Potential of recovery of glass contained in the heavy residual fraction refused by Portuguese MBT plants

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Introductory note

The present resume is based on the article *Packaging glass contained in the heavy residual fraction refused by Portuguese MBT plants* submitted in the international scientific journal Resources, Conservation & Recycling (Dias, et al., 2013).

1. Introduction

In Portugal, the PERSU, the landfill taxes and the targets regarding packaging waste (such as wood, plastic, metal, paper and card board and glass) are the main tools to push the companies and citizens to reuse and recycle materials.

Portugal, with 210,422 tonnes of glass recycled in 2011, did not attain the target for glass (227,060 tonnes), and this happened probably due to three factors: the reuse of this material since glass is a durable material, non-declaration of glass received by MRF (Material Recovery Facilities) and non-deposition in the specific stream. In 2011 were produced in Portugal, 5.159 million tonnes of Municipal Solid Waste (MSW), being glass 5.8% of it (APA, 2013), which totals 300,000 tonnes of glass present in MSW. It is estimated that 90,792 tonnes of these 300,000 tonnes are directly sent to landfill (APA, 2013). Many municipal systems have facilities for organic waste recovery for MSW, therefore the glass is sent within MSW to MBT (Mechanical and Biological Treatment).

MBT for MSW is an important technology in Europe used, mainly to minimize the quantity of biodegradables landfilled (Lornage, et al., 2007; Montejo, et al., 2010; Pires, et al., 2011; Tintner, et al., 2010; Velis, et al., 2009). In what concerns MSW, in Portugal, there has been a great effort in the construction of MBT plants. While in 2012 only 6 plants were in operation, in 2014, 8 other will be operating. Fig. 1 shows simplified flowsheets of aerobic and anaerobic MBT plants.

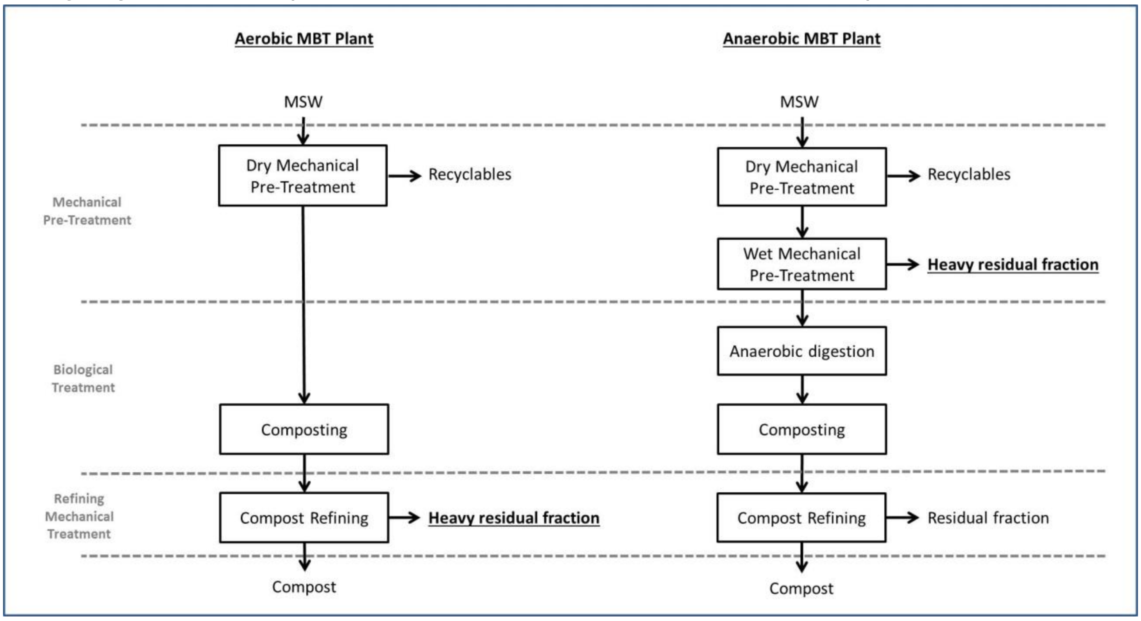


Fig. 1. Simplified solid materials flowsheets of anaerobic and aerobic MBT plant types

MBT has several outputs that have different solutions: recyclable materials that are going to MRF (Material Recovery Facilities), light rejects that are going to RDF (Refused Derived Fuel) production and compost that is used for soil correction. There is another output, heavy residual fraction that concentrates the inert materials that is sent directly to landfill. Although, it was observed in the analysis of two Portuguese plants that this MBTr are composed by high quantities of glass – 33 to 83% (Dias, 2011; Dias, et al., 2011). Depending on the type and efficiencies of the biological and mechanical process, a certain amount of organics can appear too.

So the objective to recover this glass is not only to help to increase the glass recycling rate but also avoid the environmental and economic cost of landfill, and besides this, obatin the value of the recyclables materials such as glass and also the economic incentive from Green-Dot, common practice in Europe as a result of the EPR (extended producer responsibility) principle. For the packaging glass recovered from selective deposition this value is around 35 to 60 Euros per tonne (depending on its quality), while, in the case of household glass packaging waste recovered in composting plants the incentive is 5 Euros per tonne (SPV, 2012).

To be used for recycling the glass from MBTr must, however, comply with the quality requirements of the glass industry. The Portuguese Green Dot Company (SPV) stipulates some specifications for glass cullet (Table 1), which are based on Glass MRF.

Table 1 - SPV specifications for glass cullet

Materials		**Content (%)**
Product	Glass cullet	≥ 98.00
Contaminants	Infusible with dimensions ≤ 40 mm	≤ 0.05
	Ferrous metals	≤ 0.75
	Non-ferrous metals	≤ 0.20
	Organic matters	≤ 0.50

So a study was carried out to quantify the glass appearing in the MBTr in order to evaluate the relevance of applying a process to recover this glass. The first step for such study is to find out the constraints associated with the real quantity and characteristics of the MBTr. In this paper, it is described a characterization study undertook with samples of the MBTr of all the 6 Portuguese MBT plants in operation in 2012 that feed the process with MSW, aiming at the evaluation of the quantity of packaging glass that appears in this stream. The results TRATOLIXO and VALNOR MBTr characterization presented in this paper are from previous studies. A characterization of MBT processing was also performed for each plant and compared among them.

Fig. 2 shows the localization of the plants under study which are AMARSUL, RESIESTRELA, SULDOURO, TRATOLIXO, VALNOR and VALORLIS.

Fig. 2. Portuguese MBT plants treating MSW in 2012. Adapted from (APA, 2011)

Table 2 summarizes the plants characteristics which after a careful analysis were found to have a major effect in the MBTr characteristics. These are: the existence of glass sorting before biological treatment; the screen aperture of the screen after which the MBTr is recovered and the output stage of MBTr (outputscreen). The addition of structurant constitued by wood sawdust or tree branch from tree pruning, used mainly to control the humidity and also to allow flow of air between the particles, was considered too due to its possible effect on the content of organic matter in the MBTr. Nevertheless, the addition of structurant in the anaerobic process (SULDOURO and VALORLIS plants) does not influence the characteristic of the MBTr because this product is removed before the addition of structurant.

Table 2 - Main features of the MBT processes relevant for MBTr characteristics.

Plant	Glass sorting	Output screen aperture (mm): product [(a)]	Type of biological treatment: Output stage	Structurant addition
AMARSUL	-	12: u/s	Aerobic: Refinement	Yes
RESIESTRELA	-	30: u/s	Aerobic: Refinement	-
SULDOURO	-	5: o/s	Anaerobic: WM - PT[(b)]	Yes
TRATOLIXO	-	20x7: u/s	Aerobic: Refinement	-
VALNOR	Yes	6 and 12: 6-12 mm	Aerobic: Refinement	Yes
VALORLIS	-	10: o/s	Anaerobic: WM - PT[(b)]	Yes

[(a)] u/s – underscreen; o/s – overscreen;
[(b)] WM – PT - Wet Mechanical – Pre-treatment (see Fig.1)

3. Characterization of the MBTr from the 6 Portuguese MBT plants

The sample preparation, moisture content determination, particle size analysis and composition methodologies were based in the ones developed in Dias (2011) and Dias et al. (2011).

The results of TRATOLIXO and VALNOR MBTr are from previous studies (Dias, et al., 2011b; Dias, 2011)

Moisture content

The average moisture content of each plant sample is shown in Table 3.

Table 3 - Moisture content of the MBTr samples

MBT Plant	Moisture content (%)
AMARSUL	13.05
RESIESTRELA	2.92
SULDOURO	12.95
TRATOLIXO	3.45
VALNOR	22.33
VALORLIS	12.00

RESIESTRELA and TRATOLIXO samples exhibit lower moisture content than the other samples. This is probably due to the fact that these two aerobic plants are the only ones where there is not addition of structurant material (see Table 2).

In all other plants structurant material is added. Nevertheless, in the two plants with anaerobic treatment (SULDOURO and VALORLIS) the MBTr is removed in the pulper before the structurant material is fed (see Table 2). Therefore the high moisture content in those 2 cases is not due to the presence of structurant material. The wet mechanical treatment process includes a pulper followed by a screw to separate solids from the liquid. The high moisture content of MBTr of these two plants samples is probably due to inefficiency of the solid-liquid separation process.

Particle size

Fig. 3 shows the particle size distribution of the MBTr samples. As can be seen in Fig. 3 there are 3 groups of samples. The coarser ones, VALORLIS (VL) and SULDOURO (SD), have similar distributions with about 50% of the material over 16 mm. The finer samples, AMARSUL (AS) and VALNOR (VN), also with very similar distributions are almost totally finer than 5.6 mm. The other two samples, RESIESTRELA (RE) and TRATOLIXO (TL), have intermediate particle size distribution, with most particles over 5.6 mm. The correspondent curves are quite different in shape as well.

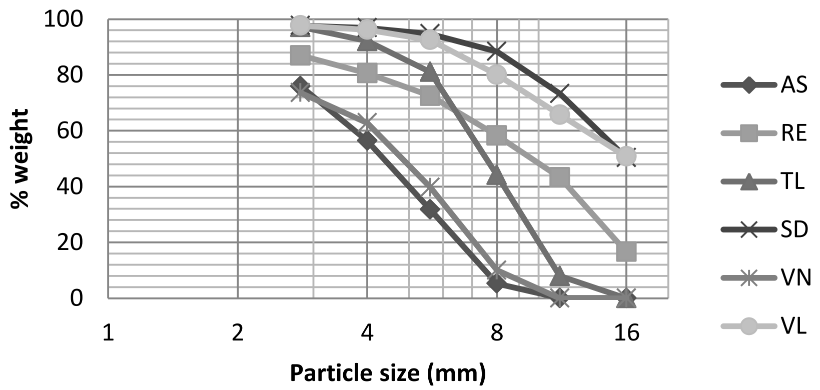


Fig. 3 MBTr samples size distribution

As previously mentioned, the inert residual fraction of the anaerobic digestion plants, VALORLIS and SULDOURO is removed early in the process while in the aerobic plants, AMARSUL, RESIESTRELA, TRATOLIXO and SULDOURO, this product is removed only at the end of the process. So, in these cases, the particles are subjected to stronger fragmentation and attrition than in the former ones, having finer particle size distributions.

On the other hand, the particle size distributions are in accordance with the screen aperture of the screens where MBTr exits the process. There are, however, two exceptions. Although the MBTr of VALNOR should be 6-12 mm particle size fraction (see Table 2), more than 60% of the sample had particle size bellow 5,6 mm. This is probably due to the agglomeration of the particles that occurs in the industrial process caused by the high moisture content (see Table 3) preventing them to pass through the under screen causing screening inefficiencies. In the particle size analysis, made in the laboratory, the agglomeration disappeared and the fineness of the product showed up. On contrary, the VALORLIS sample exhibits approximately 25% of undersize material in the over screen. Two possible causes for this are the screen inefficiency (e.g. clogging) or screen under sizing.

Composition

Fig. 4 summarizes the overall composition of the 6 samples.

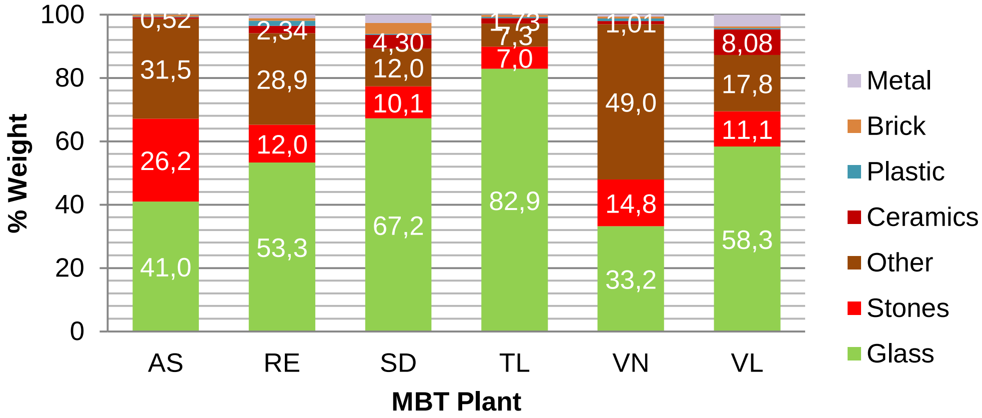


Fig. 4. Composition of each MBTr sample

It is observed that all the samples, with exception of VALNOR´s, exhibit a very high content in glass while the other recyclable materials content is only vestigial. The main contaminants are the “stone” and “others” classes.

TRATOLIXO MBTr presents the highest content in glass, while VALNOR sample is the one with the lowest content in glass. The other samples are intermediate in terms of glass content. It is observed that the higher the content in glass, the lower the content in “others”.

The fairly low glass content in the VALNOR and AMARSUL samples compared with the other samples is due to the high content in organic matter (“others”) (probably due to the addiction of structurant material) and also by the existence of glass sorting made in the case of VALNOR plant.

Despite the inexistence of structuring material and low moisture content, RESIESTRELA sample has a quite higher level of organics content and lower content in glass than TRATOLIXO’s. Probable reason for this is the screen aperture.

In both anaerobic plants (SULDOURO and VALORLIS) it is visible the efficiency of organic matter separation that constitutes a lower percentage of the MBTr composition. This is probably due to the high efficiency of disintegration of organic matter (constituted by smaller particles) in the wet mechanical pre-treatment which easily passes through the sieve screen aperture of pulpers.

4. Quantification of packaging glass occurring in MBTr in Portuguese plants

Table 4 shows the quantity of glass contained in the MBTr in the Portuguese plants in operation in 2012. Considering the glass content obtained in the characterization carried out (Fig. 6) and the most recent available values of the amount of MBTr sent to landfill .Only five of the six plants in study could supply the exact values of the annual amount of MBTr sent to landfill. RESIESTRELA does not measure the MBTr flow.

Table 4 - Glass contained in MBTr produced by the MBT plants in operation in 2012

MBT Plants	MBTr (t)	Glass content (%)	Glass contained (t)
AMARSUL	1488.6	41.0	609.7
RESIESTRELA	N.a.	53.3	N.a.
TRATOLIXO	3962.5	56.7	2246.0
VALNOR	7843.6	82.9	6500.0
SULDOURO	12423.0	33.2	4122.0
VALORLIS	5647.0	58.3	3294.5
TOTAL	**31364.7**		**16772.1**

In view of results of Table 4, it can be anticipated that, if all the glass sent to landfill (16,772 t) could be recovered and recycled, the quantity of glass sent to recycling would increase from 210,422 tonnes to 227,194 tonnes, that would be enough to achieve the PERSU target (227,060 tonnes).

It is expected that in 2014 eight new MBT plants will be in operation with MSW. With this increase of MBT plants, the glass recycling will increase too if a politic of glass recovery is implemented.
Today, there are no reliable data that can be used to predict the quantity of glass that will appear in the heavy residual fraction of these new MBT plants. Although, an approximate value can be calculated by considering the nominal capacity of the new plants (Table 5) and the actual figures obtained in plants operating in 2012 (Table 4).

Table 5 - Nominal capacity of Portuguese MBT plants that will be in operation in 2014 and current MSW feed values registered for the plants in operation in 2012

Plants	Nominal capacity (t/year)	Actual feed (t/year)	Feed/Nominal capacity[(a)] (%)
AMARSUL	50,000	42,652.0	85.3
AMBILITAL	65,000	-	-
BRAVAL	100,000	-	-
ERSUC 1	180,000	-	-
ERSUC 2	180,000	-	-
GESAMB	113,000	-	-
RESIDUOS DO NORDESTE	55,000	-	-
RESIESTRELA	150,000	50,000.0[(b)]	33.3
RESINORTE	180,000	-	-
RESITEJO	100,000	-	-
SULDOURO	50,000	23,781.1	47.6
TRATOLIXO Tr.	150,000	153,894	102,6
TRATOLIXO Ab.	200,000	-	
VALNOR	100,000	131,504	131,5
VALORLIS	50,000	37,316	74,6
TOTAL	**1,723,000**	**439147**	

[(a)] Ratio between the “actual plant feed” and the “nominal capacity”
[(b)] Value of 2011 (one year before the year of sample collection)

For the estimation some assumptions were taken:

- The samples were representative;
- Stability of the composition of the 6 MBT plants samples, assuming that the values of 2012 will not change significantly until 2014;
- Ration of real feed by nominal capacity will maintain constant until 2014;
- As there is not known the MBTr composition and mass flow, there was assumed that the ratio "glass contained in MBTr in all MBT plants/ sum of all feed os MBT plants" in 2011 it will be the same in 2014.

Considering that the "glass contained in MBTr of all plants" /"MBT feed of all plants" ratio in 2011 would be the same in 2014, the ratio will be 16,772/439,147 that equals 0.04.

The sum of feed from all MBT plants in 2014 totals 1,723,000 tonnes, although, subtracting the TRATOLIXO Tr. MBT plant, that it will not be in operation in 2014, it totals 1,573,000 tonnes.

The average of "actual feed/nominal capacity" ratio of MBT plants that were in operation in 2012 is 79.2%.

Applying the average of "actual feed/nominal capacity" ratio calculated before to the total of 1,573,000 tonnes of MBT feed in 2014, it is obtained a truer sum of feed of all MBT plant – 1,245,113 tonnes.

The two values obtained for 2014 (the "glass contained in MBTr of all plants" /"MBT feed of all plants" ratio and the sum of feed of all MBT plant) would than lead to more than 48.000 tonnes of glass appearing in the MBTr for the same year.

5. Discussion

The MBTr, as it is, could not be accepted by SPV due to the high level of contaminants (see Table 1 and Fig.4). Nevertheless, the amount of glass sent today to landfill is very high so the processing of this product should be considered.

This recovery can be made by changes in MBT processing that, as seen before, heavily influences the MBTr characteristics and/or by technologies applied to the MBTr after its exit from MBT processes.

Dias et. al (2011b) concluded that the particle size can be a discriminant property between glass and some contaminants. In the case of VALNOR, through a screening of 4mm it was eliminated more than 25% of contaminants increasing the glass content from 33.2% to 49.5%.

Fig. 5 shows the size distribution of glass, stones and "others" for each MBT plant.

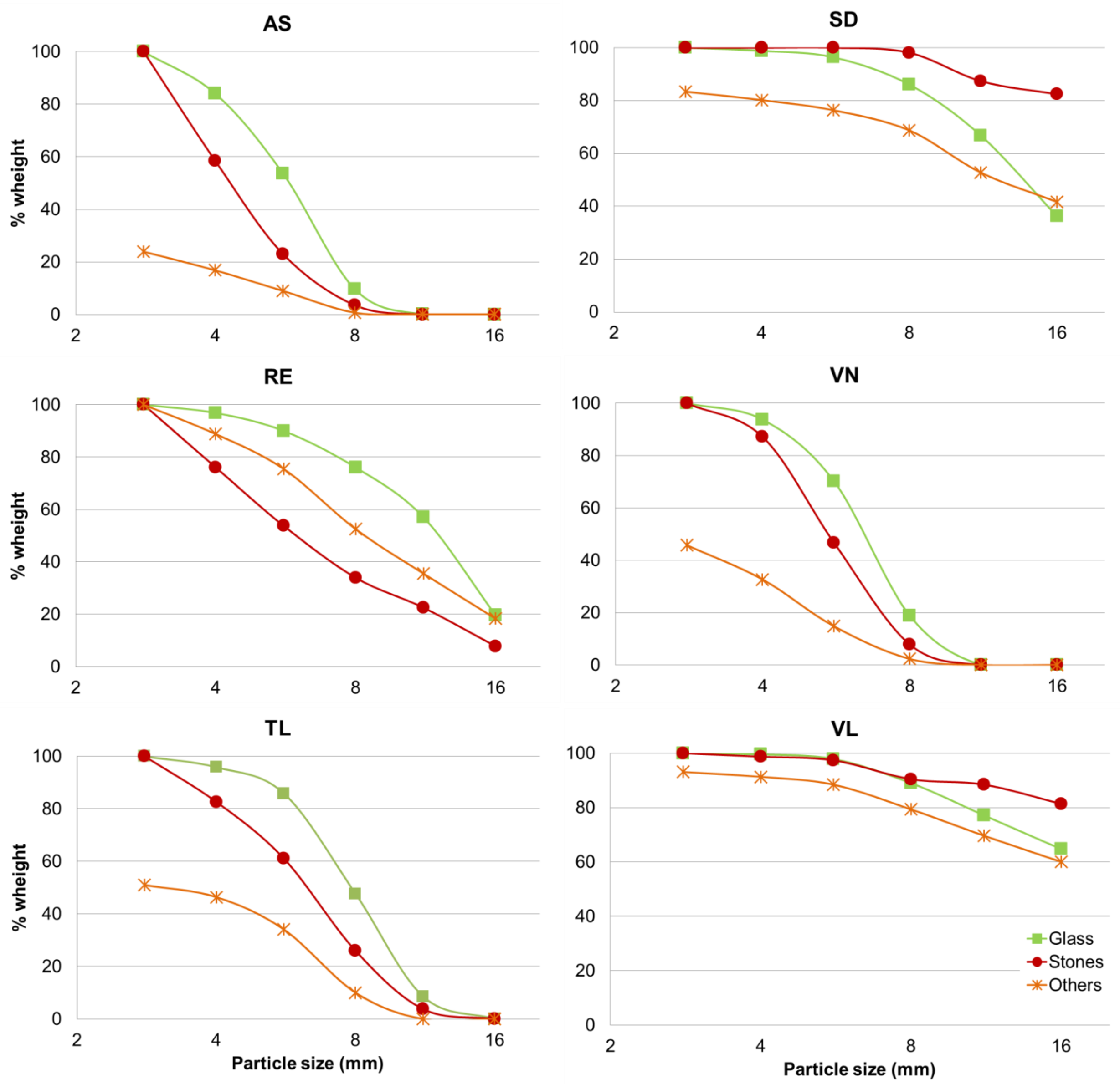
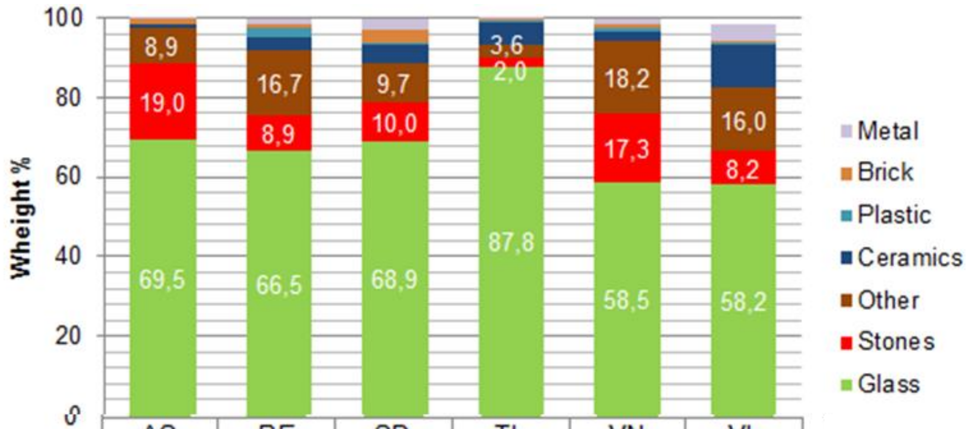


Fig. 5 – Size distribution of glass, stones and “others” from MBTr samples

As verified with VALNOR, in other MBT plants the granulometric fraction -4mm presents low glass content and high stones and “other” materials. The major Portuguese glass MRF has no efficient equipment to treat contaminated cullet bellow 5mm. Therefore, the particles that measure between 4 and 5 mm don’t have interest either the point of view of glass recovery. Thus, this fraction (-5 mm) can be removed by a screening process.

Figure 6 present the composition analysis of MBTr of each plant not considering the particle size fraction -5,6m. The figure present, also, the weight yield of particle size +5,6mm of glass, stones and “others” classes.



	AS	RE	SD	TL	VN	VL
η Others (%)	8,94	41,67	76,37	40,41	14,80	88,43
η Stones (%)	22,96	53,75	93,47	61,12	46,74	97,39
η Glass (%)	53,61	90,01	96,41	85,90	70,21	97,87

Fig. 6 – Composition above 5,6mm of each MBTr sample and recovery of glass, stone and “others”

Comparing the data from Fig. 4 with Fig. 6 it can be observed that the glass content increases. The MBT plant that reaches the higher glass content is TRATOLIXO with 87.8%. Regarding AMARSUL and VALNOR results, despite the significant contaminates removal of stones and particles within “others” class, the glass losses is also significant, being higher than 30% in both plants.

The shape can also be a discriminant property between glass and some contaminants. Carvalho, et al. (2011) developed a simple and cheap process able to upgrade the content in glass of MBTr, that explores this property. They showed, using a sample of TRATOLIXO MBTr that it is possible to concentrate the glass by removing almost 60% of the stones with a recovery of approximately 80% of glass in the final concentrated product based on the difference in particle shape (Dias, et al., 2011).

It is important to mention that all these results were obtained with dried samples. The density, magnetic susceptibility and electric conductivity are also discriminant properties between glass and some organic material, ferrous metals and non-ferrous metals respectively. Equipents that explore these properties already exist in MBT processing. Although, adding a drying stage in the MBTr treatment it will provide particles desegregation that could increase the efficiency of these processes in way that would be advantageous repeat them.

6. Conclusions

MBT plants produce an inert residual fraction (MBTr) composed mainly by packaging glass. This material cannot be recycled as it is because, mainly due to the high contamination with other material, it does not attain the adequate quality. In this study it was observed that the main contaminants of the packaging glass are the stones (6.99 to 26.19%) and “others” (7.28 to 49.05%).

In the present study the glass contained in MBTr of the 6 plants in operation in 2012 in Portugal was quantified. It was estimated that in 2014 when 8 new plants will be in operation the quantity of glass contained in the heavy reject of MBT plants that will be sent to landfill will be over 48,000 tonnes. If all these quantity of glass could have been recovered, Portugal could have attained the PERSU targets. Therefore the processing of this product should be considered. Some discriminant properties between glass and its contaminants are particle size, shape, density, magnetic susceptibility and electric conductivity. Although, a previous drying stage could be important to increase the efficiency of glass contaminants removal equipment.

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