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Insight into municipal solid waste fly ash (MSWFA) heavy metals speciation by selective extractions and geochemical modelling

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Nowadays municipal solid waste incineration (MSWI) has become a widespread and consolidated technology for MSW treatment all over the world. Indeed, it allows to reach up to 90% of waste volume reduction, while also producing energy. However, the incineration process has some drawbacks, one of which is the production of different residues that must be disposed of. Specifically, particular attention must be paid to fly ash (FA), which generally represents one of the most dangerous residues. FA is collected by the flue gas purification system and counts for around the 5% w/w of total incinerated waste. MSWI FA is regulated as a hazardous waste, mainly due to high concentrations of heavy metals (Pb, Cr, Zn, Cd) and soluble salts (chlorides and sulfates). Moreover, the average size of FA particles can be as low as 50-20 μm, thus determining a high surface area, which can increase toxic elements release into the environment. Therefore, many preliminary physicochemical stabilization treatments have been proposed over the years for their possible reuse as construction materials (e.g. water washing, thermal treatment, etc..). However, a detailed characterization of the residue in terms of heavy metals speciation is often overlooked. Indeed, this represents necessary information in order to understand and control the residue behavior in a reuse scenario and to design stabilization treatments as effective as possible.

In this work the analysis of heavy metals distribution and speciation of Turin MSW FA has been conducted, by combining both experimental treatments and geochemical modelling. In particular, a 4-step sequential extraction method has allowed to evaluate how heavy metals are distributed among four fractions with different physicochemical properties and, then, to deduct preliminary considerations about their leaching availability. In addition, pH-dependant leaching tests coupled by geochemical modelling using Virtual MINTEQ software has provided a more detailed insight into heavy metals speciation, by proposing possible phases which are often not detected by bulk analytical techniques. Finally, a general assessment of the hazardousness of Turin FA is discussed.