Failing the Test

The Unintended Consequences of Controlling Hazardous Air Pollutants from Coal-Fired Power Plants

By Lisa Evans

"This research was … to ensure that one environmental problem is not being traded for another."

US Environmental Protection Agency, Office of Research and Development, *Characterization of Coal Combustion Residues from Electric Utilities—Leaching and Characterization Data* (EPA/600/R-09/151) December 2009[1]

Introduction

In December 2009, the U.S. Environmental Protection Agency (EPA) completed a report that examined the fate of mercury and other heavy metals in air pollution control residues (coal ash, scrubber sludge and other solid wastes) to ensure "that emissions being controlled in the flue gas at power plants are not later being released to other environmental media" such as drinking water sources, rivers and streams.[2] The EPA, through regulations under the Clean Air Act, requires reduction of toxic air emissions from coal-fired power plants. These emissions not only contribute to air pollution, but deposit mercury and other heavy metal compounds into watersheds, where such pollutants can contaminate aquatic life and make fish unsafe to eat. The EPA's goal to reduce toxic air pollutants is laudable, but it ought not to be satisfied by shifting toxic metals from one part of the environment to another.

Consequently, the EPA set out to study the fate of the metals captured in the pollution control equipment of coal-fired power plants to determine the threat posed by the plants' coal combustion waste. Last December, the Agency published an analysis of the fate of these toxic metals in a report entitled *Characterization of Coal Combustion Residues from Electric Utilities—Leaching and Characterization Data*.[3] Although the report was quietly posted without public notice on the EPA's website, its conclusions are

---

[1] EPA Report available at http://www.epa.gov/nrmrl/pubs/600r09151/600r09151.html.

[2] US Environmental Protection Agency, Office of Research and Development, *Characterization of Coal Combustion Residues from Electric Utilities—Leaching and Characterization Data* (EPA/600/R-09/151) December 2009 at ii.

[3] The EPA's December 2009 report builds on two previous reports published in 2006 and 2008 that examined a much smaller universe of waste samples. *See* US EPA, "Characterization of Coal Combustion Residues from Electric Utilities Using Wet Scrubbers for Multi-Pollutant Control" (EPA/600/R-08/077) July 2008, available at: http://www.epa.gov/nrmrl/pubs/600r08077/600r08077.htm and US EPA, "Characterization of Mercury-Enriched Coal Combustion Residues from Electric Utilities Using Enhanced Sorbents for Mercury Control" (EPA-600/R-06/008) February 2006; available at: http://www.epa.gov/nrmrl/pubs/600r06008/600r06008.pdf

groundbreaking. The EPA's Office of Research and Development measured the level of hazardous pollutants in coal combustion waste **using new and improved testing procedures.** According to the EPA, the new leaching procedure is better able to determine the extent of the leaching of these toxic metals from coal ash and scrubber sludge. The report indeed found that some coal combustion waste leaches toxic chemicals, such as arsenic, barium, chromium and selenium, at levels that can far exceed federal thresholds established for **hazardous waste**. The EPA report confirms that coal ash from some sources has the potential to severely contaminate water, when improperly disposed or reused. For example, using the new test,[4] the EPA found at the highest leach level for particular coal ashes:

• Arsenic, a potent carcinogen, leached from coal ash at a concentration 1,800 times the federal safe drinking water standard, more than 3 times the threshold established for hazardous waste and over 76 times the level of previous leach tests;[5]

• Antimony, which damages the heart, lung and stomach, also leached from coal ash at a concentration 1,800 times the federal safe drinking water standard and over 900 times the level of previous leach tests;

• Chromium, which can cause cancer and stomach ailments, leached from coal ash at a level 73 times the federal safe drinking water standard, over 1.5 times the threshold for hazardous waste, and 124 times the level of previous leach tests; and

• Selenium, which causes circulatory problems in humans and is a bioaccumulative toxin extremely deadly to fish, leached from coal ash at nearly 600 times the federal drinking water standard, 29 times the threshold for hazardous waste and nearly 66 times the level of previous leach tests.

These findings have great bearing on the rule that the EPA issued May 4, 2010 to control the disposal and reuse of coal combustion waste (CCW).[6] Previous leach data in the EPA's Report to Congress[7] and test data produced by the utility industry[8] **have never revealed such high concentrations of pollutants because they used an older leach test that could not mimic the conditions under which CCW is actually disposed**. While not all coal ash will leach these dangerous contaminants at such toxic levels, the report

---

[4] In some cases, the EPA's testing protocol involved multiple tests, not a single test.

[5] EPA previously relied upon the Toxicity Characteristic Leaching Procedure (TCLP), as explained in more detail, infra.

[6] The findings in this report are cited in the preamble to the EPA's proposed rule, "Hazardous and Solid Waste Management System; Identification and Listing of Special Wastes; Disposal of Coal Combustion Residuals from Electric Utilities," available at http://www.epa.gov/osw/nonhaz/industrial/special/fossil/ccr-rule/ccr-rule-prop.pdf.

[7] *See*, for example, U.S. EPA, Report to Congress on Wastes from the Combustion of Coal by Electric Utility Power Plants (EPA530-SW-88-002), February 1988 and U.S. EPA, Report to Congress on Wastes from the Combustion of Fossils Fuels (EPA530-R-99-010), March 1999, available at http://www.epa.gov/osw/nonhaz/industrial/special/fossil/regs.htm.

[8] *See*, for example, Electric Power Research Institute, Sustainable Management of Coal Combustion Products, Recent EPRI Research, October 16, 2009, at page 8, submitted to Office of Management and Budget on October 16, 2009, available at http://www.whitehouse.gov/omb/2050_meeting_101609/.

clearly indicates that some ashes do pose a significant threat. In light of the EPA's findings that CCW can release much greater amounts of heavy metals and other toxic chemicals to water supplies than previously known, it is essential that the EPA propose regulations that provide federally enforceable safeguards for disposal and that limit reuse applications that pose threats to health and the environment.

Summary of the EPA Report

The Scope of the Report

The EPA tested 73 different samples of coal ash and flue-gas desulfurization (FGD) scrubber sludge and other residues from numerous U.S. coal–fired power plants.[9] According to the EPA, the objective of the study was to understand the fate of toxic metals captured in air pollution control residues and ensure that these are not later released to groundwater and surface water.[10] The EPA tested the coal ash for a wide range of toxic chemicals, including mercury, aluminum, antimony, arsenic, barium, boron, cadmium, chromium, cobalt, lead, molybdenum, selenium and thallium.

Findings of the Report

The EPA concludes that the addition of scrubbers, selective catalytic reduction, and activated carbon injection to capture mercury and other pollutants shifts the toxic pollutants from the stack gas to fly ash, FGD gypsum, and other air pollution control residues.[11] The increased concentration of toxic metals in coal combustion waste, in turn, increases the potential for CCW to release these pollutants into water. The EPA's tests revealed a wide range of contaminant levels in the coal ash leachate. For some toxic metals, including arsenic and selenium, and for some of the coal ash tested, the levels of chemicals leaving the CCW in leachate were hundreds to thousands of times greater than federal drinking water standards**. For several deadly pollutants, including arsenic and selenium, these levels exceeded hazardous waste thresholds from some coal ashes**.

The graph below illustrates the highest level of contaminants in coal ash leachate found in the EPA report using the new leach test. These leachate results are compared to federal drinking water standards (maximum contaminant levels (MCLs)) and hazardous waste concentration limits (toxicity characteristics or TCs). The toxicity characteristic determines at what concentration level a solid waste becomes a hazardous waste.[12]

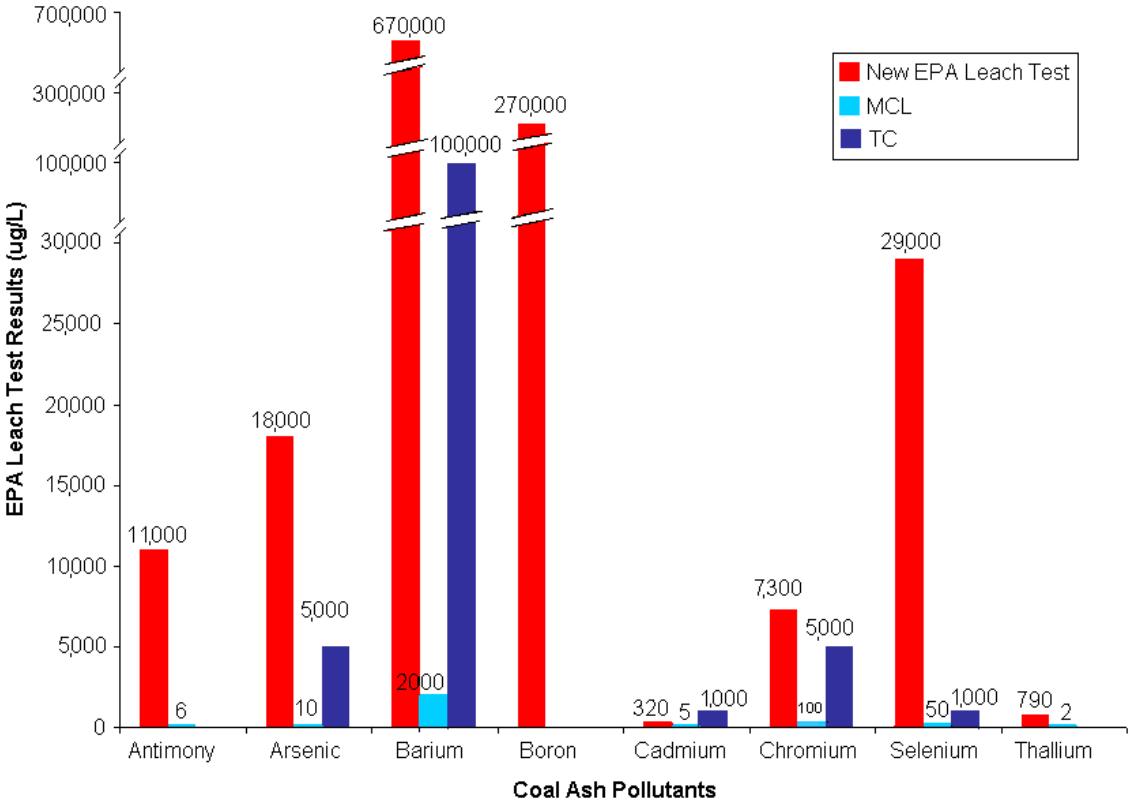
The graph indicates the magnitude by which coal ash leachate can exceed these standards. For example, the highest leaching level for arsenic found by the EPA was

---

[9] Because the intent of the report was to examine coal ash and scrubber sludge at plants with air pollution control technology, the report notes that the 73 samples were not representative of all coal combustion waste at all U.S. plants. *See* EPA Report at Sec. 2.1.
[10] EPA Report, *supra,* note 1 at ii.
[11] *Id.*
[12] *See* 40 C.F.R. § 261.44. The toxicity characteristic identifies wastes likely to leach concentrations of contaminants that may be harmful to human health or the environment.

18,000 parts per billion (ppb). **This amount is 1,800 times the federal drinking water standard and over 3 times the level that defines a hazardous waste.** The report found that the concentration of antimony in coal ash leachate reached 11,000 ppb, which is also 1,800 times the federal drinking water standard for this pollutant. For other hazardous chemicals, the exceedances were also significant. The highest leaching level for selenium found by the EPA was 29,000 ppb, a level that is **580 times the drinking water standard, 29 times the hazardous waste threshold, and 5,800 times the water quality standard**. For barium, the highest leaching level found by the EPA was 670,000 ppb, which is 335 times the drinking water standard and almost 7 times the hazardous waste threshold. For chromium, the highest leaching level found by the EPA was 73 times the federal drinking water standard and over 1.5 times the threshold for hazardous waste. Complete tables of the EPA's findings for both coal ash and scrubber sludge are found in Attachment A to this report.

Comparison of New EPA Leach Test Results for Coal Ash[1] to Maximum Contaminant Levels (MCLs) and Toxicity Characteristic (TC) Levels
(Concentrations reflect highest level of contaminants documented by new leach test)

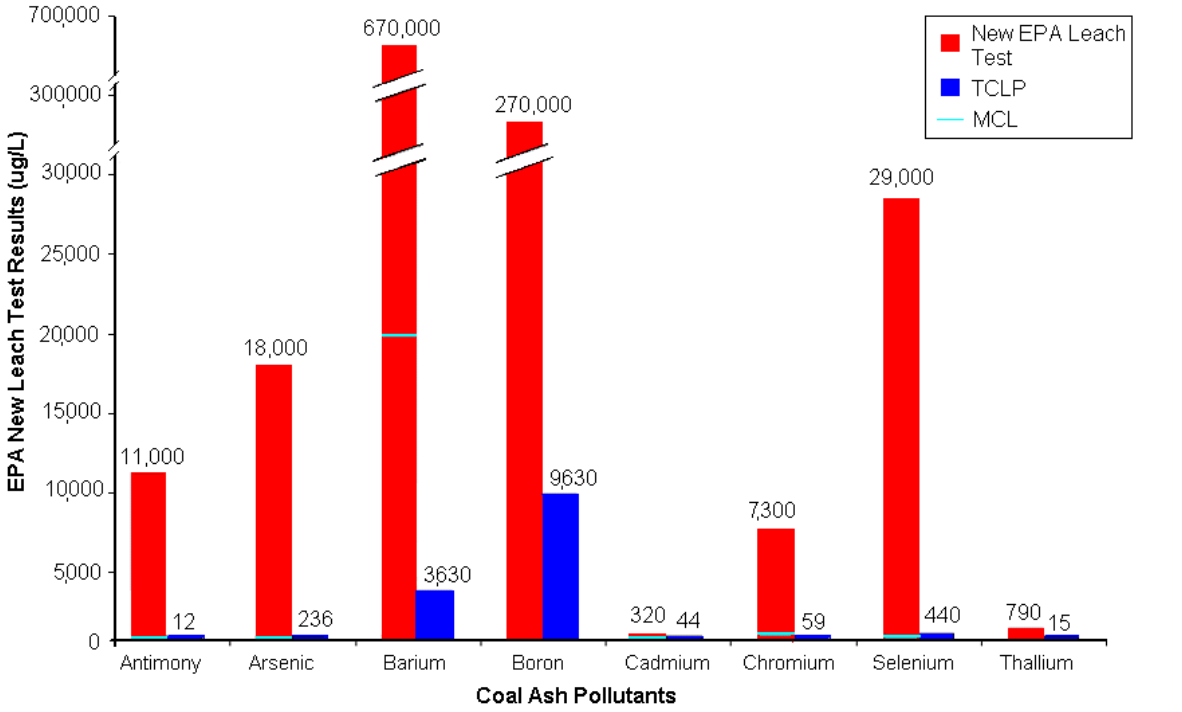


[1] U.S. EPA, Characterization of Coal Combustion Residues from Electric Utilities Using Multi-Pollutant Control Technology – Leaching and Characterization Data (EPA-600/R-09/151) Dec 2009, http://www.epa.gov/nrmrl/pubs/600r09151/600r09151.html. Laboratory leach test eluate concentrations for 5.4 ≤ pH ≤ 12.4 and at "own pH" from evaluation of 34 fly ash samples. See Table 13 at 183.

It is important to note that the EPA's new data reveal a dramatic departure from the leach test results derived from the decades-old Toxicity Characteristic Leaching Procedure (TCLP). The EPA formerly relied solely upon the TCLP, and industry and

state regulators still rely exclusively on its findings.[13] The graph below compares the results from the new EPA leach test to the results from the EPA's TCLP data. The TCLP results on the graph represent the highest levels of coal ash pollutants documented in the EPA's 1999 *Report to Congress: Wastes from the Combustion of Fossil Fuels*.[14] These results are compared to the highest levels found in coal ash leachate from the EPA's 2009 report. For all of the pollutants shown, the new test reveals very significant increases in the concentration of metals in the leachate. For example, the highest concentration of arsenic found by the new leach test is over 76 times the highest level found in the EPA's TCLP data, the highest concentration of antimony found by the new leach test is over 916 times the highest TCLP result, the highest barium concentration is over 184 times the highest TCLP result, the highest chromium concentration is over 123 times the highest TCLP result, and the highest selenium concentration is over 65 times the highest TCLP data. The differences are so great that they cannot be shown easily on a simple graph.

Comparison of New EPA Leach Tests (2009)[1] to TCLP Results (Report to Congress 1999)[2]
(Concentrations reflect highest level of contaminants documented by 1999 and 2009 EPA reports)



[1] U.S. EPA, Characterization of Coal Combustion Residues from Electric Utilities Using Multi-Pollutant Control Technology – Leaching and Characterization Data (EPA-600/R-09/151) Dec 2009, http://www.epa.gov/nrmrl/pubs/600r09151/600r09151.html. Laboratory leach test eluate concentrations for 5.4 ≤ pH ≤ 12.4 and at "own pH" from evaluation of 34 fly ash samples. See Table 13 at 183.

[2] US EPA, Report to Congress: Wastes from the Combustion of Fossil Fuels: Volume 2, Methods, Findings and Recommendations (EPA530-R-99-010) March 1999, http://www.epa.gov/osw/nonhaz/industrial/special/fossil/volume_2.pdf. Toxicity Characteristic Leaching Procedure (TCLP) results for samples of waste managed in both surface impoundments and landfills. See Table 3-9 at 3-19.

[13] *See* note 6, *supra*. *See also* Environmental Council of the States, Resolution Number 08-14, The Regulation of Coal Combustion Products, March 23, 2010, available at http://www.ecos.org/section/policy/resolution/?committee=3.

[14] U.S. EPA, Report to Congress: Wastes from the Combustion of Fossil Fuels, March 1999.

In addition to these extremely high contaminant concentrations in leachate from particular ashes found by the EPA, the new report also documents a range of toxic leaching from ashes and FGD sludges that greatly exceed federal drinking water standards for antimony, arsenic, barium, boron, cadmium, chromium, molybdenum, selenium and thallium.[15]

The EPA's Adoption of More Accurate Leaching Tests

Critically, the leach test results in the EPA's new report are based on an improved leach test that the EPA, in conjunction with other scientists, developed for the testing of coal combustion waste and a variety of other wastes.[16] Scientists developed this new test, the "leaching environmental assessment framework," to address concerns with the old leach test, the TCLP. The EPA, state regulatory agencies and utilities have used the TCLP since 1990 to determine the degree to which toxic metals will leach from CCW. But since 1991, the EPA's Science Advisory Board (SAB) has identified significant problems with the accuracy of the TCLP. Over a decade ago, the SAB wrote a scathing letter to EPA Administrator Carol Browner, criticizing EPA's continued reliance on the TCLP, stating definitively "it is time to make improvements." The SAB's 1999 letter couldn't have been clearer. The SAB stated "**The Committee's single most important recommendation is that EPA improve leach test procedures, validate them in the field, and then implement them."**[17] (Emphasis in original.)

Thus for over a decade, the EPA's Science Advisory Board has acknowledged the TCLP's failure to predict with accuracy the level of pollutants leaching from CCW. In 2006, the National Academy of Sciences (NAS) also acknowledged the inaccuracy of the TCLP and weighed in with explicit criticism of its use for testing coal ash.[18] Since at least 2006, the EPA itself, has acknowledged the need for a more sensitive test that would vary the pH of the leaching solution because of the range of field conditions that CCW is exposed to during disposal and reuse.[19] For example, CCW is frequently placed in contact with acid mine drainage and co-disposed with acidic coal refuse (pyrites). Both of these common disposal scenarios expose CCW to a wide range of pH conditions that can accelerate leaching of toxic metals.

---

[15] *See* EPA Report, supra note 1 at xiv.

[16] The EPA's new Leaching Environmental Assessment Framework is based on a test protocol published in 2002. *See* Kosson, D.S., H.A. van der Sloot, F. Sanchez, and A.C. Garrabrants, "An integrated framework for evaluating leaching in waste management and utilization of secondary materials", *Environmental Engineering Science*, 19(3), pp. 159-204, 2002.

[17] Letter from EPA Science Advisory Board to Carol Browner, Administrator, EPA. "Waste Leachability: The Need for Review of Current Agency Procedures," February 26, 1999, available at www.yosemite.**epa**.gov/**sab**/**sab**product.nsf/.../$File/eecm9902.pdf

[18] *See* EPA Report, *supra* note 1 at page viii, referencing National Academy of Sciences (2006). Managing Coal Combustion Residues in Mines, Washington, D.C.

[19] *See* US EPA, "Characterization of Coal Combustion Residues from Electric Utilities Using Wet Scrubbers for Multi-Pollutant Control" (EPA/600/R-08/077) July 2008, available at: http://www.epa.gov/nrmrl/pubs/600r08077/600r08077.htm and US EPA, "Characterization of Mercury-Enriched Coal Combustion Residues from Electric Utilities Using Enhanced Sorbents for Mercury Control" (EPA-600/R-06/008) February 2006; available at: http://www.epa.gov/nrmrl/pubs/600r06008/600r06008.pdf

In its December 2009 report, the EPA explained why the leaching method used in the new report more accurately predicts the toxic leaching that occurs in real-world coal ash disposal situations.

> The selected testing approach was chosen for use because it evaluates leaching over a range of values for two key variables [pH and liquid-to-solid ratio (LS)] that both vary in the environment and affect the rate of constituent release from waste. The range of values used in the laboratory testing encompasses the range of values expected to be found in the environment for these parameters. Because the effect of these variables on leaching is evaluated in the laboratory, prediction of leaching from the waste in the field is expected to be done **with much greater reliability**.[20]
>
> (Emphasis added.)

The EPA report also explained why the older test, the TCLP, was **not** used and why it is inappropriate to rely on TCLP results to predict CCW leaching. The EPA explained that the TCLP was specifically developed to simulate co-disposal of industrial waste with municipal solid waste.[21] However, the EPA notes that the vast majority of coal combustion waste is **not** being co-disposed with municipal solid waste. Thus the "test conditions for TCLP are different from the actual management practices for most [coal combustion residues]."[22] Also the EPA notes that the SAB and NAS expressed concerns that a broader set of conditions and test methods "**other than TCLP are needed**" to evaluate leaching of coal combustion waste in real world conditions.[23] Thus, according to the EPA:

> In seeking a tailored, "best-estimate" of [coal combustion residue] leaching, the leaching framework is responsive to SAB and NAS concerns and provides the flexibility to consider the effects of actual management conditions on these wastes, and so will be **more accurate** in this case.[24]
>
> (Emphasis added.)

The EPA is continuing to test additional ashes, FGD sludges and other scrubber wastes, using the new test, to determine which CCWs are most likely to leach aggressively and how these wastes will behave in real-world disposal and reuse scenarios over the long-term. The EPA estimates that an additional report will be completed by the end of 2010 or early 2011.

---

[20] EPA Report, *supra*, note 1 at ix.
[21] EPA Report, supra, note 1 at 18.
[22] *Id.*
[23] *Id.*.
[24] *Id*.

Correlation of High Toxic Leaching with the EPA's Damage Case Assessments

The EPA's data finding high levels of metals leaching from coal combustion waste correlates with real-world observations at contaminated CCW sites—in particular with the cases of contamination described in the EPA's 2007 Coal Combustion Waste Damage Case Assessments.[25] For example, 11 of the EPA's 24 proven damage cases involved arsenic contamination of groundwater or surface water. Similarly, 15 of the EPA's 24 proven damage cases (over 60%) involved selenium contamination of groundwater and/or surface water. Furthermore, all of the EPA's ecological damage cases noted in the 2007 report resulted from selenium contamination. Seven of the EPA's 24 proven damage cases (more than 25%) involved boron contamination, as did seven of the EPA's 43 potential damage cases. Lastly, five of the EPA's proven damage cases reveal chromium contamination, as did eight of the EPA's potential damage cases.[26] These documented cases of pollution of groundwater, lakes and streams reveal contamination by the **same toxic chemicals** that leached from CCW in high levels in the EPA's new report.

In addition, the evidence of contamination at 31 new sites in the recent report by Earthjustice and the Environmental Integrity Project, *Out of Control: Mounting Damage From Coal Ash Waste Sites,* also correlates very well with the new leaching data in the EPA report.[27] In this report, arsenic was found in excess of the drinking water standard (MCL) or water quality criteria at 21 of the 31 sites, at levels as high as 145 times the drinking water standard. Selenium, a chemical deadly to fish at very low levels, was found in excess of drinking water or water quality criteria at 7 sites, in one case exceeding the federal water quality criteria in a West Virginia stream by more than 9.5 times.

Conclusion

Industry groups and state regulators argue that coal combustion waste should not be classified as a hazardous waste because previous testing by the EPA in 1999 and in even earlier reports showed that CCW rarely tripped the hazardous waste standard. These groups base their conclusions on the TCLP, a decades-old test that the EPA and other scientific institutions, like the National Academy of Sciences, believe is no longer an accurate test for coal combustion waste. The EPA's 2009 report shows that when coal ash and scrubber sludge are tested with the EPA's new, more accurate test, the results indicate toxicity orders of magnitude higher than previously acknowledged. The significance of these findings is profound. Because coal combustion waste is often

---

[25] U.S. EPA, Coal Combustion Waste Damage Case Assessments, July 9, 2007. The damage cases discussed above do not include four additional cases acknowledged by since the 2007 report. These cases were listed, but not described in 75 Fed. Reg. 816, 869 n. 78&80 (Jan. 6, 2010).

[26] *Id.*

[27] Environmental Integrity Project and Earthjustice. Out of Control: Mounting Damages from Coal Ash Waste Sites, Thirty-one New Damage Cases of Contamination from Improperly Disposed Coal Combustion Waste, February 24, 2010, available at http://www.earthjustice.org/news/press/2010/coal-ash-waste-conatmination-study-31-new-water-pollution-cases.html.

disposed in contact with water and at sites where the pH is likely to vary, as in mines, gravel pits, ponds and open landfills in contact with acidic coal refuse, the aggressive leaching of toxic contaminants found by the EPA raises a red flag.

Plain and simple, the EPA's data indicate that some coal combustion wastes, when they come in contact with water, can release very significant quantities of hazardous chemicals. The toxic chemicals released are the same pollutants that the EPA required removed from the flue gas emissions emitted from the smokestacks of the power plants. It is contrary to public policy and sound science to allow, through the mismanagement of coal combustion waste, the concentrated release of these **same deadly pollutants** to water near power plants and dump sites where communities, both human and aquatic, can be harmed by the toxic chemicals. In the upcoming rule, the EPA must require that these pollutants be disposed in a manner that permanently prevents their release at levels harmful to human health and the environment. Otherwise the Clean Air Act requirements have simply traded water pollution for air pollution—a truly unwise and dangerous deal for human health and the environment.

Attachment A: Excerpt from EPA Report

The following tables and notes are found in US EPA, Office of Research and Development, *Characterization of Coal Combustion Residues from Electric Utilities—Leaching and Characterization Data* (EPA/600/R-09/151) December 2009 at page xiv. The Report is available at available at http://www.epa.gov/nrmrl/pubs/600r09151/600r09151.html. The highlighted numbers are identical to those highlighted in the EPA Report.

Table ES-2. Leach results for 5.4 ≤ pH ≤ 12.4 and at "own pH[13]" from evaluation of thirty-four fly ashes.

	Hg	Sb	As	Ba	B	Cd	Cr	Co	Pb	Mo	Se	Tl
Total in Material (mg/kg)	0.01 - 1.5	3 -14	17-510	590 - 7,000	NA	0.3 - 1.8	66 - 210	16 - 66	24 - 120	6.9 - 77	1.1 - 210	0.72 - 13
Leach results (µg/L)	<0.01 -0.50	<0.3 - 11,000	0.32 - 18,000	50 - 670,000	210 - 270,000	<0.1 - 320	<0.3 - 7,300	<0.3 - 500	<0.2 - 35	<0.5 - 130,000	5.7 - 29,000	<0.3 - 790
TC (µg/L)	200		5,000	100,000		1,000	5,000		5,000		1,000	
MCL (µg/L)	2	6	10	2,000	7,000 DWEL	5	100		15	200 DWEL	50	2

Note: The shade is used to indicate where there could be a potential concern for a metal when comparing the leach results to the MCL, DWEL, or TC. Note that MCL and DWEL values represent well concentrations; leachate dilution and attenuation processes that would occur in groundwater before leachate reaches a well are not accounted for, and so MCL and DWEL values are compared to leaching concentrations here to provide context for the test results and initial screening.

Table ES-3. Leach results for 5.4 ≤ pH ≤ 12.4 and at "own pH" from evaluation of twenty FGD gypsums.

	Hg	Sb	As	Ba	B	Cd	Cr	Co	Pb	Mo	Se	Tl
Total in Material (mg/kg)	0.01 - 3.1	0.14 - 8.2	0.95 - 10	2.4 - 67	NA	0.11 - 0.61	1.2 - 20	0.77 - 4.4	0.51 - 12	1.1 - 12	2.3 - 46	0.24 - 2.3
Leach results (ug/L)	<0.01 - 0.66	<0.3 - 330	0.32 - 1,200	30 - 560	12 - 270,000	<0.2 - 370	<0.3 - 240	<0.2 - 1,100	<0.2 - 12	0.36 - 1,900	3.6 - 16,000	<0.3 - 1,100
TC (ug/L)	200		5,000	100,000		1,000	5,000		5,000		1,000	
MCL (ug/L)	2	6	10	2,000	7,000 DWEL	5	100		15	200 DWEL	50	2

Note: The shade is used to indicate where there could be a potential concern for a metal when comparing the leach results to the MCL, DWEL, or TC. Note that MCL and DWEL values represent well concentrations; leachate dilution and attenuation processes that would occur in groundwater before leachate reaches a well are not accounted for, and so MCL and DWEL values are compared to leaching concentrations here to provide context for the test results and initial screening.