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Coal Ash Material Safety

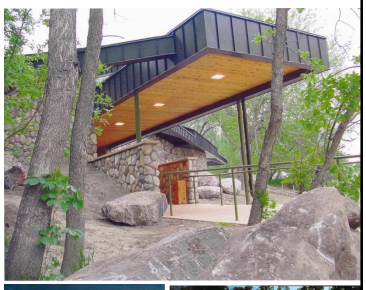
A Health Risk-Based Evaluation of USGS Coal Ash Data from Five US Power Plants

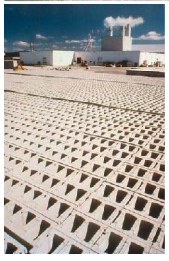
Lisa JN Bradley, Ph.D., DABT

International Concrete Sustainability Conference, May 2013

Study Objective

- In the **public debate** on regulatory and legislative fronts about coal ash, news stories and publications consistently refer to "toxic coal ash," and environmental groups state that coal ash is a "highly toxic waste stream," and that "coal ash is plainly and simply hazardous to your health."
- The US Geological Survey (**USGS**) published a report in 2011 that provides data for concentrations of metals and inorganics in **coal ash** from five power plants in across the US.
- **The objective of this study was to conduct a risk-based evaluation of the USGS CCP data in the context of beneficial use.**
- ACAA Report published July 1, 2012
  http://www.acaa-usa.org/displaycommon.cfm?an=1&subarticlenbr=109
- "Critique" of "Junk Science Report" issued January 2013
  http://earthjustice.org/sites/default/files/ACAAreport.pdf
  Addresses only the press release materials – not the full and detailed report





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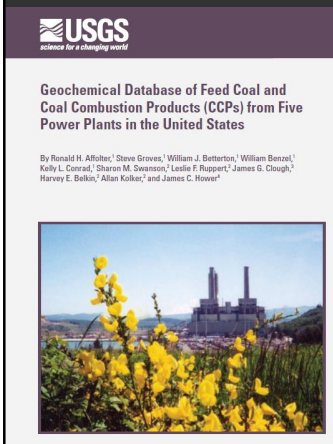
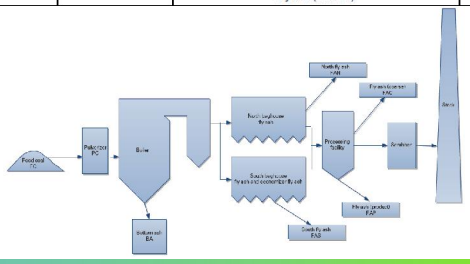
USGS Data on Coal Ash Constituent Concentrations



- **Geochemical Database of Feed Coal and Coal Combustion Products (CCPs) from Five Power Plants in the United States.** Data Series 635. US Geological Survey (USGS). Available at: http://pubs.usgs.gov/ds/635/
- **22 CCP datasets from 5 power plants available – 8 datasets were selected to be those most representative of material put into beneficial use.**

New Mexico	San Juan	Bottom Ash	X
		Fly Ash North	
		Fly Ash South	
		Fly Ash Coarse	
		Fly Ash (Product)	X



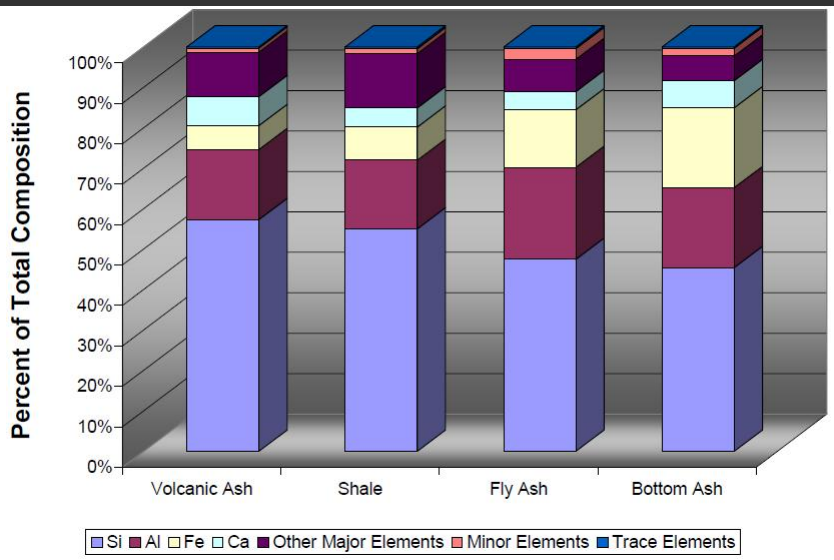
Datasets

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

- Major, minor and trace constituent data are provided by USGS.
- This report focuses on the trace constituent data.
- The USGS data provide total concentrations of each constituent.

- This worst-case evaluation addresses direct contact exposure pathways in a residential setting: incidental ingestion, dermal contact, and inhalation of suspended dusts.
- **This evaluation does not address potential leaching of constituents from CCPs in these settings; the USGS report does not provide information appropriate to address this potential pathway.**

What are in CCPs?

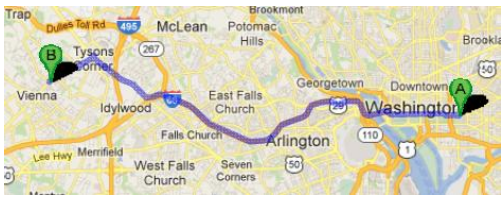


Source
EPRI, 2010. Comparison of Coal Combustion Products to Other Common Materials – Chemical Characteristics. Report No. 1020556. Available for download at www.epri.com

Trace Elements

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

- **Why are they called trace elements?**
- They are present in concentrations of milligram per kilogram (mg/kg), equivalent to:
  - One part per million (ppm):
    1 penny in a stack of $10,000
    1 second in 11.5 days
    1 inch in 15.8 miles



How do we evaluate concentrations of trace elements in soil?

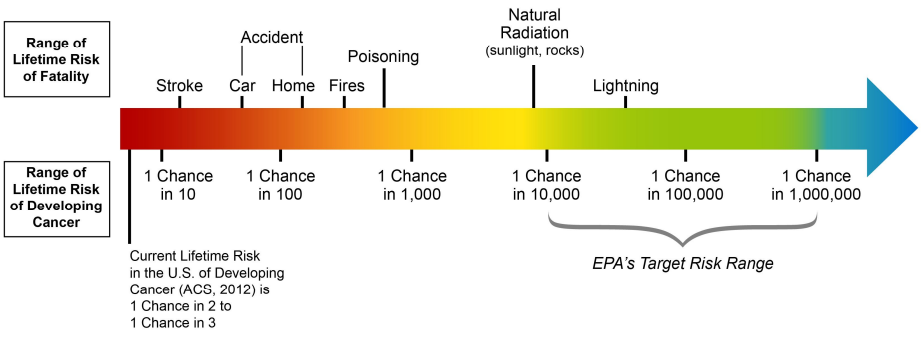
USEPA Regional Screening Levels (RSLs):

- Screening levels are calculated based on a **residential** soil exposure scenario: assumes that a child and adult are exposed to constituents in soil on a daily basis by **incidental ingestion, dermal contact, and inhalation of dusts**.
- In essence, we are assuming that a house is built on top of a coal ash landfill and instead of being exposed to dirt or soil, **all contact is with coal ash**.
- USEPA's screening levels evaluate both potential carcinogenic and noncarcinogenic effects. For noncancer effects, the screening levels are based only a **child's exposure to soil**, as a child is smaller than an adult and is assumed to have a higher conact with soil.
- As noted by USEPA, the screening levels (RSLs) are considered by the Agency to be **protective for humans (including sensitive groups) over a lifetime**, and
- Generally, at sites where concentrations fall below the RSLs, no further action or study is warranted.

RSLs: USEPA. May 2012. Values for residential soil. http://www.epa.gov/reg3hwmd/risk/human/rb-concentration_table/index.htm

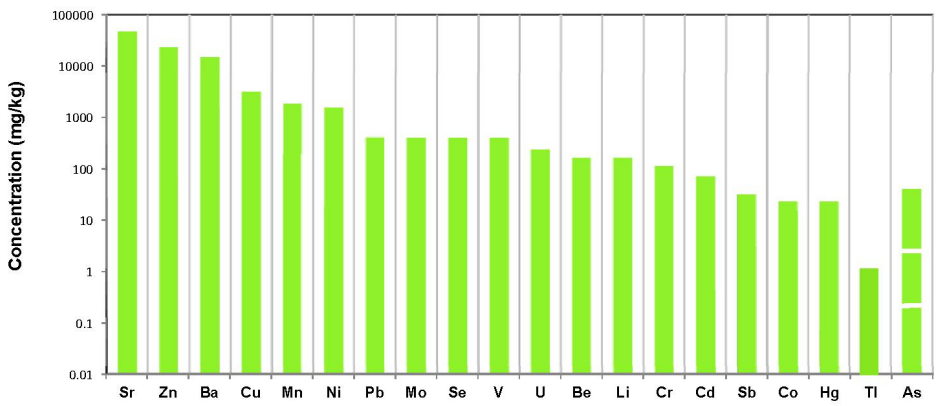
Risks in Perspective

Risks in Perspective



- Adapted from U.S. EPA 450/3-90-022, Mar. 1991, http://www.epa.gov/air/oaqps/air_risc/3_90_022.html (1996)
- American Cancer Society. 2012. Cancer Facts and Figures 2012. http://www.cancer.org/acs/groups/content/@nho/documents/document/acspc-024113.pdf

USEPA Regional Screening Levels for Residential Soils



RSLs: USEPA. May 2012. Values for residential soil. http://www.epa.gov/reg3hwmd/risk/human/rb-concentration_table/index.htm
Carcinogenic by the oral route of exposure: As
Carcinogenic by the inhalation route of exposure: As, Be, Cd, Co, Ni, Cr6 – RSL driven by oral route

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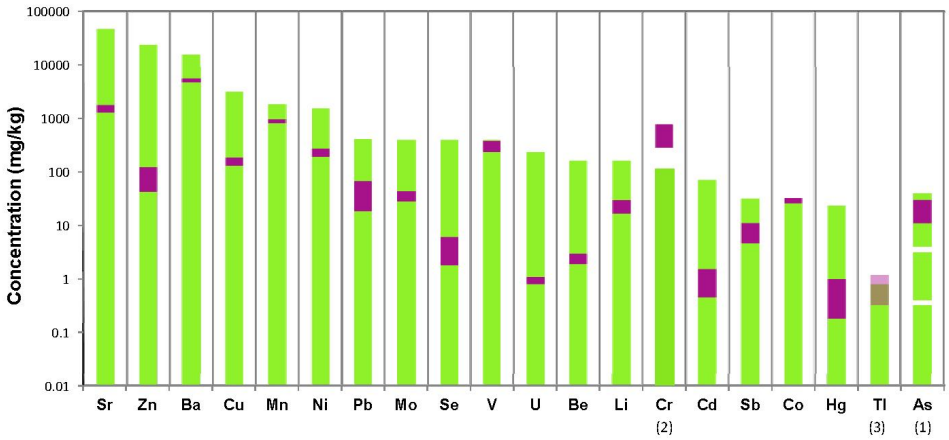
Comparison of USGS Database Constituent Concentrations in Fly/Bottom Ash at the Alaska Coal Power Plant to the USEPA RSLs for Residential Soils



RSLs: USEPA. May 2012. Values for residential soil. http://www.epa.gov/reg3hwmd/risk/human/rb-concentration_table/index.htm
CCP Data: USGS. 2011. Data Series 635. Available at: http://pubs.usgs.gov/ds/635/om

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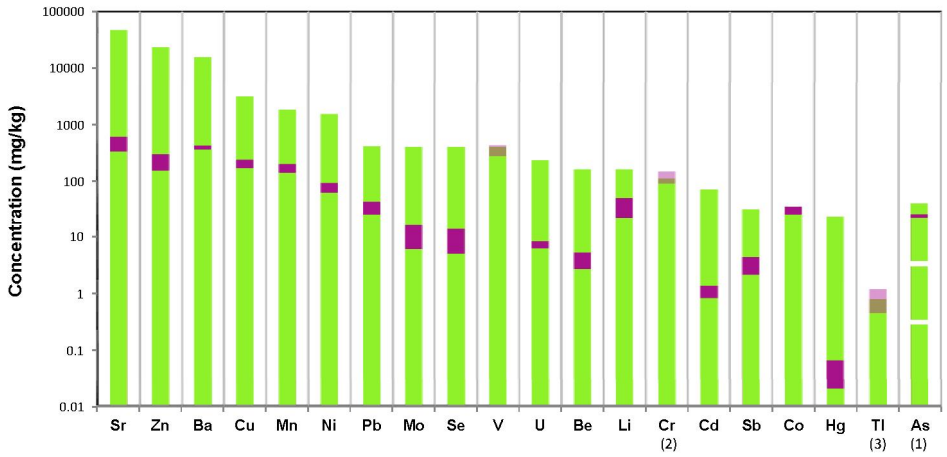
Comparison of USGS Database Constituent Concentrations in All Fly Ash at the Indiana Coal Power Plant to the USEPA RSLs for Residential Soils



RSLs: USEPA. May 2012. Values for residential soil. http://www.epa.gov/reg3hwmd/risk/human/rb-concentration_table/index.htm
CCP Data: USGS. 2011. Data Series 635. Available at: http://pubs.usgs.gov/ds/635/om

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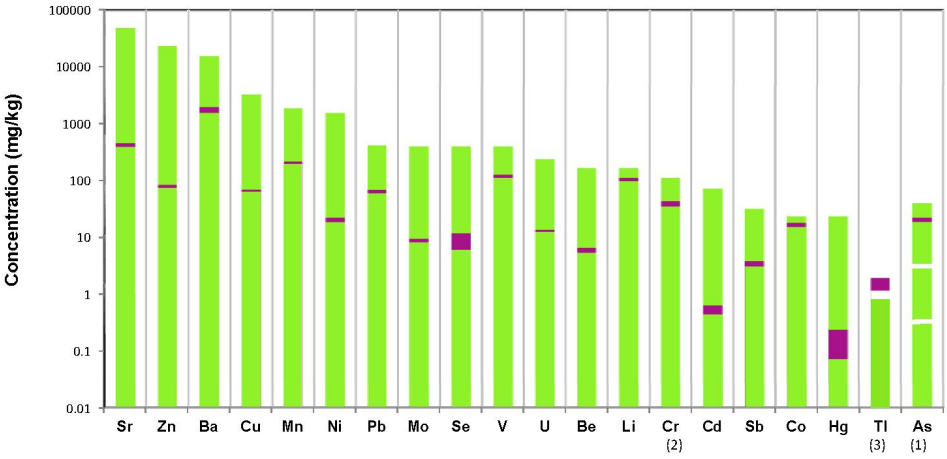
Comparison of USGS Database Constituent Concentrations in Fly Ash Product at the New Mexico Coal Power Plant to the USEPA RSLs for Residential Soils



RSLs: USEPA. May 2012. Values for residential soil. http://www.epa.gov/reg3hwmd/risk/human/rb-concentration_table/index.htm
CCP Data: USGS. 2011. Data Series 635. Available at: http://pubs.usgs.gov/ds/635/om

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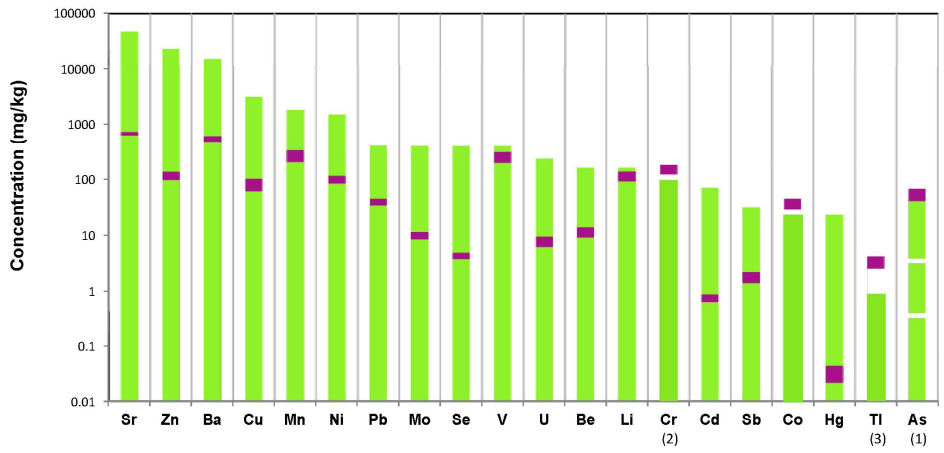
Comparison of USGS Database Constituent Concentrations in Fly Ash at the Ohio Coal Power Plant to the USEPA RSLs for Residential Soils



RSLs: USEPA. May 2012. Values for residential soil. http://www.epa.gov/reg3hwmd/risk/human/rb-concentration_table/index.htm
CCP Data: USGS. 2011. Data Series 635. Available at: http://pubs.usgs.gov/ds/635/om

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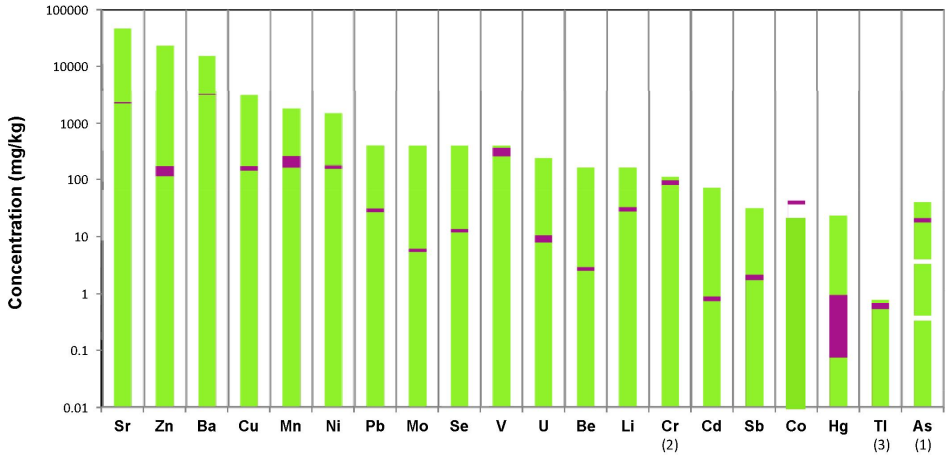
Comparison of USGS Database Constituent Concentrations in Fly Ash at the Wyoming Coal Power Plant to the USEPA RSLs for Residential Soils



RSLs: USEPA. May 2012. Values for residential soil. http://www.epa.gov/reg3hwmd/risk/human/rb-concentration_table/index.htm
CCP Data: USGS. 2011. Data Series 635. Available at: http://pubs.usgs.gov/ds/635/om

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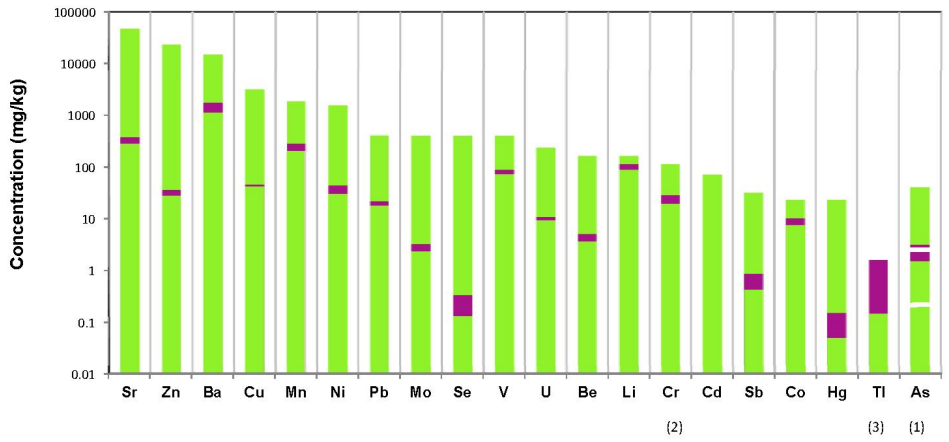
Comparison of USGS Database Constituent Concentrations in Bottom Ash at the New Mexico Coal Power Plant to the USEPA RSLs for Residential Soils



RSLs: USEPA. May 2012. Values for residential soil. http://www.epa.gov/reg3hwmd/risk/human/rb-concentration_table/index.htm
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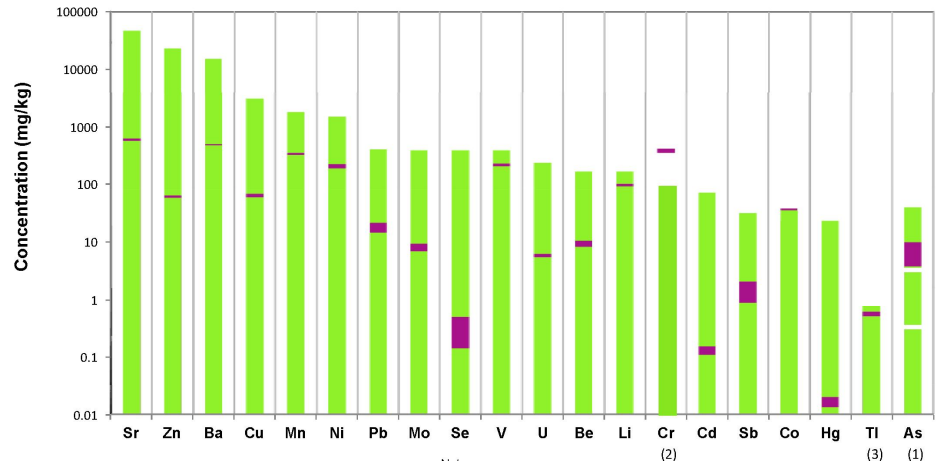

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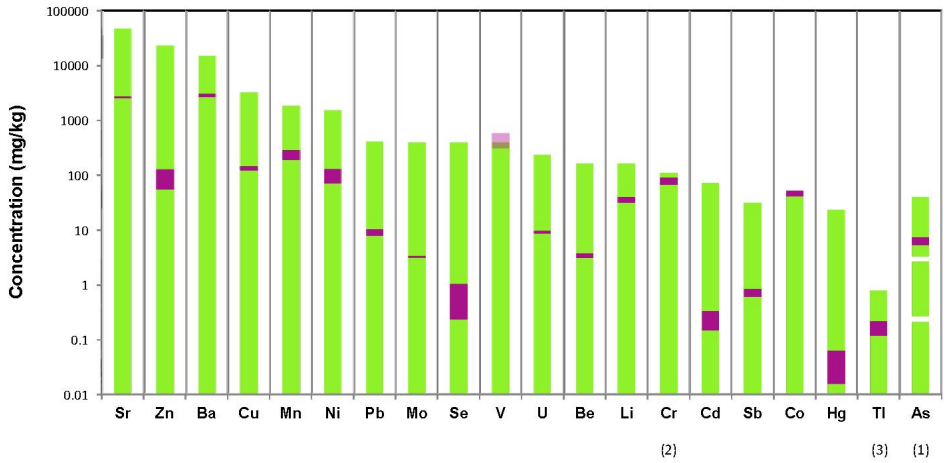

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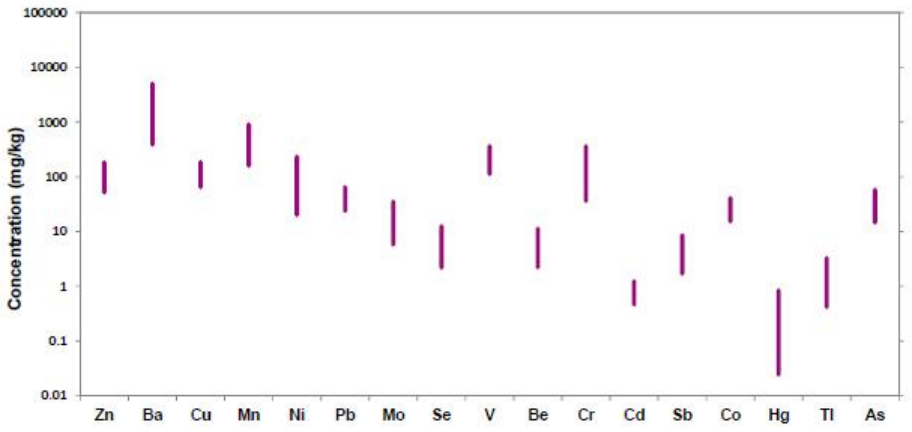
Fly Ash: 10th-90th Percentiles USGS Data Combined



CCP Data: USGS. 2011. Data Series 635. Available at: http://pubs.usgs.gov/ds/635/om

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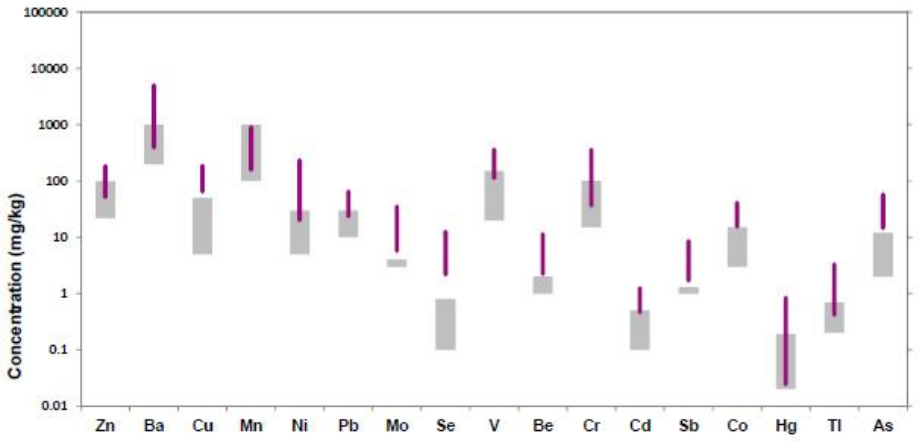
Fly Ash and Background Soils in US – 10th-90th Percentiles



Background Soils: EPRI. 2010. Report No. 1020556. Available for download at: www.epri.com
CCP Data: USGS. 2011. Data Series 635. Available at: http://pubs.usgs.gov/ds/635/om

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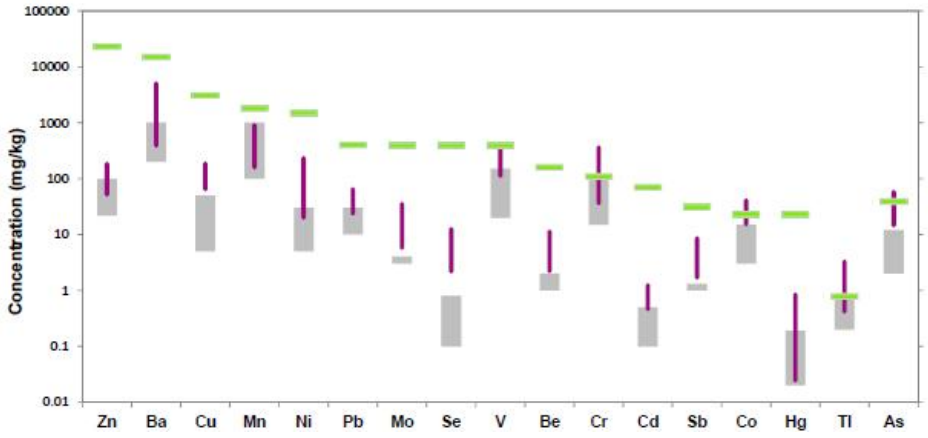
Comparison of 10th-90th percentiles in Fly Ash and Background Levels in US Soils to the USEPA RSLs for Residential Soils



RSLs: USEPA. May 2012. Values for residential soil. http://www.epa.gov/reg3hwmd/risk/human/rb-concentration_table/index.htm
Background Soils: EPRI. 2010. Report No. 1020556. Available for download at: www.epri.com
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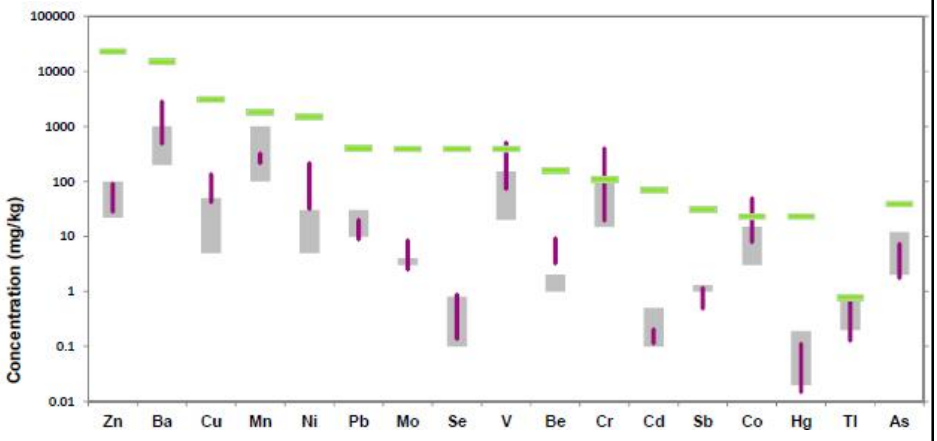
Comparison of 10th-90th percentiles in Bottom Ash and Background Levels in US Soils to the USEPA RSLs for Residential Soils



RSLs: USEPA. May 2012. Values for residential soil. http://www.epa.gov/reg3hwmd/risk/human/rb-concentration_table/index.htm
Background Soils: EPRI. 2010. Report No. 1020556. Available for download at: www.epri.com
CCP Data: USGS. 2011. Data Series 635. Available at: http://pubs.usgs.gov/ds/635/om

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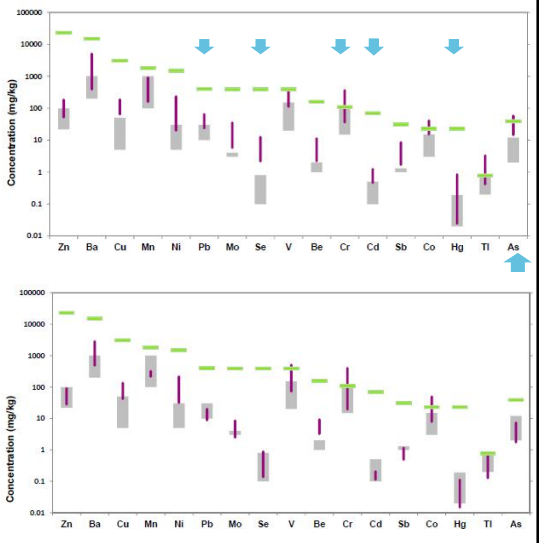
Discussion and Context

- Environmental groups continually single out the toxic effects of the following, without discussing concentrations, or putting them into an exposure context:
  - Lead, selenium, chromium, cadmium, mercury, and arsenic
- Concentrations of lead, mercury, cadmium, and selenium are consistently well below the residential soil screening levels.
- In fact, all concentrations of 15 of the 20 elements are below residential soil screening levels.
- Only the fly ash data for the Ohio plant has an upper-bound concentration of arsenic that is slightly above USEPA's risk range (2 in 10,000 vs. 1 in 10,000).
- Upper-bound levels of arsenic, vanadium, chromium, cobalt, and thallium are slightly above the RSL



Source: ACAA. July 2012. http://www.acaa-usa.org/associations/8003/files/ACAA_CoalAshMaterialSafety_June2012.pdf
Green = RSL; Purple = 10th-90th %iles in CCPs; Grey = 10th-90th %iles in US soil.

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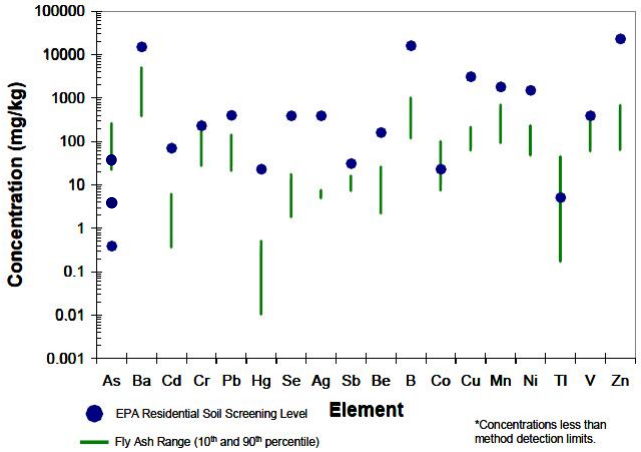
Coal Ash Levels Similar or Less than Risk-Based Screening Levels

Trace Element Concentration Ranges in Fly Ash Compared to EPA Residential Soil Screening Levels

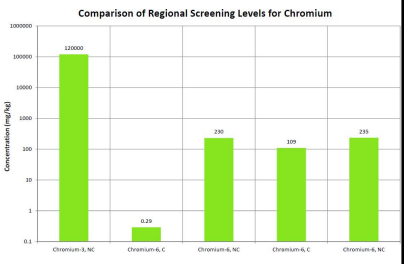


As = Arsenic
Ba = Barium
Cd = Cadmium
Cr = Chromium
Pb = Lead
Hg = Mercury
Se = Selenium
Ag = Silver
Sb = Antimony
Be = Beryllium
B = Boron
Co = Cobalt
Cu = Copper
Mn = Manganese
Mo = Molybdenum
Ni = Nickel
Tl = Thallium
V = Vanadium
Zn = Zinc

Source: EPRI, 2010. Comparison of Coal Combustion Products to Other Common Materials – Chemical Characteristics. Report No. 1020556. Available for download at www.epri.com.

Discussion and Context

- Chromium
  - It has been assumed that all chromium is in the hexavalent form, which is very unlikely.
    - Data from the Alaska plant indicate that hexavalent chromium is only 0.25% of the total chromium.
  - **There are many uncertainties with the hexavalent chromium screening levels – for this evaluation, current USEPA verified values were used.**



- Arsenic – **Screening levels for all three USEPA target risk levels were provided for context.**
- Cobalt
  - The toxicity value for cobalt is a provisional value. 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 US is higher than the toxicity value.
- Thallium – the provisional document for the toxicity value notes:
  - "For 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."
  - However "…an appendix with a "screening subchronic and chronic p-RfD" is provided, recognizing the quality decrements, which may be of value under certain circumstances"

Summary

- 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 US soils.
- Thus, not only does coal ash not qualify as a hazardous substance from a regulatory perspective, **it would not be classified as hazardous on a human health risk basis.**
- Because exposure to coal ash used in **beneficial applications**, such as concrete, road base, or structural fill would be much lower than a residential scenario, these uses would also not pose a direct contact risk to human health.

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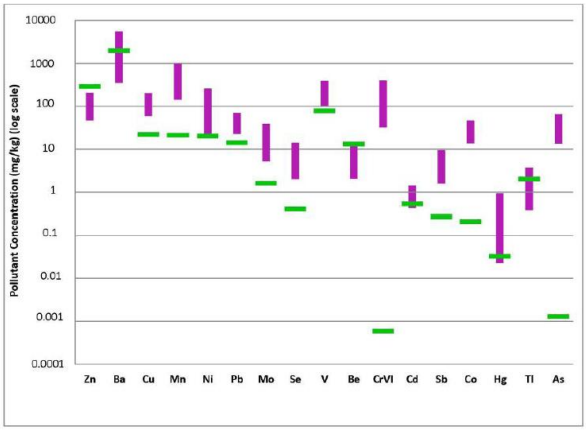
ENGO Comparison of ACAA Fly Ash Results to SGW SSLs

Figure 1: Comparison of 10th and 90th percentile fly ash constituent concentrations (purple bars, from the ACAA presentation of USGS data) to USEPA Soil Screening Levels for groundwater protection (green bars).



Source: http://earthjustice.org/sites/default/files/ACAAreport.pdf

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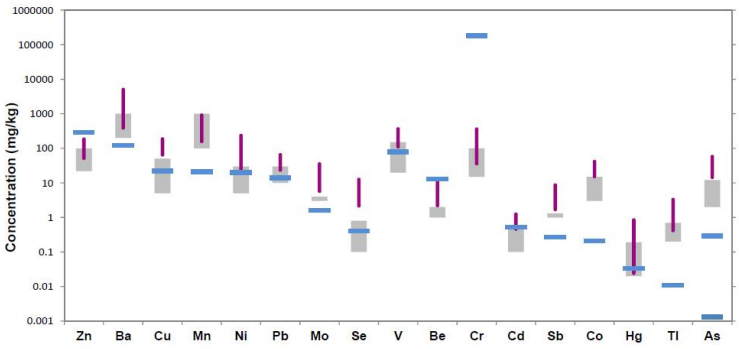
Corrected Comparison to SGW SSLs

Comparison of 10th and 90th percentile USGS Database Constituent Concentrations in Fly Ash and Background Levels in US Soils to the USEPA SSLs for Soil-to-groundwater Pathway



Soil - EPRI, 2010. Report No. 1020556. Available for download at www.epri.com

Fly Ash - AK (Fly/bottom ash), IN, NM, OH & WY power plants; USGS, 2011. http://pubs.usgs.gov/ds/635/

SSL - Soil Screening Level (mg/kg) http://www.epa.gov/region9/superfund//prg/index.html

Notes:
(1) SSL - Soil Screening Level.
(2) Risk-based soil screening level plotted; where not available, the MCL-based SSL is plotted.
(3) For chromium, the SSL based on the MCL for total chromium is plotted; the USGS data are clearly reported for total chromium.
(4) For mercury, the risk-based SSL for elemental mercury is plotted. Total mercury was analyzed by USGS, but no SSL is available for total mercury.
(5) For arsenic, both the risk-based and the MCL-based SSLs are plotted.

USEPA Fugitive Dust Report for CCR

- Report addressed fugitive dust emissions from a landfill using SCREEN3 model
  - Assumed a location with 0 precipitation
  - Did not correctly calculate PM10 (did TSP instead)
  - Did not account for ash conditioning during landfilling operations
  - Did not account for the sequential nature of landfilling operations – assumed the entire area of the landfill was a continuing source
  - The maximum modeled dust concentration was 13,390 ug/m3 – a condition that would have been experienced near the eruption of Mt. St. Helens
- Data from TVA indicate that there have been no air quality standards exceedances during the Kingston recovery project

USEPA. 2010. Inhalation of Fugitive Dust: A Screening Assessment of the Risks Posed by Coal Combustion Waste Landfills. May 2010.

Summary

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- Thus, not only does coal ash not qualify as a hazardous substance from a regulatory perspective, **it would not be classified as hazardous on a human health risk basis.**
- Because exposure to coal ash used in **beneficial applications**, such as concrete, road base, or structural fill would be much lower than a residential scenario, these uses would also not pose a direct contact risk to human health.

Resources

- ACAA
  - Coal Ash Material Safety Report: http://www.acaa-usa.org/displaycommon.cfm?an=1&subarticlenbr=109
  - "Coal Ash Material Safety: A Health Risk-Based Evaluation of USGS Coal Ash Data from Five US Power Plants." LJN Bradley. Ash at Work, Issue 1, 2012. Available at www.acaa-usa.org.
  - "Coal Ash in Context: Separating Science from Sound Bites As Regulatory and News Media Debates Continue." LJN Bradley and J Ward. Ash at Work, Issue 1, 2011. Available at www.acaa-usa.org.
- EPRI: www.epri.com
  - Constituent concentrations in CCPs: Reports 1020556 and 1019022.
  - Health Risk Comparison of MSW to CCP Leachate: Report 1020555.
  - Human Health Risks from Mercury in Concrete and Wallboard Containing Coal Combustion Products: Report 019023.
  - Current research on leaching from concrete and wallboard – to be published soon.
- **Thank you!**

Lisa JN Bradley, PhD, DABT; lisa.bradley@aecom.com