Coal Ash Is Not Toxic

By Lisa JN Bradley, Ph.D., DABT

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

- When evaluating the material as a whole, there is a wealth of information on the toxicity testing of coal ash in mammalian and aquatic species that demonstrates that coal ash is not toxic.
- The constituents in coal, and coal ash, are naturally occurring in the world around us.
- When looking at the trace elements present in coal ash on an individual basis, comparison of concentrations to screening levels developed by the U.S. Environmental Protection Agency (EPA) for a child's and adult's daily exposure to soil in a residential setting demonstrates that all are below the screening levels with the exception of the upper-bound concentrations of a few constituents.
- Adverse health effects can be caused by the constituents in coal ash, or coal ash itself, *only* if one is (a) exposed to the material, and (b) exposed at a level high enough to elicit a response.

Let's look at these conclusions individually.

Toxicity Testing of Coal Ash Under the EU REACH Program

The European Chemical Agency (ECHA)[1] of the European Union (EU) regulates a comprehensive program of toxicity testing of materials that are put into commerce. This program is referred to as REACH—the Registration, Evaluation, Authorization, and Restriction of Chemicals[2]—and has been in place since 2006. Coal ash has been registered for commerce under REACH, and the dossier for "Ashes (residues), coal," registration number EC# 931-322-8, is available for review.[3] The REACH program requires the performance of a battery of toxicity testing be conducted to support the registration dossier, including mammalian (human health) and aquatic toxicity studies.

Table 1 (see page 28) summarizes the mammalian toxicity study results, which are relevant to human health. Studies have been conducted to address 10 different toxicity endpoints for acute (short-term) and chronic (long-term) exposure durations. Oral (ingestion), dermal, and inhalation studies have been conducted. As shown in Table 1, a total of 47 mammalian toxicity studies have been conducted on coal ash—coal ash as a whole material, not separate individual components. The REACH system classifies materials by hazard category; if no hazards are identified, based on their classification system definitions, then the conclusion is that no classification is warranted due to "data conclusive but not sufficient for classification." The terminology is a bit cumbersome but means there is no hazard to classify. This is the terminology used in the GHS (Globally Harmonization System of Classification and Labeling of Chemicals) section of the dossier. Detailed information on each endpoint is provided in Table 1.

Table 2 (see page 32) provides similar information for the aquatic toxicity testing regimen. In all, 39 tests were conducted, including both acute and chronic exposures, and in all cases the conclusion is that no classification is warranted due to "data conclusive but not sufficient for classification."

There are two important aspects to these data. First, by conducting the studies on ash as a whole material, they account for any cumulative, additive, synergistic, and/or antagonistic effects that single constituents may have in these complex mixtures.

Second, included in the battery of tests were repeated-dose inhalation studies.[4] In the key study for the chronic inhalation test, the No Observed Adverse Effect Concentration and the Low Observed Effect Concentration were both 4.2 mg/m^3—or 4,200 ug/m^3 (see below for units).[5] While there were some small differences noted in the treated group of rats at this

[1]https://echa.europa.eu/home—ECHA Home Page

[2]https://echa.europa.eu/regulations/reach/understanding-reach—ECHA—Understanding REACH

[3]https://echa.europa.eu/registration-dossier/-/registered-dossier/15573/7/1 and https://echa.europa.eu/brief-profile/-/briefprofile/100.151.318—ECHA—REACH—Ashes (Residues), Coal

[4]https://echa.europa.eu/registration-dossier/-/registered-dossier/15573/7/6/3/?documentUUID=cc790b47-dc2b-4f1a-8504-3a9d24a1232a—ECHA—REACH—Ashes (Residues), Coal—Repeated Dose Toxicity: Inhalation

[5]mg = milligram of coal ash; ug = microgram of coal ash; m^3 = cubic meter of air

Coal ash is registered for commerce under the European Chemical Agency's REACH program, which requires the performance of toxicity testing, including mammalian and aquatic toxicity studies. It is now routinely used in products and applications from concrete to cement, road base, asphalt, and structural fill.

air concentration, it was concluded that "this response was considered an important natural response to inhaled particles and not being unique to coal fly ash." To put these air concentrations into context, the annual National Ambient Air Quality Standards for particulate matter of 2.5 microns or less effective diameter (PM2.5)[6] is 12 ug/m^3. *The rat inhalation studies were conducted at 350-fold higher concentrations with no adverse effects*.

Taken together, this series of detailed and comprehensive toxicity testing and the conclusions of no hazard are good news—for the industry and for the community.

Coal, Coal Ash, and Elements

Let's remind ourselves that coal is formed from the remains of plants in ancient forests and marshes that have been compacted and metamorphosed by heat and pressure over geologic time.[7] Plants take up minerals as they grow. Coal ash is the unburnable residuals from the combustion of coal for electricity production—mainly inorganic elements and compounds. Because coal is a natural geologic material, the inorganic elements and compounds in coal ash are also naturally occurring.

The U.S. Geological Survey (USGS) conducted a survey of elemental concentrations in surface soils in the U.S., and the information can be accessed online by linking to each element in the posted periodic table.[8] All of the elements listed in news stories of "toxic coal ash"—for example, arsenic, mercury, selenium, chromium, and lead—are naturally occurring, and the USGS has an occurrence map for each of them.

Because plants grow in soil and take up minerals (inorganics and elements) from the soil, these elements are also naturally present in the foods we eat. The U.S. Agency for Toxic Substances and Disease Registry does a good job of summarizing the presence of elements in the food we eat in their publications.[9] We are also exposed to soils every day—at home, at school, in parks. Therefore, we are exposed to these elements every day as well from our diet and from our incidental/inadvertent ingestion of soil when we are outside.

Evaluating Coal Ash on a Constituent-Specific Basis

The bulk of rocks/shales and coal ash are made up of silicon, aluminum, iron, and calcium (90%), with sulfur, sodium, potassium, magnesium, and titanium making up the minor elements (8%); the remaining elements are termed "trace

[6]https://www.epa.gov/criteria-air-pollutants/naaqs-table—NAAQS Table
[7]https://www.usgs.gov/faqs/what-coal?qt-news_science_products=0#qt-news_science_products—USGS—What is Coal?
[8]https://pubs.usgs.gov/sir/2017/5118/sir20175118_geo.php—Geochemical and Mineralogical Maps, with Interpretation, for Soils of the Conterminous United States
[9]https://www.atsdr.cdc.gov/toxprofiledocs/index.html—ATSDR Toxicological Profiles

elements" and make up less than 1% of the total content. The USGS conducted a survey of elements and inorganic compounds in coal ash from five different power plants, each using a coal sourced from one of the five different coal regions in the U.S.[10] Thus, we have detailed compositional data for fly ashes and bottom ashes from each of these coal sources.

The EPA semi-annually updates a set of tables that provide risk-based screening levels for over 750 elements and compounds.[11] Risk-based screening levels are provided for soil, air, and water. The risk-based screening levels for soils include a residential scenario, where it is assumed that a residential child and adult can contact soil in a yard daily over a 26-year residential lifetime. The residential soil pathway includes incidental ingestion of soil and inhalation of wind-generated dusts. In the User's Guide[12] EPA notes: "The SLs [screening levels] presented in the Generic Tables are chemical-specific concentrations for individual contaminants in air, drinking water, and soil that may warrant further investigation or site cleanup. **It should be emphasized that SLs are not cleanup standards.**" (Note: the text is bolded by EPA in the User's Guide.)

The detailed compositional data for fly ashes and bottom ashes from the USGS can be compared to the EPA risk-based screening levels for residential soil. By doing so, we are essentially assuming that the soil in a residential yard is replaced with coal ash. A detailed report on this comparison is available from ACAA,[13] and a summary of the analysis was presented in a previous *ASH at Work* article.[14] Of the 20 trace elements evaluated in the full report, 15 are present in all ashes included in the evaluation at concentrations less than the EPA screening levels for residential soils. These are: antimony, barium, beryllium, cadmium, copper, lead, lithium, manganese, mercury, molybdenum, nickel, selenium, strontium, uranium, and zinc. Concentrations of five constituents

[10]https://pubs.usgs.gov/ds/635/ - Geochemical Database of Feed Coal and Coal Combustion Products (CCPs) from Five Power Plants in the United States

[11]https://www.epa.gov/risk/regional-screening-levels-rsls-generic-tables—USEPA Regional Screening Levels (RSLs) - Generic Tables

[12]https://www.epa.gov/risk/regional-screening-levels-rsls-users-guide—USEPA RSL User's Guide

[13]https://www.acaa-usa.org/publications/freepublications.aspx—ACAA—Coal Ash Material Safety; under Technical Reports

[14]https://www.acaa-usa.org/Portals/9/Files/PDFs/AshAtWork/ASH01-2012.pdf—ACAA—pp. 21-26.

In a hypothetical scenario in which coal ash completely replaced soil in a residential yard, with few exceptions constituent concentrations of 20 trace elements evaluated in coal ash were below risk-based screening levels developed by the EPA for residential soils—and were similar in concentration to background U.S. soils.

Every element on the periodic table can elicit an adverse effect if administered at a high-enough dose.

range to above the residential soil screening level in *some* but *not all* of the coal ashes: arsenic, chromium, cobalt, thallium, and vanadium. Moreover, these concentrations are only slightly above the screening levels. This comparison demonstrates that there would be no basis for health risk for incidental contact with coal ash or fly ash on a daily or an infrequent basis.

Don't Be Confused by Misleading Graphics

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

- Coal ash is not toxic—even at the high exposure levels used in animal tests;
- There are safe levels of exposure to each of the constituents in coal ash (and in soil), as defined by EPA; and
- Exposure must occur at a high-enough level before an adverse effect can occur.

Let's Keep Our Discussions Scientific

It is easy to get press coverage when you say the sky is falling or that coal ash is toxic. Bad news sells. Reasoned responses to such claims do not. We live in a complicated world, and the results of scientific research are hard to convey in easy language, let alone in sound bites. But we have to keep trying to get the scientific message out.

Those with political and money-raising objectives may make fun of what is said here. But there is an important distinction between making fun of what someone says and providing a science-based reply. Peer review and scientific discussions are always welcome—bullying is not. Let's stop bullying and scaring people about coal ash—and start having a fact-based discussion about working to advance safe and technically sound disposal practices, as well as safe and environmentally sound beneficial uses of coal ash.

Lisa JN Bradley, Ph.D., DABT is a Principal Toxicologist with the environmental consulting firm Haley & Aldrich. She has a Ph.D. in toxicology from the Massachusetts Institute of Technology, has 25 years of experience in risk assessment and toxicology, and is certified by the American Board of Toxicology. She is serving her third 2-year term as Secretary/Treasurer of the American Coal Ash Association. In May 2014, Dr. Bradley was appointed to the National Coal Council (NCC) by the U.S. Secretary of Energy to provide risk assessment and toxicology expertise to the NCC—and has been reappointed each year since. She was named one of the 100 Global Inspirational Women in Mining in December 2015 by Women in Mining (UK).