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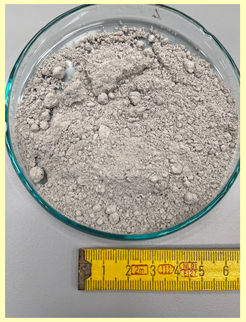
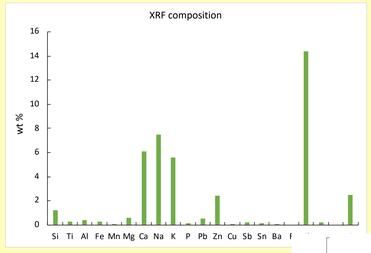
INTRODUCTION

Due to the high content of heavy metals and soluble salts, municipal solid waste incineration fly ash (MSWI FA) is classified as hazardous waste and its reuse is limited for their environmental risks. This work analyzes the steam washing application, to remove chlorides and heavy metals from MSWI FA, in order to reach a condition of non-hazardous waste, making them more suitable for stabilization as geopolymers or cement. The target of the steam application is both a sustainable and optimized utilization of water, to reduce the waste-water, and to take the advantage of the heat generation to dissolve most of the soluble salts; moreover, the steam is a resource often available in the waste-to-energy plant. Pre-treated (washed by water) samples of fly ash were also tested with steam washing for comparison. Analyses on solid FA and leachates in water were applied before and after the steam washing treatment.



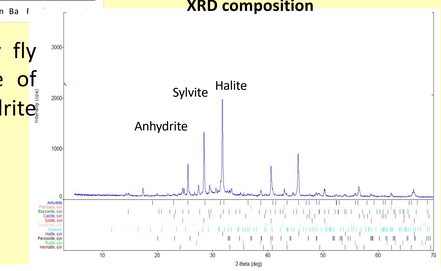
MSWI fly ash raw sample.
The particle size is fine and D50 is 149 µ.



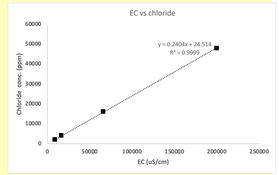
MSWI FLY ASH CHARACTERIZATION (RAW SAMPLES)

The composition of raw fly ash from MSWI is made of salts (halite, sylvite, anhydrite) and heavy metals).

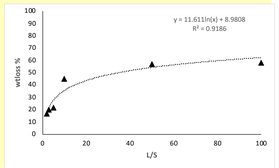
XRD composition



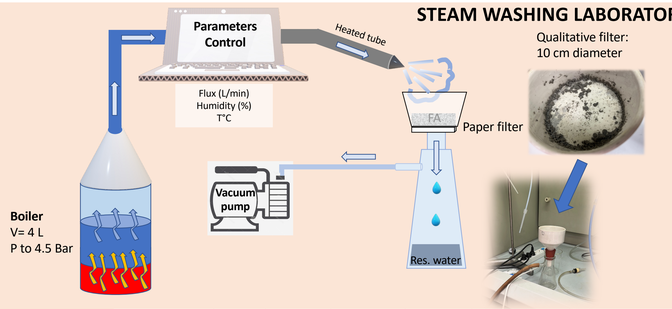
Water release at different L/S



The leachates composition of FA in deionized water shows a linear increase of EC (electrolytical conductivity) with chloride concentration.
The weight loss at different L/S ratios follows a logarithmic trend.



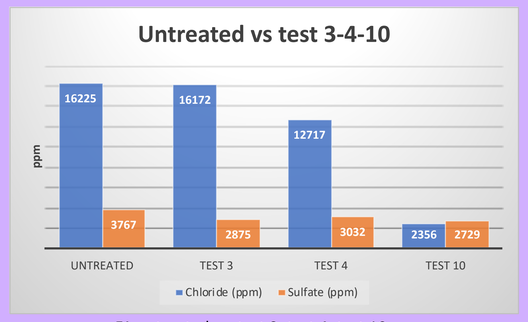
STEAM WASHING LABORATORY EQUIPMENT AND PARAMETERS

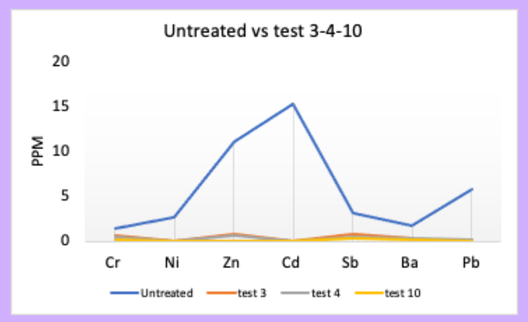


Steam washing experiments were performed at different times, air flux and humidity %, continuously monitored by sensors, keeping a low enthalpy steam (T< 100°C) for some cycles of washing; a vacuum pressure was applied continuously or alternately with steam to remove rapidly the superficial water in the washing chamber. Pretreated (pre-washed) samples or untreated samples of FA were tested, as explained in the following table.

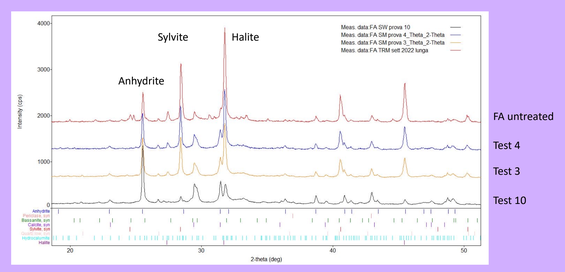
Steam wash test id. number	Sample wt (g)	Time of steam washing (min)	Humidity (%)	Air flux (L/min)	FA Pre-treatment	Vacuum pump	EC of the residual water (µS/cm)	Water used (L) for steam washing	Weight loss
3	2	4	30	2.8	No pre-treatment	Vacuum pressure applied continuously	38000	4 mL/min	17%
4	5	8	30	2.8	No pre-treatment	Vacuum pressure applied continuously	200000	4 mL/min	30%
6	4	8	35	2.4	L/S 2 wash 24 h	Vacuum pressure applied alternately with steam	120000	5 mL/min	30%
9	4	8	40	2	L/S 2 wash 24 h	Vacuum pressure applied alternately with steam	100000	5.5 mL/min	30%
10	4	8	40	2	No pretreatment	Vacuum pressure applied alternately with steam	150000	5.5 mL /min	30%

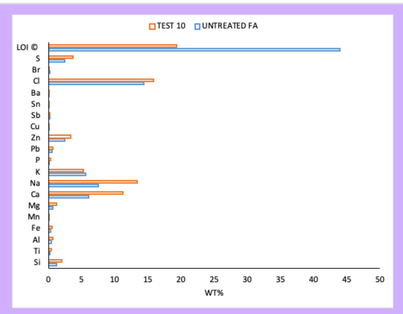
RESULTS OF STEAM WASHING TREATMENT OF UNTREATED FA SAMPLES (TEST 3,4,10)





FA untreated vs. test 3, test 4, test 10



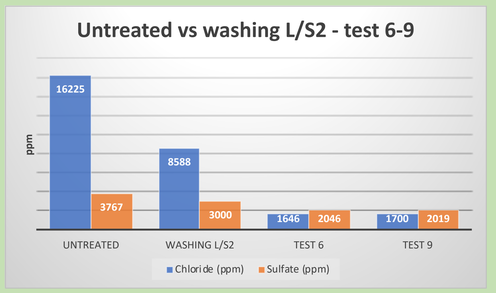


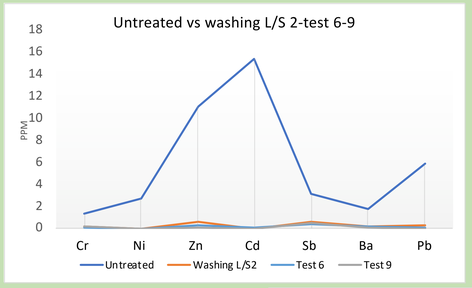
XRF analysis of untreated vs Test 10

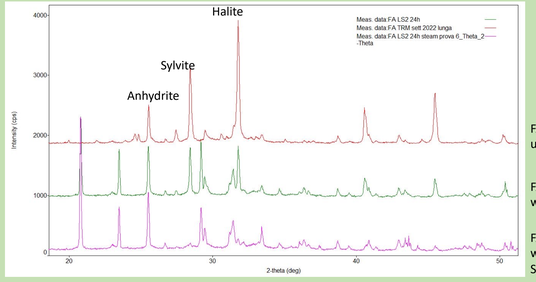
Chlorides and sulfates was seen to decrease by 85%, using a steam flux of 2L/min and humidity of 40% v/v; heavy metals, like Cd, Zn, Pb the removal was up to 80% at the same conditions.

RESULTS OF STEAM WASHING TREATMENT OF PRE-TREATED (WASHING AT L/S 2, 24 h) FA SAMPLES

Untreated FA samples are compared to: a L/S 2 washing sample and test 6 and 9 (sample washed at L/S 2 coupled with steam washing treatment)





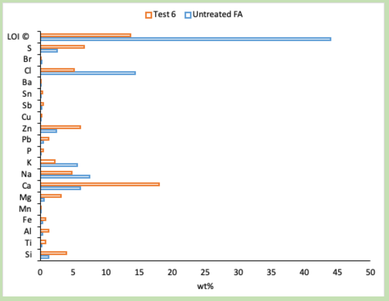


FA untreated

FA L/S 2 washing 24 h

FA L/S 2 washing 24 h + SW (test 6)

XRF analysis of untreated FA and treated FA (after test 6 with steam washing)



Chlorides and sulfates are removed by 89% and 46% respectively; for heavy metals, like Cd, Zn, Pb the removal was up to 90%. Halite and sylvite decrease in the FA washed , while anhydrite increases, because its low solubility in water: this is also confirmed by XRF analysis. The variation of humidity and air flux seem to be not so relevant in the results: test 6 and test 9 shows the same release concentrations in water.

CONCLUSIONS

The steam washing was seen to be efficient in removing water-soluble chlorides including sodium chloride, potassium chloride, sulfates as well as heavy metals. The best efficiency of chlorides and sulfates removal on untreated FA was seen to be by 85%, using a steam flux of 2L/min and humidity of 40% v/v (test 10); while for heavy metals, like Cd, Zn, Pb the removal was up to 80% at the same conditions. The application of steam washing on pretreated samples shows a higher efficacy in chloride and sulfate removal, while for heavy metals in both the cases the steam washing can bring the concentrations below the legislation limits for non hazardous waste, according to the EC/2003/33 decree and Italian Legislation Decree 121/2020. Further tests are still in progress, to optimize the steam washing efficiency, and even for wastewater treatment.