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Coal ash is one of the largest streams of industrial waste generated annually and the second largest source of industrial waste in the United States (after mining). Power plants are reported to collectively generate an estimated 140 million tons of coal ash annually. As of 2020, there were 310 active on-site landfills and 735 active on-site surface impoundments in the United States. According to the industry's data, 94% of coal ash ponds in the United States are unlined.

Coal ash, also known as coal combustion residuals (CCRs), result from burning coal in coal-fired electric power plants. Coal ash can include a mixture of solid particles and liquid droplets found in the air. There are several coal ash byproducts, including:

- *Fly ash:* This is a powdery, lightweight material consisting of silica from finely ground coal burnt in a boiler system. Fly ash particles are typically silt-sized spheres, ranging from 1-100 microns in diameter. Fly ash travels with flue gas and is generally captured by electrostatic precipitators or particle filters before reaching the stack.
- *Bottom ash:* These are coarser, angular ash particles that fall to the bottom of the coal furnace. Bottom ash has a sandy texture, and particles range from 0.1-50 millimeters in diameter.
- *Boiler slag:* This includes molten bottom ash from slag tap and cyclone type furnaces, which form pellets that are smooth and glassy after exposure to water.
- *Flue gas desulfurization (FGD) material:* This is the leftover material after reducing sulfur dioxide emissions from coal-fired boilers. This can be a wet sludge that includes calcium sulfite or sulfate or a dry powder containing a mixture of sulfites and sulfates.

Historically, fly ash was released into the air, but air pollution control standards have been implemented that require fly ash capture to prevent emission into the atmosphere. Without proper management, coal ash-related contaminants can have adverse effects on waterways, groundwater, drinking water and air quality.



Contaminants of concern in coal ash

The contaminants of concern in coal ash vary based on the source and type of coal used to generate power. All fly ash contains silicon dioxide, aluminum oxide and calcium oxide, which are the primary constituents of coal. Coal ash can contain a variety of harmful volatile and semi-volatile organic compounds and heavy metals. Specifically, metals can include aluminum, arsenic, barium, beryllium, boron, cadmium, chlorine, chromium, cobalt, lead, manganese, mercury, molybdenum, selenium, thallium and zinc. Coal combustion enhances the trace levels of these metals, many of which are highly toxic to humans and the environment.

Exposure and waste streams

Fly ash is typically stored in ash ponds (surface impoundments), and bottom ash is disposed of in landfills after combustion. Older ponds and landfills can be unlined, and contaminants can leach or be released into groundwater or the surrounding surface water. Storage ponds are often located adjacent to power plants near large sources of water, including the Great Lakes, rivers, oceans and aquifers. In soil, fly ash can increase the pH, soil

bulk density and water capacity. Fly ash can leach toxic contaminants into groundwater and concentrations can be 100 to 1,000 times higher than federal drinking water standards.

Human health effects

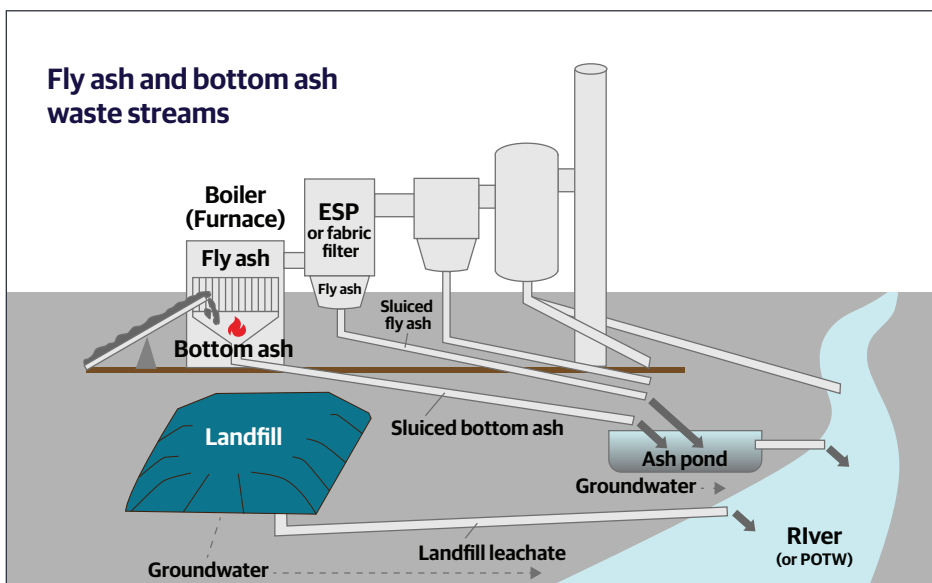
Coal ash can cause health risks to workers in coal-fired power plants and to residential receptors located near coal ash disposal sites. Contaminants in fly ash can be inhaled through dust exposure.

Short-term exposure can cause skin irritation (dermatitis). Inhalation can cause irritation to the respiratory system, eyes, nose and throat. Ingestion (eating or swallowing) coal ash can cause dizziness, nausea, vomiting, diarrhea and shortness of breath. Long-term ingestion and inhalation of some of the compounds in coal ash can cause cancer. Long-term exposure can lead to liver and kidney damage, cardiac arrhythmia and a variety of cancers. According to a United States Environmental Protection Agency study, people living within one mile of an unlined coal ash pond have a 1 in 50 chance of developing some form of cancer. US EPA also indicates that living in proximity to certain coal ash ponds is significantly more dangerous than smoking one pack of cigarettes per day.

Ecological effects

Coal ash releases can adversely affect aquatic animals by coating and degrading their habitats. Dissolved metal concentrations can directly accumulate in and affect aquatic animals. Coal ash releases have killed fish and caused deformities in fish and amphibians and health hazards to people consuming contaminated fish. High levels of contaminants, such as selenium in fish tissue, have been found in areas where coal ash was released into waterways. Other bioaccumulative pollutants include arsenic, mercury, nickel and halogen compounds, such as bromide, chloride, iodide, nutrients and total dissolved solids. Arsenic, molybdenum and selenium are potentially toxic for grazing animals, and terrestrial organisms can have increased levels of selenium. Many of these pollutants remain in the environment for years.

A 2016 Duke University study included the evaluation of coal ash ponds near 21 power plants in five southeastern states. The results found evidence that surface water and groundwater were "consistently and lastingly contaminated by unlined ponds." Elevated levels of heavy metals, including arsenic and selenium, were detected in the surface water and groundwater at each site, and 29% of the surface water samples exceeded EPA standards for drinking water and aquatic life.



Source: US EPA

According to a US EPA study, people living within one mile of an unlined coal ash pond have a 1 in 50 chance of developing some form of cancer.

Coal ash releases

Federal action to ensure the protection of human health and the environment was prompted by large coal ash releases near Kingston, Tennessee, and Eden, North Carolina.

Kingston, Tennessee:

At the Tennessee Valley Authority (TVA) Kingston Fossil Plant, the northwest side of a dike used to contain coal ash failed on Dec. 22, 2008. Following its failure, approximately 5.4 million cubic yards of coal ash flowed into Swan Pond Embayment and three adjacent sloughs, eventually releasing into the main Emory River channel. Approximately 300 acres near the fly ash dewatering and storage areas were impacted by the release. TVA entered into an Administrative Order on Consent (AOC) with the EPA Region 4 Office on May 11, 2009 (under the regulatory authority of Comprehensive Environmental Response, Compensation, and Liability Act to address the coal ash released to the environment. Because of its human health and ecological risk assessment processes and the complexity of the release, the Superfund program was selected as the preferred regulatory framework for the cleanup program. TVA, the lead federal agency, implemented cleanup activities required by the AOC. US EPA approved all cleanup actions in consultation with the Tennessee Department of Environmental Conservation.

Dan River drinking water, river sediments and surface water continue to be sampled because certain contaminants exceed risk screening levels.

Eden, North Carolina:

Between 39,000 tons of coal ash and 27 million gallons of ash pond wastewater were released from a pond at the Dan River Steam Station on Feb. 2, 2014. The facility was a retired coal-fired power plant that had ceased operations in 2012. The nearby Dan River was impacted, and animals and fish species in or around the river were immediately endangered. The river is also a drinking water resource for communities in North Carolina and Virginia. The release was caused by the failure of a 48-inch slip-joint concrete and corrugated steel storm sewer line, which extended under the ash pond. The coal ash and pond water flowed into the failed section of the line and discharged into the Dan River. Subsequent repairs were made to the sewer line, and coal ash continues to be removed from the river. The drinking water, river sediments and surface water also continue to be sampled because certain contaminants exceed risk screening levels.



At the Tennessee Valley Authority Kingston Fossil Plant, the northwest side of a dike used to contain coal ash failed.



Source: USFWS, [CC BY-SA 4.0](#) via Wikimedia Commons

Regulatory status

- The EPA currently regulates coal ash under the Resource Conservation and Recovery Act and the Clean Water Act.
- Following the 2008 Kingston Fossil Plant coal ash spill, EPA commenced the development of regulations that apply to all ash ponds.
- The Disposal of Coal Combustion Residuals from Electric Utilities Final Rule was signed by the EPA Administrator on Dec. 19, 2014, and was published in the Federal Register on April 17, 2015. The was the result of an exhaustive study of the effects of coal ash on the environment and public health. The Final Rule finalized national regulations and provided requirements for the safe disposal of CCRs from coal-fired power plants. Amendments have included providing states with approved CCR permit programs, revising groundwater protection standards for compounds that did not have drinking water standards, and providing more time for facilities triggered into closure by regulations to cease waste receipt.
- Under Subtitle D of Resource Conservation and Recovery Act the final rule establishes technical requirements for CCR landfills and surface impoundments.
- Regulations are designed to protect water, air and communities and apply to existing and new CCR landfills and surface impoundments.
- In response to a court remand, EPA published its CCR Part A Final Rule on Aug. 28, 2020, requiring all unlined ash ponds to be retrofitted with liners or closed by April 11, 2021.
- On Nov. 12, 2020, EPA published its CCR Part B rule, which allows facilities to use alternative liners following a demonstration that human health and the environment would not be affected.
- In Oct. 2020, EPA published final effluent guidelines reversing some of the 2015 provisions that strengthened the requirements for toxic metals from wastewater discharged from ash ponds.
- In March 2023, EPA published the Steam Electric Power Generating Effluent Guidelines to strengthen the wastewater discharge standards that apply to coal-fired power plants. The proposed rule established more stringent discharge standards for three wastewater generators at coal-fired plants, including FGD wastewater, bottom ash transport water and combustion residual leachate.
- EPA estimates that the proposed rule will reduce pollutants from discharged wastewater by approximately 584 million pounds per year.

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Beneficial reuse of coal ash

US EPA's Final Rule supports recycling coal ash and distinguishes beneficial use from disposal. Beneficial use reduces the use of virgin resources, lowers greenhouse gas emissions, reduces coal ash disposal costs and improves the strength and durability of materials. State environmental agencies are primarily responsible for beneficial use regulation. The EPA indicates that beneficial uses of CCRs fall into two categories:

1. Fly ash as a direct substitute for Portland cement in concrete production.
2. FGD as a replacement for mined gypsum in wallboard.

According to the American Coal Ash Association, 59% of the coal ash produced during 2020 (40.8 million tons) was recycled, increasing from 52% in 2019 but down from 64% in 2017. Coal ash recycling reduces the need to manufacture cement and results in reducing greenhouse gas emissions—an estimated 11 million tons in 2020. Other beneficial uses of coal ash include embankment engineering materials, soil stabilization, flowable fill, asphalt concrete and bricks.

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