MECHANICAL BIOLOGICAL TREATMENT AND SELECTIVE COLLECTION OF MUNICIPAL SOLID WASTE: WHICH INTERACTIONS?

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SUMMARY: Bio-mechanical treatments are extensively used for municipal solid waste management. One of the problems that can be found in this sector can be related to the change of the MSW characteristics during the lifetime of the plant. This problem is only partially related to the dynamics of composition of the generated MSW, as the main source of fluctuation of the input of the plant is the effect of the implementation of the strategies of selective collection. The present paper wants to be a contribution of the understanding of this potential problem presenting a preliminary analysis of a case-study based on the present and expected situation in a Romanian municipality. The choice of the case-study has been related to the fact that Romania has just entered into the European Union and than should modify its MSW management strategy changing from a near zero selective collection scenario to a new scenario that must comply with the principles of recycling proposed by the European Union directives.

1. INTRODUCTION

The viability of Mechanical Biological Treatments (MBT) represents a widely discussed topic regarding municipal solid waste (MSW) management in the world. The qualitative characteristics of the municipal solid waste (MSW) represent one of the most important variables for the choice of the most effective technology of waste treatment and disposal. The necessity of a correct evaluation of the quality of the waste is owed to the remarkable multiplication of the typologies of waste. The production of waste derived from human activity has increased because of the increase of the population, but especially because of the economic development that has transformed the modality of consumption of the population. Also the systems of waste collection are changing, giving a complex overall scenario.

For this reason in this paper it was chosen to analyze the interactions of the bio-drying process and the selective collection taking into account two typologies of MSW: one representative of a town without a significant selective collection (that could be related to the present situation in Piteşti, Romania) and the other representative of a town were the selective collection is adopted

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with a high efficient performance (these last data, referring to the present situation in an Italian town, have been used to describe the future situation in Piteşti, supposing a progressive and successful activation of the selective collection in the next 15 years).

In the bio-drying process a fundamental importance has the quantity of organic substance contained in the waste. Today in the European Union, thanks to the recent regulation, a progressive increase of the selective collection can be seen, in particular for the organic fraction. By this way the organic fraction remaining in the MSW is always lower and lower. This aspect may discourage the use of the MSW bio-drying process. The present paper wants to clarify this aspect.

Considerations on the role of metal, glass, inert recovery will complete the paper: indeed the recovery of these fractions can be obtained from selective collection and/or after bio-drying. In the second case, the aims are both the recovery of materials and the transformation of the bio-dried material into a refuse derived fuel (RDF).

2. MATERIALS AND METHODS

For a good understanding of this problem, in this paper results from pilot scale runs of MSW bio-drying having an organic fraction (OF) content of 50% and 8 % will be presented. The pilot scale reactor build at Civil and Environmental Department of the University of Trento (Rada et al., 2007) is a 1 m^3 adiabatic box. This biological reactor is placed on an electronic balance for monitoring the waste mass loss during the bio-drying process. The air is introduced in the biological reactor through a steel diffuser, put at the bottom of the reactor, connected to the system of feeding of air. This air crosses the waste from the lower part, favoring the exothermal reactions and goes out of the biological reactor from the upper part. For monitoring the temperature during the bio-drying process, five temperature probes are placed inside the reactor. The biological reactor is equipped with pipes for interception and collection of possible condensate, (leachate) that can form on the walls of the biological reactor. All these equipments are connected to a data acquisition system developed for a good management of the process.

A bio-drying model has been applied for the assessment of the main parameters of the process (Rada et al., 2007) and for the calibration of the balances referring to the known composition of the waste in the two studied scenarios (Piteşti today and Piteşti 2023). In practice, the pilot scale bio-drying runs were developed having as input a MSW with a target percentage of organic fraction. Data on the other fractions were used for correcting the balances starting from the experimental runs. That is possible as it has been demonstrated that the engine of the bio-drying process is the bio-oxidation of the volatile solids of the organic fraction (Rada 2005).

The building of a bio-drying plant has been supposed completed for the end of 2008.

Data on waste composition to be modelled have been derived from the most recent available data from the area of the case-study (APMAG, 2002) and some modifications have been made in order to take into account a reclassifying of the fine material, the recent activation of PET selective collection and the presence of an informal network for selective collection of paper. Data reported in Table 1 have been used for the simulation of bio-drying with 50% organic fraction, representing the situation in 2008. Data for the ultimate analysis have been adopted from the available literature for each fraction, in particular referring to (Rada 2005).

Some considerations can be made on Table 1:

- The very low efficiency of selective collection that characterises the present situation in Romania gives a composition of the produced MSW similar to the residual MSW. In the next years this aspect should change as a consequence of the implementation of the EU Directives on selective collection.

Table 1. Present scenario (0.8 $g_{residualMSW}$ $inh^{-1}d^{-1}$ containing 0.4 g_{OF} $inh^{-1}d^{-1}$)

Residual MSW compostion	%
Paper and cardboard	14%
Plastics	17%
Glass	8%
Inert	6%
Organic fraction	50%
Textiles	1%
Metals	4%

- The percentage of the organic fraction is high as no selective collection concerns this fraction.
- The Table 1 is not highly detailed as the available MSW analyses take into consideration few fractions. The optimisation of the strategy needs additional information.

In order to analyse the scenario of the future, some hypotheses have been introduced. The expected economic development after the entrance of Romania into the European Union will increase the MSW generation. A rate of a yearly increase as 4% for the following 15 years will change the daily MSW production up to about 1.4 kg_{MSW} inh^{-1} d^{-1}. Supposing an overall efficiency of the selective collection as 35% in the year 2023, the residual MSW would account for about 0.5 $kg_{residualMSW}$ inh^{-1} d^{-1}. Assuming 80% the efficiency of the selective collection of the organic fraction, its amount in the residual MSW would be 80 g_{OF} inh^{-1} d^{-1}, that in percentage would be about 8%. It must be pointed out that the *per capita* generation of organic fraction can be assumed steady in time: what changes is the percentage in the waste.

In order to base on experimental data the analysis of bio-drying in such a future scenario, a real residual MSW taken from an Italian area with high efficiency of selective collection was bio-dried on pilot scale. The characteristics of that residual MSW are presented in Table 2 (Rada et 2006a,b).

Table 2. Future scenario (0.9 $g_{residualMSW}$ $inh^{-1}d^{-1}$ containing 0.08 g_{OF} $inh^{-1}d^{-1}$)

Residual MSW compostion	%
Paper and cardboard	34.8%
Plastics	19.5%
Glass	5.2%
Inert	9.6%
Organic fraction	7.9%
Textiles	5.3%
Multimaterial	4.7%
Wood	6.3%
Aluminium	3.9%
Metals	2.8%

It has been assumed that the future scenario of Piteşti will have the same composition (the flexibility of the bio-drying model could allow to generate a number of alternative scenarios of selective collection and than similar tables and analyses. As the aim of this paper is to study mainly the consequences of a highly efficient selective collection on bio-drying and not to present an official case-study for Pitesti, these assumptions have been considered acceptable.

It is clear that 8% OF content must be considered an extreme case-study, but the choice of this scenario has been made in order to point out the effects of a high efficient selective collection.

3. RESULTS AND DISCUSSION

3.1 Scenario of the year 2008

In Figure 1 the dynamics of the LHVs of the biodried material and of the RDF are presented. The experimental run at the base of this results lasted two weeks as used for a bio-drying process (Rada, 2005). As shown, the LHV of the MSW to be treated is about 9.6 MJ/kg. Data comes from the urban area of Piteşti. The rural areas of the region of Piteşti show lower values. It has been assumed that the strategy is proposed only for the urban area as the aim is the generation of RDF.

The process concentrates the energy available with LHV in a lower amount of mass thanks to the evaporation of a part of the humidity. As a consequence, after two weeks it has been assessed that the LHV of the biodried material could reach a value of about 12.1 MJ/kg. After inert, glass and metal removal, the LHV could reach about 14.7 MJ/kg. In terms of percentage of LHV increase, the dynamics is reported in Figure2, where the weight loss is shown (26% after two weeks) with the overall energy loss (about 3% after two weeks).

A parallel consumption of volatile solids must be taken into account, as shown in Figure 3. The consumption of VS was assessed as about 32 g_{VS}/kg_{in}. The ratio net water evaporation: VS consumed has resulted about 8. It has been demonstrated that when the ratio is around this value the bio-drying process is performed in the better conditions (Rada, 2005). The energy loss (referred to the initial LHV of the MSW) has resulted about 3%.

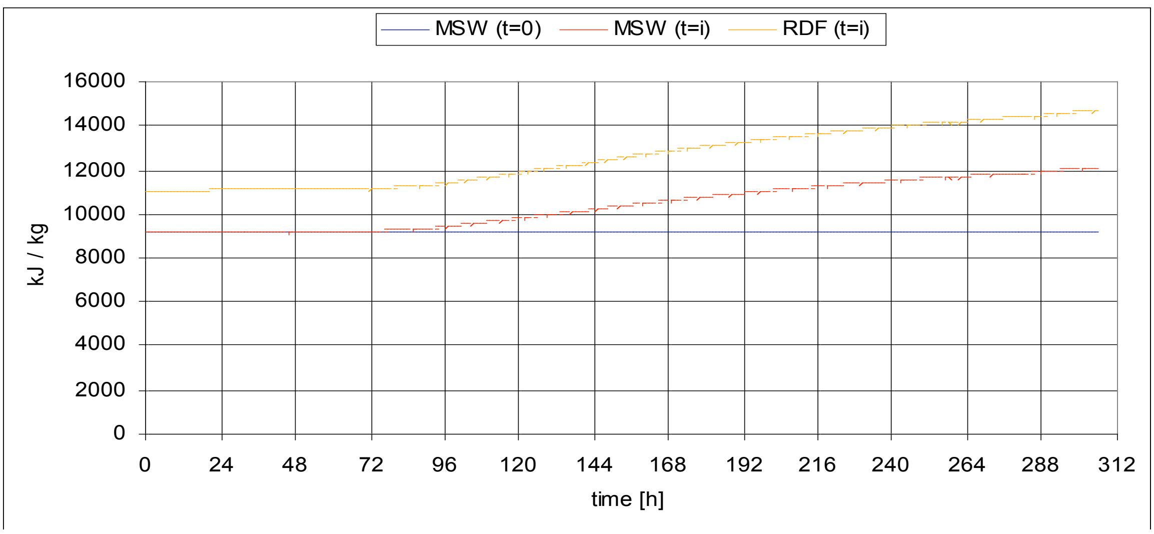

Figure 1. Dynamics of LHVs assessed for the scenario with 50% OF

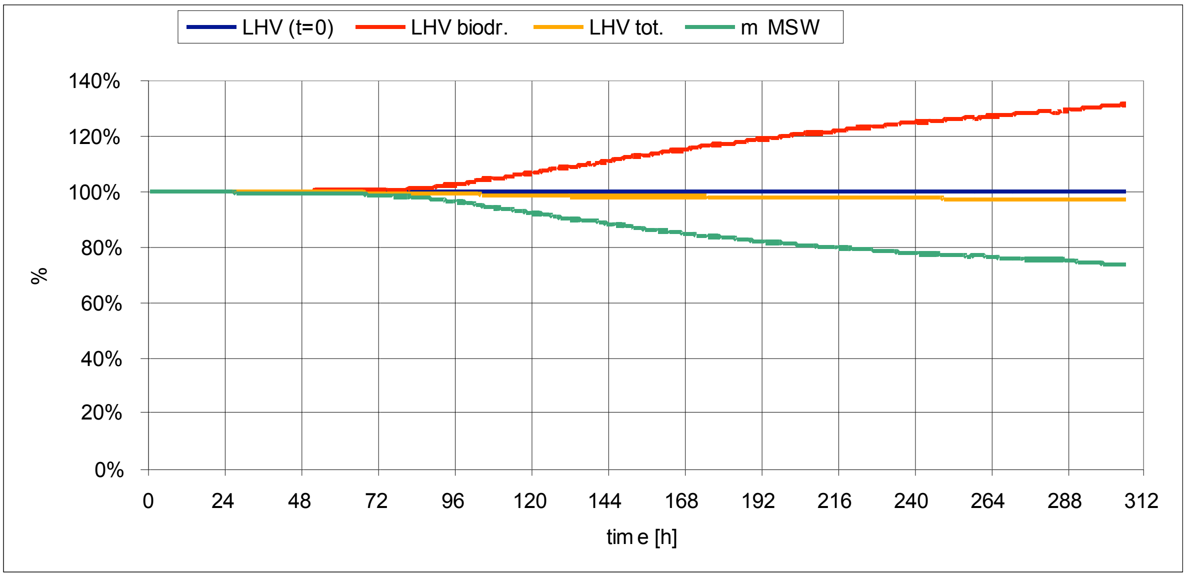

Figure 2. Dynamics of mass loss, overall and specific LHVs for the 50% OF scenario

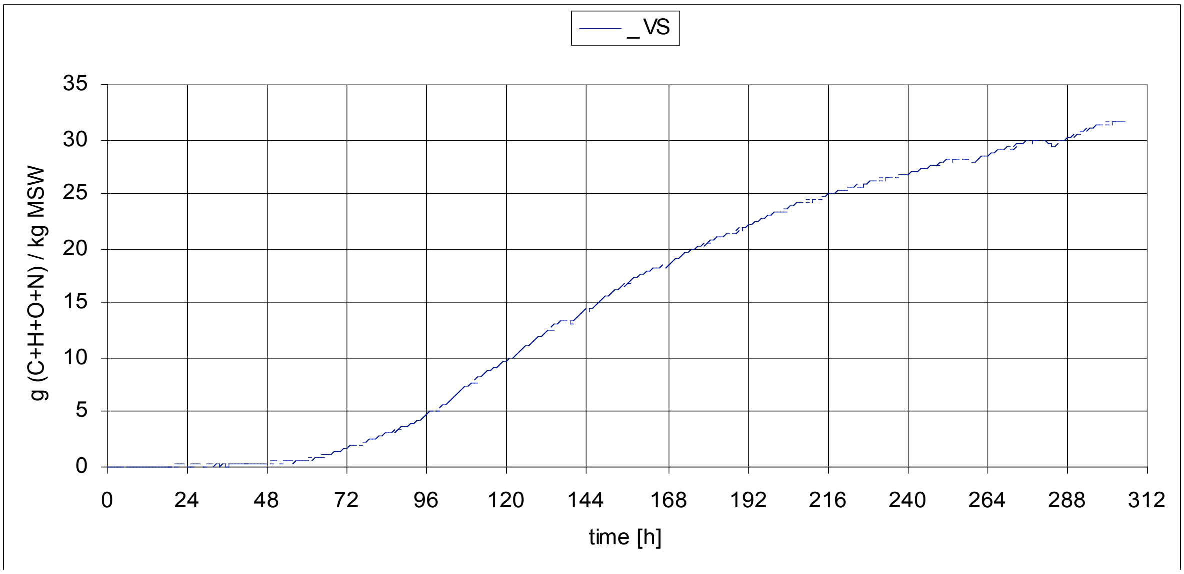

Figure 3. Dynamics of VS consumption assessed for the scenario with 50% OF

In order to generate RDF of high quality a post-screening should be added for removal of fines. Anyway, it must be pointed out that such a post-treatment can generate a putrescible side-stream not suitable for direct landfilling. Apart from that in must be underlined that the present overall amount of MSW generated in Pitesti is not suitable for dimensioning a dedicated waste to energy plant (the population of the Municipality of Pitesti is around 190,000 inhabitants). On the contrary, the region is characterized by some important cement works. The first authorization for co-combustion of waste has already been released, opening this sector in Romania. Moreover, the town of Piteşti could generate RDF for the industrial plants more and more present along the highway Piteşti-Bucharest. This sector is very young in Romania, but could be useful for contributing to the management of MSW in small areas of generation.

3.2 Scenario of the year 2023

As explained above, the present study allowed assessing the scenario for 2023.

Results about LHVs during bio-drying are reported in Figure 4. It is clear that the process of bio-drying suffers from a reduced percentage of organic fraction in the residual MSW. The weight loss resulted only 8%. As shown, the LHV of the MSW to be treated was assessed resulting about 13.5 MJ/kg. After two weeks the LHV of the biodried material could reach a value of about 14.7 MJ/kg. After inert, glass and metal removal, the LHV could reach about 18.6 MJ/kg. The overall energy loss has been assessed as negligible after two weeks. That is not a significant advantage because of the very small energy consumption is related to a very small effect of bio-drying that suffers the very low organic fraction content.

Some considerations can be made:

- LHV of MSW in the 2023 scenario is so high that selective collection can be considered a sort of indirect pre-treatment.
- The final LHV for RDF is very interesting for industrial use. Anyway, if we set a LHV target for high quality RDF equal to 20 MJ/kg, a post-refinement after inert, glass and metals separation must be present anyway.
- The effect of bio-drying is very low. The amount of organic fraction is so low that the effects of the biological pre-treatment are significantly diluted in a high amount of dry fractions.
- To this concern, it should be put under discussion the usefulness of bio-drying. But in our scenario bio-drying is supposed already built. As the plant has a cost even if it is not used (because of the investment costs), a flexible strategy should be adopted since the starting of the 2008 strategy: if bio-drying would be implemented with small parallel bioreactor, at the beginning each reactor could work as a bio-drier, but during the years some reactors could be reallocated as composting bioreactors supporting the composting process of the organic fraction selectively collected and growing in amount year after year.

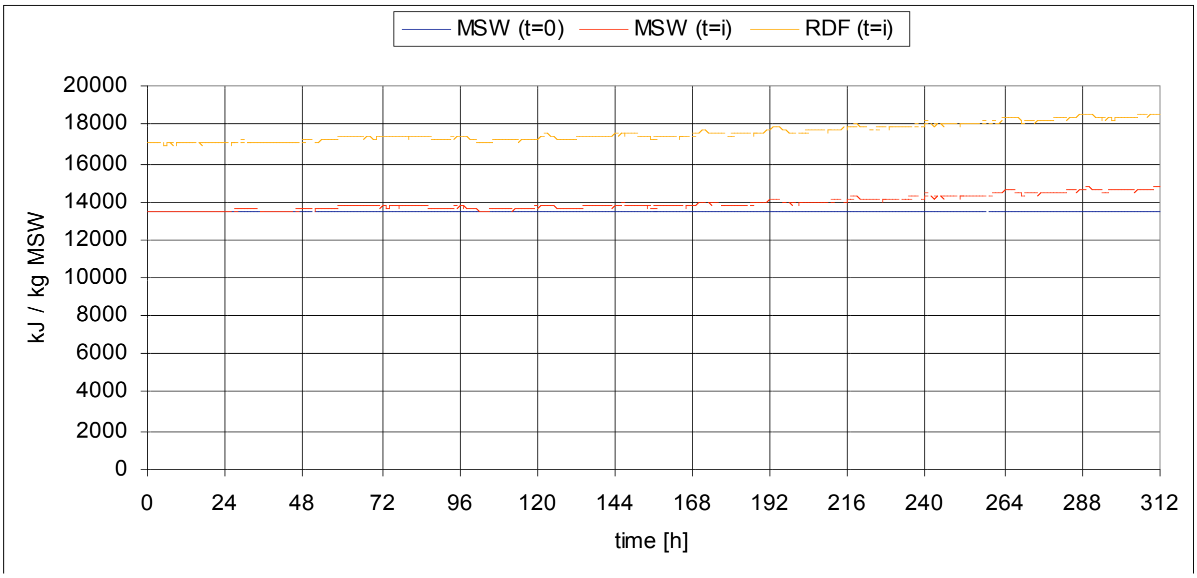

Figure 4. Dynamics of LHVs assessed for the scenario with 8% OF

The post-treatment for inert, glass and metals separation has an important role even if the scenario is related to a high percentage of selective collection. Indeed the amount of non combustible fractions keeps high. More in general, it could be interesting to study if it could be reasonable to avoid the implementation of the selective collection of inert, glass and metal in 2008 having a bio-dryer that allows recovering these fractions with a high efficiency of separation (this efficiency is generally higher than the ones obtainable through the conventional strategies of selective collection).

5. CONCLUSIONS

When a process of bio-drying is proposed as a solution for MSW management, it is important to analyse the expected dynamics of the residual MSW composition during the entire lifetime of the plant. If the overall strategy is not adequately flexible, some troubles for the correct operations of the plant could be found and some uneconomical situations could be originated. In the present paper a preliminary case-study has been analysed referring to a municipality in Romania. This country has just entered into the European Union and for this its MSW shows characteristics very different from the ones that we know for instance in Italy. These differences can be taken into account for setting adequate strategies for the present and for the future.

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