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Municipal solid waste incineration (MSWI) plays an important part in waste management strategies, as it significantly reduces the volume of municipal solid waste and the embodied energy can be recovered. Apart from energy, by-products in form of particulate materials such as bottom and fly ash are also produced. Bottom ash is already valorized in several countries, mainly in road construction or embankments, after metals are separated for recycling.

MSWI fly ash is a highly alkaline material that contains high content of soluble salts, and organic and inorganic contaminants and is therefore classified as hazardous waste. The MSWI fly ash is backfilled in mines or disposed of at hazardous waste disposal sites, although these strategies do not promote future recovery of resources in the MSWI fly ash. The potential resources in MSWI fly ash include base metals for industry (for instance Cu, Pb, Zn), critical elements (European Commision, 2020) such as Sb, Ti and REE and ash particles containing Al, Si, Fe and Ca which are eligible for construction materials. Some of these elements have declining natural

reserves or the natural reserves are more difficult to exploit, which means higher exploration costs. Therefore, the MSWI fly ash can be considered a secondary resource for elements and material, however, technology and methods for valorization need to be developed. One strategy to promote resource use from MSWI fly ash is the recovery of elements from the ash and using the MSWI fly ash itself after decontaminating/detoxificating the fly ash by manufacturing products containing the detoxified fly ash (Quina et al. 2018).

For element extraction and separation, an electrodialytic treatment method was applied to the MSWI fly ash, and removal efficiencies between 80 - 95 % can be obtained for Cd, Cu and Zn. The electrodialytically treated MSWI fly ash was tested as secondary material in cementitious material, geopolymers or ceramic bricks (Kirkelund et al. 2020, Ebert et al., 2021, Zhan and Kirkelund, 2021, Righi et al. 2022). Mechanical and environmental properties were tested for the different construction material applications. The results show that applying electrodialytic treatment enhances the material properties of MSWI fly ash, with reduced metal and chloride content, and enriched content of Al, Ca and Si. Mechanical and environmental properties of the construction materials are improved when using the treated MSWI fly ash compared to using the raw untreated MSWI fly ash.

Electrodialytic treatment has the potential for being a method to extract metals and increase the material properties of MSWI fly ash, so this fly ash can be an important urban mine for resource recovery in the future. This is further explored in the Horizon Europe project AshCycle, where 28 academic and industrial partners from 8 countries join efforts to integrate underutilized ashes into material cycles by industry-urban symbiosis.

Keywords: waste-to-energy, resource recovery, cementitious materials, alkali activated materials, ceramics, heavy metals, electrodialytic extraction

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