A COMPARISON BETWEEN DIFFERENT SCENARIOS OF MSW MANAGEMENT THROUGH AN INNOVATIVE APPROACH

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Based on the present situation in Romania concerning the waste management, this paper reports results of a comparison of four alternative scenarios for energy recovery from Romanian Municipal Solid Waste through an innovative approach. The comparison is made using mass, energy and environmental balances referred to treatments and disposals.

The first scenario consists in a MSW landfilling without pre-treatment, the second one has a mechanical biological treatment stage coupled with selective collection of only sellable materials, the third one regards the MSW sustainable landfilling after an initial high selective collection stage and the last one combines the high selective collection with a Waste-To-Energy method.

Keywords: municipal solid waste, mechanical biological treatment, sustainable landfilling, Waste-To-Energy.

1. Introduction

One of the most serious problems of the environmental protection field, both for Romania and for the other countries, is the waste generation in large quantities and their inadequate management [1].

The aim of this paper starts from the National Waste Management Plan of Romania. The paper reports results of a comparison of four alternative scenarios for energy recovery (ER) from Romanian Municipal Solid Waste (MSW) through an innovative approach.

The study is limited to demonstrate viable technologies: refused derived fuel (RDF) production through mechanical–biological treatment plants (MBT), waste-to-energy option (WTE). The use of landfilling and sustainable development is also taken into account. The goal of these scenarios is to understand whether manipulating residual waste from open dumps ahead of

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combustion in dedicated WTE plants, or use of sustainable landfilled ahead of producing RDF from MBT plants, can either increase efficiency or reduce environmental impact. The environmental impact form the chosen scenarios is compared, the mass and energy balances are presented, the comparison between which is the best scenario suitable for Romania is also presented.

2. Assessment of the MSW current situation in Romania

The specific Romanian waste composition is taken from the National Waste Management Plan. The knowledge about waste composition is poor because a systematic analyzing of waste is not available. The MSW composition used for the four scenarios is presented in Figure 1 [2].

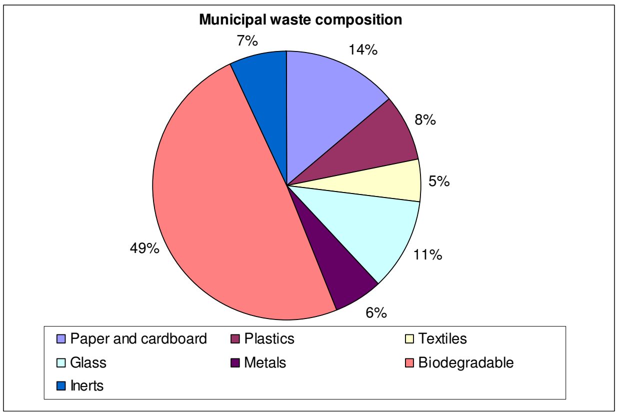

Figure 1. Municipal solid waste composition in Romania year 2006

3. Scenarios

3.1 MSW landfilling without pre-treatment and absence of selective collection

In this scenario all quantity of municipal solid waste is landfilled without any pre-treatment or selective collection (SC) to an open dump.

Figure 2. S_1: MSW landfilling without pre-treatment and absence of SC

3.2 MSW landfilling with pre-treatment (bio-mechanical treatment) and selective collection: only sellable materials

This scenario consists of applying first a selective collection to MSW, valorizing only the sellable materials (efficiency 30% applied to plastics, paper and cardboard) and the use of a pre-treatment stage: mechanical biological treatment. Two options have been considered for the MBT: bio-stabilization and bio-drying.

In the system with ***bio-stabilization***, the stream of waste is submitted first to a mechanical treatment stage: sieving process: the MSW is sorting the materials by granulometry in dry fraction (**oversieve material**) and wet fraction (**undersieve material**). The ***oversieve material*** enters to a de-ironing process which is a refinement treatment applied in order to obtain a *low quality RDF*, that can have another refinement treatment consisting in air aspiration of light fractions in order to obtain a *high quality RDF*. The remaining is a residue that is landfilled. The ***undersieve material*** has a high content of organic fraction which is subjected to a stabilization treatment, bio-stabilization with the role of obtaining stabilized organic fraction (SOF).

In the ***bio-drying*** stage, the entire quantity of waste is initially supposed to an aerobic treatment for obtaining ***bio-dried material.*** The *low quality RDF* is obtained from the bio-dried material after refinement processes: de-ironing and glass removal. For a better product the *low quality RDF* is post-treated for obtaining *high quality RDF* and residues that will be landfilled.

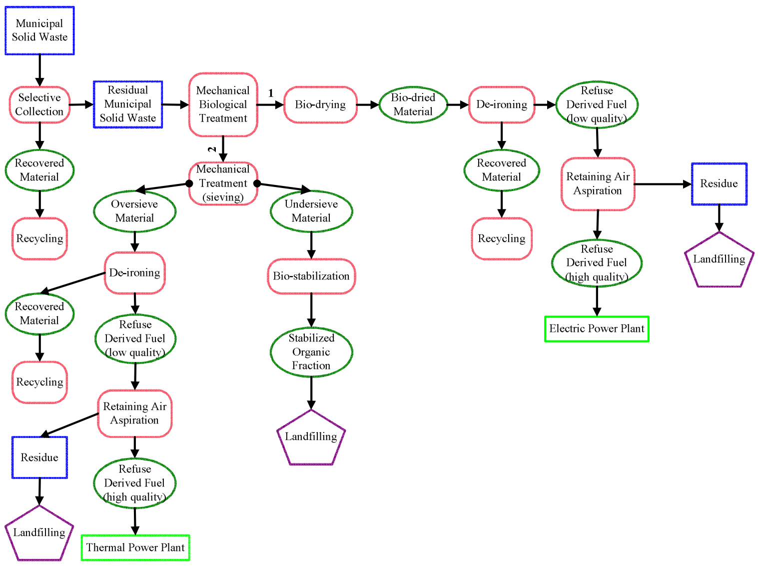

Figure 3. S_2: MSW landfilling with pre-treatment (bio-mechanical treatment) and selective collection: only sellable materials

3.3 MSW landfilling and high selective collection = Sustainable landfilling

In the case of this scenario, MSW will be landfilled taking into account a sustainable management way. A high selective collection (HSC) process is applied with efficiency 65% of recycling material from MSW (with an efficiency of 70% for paper and cardboard and for organic fraction; 80% for plastic and 90% for glass and metals), resulting a residual municipal solid waste (RMSW) suitable to be landfilled in good conditions.

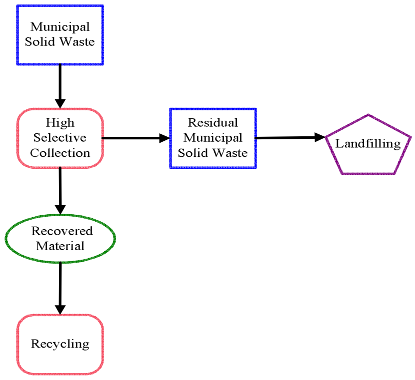

Figure 4. S_3: MSW landfilling and high selective collection = Sustainable landfilling

3.4 Waste-to-Energy and high selective collection

The last scenario consists in a HSC stage with efficiency about 74% of recycled material, with RMSW sent to Waste-To-Energy plant with the role of producing electricity directly through combustion.

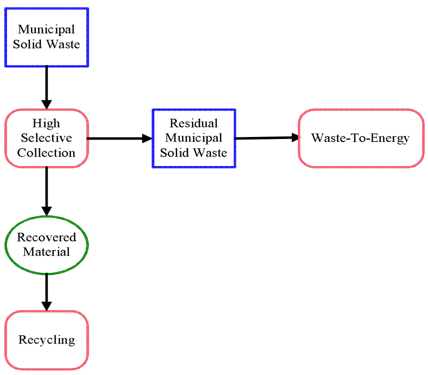

Figure 5. S_4: Waste-to-Energy and high selective collection

4. Results

4.1 Mass and energy balance

The quantity of initial MSW taken into account for all the scenarios was 1 kg_{MSW}. In order to see the energy that could be recovered from the Romanian MSW, the high and lower heating value (HHV; LHV) of MSW were calculated and also the HHV for the obtained products with Dulong formula [3]. The difference between the HHV and the lower heating value (LHV) is given by the latent heat of evaporation of the water in the products of combustion. Data for the electric energy production are obtained for each scenario from literature [4].

In Table 1 the results obtained for scenarios who don`t have a MBT stage are presented.

Table 1

Mass and Energy balance

	$Mass_{MSW}$	LHV_{RMSW}	Potential Energy
	[g]	[kJ/kg]	kJ
S_1	1000	6,379.37	6,379.37
S_3	342.00	6,133.95	2,097.81
S_4	264.90	8,728.72	2,312.24

Table 2 presents the mass and energy balance for bio-drying and bio-stabilization processes of the scenario with MBT stage.

Table 2

Mass and Energy balance of bio-drying and bio-stabilization process

	Mass	LHV	LHV	Potential Energy
	[g]	[kJ/kg]	[kcal/kg]	kJ
	Bio-drying			
MSW	934	5,397.61	1,289.44	5,041.36
Bio-dried material	758.00	7,271.23	1,737.04	5,901.06
$RDF_{low\ quality}$	541.96	8,877.81	2,120.83	5,151.38
$RDF_{high\ quality}$	239.55	14,957.25	3,573.16	3,836.22
Bio-stabilization				
MSW	934	5,397.61	1,289.44	5,041.36
Oversieve Material	433.56	8,789.47	2,099.73	3,810.77
$RDF_{low\ quality}$	387.99	9,640.90	2,303.13	3,740.56
$RDF_{high\ quality}$	182.23	15,781.18	3,769.99	2,875.80
Undersieve Material	535.70	2,373.44	566.99	1,271.46
SOF	417.85	863.38	206.26	360.76

4.2 Environmental balance

For evaluating the environmental impact of each scenario, only the emissions in air was considered and two impacts indicators have been used: Global Warming Potential (GWP) expressed as kg of CO_2 equivalent per kg of treated MSW and Human Toxicity Potential (HTP) expressed as kg of 1.4 - dichlorobenzene equivalent per kg of treated MSW [5].

In Figure 6 the results after calculating GWP are presented. GWP calculation was made considering that the emissions of CH_4 is 60% of total quantity of biogas produced and the emissions of CO_2 assumed equal to zero, being biogenic one.

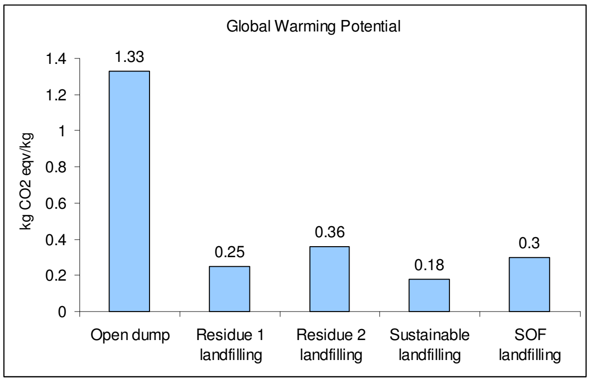

Figure 6. Global Warming Potential

The results regarding the calculation of HTP are presented in Figure 7. HTP it includes a wide range of toxic substances, with an exposure and effects for an infinite time horizon [5], in this case was considered the emissions generated to make available the energy, the materials and the infrastructure needed by the production process.

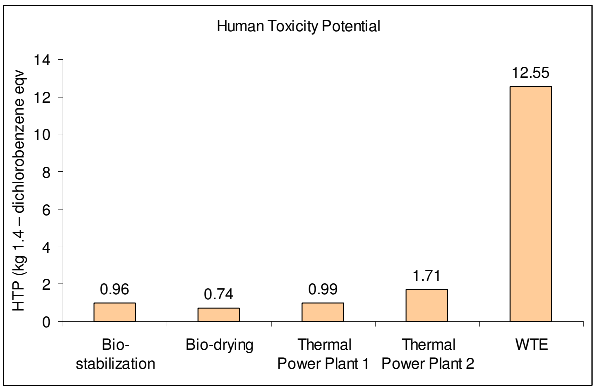

Figure 7. Human Toxicity Potential

5. Conclusions

The pre-treatment processes adopted to MSW are helping on lowering the landfill volume required for the disposal of the residues. Using the biogas produced from the sustainable landfilling for electricity production, some advantages are related to the fact that the CO_2 emissions are assumed biogenic.

In the *first scenario* when all the MSW is sent to an open dump, the energy content of waste is not exploited. The main disadvantage is the environmental issue, because it generates a high value of GWP, which is very dangerous for the environment. For the *second scenario* when the MSW is sent to a selective collection stage followed by a mechanical biological treatment for obtaining different RDF the landfilling volumes are different because of the amounts of residues resulting from different steps; instead the environmental consequences are similar. In the *third scenario* when a high selective collection stage is applied before landfilling, the environmental consequences are negligible but the energetic ones are lower. For the *last scenario* when a high selective collection stage is applied before WTE plant, the environmental consequences are good thanks to the use of the Best Available Treatment Line for the off-gas. Also the energetic recovery is good.

However, from an energetic point of view the LHV of the RDF obtained from bio-drying process (~15 MJ/kg_{MSW}) can be compared with the one from wood and lignite, respective 13.000 kJ/kg and 10.500 kJ/kg.

The best option suitable for Romania seems to be the use of MBT with bio-drying process, because of the higher possibility in producing energy, the environmental impact is lower and implicit the cost of operation can be smaller.

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