REUSE OF WASTE MATERIAL FOR CIVIL APPLICATION: A STUDY OF MUNICIPAL INCINERATOR BOTTOM ASH COMPOSITION AIMED TO INERTIZATION AND RECYCLING

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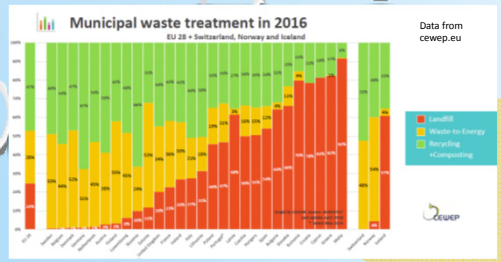
INTRODUCTION



In Italy, around 82 wt% of BA produced by incinerators was treated in 2016 for reuse and only 18% was landfilled. Statistical data of ISPRA – Institute for the Protection and Environmental Research (ISPRA, 2014,2017) show differences which depend on the geographical areas: northern Italy recovers some 75,6 wt% of the bottom ashes, while central Italy only 8,4 wt%, and southern Italy about 15,9 wt%.

Most of the recovered material is represented by additive for cement (97 wt%); the remaining is destined to ferrous and non-ferrous metals recovery (Riva et al., 2016) and to provide a base material for landfills (Puma et al., 2013).

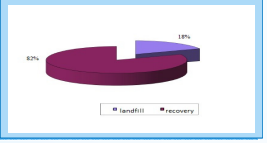
According to the Italian Legislation about reuse of waste (Decree n.186 of the 5th April 2006) BA can be reused without any treatment or acceptance test for the production of cement, bricks and expanded clay. In the case of road material, bottom ashes can be used if leaching tests comply with the thresholds provided for heavy metals (Lombardi and Carnevale, 2016).

Municipal **S**olid **W**aste after thermal treatment

20% BOTTOM ASHES (**BA**) — 2% FLY ASHES (**FA**)

In Italy BA are taken by specialized Societies and converted mostly in secondary raw materials, available only if included in other matrices (problem of the release of chemical species in the environment).

82% of bottom ash landfilled
18% recovered
(Data from ISPRA, 2017)

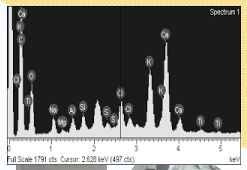


SOLID CHARACTERIZATION

A mineralogical and chemical-compositional characterization of the BA was performed; X-ray diffraction was used to define the characteristic mineralogical phases. The chemical composition was defined with different approaches: analysis by X-ray microfluorescence and ICP/OES after microwave digestion of the samples. Finally, with electronic scanning microscopy coupled with an EDS probe, compositional maps were created.

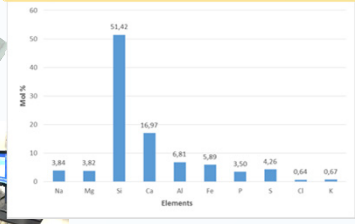
CHEMICAL AND MINERALOGICAL DETERMINATION
- XRF
- ICP/OES+MW DISSOLUTION
- SEM-EDS
- X-RAYS DIFFRACTION

CHEMICAL COMPOSITION



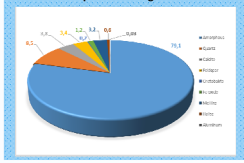
Chemical composition of BA was determined by combining data from µ-XRF, SEM-EDS and ICP-OES after microwave digestion in nitric acid. The analyzed chemical species are Si, Ca, Al, Fe, P, S, Cl, K, Ti, V, Cr, Mn, Ni, Cu, Zn, As, Sr, Se and Pb.

Overall composition (XRF + microwave digestion values) of BA; average values calculated without grain size discrimination.

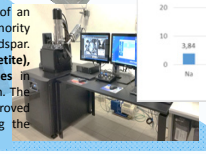


MINERALOGY AND SOLID COMPOSITION

FULL SAMPLES (no grain size)
Two samples without grain size discrimination have been analyzed



All the samples contain a large amount of an **amorphous phase** (> 50 wt%) with minority phases as quartz, calcite and feldspar. **Cristobalite, Fe oxide (hematite or magnetite), melilite and halite were found as traces** in samples with grain size lower than 10 mm. The presence of crystalline phases as **melilite** proved the reaching of high temperature during the firing process of the waste.



SAMPLING

Sampling was performed directly from the belts by placing a container under the hopper. The collected sample is representative of every element that is not affected by the granulometric differentiation phenomena that occur during the formation of the heaps.

From 150 kg of collected BA, a 20 kg sample was obtained through a quartering.

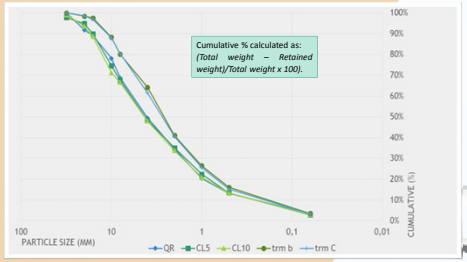
150 Kg
20 Kg

DIMENSIONAL CHARACTERIZATION

The sample taken was further subdivided to obtain subsamples of a weight of 2 kg.
A mechanical riffle splitter was used for this operation.

The granulometric distribution of the BA subsamples was defined using 10 sieves with standard openings from 0.063 mm to 20 mm.

The results show a good quality of the quartering process in terms of representativeness of the sample highlighting the D_{90} value equal to 4 mm. Following the subsequent determinations, a dimensional unification was carried out identifying the 3 classes shown in the table.



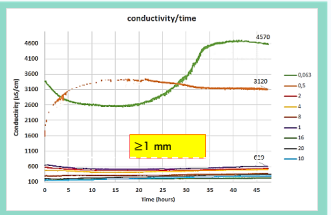
>4 mm	4 -1 mm	<1 mm	water content	loose bulk density
% wt	% wt	%wt	%wt	kg/l
39	36	25	17	1,095

RELEASE IN WATER CHARACTERIZATION

RELEASE TESTS

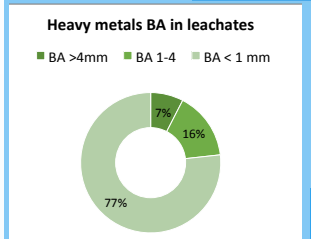
- LEACHING TESTS WITH CONDUCTIVITY LOGS
- ICP-OES AND CHROMATOGRAPHY ANALYSIS OF LEACHATES

Leaching test were performed for each grain size in deionized water, monitoring conductivity vs time, and pH.



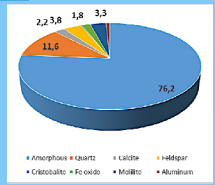
≥1 mm BA
low conductivity (< 1000 µS/cm)
pH 10-10.5,
low concentration of Cl^-(<500mg/l) and SO_4^{2-} (<100 mg/l)

< 1 mm BA
High conductivity (>4000 µS/cm)
pH > 11.5
High concentration of Cl^- (up to 1800 mg/l) and SO_4^{2-} (up to 100 mg/l)



The sum of the heavy metals concentrations in the leachates of BA <1 mm is more than three times larger than the one in the case of grain size ≥ 1 mm.

After leaching, in the residual solid fraction, halite disappears; calcite and amorphous decrease.



CONCLUSIONS
The average *mol*-composition of the BA is represented by 52% Si, 17%Ca, 7% Al, 6% Fe, 4% Na and Mg.
The highest concentrations of heavy metals (mol %) are represented by Ti (1,3%), Zn (0,3%), Cu (0,2%) and Cr (0,2%); concentrated in the finer grain sizes.
Heavy metals (Cu, Zn, Pb, Ni, Cr) after leaching concentrate in the finer grain size (< 1mm), especially Cu (<3 mg/l).

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