

U.S. EPA Public Hearing on the Proposed “Phase 2” Amendments to the Federal 2015 Coal Ash Rule

Comments by Avner Vengosh, Duke University

September 2019

[\(vengosh@duke.edu\)](mailto:vengosh@duke.edu)

1. Background:

The U.S. EPA is proposing the so-called “Phase 2” amendments to the 2015 federal Coal Ash Rule. Below are my comments on these proposed amendments, in particular on the placement of coal ash waste in the environment with significantly fewer restrictions or regulations than were included in the 2015 Coal Ash Rule. My motivation for commenting is related to my scientific research on contaminants in coal ash, their mobilization into the environment, and environmental and human health implications of coal ash that has been released into the environment. Together with my students and colleagues at Duke University, I have been conducting research on the subject of coal ash and its environmental effects for over ten years. These research projects have included the investigation of:

- The environmental effects of the Tennessee Valley Authority (TVA) coal ash spill in Kingston, TN (Ruhl et al., 2009; 2010);
- Sources of mercury in river sediments from TVA spill sites (Bartov et al., 2013; Deonarine et al., 2013);
- Selenium speciation of coal ash from the TVA spill (Liu et al., 2013);
- Discharges of effluents from coal ash impoundments to waterways in North Carolina (Ruhl et al., 2012);

- New isotopic methods for detecting coal ash contamination in the environment (Ruhl et al., 2014);
- Leaking of coal ash ponds in the southeastern U.S. (Harkness et al., 2016);
- Radioactivity of coal ash (Lauer et al., 2015);
- Possible links between hexavalent chromium and coal ash ponds in North Carolina (Vengosh et al., 2016);
- Methylmercury and coal ash (Schwartz et al., 2016);
- Leaching of arsenic and selenium from coal ash (Schwartz et al., 2016; 2018);
- Detecting coal ash isotope fingerprint in fish tissues (otolith) from lakes impacted by coal ash contamination (Brandt et al., 2018);
- Evidence for unmonitored coal ash spills to Sutton Lake in North Carolina that resulted in contamination of the lake and violation of ecological standards (Vengosh et al., 2019).

Overall, I have published 15 scientific articles on different aspects of the environmental effects of coal ash (see reference list below).

In addition, I present in this testimony new and preliminary data we have generated from experimental leaching of coal ash generated from different coal plants across the U.S. that show that toxic hexavalent chromium, as well as other oxyanions of health concern such as vanadium, molybdenum, selenium, and arsenic, can be leached out from coal ash under oxidizing conditions, similar to what one would expect from uncontrolled placement of coal ash on soil, or even buried in soil.

Based on my review of the U.S. EPA proposal for amendments of the federal coal ash regulations, and on my knowledge and experience, it is my opinion that the proposed amendments

would considerably weaken the existing federal regulations and will result in higher risks to water resources and human health. The reduction of the environmental protection and safeguards that were established as part of the federal 2015 Coal Ash Rule would severely exacerbate the already identified environmental effects associated with coal ash storage and disposal. Below I outline the major issues that could result from the proposed U.S. EPA amendments.

2. Evidence for unmonitored coal ash spills in Sutton Lake North Carolina

In order to test for the possible presence of coal combustion residuals (CCRs) solids in lake sediments following Hurricane Florence, Vengosh et al (2019) analyzed the magnetic susceptibility, microscopic screening, trace element composition, and strontium isotope ratios of bottom sediments collected in 2015 and in 2018 from Sutton Lake in eastern North Carolina and compared them to a reference lake. The results suggest multiple, apparently previously unmonitored, CCR spills into Sutton Lake from adjacent CCR storage sites. The enrichment of metals in Sutton Lake sediments, particularly those with known ecological impact such as arsenic, selenium, copper, antimony, nickel, cadmium, vanadium, and thallium, was similar to or even higher than those in stream sediments impacted by the Tennessee Valley Authority (TVA) in Kingston, Tennessee, and the Dan River, North Carolina coal ash spills, and exceeded ecological screening standards for fresh water sediments. High levels of contaminants were also found in leachates extracted from Sutton Lake sediments and co-occurring pore water, reflecting their mobilization to the ambient environment. These findings highlight the risks of contamination of water bodies from large-scale unmonitored spills of coal ash solids throughout the southeastern U.S. (Vengosh et al., 2019). The conclusions from this study are clear; uncontrolled and unlimited disposal of coal ash without adequate monitoring or limitation will result in mobilization of the

contaminants from the disposed or spilled coal ash solids into aquatic systems with ecological consequences. Brandt et al. (2018) found that the coal ash contaminants that enter the aquatic system accumulate in the ecosystem and in fish tissues.

3. Evidence for mobilization of hexavalent chromium from coal ash

Disposal or placement of coal ash on soil would expose the coal ash to rainwater or infiltrating groundwater that could leach out contaminants from coal ash. Ongoing research in my lab is focused on testing the leaching effects of water on coal ash, in particular the potential of mobilization of hexavalent chromium (Cr(VI)) from coal ash. Hexavalent chromium is a known pulmonary carcinogen and is defined by the World Health Organization as “carcinogenic to humans”. We have conducted experiments to measure the potential mobilization of contaminants from CCRs representing coals from the major production basins in the U.S., the Powder River, Illinois, and Appalachian basins. We used a modified version of EPA Method 1313 and measured total chromium (CrT) and Cr(VI) in leachates from coal fly ash under controlled pH conditions. Hexavalent chromium concentrations were measured using a modified version of U.S. EPA method 218.7 that measures chromate using a Thermo Scientific Dionex IonPac AS7 guard (4 x 250 mm) for anion exchange chromatography. A method detection limit for chromate was 0.004 µg/L, with a quantitation limit of 0.012 µg/L (Vengosh et al., 2016). Total chromium and other trace elements were measured by a VG PlasmaQuad-3 inductively coupled plasma mass spectrometry (ICP-MS). The ICP-MS method permits a method detection limit for total chromium of 0.27 µg/L, with a quantitation limit of 0.81 µg/L.

Preliminary data from CCRs originated from major coal basins in the U.S. show that fly ash contains high concentrations of chromium (median concentrations of 153, 266, and 109 ppm for the Appalachian, Illinois, and Power River Basin, respectively), and the water extracted leachates generated from the controlled experiments showed large variations in total Cr and Cr(VI) concentrations. Concentrations in the 10:1 water/solid ratio leachates ranged from below detection limit to 415 µg/L. For context, the U.S. EPA Maximum Contaminant Level (MCL) for total Cr is 100 µg/L, the previous California MCL for Cr(VI) was 10 µg/L, and the state of North Carolina's Health Advisory level is 0.07 µg/L. In most of the water CCR-leachates, Cr(VI) is the predominant species of the leached Cr, as shown by the ~1:1 ratios of Cr(VI) to total Cr in most of the extracted samples, which means that chromium found in the CCR leachates composed of almost 100% hexavalent chromium (Figure 2). While previous studies have shown trivalent chromium (Cr(III)) is the predominant (>90%) species in solid CCRs, the new data suggest that in oxic settings, chromium in CCRs is oxidized upon contact with water and the subsequent leachate is composed predominantly of Cr(VI). The experiments also show that the ambient pH plays a major role. Because of ash chemistry, most ashes produce high pH leachates with high Cr(VI) concentrations. When the pH of the leachates is manipulated, there is a decrease in Cr(VI) concentration with decreasing pH.

These experiments suggest that when coal ash interacts with water there is extensive mobilization of chromium in the form of the highly toxic hexavalent chromium. They also demonstrate that coal ash chemistry induces high pH upon interaction with fresh water, which enhances the mobilization and solubility of hexavalent chromium. Uncontrolled disposal of coal ash to the environment and placement of coal ash on soil without liners or other barriers to water

would create new sources of leached contaminants that will infiltrate into the subsurface, contaminating soil and water resources.

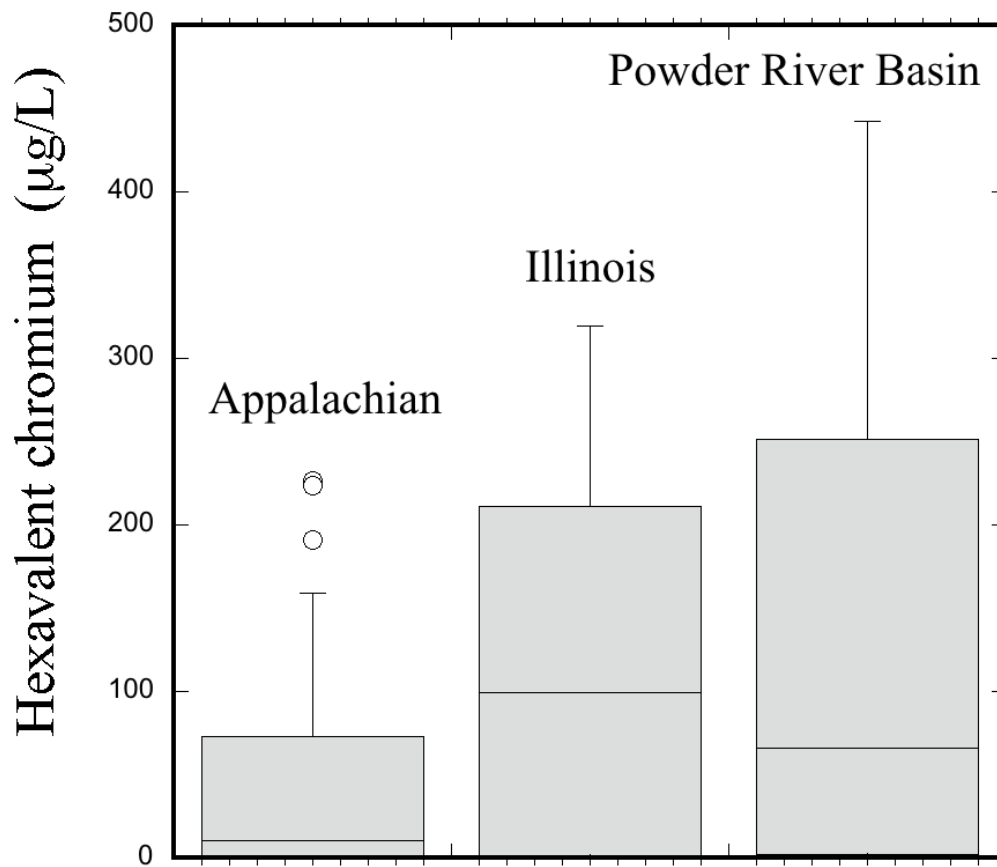


Figure 1: Concentrations of hexavalent chromium in CCR water leachates from ashes of Appalachian, Illinois, and Powder River Basin coals.

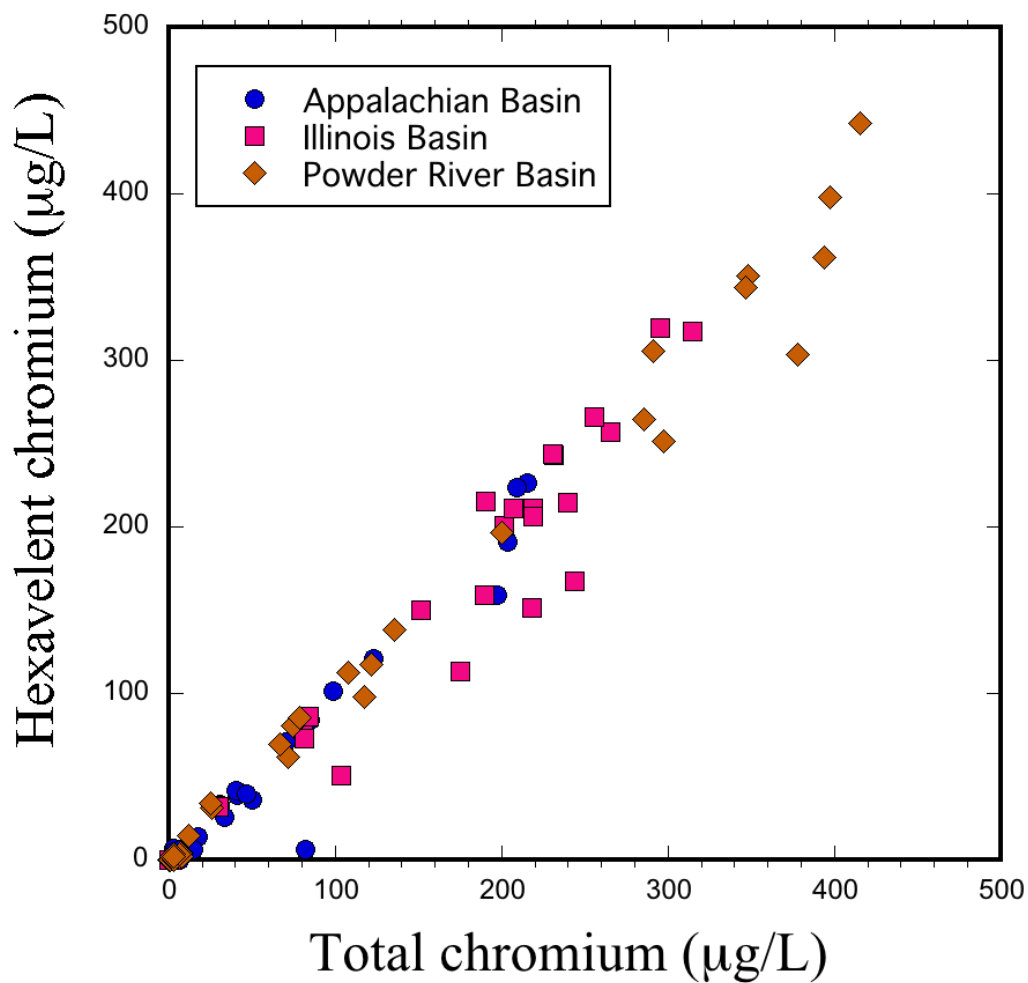


Figure 2: Concentrations of hexavalent chromium versus total chromium in CCR water leachates. The high correlation indicates that hexavalent chromium is the predominant species of chromium mobilized from coal ash.

4. Evidence for mobilization of other health-related oxyanion contaminants from coal ash

The analysis we conducted also included measurements of other health-related oxyanions in the water leachates. We found that in addition to the elevated hexavalent chromium concentrations, water leachates from coal ash that originated from the major coal basins in the U.S. contain high concentrations of arsenic, selenium, molybdenum, and vanadium. For context, the concentrations of these contaminants are higher than the EPA Maximum Contaminants Level (MCL) for arsenic (10 µg/L) as well as the health-based recommendation values for all other oxyanions. Table 1 presents the median values of these contaminants as compared to MCL and health-based recommended standards. Similar to hexavalent chromium, we found that higher concentrations in leachates are associated with high pH that reflects the natural buffering capacity of the coal ash. Consequently, interaction of rainwater or infiltration of groundwater into a large volume of coal ash with a similar solid to liquid (1:10) ratio, would result in extensive mobilization of these elements from coal ash and contamination of the ambient water with these toxic elements. For hexavalent chromium, arsenic, and selenium, the generation of such high concentrations is compared to values of National Recommended Water Quality Criteria for both the acute and chronic effects (Table 1).

Coal Sources	hexavalent chromium	Arsenic	Vanadium	Selenium	Molybdenum
Appalachian	45 (226)	43 (269)	67 (407)	151 (605)	282 (641)
Illinois	117 (320)	25 (167)	176 (827)	81 (231)	1626 (3596)
Powder River	120 (442)	11 (149)	84 (679)	68 (216)	107 (267)
Maximum Contaminant Level (MCL)	100*	10	ND	50	ND
Health Advisory Level	0.07	0	0.3	50	40
Aquatic Life Criteria (accute)	16	340	ND	ND	ND
Aquatic Life Criteria (chronic)	11	150	ND	5	ND

Table 1: Mean values of oxyanions (maximum concentrations under high-pH leaching condition in parentheses) in water leachates from CCRs of the major coal basins in the U.S. A comparison to the EPA Maximum Contaminant Level (MCL), Health advisory level, and EPA Aquatic Life Criteria (based on National Recommended Aquatic Life Criteria table) indicates much higher concentrations in the water leachates.

5. Implications of Duke University research for the proposed “Phase 2” Amendments to the Federal 2015 Coal Ash Rule

The findings of high concentrations of hexavalent chromium and other contaminants in water leachates generated from the interaction of fresh water with coal ash, particularly under alkaline (high pH) conditions, have important implications for the proposed “Phase 2” amendments to the Federal 2015 Coal Ash Rule. First, CCRs should not be placed (or disposed) near drinking water wells, wetlands, residences, flood plains and surface water bodies, nor above shallow groundwater that could be contaminated by the leachates generated during the flow and interaction of rainwater with coal ash. It should be emphasized that even buried coal ash under soil would generate leachates with elevated contaminants that could infiltrate into the subsurface. While the current Federal 2015 Coal Ash Rule puts some restrictions on the placement of large quantities of CCRs for beneficial use, the new amendments would allow the placement of unlimited quantities of CCRs in the environment, potentially near drinking water wells, waterbodies, and residences, without any restrictions or safeguards, that could result in impacts on the water quality of water resources and potentially human health.

The second direct implication is the current practice of testing the safety of CCRs and the safety of their placement on or in the ground as fill. While the new amendments do not require a specific test, the current practice of demonstrating the safety of CCRs and the potential of contaminants mobilization to the environment is based on two methods. The first method is the toxicity characteristic leaching procedure (TCLP) test, which is the extraction method for chemical analysis designed to simulate leaching in a landfill under acidic conditions. The second is the Synthetic Precipitation Leaching Procedure (SPLP) (EPA SW-846 Test Method 1312), which aims to measure mobility/leachability of contaminants from soil. While the TCLP method is conducted under acid (low pH) conditions, the SPLP method is adjusted to the local pH conditions of the soil. Neither of these methods however capture the leachability of oxyanions elements such as hexavalent chromium, arsenic, molybdenum and selenium under alkaline (high pH) conditions, which characterizes the interaction of coal ash with fresh water. Consequently, the potential toxicity of CCRs is not fully evaluated under current testing practices. To ensure environmental demonstrations accurately measure the toxicity of CCR in the environment when CCR is placed on the ground, EPA must require relevant leach tests be conducted which include also simulations of the interaction of fresh water with coal ash under a wide range of pH, including high-pH conditions.

References

- Bartov, G., Deonarine, A., Johnson, T.M., Ruhl, L. Vengosh, A. and Hsu-Kim, H. (2013) Environmental impacts of the Tennessee Valley Authority Kingston coal ash spill. 1. Source apportionment using mercury stable isotopes. *Environmental Science & Technology*, 47(6), 2092-2099.
- Brandt, J.E., Lauer, N.E., Vengosh, A., Bernhardt, E.S. and Di Giulio, R.T. (2018) Strontium Isotope Ratios in Fish Otoliths as Biogenic Tracers of Coal Combustion Residual Inputs to Freshwater Ecosystems. *Environmental Science & Technology Letters*, 5, 718-723.
- Deonarine, A., Bartov, G., Johnson, T.M, Ruhl, L., Vengosh, A., and Hsu-Kim, H. (2013). Environmental impacts of the Tennessee Valley Authority Kingston coal ash spill. 2. Effect of coal ash on methylmercury in historically contaminated river sediments. *Environmental Science & Technology*, 47(6), 2100-2108.
- Harkness, J.S., Sulkin, B., Vengosh, A. (2016) Evidence for coal ash ponds leaking in the southeastern United States. *Environmental Science & Technology*, 50, (12), 6583–6592.
- Lauer, N.E., Hower, J.C., Hsu-Kim, H., Taggart, R.K., Vengosh, A. (2015) Naturally occurring radioactive materials in coals and coal combustion residues in the United States. *Environmental Science & Technology*, 49, 11227–11233.
- Liu, Y-B., Chen, T-Y., Mackee, W.G., Ruhl, L., Vengosh, A., and Hsu-Kim, H. (2013) Selenium Speciation in Coal Ash Spilled at the Tennessee Valley Authority Kingston Site. *Environmental Science & Technology*, 47, 14001-14009.
- Ruhl, L., Vengosh, A., Dwyer, G.S., Hsu Kim H., Schwartz, G., Romanski, A., and Smith, S.D. (2012). The impact of coal combustion residue effluent on water resources: A North Carolina example. *Environmental Science & Technology*, 46, 12226–12233.
- Ruhl, L., Vengosh. A., Dwyer, G.S., Hsu-Kim, H., Deonarine, (2010). The Environmental Impacts of the Coal Ash Spill in Kingston, Tennessee: An Eighteen-Month Survey. *Environmental Science and Technology*, 44, 9272–9278.
- Ruhl, L., Vengosh. A., Dwyer, G.S., Hsu-Kim, H., Deonarine, A., Bergin, M., Kravchenko, J. (2009). Survey of the potential environmental and health impacts in the immediate aftermath of the coal ash spill in Kingston, Tennessee. *Environmental Science and Technology*, 43, 6326–6333.
- Ruhl, R.L., Dwyer, G., Hsu-Kim, H., Vengosh, A. (2014) Boron and Strontium Isotopic Characterization of Coal Combustion Residuals: Validation of New Environmental Tracers. *Environmental Science & Technology*, 48 (24), 14790–14798.
- Schwartz, G.E., Nelson, A.R., Hower, J. Vengosh, A., Hsu-Kim, H. (2018). Ranking coal ash materials for their potential to leach arsenic and selenium: The relative importance of ash

chemistry and site biogeochemistry. *Environmental Engineering Science* (DOI: 10.1089/ees.2017.0347).

Schwartz, G.E., Rivera, N.A., Lee, S-W., Harrington, J. M., Hower, J.C., Levine, K.E., Vengosh, A., Hsu-Kim, H. (2016). Leaching Potential and Redox Transformations of Arsenic and Selenium in Sediment Microcosms with Fly Ash. *Applied Geochemistry*, 67, 177-185.

Schwartz, G.E., Redfern, L.K., Ikuma, K., Gunsch C.K., Ruhl, L.S., Vengosh, A., Hsu-Kim, H. (2016) Impacts of coal ash on methylmercury production and the methylating microbial community in anaerobic sediment slurries. *Environmental Science Processes and Impact*, 18(11), 1427-1439.

Vengosh, A., Coyte, R., Karr, J., Harkness, J.S., Kondash, A.J., Laura S. Ruhl, L.A., Rose B. Merola, R.B., Dwyer, G.S. (2016) The Origin of Hexavalent Chromium in Drinking Water Wells from the Piedmont Aquifers of North Carolina. *Environmental Science & Technology Letters*, 3 (12), 409–414.

Vengosh, A., Cowan, E.A., Coyte, R.M., Kondash, A.J., Wang, Z., JE Brandt, J.E., Dwyer, G (2019) Evidence for unmonitored coal ash spills in Sutton Lake, North Carolina: Implications for contamination of lake ecosystems. *Science of the Total Environment*, 686, 1090-1103.