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Nanoscale heterogeneity of arsenic and selenium species in coal fly ash and functional predictors of leachability

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Coal combustion byproducts such as coal fly ash are enriched in arsenic (As) and selenium (Se). If these elements are mobilized at concentrated quantities into water and soils from coal ash disposal sites, these elements can be harmful to wildlife and humans. The leaching potential and bioaccessibility of As and Se in coal fly ash depends on the chemical forms of these elements and their association with the large variety of particles that comprise coal fly ash. In this study, we sought to determine solid phase mineral associations and oxidation states of As and Se in coal fly ashes. We utilized a combination of nanoscale and microscale synchrotron X-ray microprobe techniques to compare element associations in ashes derived from different coal sources in the United States. In the nanoscale analyses, we observed As and Se species that were either diffusely located around or comingled with Ca- and Fe-rich particles. The results also showed nanoparticles of Se attached to the surface of fly ash grains. The broad heterogeneity of As and Se species across the nano- and microscales demonstrates why the leachability of these elements from the ash is not easily predicted by bulk phase speciation of these elements. Therefore in a follow-up study, we explored a regression analysis approach to correlate leachable As and Se concentrations with intrinsic properties of the fly ash, including major element contents, loss on ignition and pH. These analyses reveled functional predictor parameters that could be used to screen leachable levels of As across a wide variety of coal fly ash samples.