



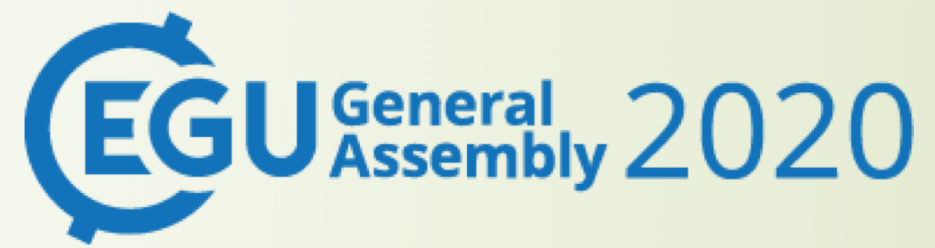
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Environmental managing of bottom ashes from municipal thermovalorization waste for civil applications, as a function of particle size, based on steam washing

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Ashes from municipal solid waste thermovalorization plant

Municipal solid waste after the treatment in the incinerator plant are:

Today



20% BOTTOM ASHES (BA)



2% FLY ASHES (FA)

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: soluble salts and heavy metals). [4], [7]

For 500.000 tonnes of waste produced every year 100.000 tonnes are represented by bottom ashes.

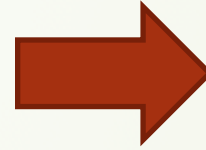
Our study is aimed to improve the environmental compatibility of the BA using sustainable methods

Reuse of bottom ash (BA)

- In Italy bottom ashes (BA) are classified as “*not dangerous special waste*” and identified by the code CER 190112.
- They are reused in cements and in the industry of brick and clay [6],[7].
- Leaching test is required to be reused for base roads and enviromental applications following the Ministerial Decree 186/2006 for waste reuse [8].

Methods to reduce the release in the environment: steam washing

- Water washing [1], [2], [3]
- Metal separation [7]
- Carbonation /maturation [5], [9]



Reducing the release in water of heavy metals and salts (chlorides and sulfates) under the threshold value for reuse



Steam washing is a sort of washing by water using the power of steam (2 bar of pressure) at different times of treatment to remove the dust from the BA surface. A thermovalorization plant can produce 220 t/h of steam



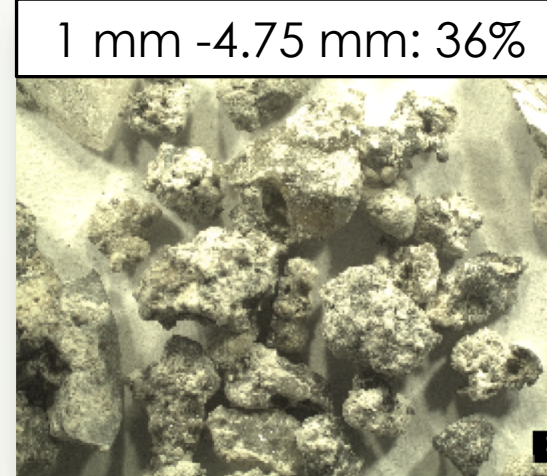
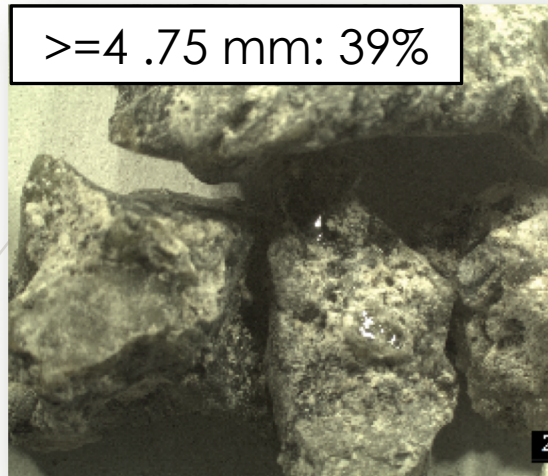
Bottom ashes grain size distribution



Before the treatment BA were separated in different grain size as function of the treatment: coarser to finer, in order to improve and optimize the time of treatments

>4,75 mm	4,75 -1 mm	<1 mm
% wt	% wt	%wt
39	36	25

Treatments to reduce the release in the enviroment



Steam washing



4.75 mm >BA ≥ 2
22%



2 mm >BA ≥ 1 mm
14%

Not suitable for washing
Need of other treatments:
carbonation, stabilization
etc...

A further split of the 1-4.75 mm grain size was seen to be functional to the steam washing

Bottom ash Washing: Water Balance

12 L water for 600 s treatment, of which 75-91% can be recovered by condensation

Water used: 35 ml-60sec

Steam Generator
(2 bar, 75°C)



Water Balance for 1 Kg BA → 0,02 l/kg/s

Grain size (mm)	Time (sec.)	Ads. Water %	Free steam %	Waste water %	Loss of weight %
≥4.75	240	3	91	6	0,4
4.75 mm >BA ≥ 2 mm	600	2	85	13	5
2 mm >BA ≥ 1 mm	600-720	13	75	12	10

free steam: 75-91 wt%

Adsorbed Water: 3-13 wt%

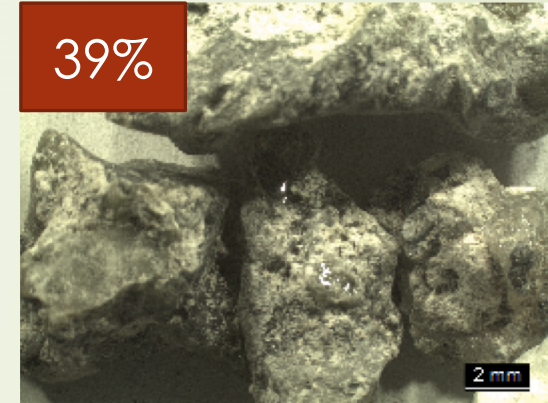
Sample weight: 30 g



Waste water: 6-13 wt%

Bottom ash grain size ≥ 4.75 mm

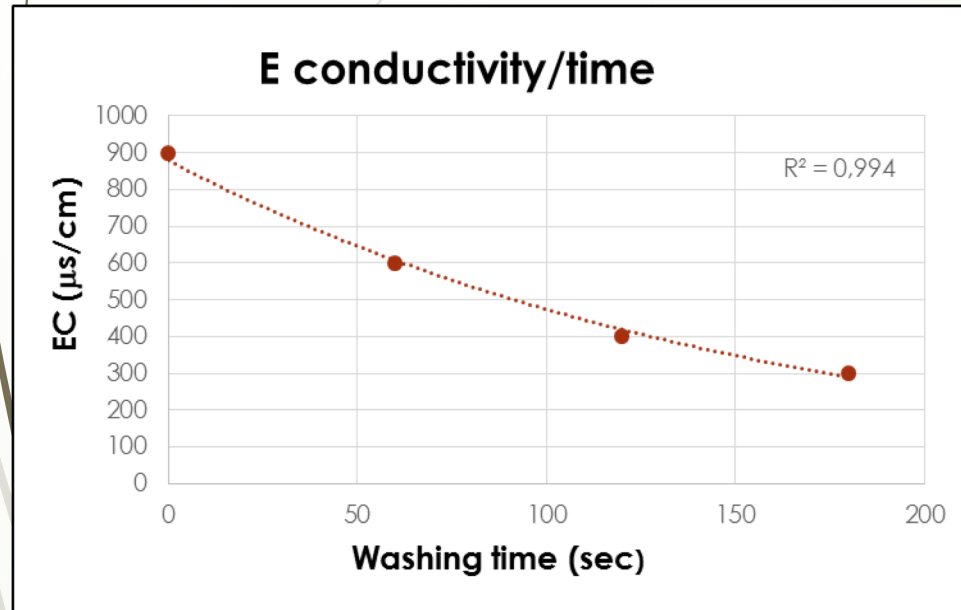
39%



Steam washing

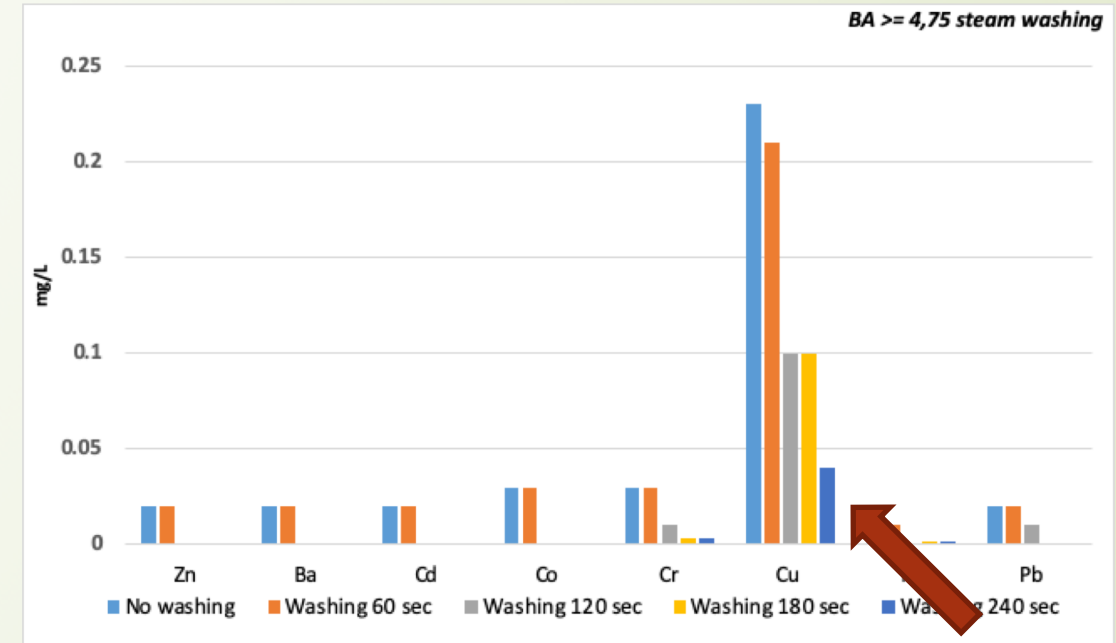
After 240 sec chlorides and heavy metals are under the threshold limits

Time of Washing: 60, 120, 180, 240 s



EC decrease from 980 to 300 $\mu\text{S}/\text{cm}$

LEACHING TEST



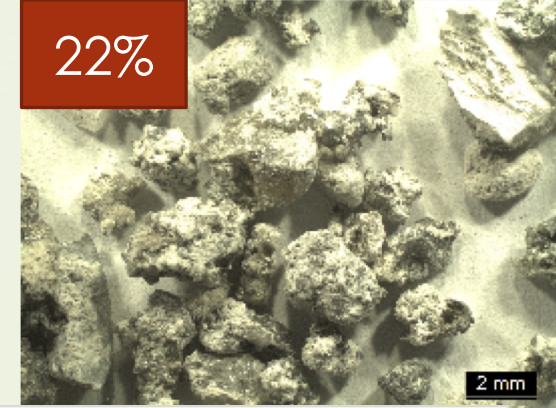
Cu value under TVL

s ≥ 4.75 mm, steam washing	Cl ⁻	SO ₄ ²⁻	NO ₃ ⁻	Zn	Ba	Cd	Co	Cr	Cu	Ni	Pb
Unwashed	254	52	0.4	0.02	0.02	0.02	0.03	0.03	0.23	0.01	0.02
Steam Washing (60 sec)	93	35	0.2	0.02	0.02	0.02	0.03	0.03	0.21	0.01	0.02
Steam Washing (120 sec)	31	19	n.d.	n.d.	n.d.	n.d.	n.d.	0.01	0.1	0.002	0.01
Steam Washing (180 sec)	42	13	0.33	n.d.	n.d.	n.d.	n.d.	0.003	0.1	0.002	0.002
Steam Washing (240 sec)	40	19	0.137	n.d.	n.d.	n.d.	n.d.	0.003	0.04	0.002	0.001
Italian Legisl. Limits (mg/L)	100	250	50	3	1	0.005	0.25	0.05	0.05	0.01	0.05

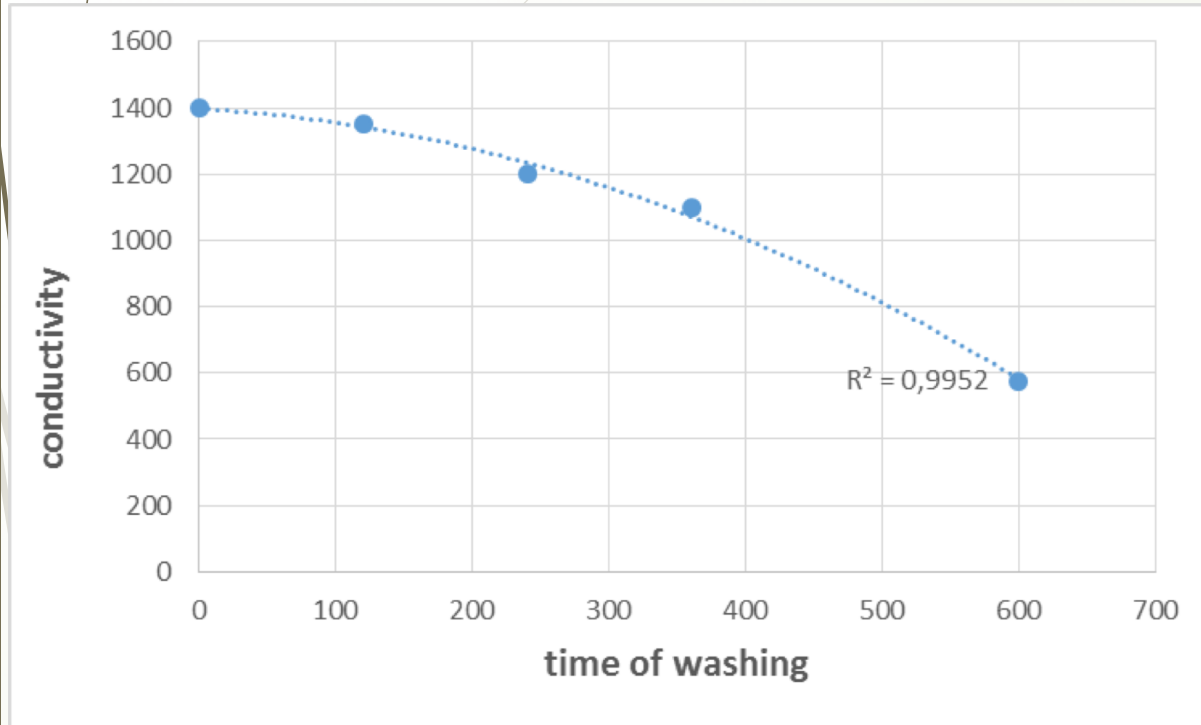


Bottom ash grain size $4.75 \text{ mm} > \text{BA} \geq 2 \text{ mm}$

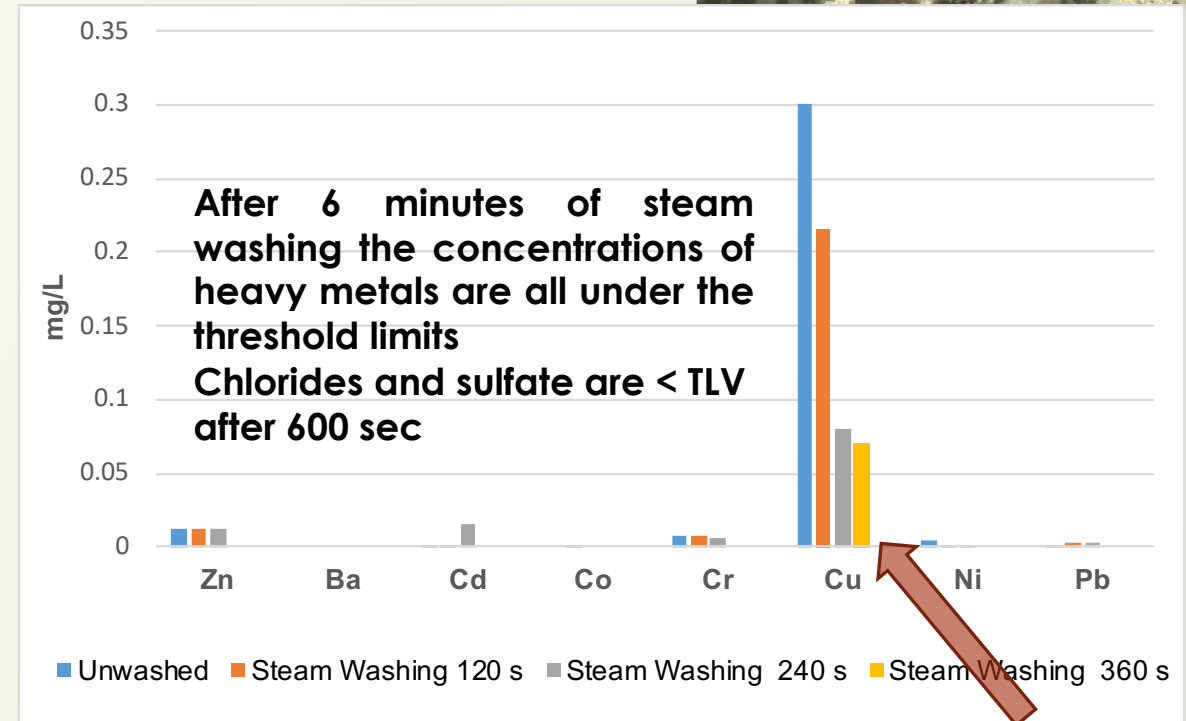
22%



Steam washing 120, 240, 360, 600 sec



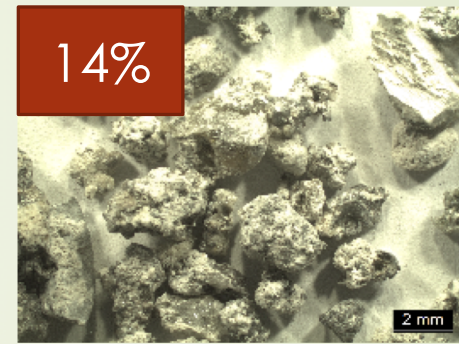
EC decrease from 1400 to 600 $\mu\text{S}/\text{cm}$



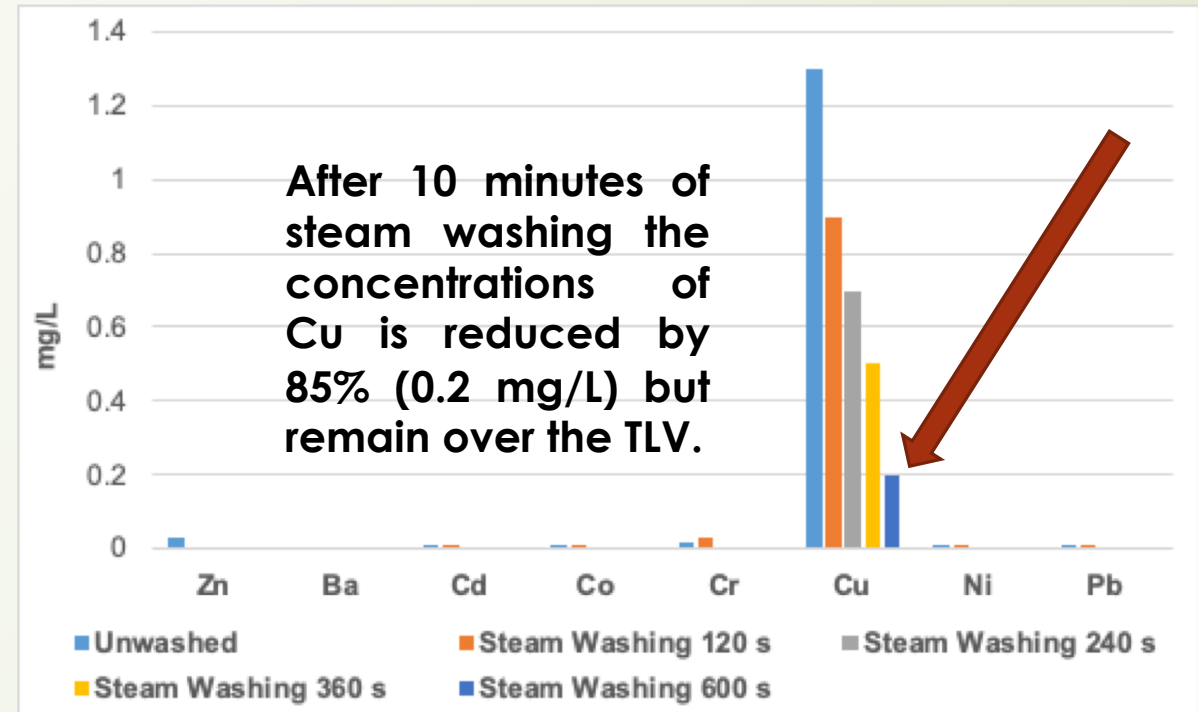
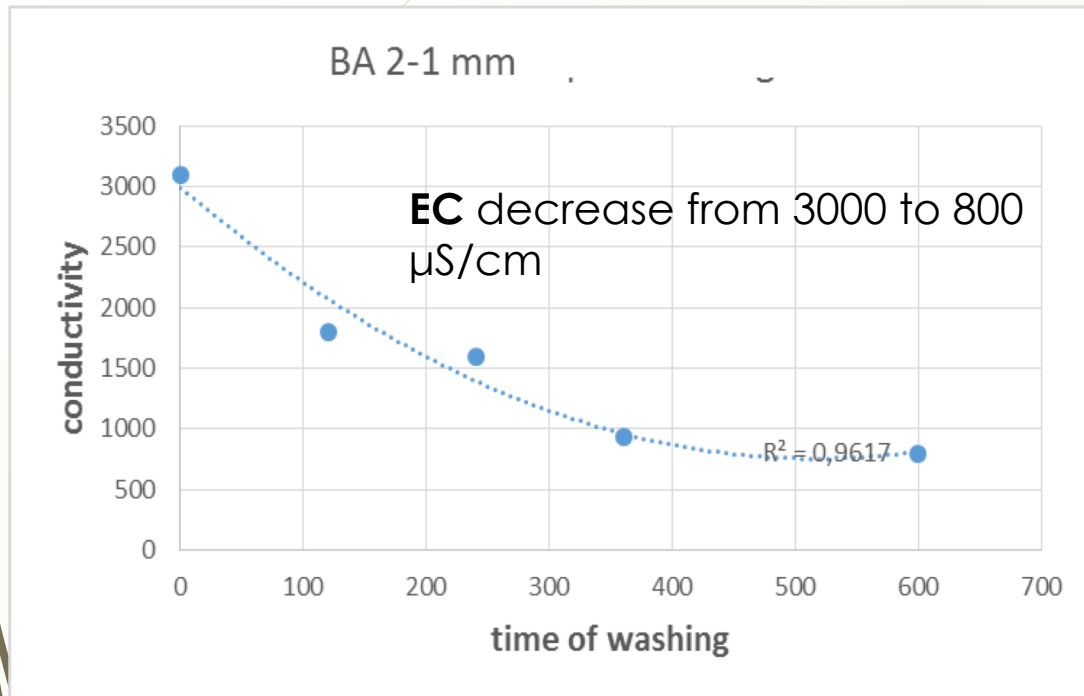
4.75 > s ≥ 2 mm steam washing	Cl ⁻	SO ₄ ²⁻	NO ₃ ⁻	Zn	Ba	Cd	Co	Cr	Cu	Ni	Pb
Unwashed	258	115	n.d.	0.012	n.d.	0.001	n.d.	0.008	0.3	0.004	0.001
Steam Washing (120 sec)	220	100	n.d.	0.012	n.d.	0.001	n.d.	0.008	0.215	0.002	0.003
Steam Washing (240 sec)	200	90	n.d.	0.07	n.d.	0.015	n.d.	0.006	0.08	0.001	0.03
Steam Washing (360 sec)	186	79	n.d.	n.d.	n.d.	n.d.	n.d.	n.d.	0.07	n.d.	n.d.
Steam Washing (600 sec)	80	44	n.d.	n.d.	n.d.	n.d.	n.d.	n.d.	n.d.	n.d.	n.d.
Italian legislation thresholds (mg/L)	100	250	50	3	1	0.005	0.25	0.05	0.05	0.01	0.05

Bottom ash grain size 2 mm > BA ≥ 1mm

14%



Steam washing 120, 240, 360, 600 sec

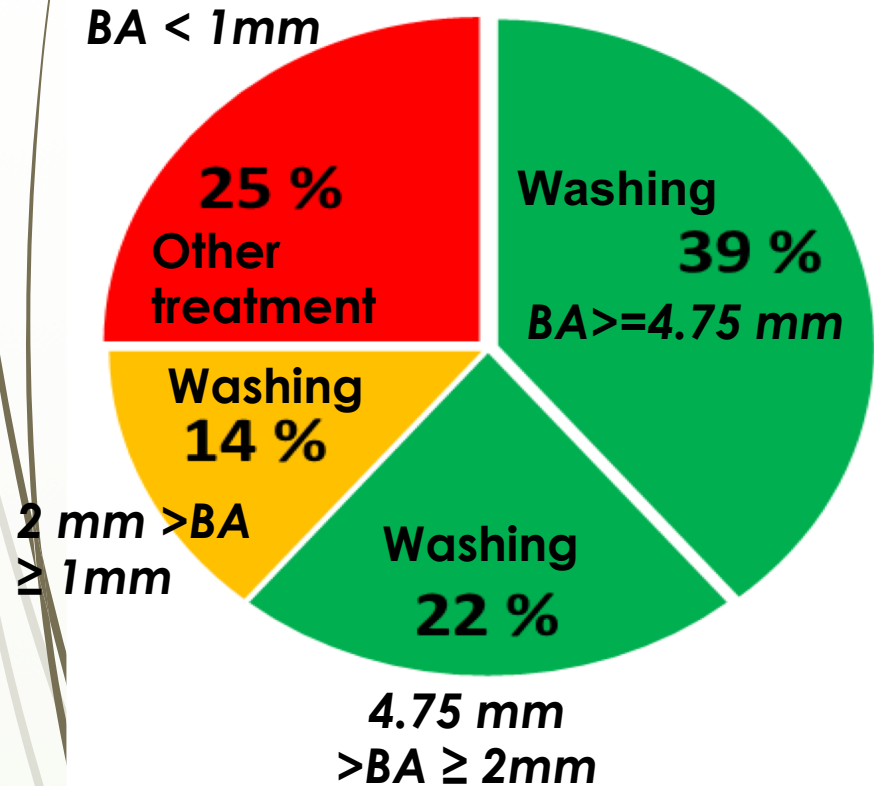


2 > s ≥ 1 mm steam washing	Cl ⁻	SO ₄ ²⁻	NO ₃ ⁻	Zn	Ba	Cd	Co	Cr	Cu	Ni	Pb
Unwashed	600	250	n.d.	0.031	n.d.	0.001	0.003	0.02	1.3	0.004	0.003
steam washing (120 s)	550	200	n.d.	n.d.	n.d.	0.005	0.006	0.02	0.9	0.001	0.003
steam washing (240 s)	410	180	n.d.	n.d.	n.d.	n.d.	n.d.	n.d.	0.7	n.d.	n.d.
steam washing (360 s)	118	67	n.d.	n.d.	n.d.	n.d.	n.d.	n.d.	0.5	n.d.	n.d.
steam washing (600 s)	16	11	n.d.	n.d.	n.d.	n.d.	n.d.	n.d.	0.2	n.d.	n.d.
Italian legislation thresholds (mg/l)	100	250	50	3	1	0.005	0.25	0.05	0.05	0.01	0.05

Chlorides and sulfate are < TLV



Results of the treatments



39+22%: OK after steam washing (240-600 s);

14%: OK chlorides and sulfates after steam washing, Cu reduced by 85% (0.2 mg/l) over 720 s

25%: OK heavy metals by accelerated carbonation; chlorides > legal limits

- Need to improve pressure and T° of the steam;
- Metal separation before treatment

Need to improve treatments

Bottom Ash Steam Washing

Water Balance for 1 Kg BA treated

Grain size (mm)	BA weight (KG)	Time (sec)	Water used (L)	Ads. Water (L)	Free steam (L)	Waste water (L)	Loss of weight (Kg)
≥4.75	1	240	4.8	0.144	4.368	0.288	0.004
4.75 mm >BA ≥ 2mm	1	600	12	0.24	10.2	1.56	0.05
2 mm >BA ≥ 1mm	1	600	14.4	1.872	10.8	1.728	0.1

Results and conclusions

- Around 39+22% of the whole bottom ash production of a MSWI plant can be recovered using steam washing:
- $BA \geq 4.75$ mm can be recovered using steam washing for 240 seconds
- $4.75 \text{ mm} > BA \geq 2 \text{ mm}$ can be recovered using a steam washing up to 600 seconds.
- The group $2 \text{ mm} > BA \geq 1 \text{ mm}$, after a steam washing of 600 seconds, has still $\text{Cu} > 0.05 \text{ mg/L}$. Pressure and T° of the steam need to be improved.
- Waste water is proportional to the time of treatment (6 to 13% of the total of water used for steam washing) and needs to be treated
- The grain size $< 1 \text{ mm}$ requires different treatments to improve its environmental quality due to the high concentration of heavy metals and salts.

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