Is Coal Ash Toxic?

Technical Brief

A number of recent media reports have referred to coal ash as being toxic. However, the meaning of the term *toxic* is not well defined in these reports, which suggest that toxicity is an inherent property of the coal ash. Coal ash, like all other natural and man-made materials, does contain elements that can be toxic under certain circumstances, but the toxicity of any material depends on a large set of factors that control specific exposure conditions. This Technical Brief provides an overview of the issues that need to be considered when assessing toxicity in general, and specifically for coal ash.

Introduction

All coal naturally contains inorganic matter derived from the rocks and minerals associated with the coal seam. During the process of burning coal to create electricity, the incombustible inorganic matter is collected as coal ash, which consists of two major fractions: fly ash and bottom ash.[1] The most abundant of these materials is coal fly ash, which accounts for about 78% of the 92 million tons of coal ash generated annually in the United States. While just over half of the coal fly ash is managed in landfills or other containment units, about 44% is recycled for beneficial use, such as in concrete or as engineered fill.[2]

Recently there has been increased interest in whether coal ash is toxic to humans and presents a public health concern. As with any substance, evaluating potential health risks associated with coal fly ash requires an understanding of both the toxicity of its constituents and the nature of the exposures involved. As a point of reference, it is also useful to examine how exposures to compounds in coal ash compare to everyday exposures to the same compounds contained in other sources—such as our food and drinking water.

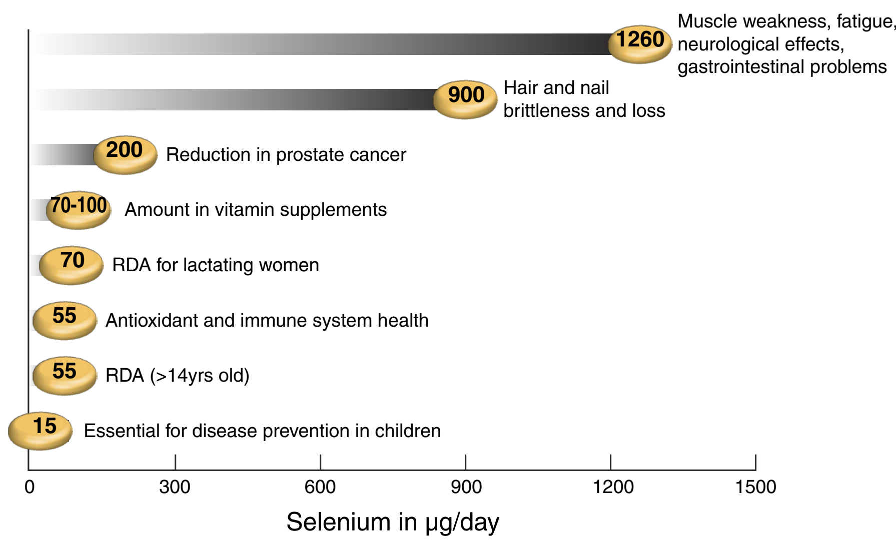
What is Toxicity?

Toxicity can be defined as the degree to which a substance can cause harm in humans or animals. A substance is acutely toxic if a single or short-term exposure can cause adverse effects. Chronic toxicity describes the harmful effects that result from continuous, long-term exposures, usually over several years or longer.

A key concept in toxicology is the dose-response relationship, which holds that the nature and severity of biological effects depend on the magnitude of exposure (or dose). In other words, anything can be toxic if the dose is high enough. At lower doses, a compound may lack the potency to cause toxic effects and may even be beneficial to health. This is the case, for example, with vitamins, medicines, and many essential nutrients.

Figure 1 demonstrates how the biological effects associated with the ingestion of selenium, one of the constituents present in coal ash, depend on dose. If selenium intake is too low, individuals may be susceptible to disease because they lack this essential nutrient. Mid-range intakes provide documented health benefits, while the highest ingestion exposures cause adverse effects.[3,4,5]

Over 90% of the mineral component of coal fly ash consists of oxides of four common elements that make up soil and rocks: silicon, iron, alu-



RDA = Recommended Daily Allowance established by the National Academy of Sciences. This is a level that is necessary for optimal health.

See references 3, 4, and 5.

Figure 1: The dose-response relationship for selenium.

minum, and calcium. Like soil and rock, coal ash also contains trace elements that can pose potential public health concerns under conditions of high exposure. Collectively, the trace elements comprise less than 1% of the weight of the fly ash. Because all of the elements contained in coal ash exist naturally in the environment, humans are exposed to some form of them every day.

If the mere presence of these elements means a material is toxic, then all soils and rocks and many other common materials, including food and multi-vitamins, would also be considered toxic. Assessing toxicity, therefore, requires more than knowing that a specific element or compound is present; it also requires an understanding of the form of the element or compound (bioavailability), potential exposure pathways, and magnitude of that exposure.

Potential for Exposure

Living Near a Coal Ash Storage Facility

Understanding how people living near an ash containment facility may be exposed to coal ash is important not only for evaluating any potential health risks, but also for developing strategies to limit exposure. In any instance where the potential for exposure exists, it is critical to identify the chemicals present in the coal ash and evaluate the specific exposure pathways to determine the potential for adverse health effects.

Potential exposure to the constituents in coal ash can occur through a number of different pathways. For example, windblown transport of fly ash from uncovered landfills is one potential exposure pathway. Windblown ash can lead to exposure via dermal contact (absorption through the skin), inhalation (from breathing), and incidental ingestion (the non-intentional oral ingestion that could occur through the touching of hands partially covered with fly ash to lips and mouth). While potential risks associated with each of these pathways will be chemical-specific and facility-specific, some general observations have been made. A broad screening analysis by US Environmental Protection Agency (US EPA) demonstrated risks to an individual living near a landfill from various pathways such as incidental ingestion and inhalation to be negligible.[6] In separate studies, assessment of power plant workers exposed to ash dust on a daily basis suggested only limited potential for heath risks under normal operations;[7,8] public exposure would be significantly less than for these workers. With respect to ingestion, Figure 2 shows that the daily intake of trace metals from the incidental ingestion of typical coal ash (assuming 100 mg/day, based on soil ingestion studies) is similar to or less than the allowable intake of the same metals from drinking water (i.e., the safe drinking water limits) and from a typical U.S. diet.

Another potential exposure pathway for coal ash constituents is leaching from management units and release to groundwater that may be used as a drinking water source. There are several types of tests that are used to evaluate whether constituents present in coal ash management facilities can leach at concentrations that could pose a public health concern. The test used to evaluate leachate to determine if waste is hazardous under federal waste management regulations is the Toxicity Characteristic Leaching Procedure (TCLP). In an evaluation

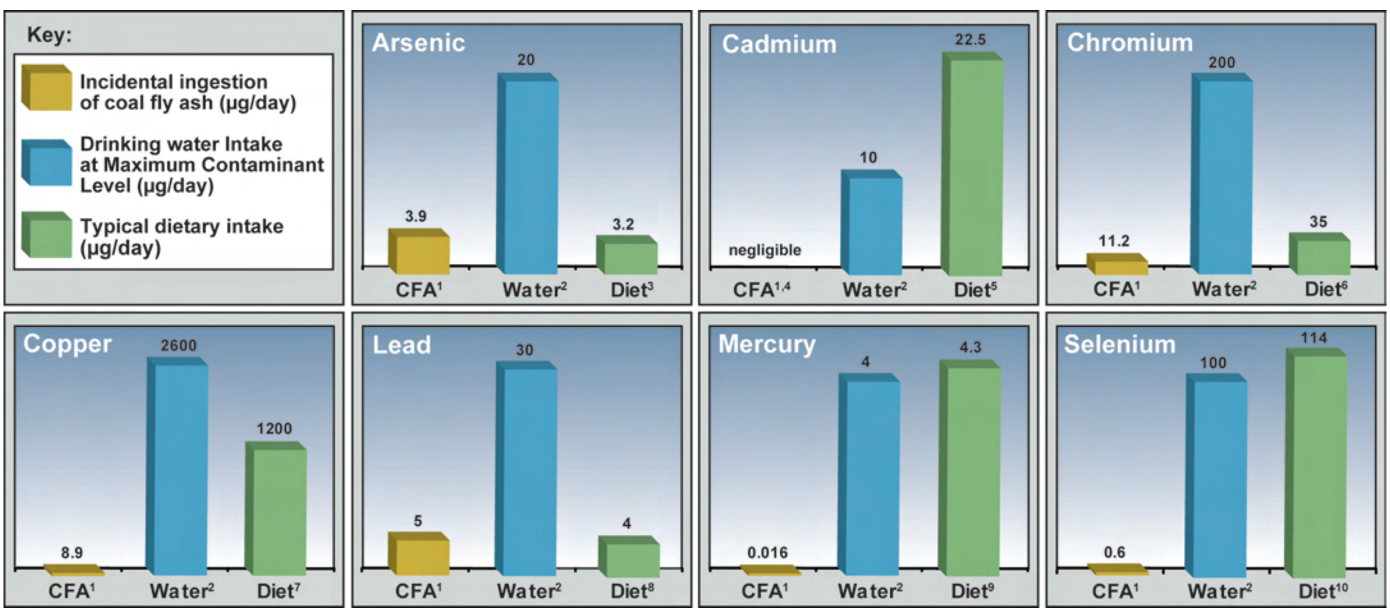


Figure 2: Potential daily intake of trace constituents from non-intentional ingestion of coal fly ash vs. drinking water and dietary intake (µg/day).

Notes: (1) Assumes median coal fly ash concentration (reference 9) and an ingestion rate of 100 mg/day (ingestion rate based on soil ingestion studies). (2) Assumes ingestion of 2 liters of water per day at chemical-specific Maximum Contaminant Level. (3) Mean inorganic arsenic intake from reference 10. (4) Median concentration of cadmium in fly ash is less than the detection limit and, thus, intake is negligible. (5) Mean cadmium in diet from reference 11 (assumes 70 kg person). (6) Mean chromium in diet from reference 12 (assumes 70 kg person). (7) Typical copper intake as reported in reference 13. (8) Mean lead intake for 25- to 30-year-old males in reference 14. (9) Mean mercury intake from reference 15. (10) Mean selenium intake from reference 3.

of about 80 coal fly ash samples from 33 power plants, no samples exceeded the TCLP limits for any of the metals included in the protocol.[9] These results are consistent with results reported by US EPA in the 2000 regulatory determination on comanagement of coal combustion products.[16, 17]

While the TCLP and other leaching tests are useful indicators of leaching behavior, each CFA management unit is different and must be evaluated on a case-by-case basis. Site-specific factors potentially affecting release and exposure from these facilities include CFA chemical characteristics, surrounding topography, soil characteristics, hydrogeology, precipitation patterns, design of the facility, and distance to the potential receptors. Operators of coal ash management facilities commonly take measures to minimize exposure, such as dust suppression to limit windblown ash, covering to limit water infiltration, runoff control, liners to limit leachate release, and groundwater monitoring.

Accidental Releases

In instances where an accidental release occurs, such as the 2008 failure of the Kingston dike in Tennessee, it is possible that people living nearby may be exposed unexpectedly through one or more of the exposure pathways discussed above, primarily dermal contact, inhalation, or incidental ingestion. However, even in these cases, it should not be assumed that exposures to the constituents in coal ash will pose a health risk. As mentioned earlier, the constituents in coal ash are the same as those found in soil and rock, and short-term contact from the release is unlikely to cause any acute health effects. When a release or spill does occur, remedies, such as dust suppression and removal or covering of the ash, are quickly put in place to limit exposure. Extensive air, soil, and water monitoring systems are employed to evaluate the effectiveness of the remedies, to determine the need for additional actions, and to ensure that the potential for long-term exposure is minimized.

Conclusion

The constituents found in coal ash are the same as those found in rocks and soils. And like other naturally occurring and manmade materials, coal ash contains some constituents that can be toxic. However, the mere presence of these constituents in coal ash does not equate to toxicity; the magnitude and duration of exposure to these constituents (the *dose*) must be sufficiently large to cause adverse health effects. At ash management facilities, public exposure to the constituents in coal ash can be minimized by standard operational practices. When an accidental release does occur, additional steps are taken to contain the release and limit the potential for public exposure. Determination of toxicity ultimately requires health risk assessments conducted on a case-by-case basis, with an in-depth knowledge of specific exposure conditions.

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