Sustainable management of oil refining sludge by means of geopolymers production

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The main objective of this study is the development of new geopolymeric materials using as raw material by-products or industrial waste industrial sewage sludge from the oil and fat refining industry, in order to valorise a new type of raw material that has not been used so far in the manufacture of these materials.

Sewage sludge is an important type of by-product resulting from different physical and biological water treatment processes that generate a large volume of waste. The disposal of sludge represents between 25% and 65% of the total management costs, therefore, the valorisation of the obtained by-products becomes a necessity within the framework of sustainable development and circular economy.

There are currently several ways of reducing their volume, such as: incineration, application to agricultural land, landfill and dumping at sea. All of the above have drawbacks, as environmental constraints are increasing and the quality required of sludge for agricultural use is higher, there is a shortage of areas dedicated to landfill or sea disposal, problems of groundwater contamination, degradation of soil quality, etc. In addition, none of the above contribute to the reuse of the beneficial components of sludge. For this reason, new viable alternatives for the use of these wastes are being studied, leading to some very promising solutions such as their use as a raw material in the manufacture of sustainable building materials.

The sludge used in this study comes from an olive oil company located in the town of Vilches in the province of Jaén. In order to use them as a precursor, it is first necessary to dry them in an oven and then carry out a calcination process. The chemical composition of this sludge was obtained by means of X-ray fluorescence, obtaining Al_2O_3 as the main component (62.04 %) and SiO_2 (2.16 %).

Initially, the compressive strength of the sludge residue was studied without adding any other material. For this purpose, different tests have been carried out in which the activator used was NaOH 12M. The best results were obtained using a liquid/solid ratio of 1.7. In this way, the compressive strength achieved was 2.3 MPa after 7 days of curing, increasing to 6.6 MPa after 28 days of curing. Once the achievable strength of the 100 wt % sludge residue is known, other residues with a higher SiO_2 percentage than the sludge residue are incorporated into the sludge residue. Initial tests have been carried out with two types of waste, the first is fly ash (FA) from biomass burning, while the second waste is chamotte (CH), a product from the remains of bricks from the construction sector, whose silica percentages are 14.2 % for the first and 59.77 % for the second. As alkaline activator, in both cases, a mixture of Na_2SiO_3 and NaOH at 50 % has been used, the liquid/solid ratio used is 0.6. By adding 80 wt % FA, a compressive strength of 9.8 MPa was achieved after 7 days of curing, increasing to 10.7 MPa after 28 days, while, with 80 wt % CH, the strengths obtained were 7.1 MPa and 7.8 Mpa respectively. In all cases, the tests were carried out at room temperature.

The results of these initial tests show that satisfactory results can be obtained with the use of this type of waste, facilitating its reincorporation into the market, allowing the reuse, recycling and recovery of sludge waste, developing an alternative market for it and bringing us closer to a circular economy. In addition to being environmentally sustainable by requiring less energy consumption than portland cement and reducing carbon dioxide emissions significantly.

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