Natural stone sludge as secondary raw materials: towards a new sustainable recovery process

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Lorena Zichella

Abstract

The problem related to the reuse of sludge deriving from the cutting of ornamental stone is a relevant topic at National and International level. According to the European Commission's Thematic Strategy on the Prevention and Recycling of Waste (EC raw materials strategies), proper management of sawing sludge by means of its characterization is essential to predict its future recovery. The sawing sludge is classified, according to the Italian framework in force (Legislative Decree 152/2006) as inert waste codified with the CER code 010413, produced by the processing of ornamental stone, in particular by volume treatments and destined to disposal operations. The volume treatments considered derive from the stone block sawing into slabs through the three technologies: gangsaw, diamond blade and diamond wire.

The main challenges to deal with for their correct management are:

- huge volume produced in quite limited areas.

- very fine particle size distribution.

- chemical properties of waste due to the presence of heavy metal content, sometimes over the threshold values, which can polluted the water and the soil if the residual sludge is not properly managed.

The aim of the PhD research project is the development of a guideline for the correct management of this waste by means of its characterization, to provide a specific recovery based on chemical characteristics.

The first step of the thesis consists in quantifying the amount of material that can be recovered as a by-product for other processes. A comparison between the data obtained from the Piedmont Institute (ARPA and IRES) and the empirically calculated data on the three different cutting technologies (band saws, diamond blade and diamond wire) was carried out. In particular for the diamond wire a study on the wear of the cutting tools based on the rocks workability classification was performed. Topics discussed for the European EASE R3 Project and deepened during the PhD research.

The second step of the study involves the characterization of 10 different sawing sludge, deriving from the cutting of silicate stones in the Piedmont districts of Turin, Cuneo and Verbania. The following characterization analyzes have been carried out: distribution particle size, chemical analysis, leaching test, specific density, wet magnetic separation, SEM analysis, XRPD and image analysis.

The third step of the project involves the choice of the type of recovery, based on sludge properties and in particular in its heavy metals content. For this purpose the magnetic separation, the SEM analysis, the XRPD and the image analysis by means of Image J software, were useful to understand the

nature and quantity of the metallic elements present. Two applications have been foreseen, using materials in their as it is state:

- Control Low Strength Material (CLSM): performed with sludge characterized by a high metals concentration.

- Thermal eco-mortar for application of light macropore plasters: with sludge characterized by low concentration of metals.

The sludge used for the application as CLSM comes from two plants located in the Verbano District, where different rocks are cutting by means of different technologies. This two sludge have different physical and chemical properties. The cement mortar required for the filling of road substrates must meet certain requirements, such as self-leveling capacity, adequate fluidity, and a high and constant thermal conductivity. These properties are fundamental considering the presence of cables for the transmission of electricity. The material must be able to dissipate the heat produced by the cables throughout their life. The choice of using quartzite aggregates and sludge with a high percentage of metals, for the composition of the mix design, has been carried out as they increase the thermal conductivity of the concrete conglomerate. Four mixes have been prepared, whit two different sludge and dosage of the components. Laboratory tests, thermal conductivity and triaxial cell, were performed to validate the required requisites.

The sludge used for the application as plaster instead, must satisfy requirements related to thermal insulation, resistance to moisture, mechanical resistance and good injection. For this purpose low-content metals sludge was used for the composition of the mix design. The laboratory tests carried out on finished product, in accordance with European standards, are as follows: water absorption, specific density, flexural and compressive strength resistance before and after freeze and thaw cycles, pull out, salt crystallization cycle resistance and thermal conductivity.

In both applications the chemical and leaching test were carried out to verify the possible release of heavy metals into the environment after installation. The quality of the products obtained has been demonstrated as the cement mortars incorporate the metals and do not allow their release in nature.

A sludge recovery in unaltered state is provided, to reduce any costs connected to a pre-treatment and to make the recovery economically advantageous for companies. In the case of sludge with high heavy metal contents, which exceed the Law threshold limits, a magnetic separation can be provided downstream of the cut, as a pre-treatment. In this way obtaining two distinct by-products, of which the amagnetic fraction can be used as an application for plaster, and the magnetic fraction can be disposed in specialized landfill. In this way, the quantities and costs related to disposal would be reduced.

The circular economy approach, with the decrease in costs related to disposal, the improvement of environmental conditions and the retrieval of still exploitable secondary raw materials, must be necessary in an era in which the

quantity of waste increases considerably. A collaboration between entities that produce waste and administrations that provide guidelines to recover it is necessary to make what is now a unidirectional system, a circular system.