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Technology train for reusing excavated material in a Brownfield regeneration context

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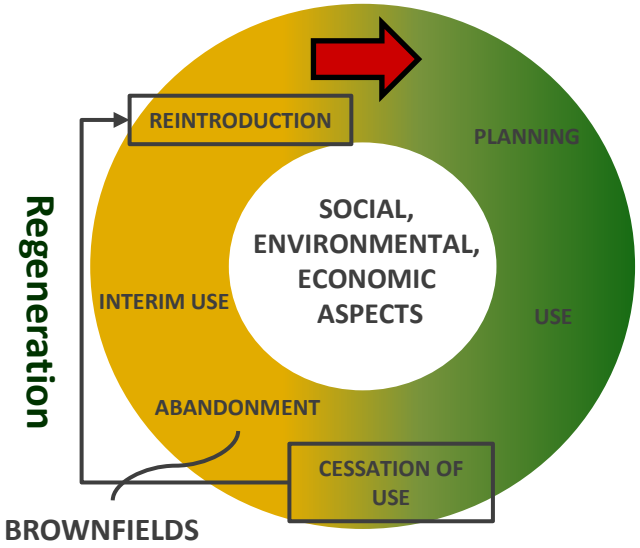
Background

Land Cycle Management

- A site goes through different phases during its life
- "Cessation of use" can lead to the formation of a Brownfield
- A proper management of the site may reintroduce the Brownfield within the Land Cycle.



Regeneration approach

Traditional "bottom-up" approach

Selection of one or more best available technologies that can respond to the site-specific needs

For excavated soil, often the easiest choice in terms of time, costs and performance guarantee is:

Dig & Dump

- Land consumption
- Resources consumption
- Environmental impact

Environmental problems as an opportunity to provide a product or service

Innovative "top-down" approach

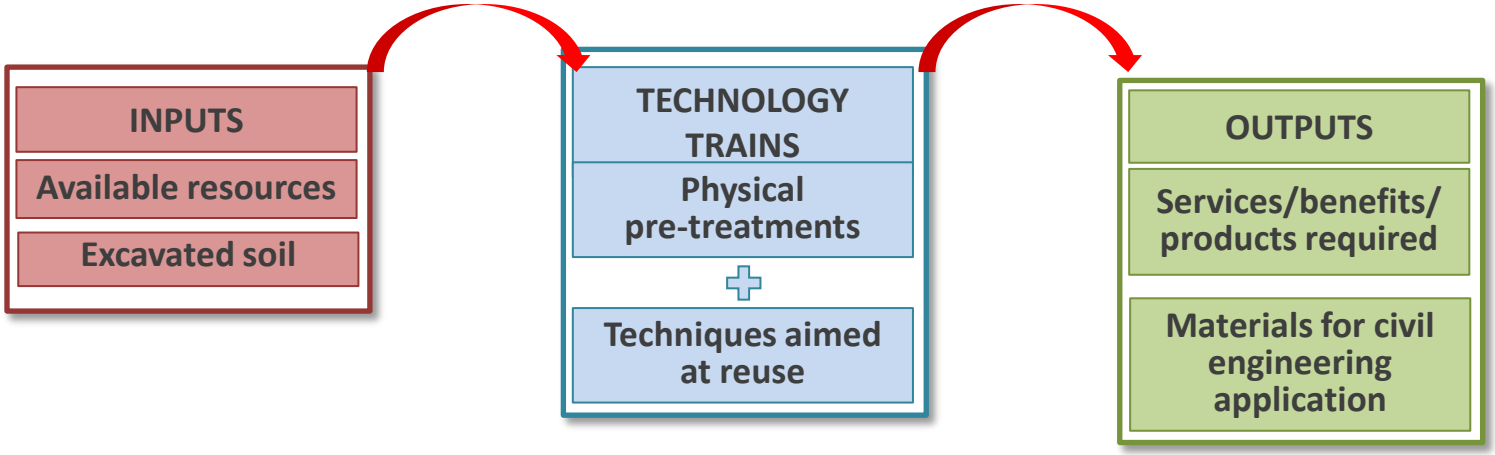
Identification of OUTPUTS: the products/services needed in the site or in the surrounding area

Identification of INPUTS: material generated as a result of the regeneration activities

TTs fitted for reuse

- Land consumption
- Resources consumption
- Environmental impact

Technology train aimed at reuse of excavated soil



GENERAL TARGETS

- ❑ Maximize the reuse of materials resulting from excavation activities within Brownfield regeneration projects
- ❑ Close the cycles of soil and other excavated materials
- ❑ Make the use of resources more sustainable
- ❑ Reduce the consumption of virgin raw materials

Individual techniques aimed at soil reuse

STABILIZATION/SOLIDIFICATION

Civil engineering-based remediation technique that relies on the reaction between a binder and a contaminated solid matrix to form a new solid material, either in a granular or a monolithic form

- ❑ Improvement of mechanical strength
- ❑ Encapsulation of the contaminants in a cementitious matrix

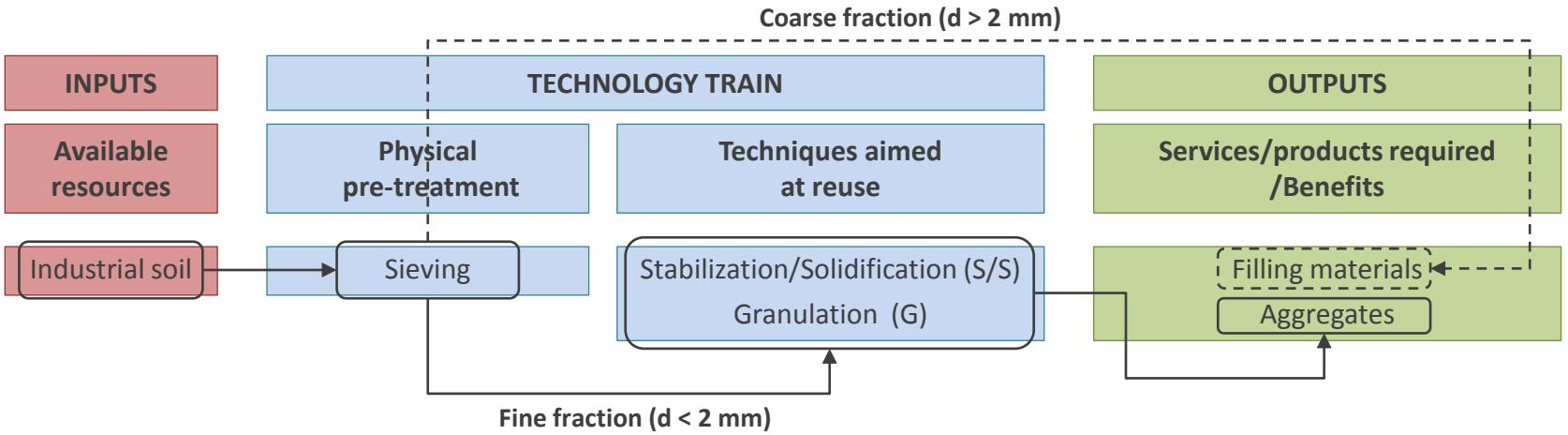
GRANULATION

Process of agglomerating particles together into larger, semi-permanent aggregates. In wet granulation processes, this is performed by spraying a liquid binder onto the particles as they are agitated in a proper device

- ❑ Particle size enlargement
- ❑ Reduction of dustiness
- ❑ Improvement of material management

Technology train (TT2)

The concept

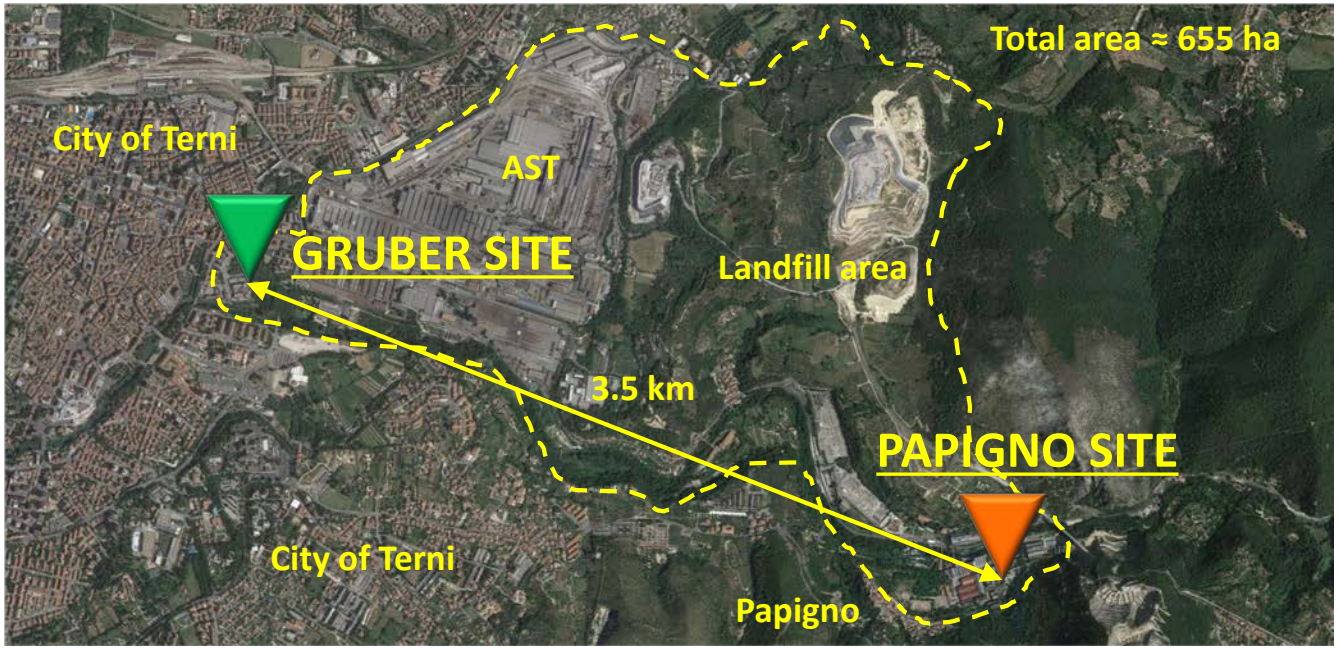


Objectives

- Evaluate the applicability of the combined S/S – G process to treat a metals contaminated Brownfield soil
- Analyze the influence of the combined S/S – G process on the properties of the obtained aggregates
- Provide a first assessment of the conditions of applicability, i.e. operating windows, of the proposed technology train

The Terni Papigno case study

- The Terni – Papigno site belongs to the list of the 39 Italian national priority sites, whose management is performed under the supervision of the Ministry of the Environment.
- The site includes a large active industrial complex (the stainless steel company Acciai Speciali Terni – AST), a landfill area and two Brownfield sites: Gruber and Papigno.



The Gruber site

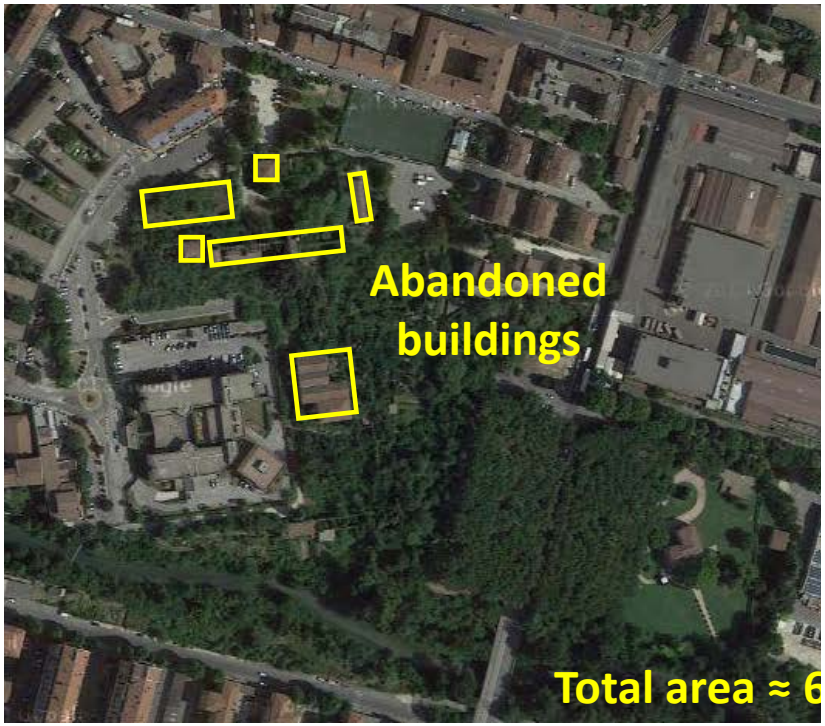
- The Gruber site, located very near to the city center, was established as industrial site in 1846 and was a cotton mill till 1867 when it became a wool mill till 1937;
- The site was used as military site duting WWII and was later used for a while for housing and small activites. Currently, the site is abandoned and closed to any kind of use.

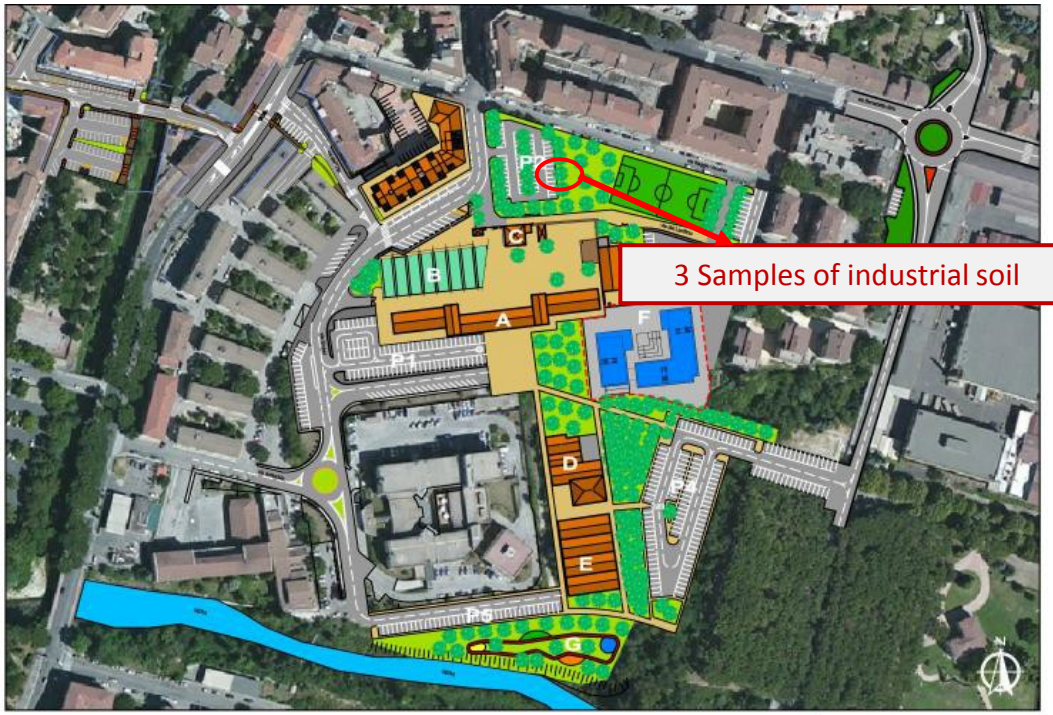
The Gruber site: some pictures

The Gruber site: some pictures

TT2 application to Terni-Papigno case study (Gruber site)

- The Municipality of Terni has approved a requalification project of the site, that will be converted partially to residential use and partially to public services. Most of the outpace will be sealed.
- The applicability of TT2 was assessed by applying the S/S –granulation process to a reference natural soil and to an industrial soil, the latter sampled at the Gruber site;
- It is supposed that during the construction works, the soil shall be excavated.

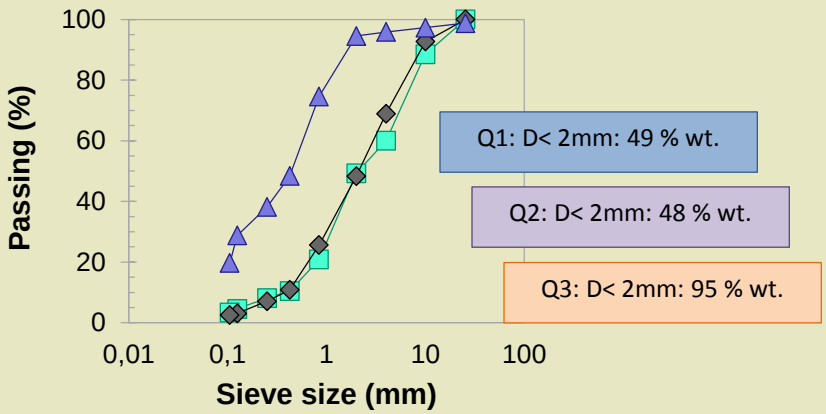




Testing of TT2: materials

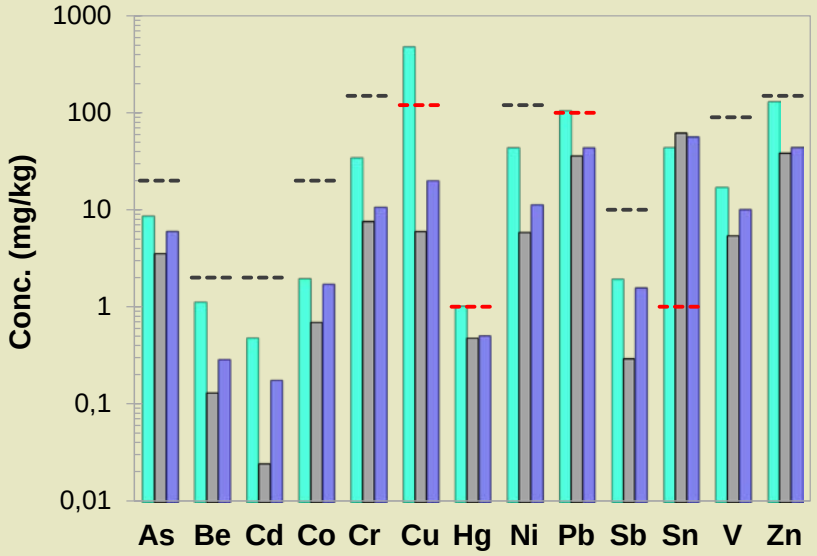
- Natural soil: Collected in a clean site nearby Rome:
- BF soil: 3 samples collected from the BF site were characterized prior of being tested

Soil texture



	Major elements	f_{oc}
Sample Q1	Fe, Al, Ca	1.2 % wt.
Sample Q2	Fe, Al, Ca	< 0.05 % wt.
Sample Q3	Fe, Al, Ca	< 0.05 % wt.

Soil contamination



Fairly low contamination by metals

Italian regulatory limits for residential use (It. LD 152/06)

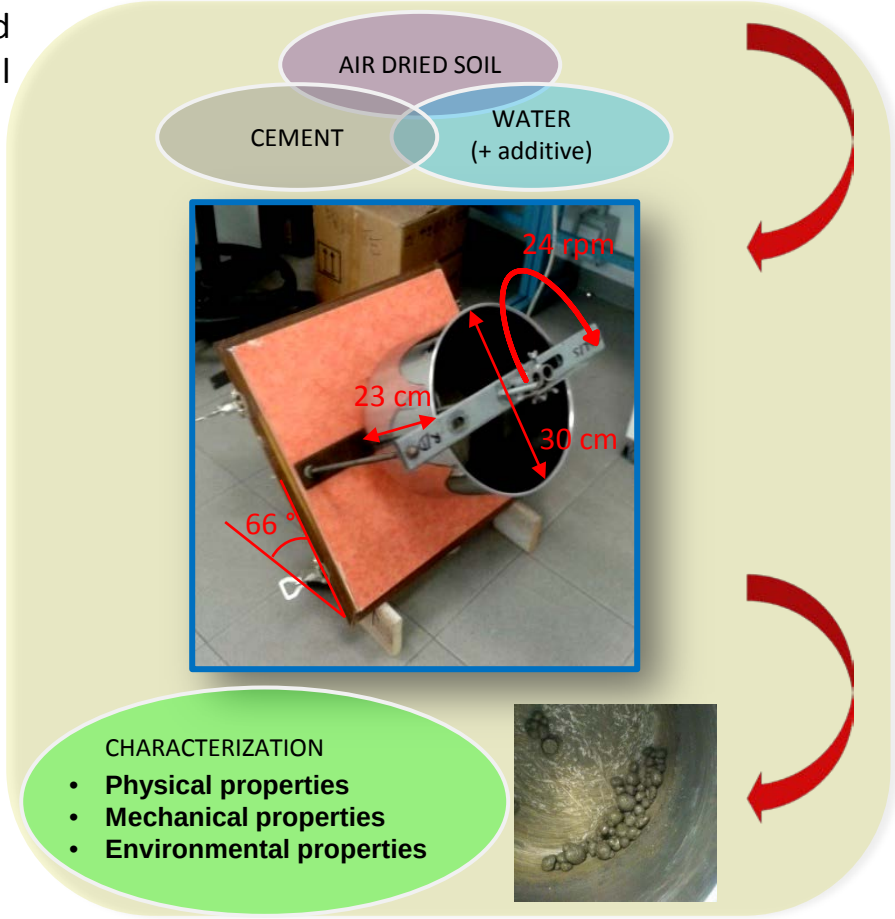
Limits exceeded

Testing of TT2: methods

STAGE 1: preliminary screening tests on natural soil

AIM: investigate the effects of the operating conditions and mixture formulations on the physical and mechanical properties of the product

Changed parameters	
Water content (W/S)	Cement type (CEM 42.5R, CEM 52.5R)
Additive content (A/C)	Cement content (C/S)
Additive type (sulfonate-based (A1), acrylic-based (A2) superplasticizers)	



STAGE 2: tests on brownfield soil

AIM: analyze the influence of the combined S/S – G process on the properties of the obtained aggregates and evaluate its applicability to treat a metal - contaminated Brownfield soil

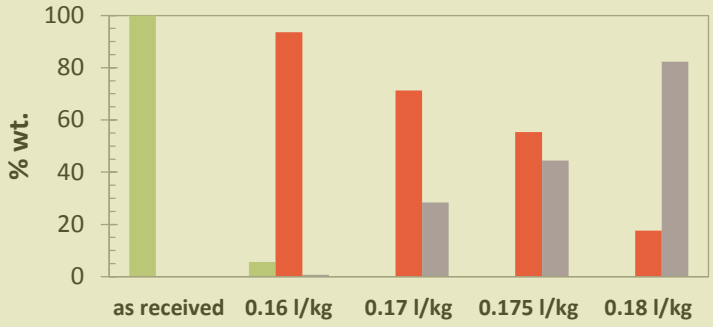
Testing of TT2: results of stage 1 (natural soil)

Physical properties – Particle Size Distribution

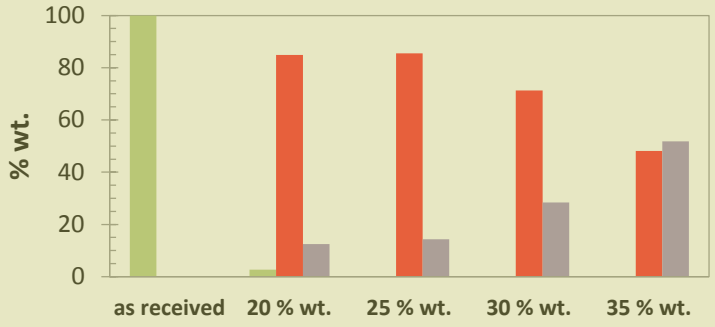
CEM R 52.5

UNTREATED SOIL $D_{50} \approx 0.5$ mm → **GRANULES** $D_{50} = 6 - 10$ mm

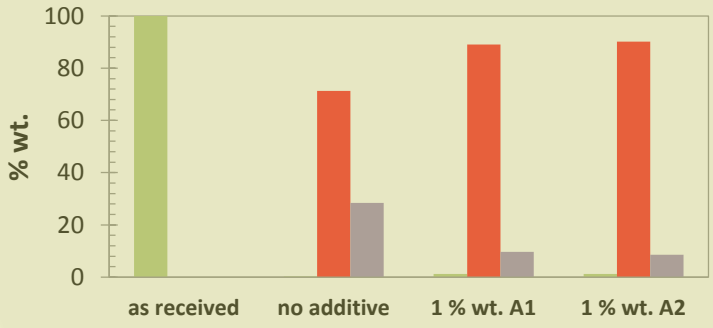
Effect of water content



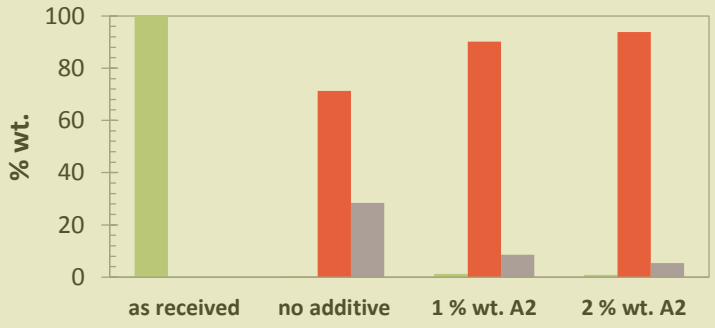
Effect of cement content



Effect of additive type



Effect of additive content

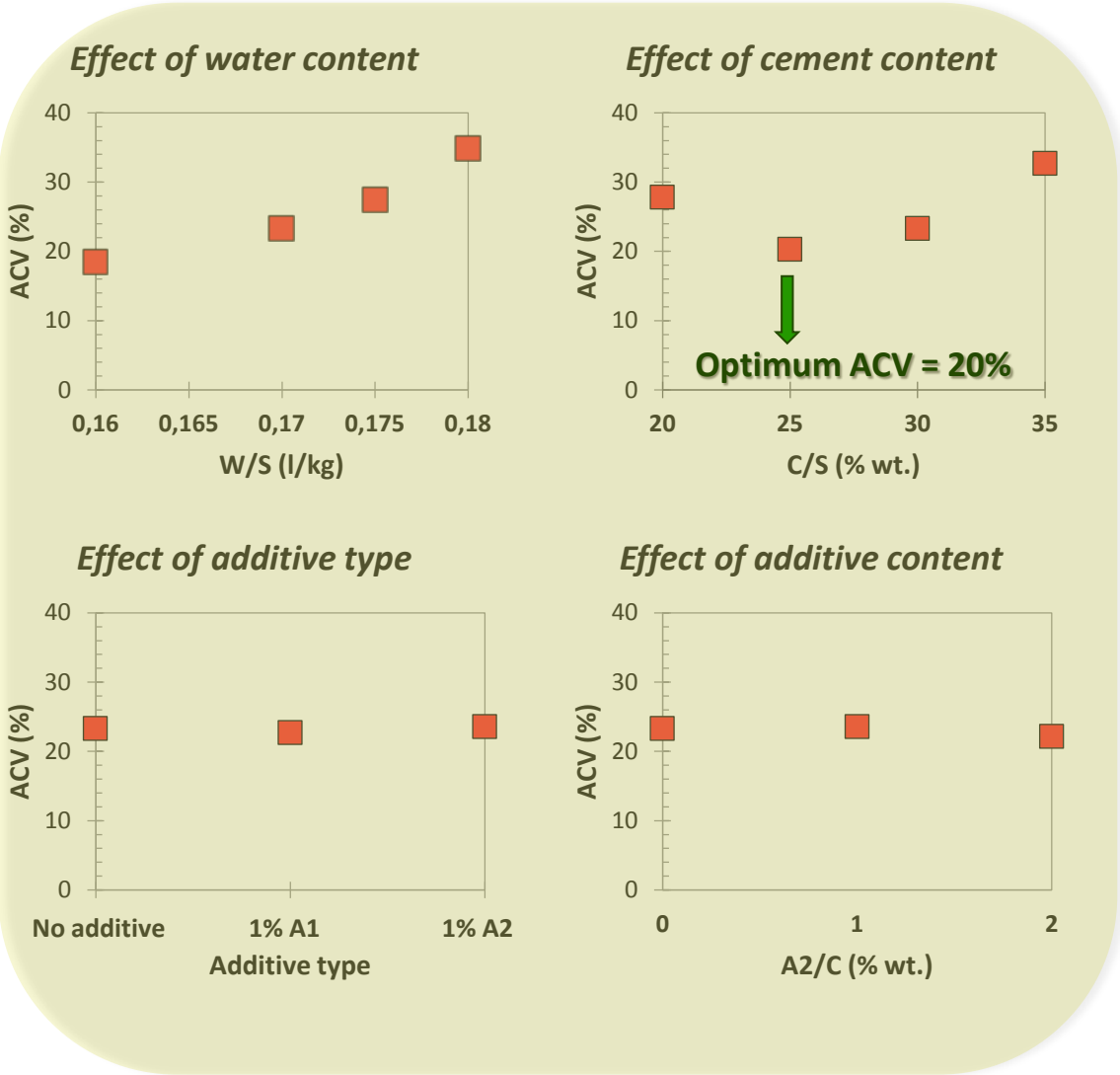


D< 2 mm 2< D< 10 mm D > 10 mm

Testing of TT2: results of stage 1 (natural soil)

Mechanical properties – Aggregate Crushing Value (ACV)

CEM R 52.5



ACV ↓

Granules strength ↑

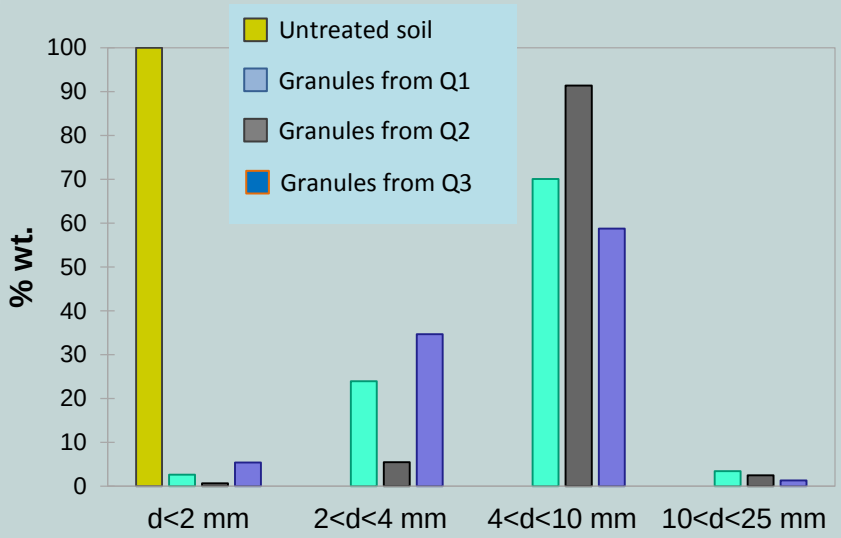
- Linearly increasing trend of ACV with the water content
- Best ACV values obtained at a C/S ratio equal to 25 % and 30 % by weight
- No appreciable effects of additive type and additive content

Testing of TT2: results of stage 1 (natural soil)

Changed conditions	Main results	Selected conditions
Cement type	Aggregates showing a mechanical resistance comparable to that of natural gravel were obtained by employing CEM 52.5 R	Cement 52.5 R
Cement content	Cement/solid ratios higher than 30 % wt. and lower than 25 % wt. resulted in a significant decrease of the mechanical resistance of the aggregates	30 % wt.
Additive type	The use of both additives led to obtain finer and weaker aggregates	No additive
Additive content	No effects of additive content on the aggregates size and strength was noted	No additive

Testing of TT2: results of stage 2 (BF soil)

Physical properties
(Particle Size Distribution – ASTM D422)

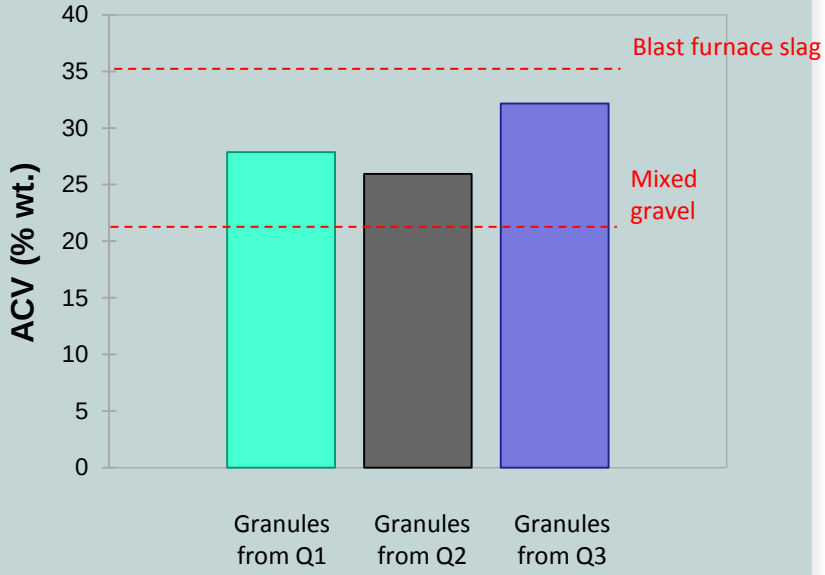


UNTREATED SOIL — GRANULES

$D_{50} \approx 0.7$ mm ⇒ $D_{50} = 5 - 8$ mm

Selected operating conditions:
30 % CEM 52.5, no additives, optimum water content

Mechanical properties
(Aggregate Crushing Value – BS 812-110)



ACV ↓ ⟺ *Granules strength ↑*

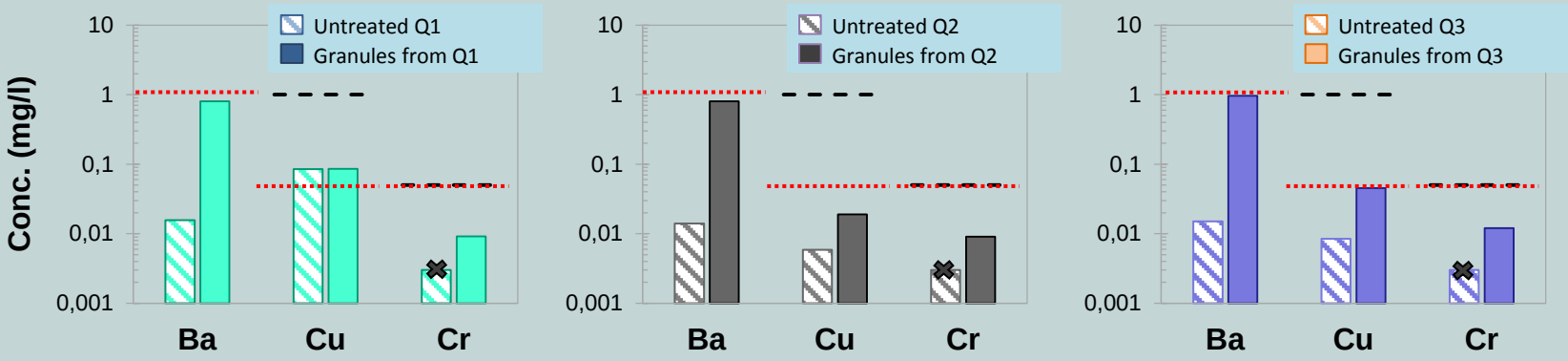
Selected operating conditions:
30 % CEM 52.5, no additives, optimum water content

Testing of TT2: results of stage 2 (BF soil)

Environmental properties
(Leaching behaviour – EN 12457-2)

- – – – *Limits for groundwater quality (It. LD 152/06)*
- ..... *Limits for reuse in simplified procedure (It. MD 186/06)*
- ✖ *Concentrations lower than the instrumental quantification limit*

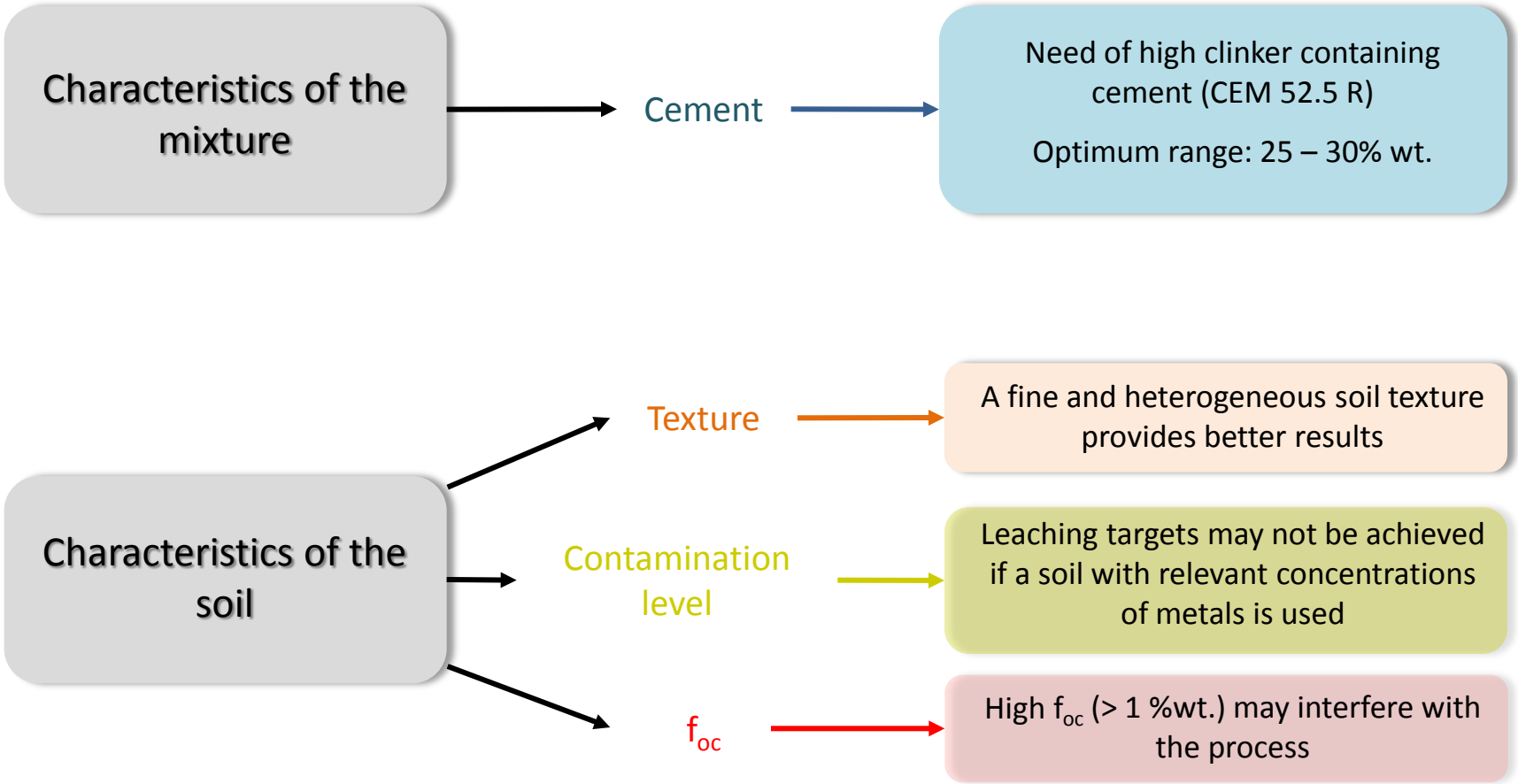
- Leaching of most metals for both untreated soil and produced aggregates was lower than the instrumental quantification limits
- Exception: Ba, Cu, Cr



Factors influencing Ba, Cu and Cr release:

- Characteristics of the cement
- Increased pH
- Contamination degree and foc of the starting material (e.g. Cu and >1.2% for sample Q1)

Assessment of TT2: operating windows



Assessment of TT2: comparison with Dig&Dump

Traditional endpoints

- ❑Protection of groundwater resources by minimizing the leaching of contaminants (GW);
- ❑Protection of human health by reducing the exposure to fine particles (HH);
- ❑Physical/mechanical properties of the material for civil engineering applications (PM).

Sustainability endpoints

- ❑Greenhouse gas emissions (GHG);
- ❑Land consumption (L);
- ❑Consumption of abiotic resources (AR)

	Starting soil conditions			Future site conditions		Potential of achieving the "traditional" endpoint			Potential of achieving sustainability endpoints		
Technology	Low foc	Low contamination	Fine texture	Sealed	Unsealed	GW	HH	P/M	GHG	AR	L
TT2	X	X	X	X	-	High	High	High	Average	High	High
	X	X	X	-	X	High	Average	High			
	-	-	X	X	-	Average	Average	Average			
Samples Q2 and Q3	-	-	X	-	X	Low / Average	Low / Average	Average			
	-	X	X	X	-	Average	High	Low / Average			
	-	X	X	-	X	Low	Low	Low / Average			
	X	X	-	X	-	Average	High	Low / Average			
	X	X	-	-	X	Average	Low	Low / Average			
D&D	*	*	*	*	*	High	High	High	Low / Average	Low	Low

Conclusions

- Within the HOMBRE project, technology trains are proposed as a tool to exploit the resources present at Brownfield (BF) sites in order to achieve products and/or services for the site itself and/or the surrounding land;
- With reference to the issue of managing large volumes of excavated soil arising from regeneration activities, the coupling of Stabilization/Solidification and granulation technologies (TT2) may provide aggregates to be reused as construction material;
- The application of TT2 to the Gruber soil allowed to obtain aggregates with suitable physical, mechanical and environmental properties for reuse (**samples Q2 and Q3**) ;
- The performance of TT2 (**samples Q2 and Q3**) in terms of "Traditional" endpoints may be comparable to that of traditionally applied techniques (D&D)
- Compared to standard solutions, the proposed technology train may provide a higher performance in terms of "sustainability" endpoints.