Tecnologie e Metodi Avanzati per il Recupero e il Riciclo dei Materiali

Case Study:

Bottom ash recycling from MSW incineration

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Incineration

Incineration is the preferred process option for household waste in density populated areas in Europe and Japan.

Incineration allows to:

- **Reduce the amount of waste disposal in landfill and the environmental impact**
- **Recover energy**
- **Recycle different fractions from bottom ash**

The Dutch MSWI reduce 5 Mt of domestic waste to 1 Mt of bottom ash and 130,000 t of fly ash.

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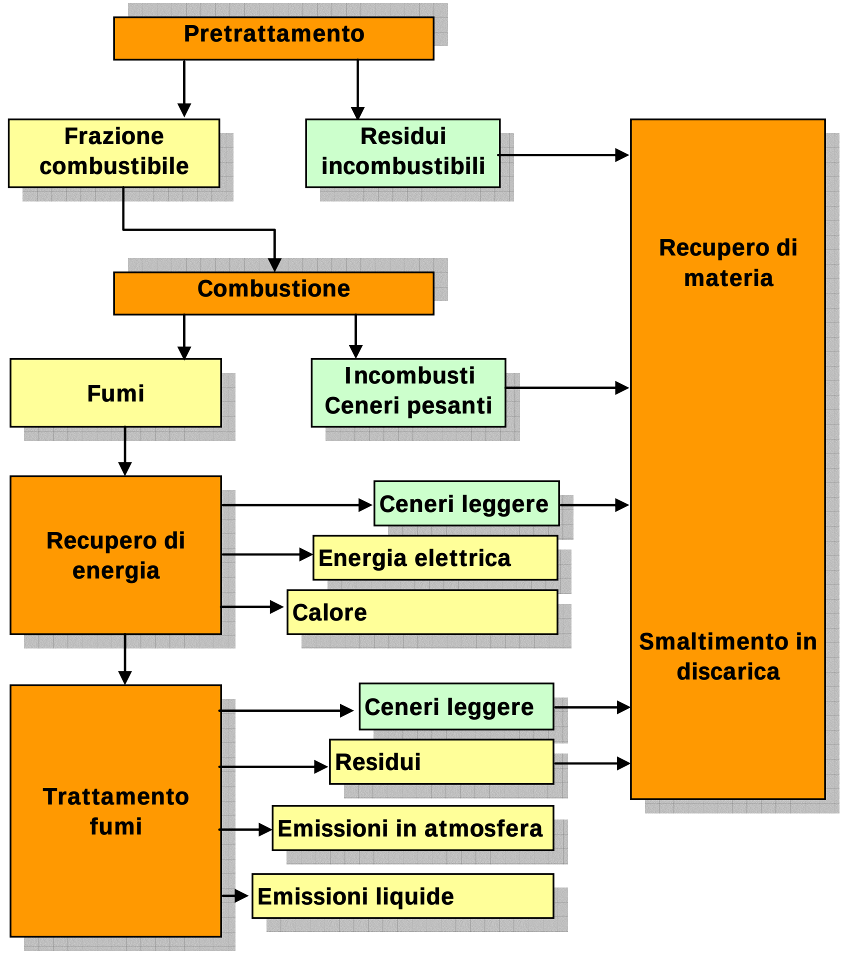
Incinerator



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Ash residues

Ash residues from combustion of municipal solid waste (MSW) generally represent about **25% of incoming waste**.

In Europe **landfilling** of ash residues has been **restricted**, due to scarcity of land and its potential uses for different purposes and to its environmental impact.

Recycling and beneficiation of bottom ash has been encouraged, both economically and by favorable regulations. Whether placed in landfills or beneficially used, account must be taken of **ash residues characteristics** and their environmental impact.

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Bottom ash composition

Bottom ash consists of inert residues, glass, unburned organic matter and metallic particles.

Their properties are strongly related to the MSW burned and to the combustion process.

Bottom ash residues, after different and specific processing strategies, mainly based on separation (magnetic and eddy current based) and classification (screening and cycloning) actions can be profitably utilized for fill and road base.

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Pilot plant in Amsterdam

Bottom ash processing

In the summer of 2002 a **pilot plant** was built and run in the **Amsterdam** port area to test a **new wet process** on the bottom ash.

The process combines a washing step to **remove the residual organic matter** and the fines with separation technology for recovering the **non-ferrous metals.**

The **objective** was:

- to produce **sand** and **granulate** fractions to be used in **building materials** and
- **recover as much as possible** of the **non-ferrous metals** from the ash (**especially fine fractions**).

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Bottom ash processing

1) Hot bottom ash is quenched in water

2) Material fed to a shredder circuit to:

- Remove steel scrap
- Remove large pieces not well incinerated
- Reduce the size below 40 mm
- Remove by eddy-current separator pieces > 15 mm

The resulting -40 mm bottom ash contain only a few percent of steel but still about 90% of its original content of non-ferrous metals (about 2.5% of the dry matter).

3) Such fraction is the feed for the pilot plant.

4) Classification by wet screening and cyclones into three fractions:

- Granulate (2-40 mm)
- Sand (63 – 2000 μm)
- Sludge (< 63 μm)

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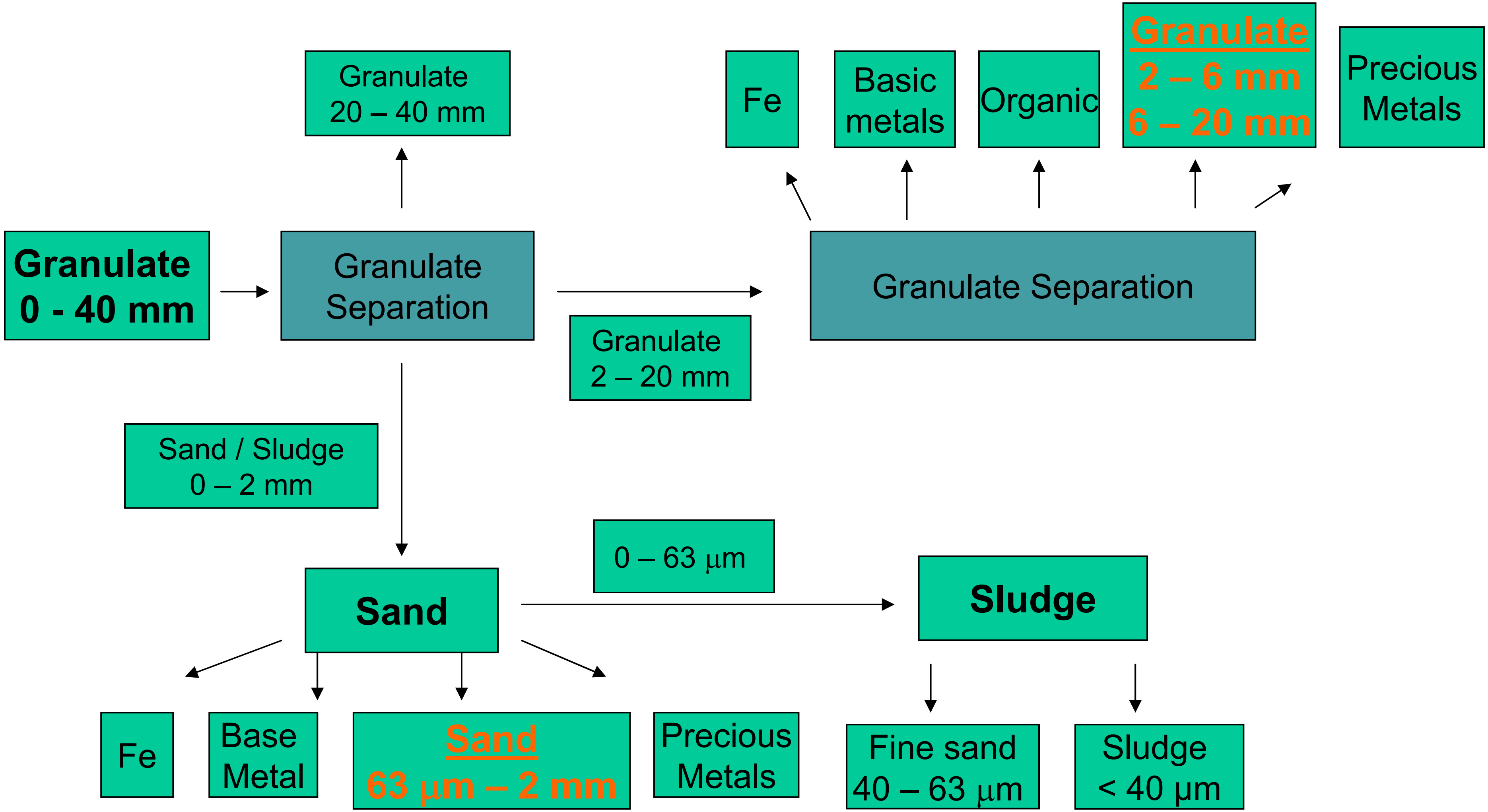
Bottom ash processing



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The products: Metals

Iron is separated from other waste and is supplied to the scrap metal trade, where it is finally recycled.

Basic and precious metals go to metal processing companies such as aluminium and copper smelters.

The quantity of metals and precious metals reclaimed is 3%.

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The products: Granulated material

The granulate fractions are supplied to the concrete industry to be converted into concrete with a clearly recognizable granulate structure.

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The products: Sand

The fine fractions obtained from bottom ash are used instead of natural sand in the sand-lime brick industry. The only difference from traditionally manufactured sand-lime brick is the color. It is therefore possible to replace quarried sand entirely.

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Bottom ash

The investigated problem

Considering that for their reuse bottom ash must comply with strict regulations, consisting of civil-technical and environmental requirements, its characterization is thus an important step in view of sustainable waste management. In particular, the presence of the so-called "organic matter" fraction represents a strong and severe constraint in respect of their re-use as "common" inert material.

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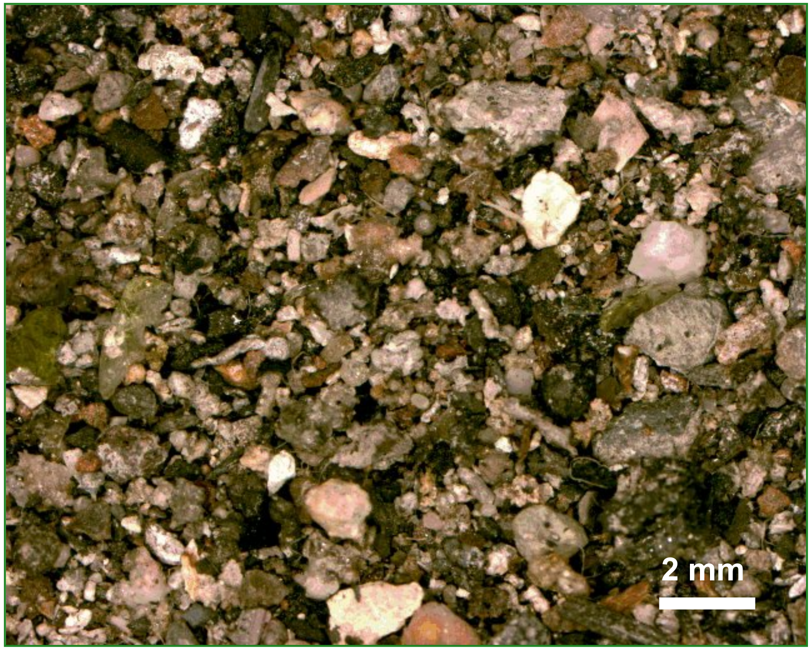
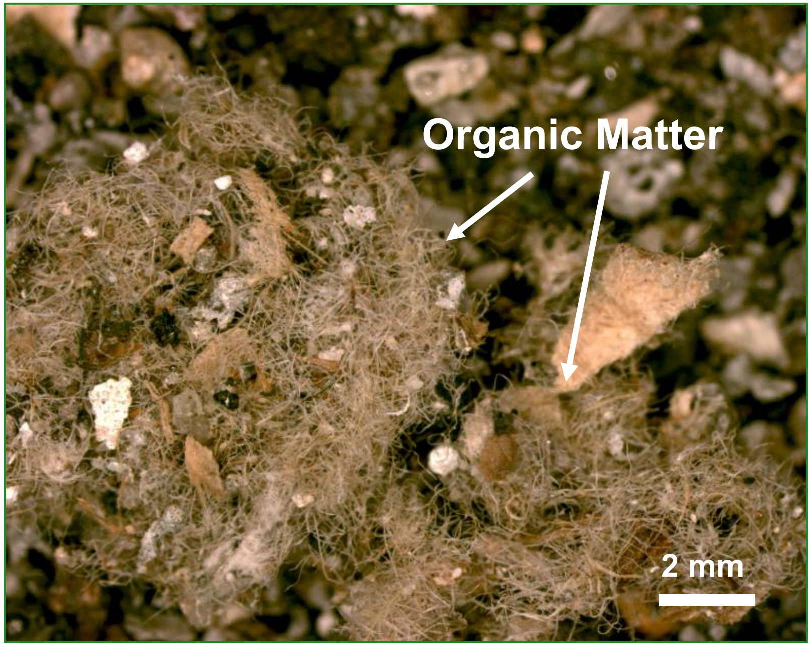
Materials and methods

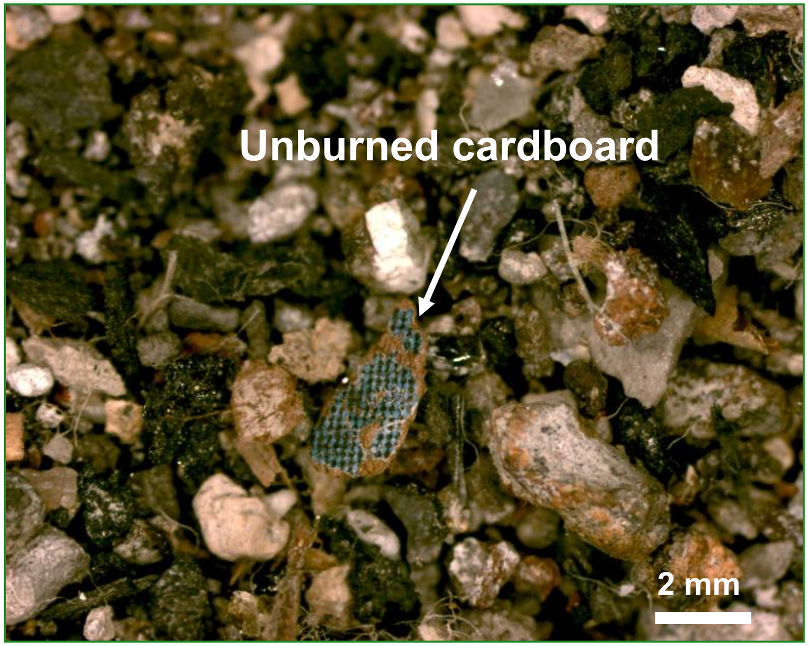


Selected samples of sand fraction (63 μm – 2 mm) obtained after bottom ash processing in the previous mentioned pilot plant have been collected and analyzed. Both chemical and hyperspectral imaging analyses have been carried out, in order to find a correlation between chemical composition of sand product, with particular reference to the organic matter content, and spectral signature in the VIS-NIR wavelength range.

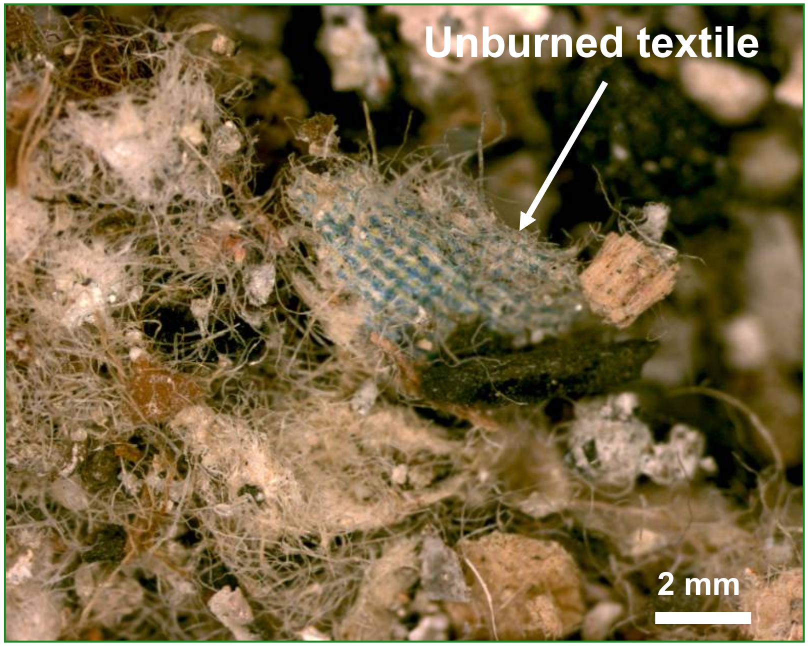
The analysed samples

Stereomicroscope images

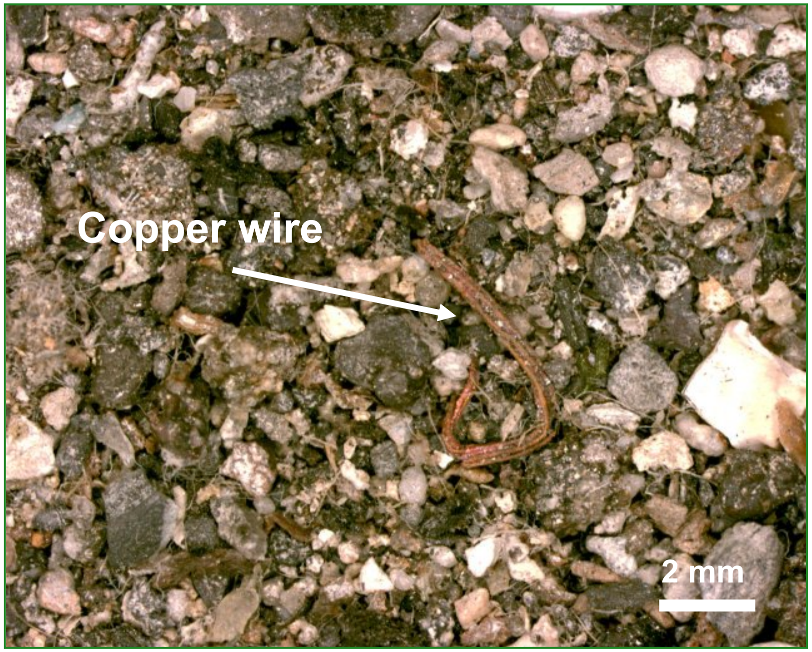


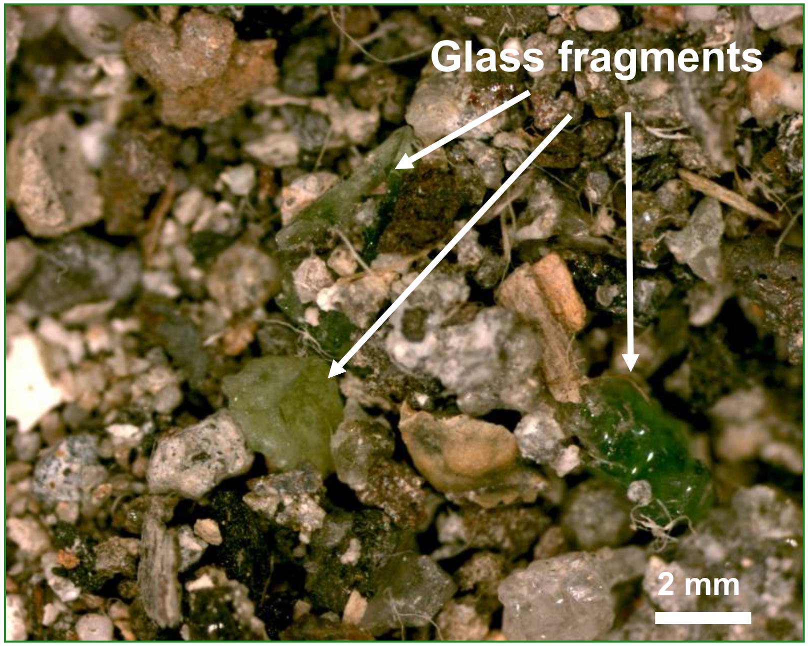


The analysed samples



The analysed samples





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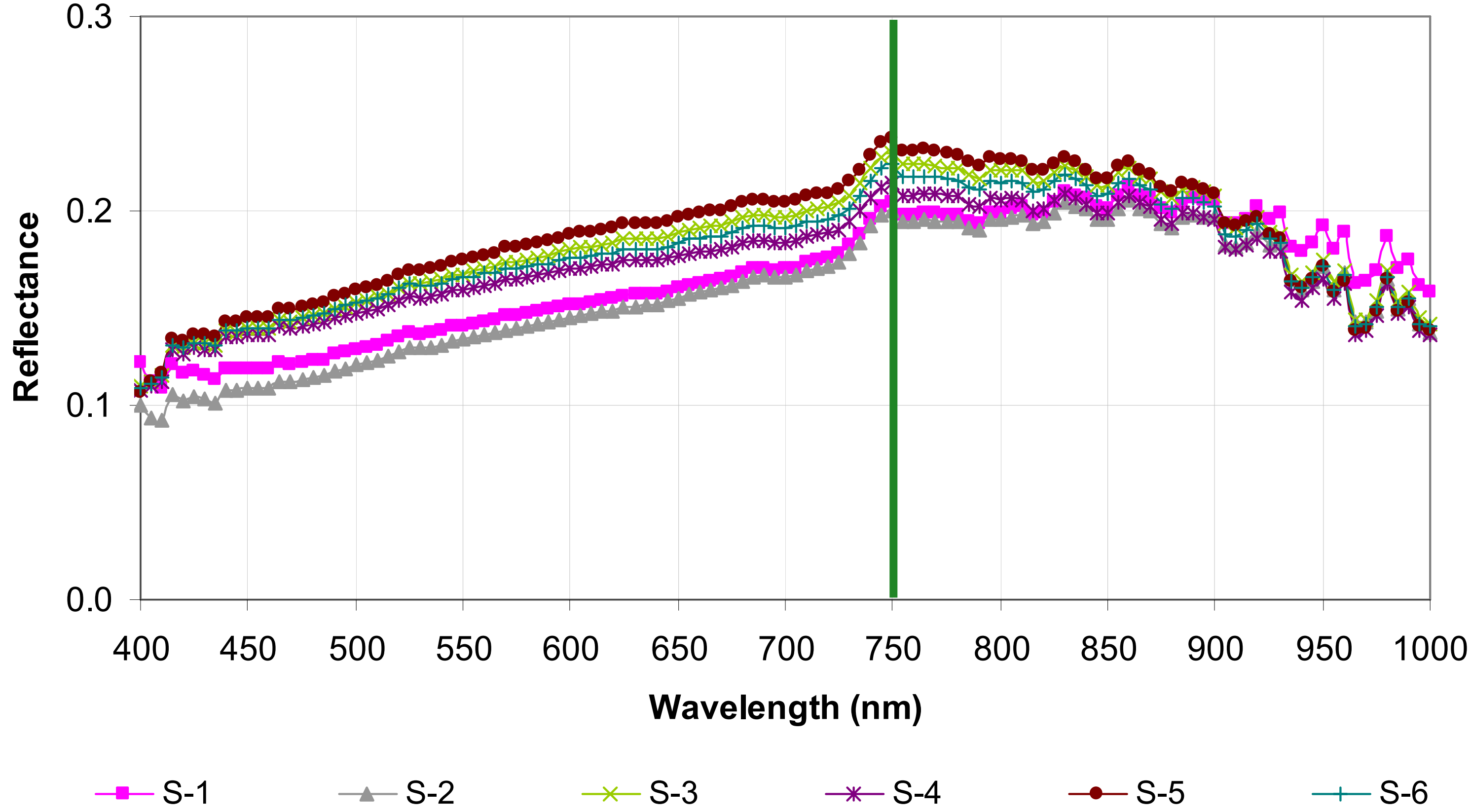
Experimental results

Reflectance spectra in the VIS-NIR field



Comparing the average spectral signatures of the different sand samples, it appears that they are characterized by curves presenting similar shape but increasing reflectance levels in the following order: S-2, S-1, S-4, S-6, S-3 and S-5.

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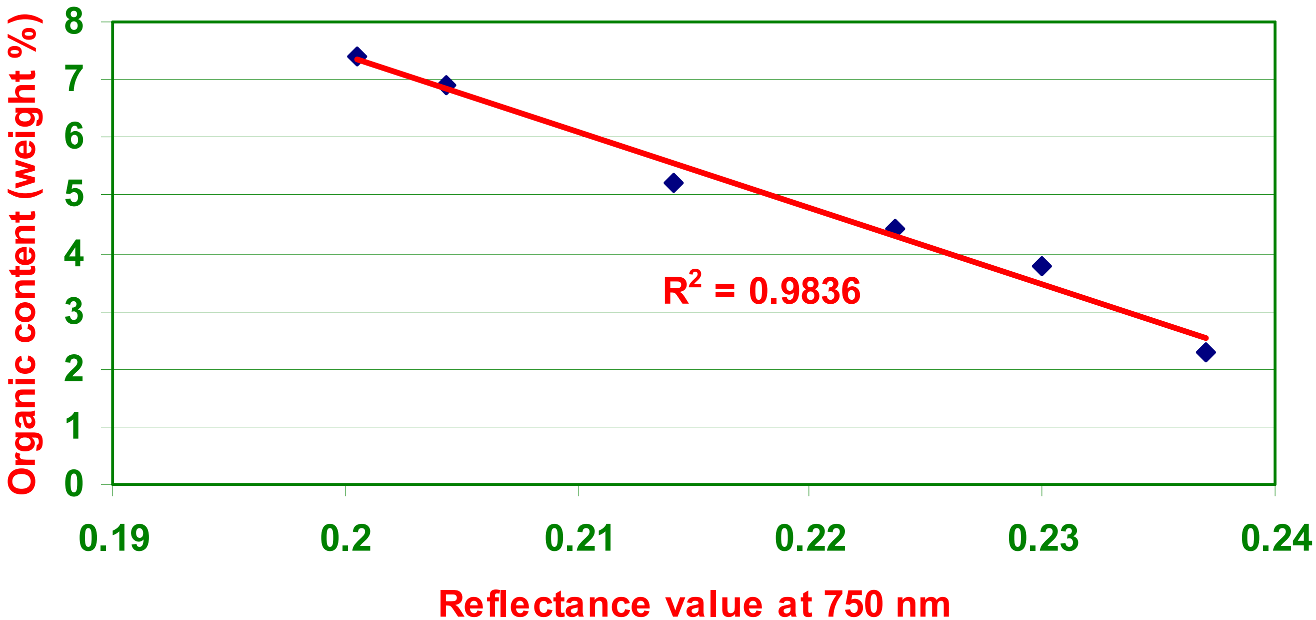
Experimental results

Organic matter (weight %) content

	S1	S2	S3	S4	S5	S6
Organic matter (%)	6.9	7.4	3.8	5.2	2.3	4.4



There is an **inverse correlation** between **reflectance level** and **organic matter content**. Such result is quite interesting as it would involve the possibility to introduce a sensor, on the final section of the bottom ash processing plant for **quality control of products** to be used as building materials.

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PCA

Principal Component Analysis

L'analisi delle componenti principali (PCA: Principal Component Analysis) è una tecnica per la semplificazione dei dati utilizzata in ambito della statistica multivariata.

Lo scopo primario di questa tecnica è la riduzione di un numero più o meno elevato di variabili (rappresentanti altrettante caratteristiche del fenomeno analizzato) in alcune variabili latenti.

Ciò avviene tramite una trasformazione lineare delle variabili che proietta quelle originarie in un nuovo sistema cartesiano nel quale la nuova variabile con la maggiore varianza viene proiettata sul primo asse, la variabile nuova seconda per dimensione della varianza sul secondo asse e così via.

La riduzione della complessità avviene limitandosi ad analizzare le principali (per varianza) tra le nuove variabili.

PCA

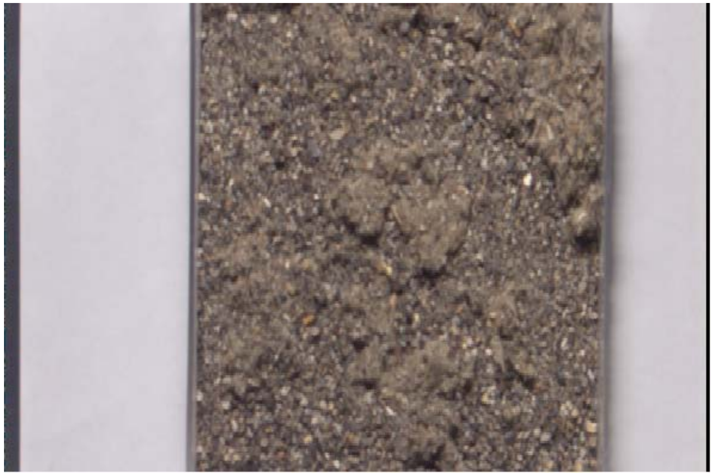
Vantaggi:

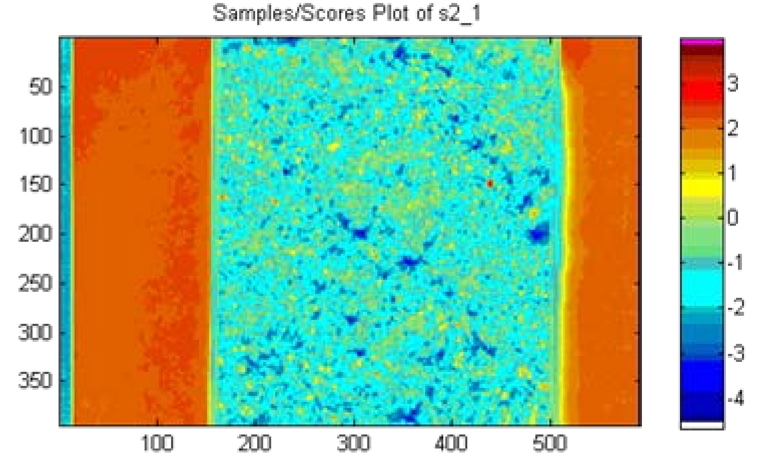
- Riduzione numerica della popolazione campionaria non ridondante
- Identificazione di pochi “caratteri salienti” per un campione
- Previo addestramento, possibilità di correlazione tra componenti principali e caratteristiche fisico-chimiche del campione (regressione ai minimi quadrati parziali o PLS)

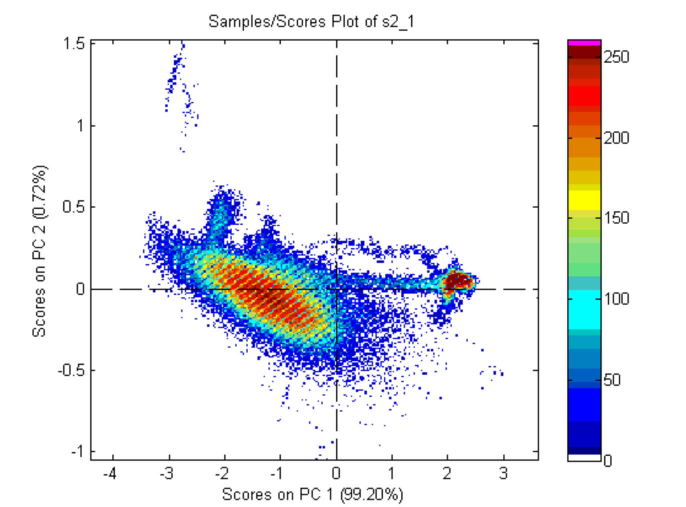
Svantaggi:

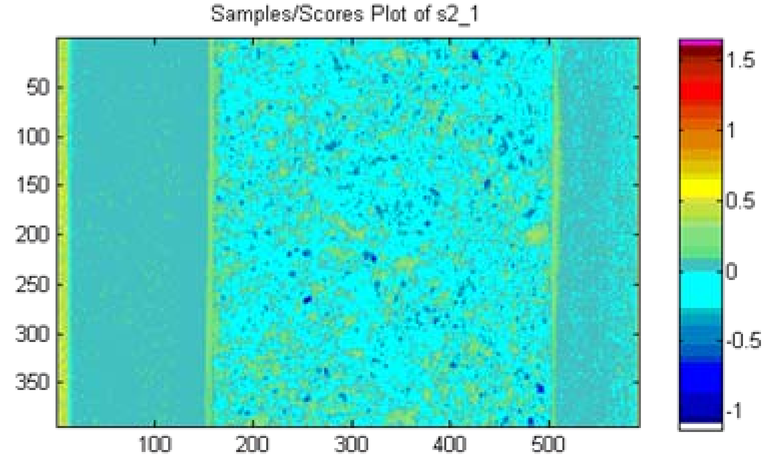
- Difficoltà di associazione tra componente principale e caratteristica reale del fenomeno analizzato

PCA: Immagine ricostruita









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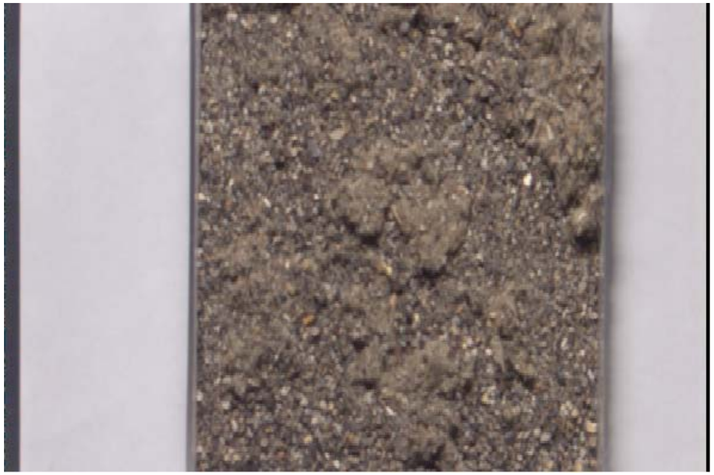
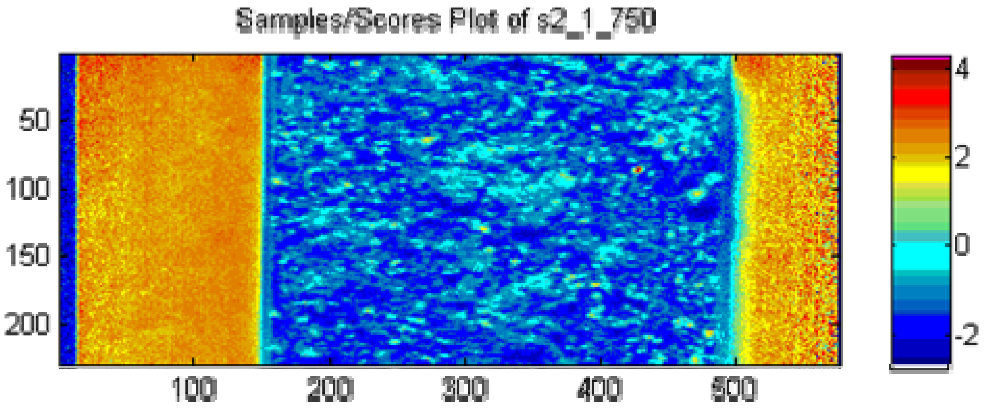
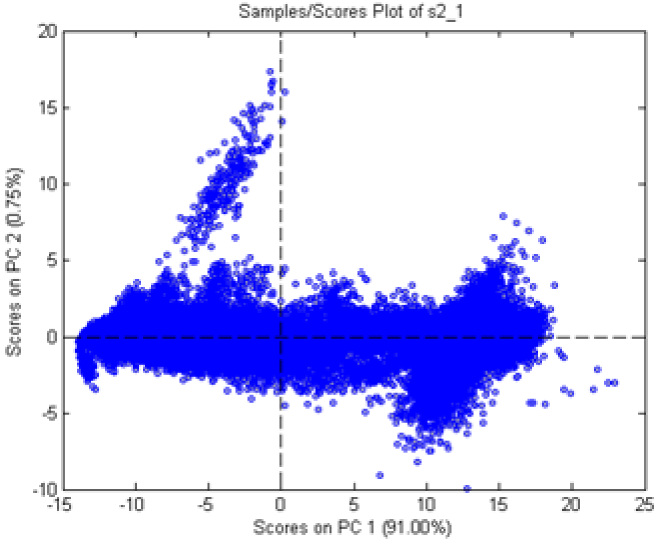
PCA: Dati numerici e single wavelenght







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