**CLEANSTONE**

**Recovery and valorization of stone processing waste for environmental sustainability**

**Milestone 4.3 Identification of options of reuse/re-use**

Program:

Interreg V-A Italia-Austria

Partner:

Università degli Studi di Udine – Dipartimento Politecnico di ingegneria e architettura – DPIA

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# Goals of the Cleanstone project

The quarrying of aggregates and natural stones has various impacts on the environment. The objective of CLEANSTONE is to improve environmental protection and resource efficiency in the natural stone producing industry by developing innovative technology that minimizes and reuses waste from stone processing and promotes the adoption of optimized manufacturing processes. This is done through actions at several levels (technological, behavioral, normative) to make the stone production sector more competitive and environmentally sustainable. The main project outputs are:

1) Development of guidelines to define the criteria for environmental impact assessment, as well as quality assurance of innovative process flows that allow optimized recovery of usable secondary raw materials from slurries and crushed slabs of different stone types;

2) A basic document with proposals for amending the waste legislation for stone products in Austria and Italy. The project is pioneering, as various reuse techniques for waste and dust products are brought in a context specifically designed for companies in the stone sector (mostly SMEs).

Through this, all will benefit from a greater awareness generated by the implementation of the proposed work in relation to the dynamics of the circular economy and environmental protection.

# Application content

## WP4: Identification and development of new best-practice solutions for the recovery of scrap as secondary raw materials

The objective of WP4 is to identify best-practice solutions for the optimal recovery of waste materials (silts, shingles) into reusable secondary materials (especially chloride, nitrate and calcium carbonate, which are widely used in the construction, paper, road building and paint industries). Conversion by drying and pulverisation will be considered. To identify such solutions, the following will be carried out:

1) Laboratory analyses of stone material extracted in Austrian and Italian quarries, performed in synergy by academic PPs to determine the most suitable reuse options for the specific mineralogical composition of the material. Different stone types will be tested and the results analysed to define the best re-use option.

2) Validation of the re-use option through industrial trials at the quarry sites involved in the tests.

3) Economic evaluation and ranking of the re-use options. On the basis of this evaluation, guidelines will be identified to select the most suitable material cutting and processing methods.

The guidelines will be distributed free of charge to quarries and industries in the sector.

1. **Milestone 4.3 Identification of options of reuse/re-use**

The activities implemented with the stakeholders involved (activities carried out within the framework of WP3) led to a final phase was dedicated to the identification and analysis of the best practices for the recovery of waste materials already implemented by Italian companies in the stone sector, and made available by the academic partners of the project: University of Padua and University of Udine.

Thanks to the direct dialogue with the stakeholders, it has been tried, moreover, to classify the best practices of waste recovery - in secondary raw materials - according to the principles of replicability and economy.

## Objectives

- Identify and promote best practices already implemented;

- Highlight critical issues and difficulties of a technical and regulatory nature;

- Classify best practices in terms of replicability and cost-effectiveness;

- Promote dialogue and exchange of experiences among the various parties involved.

## Work and methodological phases

On the basis of the results shared by the academic partners (following analytical characterization of samples, scientific literature, on-site visits), 12 best practices (understood as "processes for the valorization" of silt and shards) have been identified, belonging to the following macro areas:

**CONSTRUCTION/BUILDING AREA**

- Agglomerate cement and agglomerate resin

- Tiles and decorative artefacts

- “Venetian" terrazzo and mosaics

- Prefabricated buildings and urban design (to cover reinforced concrete structures)

- Colours and marbles for interiors and exteriors

- Adhesives and stuccoes (as primary base and reducing element of shrinkage and cracks)

- Plastics (to improve performance characteristics and give the desired degree of white colour) and paper

- Gardens (mulching and aesthetics)

- Environmental recovery of abandoned areas and for topographical depressions to be reshaped

- Fine aggregate for mortars and concretes (instead of clay fraction)

**AGRICULTURE**

- To correct the degree of acidity, absorb pollutants and as a filler of fertilizer products (neutralization acidic soils)

**CHEMISTRY**

- Charge element with neutral behaviour to control the chemical reactivity of products or Chemical reagent (also in the case of flue gas desulfurization).

Of these, only two practices do not fall into the "already in use" category: the use of waste as fine aggregate for mortar and concrete, and the use of silts in the chemical industry. However, they were included among the best practices because they were deemed by the University of Padua to be potentially "more sustainable and cost-effective" than those currently in use.

Once the practices were identified, a qualitative evaluation was carried out for each of them, together with companies in the stone industry, according to the following parameters of use:

- Actual adoption

- Reference period

- Motivations/opportunities of the choice

- Criticalities and obstacles to correct adoption.

Together with the companies of the stone industry, a simplified SWOT analysis was conducted for each best practice. These results should be considered as complementary data to the chemical analysis and industrial tests conducted by the academic partners.

In addition to the twelve practices, another valorisation process was also evaluated, here considered as a "pre-requisite": the separate collection of limestone sludge from silica sludge; according to the University of Padua, it is a necessary procedure for the proper transformation of silica into secondary raw materials.

For further information, please refer to the studies conducted by the University of Padua within the Cleanstone project

## Results

Here below observations gathered from the companies interviewed considering only practices already in use or used, and most relevant. The only exception is the process considered as "pre-requisite" because of its importance in the processes of recovery and reuse of stone waste. For privacy reasons, the companies are referred to as Company 1 and Company 2.

*PRE-REQUISITE*

Generally speaking, the separate collection of limes is not practised by the companies interviewed because they process exclusively material of a siliceous or calcareous nature, making the distinction a superfluous procedure.

In any case, according to Company 1, it is a practice that would reduce costs and management time and to expand commercial opportunities. It should be noted that the main obstacle to this procedure could be the stringent regulations.

In addition to this, Company 2 sees further obstacles: the time required for authorization procedures, the cost of new technologies/instruments to separate waste and the greater risk of dispersion of waste during transport.

*AGGLOMERATE CEMENT – AGGLOMERATE RESIN*

Company 2 and Company 1 have been contributing to the production of agglomerate cement and agglomerate resin for a long time, due to the high economic and commercial value (especially in the case of Verona) of the second raw material generated and the possibility of reducing waste management costs.

If we consider the production area, there are two companies dedicated to the crushing of waste processing/ extraction of marble, while there is a total of three companies involved in the production of manufactured products/products agglomerated or that use fragments.

Among the critical points highlighted by Company 2 and the Company 1 are the following:

- need for an area dedicated to instrumentation and processing

- use of materials foreign to stone (resin in case of agglomerate resin)

- high cost of material traceability processes

- lack of manpower (not only specialized)

- competition from ceramic materials or of Chinese production

- distrust of the use of waste material.

The last three considerations have already emerged in other phases of the project.

*VENETIAN TERRAZZO AND MOSAIC*

Only Company 1 implements this practice because of the high aesthetic and commercial value of the waste obtained from the processing and extraction of marble. It was chosen as a supplier by the renowned Friuli Mosaic School of Spilimbergo (PN).

In addition to the positive aspects already identified in the previous practices (reduction of waste management costs, recovery of waste, increase in the commercial offer), it should be noted that it is still a niche production that requires skilled labour and is affected by competition from other synthetic products or those made in China.

*COLOURS AND MARBLING FOR INTERIORS/EXTERIORS*

In this case, it is Company 2 that contributes to this good practice, recovering the waste from the quarry activity (about 8% of the total raw material extracted) to supply small local building realities.

*ENVIRONMENTAL RESTORATION FOR BROWNFIELD SITES/TOPOGRAPHIC DEPRESSION REMODELLING*

This is one of the most effective practices pursued by both of the companies interviewed, but in different ways.

While Company 2 delivers its waste to the third party organisation, Company 1, on the other hand, directly manages (without any economic benefit) the environmental restoration of a quarry in province of Verona.

The quarry is currently in operation and also serves as a landfill for the companies associated with the company 1; the landfill delivery (of silts and shale) proceeds in parallel with the progress of the quarry activity.

Company 2 identifies as main criticalities: relying on a single interlocutor - which determines, therefore, conditions and costs - and of not being able to restore the quarry. Company 1 identifies other problems, such as:

- early closure of the quarry/reduction of the areas dedicated to the landfill/restoration;

- management costs related to the modalities and size of the areas granted (in recent years the quarry has granted small portions, increasing management costs; the range has varied from 5 to 8 euros/ton)

- management of landfill and environmental restoration by a party other than the Company (according to the Company this would entail an increase in management costs of at least 50%).

Project KPIs

- Number of practices analysed/ planned: 12/12 (for each company)

- Number of practices in use/ planned: 4/12 (Company 2); 5/12 (Company 2)

-Estimated time for compilation/actual time; 180'/180' (one meeting)

- Company contact person role (if apical/owner or operative): 50% company owner (in the case of Company 2)

## Notes

The evaluation considers the entire value chain of the companies interviewed.

The evaluation activity was conducted together with the companies Company 2 and Company 1.

As foreseen by the project, the practices analysed were, in most cases, of the type "already in use" by Italian companies and aimed at the recovery of both silt and shard. This is to make the principle of replicability and cost-effectiveness more effective.

In the absence of quantitative and comparable data, in evaluating the practice, greater importance was given to the qualitative judgement expressed by the companies interviewed.

The following is a detailed analysis of the identified best practices.

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| **Field** | **Number** | **Practices** | **In use/Already used** | **Number** | **Period** | **Motivation (streght )** | **Criticalities (weaknesses)** | **Opportunities** | **Risks** | **Note** |
| **Pre-requisite** | 0 | **Limestone/siltstone division** | Company 1 |  | In use | Cost and time saving |  | Opening up to new reuse markets | **Restrictive regulation** | There is no real need to distinguish between the two types of limestone because the companies are specialized in working one material or the other; the limestones, therefore, are almost all distinguished at the origin; in any case, it should be noted that for calcareous limestones it is easier to find a  relocation. |
| Company 2 |  | There would be no additional costs for disposal | Start of authorization process; purchase of new technology (shovel); risk of silt dispersion during transport between container and settling area | Opening up to new reuse markets | Increase in cost for Decantation tank | The division is not necessary since Vicenza stone is a material exclusively of calcareous nature. |

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| **Construction/Building** | 1 | **Agglomerate concrete**  **Agglomerate**  **resin** | Company 2 | **1** | In use | Reduce costs  waste management | Traceability is  expensive | High market demand | Distrust by the user; difficulty in tracing the material; competition from materials generated from scrap and perceived to have the same value as the original. | Only waste material extracted from quarries is used (size similar to gravel) |
| Company 1 | In use | Reduce waste management costs; high economic value of secondary raw material | Technological instrumentation and dedicated processing area | High market demand (international); specific professional qualifications required | Use of non-natural material (resin); lack of skilled labor; competition from ceramic materials and Chinese production | Today, 3 companies make agglomerate concrete (1 of which also makes agglomerate resin ); agglomerate concrete was first made around 1960;  Agglomerate resin about a decade later. |

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|  |  |  |  |  |  |  |  |  |  | The first attempt to create agglomerate concrete by an artisan company in the area dates back to 1934. There are 2 companies in the Valpantena area that crush marble processing/extraction waste to create agglomerate concrete and all manufactured goods/products that use shards. |
| 2 | **Tiles and decorative artifacts** |  | **1** |  |  |  |  |  |  |
| Company 1 | In use |  |  |  |  | The decorative artefacts are made of agglomerate concrete  See the evaluations regarding the relative practice |
| 3 | **“Venetian" terrazzo and mosaics** |  | **1** |  |  |  |  |  |  |

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|  |  |  | Company 1 |  | In use | Reduction of waste management costs; increase in product offerings; recovery of waste as a secondary raw material (mosaic) | Niche production that requires production costs, technical experience, etc. | High level of craftsmanship; dedicated district (material is also purchased from the Friuli Mosaic School of Spilimbergo). | Changes in market demands; entry of new products (synthetics, ceramics); China |  |
| 4 | **- Prefabricated buildings and urban design (to cover reinforced concrete structures)** |  | **0** |  |  |  |  |  |  |
|  |  |  |  |  |  |  |
| 5 | **Colours and marbles for interiors and exteriors** | Company 2 | **1** | In use | Recovery of extraction waste (8% of total crude extracted) | Reduces the % of product processed from "noble" crude material | Diversify the market; satisfy the request of local micro enterprises (painters) |  | Only from mining (querry) |

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|  |  |  |  |  |  |  |  |  |  |  |
| 6 | Adhesives and stuccoes (as primary base and reducing element of shrinkage and cracks) |  | **0** |  |  |  |  |  |  |
|  |  |  |  |  |  |  |
| 7 | **Plastics (to improve performance characteristics and give the desired degree of white colour) and paper** |  | **0** |  |  |  |  |  |  |
|  |  |  |  |  |  |  |
| 8 | Gardens (mulching and aesthetics)  -  Fine aggregate for mortars and concretes (instead of clay fraction) |  | **1** |  |  |  |  |  |  |
| Company 1 | **In use** |  |  |  |  | See section "Venetian Terrazzo” |
| 9 | Environmental recovery of abandoned areas and for topographical depressions to be reshaped | Company 2 | **1** | In use (Since 1990) | Reduction of waste management costs (managed by Co.Trim) | Not being able to restore the quarry owned by Company 2 | Being associated with Co.Trim (third party that solves a management problem) | **Increased cost/modality of associating Co.Trim members: relying on a single interlocutor** | Co.Trim requires a "lifetime" membership |
| Company 1 | In use(since 2009) | **Proximity to the producing companies; reduction of waste management costs; direct management by the company (without profit)** | **Proceeding together to the quarry;** | **Environmental restoration** | **Early closure of the quarry; reduction of available lots; non-renewal of authorization for expansion; change in regulations; increase in energy/diesel costs** | Currently it is the Orsara quarry; previously they turned to external waste dumps |
| 10 | Fine aggregate for mortars and concretes (instead of clay fraction) | Company 2 | **0** |  |  | Limo is not suitable for this type of processing ("floury" consistency;  binder required) |  |  |  |
| Company 1 |  | Aptitude for process/product development | Very specific chemical and physical characteristics required; careful processing of distinct processing and recovery processes; lack of knowledge of the required characteristics | Performing and promising practice | Lack of real links between producers and end users |  |

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| **Other (agricolture and Chemistry)** | 11 | To correct the degree of acidity, absorb pollutants and as a filler of fertilizer products (neutralization acidic soils) | Company 2 | **1** | Till 1990 | **Waste recovery; 100% natural silt** | **Filter press silt difficult to disperse on land; lack of in-house laboratory**  **for chemical-physical analysis** | Natural" soil conditioner" | **Restrictive standards; no knowledge of requirements** | Practice in use when they had settling tanks |
|  |  |  |  |  |  |  |
| 12 | Chemical industry (reagent or  filler) |  | **0** |  |  |  |  |  |  |
| Company 1 |  |  |  |  |  | See Previous section |
|  |  |  |  | **7** |  |  |  |  |  |  |