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Characterization of Coal Combustion Residues from Electric Utilities – Leaching and Characterization Data

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3. RESULTS AND DISCUSSION

The EPA Risk Report (EPA, 2007b) identified the following COPCs based on the potential for either human health or ecological impacts using a screening risk assessment: aluminum (Al), arsenic (As), antimony (Sb), barium (Ba), boron (B), cadmium (Cd), cobalt (Co), chromium (Cr), lead (Pb), mercury (Hg), molybdenum (Mo), selenium (Se), and thallium (Tl).[39] Thus, the evaluation provided here focuses on the same thirteen constituents and can be used in future risk and environmental assessments.

3.1. TOTAL ELEMENTAL CONTENT

Total elemental content of CCR samples was analyzed by acid digestion (digestion Method 3052 and ICP-MS analysis by Method 6020; see Section 2.3.7) for constituents of potential concern (Al, As, Ba, Cd, Co, Cr, Mo, Pb, Sb, Se, Tl)[40] and mercury was analyzed by Method 7470 with selected samples also analyzed by Method 7473; results of these analyses are provided in Figure 9 through Figure 21, with tabular results in Appendix D. Total elemental content for boron was not analyzed because of interferences by the sample digestion method. Total elemental content also was analyzed by XRF for major constituents and other detectable constituents (Al, Ba, Ca, Cl, F, Fe, K, Mg, Na, P, S, Si, Sr, Ti) and carbon was analyzed independently; results of these analyses are provided in Figure 22 through Figure 36, with tabular results provided in Appendices E and C. Several of the COPCs analyzed by ICP-MS were below the detection limits for XRF analysis (e.g., As, Sb, Se).

Two elements, Al and Ba, were analyzed by both acid digestion and XRF methods. Measurement accuracy and precision is better by acid digestion for low concentrations (e.g., less than 10,000 μg/g) and better by XRF for higher concentrations (e.g., greater than 10,000 μg/g).

Results suggest higher content for some trace elements in CCRs when SCR is in use, however, these observations are based on single samples from a limited number of facilities and evaluation of additional samples from the same and additional facilities is warranted. Primary observations for the constituents of concern (Figure 9 through Figure 21 and Figure 22 through Figure 36) are as follows:

Aluminum (Al) (Figure 9 and Figure 22). Al content in fly ash was 6-15 percent, in gypsum between 0.3-1 percent, and in scrubber sludges 0.7-20 percent. There is no apparent systematic effect of coal type or air pollution control system on Al content in CCRs. One likely source of variability is the Al content of the additive used for flue gas desulfurization (e.g., limestone or magnesium lime).

Arsenic (As) (Figure 10). As content in fly ash was 10-200 μg/g, with a higher content (500 μg/g) observed in one sample from a COHPAC facility with ACI (Facility C, sample GAT). As content in gypsum was 1-10 μg/g, in scrubber sludge and blended CCRs 3-70 μg/g. There was

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[39] The database used in the EPA Risk Report (EPA, 2007b) for the assessment was based on both measurements of field samples (e.g., leachate, pore water) and single point laboratory leaching tests (e.g., TCLP, SPLP).

[40] The total elemental content of boron in CCRs was not measured for samples reported here because of analytical interference (digestion Method 3052 uses boron as part of the method).

no clear effect of coal type at the high level categorization based on coal rank and region on As content in CCRs, although coal from within a region has been observed to have considerable variability with respect to trace element total content.

Barium (Ba) (Figure 11 and Figure 23). Ba content in fly ash from bituminous and lignite coals was 0.06-0.2 percent, and 0.6-1.5 percent in fly ash from sub-bituminous coals. Ba content in gypsum was 2-80 μg/g, and in scrubber sludges 80-3,000 μg/g. Likely sources of variability of Ba content in gypsum include the source of limestone used in flue gas desulfurization and the extent of carryover of fly ash into the gypsum.

Cadmium (Cd) (Figure 12). Cd content in all CCRs was less than 2 μg/g, with lower content typically in gypsum than fly ash samples. An exception was the fly ash sample from Facility U (UFA) which had Cd content of 15 μg/g.

Cobalt (Co) (Figure 13). Co content in fly ash was 20-70 μg/g, and 0.8-4 μg/g in gypsum. Results for scrubber sludge suggest less Co content in samples from facilities without NOx controls (1-2 μg/g) than for facilities with NO_x controls (SCR or SNCR) in operation (3-40 μg/g, including paired comparisons).

Chromium (Cr) (Figure 14). Cr content in fly ash was 70-200 μg/g, and 1-20 μg/g in gypsum with no apparent relationship to coal type. Higher Cr content in scrubber sludges was associated with facilities using SCR (Facilities B and K, samples BGD and KGD; 50-300 μg/g compared to 9-20 μg/g for other samples).

Mercury (Hg) (Figure 15 and Figure 16). Hg content in all CCRs was from 0.01-20 μg/g with highest Hg content associated with fly ash samples from facilities with ACI and gypsum from a facility burning lignite coal (Facility Ca, sample CaAW).

Molybdenum (Mo) (Figure 17). Mo content in fly ash and scrubber sludges was similar at 8-30 μg/g, with one exception in fly ash at 80 μg/g (Facility U, sample UFA). Mo content in gypsum was 1-10 μg/g. No apparent relationship to coal type or air pollution control system was observed.

Lead (Pb) (Figure 18). Pb content in fly ash was 20-100 μg/g, 0.4-10 μg/g in gypsum and 2-30 μg/g in scrubber sludges. No apparent relationship to coal type or air pollution control system was observed.

Antimony (Sb) (Figure 19). Sb content in fly ash and scrubber sludge was 3-15 μg/g and 0.15-8 μg/g in gypsum. No apparent relationship to coal type or air pollution control system was observed.

Selenium (Se) (Figure 20). Se content in all CCRs was distributed over range with typical content of 2-50 μg/g with two samples with approximately 200 μg/g (Brayton Point, sample BPT; Facility C, sample GAT).

Thallium (Tl) (Figure 21). Tl content was 0.8-15 in fly ash and scrubber sludges, and 0.2-2 μg/g in gypsum. No apparent relationship to coal type or air pollution control system was observed.

Major species analysis by XRF (Figure 22 to Figure 36) indicated that fly ash from facilities burning sub-bituminous coals had greater content of Ba, Ca, Mg, Na, P and Sr than fly ash from facilities burning bituminous or lignite coals. Total Ca content in fly ash can be divided into three groupings related to coal types: (i) sub-bituminous, 10-20%, (ii) high calcium bituminous and lignite, 1-6%, and (iii) low calcium bituminous, 0.3-0.7%. Fly ash samples with low total

calcium had acidic own pH values (typically $4 < pH < 5$) compared to samples with medium and high calcium content that had alkali own pH values (typically $pH > 10$). The relationship between total calcium content (by XRF) and own pH for fly ash samples is illustrated in Figure 37. Higher calcium content results in greater fly ash alkalinity, as indicated by higher pH values.

Major species analysis also indicated that gypsum contained up to 5 wt% carbon and up to 7 wt% Si, both indicative of fly ash carry over into the FGD scrubber. Based on Si content in gypsum, this suggests up to 5% of the non-carbon content is comprised of fly ash.

In interpreting these results, please note that the CCRs analyzed in this report are not considered to be a representative sample of all CCRs produced in the U.S. For many of the observations, only a few data points were available. It is hoped that through broader use of the improved leach test methods (as used in this report), that additional data from CCR characterization will become available. That will help better define trends associated with changes in air pollution control at coal-fired power plants.