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Characterisation of automobile shredder residue

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The objective of this work was to describe the automobile shredder residue in order to study an appropriate final destination for this waste.
Granulometric classification was operated and it was noticed that 60% of car fluff sample was a fraction < 0.5 mm of diameter. Metals content was investigated and results showed that Fe were 65% of total metals content while the second most abundant metal was Cu or Zn depending on granulometric fraction. A metal speciation was operated and it was noticed that only Zn and Cd were easily removable by bland acid attack, while Fe and Al required a stronger acid attack to be removed.

1. Introduction

Growing concern towards environmental impact of end of life vehicle (ELV) along with the lack of primary raw materials focused the attention towards the development of new recycling strategies occurring to the valorisation of secondary raw materials.
Currently, about 75% of ELV (expressed as total weights) is recycled in EU countries while the remaining 25%-30% is called auto shredder residues (ASR) or car fluff. This waste is made up of plastic, rubber and tissue (70%), metals (20%), glass and other rubbles (10%).
Due to its highly heterogeneous and variable composition car fluff can be classified as "special waste" or as "hazardous waste" depending on the presence of hazardous substances (Decisions 2000/532/EC, 2001/18/EC2, 2001/119/EC3 e 20001/573/EC4 of Council). Nevertheless car fluff is generally disposed of as landfill.
Guideline 2000/53/EC established that after January 2015:

1. reuse and recovery of all ELV shall be increased to a minimum of 95%
2. recovery and recycling of all ELV shall be increased to a minimum of 85%

Conventional route for recovery of end of life vehicle include pre-treatment or de-pollution (e.g. removal of tires, the battery, lubricants and fuel), shredding and sorting of the vehicle to recover valuable metals (75%) which can be recycled in iron and stealmaking processes.

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Car fluff generated from this process, after shredding of the ELV, can be used for energy recovery in a cement kiln, for feedstock in a blast furnace and for syngas due to a high heat of combustion of this waste.

Car fluff is the fraction which is obtained from the process of shredding cars, after recovery of iron and steel by magnetic separation (fig.1). In the "Italferro s.r.l" plant, car wrecks are shredded by special mill and then cleaned from light materials such as paper, rubber, etc, by counter-current air flow. After this cleaning a separation between ferrous metals and non ferrous metals was performed by cochlea extractor and a separation by four sieves into four granulometric fraction was done. At last, after magnetic separation and after electroconductive separation, car fluff investigated in this work is obtained.

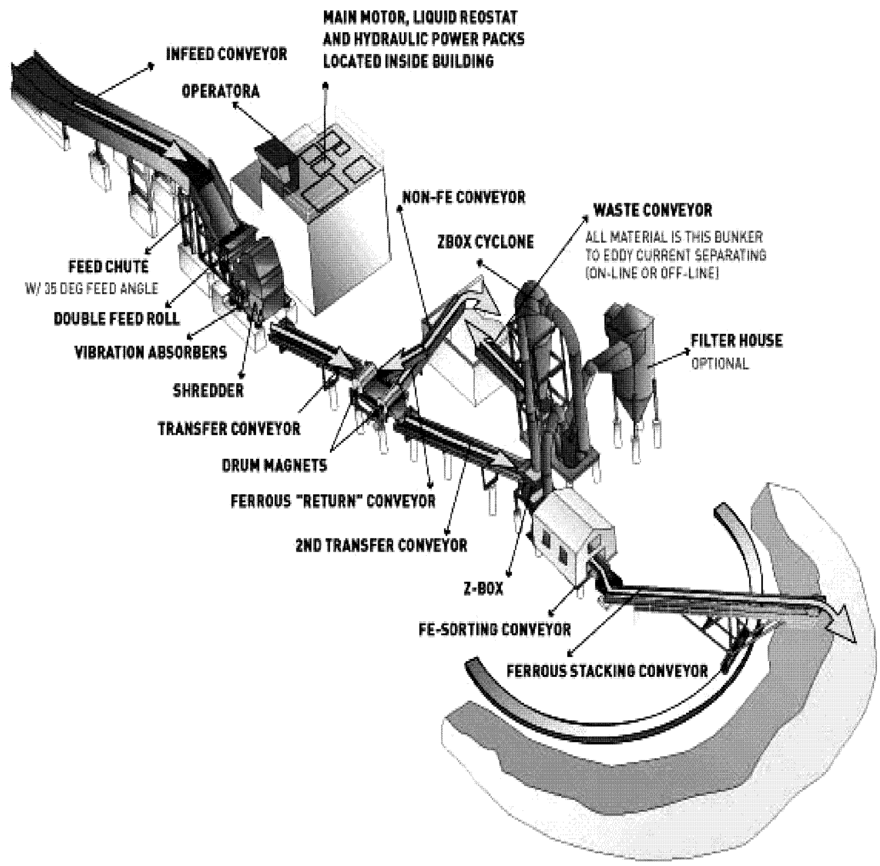

Fig.1: car fluff production in the "Italferro" plant

The quantities of shredder fluff are likely to increase in the coming years due to the growing number of cars being scrapped and to the increase in the amount of plastics used in car production [2].

Now day about 3 Mtonnes of car fluff are generated annually in North America [8] and 2 Mtonnes of car fluff per year are generated in EU countries.

The aim of this study was to characterise car fluff by granulometric distribution, total metal content and metal speciation of car fluff in order to figure out an appropriate final destination for this waste.

2. Material and methods

2.1 Granulometric distribution

1Kg of original sample was thoroughly mixed by the ring and cone method, quartered three times. This sample was shredded into 4 mm fractions.

Particle size distribution was measured by using a particle size separator consisting of four sieves to separate bulk car fluff into four particle size ranges $d<0.5$, $0.5<d<1$, $1<d<2$, and $d>2$ mm.

The sieves were shaken on a sound wave hand sifter shaker to achieve fractionation.

2.2 Total metal content

Total metal content (Al, Cd, Cr, Cu, Fe, Mn, Ni, Pb, Zn) was investigated by extraction with aqua regia. 10g of dried car fluff sample were leached using a mixture 3:1 of HCl-HNO_3 for 16 h at room temperature and for 2 h at 130°C in the presence of H_2O_2. Metal determination was operated by ICP/OES

2.3 Metal speciation

Metal speciation was performed by batch sequential extraction (BCR) using three different extraent agents with increasing extractive strength in three different steps. Reagents used were CH_3COOH 0.11 M, NH_2OH-HCl 0.5 M and H_2O_2-CH_3COONH_4 1 M. They were used in solid-liquid ratio 1:40 and for 16 in the Dubnov stirrer. After every extractive step solid was separated from liquid by filtration and then dryed, weighted and used in the following step. Liquid sample was further filtred and analysed by ICP/OES

3. Results and discussion

3.1 Granulometric distribution

Granulometric distribution results showed that about 60 wt.% of shredded car fluff was a fraction < 0.5 mm. Experimental results were listed in fig.2.

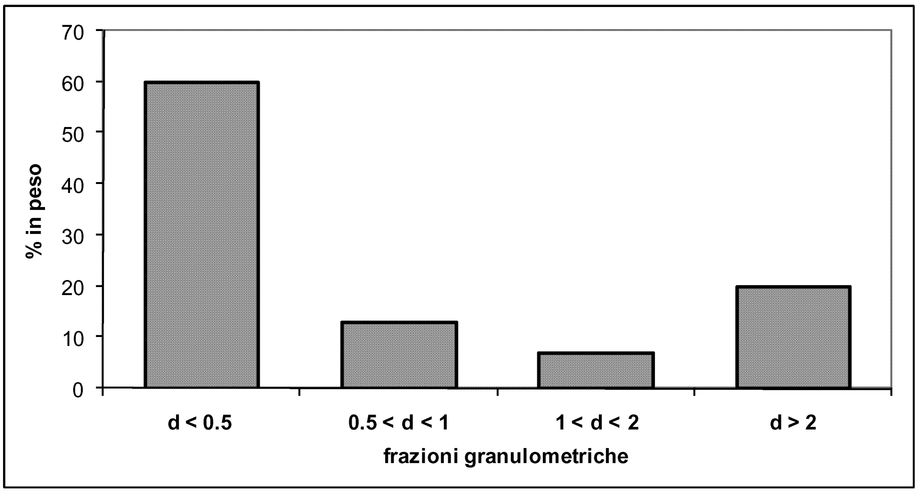

Fig.2: granulometric distribution (mm)

3.2 Total metal content

Results of metal characterisation showed clearly that Fe was the most abundant metal (65%) in every granulometric fraction. Zn was the second most abundant metal only in the fraction lower than 0.5 mm, whereas Cu was the second most important metal in the fraction 0.5-1 mm and in the fraction 1-2 mm. All results of chemical analysis were listed in Table 1

Granulometria	Al (mg/g)	Cd (mg/g)	Cr (mg/g)	Cu (mg/g)	Fe (mg/g)	Mn (mg/g)	Ni (mg/g)	Pb (mg/g)	Zn (mg/g)
<500µm	12.4 ± 0.5	0.12 ± 0.01	0.3 ± 0.1	6 ± 2	119 ± 8	1.2 ± 0.5	0.3 ± 0.1	5.1 ± 0.3	16 ± 1
>500,<1000µm	12 ± 2	0.030 ± 0.001	0.18 ± 0.05	35 ± 9	120 ± 20	1.0 ± 0.3	0.19 ± 0.05	2.0 ± 0.3	9 ± 1
>1000,<2000µm	20 ± 7	0.032 ± 0.001	0.18 ± 0.02	22 ± 9	140 ± 50	1.2 ± 0.5	0.14 ± 0.02	1.03 ± 0.07	9 ± 1
>2000µm	7 ± 3	0.02 ± 0.001	0.088 ± 0.005	5 ± 2	60 ± 10	0.40 ± 0.05	0.08 ± 0.01	1.2 ± 0.2	5 ± 1
TAL QUALE	15 ± 2	0.03 ± 0.01	0.31 ± 0.08	15 ± 4	93 ± 7	0.9 ± 0.2	0.4 ± 0.1	3.1 ± 0.9	11 ± 2

Table 1: metal concentration in the different granulometric fractions

3.3 Metal speciation

Sequential extraction results showed that only Zn, Cd, Fe and Al present the same behaviour in the different particle size samples. Zn and Cd were weakly bounded to the matrix and they were easily extraible by weak acid attack (first step of BCR).

Fe and Al were always mainly extracted in the second step of BCR by acid-reducing attack

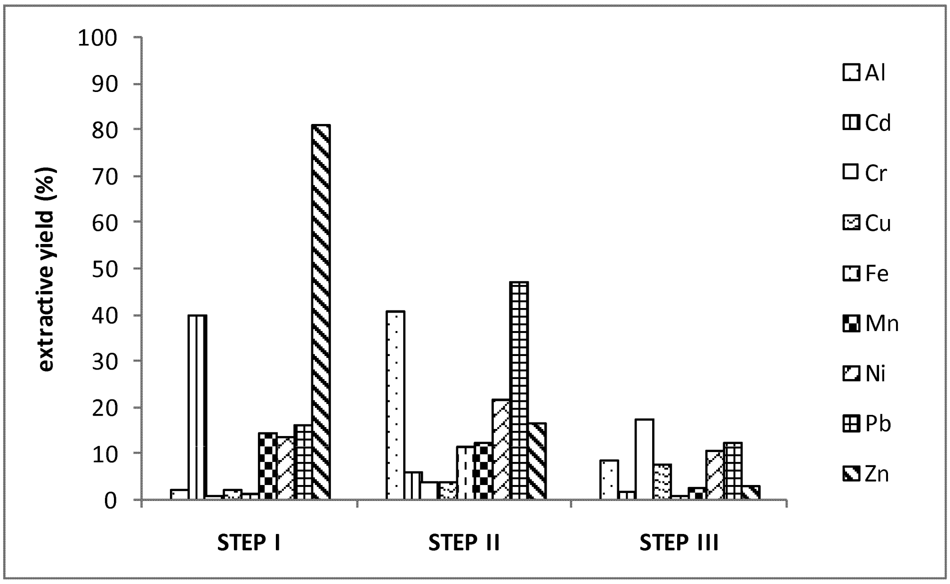

Fig.3: metal extractive yield in the fraction <0.5 mm

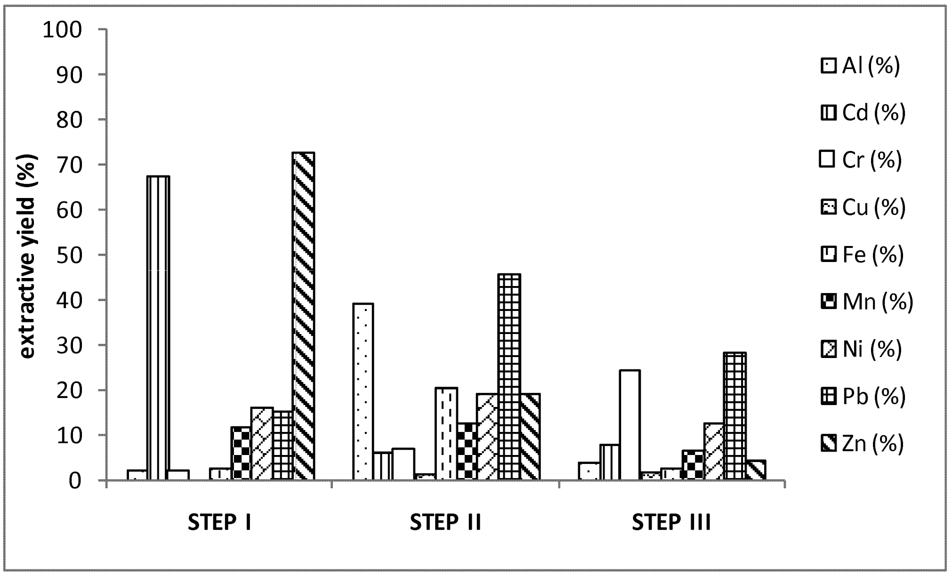

Fig.4: metal extractive yield in the fraction 0.5-1.0 mm

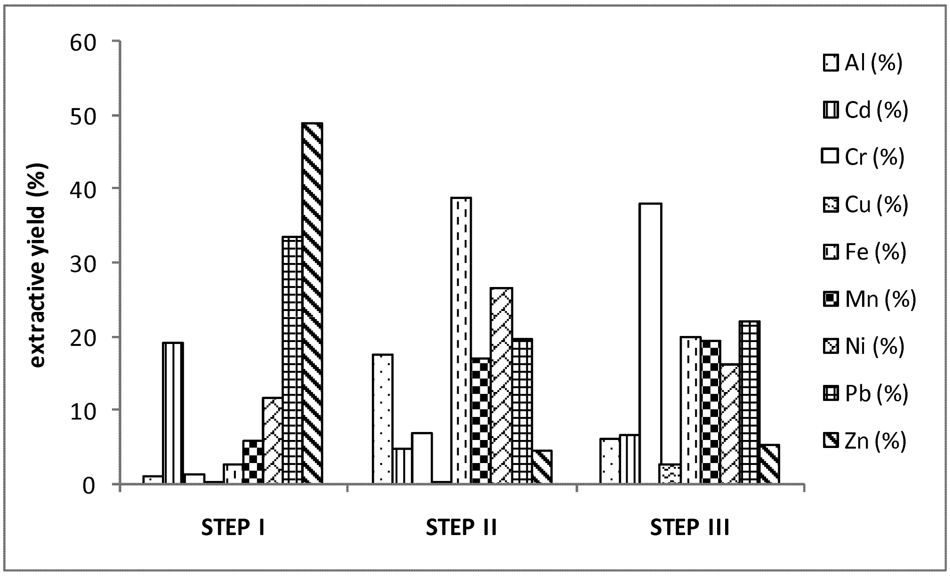

Fig.5 metal extractive yield in the fraction 1.0-2.0 mm

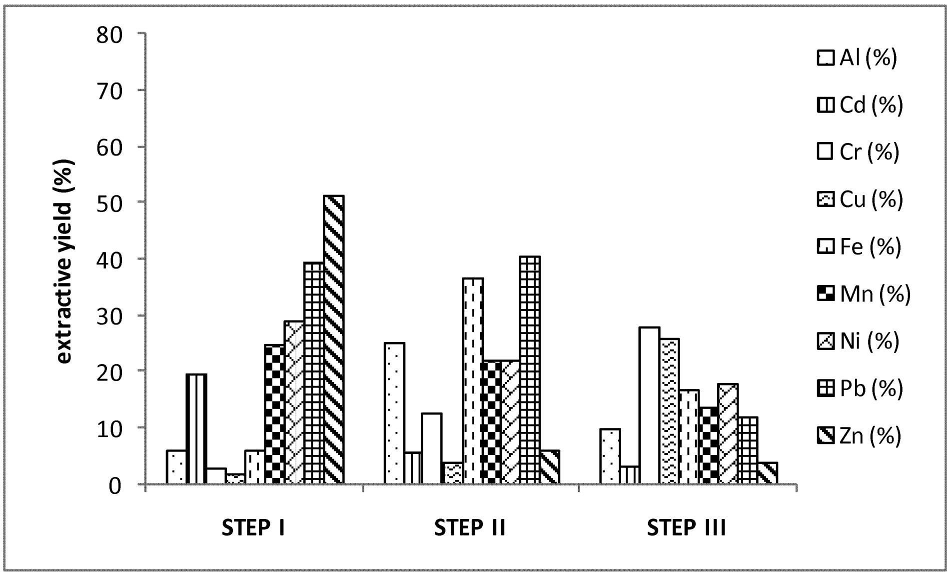

Fig.6: metal extractive yield in the fraction >2.0 mm

4. Conclusions

The objective of this work was a car fluff characterization in order to figure out an appropriate final destination for this waste. On the base of the obtained results two ways appear practicable. First way could be car fluf decontamination from toxic heavy metals before waste valorisation by gasification.

Second way could be car fluff valorisation by hydrometallurgical zinc recovery. In fact zinc was the second most abundant metal in the fraction < 0.5 mm, it had a fairly good market value (1100-1500 $/t) and it was easily removable by bland acid attack.

Direct car fluff combustion would cause the loss of valuable materials as plastic or metals, hence considering the exhaustion of natural metal resources a hydrometallurgical process for zinc recovery from car fluff will be studied.

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