Mining waste: a potential ceramic resource

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Extractive waste from mining and quarrying operations accounted, in 2018, for over a quarter of all the EU-27 waste output. This waste involves materials from extraction and processing of mineral ores, such as waste rock and tailings, respectively. When mismanaged, extractive waste can be considered as a significant environmental and health hazard. Sulphidic mining waste pose a large challenge, as it can lead to acid mine drainage. Apart from hazardous metal(loid)s, these mine waste residues contain valuable base, precious and critical metal(loid)s which can be used in different technological applications. Furthermore, the mineral fraction of these mine waste residues can contain considerable concentrations of ceramic-friendly minerals, such as quartz and phyllosilicates, which indicates that the mineral residues can possibly be used in different ceramic applications.

The goal of this study is to evaluate the potential use of sulphidic mine waste rock from an active Cu-Zn mine (Neves Corvo, Portugal) and sulphidic mine tailings from two inactive Pb-Zn (Plombières, Belgium) and Cu-Zn-Pb (Freiberg, Germany) mines, in different ceramic products (roof tiles, blocks and pavers) taking into account production parameters, product quality and environmental regulations. After a detailed physical, mineralogical, chemical and thermal characterisation of the mine waste residues, one company-specific blend has been modified on a lab scale for each of the proposed ceramic products, by partly or totally replacing primary raw materials by the mine waste residues (up to 20 wt%). The required technical, aesthetical and chemical properties, as well as environmental performance were evaluated for each ceramic product.

The Freiberg tailing and Neves Corvo waste rock material present high S (mainly present in pyrite) and metal(loid) content, which make them not suitable to partly or totally replace primary raw materials in ceramic roof tile (5 wt%), block (10 wt%) and paver (10 wt%) blends. The high sulphur content resulted in higher SOx emissions, technical and aesthetical issues. Nevertheless, the Plombières clayey-silt tailing has a low S and metal(loid) content, and shows compliance with the Flemish environmental regulations concerning the use of waste materials as or in building products. Moreover, Plombières fine tailing has no need of mechanical pre-treatment before being incorporated in the ceramic blends compared to the coarse Neves Corvo waste rock material. The technical, aesthetical, and chemical properties of the fired bodies using this fine tailing material (5 wt%, 10 wt% and 20 wt%), were comparable to the standard fired bodies for roof tiles, blocks and pavers. Considering a 2nd life scenario of demolished shaped products (non-shaped), column leaching tests were performed on the grinded ceramic blends of roof tiles, blocks, and pavers, using 20 wt% of the Plombières tailing. The cumulative release of metal(loid)s in the leachates showed that only the roof tile and block blends can be recycled as granular (non-shaped) building material.

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