COAL ASH MATERIAL SAFETY

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

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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 10th to 90th 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.

RESULTS

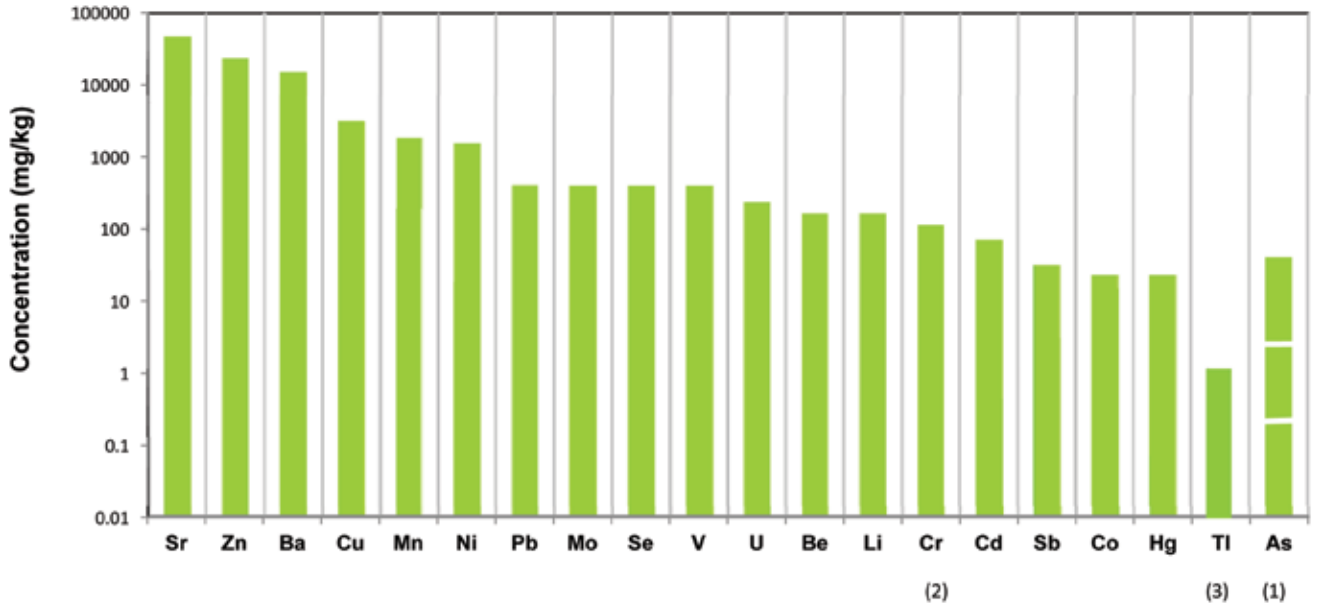
When plotted on the chart in Figure 1, constituent concentration ranges that fall within the green bar ranges are below the USEPA screening level for residential soil. If coal ash is the "toxic" material that some groups characterize it to be, we would expect that the constituent concentrations as reported 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 10th-90th 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.

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



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

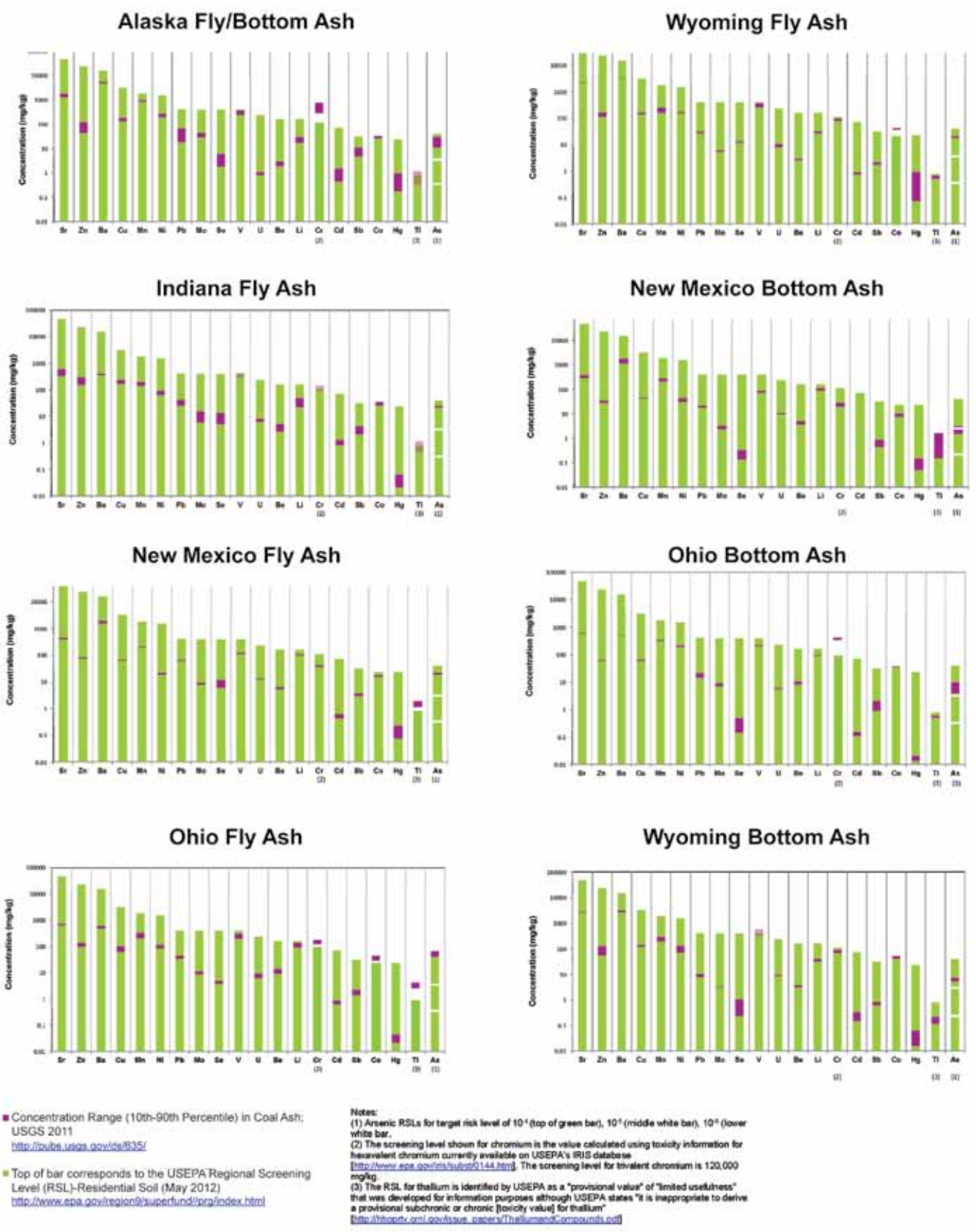


Figure 2 – Comparison of 10th to 90th Percentile USGS Database Constituent Concentrations in Coal Ash to USEPA Screening Levels for Residential Soils

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.

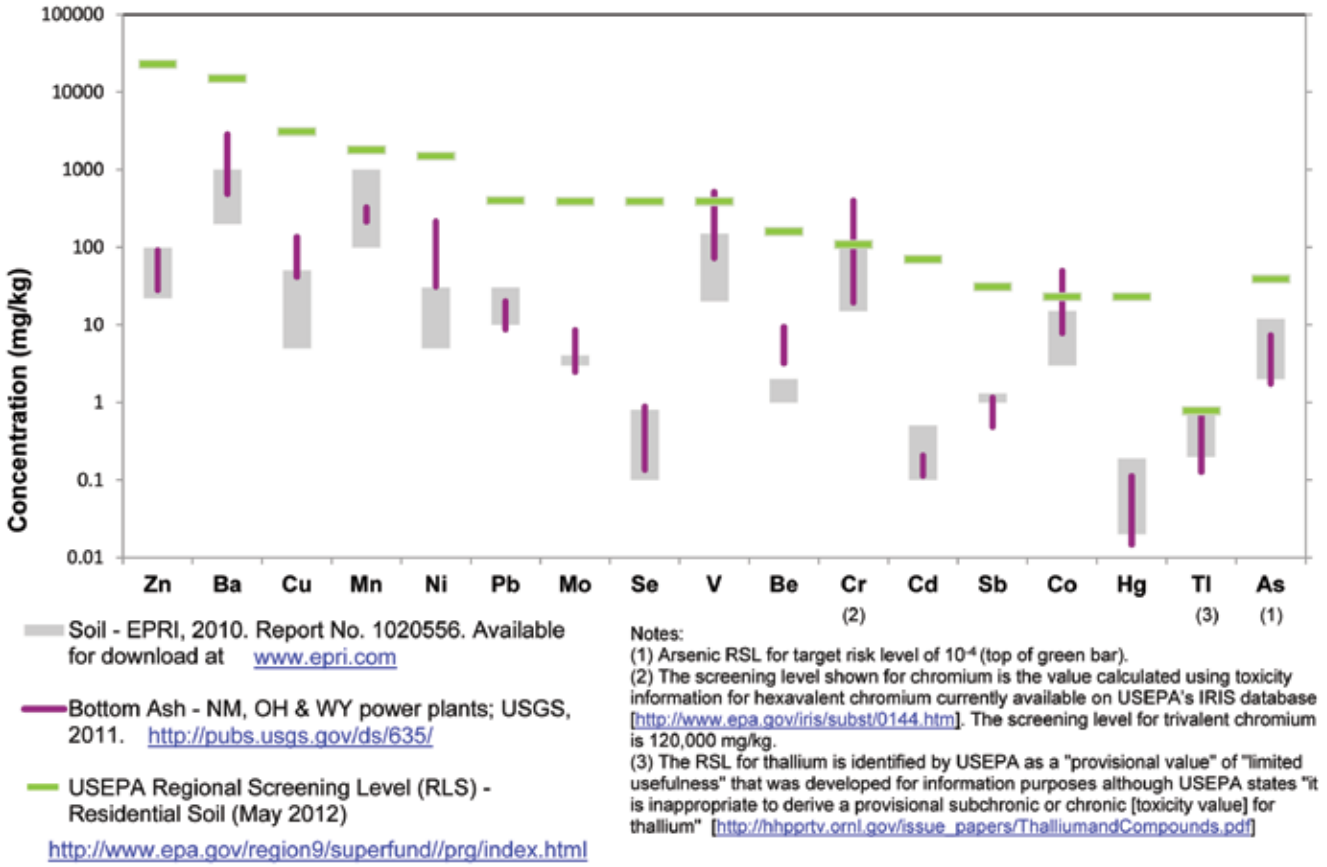


Figure 3 – Comparison of 10th and 90th percentile USGS Database Constituent Concentrations in Bottom Ash and Background Levels in US Soils to the USEPA Regional Screening Levels for Residential Soils

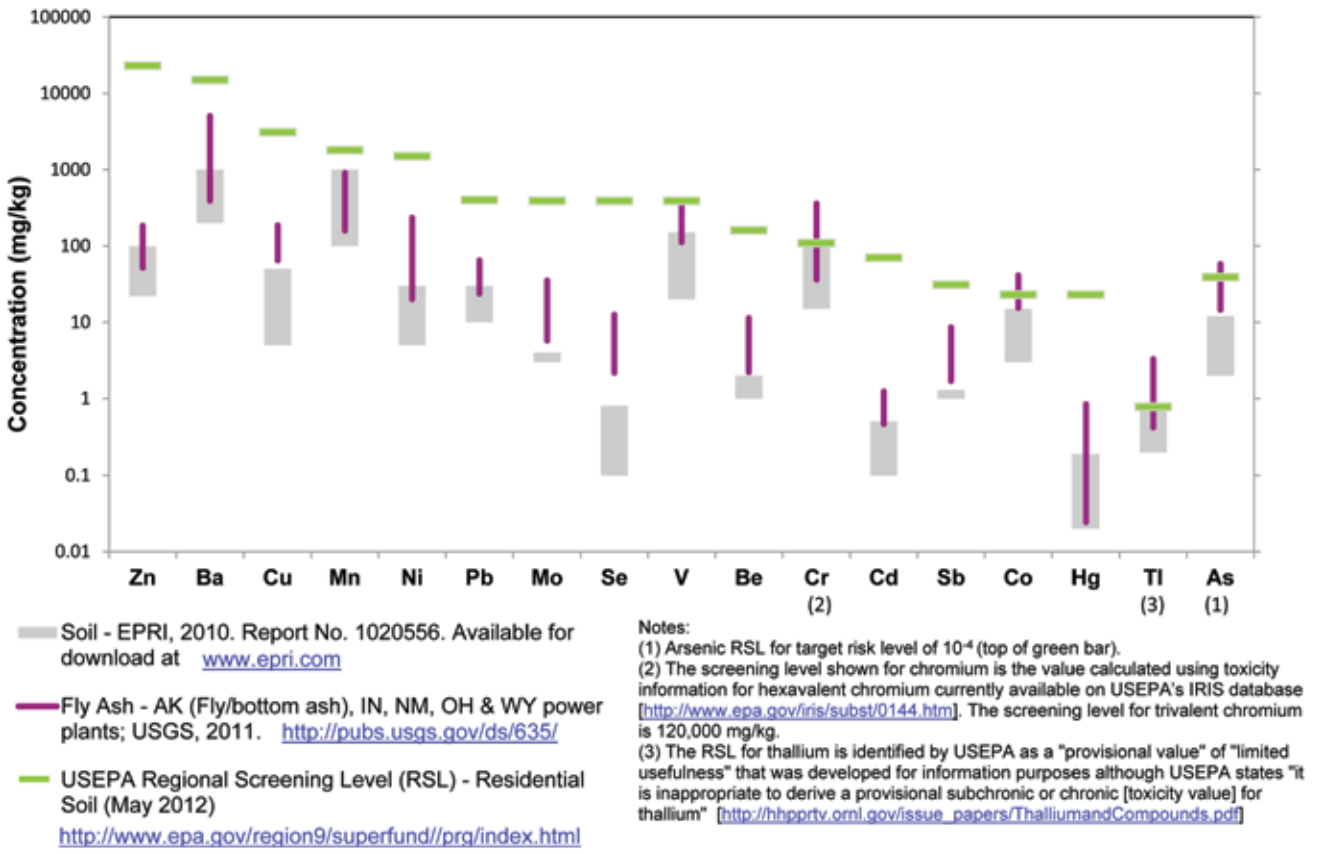


Figure 4 – Comparison of 10th and 90th percentile USGS Database Constituent Concentrations in Fly Ash and Background Levels in US Soils to the USEPA Regional Screening Levels for Residential Soils

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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