partially corrected the five nutrient deficiencies of plants.*

Pilot greenhouse studies will be continued to determine if fly ash application corrects other nutrient deficiencies. The information obtained in the greenhouse studies will be used to design field experiments. These experiments will be conducted to determine whether fly ash application corrects nutrient deficiencies of plants grown under field conditions.

A second group of field experiments will be initiated to determine the levels of fly ash that can be applied to agricultural soil without adversely affecting plant growth. Detrimental effects on plant growth including boron toxicity, soluble salt damage, and nutrient deficiencies due to increases in soil pH, are possible when higher than optimum amounts of fly ash are applied.

VPI studies show correction of zinc deficiency in corn by application of fly ash.

An ASH at Work cover story in 1971 focused on agricultural uses of coal ash.

includes hundreds of international studies ranging from South Africa to China by way of India and Europe. Agricultural research in India on CCPs of all types has been particularly extensive and is well-documented. ACAA has devoted a number of detailed articles on this subject in the *ASH at Work* magazine dating back to 2005. All these issues are available on the ACAA website and merit further review if you are interested in learning more about the value that CCPs provide to the agricultural industry.

Since its founding in 1968, ACAA has followed and promoted science-based research on CCPs in land and soil settings. Even though to some this may seem to be a new subject, use of CCPs in these applications has "roots" going back five decades. ❖

Steve Thomas glides by fellow Wayne State students Joe Wolf and Claire Bourseleth in his concrete canoe which contains both fly ash and cenospheres.

Livestock pads made from CCPs save money, landfill space

Livestock pads for several rhinoceros feedlots were constructed at the Wilds, a wildlife safari park near Cambridge, Ohio. The pad was constructed in June 1998 using lime-enriched FGD materials. The program is under the direction of Tarunjit Butalia, coordinator of Ohio State University's Coal Combustion Product (CCP) Pilot Extension Program. For more on this story, see page 21.

Even a rhinoceros got in on the action in 1998.

IN & AROUND ACAA

ACAA SUMMER MEETING – JUNE 19-20, 2012

The summer membership meeting of the American Coal Ash Association in Portsmouth, Virginia, attracted 174 attendees. In addition to regular committee meetings and social events, a keynote address was provided by Lisa Feldt, Deputy Assistant Administrator for the U.S. Environmental Protection Agency's Office of Solid Waste and Emergency Response. Other speakers included Dr. Lisa Bradley, AECOM; Dr. Rufus Chaney, US Department of Agriculture; Janet Gellici, American Coal Council; Ken Ladwig, Electric Power Research Institute; Dr. Richard Livingston, University of Maryland; and Jim Roewer, Utility Solid Waste Activities Group.

EPA Deputy Assistant Administrator Lisa Feldt (center) talks with ACAA Chair Lisa Cooper and Past Chair Mark Bryant following her keynote address.

Mark Bryant of Ameren included family members in the last meeting of his four-year tenure as ACAA chair.

Committee meetings and social events are always well-attended at ACAA meetings.

ACAA WOMEN'S LEADERSHIP FORUM LUNCHEON – JUNE 19, 2012

The ACAA Women's Leadership Forum conducted its third luncheon meeting with a keynote address by Janet Gellici, Chief Executive Officer of the American Coal Council. The Forum is an informal group of ACAA women members working to develop interest and qualifications of women members for ACAA committee leadership and officer positions; to acquaint ACAA women members with the wide range of energy and building materials careers, and professional organizations and meetings with the goal of opening paths for further career development; and to promote professional interactions and camaraderie among ACAA women members and women in related fields, including government, energy, building materials, and consulting.

ACAA Chair Lisa Cooper greets keynote speaker Janet Gellici of the American Coal Council.

Anne Ellis of AECOM (and Vice President of the American Concrete Institute) and Lori Tiefenthaler of Lehigh Cement Company attended the luncheon.

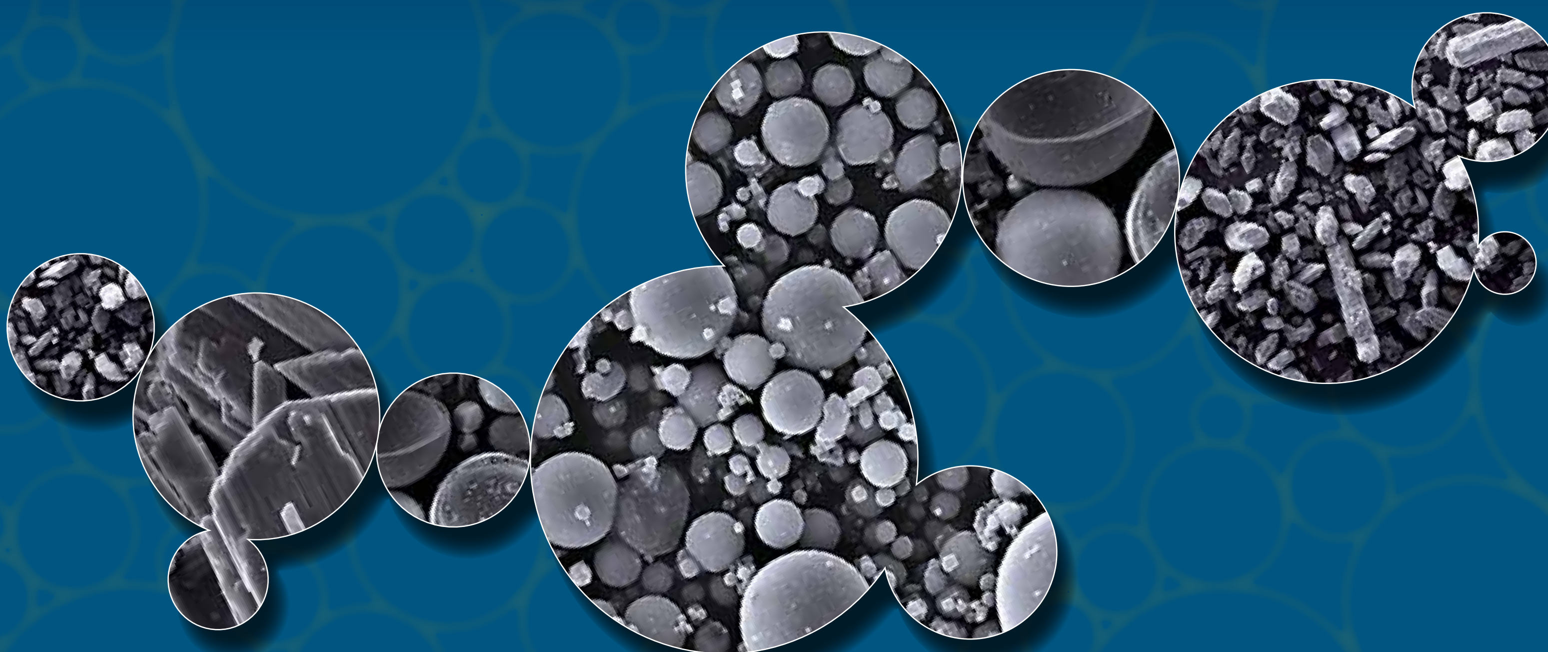
Kate McMillan of Southern Company Generation and Dawn Santoianni of Tau Technical Communications were among the forum attendees.

NATIONAL PRESS CLUB NEWS CONFERENCE – JUNE 6, 2012

American Coal Ash Association conducted a news conference at the National Press Club in Washington DC to release the results of its new study: "Coal Ash Material Safety – A Health Risk-Based Evaluation of USGS Coal Ash Data from Five US Power Plants." The study used scientific methods to demonstrate that coal ash does not qualify as a hazardous substance based on its composition and also should not be classified as hazardous on a human health risk basis. The news conference was conducted by ACAA Executive Director Thomas Adams and the study author, Dr. Lisa Bradley of AECOM.

Dr. Lisa Bradley presents study data to Washington DC energy and environment reporters as Thomas Adams observes.

coal combustion and gasification products



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Coal Combustion & Gasification Products – the journal

Welcome to the second CCGP insert in ACAA's Ash-at-Work. You will find abstracts of the papers published during 2010-2011 in the online journal, ***Coal Combustion and Gasification Products*** (www.coalcgp-journal.org). The ***CCGP Journal*** is a science and engineering journal devoted to the sustainable production and utilization of an economic resource and the environmentally-sound disposal of the portion of the material that cannot, at least for now, be utilized. It is collaboratively published by the American Coal Ash Association and the University of Kentucky, Center for Applied Energy Research. Allen Press, a respected publisher of scientific journals, provides the electronic submission portal and manuscript processing services. Together we pledge the following:

- First, this journal is carefully reviewed and judicated by academic and industrial experts. We strive to publish papers of the highest quality and that meet the highest scientific standards. What you will find will be reliable, honestly presented, and worth reading.

- Second, it will be free and universally available. High quality, full versions of the papers are published upon final acceptance online and downloadable anywhere in the world via the web, yielding the most impact from a focused, one-stop location for the latest research and news. The journal is also free to the authors, within the bounds of reasonable page limits.

- Third, we keep it relevant. By adding a print version of the journal consisting of abstracts of the online journal and other relevant materials to *Ash at Work*, the premier trade magazine published by ACAA, we will provide readable synopses of current research to all stakeholders.

Coal Combustion and Gasification Products fills an underserved niche in the literature as a high-quality refereed journal. To this end, we have assembled a knowledgeable and experienced editorial board to serve as our first line of paper reviewers. In addition, we will continue to reach out to the broader community of ash scientists and engineers to review papers. The success of the journal depends on all of us: authors, reviewers, readers, and the editorial staff at the CAER.

We invite you to browse the following pages and to read the full-text papers from the journal web site: www.coalcgp-journal.org.

Feel free to contact us with ideas on ways this journal can assist our shared industry.

On behalf of UK CAER and ACAA
Jim Hower, Editor-in-Chief
Tom Adams, Tom Robl

The CCGP Journal is accepting manuscript submissions. In order to submit a paper, select the ***Submit a Manuscript*** button from the journal homepage: **www.coalcgp-journal.org.** Submission guidelines can be found on the web site.

Phaselous vulgaris Growth under the Influence of Manufactured Coal Ash Aggregates

Sangchul Hwang, Imiraily Hernandez, Isomar Latorre, Sahid Rosado, *Department of Civil Engineering, University of Puerto Rico.*

Manufactured coal ash aggregates (MAs) are a 2:1 (w/w) solidified composite of fly and bottom ash. The current study assessed the feasibility of beneficial utilization of MAs as a subsoil substitute for open-pit restoration to phyto-viable land. A series of indoor and outdoor experiments examined Phaselous vulgaris growth under the influence of MAs in the soil environment.

With the MAs layer below the topsoil, P. vulgaris showed enhanced growth with respect to shoot height, leaf number, and leaf chlorophyll intensity. Similar growth enhancement was observed when the MAs were mixed with topsoil or applied as a micronutrient source over the topsoil. Thus, MAs are beneficial as a subsoil substitute for open-pit restoration to phyto-viable land, reducing exploitation of natural soil resources and enhancing plant growth.

Full paper available at: www.coalcgp-journal.org

Enriched Coal Ash Utilization for Augmenting Production of Rice under Acid Lateritic Soil

S. Karmakar, *Department of Agronomy - Birsa Agricultural University, India.* B.N. Mittra, B.C. Ghosh, *Indian Institute of Technology, India.*

The use of industrial wastes such as fly ash (FA) or rice husk ash (RHA), along with paper factory sludge (PFS), farmyard manure (FYM), and chemical fertilizers (CF), under integrated nutrient management, was studied in acid lateritic soil on rice. Application of combined fertilization sources increased growth, yield attributes, and yield (up to 92.3 and 9.7% over control and CF, respectively) of wet season rice. The uptake of N, P, K, Ca, Mg, Fe, Mn, Zn, Cu, and Co was increased under combined fertilization sources. The study also indicated that such integrated plant nutrition system improved physico-chemical properties of soil with respect to bulk density, pH, electrical conductivity, organic carbon, and available nutrient content.

Utilization of these wastes saved chemical fertilizers to the extent of 37.8, 59.7, and 86.5% N, P, and K respectively, with an added advantage of minimizing environmental pollution.

Full paper available at: www.coalcgp-journal.org

Mineralogy and Leaching Characteristics of Coal Ash from a Major Brazilian Power Plant

Luis F.O. Silva, Marcos L.S. Oliveira, *Catarinense Institute of Environmental Research and Human Development, Brazil.* Colin R. Ward, Zhongsheng Li, *University of New South Wales, Australia.* James C. Hower, *University of Kentucky Center for Applied Energy Research.* Maria Izquierdo, Xavier Querol, *Institute of Environmental Assessment and Water Research, Spain.* Frans Waanders, *North West University, South Africa.* Rachel S. Hatch, *University of Kentucky Department of Earth and Environmental Sciences.*

The feed coals, fly ashes and bottom ashes collected from seven different units in a major Brazilian PF power plant have been subjected to comprehensive mineralogical, geochemical, and petrographic studies, to investigate the links between feed coal and ash characteristics. Ashes from two of the units were collected while the coal was being co-fired with oil as part of the boiler start-up procedure, allowing the impact of oil co-firing on ash characteristics also to be evaluated. High proportions of unburnt carbon and high proportions of retained sulphur were found in the fly ashes produced during oil co-firing, probably reflecting less efficient combustion and associated lower combustion temperatures. Higher concentrations of a number of relatively volatile trace elements were also noted in these fly ashes, compared to the fly ashes collected from units under normal operating conditions.

The fly ashes produced during oil co-firing gave rise to acid pH conditions in water-based leaching tests, in contrast to the alkaline pH associated with fly ashes produced during normal operations. This probably reflects higher SO3 contents relative to total CaO + MgO for the co-fired ash samples. Many trace elements that are typically mobilised as cations were also more abundant in leachates from the co-fired fly ashes. This is due, most likely, to the more acid pH conditions involved. Despite similar or even higher total concentrations, however, elements that are typically released from coal ash as oxy-anions were less mobile from the co-fired fly ashes than from the normally-fired fly ash materials.

Full paper available at: www.coalcgp-journal.org

Fullerenes and Metallofullerenes in Coal-Fired Stoker Fly Ash

Luis F.O. Silva, Ka´tia DaBoit, *Catarinense Institute of Environmental Research and Human Development, Brazil.* Carmen Serra, *Universidade de Vigo, Spain.* Sarah M. Mardon, *Kentucky Department for Natural Resources, Division of Abandoned Mine Lands.* James C. Hower, *University of Kentucky, Center for Applied Energy Research.*

A suite of high-As, high-C fly ashes from a university-based stoker-fired coal boiler were analyzed by a number of techniques, including high-resolution transmission electron microscopy (HR-TEM), time-of-flight secondary ion mass spectrometry (TOFSIMS), X-ray

photoelectron spectroscopy (XPS), and field-emission scanning electron microscopy (FE-SEM). The sooty carbon is in the form of nano balls with the major fullerenes at C60 +, C70 +, and C80 +, with species at C2 increments from C56 + to C78 +.

Arsenic and Hg, among other metals, are found in association with the fullerenes, but, with our techniques, it is not possible to determine if the metals are encapsulated by the fullerenes or attached to the side of the structure. TOF-SIMS studies suggest an association of As with the Al-Si glass; an association of Pb with oxides, sulfates, and carbon; Hg with carbon; Se in elemental form with carbon; and Cr in a variety of forms, including nano carbons, Fe sulfates and oxides, glass, and Cr-oxyhydroxides.

Full paper available at: www.coalcgp-journal.org

Impact of Manufactured Coal Ash Aggregates on Water Quality during Open Pit Restoration: 1. A Statistical Screening Test

Sangchul Hwang, Isomar Latorre, ***Department of Civil Engineering, University of Puerto Rico.***

Utilization of manufactured coal ash aggregates (MAs) as a subsoil substitute during restoration of an open pit was assessed in a three-factor, two-level factorial analysis. The factors of interest were the MA application rate (2:1 or 1:2 topsoil/MA volume ratio), rainfall intensity (high or low), and aggregate size (2.36–4.75 mm or 4.75–9.53 mm). Among the water quality parameters examined (pH, turbidity, heavy metal content (lead and cadmium), conductivity, and hardness), the last two parameters were significantly higher (p,0.05) in soil amended with MAs than in a control reactor using sand. A low rainfall intensity and larger aggregate size resulted in a lower water quality with regard to conductivity (7,12 mS/cm) and hardness (600,2000 mg/L as CaCO3) during the 63 day experiment.

Full paper available at: www.coalcgp-journal.org

Trace Element Partitioning and Leaching in Solids Derived from Gasification of Australian Coals

Alexander Ilyushechkin, Daniel Roberts, David Harris, Kenneth Riley, ***CSIRO Energy Technology, Australia.***

Trace element concentrations vary between coals from ppb to ppm levels and can depend on the rank of the coal and its geological origins. During gasification, some of the trace elements are volatilised at high temperatures and may condense and deposit in cooler downstream parts of the system or in quench water streams. Some species may appear in condensed phases such as slag or fly ash. Changes in the trace element concentrations in the slag and fly ash from that of the parent coal are expected due to the reactions occurring at high temperatures and the different chemical activity of the trace element phases in the slag, fly ash, and syngas. Four Australian coals were used in an entrained flow gasification test program conducted in the Siemens 5 MWth gasification test facility. Solid samples were collected from different points in the gasification process during each test.

Compositions of these samples were analyzed and the distribution of trace elements was studied.
The elements can be classified as follows, according to their tendency to appear in the slag and fly ash:

- Partitioned between slag and fly ash: Cu, W, Mo, Cd, Bi, Zn, Sn, Sb
- Partially volatile and depleted from either slag or fly ash: Be, Th, Sc, Y, Li, Mn, Ni, Sr, Ba
- Highly volatile (i.e. were not observed in either slag or fly ash): As, Se, B, Hg, F, Pb, V.

Comparison of these experimental results with equilibrium calculations of trace element appearance in the condensed phases suggests that the modelling approach is suitable only for certain elements. For several of the trace elements of significance in this study, kinetic factors have to be considered in conjunction with thermodynamic modelling. The leaching behaviour of the trace elements in the slag was also studied. This work shows very low leachability for most of the trace elements except Zn and Sb, which, due to their relatively high volatility, reported to the slag samples in very low concentrations.

Full paper available at: www.coalcgp-journal.org

Co-Disposal of Dry FGD By-product with Coal Gasification Ash and Inorganic Brines

Jabulani S. Mahlaba, P.C. Pretorius, M.P. Augustyn, ***SASOL Technology (Pty) Ltd, South Africa.*** **Subal Maharajh,** ***SASOL Technology (PTY) Ltd, South Africa.***

There is a growing pressure from the environmental authorities and public bodies to reduce anthropogenic pollution. Stringent environmental legislation is being implemented for industries around the world, even more so for coal consuming industries. Control of gaseous emissions is one of the areas that are receiving considerable attention towards sustainable development. Coal combustion in coal-fired power utilities emits SOx to the atmosphere.

Flue gas desulphurisation (FGD) is a well known technology often used to mitigate sulphur emissions in coal-fired power utilities. Dry FGD technology traditionally uses lime to neutralise SOx, and forms a mixture of anhydrite (CaSO4), and calcium sulphite (CaSO3). It is apparent that scrubbing of SOx from the air converts an atmospheric problem into a solid form requiring acceptable fate. Several options are reported in literature such as utilisation in agriculture, cement and concrete manufacturing, and wallboards. A feasibility study for the implementation of a dry FGD technology is presented.

This paper reports the preliminary findings of the option where FGD by-product is co-disposed with coarse ash and brine;

assuming that quantities of FGD by-product exceed utilisation demand. Coarse ash is defined as the combination of gasification ash and bottom ash in a 4:1 ratio. The study examined the influence of moisture content, chemistry of the liquid medium, and ratio of FGD by-product to coarse ash on the physical and chemical properties of the cured mix. The results demonstrate that the chemistry of raw materials influences the final properties of the resultant product. Based on the preliminary results co-disposal of coarse ash, excess FGD by-product, and brines will potentially present an environmentally less harmful option in a single site.

Full paper available at: www.coalcgp-journal.org

Compositional Variations in Pilot Gasifier and Laboratory-Produced Slags and their Impacts on Slag Viscosity and Coal Assessment

Alexander Ilyushechkin, Daniel Roberts, David Harris, ***CSIRO Energy Technology, Australia.***

The flow behaviour of coal mineral matter at high temperatures is an important parameter for coal use in entrained-flow gasification technologies. Recently, gasification performance data was obtained from a series of pilot-scale gasification tests on a suite of well-characterised Australian black coals. Evaluation of the results of the pilot tests and the detailed laboratory investigations provided the opportunity for evaluation of the practical applicability of different laboratory and modeling techniques for coal assessment in terms of mineral matter behaviour in entrained flow gasification.

A series of viscosity measurements was made over the range 1200–1600uC using slags produced in a pilot scale gasifier at temperatures between 1200 and 1700 uC, and laboratory-produced slags. These data were compared with viscosity predictions based on an empirical model developed from an extensive database of slag viscosity measurements. Major differences between predicted and measured viscosities were investigated and, where appropriate, related to slag composition and microstructure.

There were some significant differences (in some cases up to 100% of the viscosity values) in the viscosity behaviour of laboratory-prepared slags and those produced during the pilot-scale gasification test runs. These differences were attributable to differences between the composition of the laboratory-produced slags and those tapped from the pilot scale gasifier. The major source of these compositional variations appears to be a result of partitioning of mineral matter components into fly ash and slag in the gasifier, and the possible subsequent interaction of this slag with slag already present on the wall of the gasifier.

These observations have implications for the manner in which coal mineral matter is assessed for its likely behaviour, and ultimate suitability for use, in entrained flow gasification systems. In order to improve the reliability of coal slag assessment procedures, test procedures should include preliminary modeling based on expected coal ash and slag compositions, viscosity measurements of laboratory-produced slags, and analyses of ash and slag compositions where possible to ascertain the degree of compositional partitioning and its impact on slag behaviour.

Ongoing work is required to better understand the nature of mineral matter transformations under gasification conditions and the impact of this on coal and gasifier performance.

Full paper available at: www.coalcgp-journal.org

The Leachability of Major Elements at Different Stages of Weathering in Dry Disposed Coal Fly Ash

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Large quantities of solid residue are generated by coal-fired power stations in many parts of the World. The disposal and management of the unused fly ash remains a major problem to the environment. The weathered dry disposed ash cores comprise of major element constituents such as Al, Si, Ca, Mg, Fe, Mn, Na+ and K+. The mobility patterns and mineralogical associations of major elements in weathered dry disposed ash dumps aged 1-year-old, 8-year-old and 20-year-old from a coalfired power station in South Africa were investigated using a modified sequential extraction scheme. The extraction sequence was as follows: (1) water soluble, (2) exchangeable, (3) carbonate, (4) Fe and Mn and (5) residual. A total acid digestion was carried out on the original sample prior to extraction to validate the extraction procedure. The distribution of Si, Fe, Mn, Ca, Mg, Na+, and K+ in 59 drilled ash core samples was determined by inductively coupled plasma mass spectrometry.

The leachability of the seven elements from different fractions proved to be different; so various distribution patterns have been achieved. The highest concentration of analytes is recorded in the water soluble, exchangeable, and carbonates of 1-year-old ash cores hence it is the least leached. The concentration of each element in each fraction was calculated as a percentage of the total metal content for the 1-year-old ash cores. The average amount of the major elements in the easily soluble fractions of 1-year-old ash core samples are: water soluble: Na (21%) . Ca (10.2%) . Mn (8.4%) . Si (4.0%) . K (2.58%) . Mg (0.05%) . Al (0.003%) . Fe (0.001%), exchangeable: Ca (37.04%) . Mg (12.6%) . Na (11.26%) . Mn (10.3%) . K (3.17%) . Si (1.6%) . Al (0.27%) . Fe (0.33%), carbonate: Mn (41.21%) . Ca (37.9%) . Mg (32.9%) . Al (29.25%) . Si (25.39%) . Fe (21.39%) . Na (2.6%) . K (2.23%).

The mobility of major elements in the weathered ash dumps are influenced by heterogeneity in the ash dump, inhomogeneous continuous brine irrigation and chemical interaction of ash cores with ingressed CO2 from atmosphere and percolating rain water.

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Zinc Speciation in Power Plant Burning Mixtures of Coal and Tires

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Fly ash from the cyclone-boiler co-combustion of high-S, high volatile bituminous coal and tire-derived fuel (tdf) was studied using a variety of chemical, optical, and microbeam techniques. Fly ash, dominated by Al-Si glass with lesser amounts of coalderived carbons, Fe-spinels, and tire-derived carbons, has Zn concentrations ranging from 2200 ppm (1st ESP row) to 6900 ppm Zn (3rd ESP row). Zinc occurs in Zn-rich nanoparticles in the Al-Si glass phases and as ZnO in amorphous and crystalline nanominerals, Fe- and Zn-sulfides, Pb-Al-Fe sulfates, and Zn sulfates. Iron-rich, Al- and Ti-bearing spinels contain accessory Zn2+, Cr3+, Mn2+, and Pb2+. Fe-sulfates and phosphates nanoparticles incorporate As, Cr, V, Ni, and Zn. Fullerenes were not detected in this fly ash, potentially due to the higher temperature of combustion in the cyclone boiler. Zinc was detected by XPS, but the low binding energies mitigated against the determination of the speciation of the element.

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A Multi-Analytical Approach to Understand the Chemistry of Fe-Minerals in Feed Coals and Ashes

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Seven feed coals used in the Brazilian power generation industry were obtained and subsequently analysed together with fly ash and bottom ash from a major Brazilian power plant. The samples were investigated by means of room temperature Fe-Mo¨ssbauer analyses, X-ray diffraction, Raman spectroscopy, scanning electron microscope and petrographic analysis. In addition, nanometer-sized crystalline phases in coals and ashes were characterized using an energy-dispersive X-ray spectrometer and a high-resolution transmission electron microscope. The major identified Fe-bearing minerals in the coals were found to be actinolite, ankerite, chalcopyrite, chlorite, goethite, illite, ilmenite, magnesioferrite, natrojarosite, pyrite, pyrrhotite, and siderite; whilst in the fly ash and bottom ash, ankerite, chlorite, chromite, goethite, hematite, hercynite, jarosite, maghemite, magnesioferrite, and magnetite were identified. Most of the Fe in the ash samples was present as Fe3+ resulting from the melting of Fe and silicates during combustion. The fraction of glassy Fe in those particles is high because of the high contact probability between Fe melt and silicates. The combination of the various methods offers a powerful analytical technique in the study of coal and coal ashes. This investigation can be regarded as an introductory and prospective study prior to further quantification.

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Geochemical Controls of Coal Fly Ash Leachate pH

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When coal fly ash is initially mixed with water, the initial pH of resulting extract or leachate may be strongly acidic (4) or alkaline (12). With time, however, this pH range tends to narrow because of geochemical buffering reactions. Because pH is the major variable that controls the leaching of many potential groundwater contaminants, understanding the long-term pH behavior of fly ash leachate is crucial to evaluating the environmental impacts of fly ash management. Using laboratory extract data, kinetic-geochemical models were created to gain a better understanding of the potential buffering that influences the long-term pH of ash leachate.

We used the kinetic software REACT which is a part of the software Geochemist's Workbench, Release 7.0.5 with the thermodynamic database thermo.com.v8.r6+. For this investigation, two fly ash samples were chosen. An alkaline fly ash sample was selected for this study to initially help validate the application of model. Then the leaching of an acidic fly ash sample was modeled. These specific ash samples were selected because appeared to be reasonably representative of an alkaline and acidic fly ash. These samples were also selected because of the availability of time-dependent leaching data to compare with the kinetic models, and detailed mineralogical and chemical characterization to use as a basis for constructing ash models.

The initial acidity observed in the laboratory studies was matched by using sulfuric acid and pyrite as reactants in the kinetic model. The initially low pH of acidic fly ashes was short-lived because the acidity was neutralized by the dissolution of calcium and magnesium oxides, then buffered by carbon dioxide yielding a pH of 7 to 8. Alkaline fly ash leachate (pH > 10) tends to absorb carbon dioxide, and the resulting pH of the liquid phase decreased with time to a pH between 8 and 9. Kinetic modeling suggests that the chemical composition of short-term laboratory extracts of coal fly ash will not be representative of long-term leachate after equilibrating with the atmosphere. The rate of change in pH, however, was accelerated in the laboratory studies because the slurries were well mixed. Under field conditions, the impacts of passive carbonate buffering would likely require longer periods of time. It appears that kinetic models such as REACT can be used to estimate the pH of leachate from coal combustion products for time frames that are not practical under laboratory conditions. Additional research is needed, particularly using field-scale data.

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Effect of Additive on the Performance Characteristics of Centrifugal and Progressive Cavity Slurry Pumps with High Concentration Fly Ash Slurries

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Slurry pumps that are used in the hydraulic transportation of fly ash slurries through pipes in thermal power plants can be broadly classified into two main categories namely positive displacement and centrifugal pumps. The two types of pumps differ considerably in construction as well as in operating principle compared to the conventional pumps.

The present study reports the effect of additive on the performance characteristics of centrifugal and progressive cavity screw pumps with fly ash slurries at high concentrations (above Cw < 50% by weight). Mixture of sodium carbonate and Henko detergent (5:1) at a concentration of 0.2% by weight has been used as an additive. For each type of pump, the effect of additive on the performance characteristics has been experimentally evaluated at rated speed with fly ash slurries in the concentration range of 50 to 70% by weight. The pump total head, overall efficiency and pump input power as a function of flow rate have been measured.

The results obtained from the centrifugal slurry pump performance show that at rated speed, the performance of the pump improves with the addition of drag reducing additive. In the case of progressive cavity screw pump, pump performance characteristics and behavior were completely different as compared to the centrifugal slurry pump. At rated speed, the performance of screw pump deteriorates with the addition of drag reducing soap solution.

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Compaction of High-Ca Fly Ash-Al- and Al-Alloy-Composites: Evaluation of their Microstructure and Tribological Performance

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In this study, highly calcareous and siliceous fly ash particles were utilized for the fabrication of Al- and Al-alloy-based Metal-Matrix Composites (MMCs) by means of powder metallurgy. After compacting and sintering Al and Al/Si powders containing 10, 15, and 20wt. % ash particles, the homogenous (and with minimal amount of voids) microstructure of the produced composites was verified by means of Scanning Electron Microscopy (SEM). The composites were tested for their dry sliding wear behavior using a pin-on-disc machine against spheres of alumina. The worn surfaces of composites were then examined by using SEM and Energy Dispersive X-Ray Spectroscopy (EDS). It was shown that the addition of both types of FA enhanced the tribo-performance of Al, with the optimum metal powder replacement determined to the point of 15% wt., in the case of high-Si and 10% wt., in the case of high-Ca ash particles. Regarding alloy-matrix composites, although they generally presented worse tribological performance than pure Al/Si products, the additions of ashes up to 15% wt. resulted in only slight deterioration of the wear performance of composites.

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Influence of Chemical Reagents on Rheological Properties of Fly Ash-Water Slurry at Varying Temperature Environment

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About 70% of total electrical energy is generated from thermal power plants in India which in turn release about 160 Mt of fly ash as solid waste annually. Transportation and disposal of such a huge amount of fly ash is a major problem faced by the power plants. Presently fly ash is transported as lean slurry in pipe lines requiring about 80 to 85% of water with high energy input.

A major impediment in high volume transportation of fly ash is its high specific gravity as compared to that of water. The objective of the present study was to evaluate the rheological characteristics of high concentration fly ash slurry with and without a chemical reagent at varying temperature environment to facilitate smooth flow of materials in the pipelines. Six different composition of fly ash slurry samples were considered for investigation. The main constituents of the slurry were fly ash, water, a cationic surfactant, and a counter-ion. Detailed rheological properties were determined using a cylindrical coaxial rotational rheometer at shear rates varying from 25s21 to 1000s21 for 40% solid concentration (by weight).

Temperature was varied from 20uC to 40uC for all the shear rates investigated. Test results showed that all the slurries exhibited shear thinning behaviour in the presence of the surfactant. The influence of cationic tenside on drag reduction of fly ash slurry was also studied. The distinctive reduction of surface tension on colloidal dispersion characteristics of the fly ash slurry was observed in the presence of the tenside. It revealed that the slurry developed in the above manner has a potential to be transported through pipelines with minimal energy consumption.

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