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Legacy of coal ash contamination in lake sediments revealed by trace elements and strontium isotope ratios

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Coal ash is generated from burning coals for electricity and represents one of the largest industrial solid waste streams in the United States. A significant amount of coal ash is disposed of in surface impoundments and landfills, many of which are adjacent to waterways used for turbine cooling in coal-fired power plants. The release of coal ash to the environment, either intentional or incidental, has raised serious public concerns about the potential risks posed to human and ecological health. In order to track coal ash contamination in both aquatic and terrestrial environments, various geochemical and isotopic tools have been developed and applied, including trace elements and Sr isotope ratios.

Lake sediments are considered an important geologic archive for recording the impacts of Anthropocene on the natural environment. Here we show the evidence for both chronic and acute coal ash contamination in ^{210}Pb- and ^{137}Cs-dated sediment cores in five lakes near coal-fired power plants across North Carolina. Trace elements such as As, Se, Mo, Cd, Sb, Tl, and Pb, which are abundant in coal ash, were abnormally elevated in the sediments near and downstream from the plants relative to upstream reference sediments. The bulk ^{87}Sr/^{86}Sr ratios of the impacted sediments also exhibited a close resemblance to that of fly ash and were distinctive from that of reference sediments. Furthermore, both optical and scanning electron microscopic observations supported the geochemical data by showing the presence of coal ash in the sediments. Occurring mostly as fine grained and magnetic particles with spherical and amorphous morphologies, they are selectively more enriched in toxic elements than bulk ash. Our data suggest that the contamination largely resulted from current and historic mishandling practices of coal ash (e.g., wastewater discharge) combined with extreme natural hydrologic events (e.g., stormwater runoff). Given that there are hundreds of coal plants in close proximity to waterways across the U.S., we assert that such contamination is more common than previously thought and its consequential ecological risks are prevalent nationwide.