# Environmental evaluation and nano-mineralogical study of fresh and unsaturated weathered coal fly ashes

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# Abstract

Coal combustion and the disposal of combustion wastes emit enormous quantities of nano-sized particles that pose significant health concerns on exposure, particularly in unindustrialized countries. Samples of fresh and weathered class F fly ash were analysed through various techniques including X-ray fluorescence (XRF), X-ray diffraction (XRD), focused ion beam scanning electron microscopy (FIB-SEM), field-emission gun scanning electron microscopy (FE-SEM), high-resolution transmission electron microscopy (HR-TEM) coupled with energy dispersive x-ray spectroscopy (EDS), and Raman Spectroscopy. The imaging techniques showed that the fresh and weathered coal fly ash nanoparticles (CFA-NPs) are mostly spherical shaped. The crystalline phases detected were quartz, mullite, ettringite, calcite, maghemite, hematite, gypsum, magnetite, clay residues, and sulphides.

The most abundant crystalline phases were quartz mixed with Al-Fe-Si-K-Ti-O-amorphous phases whereas mullite was detected in several amorphous phases of Al, Fe, Ca, Si, O, K, Mg, Mn, and P. The analyses revealed that CFANPs are 5–500 nm in diameter and encapsulate several potentially hazardous elements (PHEs). The carbon species were detected as 5–50 nm carbon nanoballs of graphitic layers and massive fullerenes. Lastly, the aspects of health risks related to exposure to some detected ambient nanoparticles are also discussed.

Keywords:

Coal fly ash, Nanoparticles, Nanomineralogy, Potential hazardous elements, Human health